Tomoaki Taguchi · Tadashi Iwanaka
Takao Okamatsu *Editors*

Operative General Surgery in Neonates and Infants

Springer

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Preface

I am very happy to publish *Operative General Surgery in Neonates and Infants*, the first book on pediatric surgical procedures in English by young and enthusiastic Japanese pediatric surgeons. The purposes of this book are to introduce current Japanese surgical procedures in pediatric surgery and to provide educational materials for the surgical procedures using simple illustrations and explanatory photographs for new pediatric surgeons. As the graphic illustrations demonstrate operating scenes in great detail, readers can envision the operating field more clearly than they could with photographs alone. Consequently, this book is recommended for new Asian pediatric surgeons and trainees.

One of the motives in editing this book can be explained as follows. It was clear that Cambodia's medical society, which had been entirely devastated by the Khmer Rouge from 1975 to 1980, was in need of help to reorganize with the standards of contemporary associations. Remarkable achievement now has been made by the enthusiastic efforts of Cambodian doctors who survived that dark period, and by foreign initiatives. In order to spread pediatric surgical service to rural areas of Cambodia, the Department of Pediatric Surgery of the National Pediatric Hospital (NPH) started a 1-year training course in pediatric surgery for young postgraduate surgeons in rural hospitals starting in 2006 in collaboration with the University of Health Science and the Foundation for International Development/Relief (FIDR). As this program has been running very effectively, more than 20 authorized pediatric surgeons are working in rural hospitals of Cambodia currently. Still, however, they feel the lack of clinical experience and educational tools.

Contributors to this book are all experts with sufficient experience. I believe the book will be a good tutor in pediatric surgical procedures for those young pediatric surgeons. Here, we have attempted to bring into focus not only current knowledge of pediatric surgical techniques in Japan but pre- and postoperative care of patients, and we have presented this material as guidelines to the staff caring for infants with surgically treatable diseases.

I particularly appreciate Prof. Tomoaki Taguchi, M.D, Ph.D., professor of pediatric surgery and the chief editor of the book, for his strong leadership in arranging the work of editing this volume. This new English publication, *Operative General Surgery in Neonates and Infants*, would not have been realized without his leadership.

Thanks also to the editors and all contributors for their professional advice and contributions, and thanks as well to the Japanese Society of Pediatric Surgeons for their kind support.

I would like to express special gratitude to Mr. Kiyohiko Takayama, Springer Japan, and Ms. Maya Kiyosawa, Medical View Co. (the publisher of the original Japanese book), for their sincere cooperation in publishing this present volume.

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Preface

Operative General Surgery in Neonates and Infants was proposed by Dr. Takao Okamatsu in order to create educational materials for young pediatric surgeons around the world. Actually, we had already published *Standard Pediatric Surgical Procedures* (Medical View Co., edited by Tomoaki Taguchi and Tadashi Iwanaka) in Japanese in 2013, in order to cover all operative procedures of pediatric surgery. Following the proposal by Dr. Okamatsu, we picked up the important basic procedures from this Japanese book and asked the original authors to translate their Japanese to English. Medical View Co. (Ms. Maya Kiyosawa and Mr. Naohiro Asami) kindly permitted us to use the original figures from that book in this new English-language volume.

The present publication introduces the most up-to-date representative Japanese pediatric surgical procedures and points in pre- and postoperative management. Furthermore, *Operative General Surgery in Neonates and Infants* is characterized by the use of many simple illustrations to explain each procedure. We always insist that young trainees themselves draw illustrations in the operational record and encourage them by saying that "Good illustrators can become good surgeons." We are confident that their drawing illustrations by themselves is a gold-standard shortcut to understanding operative anatomy and procedures. Therefore, *Operative General Surgery in Neonates and Infants* will become a standard bible for young trainees around the world, especially in developing countries.

The authors for each procedure are experts in pediatric surgery who are operating almost every day as surgeons-in-chief in university hospitals or children's hospitals. All of them are qualified pediatric surgeons and members of the Japanese Society of Pediatric Surgeons. They are all good clinicians as well as educators. We appreciate their efforts and contributions to *Operative General Surgery in Neonates and Infants*.

Finally, we would like to thank Mr. Kiyohiko Takayama and Ms. Mariko Kubota, Springer Japan, for their wise decisions and kind consideration in publishing this book.

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Basic Procedure

1 Vascular Access

Kouji Masumoto

Abstract

In the field of pediatric surgery, the central venous catheterization technique is frequently used for the purposes of intensive care, nutrition management, administration of anticancer agents, and so on. Therefore, it is critical for pediatric surgeons to be proficient in the catheterization technique to secure a central venous route. This chapter describes the reality of and necessary precautions in central venous catheterization for children and presents complications that may occur due to catheterization. In this chapter, the first two basic central venous catheter (CVC) insertion techniques are described: the Seldinger technique and the cutdown technique. Then catheterization techniques for long-term catheter placement such as port-type and Broviac/Hickman catheters and CVC insertion techniques for continuous hemodiafiltration (CHDF) are also described.

Keywords

Central venous catheter • Catheterization • Seldinger technique • Cutdown technique • Complications

1.1 CVC Insertion Techniques

Typically external or internal jugular veins are used as a route for CVC insertion, and the veins are basically accessed via a subclavian vein [1–3]. There are two subclavian puncture techniques: the Seldinger technique to insert a catheter by using a guide wire and the direct puncture technique to make a puncture on a subclavian vein by directly using a puncture needle and inserting a catheter from its outer tube. Normally, the Seldinger technique is selected for better safety [4]. These techniques are commonly used for catheterization for long-term placement, e.g., port-type and Broviac/Hickman catheters, and continuous hemodiafiltration catheterization. If a route cannot be secured by these techniques, instead, the cutdown technique is used for insertion.

1.1.1 Seldinger Technique (Figs. 1.1 and 1.2)

1. Before inserting the catheter, check its length with a chest plain film.

2. Place the patient in the Trendelenburg position. Usually, in the past, a pillow was placed beneath the shoulder to hold the chest out. However, the author does not do this because the pillow itself may make the body lean toward either side. If you decide to use a pillow, make sure the pillow is placed at the center of the body with due caution. To make sure the guide wire is inserted into the right atrium when inserting it (as described later), prepare for electrocardiographic monitoring.

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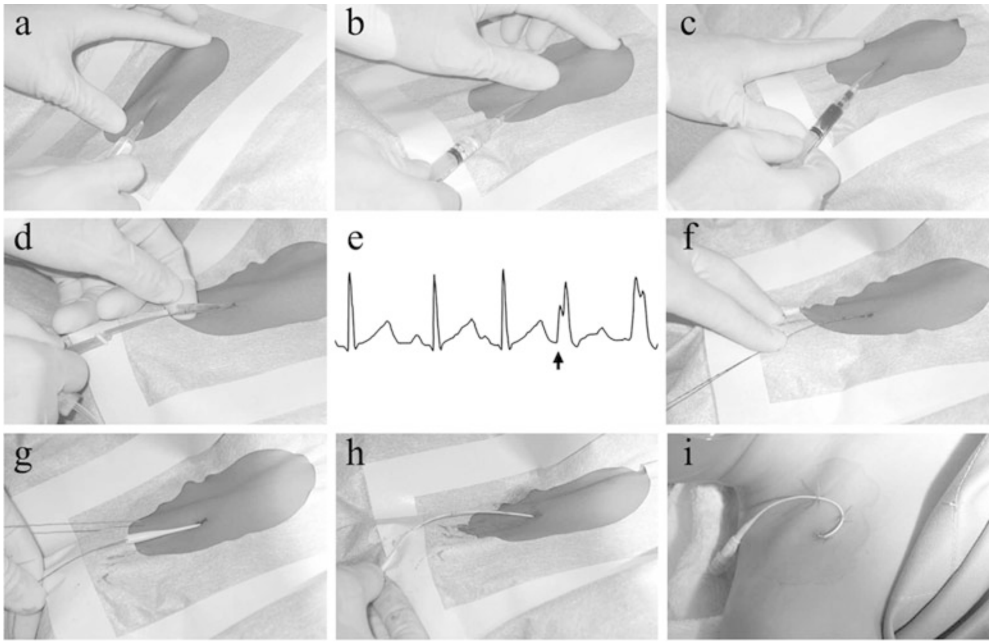

Fig. 1.1 Central venous catheterization by subclavian puncture (Seldinger technique). (**a**) Anesthetizing the right subclavian area. Exploratory puncture will follow. (**b**) Using the supplied sheathed catheter for the puncture. (**c**) Reversed venous blood flow observed with the puncture. (**d**) Inserting the guide wire along the sheath. (**e**) Irregular heartbeats observed on an electrocardiogram during guide wire insertion (*Arrow*). (**f**)The sheath removed and the guide wire drawn back to the point where no irregular heartbeats are observed. (**g**) Inserting the dilator for route dilation. (**h**) Inserting the catheter along the guide wire. (**i**) Fixing the catheter

3. In principle, use advanced barrier precautions; operators should wear a sterile gown, mask, cap, and sterile gloves and sterilize a sufficient area on and around the skin part where the insertion will take place.
4. Use a 2.5-cc syringe of 1 % Xylocaine or procaine hydrochloride with a 25G or 23G needle to locally anesthetize the insertion point and the portion below the skin (Fig. 1.1a).
5. Then, use a 2.5-cc syringe with 23G needle to conduct an exploratory puncture. The puncture site should be the outer third of the clavicle, and the needlepoint should start from the point of 1–2 finger widths toward the tail from the center of the clavicle and go toward the suprasternal area. When the exploratory puncture on the subclavian vein is confirmed as successful, mark the direction in preparation for the puncture. Recently, it has been recommended to check the subclavian vein location under echographic guidance [5].
6. For the puncture, an indwelling needle supplied with a respective catheter is often used (Fig. 1.1b). However, 22G or smaller indwelling needles may not reach the subclavian vein and may be deflected depending on the force of the puncture, which may lead the needlepoint toward the pleural cavity. So, it is better to use an 18G or 20G indwelling needle. If echography is available for this puncture, it will help effectively track the puncture needlepoint and improve the safety.
7. If any reversed vascular flow is observed (Fig. 1.1c), advance the outer tube of the puncture needle further, take out the inner tube, and insert the guide wire (Fig. 1.1d). The guide wire is inserted into the vessel if it can go in smoothly. If any resistance is felt, it may be inserted outside the blood vessels. In this case, be sure to remove the guide wire and check for reversed blood flow from the outer tube of the indwelling needle. If no reversed blood flow is observed, you should redo this puncture procedure.
8. When the guide wire is inserted into the vessel, turn the neck toward the punctured side to prevent the guide wire being inserted into the jugular vein and then further advance the guide wire. When the guide wire enters deep into the vessel, abnormal cardiac rhythm should be observed on an electrocardiogram (Fig. 1.1e). These irregular heartbeats should be caused by stimuli on the right ventricle from guide wire insertion. So at this point, slightly withdraw the guide wire and hold it where no irregular heartbeats are observed (Fig. 1.1f).
9. Cut the puncture site with a sharp-pointed knife and insert a supplied dilator along the guide wire (Fig. 1.1g) to dilate the catheter insertion route.
10. Withdraw the dilator and insert the catheter to the extent determined in advance (Fig. 1.1h).

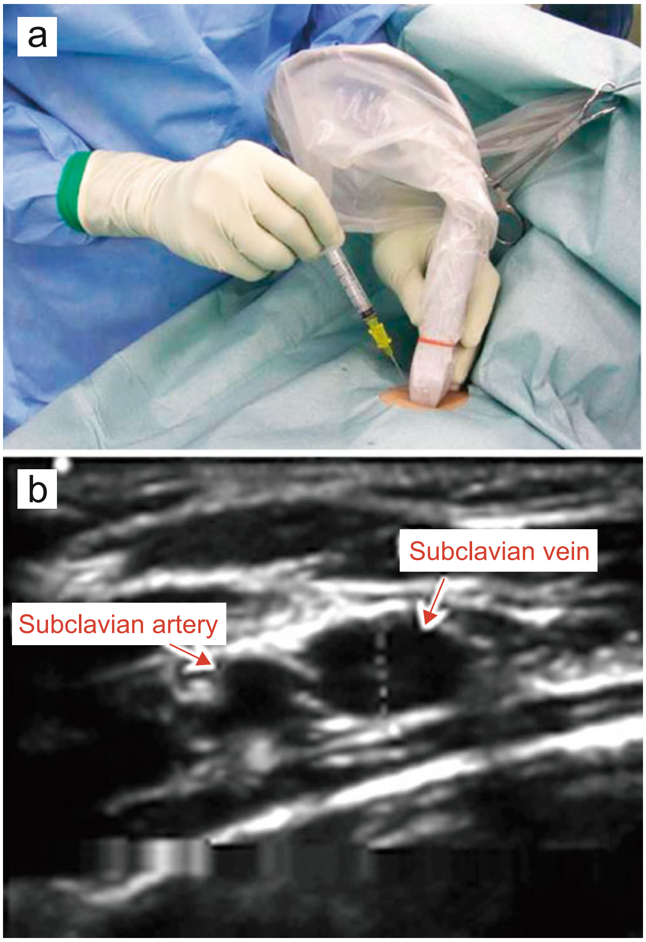

Fig. 1.2 Locating the subclavian vein under echocardiographic guidance. (**a**) Subclavian puncture under echocardiographic guidance. (**b**) Subclavian vessels on echocardiography. When pressed by an echocardiographic probe, the vein is flattened but the lumen of the artery is maintained and beats can be observed

11. Fix the catheter on the skin (Fig. 1.1i). If any fixing device is supplied with the catheter, it is better to use it to minimize the risk of accidents during withdrawal.
12. After catheter insertion, be sure to take a chest plain film and check that the tip of the catheter is in the superior vena cava or the right atrium. Also, check whether any complications (pneumothorax, hemothorax, or breast-wall hematoma) have developed.

1.1.2 Cutdown Technique

For the central venous approach, the cutdown technique is a final procedure for route securement and is used when a puncture is unsuccessful with the Seldinger technique or when risks associated with a puncture technique should be avoided [1–3]. Typically it is used for approaches to internal jugular veins and femoral veins but it is also used for cases where making a puncture on a peripheral vein is difficult or in order to secure an arterial line through the radial artery. In this section, the cutdown procedure on a right internal jugular vein is described.

1. Before inserting the catheter, check its length with a chest plain film.
2. Turn the head of the patient to the left and check the position of the right sternocleidomastoid muscle. To make sure the guide wire is inserted into the right atrium, when inserting it (as described later), prepare for electrocardiographic monitoring.
3. In principle, use advanced barrier precautions; operators should wear a sterile gown, mask, cap, and sterile gloves and sterilize a sufficient area on and around the skin part where the insertion will take place.
4. Use a 2.5-cc syringe of 1 % Xylocaine or procaine hydrochloride with a 25G or 23G needle to locally anesthetize the incised skin site and the portion below the skin.
5. An internal jugular vein forms a sheath together with the common artery at the back of the sternocleidomastoid muscle. For a normal puncture procedure, the vertex of the triangle formed by the sternocleidomastoid muscle attachment sits on the clavicle and the sternal bone, and the clavicle should be the puncture site. However, for children's cutdown procedures, the skin at the point 1–2 cm closer to the head than this triangle should be cut by approximately 2 cm (Fig. 1.3).
6. Use a mosquito pean to dilate the skin and platysma, and the sternocleidomastoid muscle below them will be exposed. Vertically split the sternocleidomastoid muscle and then the internal jugular vein covered with a sheath becomes directly visible (Fig. 1.4).
7. Scoop up the internal jugular vein and appropriately exfoliate the tissue around the vein to allow two silk threads to pass through it. Divide these threads into the central side and peripheral side to grasp and hold the vein. Check that the vessel is dilated when the central side is lifted up while the peripheral side is loosened. However, as veins are prone to constrict due to spasms caused by procedure and stimuli, dilation may not be observed immediately. In such cases, spray 1 % Xylocaine around the vessel and then the internal jugular vein gradually dilates (Fig. 1.5).
8. Pull up the threads and insert the puncture needle supplied with the catheter into the central part of the internal jugular vein. Alternatively, use a sharp-pointed knife to make a small vertical incision and insert the puncture needle from the incision site. When the needle is inserted approximately 1 cm into the vessel, withdraw the puncture needle's inner tube, loosen the silk thread

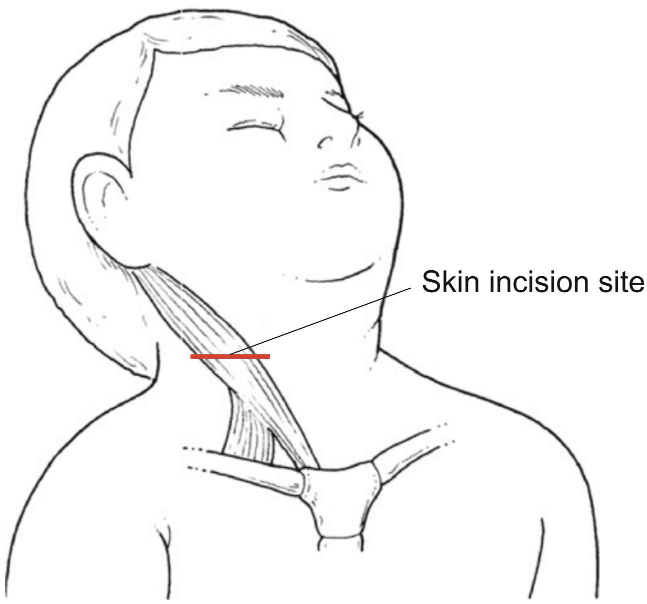

Fig. 1.3 Reference skin incision size for cutdown of the internal jugular vein

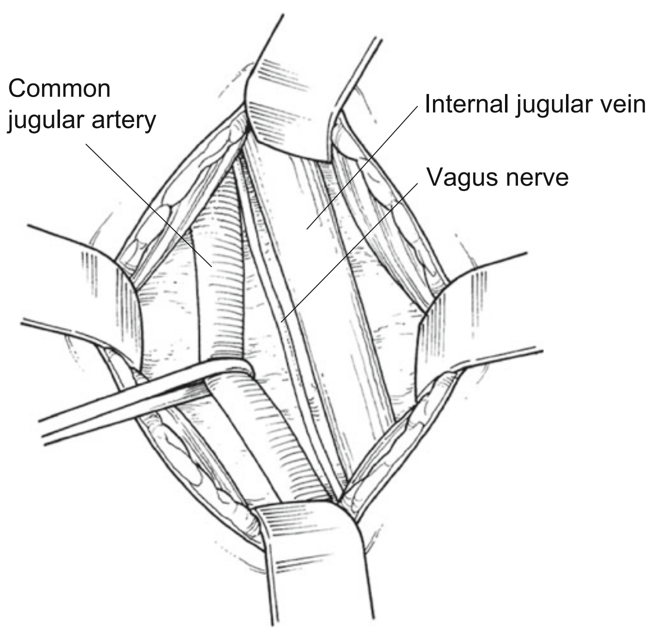

Fig. 1.4 Positional relation of the internal jugular vein and common artery

on the central side, advance the outer tube only, and place the puncture needle's outer tube in the inner jugular vein.

9. Confirm a reversed blood flow through the puncture needle's outer tube and insert the guide wire. When the guide wire enters deep into the vessel, abnormal cardiac rhythm should be observed on an electrocardiogram. At this point, slightly withdraw the guide wire and grasp it at a point where no irregular heartbeats are observed.
10. Insert the supplied dilator along the guide wire to dilate the catheter insertion route. Then withdraw the dilator and insert the catheter along the guide wire to the extent determined in advance.
11. If bleeding from the puncture is low after the catheter insertion, remove the grasping silk threads. In the event that bleeding from the incision is expected, ligate the peripheral side. The central side should also be ligated but to the extent that no catheter obstruction is caused. At this point, ensure that blood can flow into the catheter.
12. After closing the wound and fixing the catheter on the skin, finally, be sure to take a chest plain film and check that the tip of the catheter is in the superior vena cava or the right atrium.

1.2 Insertion of Port-Type Catheter for Long-Term Placement

A port-type catheter consists of a catheter tube that is inserted into a vessel and a reservoir which is embedded under the skin. It is often used for administration of anti-cancer drugs and long-term nutrition management [6]. As there is no risk of spontaneous extraction and no part is exposed except during the administration period, patients may even have a bath; thus QOL is improved. At the same time, however, a skin puncture procedure is necessary for use and repeated puncture procedures may cause the risk of skin necrosis of the site [6]. Basal plane sizes in most port-type catheter reservoirs are about 25–30 mm and the height range is 10–15 mm. Thus, they are typically used for patients in childhood or later. A catheter size appropriate for the body size of each patient should be selected. Typical insertion sites are subclavian and internal jugular veins.

1.2.1 Reality of Port-Type Catheter Insertion Techniques

In practice, two processes are conducted: catheter insertion and reservoir placement [7]. Venous puncture for catheter insertion will not be covered here, because the use of the aforementioned Seldinger technique or cutdown technique is assumed. For insertion of a port-type catheter, fluoroscopy during operation is essential to identify the location of the catheter tip.

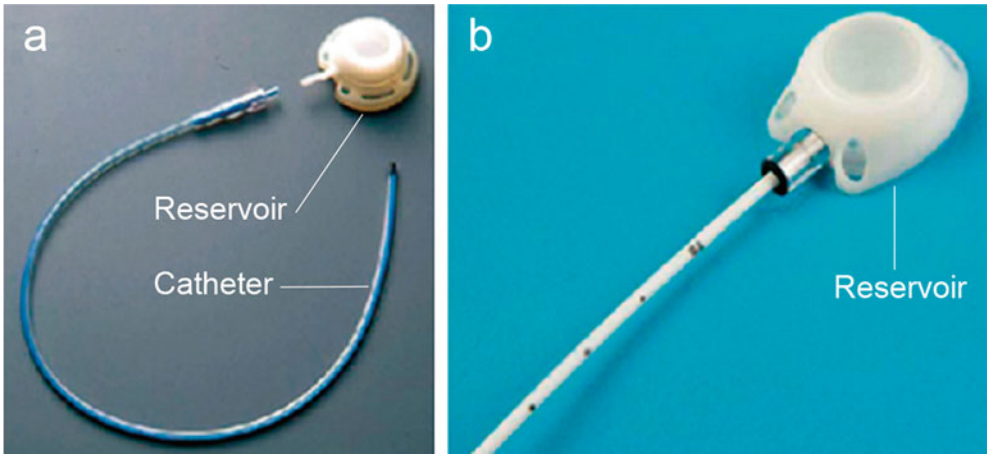

Fig. 1.5 Port-type catheter. Consists of (**a**) a catheter tube to insert into a vessel and (**b**) a reservoir embedded under the skin for infusion from outside through a needle puncture

1.2.2 Procedures of Access of Central Venous Route by Using the Subclavian Vein

1. The procedures are the same as for the Seldinger technique through to Step 8 (guide wire insertion). After the guide wire insertion, make an incision of approximately 1 cm on the skin for easy insertion of the sheath introducer for catheter insertion.
2. Insert the sheath introducer into the vein. The point is the insertion with rotating the sheath introducer equipped with a dilator through the guide wire to dilate the route (Fig. 1.8). At this point, use fluoroscopy during operation to make sure the sheath introducer tip does not advance too deeply.
3. Withdraw the dilator and leave the sheath introducer only. At this point, close off the sheath introducer outlet using one finger to prevent bleeding and air tapping.
4. Insert the catheter through the sheath introducer under the fluoroscopic guidance. Ensure that the catheter tip goes into the superior vena cava with care.
5. Peel away and withdraw the sheath introducer. At this point, it is important to have an assistant hold the catheter to prevent extraction. After withdrawing the sheath introducer, under fluoroscopic guidance, be sure to check that the catheter tip location remains unchanged.
6. Proceed to the reservoir placement process. The placement position should be as flat a plane as possible in the precordial region. It should also have relatively thicker subcutaneous fat while not overlapping with the mammary gland. After selecting an appropriate position, make an incision of approximately 2.5 cm in the skin.
7. From the skin incision opening, create a subcutaneous pocket equivalent to the size of the reservoir. Puncturing by needle is difficult if subcutaneous fat on the reservoir is thick, but if it is too thin, skin necrosis may be caused. Therefore, generally a subcutaneous thickness of 5–20 mm on the reservoir is recommended. Also, the skin incision must not overlap with the placement site of reservoir unit (Fig. 1.6).
8. With the supplied tunneller (see Fig. 1.8), develop a subcutaneous tunnel between the catheter insertion site and the skin incision for reservoir placement (Fig. 1.6).
9. Connect the peripheral side of the catheter with the tunneller, let it through the subcutaneous tunnel and carefully draw it through to the subcutaneous pocket for reservoir placement. At this point also, under fluoroscopic guidance, check that the catheter tip is not dislocated.
10. After checking the appropriate catheter length to remain in the body, cut the catheter to the required length and connect it to the reservoir. Then use the supplied catheter lock to lock the catheter to the reservoir. For this step, care must be exercised not to let the catheter come out.
11. Place the reservoir in the subcutaneous pocket and fix it to the fascia of the pectoral major muscle using two- or three-point suturing.
12. Use the non-corning needle (Huber needle; Fig. 1.7) to puncture the reservoir to check for any obstruction in the lumen.

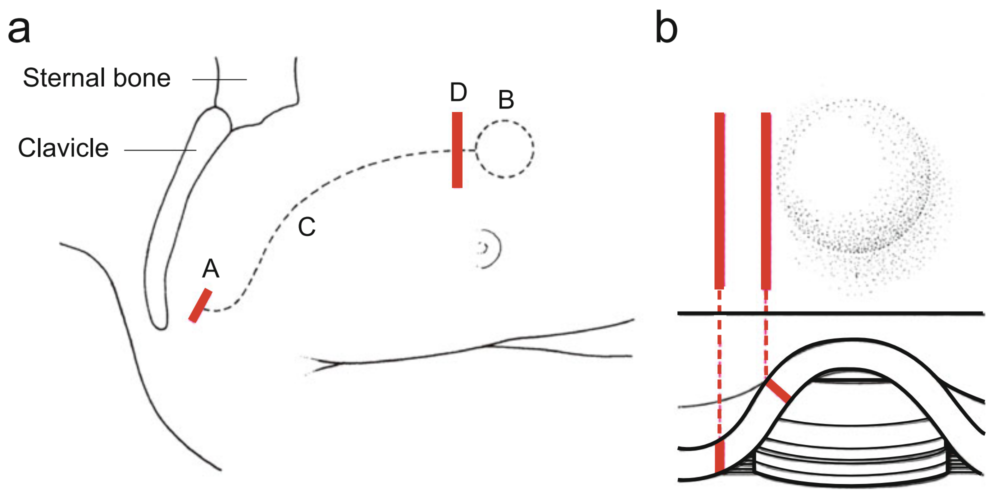

Fig. 1.6 Reservoir placement position. (**a**) Reservoir placement position and subcutaneous tunnel (*A* skin incision for catheter insertion, *B* subcutaneous tunnel for catheter, *C* reservoir placement position, *D* skin incision for reservoir insertion). (**b**) Reservoir placement position and skin incision (suture) site. The solid line represents a skin incision (suture) site. As skin troubles may occur when the skin incision (suture) site is close to the reservoir line as indicated in the left figure, ensure that the skin incision (suture) site does not overlap with the reservoir as indicated in the right figure

Fig. 1.7 Huber needle. The *right* and *left* figures show an example of a Huber needle (Smith Medical's Gripper Needle) and a puncture image of a Huber needle into the reservoir (Toray Medical's Winged Surecan)

13. Close off each skin incision opening to end the procedures. At the end, be sure to take a chest plain film and check for any complications.

1.3 Insertion of Broviac/Hickman Catheter for Long-Term Placement

A Broviac/Hickman catheter has a Dacron cuff on the catheter tube, which is to be buried and subsequently adhere to subcutaneous tissues (Fig. 1.8) [5, 7]. As with port-type catheters, it is often used for the administration of anticancer drugs and long-term nutrition management. It has advantages in that adhesion of the cuff reduces the possibility of accidental withdrawal and localized infection of the catheter insertion site to systemic infection is blocked by the cuff. The minimum diameter of the catheters is 2.7 Fr for a single lumen and 5 Fr for double lumens. It is often used for patients in infants or later and appropriate catheters should be selected according to the body size [8]. Typical insertion sites are subclavian and internal jugular veins.

1.3.1 Reality of Broviac/Hickman Catheter Insertion Techniques

For insertion of a Broviac/Hickman catheter (Fig. 1.8), there are two processes: insertion of the catheter and placement of the Dacron cuff equipped on the catheter. Venous puncture for catheter insertion will not be covered here because the use of the aforementioned Seldinger technique or cutdown technique is assumed. For insertion of a Broviac/Hickman catheter, fluoroscopy during operation is essential to adjust the catheter length and identify the location of the catheter tip.

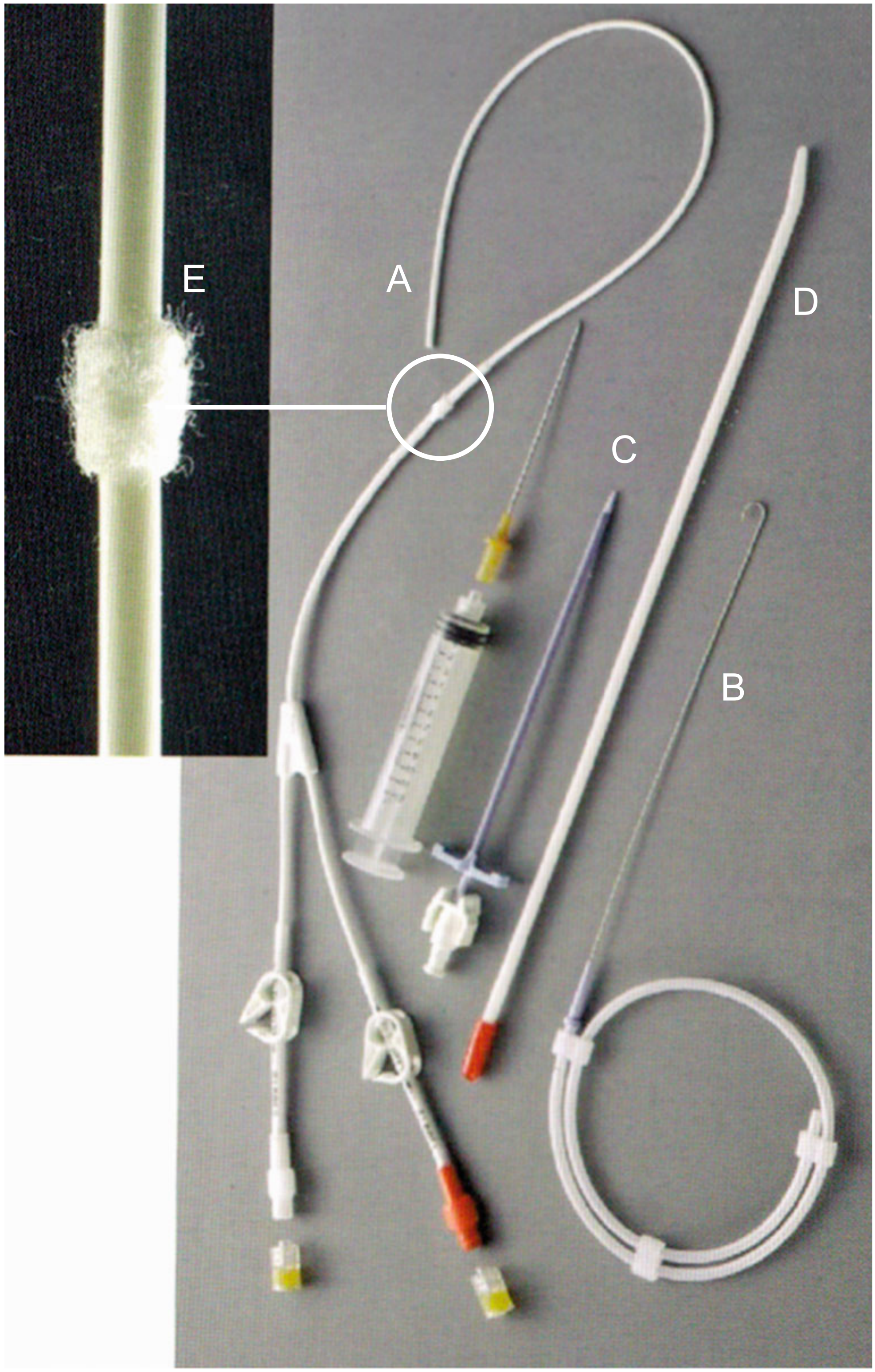

Fig. 1.8 Hickman catheter set. A Broviac/Hickman catheter has a Dacron cuff (E) on the catheter tube to insert into a vessel, which is to be buried and subsequently adhere to hypodermal tissues. (**a**) catheter, (**b**) guide wire, (**c**) sheath introducer with dilator, (**d**) tunneller, (**e**) Dacron cuff

1.3.2 Procedures of Access of Central Venous Route by Using the Subclavian Vein

1. The procedures are the same as for the CVC insertion technique through to the step of guide wire insertion. After the guide wire insertion, use the same procedures for the port-type catheter for insertion of the sheath introducer for catheter insertion (Steps 1–3 of the port-type catheter insertion).

2. Following the insertion of the guide wire, determine a Broviac/Hickman catheter insertion site on the skin and check the Dacron cuff (Fig. 1.8) placement site under the skin. Then, under the fluoroscopic guidance, cut off the tip to adjust its length so that the tip position is in the superior vena cava or right atrium.
3. Make a 7–8 mm skin incision for insertion of the Broviac/Hickman catheter, and use the supplied tunneller to guide this catheter to the insertion port of the sheath introducer. At this point, make sure to set the Dacron cuff placement site sufficiently apart from the skin insertion site.
4. With the dilator extracted, insert the catheter through the sheath introducer under the fluoroscopic guidance. Ensure that the catheter tip goes into the superior vena cava or right atrium with care.
5. Peel away and withdraw the sheath introducer. At this point, it is important to have an assistant hold the catheter to prevent extraction. After withdrawing the sheath introducer, check again, under fluoroscopic guidance, that the catheter tip location remains unchanged.
6. Check the catheter tip position and the cuff position, and close off the wound and fix the catheter to the skin (Fig. 1.9). It takes 2–3 weeks until the cuff is fixed under the skin. Exert care not to let the catheter come out during the period.

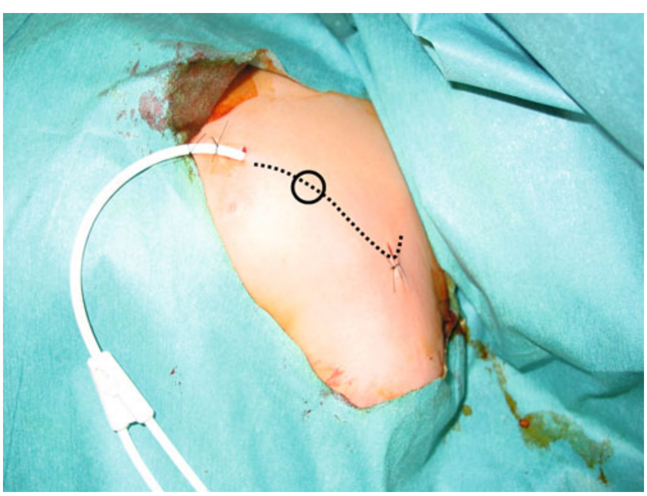

Fig. 1.9 Broviac catheter placement. Place the Dacron cuff under the skin away from the catheter insertion site (the part indicated in the *solid circle*). The *dotted line* indicates the subcutaneous tunnel site of the catheter

1.4 CHDF (Continuous Hemodiafiltration) Catheter Insertion Techniques

In the past, rapid hemodialysis therapies were difficult for many children as only a few kinds of equipment and catheters appropriate for children were available. In recent years, however, development of equipment, modules, and small-diameter catheters (6 Fr/7 Fr) intended for use in children have been advanced, and techniques are becoming available for treating them. For CHDF in rapid hemodialysis therapies, it is important to keep a stable blood flow rate and stabilize the circulation dynamics. In particular, continuous reversed blood flow is an important factor [9]. The radial artery or internal jugular veins/superior vena cava are often used to cause sufficient reversed blood flow, and the recent trend is to use the latter. Options for children include the superior vena cava and subclavian veins, but internal jugular veins are generally regarded as the first choice in consideration of safety in puncture and placement procedures and effectiveness for infection prevention [10].

There are two types of CHDF catheters depending on hole positions: side holes and end holes. Side-hole catheters are generally thin and easy to insert, but have a risk of poor reversed blood flow with a small vascular diameter. End-hole catheters are necessarily larger and usage is relatively limited. For your reference, the corresponding catheter sizes to body weight are indicated in Table 1.1. Notably, the finest-diameter (6 Fr) catheter is most often used for newborns and infants.

The insertion procedures of the CHDF catheters are the same as those of CVC insertion using the Seldinger technique. In recent years, the insertion procedures are often conducted under echocardiographic guidance for the purpose of safety. Thus, the insertion procedures are not covered in this section. However, it is still important to note that the catheter tip must be placed in the superior vena cava or the right atrium in consideration of the reversed blood flow rate.

Table 1.1 The corresponding catheter sizes to body weight

Body weight (kg)	Catheter's size (Fr)	Catheter's length (cm)	Flow (mL/min)
Less than 5	5–7	Less than 10	<15
5–10	7–8	10–13	15–30
10–20	9–11	10–15 (femoral, 20)	30–60
More than 20	11–13	More than 15 (femoral, 20–25)	>60 (3–4 mL/kg)

1.4.1 Complications to Be Specifically Noted for Placement of Central Venous Catheter [11, 12]

1.4.1.1 Pneumothorax

When a puncture needle is inserted too deeply toward the thoracic cavity for subclavian puncture, it breaks the thoracic parietal and visceral pleurae and damages the lung parenchyma, leading to pneumothorax. Although it could be noticed due to suctioning of air from the puncture needle in some cases, it may be left unnoticed until the completion of the insertion procedures in other cases. If coughing is observed after the insertion, pneumothorax is suspected. After catheter insertion, check for coughing, asymmetry in breath sounds on auscultation, and reduction of oxygen saturation by using a pulse oximeter and check with a chest plain film.

1.4.1.2 Hemothorax

Hemothorax occurs when the subclavian artery or vein and thoracic parietal pleura are damaged by the same mechanism as pneumothorax or when the intercostal artery or the lung parenchyma artery is damaged. As with pneumothorax, after catheter insertion, check for asymmetry in breath sounds and reduction of oxygen saturation by using a pulse oximeter and check with a chest plain film.

1.4.1.3 Mislodging/Malposition of Catheter Tip

For prevention of mislodging/malposition, it is important to turn the cervical part toward the puncture side when the tip is inserted into the subclavian vein. In the procedure of subclavian puncture, the catheter tip is often prone to settle in the internal jugular vein, so check the location with a chest plain film after catheter insertion. When malposition into the internal jugular vein is observed, draw the catheter tip back to the innominate vein.

1.4.1.4 Arterial Puncture

The subclavian artery runs along a slightly deeper path in parallel with the subclavian vein; so there is a risk of the arterial puncture when a puncture needle is inserted deeply for subclavian puncture. In the event of arterial puncture, the puncture needle should be withdrawn promptly and sufficient pressure hemostasis should be applied on the site to prevent hematoma formation over 5 min. In such cases, the puncture procedures should be conducted on the opposite side.

1.4.1.5 Injury to the Thoracic Duct

This complication occurs when a merging section of the internal jugular vein and subclavian vein is accidentally damaged at the time of subclavian puncture on the left side. It is associated with no symptoms immediately after the puncture and most often noticed from contamination of the dressing by lymph fluid or accumulated fluid in the left thoracic cavity in a chest plain film.

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Thoracotomy and Laparotomy

2

Noriaki Usui

Abstract

General procedure of thoracotomy and laparotomy is described in this chapter. In terms of thoracotomy, three different types of incision such as posterolateral thoracotomy, axillar vertical incision, and axillar skin crease incision were illustrated. Thoracotomy with conservation of the perithoracic muscles by using axillar skin crease incision was described in detail. The position of patient, selection of intercostal space, and postoperative care tips were also discussed. In respect to laparotomy, various types of approaches such as upper abdominal transverse incision, lower abdominal transverse incision, subcostal incision, Mercedes-Benz incision, pararectal incision, and transumbilical approach were illustrated. Transumbilical approaches including upper half-circumumbilical incision, lower half-circumumbilical skin incision, vertical incision in the umbilicus, and umbilical sliding-window technique were described in detail. Abdominal wound closure and postoperative care tips were also discussed.

Keywords

Thoracotomy • Laparotomy • Axillar skin crease incision • Transumbilical approach

2.1 Thoracotomy

2.1.1 Preoperative Management

A patient is basically in the lateral position under general anesthesia. Although the pulmonary lobe can be easily excluded in neonates and infants, a better operative field can be obtained by degassing the lungs via differential lung ventilation by using a Fogarty catheter as needed in older children. For patients in whom the intraoperative tip position of the endotracheal tube is problematic (e.g., patients with esophageal atresia), the tip position of the endotracheal tube should be confirmed by using a bronchofiberscope before and after postural change.

2.1.2 Operations

2.1.2.1 Position of Patient

After the patient is placed in the lateral position, a pillow of proper height is inserted below the side of the chest to protect the shoulders. Simultaneously, the intercostal space in the affected side should be dilated with slight curvature of the entire chest. The affected arm is elevated by using a handstand or bed cradle to expand to 100–120° (Fig. 2.1). Especially, expanding the arm is necessary for the axillary fold incision. However, caution must be used because an excessively expanded arm may cause brachial plexus palsy. Because infants' bodies are flexible and tend to assume

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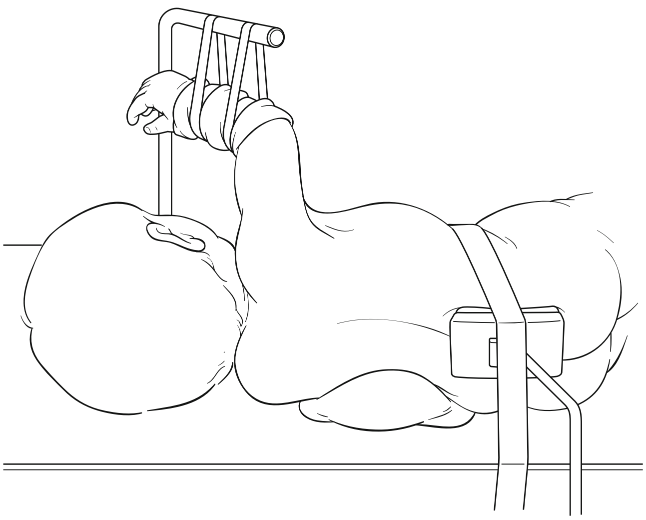

Fig. 2.1 Position of children during thoracotomy

unstable postures, the anterior and posterior hips should be grasped and fixed thoroughly.

2.1.2.2 Selection of Incision

A selection should be made from among the following skin incision approaches: posterolateral thoracotomy, axillar vertical incision, and axillar skin crease incision [1]. Posterolateral thoracotomy (Fig. 2.2a) provides the largest visual field. However, the use of this approach can easily result in subsequent thoracic deformity or elevation of the shoulder because suturing involves a divided part of the muscle, such as the latissimus dorsi muscle, pectoralis major muscle, and sometimes the trapezius muscle (Fig. 2.3). In the axillar vertical incision, a straight skin incision line is made along the middle axillary line (Fig. 2.2b). In the axillar skin crease incision, a loop-shaped skin incision line is made along the skin folds that are located at the most caudal region of the folds existing in the axilla naturally (Fig. 2.2c). After making the skin incision for both the axillar vertical incision and axillar skin crease incision, the dermal flaps should be generated, followed by the performance of thoracotomy by abduction in flexion of the latissimus dorsi muscle and pectoralis major muscle, without dissecting them. The visual field of surgery depends on the size of the window formed by the dermal flaps. However, for the axillar vertical incision, the window can be expanded by extending the skin incision line (Fig. 2.4). Meanwhile, for the axillar skin crease incision, the size of the window is limited. The axillar skin crease incision is the best from a cosmetic viewpoint because the surgical wound will be unified with the folds of the axillary in the long term, with little chance of keloid scar formation (Fig. 2.5). While considering that the visual field is better in the axillar vertical incision, the skin incision approach should be chosen according to the operator's habituation and skill, the degree of adhesion, etc.

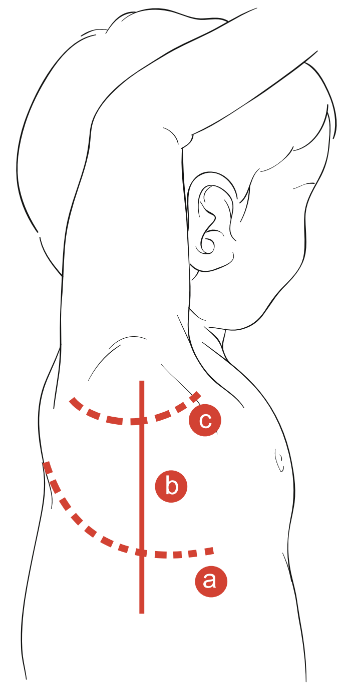

Fig. 2.2 Skin incision line for thoracotomy. (**a**) Posterolateral thoracotomy. (**b**) Axillar vertical incision. (**c**) Axillar skin crease incision

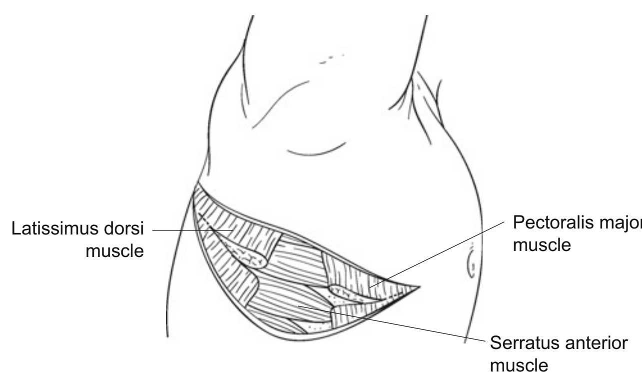

Fig. 2.3 Posterolateral thoracotomy: Dissection of the latissimus dorsi muscle and pectoralis major muscle

2.1.2.3 Selection of Intercostal Space

The intercostal space should be chosen according to the targeted site. The standard selections are as follows: the third or fourth intercostal space for patients with esophageal atresia, the fourth or fifth intercostal space for patients who undergo superior lobe resection, the fifth or sixth intercostal space for patients who undergo inferior lobe resection, and the sixth or seventh intercostal space for patients who undergo surgery for the diaphragm or lower esophagus.

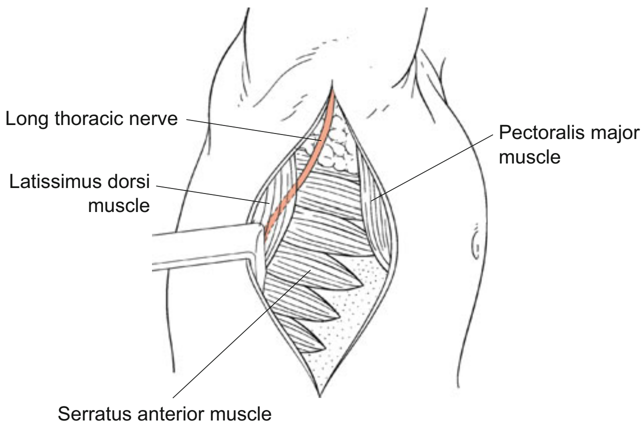

Fig. 2.4 Axillar vertical incision: Exposure of the serratus anterior muscle

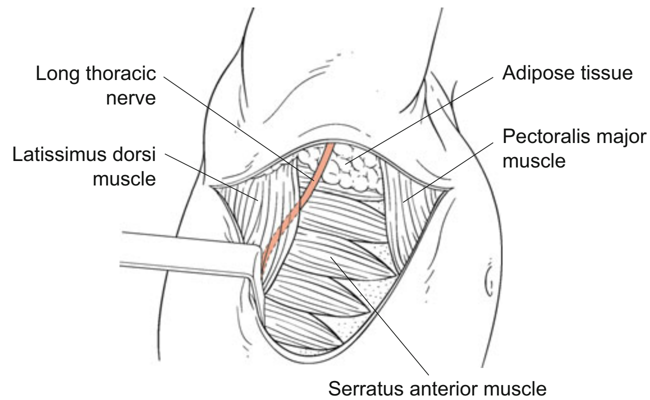

Fig. 2.6 Axillar skin crease incision. Displacement of the latissimus dorsi muscle posteriorly

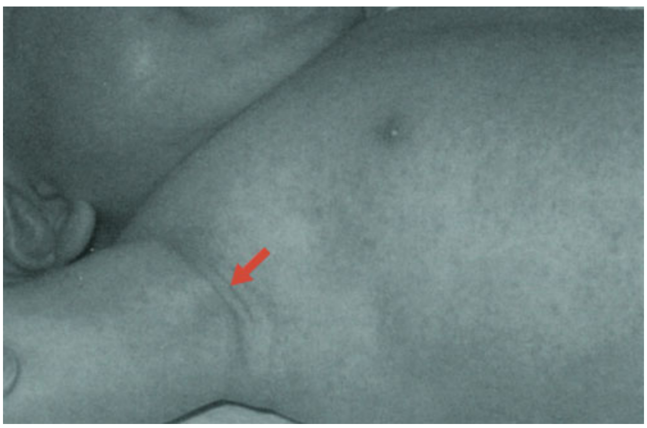

Fig. 2.5 Postoperative wound from the axillar skin crease incision for esophageal atresia (at sixth month after surgery). The skin incised wound (*arrow*) can barely be distinguished from the folds of the axillary

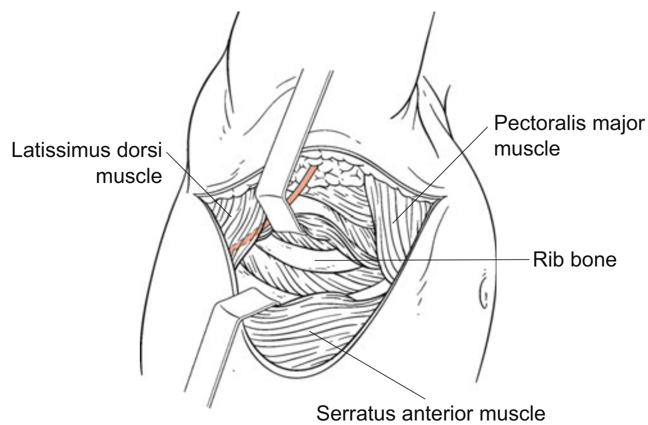

Fig. 2.7 Axillar skin crease incision. Abduction in flexion of the serratus anterior muscle

2.1.2.4 Thoracotomy with Conservation of the Perithoracic Muscles

Regardless of the skin incision approach, it is important to perform thoracotomy while conserving the muscles forming the surroundings of the thorax, such as the latissimus dorsi muscle, pectoralis major muscle, and serratus anterior muscle, as much as possible. This helps to prevent the postoperative limitations of movement and pain and the occurrence of thoracic deformity and elevation of the shoulder during the convalescent phase.

The following section describes thoracotomy with conservation of the perithoracic muscles by using axillar skin crease incision [1] as an example:

Choose the skin incision line located at the most caudal region of the folds. If it is within the area of folds, it can deviate from the axilla to some extent.

Make an incision in the subcutaneous tissues slightly toward the caudal region, and displace the adipose tissues toward the cephalad portion while being careful not to cut the inside of the adipose tissues of the axilla.

To form the dermal flaps, adequately remove the subcutaneous tissues in the layer of the anterior surface of the fascia. Since the skin of neonates and infants is sufficiently extensible, secure the window of the dermal flaps widely.

In the dorsum, incise the fascia along the anterior border of the latissimus dorsi muscle, which traverses and displaces the latissimus dorsi muscle with the long thoracic nerve posteriorly (Fig. 2.6).

In the ventral aspect, perform blunt removal of the pectoralis major muscle until clavicle can be palpated by the finger, and displace the pectoralis major muscle anteriorly.

Identify the intercostal space where thoracotomy is planned, and perform abduction in flexion of the serratus anterior muscle so that the chest wall is exposed on the targeted intercostal space. Remove a part of the serratus anterior muscle because it attaches to the ribs in the ventral aspect, and expose the entire intercostal space where thoracotomy is planned (Fig. 2.7).

Separate the intercostal muscle by using electrocautery while collecting it little by little. In normal thoracotomy, only the pleura are incised. In the extrapleural approach, enter the extrapleural space from outside of the pleura.

2.1.2.5 Exposure of Operation Field and Protection of Wound Border

A rib retractor should be used in the intercostal space in order to expand the operative field by dilating the intercostal spaces. In axillar vertical incision and axillar skin crease incision, to dilate the window of the dermal flap, a retractor should be used at right angles to the rib retractor. Caution must be used to avoid crushing the border of the wound when it is excessively dilated. A wound protector can be used to protect the wound border.

2.1.2.6 Wound Closure

For the closure of the chest wound, care must be taken not to close the intercostal space excessively. Regardless of the dissected length of the intercostal space, three to four stitches for the ribs with absorption threads are adequate for closing the space without causing narrowing of the original intercostal space. When the intercostal space is closed excessively, rib fusion may occur, leading to deformation of the thorax. A drain should be inserted into the thoracic cavity as needed. When the subcutaneous tissues are widely removed, a drain can be placed subcutaneously for the short term.

2.1.3 Postoperative Care Tips

After surgery for treatment of pulmonary hilar lesion and the mediastinum, the postoperative course should be followed by obtaining chest X-rays while carefully monitoring for the onset of chylothorax and complications due to phrenic nerve paralysis.

2.2 Laparotomy

2.2.1 Preoperative Management

A patient is basically in the supine position under general anesthesia. For a patient in whom the operative field is located at the retroperitoneum or at a deep site, a pillow of proper height should be inserted below the back, and the abdomen should be elevated with curvature of the vertebral body according to the targeted site.

2.2.2 Operations

2.2.2.1 Selection from Among the Laparotomy Approaches

The procedures of laparotomy consist of skin incision, subcutaneous tissue incision, fasciotomy, isolation of the muscle or abduction in flexion, and peritoneum incision. Various approaches can be used, depending on the extent of the surgical field. Generally, in children, a transverse incision made across the cleavage lines is preferable to a vertical incision. Various approaches are described in the following section.

2.2.2.2 Upper Abdominal Transverse Incision

This incision is a basic approach for abdominal surgery in children (Fig. 2.8a). This approach allows for a large visual field, and the surgical wound is inconspicuous because the incision is made across the cleavage lines. It crosses the rectus abdominis muscle or the round ligament of the liver. In neonates, ensure that ligation of the round ligament of the

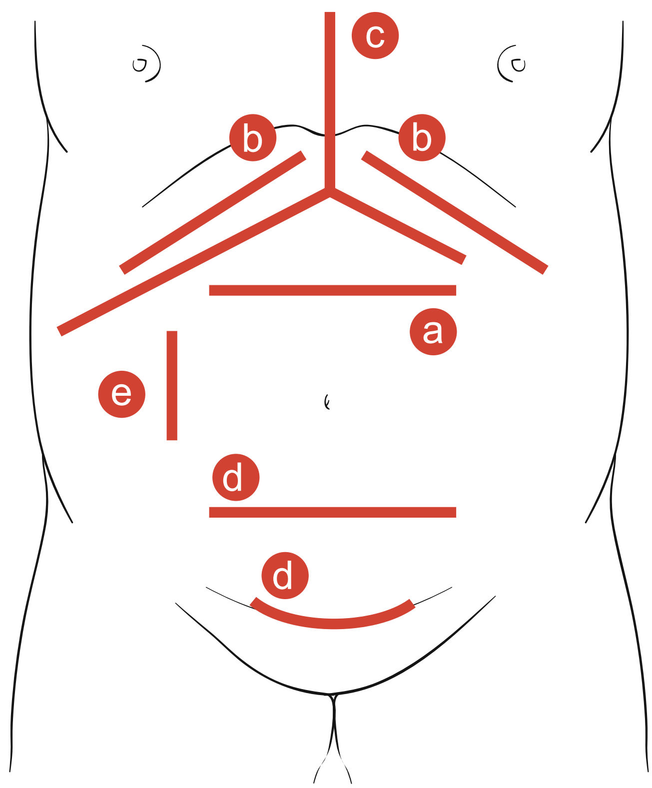

Fig. 2.8 Various approaches for laparotomy. (**a**) Upper abdominal transverse incision. (**b**) Subcostal incision. (**c**) Mercedes-Benz incision. (**d**) Lower abdominal transverse incision (**e**) Pararectal incision

liver is definitely performed because bleeding may occur. This approach is appropriate for gastrointestinal perforation in which the location of perforation cannot be identified.

Make a skin incision along the horizontal line passing through the midpoint between the xiphoid process and the umbilicus.

The length of the skin incision is based on the circumference of both rectus abdominis muscles, and the left and right lengths are adjusted according to the targeted site (Fig. 2.9).

After dilating the subcutaneous tissues, incise the anterior sheath of the rectus abdominis muscle by using electrocautery.

Hold and incise the peritoneum in order to avoid causing damage to the abdominal organs, and subsequently perform the operation.

2.2.2.3 Subcostal Incision

This approach is used for surgery in the hepatobiliary system and the right diaphragm on the right side and for the left diaphragm and the gastric cardia on the left side (Fig. 2.8b). In small infants whose costal arch is almost horizontal and whose skin is sufficiently extensible, the transverse incision along the cleavage is made only on the skin, and the subcutaneous tissues can be removed at the anterior surface of the fascia to incise the fascia and muscle under the costal arch.

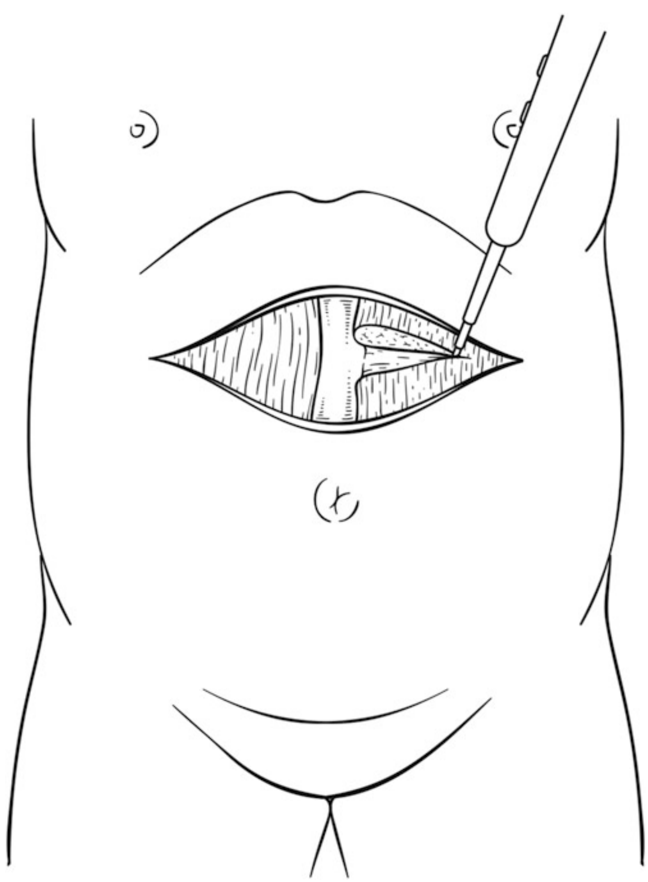

Fig. 2.9 Upper abdominal transverse incision

2.2.2.4 Mercedes-Benz Incision

This is a laparotomy approach in which the bilateral subcostal incisions are connected at the center, and a median incision is made in the cephalad portion. It is used for liver transplantation in older children (Fig. 2.8c).

2.2.2.5 Lower Abdominal Transverse Incision

This approach is used for surgery of the ileocecum, the colon and rectum extending from the sigmoid colon, the genitourinary system, and the pelvic structures (Fig. 2.8d). In a type of surgical incision known as the Pfannenstiel incision, only the line of the skin incision is made caudally, and a loop-shaped incision is made on the folds so that the scar will be hidden by the pubic hair; for the fasciae and muscle, a transverse incision is made on the center of the lower abdominal region.

2.2.2.6 Pararectal Incision

This approach is used for cholecystectomy and appendectomy, although it is currently not used frequently because laparoscopic surgery has been developed (Fig. 2.8e).

2.2.2.7 Transumbilical Approach

Since the umbilicus has been defined as an insertion site for a laparoscopic port, abdominal surgery that utilizes the umbilical region is performed with the purpose of making a surgical wound smaller and less noticeable from a cosmetic viewpoint.

- **Upper half-circumumbilical incision**: a skin incision is made on the cranial semicircle of the folds at, or slightly inside of, the umbilical ring, and the subcutaneous tissues are removed to expose the white line and anterior sheath of the rectus abdominis muscle; subsequently, laparotomy is performed with a median incision (Fig. 2.10a). A transverse incision is also made on the rectus abdominis muscle, if necessary. This approach is used for hypertrophic pyloric stenosis, duodenal atresia, and intestinal atresia. When the window of the skin secured with a wound retractor is too small, dilate it by adding a horizontal supportive incision to the skin (omega-shaped [Ω] incision).
- **Lower half-circumumbilical skin incision**: incise the caudad semicircle of the folds of the umbilical ring, and similarly perform an operation at the lower abdomen (Fig. 2.10b). This approach is used for ovarian cyst and Meckel's diverticulum.
- **Vertical incision in the umbilicus**: since surplus skin is folded in the camerostome of the center of the umbilical region, when retracting and exposing the bottom of the umbilicus to make an incision, a long incision line can be secured sufficiently only in the umbilical ring (Fig. 2.10c). This approach can be applied when performing surgeries for appendicitis, Meckel's

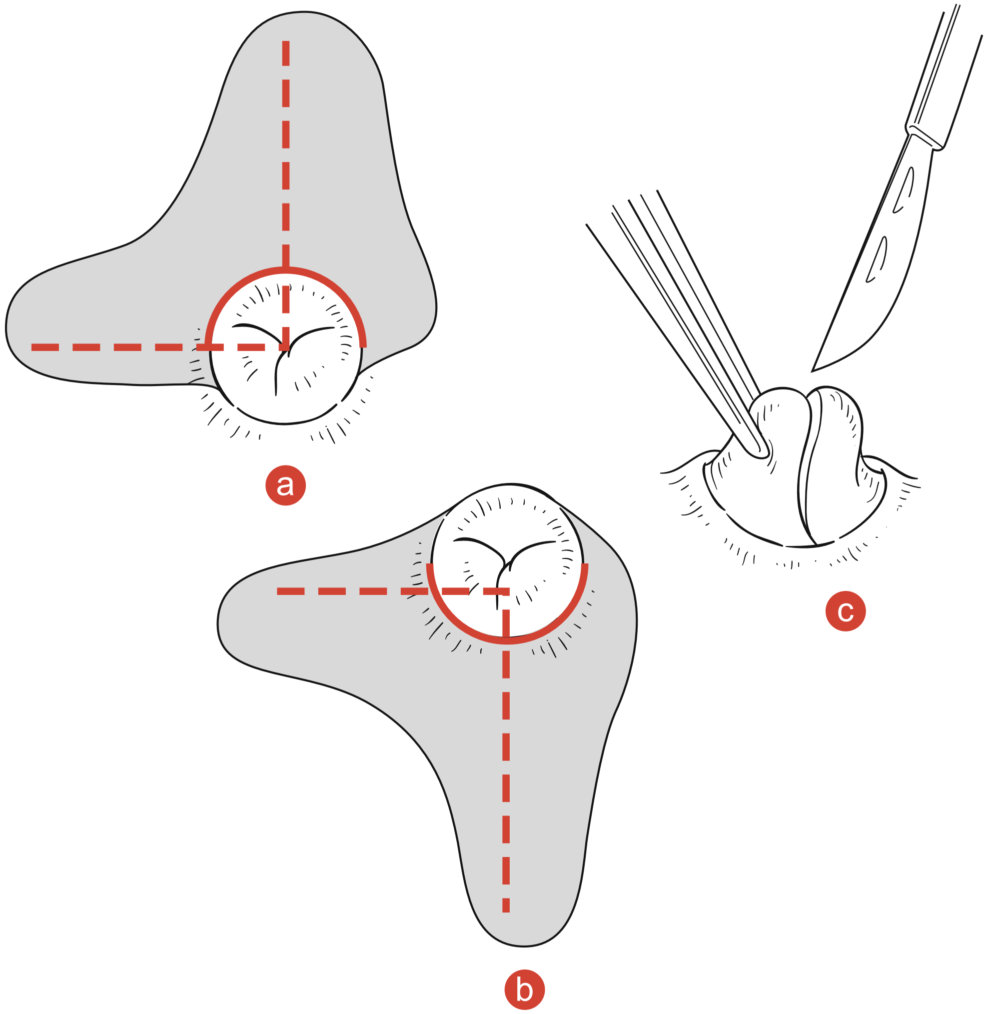

Fig. 2.10 Skin incision for the transumbilical approach. The *oblique line* indicates the range of removal of the subcutaneous tissues. The *dotted line* indicates the incision line of the fascia. (**a**) *Upper half*-circumumbilical incision. (**b**) *Lower half*-circumumbilical skin incision. (**c**) *Vertical* incision in the umbilicus

diverticulum, ovarian cyst, etc., by displacing the targeted organ outside the wound from the window by using a scope with forceps.

- **Umbilical sliding-window technique** [2]: make a circumferential skin incision along (or slightly inside) the umbilical ring, and widely remove the subcutaneous tissues in the anterior surface of the fasciae while leaving the skin of the umbilical region on the abdominal wall (Fig. 2.11a). Then, move the window formed by the dermal flap horizontally to the incised part of the muscle (Fig. 2.11b: sliding). For hypodermatomy of the umbilical region, leave the subcutaneous fat around the skin in the umbilical region and maintain blood flow of the skin. In addition, the skin window can easily be moved horizontally by removing the subcutaneous tissues thoroughly from the incised fascia as well as the contralateral navel. This technique can be applied at various sites, including the upper and lower abdomen, because the operation is performed right over the targeted organ. By expanding the range of removal of the subcutaneous tissues, laparotomy can be performed in the region away from the navel. By expanding the window with supportive incision of the skin, this technique can be applied to surgery for the biliary system and diaphragm.

2.2.2.8 Exposure of Operation Field and Protection of Wound Border

Operations, including the transumbilical approach, have recently tended to be performed with smaller skin incision wounds. A wound protector helps to secure the visual field of the surgery and to protect the wound border (Fig. 2.12).

2.2.2.9 Wound Closure

The closed abdomen procedures include suturation of the peritoneum and the transversalis fascia, suturation of the anterior layer of rectus sheath, and suturation of the subcutaneous tissues and the skin. Dehiscence of the fascia may cause abdominal incisional hernia and scarring in the wounded area. Therefore, double-layer suture is desirable for the peritoneum, muscular layer, and subcutaneous tissues

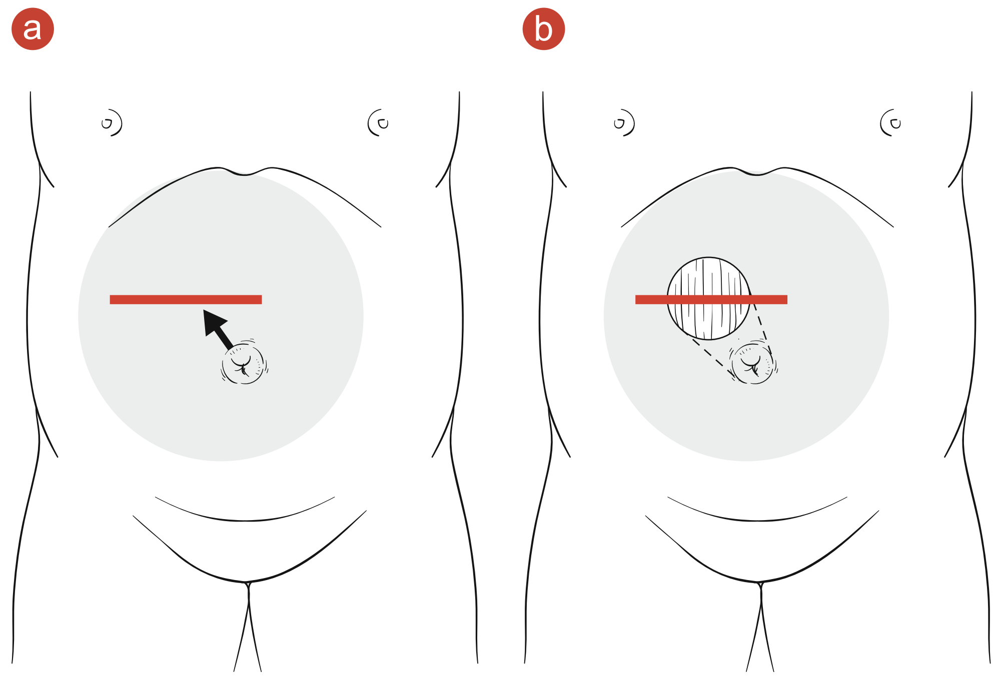

Fig. 2.11 Umbilical sliding-window technique. (**a**) Widely remove the subcutaneous tissues from the region around the incised muscle to the contralateral navel (*shadow area*). (**b**) Move the skin window horizontally to the incised part of the fascia

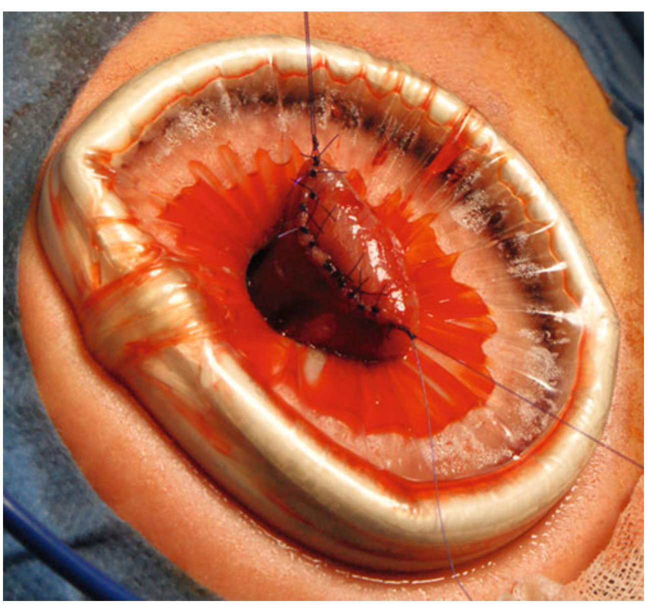

Fig. 2.12 Exposure of operation field and protection of wound border by a wound protector. Duodenoduodenostomy by using umbilical sliding-window technique with a wound protector

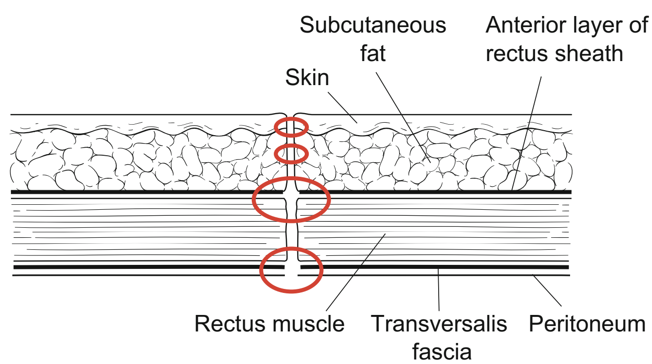

Fig. 2.13 Layer-to-layer suture for abdominal wound closure. Using absorption threads, suture the peritoneum, transversalis fascia, anterior layer of rectus sheath, subcutaneous tissues, and skin by each layer

to layers (Fig. 2.13). For patients in whom re-laparotomy is expected at a higher rate (e.g., patients with biliary atresia), absorbable adhesion barrier materials for preventing adhesion should be used before closing the abdomen.

2.2.3 Postoperative Care Tips

Currently, with the exception of peritonitis associated with intestinal perforation, the abdominal cavity drain is rarely used. When the subcutaneous tissues are widely removed by using the umbilical sliding-window technique, subcutaneous emphysema or redness may occur postoperatively. If this is troublesome for the patient, a thin subcutaneous drain should be placed with slight compression of the skin.

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3 Laparoscopy and Thoracoscopy

Tetsuya Ishimaru and Tadashi Iwanaka

Abstract

Endoscopic surgery, including laparoscopic and thoracoscopic surgery, in children has become widespread in the past few decades due to its minimal invasiveness and better cosmetic results. However, it requires specific expertise and skills that are different from conventional open procedures. Surgeons have to fully understand the basics of endoscopic surgery, such as the lack of three-dimensional information, faint tactile sensation, and restricted movement of surgical devices; in such cases, numerous physiological pneumoperitoneum/pneumothorax effects appear in the patient. In addition, surgeons are required to be proficient in the endoscopic surgical skills acquired through extensive training using box trainers, virtual reality simulators, or animal surgery prior to clinical cases. With regard to pediatric endoscopic surgery, the organs of children are more fragile and the working space is smaller than in adult endoscopic surgery. Therefore, smaller devices and special considerations are needed when performing such procedures in children, particularly among neonates and infants. Moreover, collaboration with a pediatric anesthesiologist is vital for safe and secure procedures.

Keywords

Laparoscopy • Thoracoscopy • Children

3.1 Introduction

Endoscopic surgery offers several advantages, primarily due to its minimal invasiveness, that prevail over its various disadvantages such as

(1) the lack of information on the depth of the operative field, wherein surgeons need to perform procedures assisted by a two-dimensional video monitor;
(2) the limitation in the devices available for endoscopic surgery that can be placed through a thin trocar;
(3) the lack of haptic information;
(4) the difficulty in capturing the entire operative field visually using a camera;
(5) the need to consider the patient's position to obtain an adequate working space; and
(6) the physiological effects of pneumoperitoneum or pneumothorax with carbon dioxide on the patient's condition.

Although the minimal invasiveness and better cosmetic appearance associated with such procedures are promising for pediatric patients, there are challenges and difficulties specific to pediatric surgery, including the presence of

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Table 3.1 Pediatric laparoscopic surgery: indications and procedures

Pyloromyotomy for hypertrophic pyloric stenosis
Fundoplication for gastroesophageal reflux disease
Ladd procedure for malrotation
Small bowel resection for Meckel's diverticulum or enteric duplication
Appendectomy for acute appendicitis
Endorectal pull-through for Hirschsprung's disease
Anorectoplasty for high (intermediate) type of imperforate anus
Portoenterostomy for biliary atresia
Hepaticojejunostomy for congenital biliary dilatation
Splenectomy for some hematological diseases
Catheter insertion (ventriculoperitoneal shunt, peritoneal dialysis catheter, etc.)
Biopsy or excision of abdominal tumor
Repair of congenital diaphragm hernia
Repair of inguinal hernia
Pyeloplasty in hydronephrosis
Nephrectomy for dysplastic kidney
Enucleation for ovarian disease

various diseases and a paucity of cases that necessitates a longer time for standardizing procedures and acquiring excellent surgical skills. Laparoscopic surgery is applied to different diseases in pediatric surgery, as shown in Table 3.1, and its indications are increasing. In this chapter, the basic principles of pediatric laparoscopic and thoracoscopic surgery have been described.

3.2 Laparoscopy

3.2.1 Preoperative Management

No specific preoperative preparation is needed for pediatric endoscopic surgery, but bowel preparation to obtain an adequate working space is desirable. In general, the combination of overnight fasting and an enema prior to surgery is sufficient. However, in some cases with aerophagia, which is frequently associated with neurologically impaired children, a preoperative intermittent aspiration of the stomach through a nasogastric tube is useful to decompress the bowels, especially the transverse colon, because the dilatation of the bowels often interferes with the operative view. In elective cases, the umbilicus is cleaned using olive oil on the day before the planned procedure. In emergency cases involving abdominal pain, such as acute appendicitis, umbilical cleansing is performed after the induction of general anesthesia. Shaving is rarely needed.

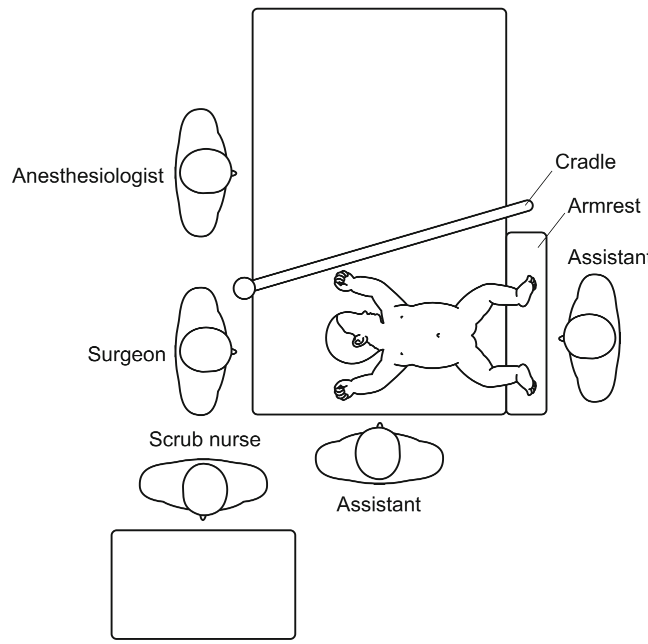

Fig. 3.1 Patient's position for pelvic surgery in infants. In pelvic surgery in infants, it may be helpful to place the patient transversely at the bottom of the bed. An armrest is useful for positioning a taller infant

3.2.2 Patient's Position

Obtaining an adequate working space is critical in pediatric endoscopic surgery. The efficient use of gravity to keep untargeted organs out of view is one of the key factors for successfully completing the procedure. Therefore, the patient's position is fundamental. For upper abdominal procedures, the patient is placed in the reverse Trendelenburg position after inserting trocars. On the other hand, for pelvic procedures, the Trendelenburg position is sufficient to achieve a sufficient working space. For splenectomy or some retroperitoneal tumor resections, the semilateral position is helpful to remove the bowels from the operative field during the procedure. Therefore, it is recommended that the patient should be placed in a semilateral position for the ease of dissection and then moved to the supine position by rotating the bed at the beginning and the end of the procedure for inserting and removing trocars. In pelvic surgery in infants, such as endorectal pull-through for Hirschsprung's disease or anorectoplasty for high-type imperforated anus, it might be helpful to position the patient transversely at the bottom of the bed (Fig. 3.1).

3.2.3 Basic Principles

3.2.3.1 Arrangement of the Operative Theater and Port Placement

The principles of port arrangement for children are identical to those for adults, and a baseball diamond is often used as an analogy (Fig. 3.2). The surgeon stands at the home plate; the surgeon's working ports for his right and left hands are placed at the first and the third bases, respectively; the target lesion is located at the second base; and a scope is inserted from the pitcher's mound. The video monitor is set at the center field; the surgeon and the assistant handling the scope during the procedure should share the same monitor.

3.2.3.2 Pneumoperitoneum

Pneumoperitoneum with carbon dioxide is used in children as well as in adults to achieve sufficient working space. However, the intra-abdominal pressure for children, especially neonates or infants, should be set at a lower level, as its effects on the circulatory system could be more serious, as compared to that of adults. The ideal pneumoperitoneum pressures for children classified by their weight are listed in Table 3.2, and it is preferable to set the pressure to the lowest possible value so as to not interfere with the operative field.

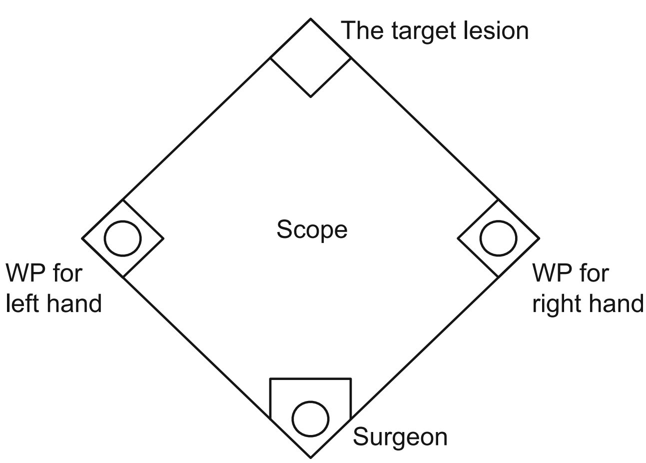

Fig. 3.2 Basic port arrangement. Based on the baseball diamond configuration, a surgeon stands at home plate; the surgeon's working ports (WP) for the right and left hands are placed at the first and the third bases, respectively; the target lesion is located at the second base; and a scope is inserted from the pitcher's mound. Additional ports for retracting or grasping organs are placed depending on the situation

Table 3.2 Ideal pneumoperitoneum pressure

Body weight (kg)	2	5	10	15	20	30
Pneumoperitoneum pressure (mmHg)	5	5	7	8	10	12

3.2.3.3 Collision of Instruments

Pediatric endoscopic surgeons sometimes encounter collisions of the instruments, which can occur both inside and outside the body, making the procedure particularly difficult. Surgeons are sometimes forced to convert to open surgery due to the difficulty in continuing the procedure when severe collision occurs. A flexible scope, with a tip that can be bent, is useful in adult endoscopic surgery, wherein there is sufficient space inside the body; however, its curvature radius is too large to be used inside the smaller body of a neonate or infant, and the oversized tip causes frequent collision with other instruments. A 30° telescope is desirable to avoid collision in children.

Collision is less likely to occur when a fewer number of trocars are used. Therefore, effectively using the patient's position and taking advantage of gravity are vital because these measures can reduce the number of trocars required. Careful selection of the extracorporeal length of trocars is also important for avoiding collision outside the body, and the usage of various lengths of trocars is beneficial in some cases.

3.2.3.4 Considerations of Anesthesia for Pediatric Laparoscopy

The rule a "child is not a miniature form of an adult" applies to anesthesiology, and special considerations are required when performing pediatric anesthesia. The differences between adults and children are greater in endoscopic surgery than in conventional open surgery, and most of these differences are associated with the use of pneumoperitoneum or pneumothorax with carbon dioxide. The elevation of the diaphragm by pneumoperitoneum or collapse of the lung by pneumothorax results in a decrease in the functional residual capacity of the lungs and causes atelectasis. Moreover, increased intra-abdominal or intrathoracic pressure decreases the venous return and leads to reduced cardiac output and low blood pressure. Carbon dioxide absorbed from the peritoneum or pleura causes hypercapnia and careful respiratory management, i.e., a hyperventilation setting, using an end-tidal carbon dioxide monitor, is mandatory. Unilateral intubation may occur due to elevation of the diaphragm after pneumoperitoneum is established, when the tip of an endotracheal tube is placed near the bifurcation. Furthermore, rapid insufflation of a large amount of carbon dioxide can result in hypothermia, and thus, prevention of gas leakage from the port site and efforts to decrease the intraoperative bleeding to avoid frequent suctions are necessary. Warming of the gas is also needed (Fig. 3.3).

3.2.3.5 Suturing and Knot Tying

Techniques of suturing and knot tying in endoscopic surgery are quite different from those used in conventional open surgery. Knot tying can be performed either intracorporeally or extracorporeally depending on the situation. Intracorporeal

Fig. 3.3 Insufflation gas warming system. An infusion extension tube is attached to the tip of the warming tube as the tube is heavy. The insufflation gas warming system by Olympus Medical Systems Corp. is shown. Left warmer (*upper left*). Right tube for warmer

knot tying is performed using instruments with both hands inside the body, such as the use of a needle holder in the right hand and forceps in the left hand. Extracorporeal knot tying is performed using a knot pusher, which is used to push down a knot to the target tissue after tying it manually outside the body (Fig. 3.4). Even a meticulous anastomosis such as the repair of esophageal atresia can be performed using the extracorporeal knot-tying technique by skilled surgeons. In contrast, intracorporeal knot tying is not preferable in small children due to the difficulty of its execution in a small working space.

Some stapling devices are often used in endoscopic surgery not only for bowel cutting or anastomosis but also for dividing the hilar area of the lung or spleen and excision of the bronchus. However, the shaft of these devices is 10 mm in diameter and the length of the blade is over 30 mm; therefore, these devices are sometimes too large to be used in children. The development of instruments appropriate for use in small children is expected.

3.2.4 Instruments for Pediatric Endoscopic Surgery

The typical instruments available for pediatric endoscopic surgery are shown in Fig. 3.5. The length of the instruments is shorter than those used in adult endoscopic surgery, and various types of forceps are commercially available. Instruments, which have a shaft of 3 mm in diameter and approximately 20 cm in length, are usually used for procedures in neonates and small infants. In particular, instruments measuring 5 mm in diameter and 30 cm in length are used for procedures in toddlers. Surgeons can choose the appropriate forceps from various types, including one with fine tip for a more meticulous procedure or one with an atraumatic dull tip, depending on the situation.

Three-mm trocars are often used for surgery in neonates and infants; however, in a procedure requiring suturing, 4-mm trocars are used to insert a needle through the trocar. A 5-mm trocar is needed in procedures where an energy device such as laparoscopic coagulation scissors (LCS) or an ultrasonically activated device (USAD) is used. In children, the abdominal wall is thinner than in adults and the trocar should be fixed to the skin by suturing (Fig. 3.6).

Small wounds are distinctive characteristics of endoscopic surgery. The elongation of the wound to manipulate the tissue outside of the body nullifies this benefit. An endosurgical bag is used for the extraction of specimens from a tiny trocar incision. Cutting the tissue into small pieces in the bag and then removing them is an acceptable technique for some cases, although it is not permitted in cases involving malignant tumors. If a small incision is needed to remove the specimens from the body, the consideration of cosmetic appearance is necessary. An incision along the skin crease at the lower abdomen is preferable (Fig. 3.7). A natural orifice such as the anus can be used for extraction of specimens in some bowel surgery procedures, especially those involving the colon.

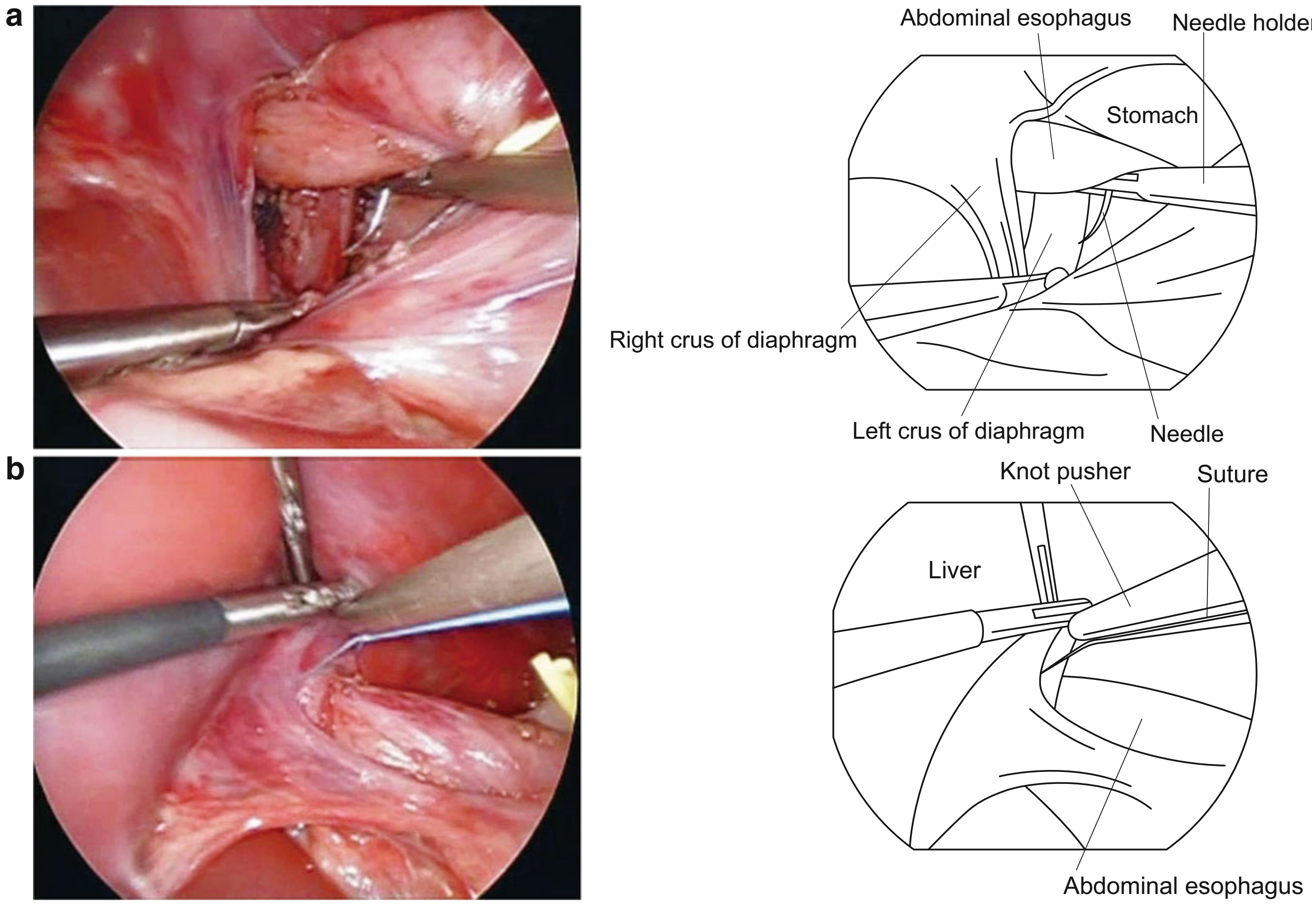

Fig. 3.4 (**a**) Suturing the esophageal hiatus in fundoplication. (**b**) Extracorporeal knot tying in fundoplication

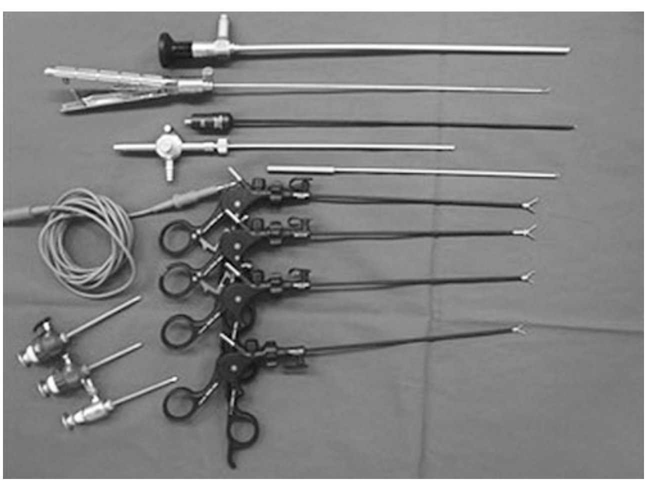

Fig. 3.5 Typical instruments for pediatric endoscopic surgery. A set of 3-mm diameter instruments for neonates and infants produced by Karl Storz is shown. In addition to the diameter of the instruments, the length (20 mm) is also important. The 3-mm diameter trocar is reusable

Fig. 3.6 Ports used in pediatric endoscopic surgery. VersaStep™ (Covidien, left three ports): An access needle, which is bladeless and enables safe entry, covered with an expandable sleeve is inserted into the abdominal or thoracic cavity, and the sleeve is dilated to an appropriate diameter after removing the needle. This system does not require the incision of the fascia and muscle and results in excellent fixation. Endopath® Xcel Bladeless (Ethicon, right three ports): the bladeless optical tip enables direct visualization and eliminates blind entry during initial trocar insertion by using a scope within a trocar

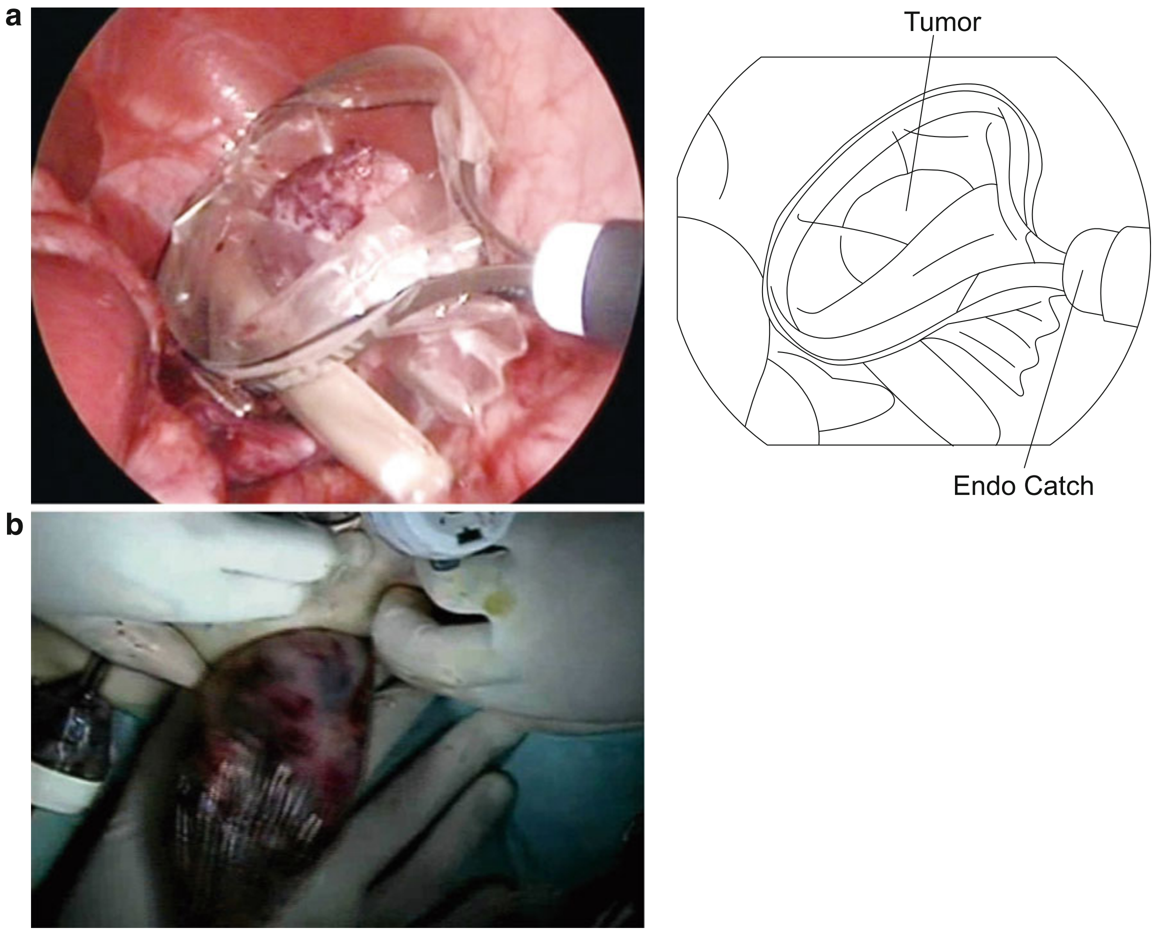

Fig. 3.7 Extraction of specimens from tiny trocar incisions. (**a**) Extraction of a tumor using a disposable specimen bag, Endo Catch™ (Covidien, Japan), in the case of neuroblastoma originating from the left adrenal gland; the bag, which is folded when set in the shaft, is opened within the body. The polyurethane pouch is tough and sufficiently large to contain a specimen measuring 10 cm in diameter. (**b**) Removal of the right kidney from a small incision made at the lower abdomen in a case of renal carcinoma; a 4-cm Pfannenstiel incision was made to remove the kidney measuring 12 cm in length across the major axis

Hemostasis in endoscopic surgery is more challenging and takes longer to achieve than in conventional open surgery. A USAD or a vessel-sealing system is often used for the procedure. The use of a USAD, a cutting device using ultrasonic energy, is now widespread due to the following benefits: less thermal damage, secure coagulation and hemostasis, and less smoke generation. Therefore, it is now used in most advanced pediatric endoscopic surgical procedures (Fig. 3.8). The vessel-sealing system can dissect larger vessels up to 7 mm in diameter safely without lateral thermal damage by denaturing collagen and elastin in the vessel wall and completely blocking the vessel.

3.2.5 Complications in Pediatric Endoscopic Surgery

3.2.5.1 Complications Associated with Trocar Insertion

Trocar insertion can lead to complications such as injury to intra-abdominal organs or great vessels including the aorta and inferior vena cava, as well as bleeding from the abdominal wall. Surgeons should be careful regarding these potential complications. To avoid these complications, the first trocar should be inserted using the open Hasson technique (Fig. 3.9), i.e., through a small laparotomy incision under direct vision of peritoneal space, and the other trocar should be inserted following the movement of the tip of the trocar displayed on the monitor. Particular attention should be paid in children, especially in infants and neonates, because their thin abdominal wall is easily stretched and because of the difficulty in elevating the pneumoperitoneum pressure.

3.2.5.2 Visceral Injury

Children's organs are fragile, and care must be taken when a surgeon uses forceps with sharp tips as injury of the serosa or the muscular layer of the bowel can occur easily. Although rare, perforation can be caused by rough manipulation of the bowel. Peritoneal injury of solid organs, such as liver injury seen in fundoplication by a liver retractor, is a common complication. Meticulous manipulation of forceps is mandatory and moving the forceps out of the view should be

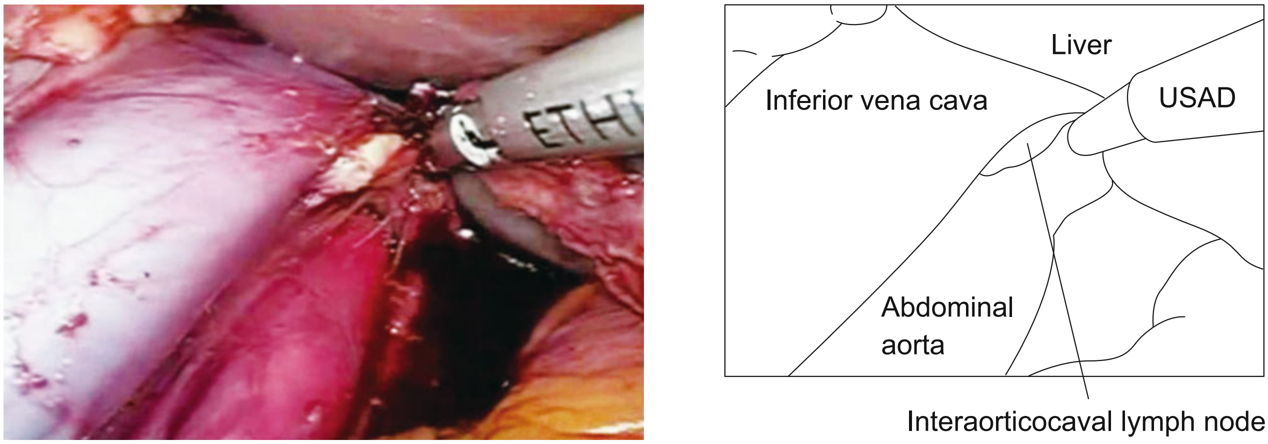

Fig. 3.8 Interaorticocaval lymph node dissection using an ultrasonic coagulation incision device. A Harmonic® scalpel (Ethicon) is shown. Various tip shapes and shaft lengths are available for 5-mm instruments

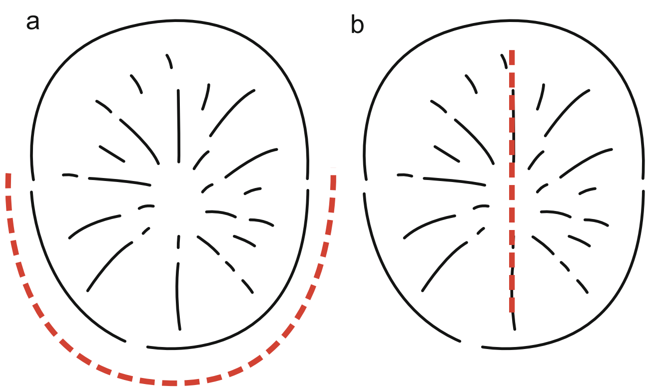

Fig. 3.9 Skin incision for the first trocar (open Hasson method). (**a**) Infraumbilical incision: applicable for neonates with a wet umbilicus, cases requiring extraction of large specimens, and cases with umbilical hernia in which umbilical repair is performed simultaneously. (**b**) Intraumbilical vertical incision: a simple procedure, which is frequently used for infants with thick subcutaneous fat or obese children

avoided. These complications often occur when all members of an operating team do not pay attention to what is displayed on the monitor.

3.2.5.3 Vascular Injury

One of the benefits of endoscopic surgery is that surgeons can perform delicate procedures while assisted by TV monitor that provides a magnified view of the operative field. Nevertheless, surgeons tend to have difficulty in viewing the entire operative field. Inadvertent movement of the assistant's forceps in a blind area, such as an area not displayed on the monitor, for retraction can result in bleeding. In the event of a hemorrhage, hemostasis becomes more difficult as bleeding impairs the maintenance of clear visualization of the operative field. Hence, limiting dissection to the correct layer and achieving hemostasis are essential.

The more common complications have been mentioned in this chapter; however, other more rare complications have also been reported. For example, pneumothorax may be caused by the insufflation of the gas through the esophageal hiatus due to the rapid increase of the pneumoperitoneum pressure as a result of abdominal compression or irrigation. For more details regarding other rare complications, please refer to the literature.

3.3 Thoracoscopy

The practice of pediatric thoracoscopic surgery was introduced several years after adult thoracoscopic surgery was introduced. As in laparoscopic surgery, it was applied in hospitals where there were collaborative adult respiratory surgeons, because pediatric thoracoscopic surgery was initially indicated for diseases commonly observed in older children such as spontaneous pneumothorax. In infants and toddlers, the narrowness of the intercostal space restricts the usage of large trocars, and this approach could be adopted among such patients only after the development of 5-mm instruments including the scope and other devices. In addition, with the introduction of the thoracoscopic Nuss procedure for the correction of pectus excavatum, and given the potential for avoiding potential cardiac injury, pediatric thoracoscopic surgery gained more widespread acceptance and became even more popular. These were the only procedures available in the early period of pediatric thoracoscopic surgery; however, the indications soon expanded to children-specific diseases (Table 3.3) as various specialized devices were developed and anesthetic methods such as differential lung ventilation became more sophisticated.

Table 3.3 Pediatric thoracoscopic surgery: indications and procedures

Lobectomy for congenital lung disease
Partial lung resection for metastatic lung tumor or cystic lung disease (bullae)
Mediastinal mass resection for lung sequestration or bronchopulmonary foregut malformation
Mediastinal tumor resection for neuroblastoma, teratoma, or thymoma
Repair of tracheoesophageal fistula
Repair of esophageal stenosis

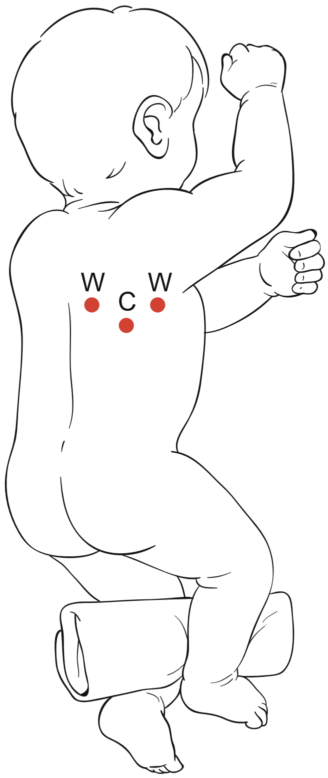

Fig. 3.10 Patient's position and port arrangement in thoracoscopic repair of tracheoesophageal fistula. The patient is set in the prone position with the right side elevated. A 5-mm port for a camera is placed just caudal to the scapula. Two 4-mm ports for the surgeon are inserted in the axillary space and in the dorsal site. The surgeon stands at the ventral side and slightly to the caudal side of the patient. *C* camera, *W* working port

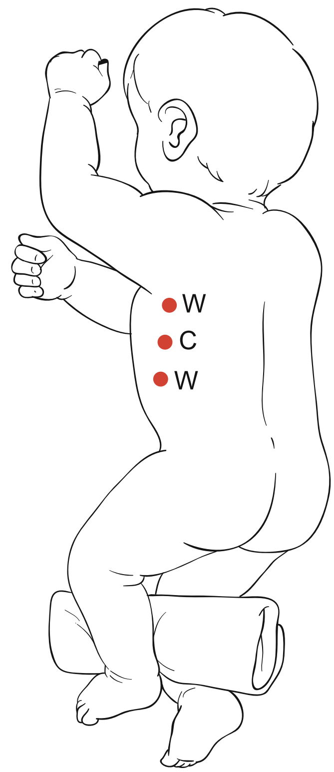

Fig. 3.11 Patient's position and port arrangement in left posterior mediastinal tumor resection. The patient's position is similar to that shown in Fig. 3.9. Ports are arranged in a vertical line between the anterior and the posterior axillary lines. A specimen is removed through the wound located in the most caudal intercostal space as it is wider compared to others. A surgeon stands at the ventral side of the patient. *C* camera, *W* working port

3.3.1 Preoperative Management and Considerations for Anesthesia in Pediatric Thoracoscopy

A specialized preoperative workup in pediatric thoracoscopic surgery is not required, but careful preparation in collaboration with anesthesiologists is mandatory. Food intake is permitted until the evening of the day before the surgery.

Lung collapse on the affected side is vital to achieve an adequate operative field in thoracoscopic surgery. Anesthesiologists should select a method they are familiar with based on the patient's body size. A commercially available bronchial blocker can be used in a patient in whom an endotracheal tube with an internal diameter of >4.5 mm is inserted (this can be applied in patients at least aged one and a half year old), and differential lung ventilation is then established. A double lumen tube, which is routinely used in adult cases, is available for older children and enables obtaining a suitable operative field. A Fogarty catheter originally developed for the removal of blood clots from vessels is sometimes used to occlude the main bronchus in infants and neonates, but it is not recommended for the following reasons: (1) the shorter bronchi in small children can lead to slippage of the balloon and failure to obtain adequate lung separation and independent lung ventilation, (2) the slipped balloon may occlude the unaffected side of the bronchi and lead to ventilatory failure, and (3) difficulty in intraoperative intratracheal suction of the affected lung may cause an overflow of secretion from the affected lung to the unaffected lung. Moreover, such usage is not in line with the manufacturer's recommendation. Therefore, carbon dioxide pneumothorax is used to collapse the affected lung and

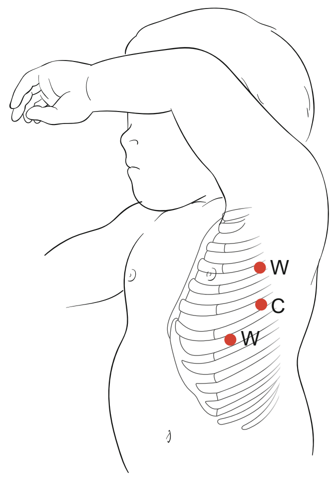

Fig. 3.12 Patient's position and port arrangement in thymectomy for myasthenia gravis. The patient is set in the semi-supine position. It is easier to perform thymectomy through the left thoracic cavity. The most caudal port is used to extract the specimen. The surgeon stands slightly caudal to the patient. *C* camera, *W* working port

achieve an appropriate operative field in infants and neonates. The pressure is usually set at 8 mmHg for collapsing the lung and decreased to 4 mmHg once a sufficient operative field is obtained. This low-pressure pneumothorax is effective for the evacuation of mist and smoke. High frequency ventilation with a relatively low intratracheal pressure is effective for intraoperative hypercapnia. Repeated breaks in the procedure with the release of pneumothorax and hyperventilation could be another option. In cases requiring complete differential lung ventilation, unilateral intubation of the intact lung should also be considered, although it must be noted that the tip of the endotracheal tube is easy to change.

3.3.2 Patient's Position and Arrangement of Port Placement

It is understandable that the key to success in pediatric thoracoscopic surgery is the patient's position and port arrangement. Displacing the lung by using its own weight is a useful trick. For example, in cases with an anterior mediastinal lesion, the patient is placed in the supine position with the affected side elevated, whereas in cases with a posterior mediastinal lesion, the patient is placed in the prone position with the affected side elevated. In cases of lobectomy, the patient is placed in the lateral position and rotation of the table is used for making minor adjustments.

It is preferable that all trocars be placed inside the area between the anterior and posterior axillary lines from a cosmetic standpoint. The width of the intercostal area is too narrow to insert a thick trocar in neonates and infants. In cases requiring a 12-mm trocar for staplers or an endosurgical collecting bag, the site near the anterior axillary line is somewhat more accessible. The patient's position and trocar arrangement in typical pediatric thoracoscopic surgery are shown in Figs. 3.10, 3.11, 3.12, and 3.13.

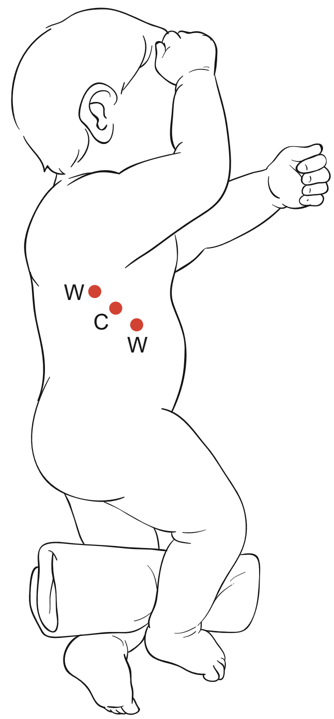

Fig. 3.13 Patient's position and port arrangement in plication of eventration of the diaphragm. The patient is placed in the lateral position and trocars are inserted diagonally along the intercostal region. Plication is easier when the trocars are placed relatively toward the cranial side (around the sixth intercostal region). The surgeon stands at the ventral and slightly cranial side of the patient and sometimes moves to the dorsal side when suturing the medial side of the diaphragm. *C* camera, *W* working port

3.3.3 Complications in Pediatric Thoracoscopic Surgery

There are no specific complications in pediatric thoracoscopic surgery, except for cardiac injury in the thoracoscopic Nuss procedure. Port arrangement in thoracoscopic surgery has limited options compared to those used in laparoscopic surgery, and pediatric thoracoscopic surgery is technically demanding. The surgeon should not hesitate to convert to thoracotomy when there is an insufficient operative field due to incomplete lung collapse.

4 Foreign Body Extraction

Tomohiro Ishii and Takeo Yonekura

Abstract

Aerodigestive tract foreign bodies (FBs) can be life threatening or cause significant morbidity, therefore, the extraction should be conducted in a prompt and proper way depending on the type and location of the FBs. Nuts and seeds are the most common airway foreign objects. Rigid bronchoscopy and flexible bronchoscopy are complementarily used for the diagnosis, localization, and extraction of the airway FBs. Since airway management during the procedure is the most important issue for the safe extraction, full cooperation among the endoscopist, anesthesiologist, and assistants is important. Most ingested FBs are expelled spontaneously, but esophageal FBs can also be extracted endoscopically. Blunt FBs such as coins can also be retrieved by using balloon extraction under fluoroscopy. Special caution is emphasized in case of button-shaped battery ingestion since it causes a rapid local injury which may eventually develop into serious complications. Therefore, endoscopic examination must be performed as soon as possible.

Keywords

Airway foreign body • Esophageal foreign body • Bronchoscopy • Esophagoscopy

4.1 Introduction

Aspiration and ingestion of FBs are mainly seen in children less than 3 years old. Obstruction of the airway or esophagus by a FB should promptly be evaluated and treated, because it can cause significant morbidity and mortality. To diagnose an aerodigestive tract FB, however, is sometimes challenging because of the difficulty in obtaining a precise history and also because the symptoms may be obscure, not specific, or may even cease by the time the patient presents to the health professional. Therefore, a high level of suspicion is very important when assessing children who present with aerodigestive presentations.

4.2 Airway Foreign Bodies

Careful clinical assessment and radiography including plain X-ray and multidimensional CT scans are necessary to evaluate aspiration of FBs. Airway FBs in children are reported to be located 3 % in the larynx, 13 % in the trachea, 52 % in the right main bronchus, 6 % in the right lower lobe bronchus, fewer than 1 % in the right middle lobe bronchus, 18 % in the left main bronchus, and 5 % in the left lower lobe bronchus; 2 % were bilateral [1].

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4.2.1 Choice of Treatment

Bronchoscopic extraction under general anesthesia is generally applied to the patients with an airway FB. Transoral rigid endoscopy has been the gold standard method for the removal [2]. Flexible bronchoscopy has been recognized as an alternative approach, particularly for older patients. It is also recommended as the diagnostic tool in equivocal cases, or in cases of a FB with peripheral localization. Rigid bronchoscope and flexible bronchoscope, therefore, are utilized complementarily [3].

4.2.2 Bronchoscopic Extraction

4.2.2.1 Preparation, Anesthesia, and Positioning

Rigid bronchoscope using the Hopkins rod-lens system and the ancillary equipment should be prepared beforehand (Fig. 4.1). The recommended sizes of rigid bronchoscopes relative to the patient's age and cricoid diameter are shown in Table 4.1 [4]. In general, a largish size which does not cause airway trauma should be used. Fogarty catheters (#3 and #4) are also prepared for the passing-through extraction technique (will be described later). A variety of optical forceps (Fig. 4.2), laryngoscope, and Magill forceps should also be prepared to use. Good cooperation between endoscopist and anesthesiologist is important for the safe and successful procedure. General anesthesia under spontaneous ventilation is preferable because positive pressure ventilation can displace the FB and produce complete airway obstruction. The patient is placed in a supine position and the neck is extended by placing a roll underneath the shoulders (Fig. 4.3). The patient's eyes should be closed and covered for protection.

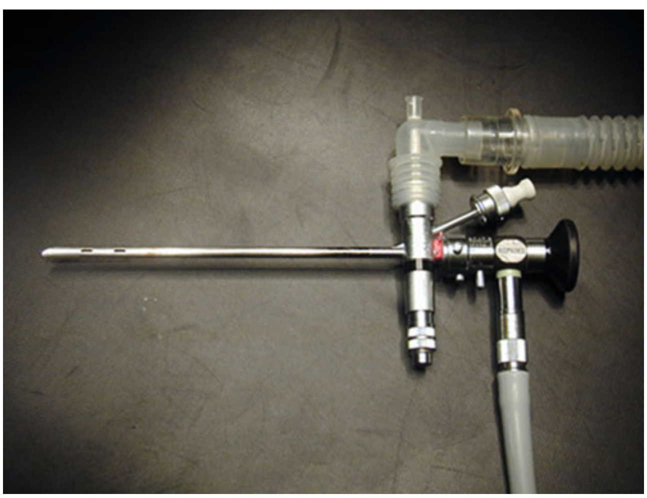

Fig. 4.1 A set of rigid bronchoscope using the Hopkins rod-lens system

4.2.2.2 Bronchoscope Insertion and Exploration

A laryngoscope is inserted to expose the larynx for the possible laryngeal FB. The bronchoscope is inserted with care to prevent vocal cord injuries. As the tip of the scope enters the trachea, the anesthetic circuit is connected to the port of the bronchoscope, and the establishment of the ventilation through the circuit is confirmed. The anesthesiologist may give positive pressure assist if necessary. Left fingers are placed between the scope and the lip/alveolus to protect them from the fulcrum force. A systematic view of the trachea and bronchus is performed; the bronchoscope is moved distally to the bifurcation and then into the bilateral bronchus to identify and localize the FB. The endoscopist should be aware that more than one FB can exist. A flexible bronchoscope can be inserted either orally or nasally under face mask ventilation, laryngeal mask ventilation, or endotracheal intubation to ensure the breathing during the procedure.

4.2.2.3 Extraction of the Foreign Body

The optimal technique and instrument is determined by the type and the shape of FBs. Soft and round-shape FBs such as peanuts (peanuts will absorb the water in the airway and become soft and fragile) are usually retrieved by passing-through technique with a Fogarty catheter. Before starting the extraction, local secretions are suctioned for obtaining a better view. The tip of a rigid bronchoscope is placed just above the FB. A well-lubricated Fogarty catheter (optimal size is #4) is inserted through the instrumental channel, and its tip is passed through between the FB and tracheal/bronchial wall (Fig. 4.4a, b). The inner telescope is then drawn back from the outer sheath for about 1 cm, so that holding room for the FB is created. After the assistant inflates the balloon of the Fogarty catheter, it is gently pulled back until the FB moves into the tip of the outer sheath and gets caught (Fig. 4.5a, b). The degree of the balloon inflation is adapted to the size of the trachea/bronchus in which the FB is located.

Table 4.1 Cricoid cartilage diameter compared to recommended sizes of rigid bronchoscopes [4], modified

Age		0–6 months	6–18 months	18 months–3 years	3–6 years	6–9 years	9–12 years
Cricoid cartilage diameter	ID (mm)	4.8–5.8	5.8–6.5	6.5–7.4	7.4–8.2	8.2–9.0	9.0–10.7
Bronchoscope size (Storz)	Size #	3.0	3.5	4.0	4.5	5.0	6.0
	ID (mm)	4.3	5.0	6.0	6.6	7.1	7.5
	OD (mm)	5.0	5.7	6.7	7.3	7.8	8.2

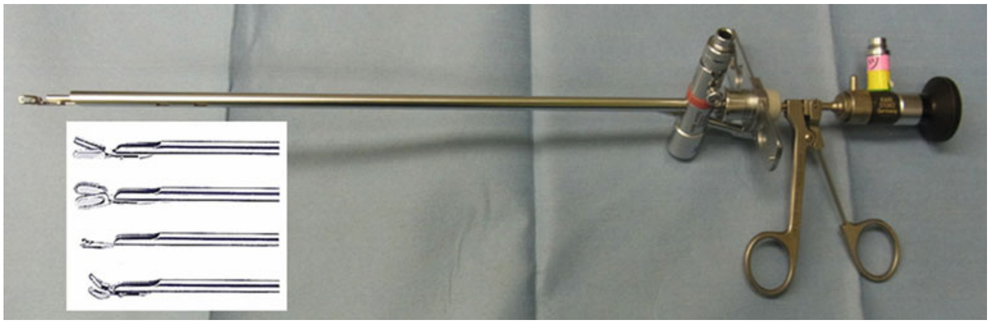

Fig. 4.2 Optical forceps mounted on the telescope

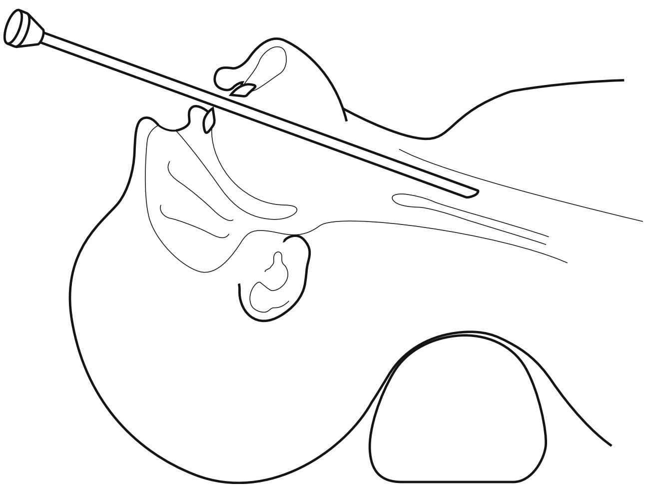

Fig. 4.3 Position of the patient for rigid bronchoscopy

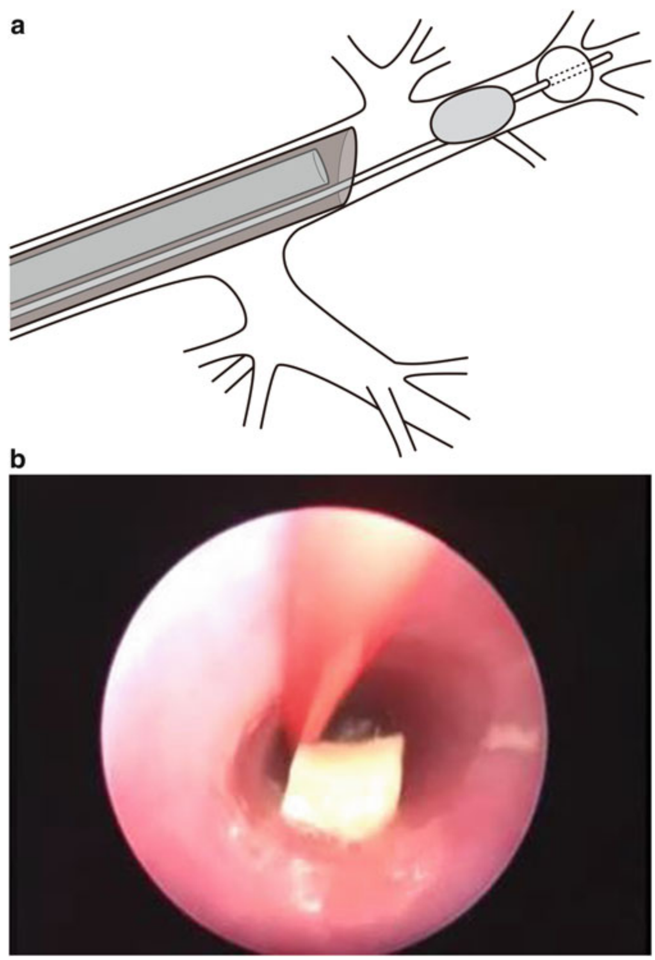

Fig. 4.4 Passing-through technique. A Fogarty catheter inserted beyond the FB. (**a**) Schema. (**b**) Actual view

Finally, the bronchoscope, Fogarty catheter, and the FB, as an assembly, are taken out from the airway, while FB is continuously visualized. A further bronchoscopic exploration should be performed to rule out the multiple FBs. Optical forceps are suitable for extracting FBs that have a flat shape such as seeds or button-shaped batteries. After grasping the FBs, the forceps are drawn back into the outer sheath (Fig. 4.6). Laser may be required for long-time residing FBs when the FBs are surrounded by reactive granulation tissue, which is very easy to bleed and disturb the extraction. Flexible bronchoscopy can also be utilized for FB extraction with several types of forceps, which are inserted through the channel (Fig. 4.7a–c). Flexible bronchoscopy is more helpful than rigid bronchoscopy when FBs locate more peripherally where a rigid bronchoscope cannot reach.

4.2.2.4 Postoperative Care

Mucosal edema of the airway may occur after the procedure. In such circumstances, intravenous dexamethasone administration and/or epinephrine inhalation therapy should be provided. In case of worsening airway obstruction, intratracheal intubation is needed. Antibiotics may be given for the patients presenting with airway infection.

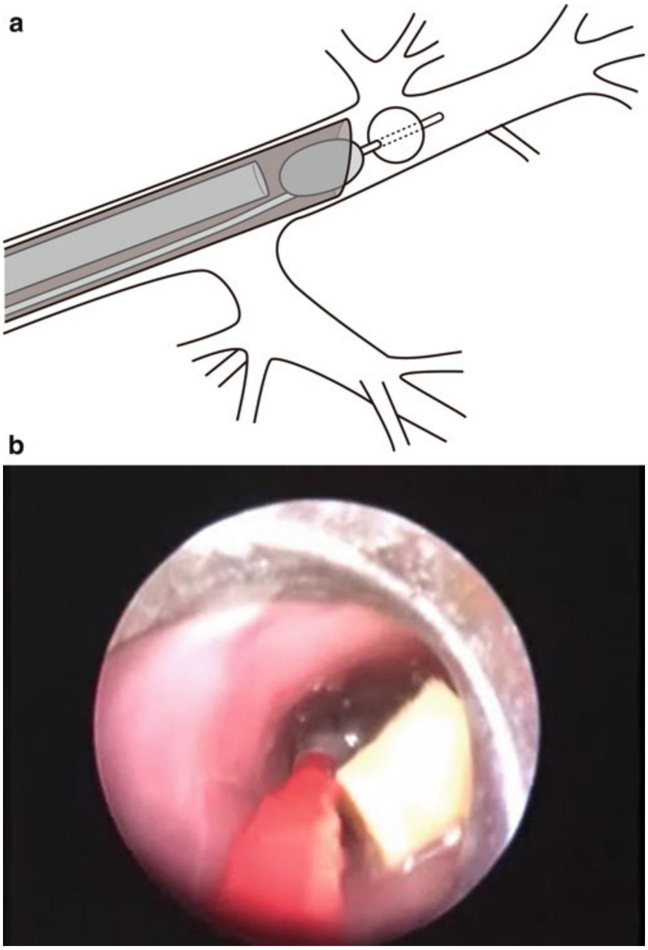

Fig. 4.5 Passing-through technique. Pulling back the Fogarty catheter after the drawing back of the inner telescope. (**a**) Schema. (**b**) Actual view

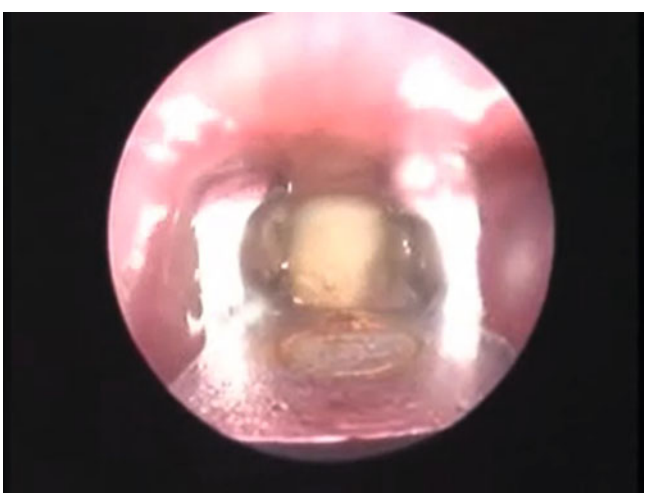

Fig. 4.6 FB extraction using optical forceps

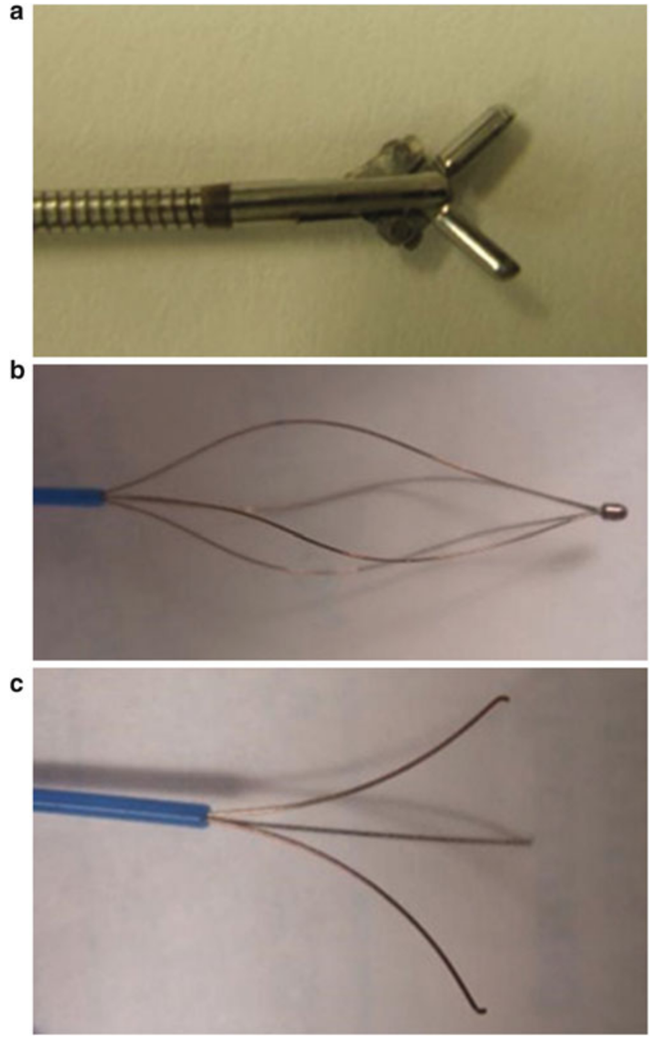

Fig. 4.7 Several types of forceps used for flexible bronchoscopic FB extraction. (**a**) Biopsy forceps. (**b**) Basket type. (**c**) Three-nail type

4.3 Esophageal Foreign Bodies

Approximately 80 % of cases of foreign body ingestions occur in children between the ages of 6 months and 3 years. Button-shaped battery ingestion is increasing in number. A warning is necessary in a lithium button-shaped battery foreign body because a deep intestinal mucosal injury develops within 2 h of ingestion [5].

4.3.1 Choice of Extraction Method

The options of the dull FB extraction in the esophagus include rigid esophagoscopy, flexible esophagoscopy, and

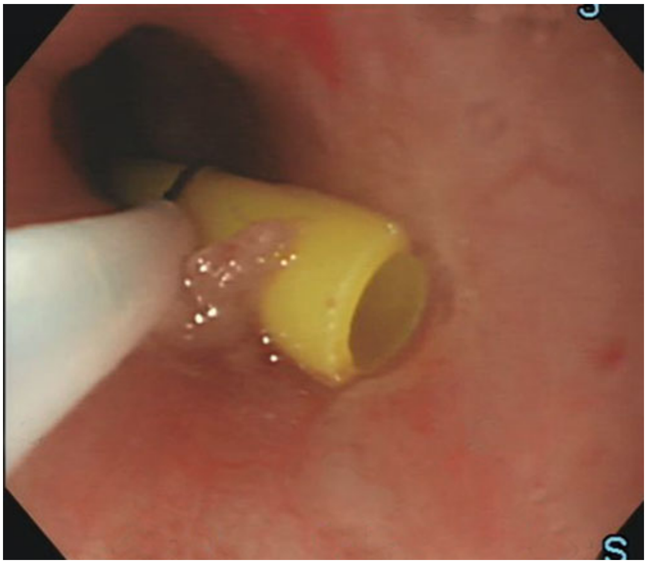

Fig. 4.8 Flexible esophagoscopic FB extraction using snare forceps

balloon extraction. There seems to be no significant difference in the successful rates. But direct visualization by rigid or flexible esophagoscopy should be performed when FBs such as sharp-edged FBs or button-shaped batteries are ingested because of the risk of deep esophageal wall injuries. Insertion of a tube outfitted with magnetic device can be used for the extraction of magnetic FBs.

4.3.1.1 Esophagoscopy

It is usually performed under general anesthesia except flexible esophagoscopy for older patients. Several kinds of devices such as foreign body forceps, biopsy forceps, basket catheter, snare catheter, retrieval nets, etc. can be used for FB extraction (Fig. 4.8). If possible, practice of grasping the FB (or similar object) is performed before the esophagoscopy to determine the most appropriate device for the retrieval. Using the appropriate size of an overtube protects the esophageal and pharyngeal mucosa from the injury due to sharp or pointed FBs; however, its use is generally limited to older children because of the size of the available overtube. The FB, which is difficult to grasp in the esophagus, may be pushed into the stomach to facilitate the retrieval. Rigid esophagoscopy may be beneficial for the extraction of FBs located in the proximal esophagus and hypopharyngeal region. Several kinds of forceps are available for the retrieval, as is described in the airway FB extraction.

4.3.1.2 Balloon Extraction

Blunt esophageal FBs, such as coins, can be extracted using the passing-through technique with a Foley catheter under fluoroscopic guidance. The advantage of this technique is that it does not need general anesthesia or sedation, but the suction and tracheal intubation should always be prepared. A

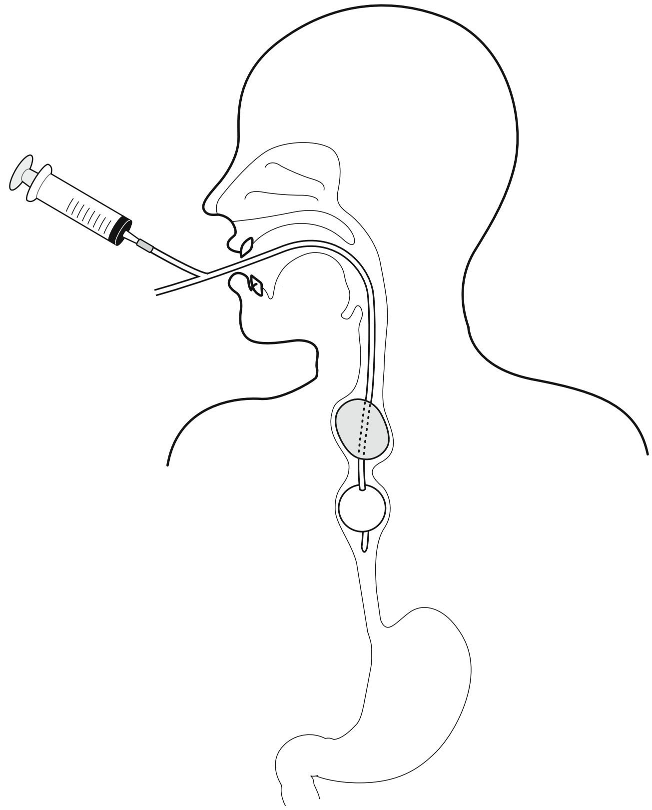

Fig. 4.9 Balloon extraction of esophageal FB

Foley catheter is inserted orally until the balloon is advanced distal to the FBs. After the inflation of the balloon to the appropriate size, that is, not too small to let the FB slip out and not too large to avoid esophageal injury, the catheter is gently pulled back until the FBs move to the oral cavity (Fig. 4.9). FBs are then retrieved with Magill forceps. The operator should be aware of the risk of esophageal wall injury, and therefore, this technique should only be used for a blunt foreign body. It is also emphasized that FBs can fall into the airway during the retrieval.

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Tracheostomy

5

Kosaku Maeda

Abstract

Tracheostomy is a means of managing the airway obstruction caused by various airway lesions. The three major indications for long-term tracheostomy in children are airway obstruction, ventilator support, and pulmonary toilet.

Most children with tracheostomy tubes in place for airway obstruction undergo the procedure as infants, either for acquired laryngotracheal stenosis related to prolonged endotracheal intubation or for congenital lesions that compromise the airway.

Pediatric tracheostomy should be performed as an elective surgical procedure using conventional dissection technique in the operating room under general anesthesia.

Keywords

Tracheostomy • Infants and children • Pediatric airway

5.1 Indications for Tracheostomy

1. Airway obstruction
2. Clearance of secretions
3. Long-term respiratory support
4. Home respiratory care
5. Laryngotracheal reconstruction surgery

5.2 Preoperative Management

Pediatric tracheostomy should be performed as an elective surgical procedure using conventional dissection technique in the operating room under general anesthesia.

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5.3 Operation

5.3.1 Position of Patient

The neck must be hyperextended. A pillow is placed under the shoulders. A thinner head ring supports the occiput. The patient is tipped into a slightly head-up position (Fig. 5.1). The neck extends sufficiently by this posture, and the trachea is drawn out from a mediastinum.

5.3.2 Skin Incision

The neck is palpated carefully so that the hyoid bone, thyroid notch, and cricoid cartilage can be felt. In neonates and infants, the cricoid cartilage is not easily palpable.

The skin midway between the cricoid and the suprasternal notch is marked. A horizontal skin incision 2–3 cm in length is made, cutting through fat and platysma (Figs. 5.2 and 5.3).

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Fig. 5.1 Positioning

Fig. 5.2 Skin incision

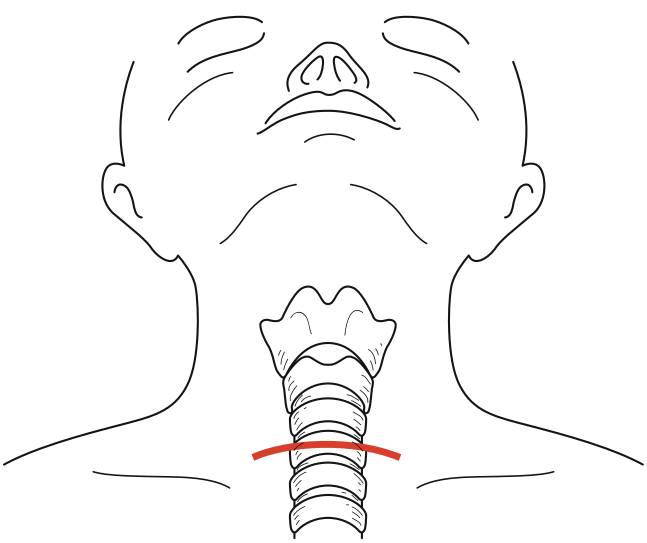

Fig. 5.3 Skin incision

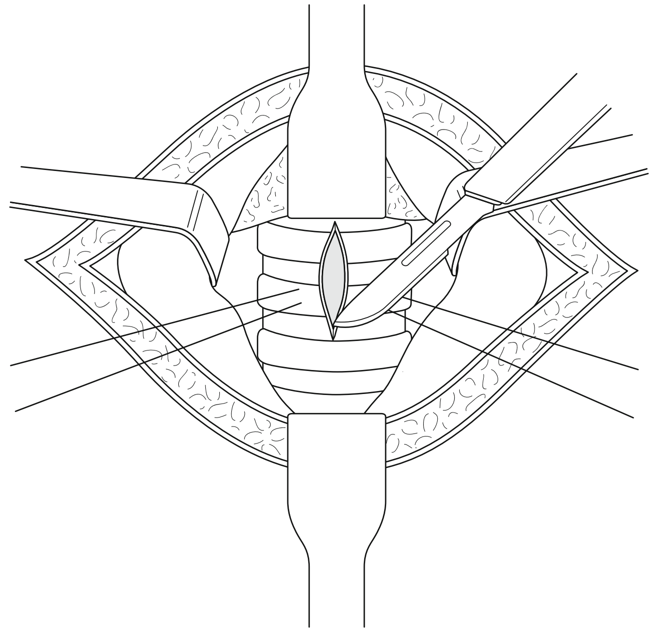

Fig. 5.4 Tracheotomy

5.3.3 Division

The incision is deepened in a horizontal plane until the deep cervical fascia investing the sternohyoid and sternothyroid strap muscles is encountered.

Branches of the anterior jugular vein will be seen during this dissection; these should be coagulated and divided with cautery. Only anterior tracheal wall should be entered by blunt dissection carefully.

Retraction of the strap muscles reveals the thyroid gland with the thyroid isthmus joining the two lobes of the gland. Above the isthmus, the cricoid is seen. In almost of all cases, the isthmus should be divided. A small incision is made through the condensation of the pretracheal fascia at the upper border of the isthmus, and the isthmus is then separated from the underlying trachea by blunt dissection. Branches of the inferior thyroid vein will be encountered at the lower border of the isthmus, and these should be coagulated.

Careful hemostasis is achieved, the cricoid is identified, and the tracheal rings are counted. The first tracheal ring must not be included in the tracheostomy. In neonates and infants, where distances are small, it is preferred to preserve the second ring.

Before making the incision, 4-0 Prolene stay sutures are placed to help distract the tracheal opening; these are later taped to the skin and left in place until the first tracheostomy tube change (Fig. 5.4).

5.3.4 Opening the Trachea

A vertical incision is made in the trachea through the third, fourth, and fifth tracheal rings. Care should be taken with a low tracheostomy that the end of the tracheostomy tube is clear of the carina. The tracheal cartilages should not resect in pediatric case. Tracheal wall is weakened and stenosis of trachea is formed as a result.

The stay sutures are now used to distract the cut edge of the trachea. The anesthetist is asked to withdraw the endotracheal tube until its tip is just above the tracheostomy. The endotracheal tube will then be easily seen.

5.3.5 Insertion of Tracheostomy Tube

A soft material tracheostomy tube (polyvinyl chloride, urethane, and silicone) with a 15-mm slip joint is then inserted into the tracheal opening, a sterile anesthetic connector is fitted to it, and the end of the connector is passed out of the surgical field beneath the drape to the anesthetist (Fig. 5.5).

At the end of the procedure, the surgeon should listen to the chest to ensure that air entry is symmetrical; if it is reduced on the left, this suggests that the tracheostomy tube is too long and has intubated the right main bronchus. If necessary, a flexible laryngoscope or bronchoscope may be passed through the tracheostomy tube in order to confirm the position of the tube tip.

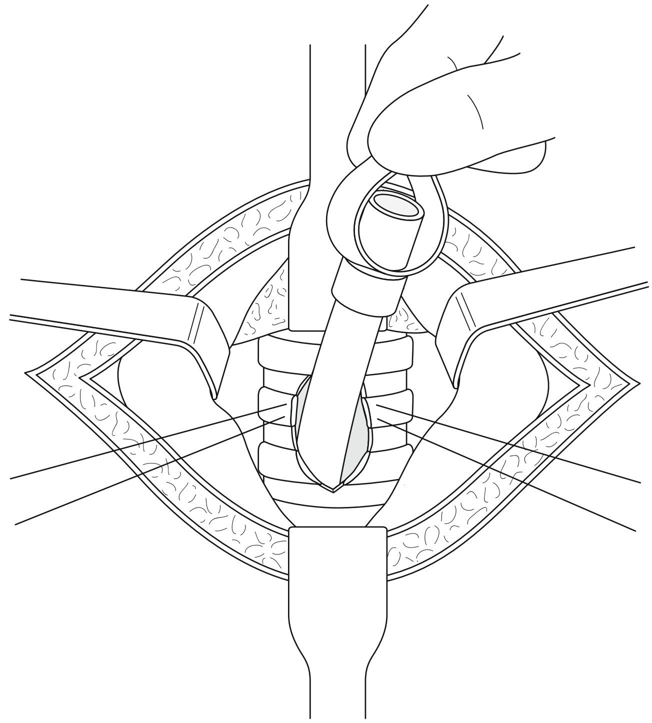

Fig. 5.5 Insertion of tracheostomy tube

5.3.6 Tracheostomy Tube Size by Age

Premature, 2.5 mm; 0–3 months, 3.0 mm; 3–7 months, 3.5 mm; 7–15 months, 4.0 mm; 15–24 months, 4.5 mm; 2–10 year, (16+ age)/4.

When there are a lot of air leaks, exchange the tracheostomy tube for a larger tube.

5.3.7 Fixation of Tracheostomy Tube

When the tracheostomy tube is fully inserted, the assistant must hold it until it is properly secured. The skin edges are approximated with a suture on each side of the tube. It is essential to leave gap around the tube to avoid postoperative surgical emphysema. The Prolene stay sutures should be taped to the anterior chest wall (Fig. 5.6).

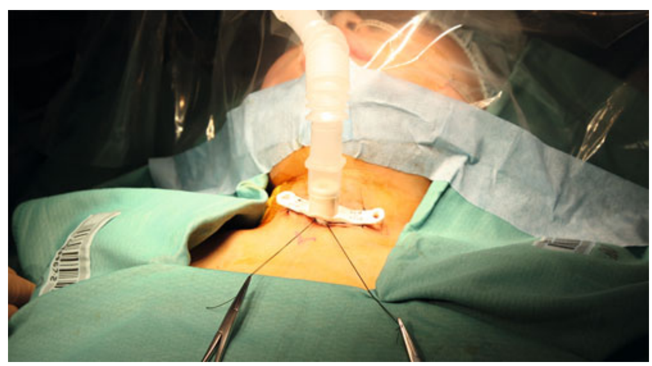

Fig. 5.6 Fixation of tracheostomy tube

The pillow is then removed from beneath the patient's shoulders, and the tracheostomy tube is secured by tying the tapes with a reef knot with the neck flexed.

It is extremely important to remember this neck flexion and to tie the tapes fairly tightly; failure to do this may result in the tube becoming dislodged. Dislodgement of the tracheostomy tube must be avoided during the immediate postoperative period, as its subsequent reinsertion can be difficult in the first few postoperative days.

A nonadherent dressing should be kept clean and changed when necessary.

5.4 Postoperative Care

A portable chest radiograph should be arranged in the operating room or immediately on return to the ward, to check the length of the tracheostomy tube.

The tube must be kept clear of secretions by the regular application of suction at hourly intervals for the first 12–24 h and thereafter as required.

The tracheostomy tapes are changed daily, and the tracheostomy tube is changed routinely after 14 days, at which time the skin sutures and stay sutures are removed.

Changing of the tube can sometimes be difficult with a new tracheostomy and should be done with adequate help. This procedure must be done in the operating room.

The following must be at the bedside: a spare tracheostomy tube of the same pattern and size as that in the patient, a tube one size smaller (for use if difficulty is encountered replacing the tube with one of the same size), and a supply of humidified air and an Ambu bag.

5.5 Complications

5.5.1 Intraoperative

- Bleeding may be encountered from an abnormally high left innominate vein; careful dissection of the structures in the lower part of the neck should avoid this.
- Damage to the cervical pleura may cause pneumothorax or possibly a pneumomediastinum; dissection lateral to the trachea should be avoided.
- Accidental decannulation may occur if the assistant does not hold the tube securely or if the tapes are tied too loosely.

5.5.2 Postoperative

- Blocking and displacement of the tracheostomy tube
- Wound infection
- Postoperative pneumonia
- Stenosis
- Granuloma formation
- Suprastomal collapse
- Difficult decannulation
- Persistent tracheocutaneous fistula

Tube Gastrostomy and Enterostomy

6

Yoshiaki Takahashi and Yoshinori Hamada

Abstract

Tube gastrostomy by laparotomy has been one of the important operations for pediatric patients who have serious difficulty swallowing or eating. Percutaneous endoscopic gastrostomy (PEG) procedure has been reported in 1980 by Gauderer et al. [1]. Since PEG can be performed without laparotomy and general anesthesia, its use had spread rapidly from the 1990s in Japan. In the pediatric surgery, PEG has also become an alternative method for gastrostomy placement with the development of endoscopy. More recently, laparoscopy-assisted PEG can be considered when other minimally invasive methods such as PEG are not feasible or fail.

Tube jejunostomy is applied for pediatric patients who require enteral feeding but cannot receive nutrients from stomach by anatomical reasons. Purpose is not only injection of nutrients but also drainage of intestinal fluids and stool. Types of tube jejunostomy and postoperative management are described.

Keywords

Gastrostomy • Percutaneous endoscopic gastrostomy (PEG) • Tube jejunostomy • Witzel jejunostomy • Stamm-Kader jejunostomy • Needle catheter jejunostomy

6.1 Indication for Gastrostomy

Tube gastrostomy is performed because a patient temporarily or permanently needs to be fed directly through a tube in the stomach. Reasons for feeding by gastrostomy include congenital anomalies of the upper gastrointestinal tract and disorders in sucking or swallowing. At the pediatric surgical specialty, the main individuals which are susceptible to gastrostomy are children with esophageal atresia and severely retarded who have been performed long-term tube feeding. Indication for PEG was proposed by gastroenterological endoscopy guideline [2] (Tables 6.1 and 6.2).

6.2 Selection of Gastrostomy Tube

The gastrostomy tube can be classified into four types: button type and tube type from the form of outside of the abdominal wall and bumper type and balloon type from the form of inside of the stomach (Fig. 6.1). In the case of the button type, the tube is noticeable and the accidental extraction is rare. But it needs delicate procedure at the time of opening and shutting of the button. In the case of the tube type,

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Table 6.1 Indication of PEG

1	*Ingestion/swallowing difficulty*
	Cerebrovascular disease, neuromuscular disease, head and facial injury, stricture of the laryngopharynx and esophagus, and gastroesophageal junction
2	*Repeated aspiration pneumonia*
3	*Inflammatory bowel disease*
4	*The purpose of decompression*
	Pyloric stenosis, upper small intestinal stenosis
5	*Others*

Table 6.2 Contraindications of PEG

Definitive contraindications	Contraindication of ordinal endoscopic examination
	The stricture of the laryngopharynx or the esophagus
	The stomach not able to reach the abdominal wall
	Uncontrolled bleeding tendency
	Gastrointestinal obstruction
Relative contraindications	Excessive ascites
	Obesity
	Liver enlargement
	Gastric malignancy and acute mucosal lesion
	Diaphragmatic hernia
	Bleeding tendency
	Pregnancy
	Portal hypertension
	Peritoneal Dialysis
	Carcinomatous peritonitis
	Poor general condition
	Poor life prognosis
	Postsurgical condition for stomach
	No Informed consent

the accidental extraction is more frequent, but it is easier to connect the tube than the button type. In the case of the bumper type, it is hard to fall out and the time to replace is long (about 4–6 months) because of strong durability. But it causes pain at the time of replacement, and occasionally fistula injury occurred at that time. On the contrary, the balloon type is less painful at the time of replacement, but the frequency of accidental extraction is higher than the bumper type because of balloon injury or transpiration of distilled water. So interval of replacement is short (about 1–2 months). We should consider the tube selection comprehensively from both the ability of daily life of each patient and skill of caregiver.

6.3 Preoperative Examination

It is necessary to comprehend the position of the stomach, especially the relationship between the stomach and the abdominal wall. In patients with scoliosis, we should perform a preoperative upper gastrointestinal contrast study and confirm that the stomach is not located within the upper costal arch and that the gut is not located between the stomach and abdominal wall. Abdominal ultrasound and abdominal computerized tomography are helpful in understanding these anatomical features. In addition, the patient who is intended to undergo gastrostomy is often comorbid with gastroesophageal reflux disease (GERD), so it is important to perform 24-h pH monitoring and examine if GERD is present or not. Even in the case of percutaneous endoscopic gastrostomy (PEG), as most pediatric patients are performed under general anesthesia, it is essential to examine general conditions including respiratory function and coagulation status.

6.4 Selection of the Operative Methods

Which operative method do we select? Laparotomy or endoscopy? We should select by the following contents: (1) whether we can perform gastroscopy safely, (2) adequate size of gastrostomy tube, and (3) position of the stomach. Suitable age and weight are not defined, but there have been reports that PEG was performed on a 49-day-old baby weighing 3,626 g in Japan. In general, high level of skills is required to perform gastroscopy for newborn. The minimum diameter of the catheter kit for PEG is 14Fr (external diameter 4.0 mm), and it does not coincide with physical constitution and gastric volume. PEG can be performed even in small infants; however, laparoscopy-assisted PEG has further been reported to be a feasible and an alternative method.

6.5 Operations

6.5.1 Gastrostomy by Laparotomy

The stomach is approached by a short left upper transverse incision. The gastrostomy tube is placed on the left upper quadrant approximately 2 cm apart from both the left costal arch and skin incision (Fig. 6.2). The gastrostomy tube is placed on the anterior surface of the lower body of the stomach, slightly on the side of the greater curvature. A

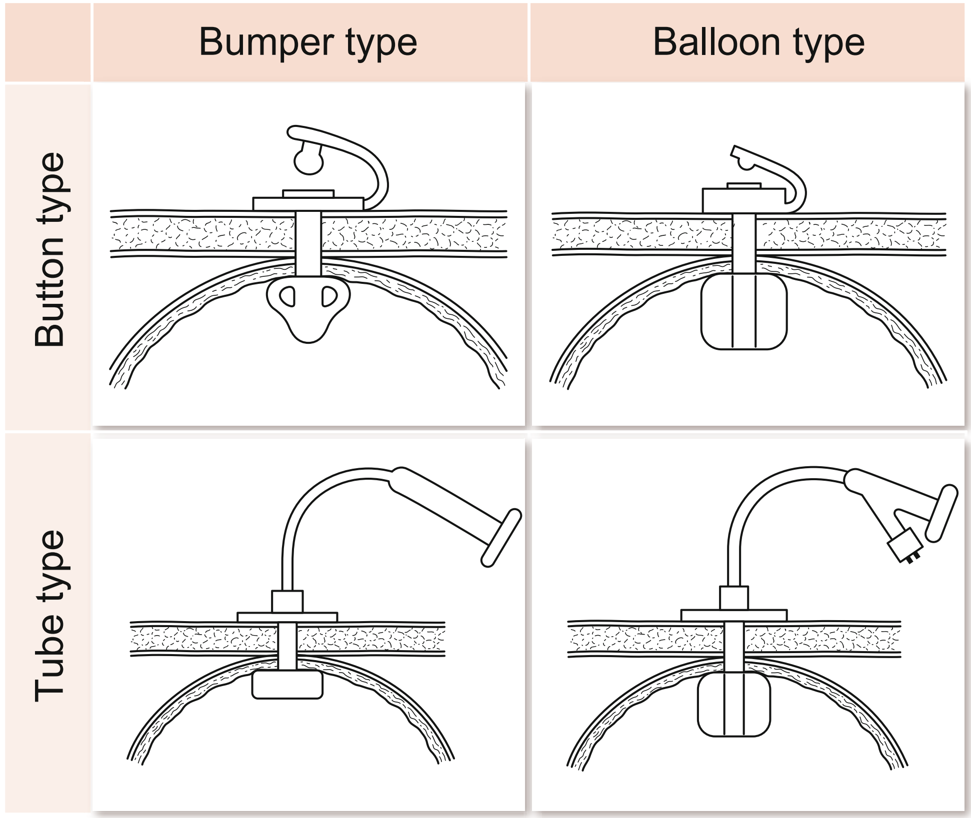

Fig. 6.1 Type of gastrostomy tube

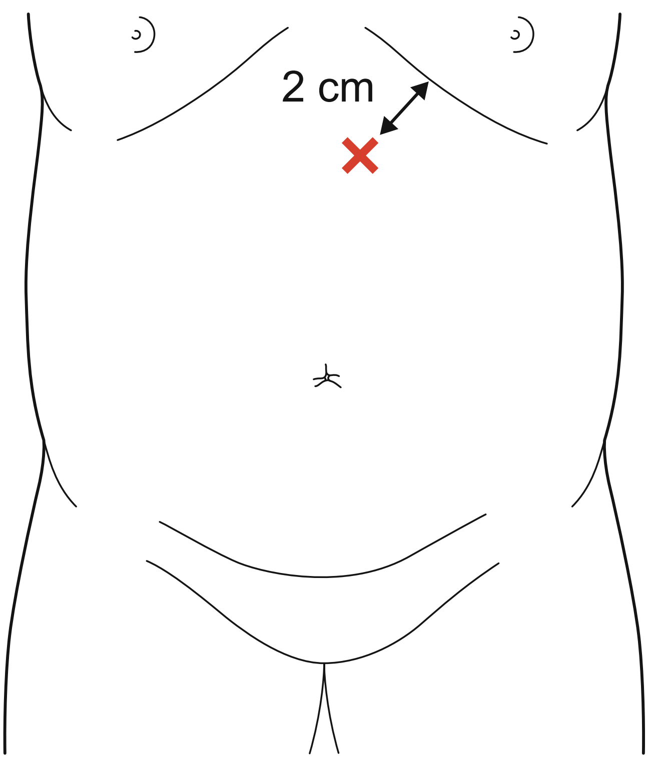

Fig. 6.2 The location of gastrostomy

small incision is made on the stomach wall, and the gastrostomy tube is placed intragastrically (Fig. 6.3). Two purse-string sutures are placed using absorbable fine threads. Then the stomach wall near the tube is approximated to the abdominal wall by two or three sutures to facilitate the fixation and prevent leakage of gastric juice.

6.5.2 Percutaneous Endoscopic Gastrostomy (PEG)

There are pull procedure, push procedure, and introducer procedure. In the pull and push procedures, the gastrostomy tube is inserted into the stomach orally using a guide wire, so bacterial contamination and risk of infection are increased. In these procedures, two endoscopic insertions are needed during guide wire insertion and gastrostomy tube insertion. On the contrary, in the introducer procedure, endoscopic insertion is done only once, so risk of infection is less.

6.5.2.1 Pull Procedure

An endoscope is inserted into the stomach under the left lateral decubitus position, and the stomach is dilated with sufficiently supplied air. Then the position is changed to

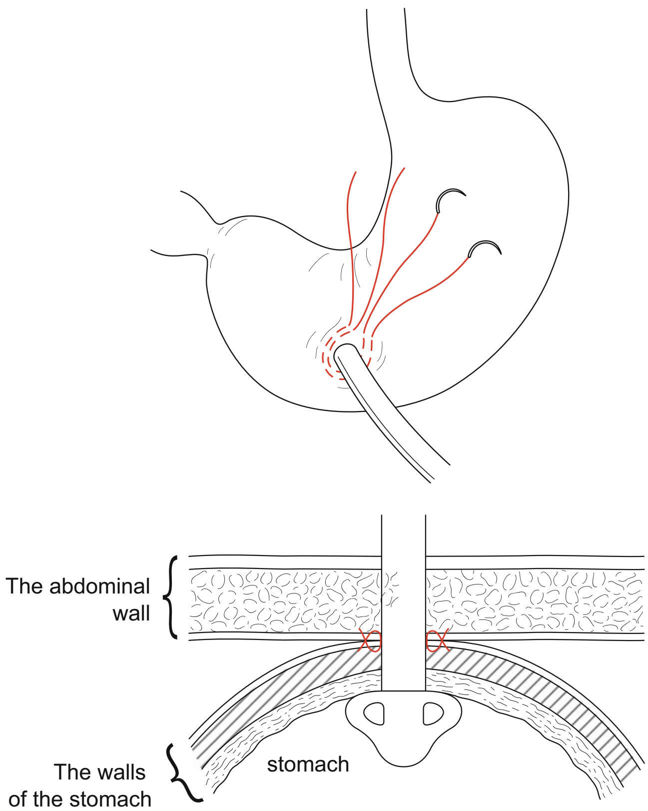

Fig. 6.3 Placement of gastrostomy tube

supine. The endoscope is rotated to the lower anterior surface of the stomach, and we visualize the transmitted light through the abdominal wall. Then the operator pushes the abdominal wall and confirms that the gastric mucosa is protruding using hand pressure (Fig. 6.4a). Thus, the most suitable puncture point is decided. At this time, the operator should confirm the vessel of the abdominal wall to avoid useless bleeding. At this point, the operator sterilizes the skin around the puncture point and performs local anesthesia. The needle for PEG is then navigated into the stomach while looking at the endoscopic monitor (Fig. 6.4b). To prevent puncture of the intestines, an operator must confirm that air suction does not happen until the needle reaches the stomach. In the case of the button type, the operator measures the distance to the stomach at puncture test and selects a tube with a length of 1 cm longer than the measurement in adults. For children, it is recommended to select a tube 1 cm shorter than measurement. T- or Y-shaped incision about 1 cm long is made, and the subcutaneous tissue is exfoliated. A loop wire is then passed through the puncture needle and is introduced into the stomach. Then the endoscopist grasps the loop wire with a snare and pulls the loop wire and endoscopy out of the oral cavity (Fig. 6.4c). The loop wire and the device with the gastrostomy tube are tied and pulled out from the stomach to the abdominal wall. The device with the gastrostomy tube should be pulled back slowly with great care to avoid injury of the mucosa (Fig. 6.4d). The endoscopist inserts the fiber scope again and observes the tube position, bleeding, or mucosal damage (Fig. 6.4e).

6.5.2.2 Push Procedure

This procedure is performed in the same way until insertion of endoscope and puncture, but a guide wire is inserted instead of a loop wire and is pulled out from the oral cavity. The device with the gastrostomy tube is inserted into the stomach along with a guide wire through the oral cavity. The operator pulls it out from the abdominal wall. After removal of the guide wire, the endoscopist observes the gastrostomy tube.

6.5.2.3 Introducer Procedure

The stomach wall and abdominal wall are fixed under endoscopic observation. In children, three approximations are recommended due to thinness of the abdominal wall and gastric wall and to prevent tearing injury by fine threads. The stomach wall fixture is packaged in the same gastrostomy kit. T- or Y-shaped incision about 1 cm long is made, and the subcutaneous tissue is exfoliated. The operator punctures the stomach wall, pulls the inner barrel and inserts the guide wire, and extends the gastric fistula by inserting the dilator along the guide wire. After dilation, the operator inserts the gastrostomy tube along the guide wire.

6.5.3 Laparoscopy-Assisted PEG

PEG cannot be performed in cases when the bowel is between the stomach and the abdominal wall, or when the stomach is located cranial to the left costal margin. In these cases, gastrostomy can be performed safely under laparoscopic guide and aid. Port for laparoscopy is made on the umbilicus, and PEG can be performed safely by observing intraperitoneal conditions. The operator can guide the gastric wall to the portion of gastrostomy by making additional port for the forceps; however, we must be aware that excessive traction of the stomach causes dehiscence of gastrostomy or buried bumper syndrome.

6.6 Purpose of Tube Jejunostomy

Injection of nutrient: The patients with gastrointestinal obstruction and eating disorder (e.g., gastroesophageal reflux, cerebral palsy) are subject to tube jejunostomy.

Drainage of intestinal fluids and stool: The patients with bowel dysfunction (e.g., total colonic aganglionosis, CIIPS)

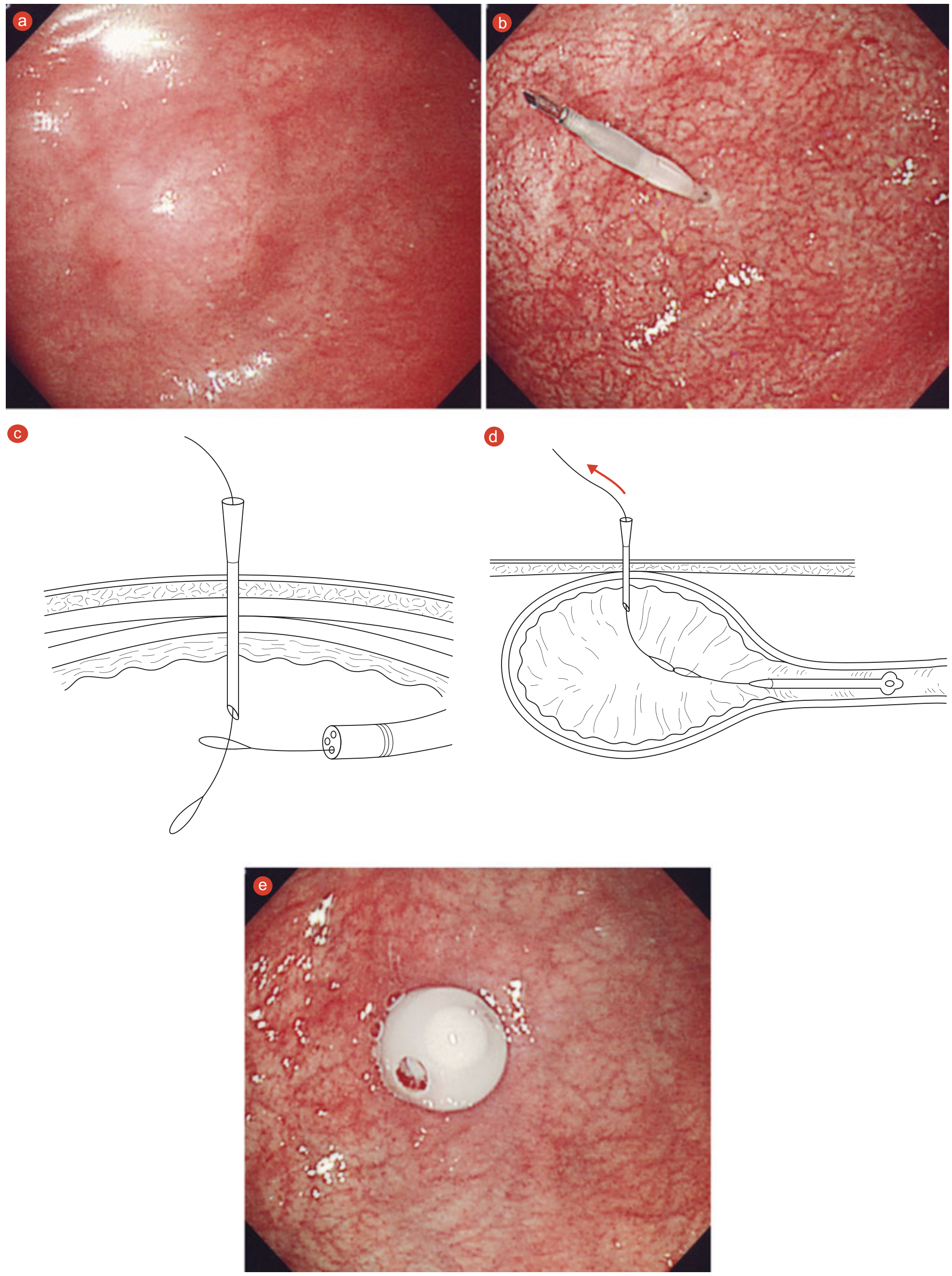

Fig. 6.4 Pull procedure. (**a**) Endoscopic observation on the site for gastrostomy. (**b**) The needle is navigated into the stomach under endoscopic observation. (**c**) Endoscopist grasps loop wire with snare and pulls loop wire and endoscopy out of the oral cavity. (**d**) Loop wire and gastrostomy tube are tied and pulled from the stomach to the abdominal wall. Device with gastrostomy tube should be pulled back slowly. (**e**) Endoscopist inserts fiber scope again and observes the tube position, bleeding, and mucosal damage

and requiring intestinal tract decompression (e.g., meconium-related ileus, intestinal perforation) are also the subject to tube jejunostomy.

6.7 Types of Tube Jejunostomy

There are three kinds of methods of tube jejunostomy.

6.7.1 Witzel Jejunostomy (Fig. 6.5)

The Witzel jejunostomy is the most common method of jejunostomy creation. It is an open technique where the jejunostomy is created on the jejunum approximately 20–30 cm distal to the ligament of Treitz. A purse-string suture is placed at the site of the antimesenteric border, and the catheter is anally inserted into the intestinal lumen. Then the catheter is tunneled 2–3 cm long by seromuscular

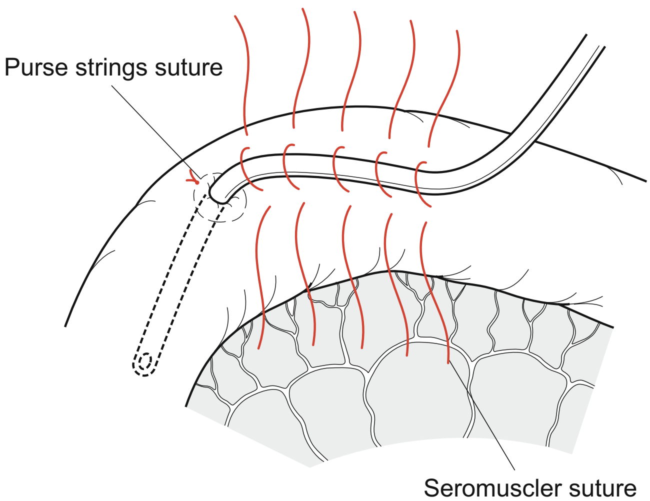

Fig. 6.5 Witzel jejunostomy. The purse-string sutures are secured and then the catheter is tunneled in a seromuscular groove

sutures. The serosa around the jejunostomy tube is fixed to the abdominal wall with three to five sutures.

6.7.2 Stamm-Kader Jejunostomy (Fig. 6.6)

Two subsequent purse-string sutures are placed at the site of the antimesenteric border of the jejunum. A stab wound is placed on the skin, and the distal end of the tube is drawn into the abdomen. A hole is placed in the middle of the purse-string sutures and then the tube is inserted. The purse-string sutures are secured, invaginating the serosa around the tube as the sutures are tied down. The serosa around the catheter is tacked to the abdominal wall with three to five sutures.

6.7.3 Needle Catheter Jejunostomy (Fig. 6.7)

A needle catheter is inserted into the antimesenteric side of the jejunal wall and is passed through the submucosal layer to prevent from fistula formation after removal of the catheter. The needle is withdrawn over the catheter, and a purse-string suture is made on the jejunal wall around the catheter. The catheter is threaded through the anterior abdominal wall; finally the loop of jejunum is attached to the parietal peritoneum and then the catheter fixed to the skin.

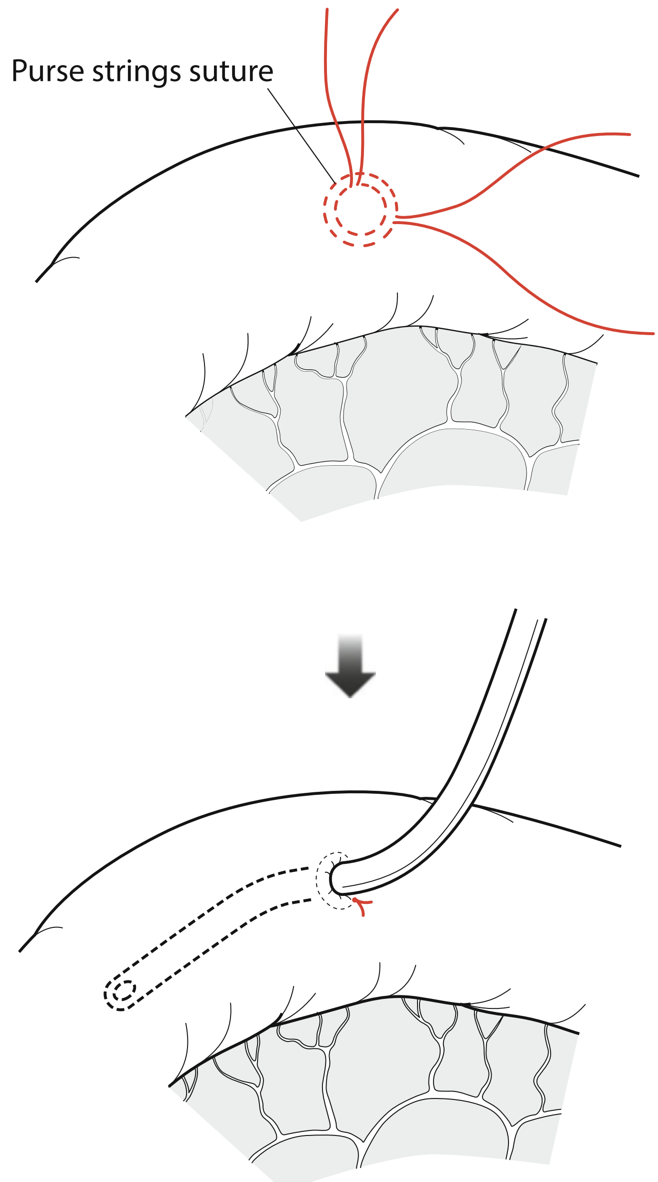

Fig. 6.6 Stamm-Kader jejunostomy. Two subsequent purse-string sutures are placed at the site of the antimesenteric border. The purse-string sutures are secured, inverting the serosa around the tube as the sutures are tied down

6.8 Postoperative Management

6.8.1 Management After Fistula Formation

Dermatitis: This is caused by leakage of intestinal fluids or nutrient and skin rash by the fixing tape. To reduce dermatitis, it is necessary to wash the skin and paste adequate coating materials.

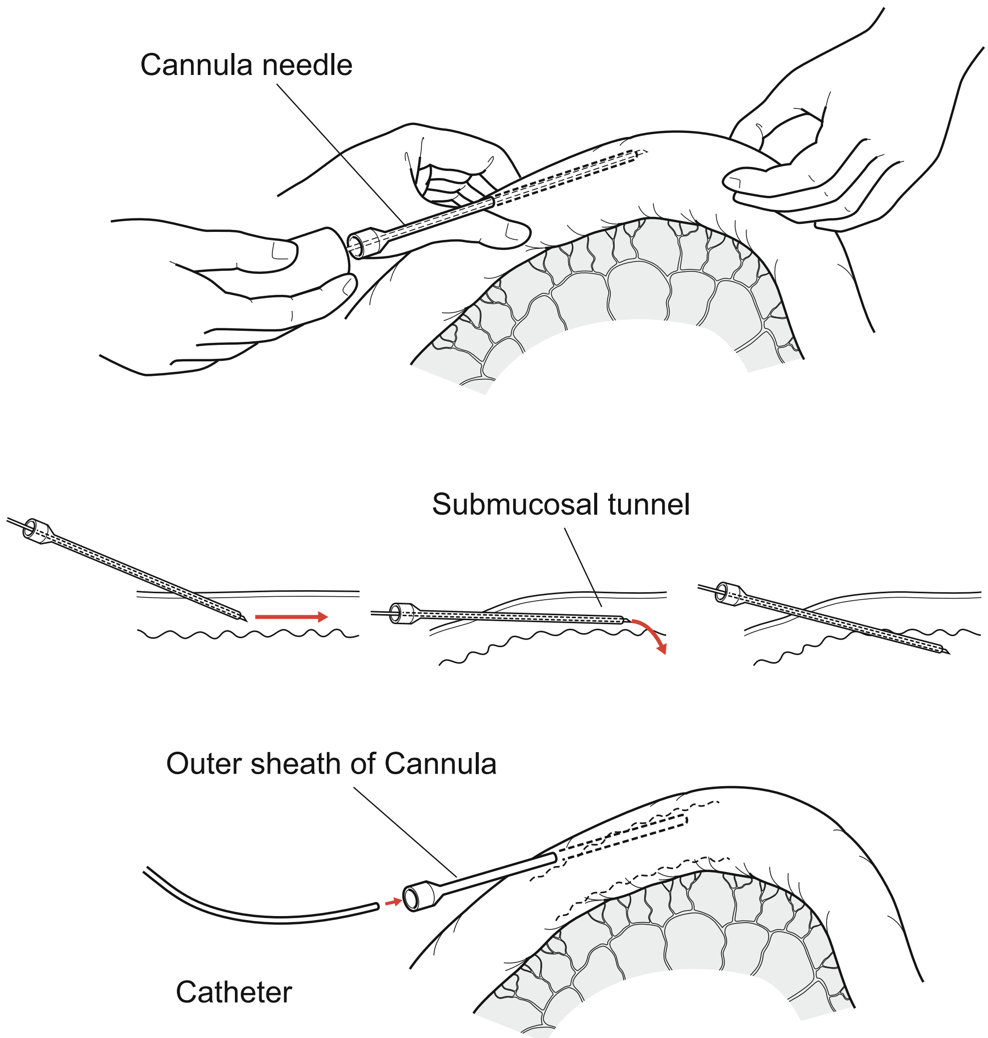

Fig. 6.7 Needle catheter jejunostomy. The needle is inserted to the intestinal wall and a submucosal channel is made in the antimesenteric intestinal wall. And the catheter inserted to the outer cylinder

Formation of granulation: This is caused by infection of the fistula and chronic stimulation. Fixing the catheter without pressing the same site is necessary.

6.8.2 Management of the Catheter

Obstruction of the catheter: It is caused by nonuniformity of mixing and consolidation of nutrients by enteric bacteria. It is necessary to dissolve the powdered nutrients with lukewarm water thoroughly so as not to leave solid components and to administer the nutrient within 8 h after mixing. We should flush the catheter using lukewarm water before and after administration.

Accidental extubation and self-extubation of the catheter: When the catheter is fixed to the skin, it is necessary to put a mark on the catheter. We must take care not to loosen anchoring sutures and peeling off of the fixing tape.

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Colostomy: Creation and Closure

7

Yoshinori Hamada

Abstract

Colostomy is an operation frequently performed in pediatric surgery, especially for cases of anorectal malformations and Hirschsprung's disease. Despite its benefits, it can produce significant morbidity. Double-barreled colostomy is common in pediatric surgery. The technical details of creation and closure of the sigmoid double-barreled loop colostomy for the intermediate-type anorectal malformation are described. Surgical technique of umbilical double-barreled loop colostomy is also described as an alternative, unique, and cosmetically excellent method.

Keywords

Colostomy • Double-barreled loop colostomy • Anorectal malformation • Umbilical colostomy

7.1 Creation of Colostomy

Colostomy is an operation frequently performed in pediatric surgery [1]. Indication of the colostomy includes intermediate type and high type of anorectal malformation (ARM) and long-segment-type Hirschsprung's disease. The colostomy is created almost in the early neonatal period and is kept as a temporal stoma for several months before closure of the colostomy.

Creation of colostomy is possible by a short skin incision just on a planned stoma site of the colon for ARM. In Hirschsprung's disease, stoma site varies with length of an aganglionic segment.

Enterostomy for necrotizing enterocolitis (NEC) or meconium-related ileus is performed by nearly same procedure of the colostomy. In this issue, special procedures such as Bishop-Koop-type enterostomy were omitted, because of the tendency of advancing use of the parenteral nutrition and decreasing use of enterostomy.

7.1.1 Preoperative Management

After establishment of a definite diagnosis, immediate fasting and gastric decompression with intravenous infusion therapy is needed to prevent a progressive distension of the colon. Spontaneous decompression through the rectourethral or rectovesical fistula seldom occurs except in case of a fistula large enough to pass sticky meconium. Direct puncture of the dilated rectal pouch through the perineum is a possible attempt to be a decompression method, but we should take into consideration that it has a potential to injure the urethra in the early neonatal periods. In case of a long-segment-type Hirschsprung's disease, decompression of gas and stool should be done to prevent enterocolitis and bacterial translocation by using soft irrigation tube.

Stoma site marking is performed by a wound, ostomy, continence (WOC) nurse. Each combination of the pulled-

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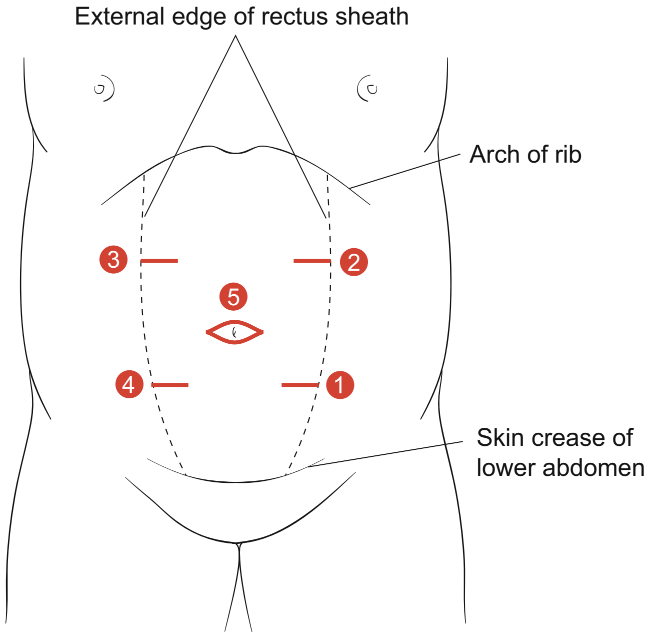

Fig. 7.1 Stoma site and bowel to be pulled through: **1** left-lower quadrant (sigmoid colon), **2** left-upper quadrant (left side of transverse colon), **3** right-upper quadrant (right side of transverse colon), **4** right-lower quadrant (ileum), **5** umbilicus (every bowel)

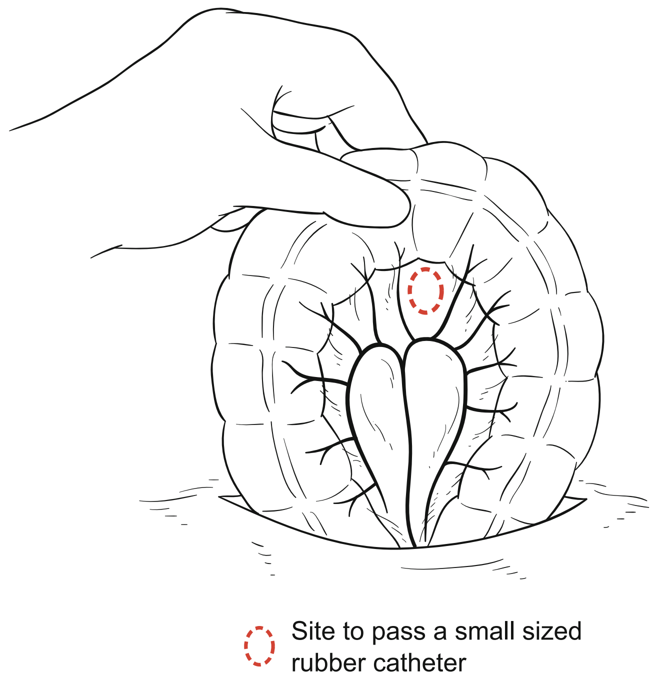

Fig. 7.2 Drawn of the loop

through intestine and stoma site is as follows: sigmoid colon and left-lower quadrant, left-sided transverse colon and left-upper quadrant, right-sided transverse colon and right-upper quadrant, and ileum and right-lower quadrant. In cases of umbilical site colostomy, every part of the intestine can be drawn into an umbilical wound, and selection of the pulled-through intestine is usually unnecessary (Fig. 7.1).

7.1.2 Surgical Technique

Double-barreled colostomy is common in pediatric surgery. Double-barreled colostomy includes both a loop colostomy and skin bridge loop colostomy. In this issue, sigmoid double-barreled loop colostomy in the intermediate-type ARM is described as the most frequent surgical technique.

7.1.2.1 Surgical Technique of Double-Barreled Loop Colostomy on the Left-Lower Quadrant

Transverse skin incision 2–3 cm long is made under general anesthesia. The left anterior rectus sheath is incised transversely. The rectus muscle is then split longitudinally side by side. The posterior rectus sheath and peritoneum are simultaneously incised transversely and thus abdominal cavity is opened. In the case of severe dilatation of the sigmoid colon, a gentle pulling-out maneuver is needed to prevent iatrogenic rupture. Elongation of the skin incision is needed in case of inability of safe pull-through of the intestine. Puncture and decompression of the dilated intestine can be performed with great care of preventing spillage and contamination, if suitable site for stoma is ascertained.

The most proximal part of the sigmoid colon is drawn into the wound as a loop, and the afferent limb is situated left side to the efferent limb, thus diminishing the opportunity for spillage into the distal sigmoid colon. The mesentery is opened of minimal size to place through a small-sized rubber catheter. Care must be taken not to injure the marginal vessels (Fig. 7.2).

The loop is drawn approximately 4 cm high from the abdominal cavity. The skin is not closed between the two limbs of the loop so that the bowel does not bridge a portion of the skin. Two limbs are fixed side by side on both mesenteric aspects of the loop, with great care not to injure mesenteric vessels. Approximation is performed at four different levels with 5 mm interval by interrupted seromuscular sutures (Fig. 7.3). This approximation prevents prolapse of the stoma. These four suture points are used as a good landmark for the following fixation sutures. 5-0 absorbable sutures with atraumatic needle are commonly used. The rubber catheter is then cut shortly and formed as a small loop.

Fixation of the limb to the abdominal wall is then performed; the seromuscular layer of the colon is

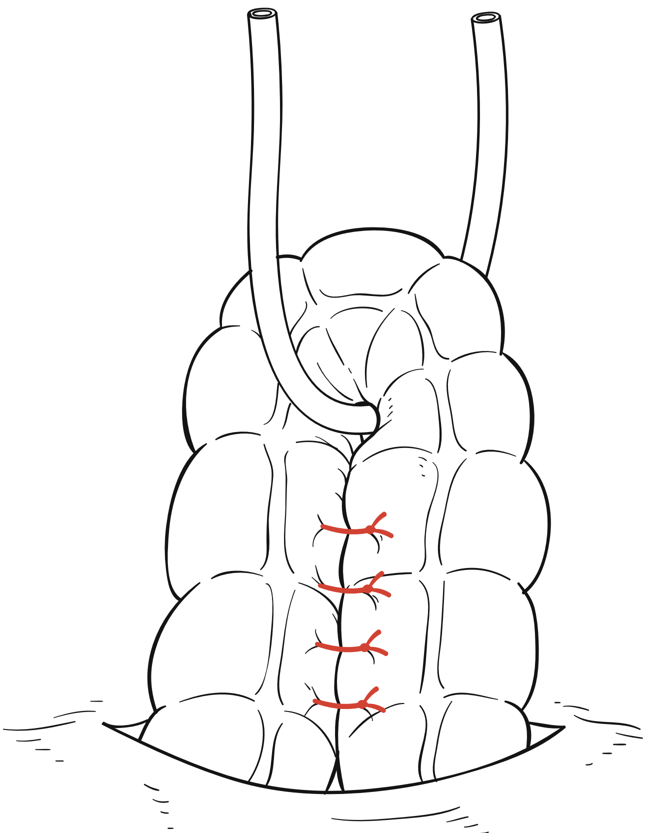

Fig. 7.3 Approximation of two limbs of the loop

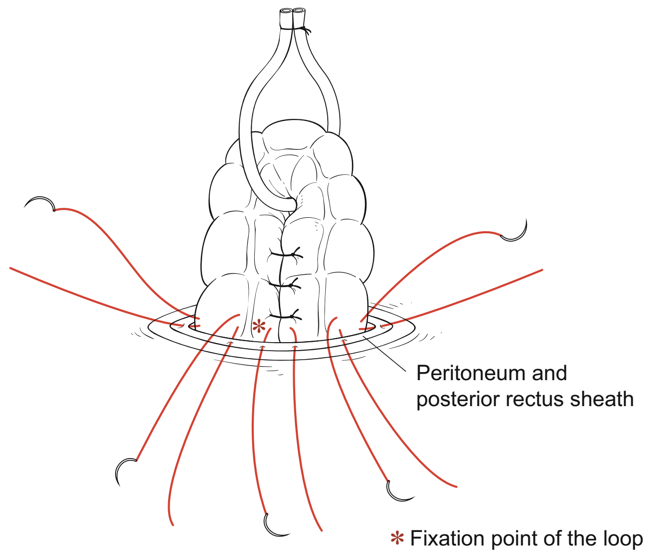

Fig. 7.4 Approximation of the colon to both the peritoneum and posterior rectus sheath

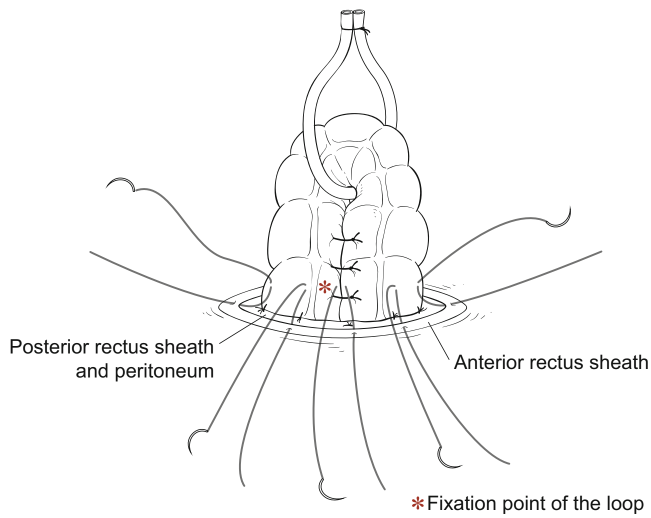

Fig. 7.5 Approximation of the colon to the anterior rectus sheath

approximated to both the peritoneum and posterior rectus sheath simultaneously by interrupted sutures around the two limbs. Eight to ten sutures are usually performed at height of level between the third and fourth suture. Loop-fixed site (※) is situated 6:4 in the incision from the afferent to efferent limb, so that orifice of the proximal limb is wider than that of the distal limb. At the loop-fixed site, a vertical mattress suture is each performed on both aspects of the loop to prevent herniation of the small intestine or omentum. Large opening of the fascia is closed to suitable size, since the dilated bowel will become considerably smaller after it is decompressed (Fig. 7.4).

Fixation of the colonic wall to the anterior rectus sheath is successively performed. Level of these sutures should be at the level between the second suture and third suture. The number and site for suturing are the same as that of fixation to the peritoneum and posterior rectus sheath (Fig. 7.5).

Ointment-containing antibiotics are applied between the skin and colonic wall just before incision of the bowel wall. The anterior wall of the looped colostomy is then opened longitudinally for 2–3 cm in length along a taenia, and the mucosa is immediately everted without suturing to the skin (Fig. 7.6). The transverse incision should be close to the skin margin to permit proper eversion of the both limbs. The contents of the colon is aspirated and irrigated by sterile six-time diluted Gastrografin solution to remove meconium.

One week later, a rubber catheter as a supporting bridge is removed, and two limbs are completely separated using electrocautery. This makes a loop colostomy to be matured two adjacent, separated, and divided stomas. The completed stoma should protrude from the abdominal wall for at least 1 cm.

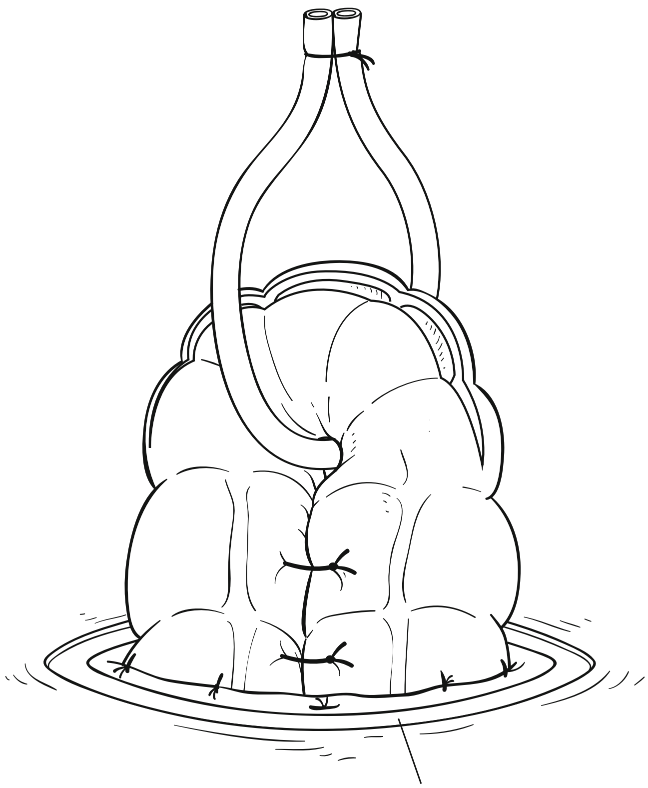

Fig. 7.6 Opening of the anterior wall of the looped colostomy

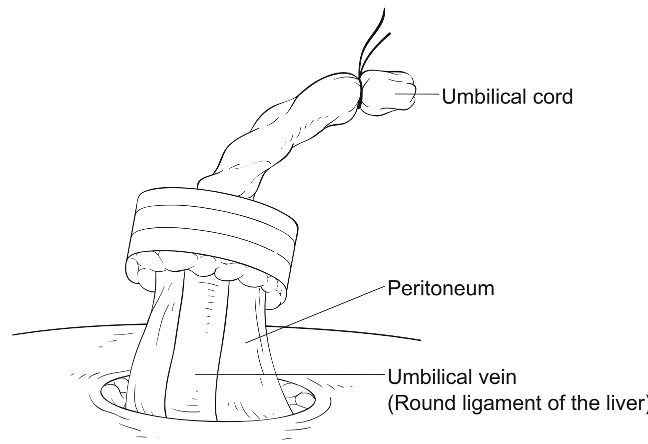

Fig. 7.7 Umbilical appearance in the umbilical double-barreled loop colostomy

7.1.2.2 Surgical Technique of Umbilical Double-Barreled Loop Colostomy [2]

A circumferential skin incision is made at the base of the umbilical cord. The skin, subcutaneous tissue, and fascia around the umbilical cord are cored out vertically, and the umbilical vessels and urachus remnant are individually ligated apart from the opening in the fascia (Fig. 7.7). A loop colostomy is created in double-barreled fashion with a high chimney more than 2 cm above the level of the skin. The final size of the opening in the skin and fascia is modified according to the size of the bowel. The bowel wall is fixed separately to the peritoneum and fascia with interrupted 5-0 absorbable sutures. The bowel is opened longitudinally and everted without suturing to the skin. The loop is divided 7 days postoperatively, and diversion of the oral bowel is completed. Although it is initially created as a loop colostomy, the loop is divided 7 days postoperatively to stop fecal flow toward the distal rectal pouch and prevent fecal impaction.

The umbilicus is located in the center and on the apex of the abdominal wall even in small infants. It is thus an advantageous stoma site in terms of attachment of the stoma bag and avoidance of dislodgement by the thigh. This minimizes stoma complications and enables easy stoma care. From the cosmetic point of view, the best indication for the umbilical stoma may be for infants with intermediate-type ARM. In such infants, radical anorectoplasty can be performed via the sacroperineal approach such as Pena's posterior sacral anorectoplasty, not by abdominal approach, with just umbilical wound scar remained. Umbilical stoma is further applied for a laparoscopic two-stage repair for high-type ARM [2].

7.1.2.3 Extremely Low Birth Weight Infant (ELBWI)

Bowel wall of ELBWI is thinner than that of normal infants, and dilatation of the bowel makes the wall much thinner. Although atraumatic fine needle is used, the needle tends to easily penetrate the bowel wall. Use of 2.5× glass is essential to avoid such complication. Further, postoperative diminished dilatation of bowel sometimes causes unbalance between bowel size and fascia fixation site, and it makes tearing effects on the fixation point. This may cause breakdown of the bowel wall and subsequent mucosal prolapse from the lateral wall or fistula formation. As the umbilicus is located in the center and on the apex of the abdominal wall even in very small infants, it is thus an advantageous stoma site especially in ELBWI.

7.1.3 Postoperative Management

Colostomy care consists of careful cleansing and drying of the skin. Early postoperative complications include necrosis, retraction, wall breakdown, peritonitis, wound dehiscence, visceral exteriorization, and misconstruction of the stoma. Late complications include skin erosion, prolapse, fistula, stricture, mucosal bleeding, bowel obstruction, and parastomal hernia. High stoma prevents skin erosion. WOC nurse's treatment and advice are preferable to reduce such complications. After stoma care education is performed for parents, patients will be discharged and wait for approximately 3 months after closure of colostomy.

7.2 Closure of Colostomy

Closure of colostomy would be the last surgical procedure of patients with ARM and Hirschsprung's disease. Despite its benefits, it can produce significant morbidity and mortality [3]. Preoperative preparation and accurate surgical procedure are essential to make an uneventful postoperative clinical course.

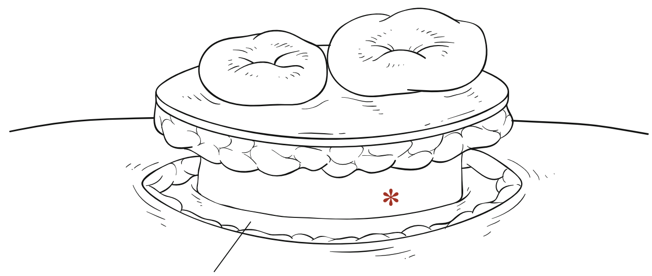

Fig. 7.8 Adhesiolysis between bowel wall and anterior rectus sheath

7.2.1 Preoperative Management

The colostomy is closed 2–3 months after a definitive surgery in ARM and Hirschsprung's disease. No anastomotic stricture should be achieved before closure of colostomy, because continuity of fecal stream causes difficulty of anal stool passage. For this purpose, well-planned constant bougienage in outpatient clinic and at home is mandatory before admission for colostomy closure. Erosion of the peristomal skin should be controlled to decrease wound infection. Bowel preparation is also essential to reduce anastomotic dehiscence.

7.2.2 Surgical Technique

Direct closure of the stoma orifice is usually unnecessary. A peristomal skin incision is made and the subcutaneous tissue is divided by blunt and sharp dissection. To enter an abdominal cavity, the first break through is done at fixing point of the bowel wall to the anterior rectus sheath. Meticulous technique should be done to avoid incision through the intestinal wall by sharp dissection using a fine curved mosquito clump (Fig. 7.8). Once a good point is broken through to enter into the free abdominal cavity, circumferential adhesiolysis is further made by blunt and sharp dissection. After enough length of the two limbs is obtained, each end of the stoma is resected 1–2 cm in length, and minimal resection of adjacent mesenteric vessels is made (Fig. 7.9). As size discrepancy is usually less than 2:1 between the proximal and distal bowel, a two-layer, end-to-end anastomosis by Albert-Lembert fashion can be performed using interrupted 5-0 absorbable sutures. Basically, functional end-to-end anastomosis using staples or anastomotic devices is not applied as a first choice. In case of wall breakdown or leakage of intestinal fluid, abdominal irrigation with warm saline and abdominal drainage are indicated. The peritoneum with posterior rectus sheath and anterior rectus sheath is each approximated with 4-0 or 3-0 interrupted absorbable sutures. Wound is irrigated and skin is approximated by subcutaneous interrupted buried sutures with 6-0 absorbable sutures.

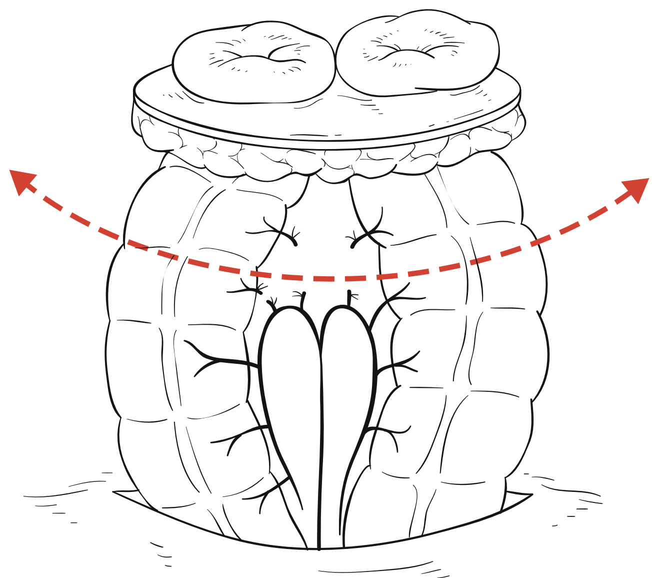

Fig. 7.9 Resected area of the loop colostomy

In the cases of umbilical stoma, final skin and subcutaneous wound closure is performed in a semi-opened fashion to create a deep umbilicus from viewpoint of excellent cosmetic results.

7.2.3 Postoperative Management

In the uneventful clinical course, fasting and continuous drip infusion are kept for 3 days after closure of colostomy. Oral intake starts on postoperative day 4 and daily feeding amount is increasing. Perianal skin erosion may occur due to soft and frequent stool just after closure of colostomy. Antidiarrhoeic drug and ointment for skin protection are useful.

The most frequent complication is wound infection. Other complications such as wound dehiscence, incisional hernia, anastomotic leakage, and fistula formation may occur after bowel wall breakdown at times of closure of colostomy, and these complications sometimes need surgical management.

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Gastrointestinal Anastomosis

8

Yoshinori Hamada

Abstract

Gastrointestinal anastomosis is an operation frequently performed in pediatric surgery. Pediatric surgical indications for which gastrointestinal anastomosis may be required include congenital anomalies and inflammatory diseases and may be required as a part of surgical procedures. The key to a successful anastomosis is the accurate union of two viable bowel ends with complete avoidance of tension. In the newborn surgery, with the size and thickness discrepancy between the proximal and distal bowel, we must take great care about surgical techniques. A meticulous suturing technique and adequate strength in tying would be required especially for cases of extremely thin bowel wall. General principles of intestinal anastomosis for congenital intestinal atresia in the neonates are described about sutures, anastomotic method, suture materials, and postoperative complications.

Keywords

Gastrointestinal anastomosis • Single layer • Interrupted suture • Atraumatic needle • Absorbable thread

8.1 Gastrointestinal Anastomosis

Gastrointestinal anastomosis is an operation frequently performed in pediatric surgery. Pediatric surgical indications for which gastrointestinal anastomosis may be required include congenital anomalies (e.g., intestinal atresia and stenosis, malrotation with midgut volvulus leading to gangrene, Meckel diverticulum, duplication cysts, Hirschsprung disease, anorectal malformations), inflammatory diseases (e.g., necrotizing enterocolitis, ulcerative colitis, Crohn's disease, gastrointestinal perforation), and other conditions (e.g., intussusception, enteric aberrant pancreas, polypoid lesions) and may be required as a part of surgical procedures (e.g., colostomy closure, congenital biliary dilatation, Kasai portoenterostomy).

It has been stated that the key to a successful anastomosis is the accurate union of two viable bowel ends with complete avoidance of tension [1]. In the newborn surgery, as the size and thickness of bowel wall to be anastomosed differ in both sides of the intestine, we must take great care about surgical techniques by the use of 2.5× surgical glass. We use atraumatic needles with 5-0 or 6-0 absorbable threads as suture materials to facilitate accurate approximation. A meticulous suturing technique and adequate strength in tying would be required especially for cases of extremely thin bowel wall.

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8.2 Sutures

Intestinal anastomosis can be performed with sutures, staples, or anastomotic devices. A sutured anastomosis by a hand-sewn technique is the most common option in neonatal pediatric surgery, because of the small size and discrepancy of the proximal and distal lumen. To obtain appositional suture, inversion reduces the lumen diameter and eversion can increase adhesion formation. Using surgical staplers to anastomose intestines reduces surgery time and provides bursting strength, lumen diameter, and healing similar to anastomosis with simple interrupted sutures. Even in neonates, endoscopic device (e.g., ENDO GIA 30) is recently available if the distal lumen is more than 8 mm in diameter.

8.2.1 Single-Layer Suture and Double-Layer Suture (Figs. 8.1 and 8.2)

Single-layer suture is a suturing method that bowel wall is approximated by one layer of stitches. Single-layer suture includes inversion suture and eversion suture. In neonates, inversion suture would be avoided because it can reduce the lumen diameter, and thus eversion suture is recommended because it can increase adhesion formation but not interfere with luminal passage. In addition, double-layer closure is not recommended because of luminal compromise, poor submucosal apposition, avascular necrosis, and prolonged healing time. Single-layer suture causes least damage to the submucosal vascular plexus and least chances of narrowing of the lumen and incorporates strongest submucosal layer and accurate tissue apposition. Other single-layer sutures include Gambee suture and Hepp and Jourdan suture. In Gambee suture, the suture goes from the serosal to mucosal surface, back into the mucosa on the same side of the incision, out into the middle of the cut surface to be approximated, across the incision into the wound edge opposite, down into the gut lumen, back through the mucosa, and through the wall to the serosal surface and a tie with the tail of the suture across the incision. In Hepp and Jourdan suture, the suture goes from the serosal to submucosal layer, not to the mucosal surface, out into the middle of the cut surface to be approximated, across the incision into the wound edge opposite, up into the submucosa, and through the wall to the serosal surface. These two methods are suitable for adults but not for neonates with thin wall intestine due to difficulty of suturing.

Double-layer suture includes Albert-Lembert anastomosis and layer-to-layer anastomosis. Lembert suture is the second row of the Albert-Lembert intestinal suture, an inverting suture for intestinal surgery, used either as a continuous suture or interrupted suture, producing serosal apposition and including the collagenous submucosal layer, but not entering the lumen of the intestine. Double-layer suture fails to oppose clean serosal surfaces, and it results in large amount of ischemic tissue within suture line which increases the chances of leakage. Further excessive inversion leads to narrowing of the lumen. Layer-to-layer anastomosis is recommended based on the idea that approximation of the submucosal layer is most important in anastomosis. Approximations of mucosa to mucosa and seromuscular layer to seromuscular layer are independently performed.

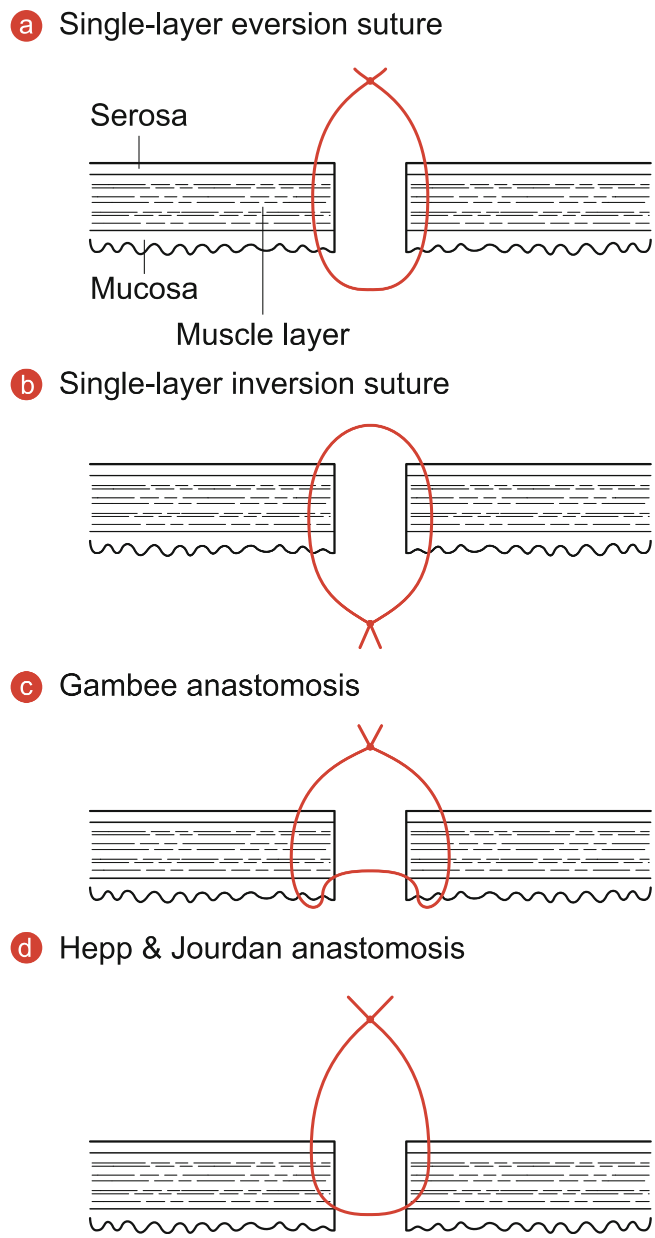

Fig. 8.1 Single-layer suture. (**a**) Single-layer eversion suture. (**b**) Single-layer inversion suture. (**c**) Gambee anastomosis. (**d**) Hepp and Jourdan anastomosis

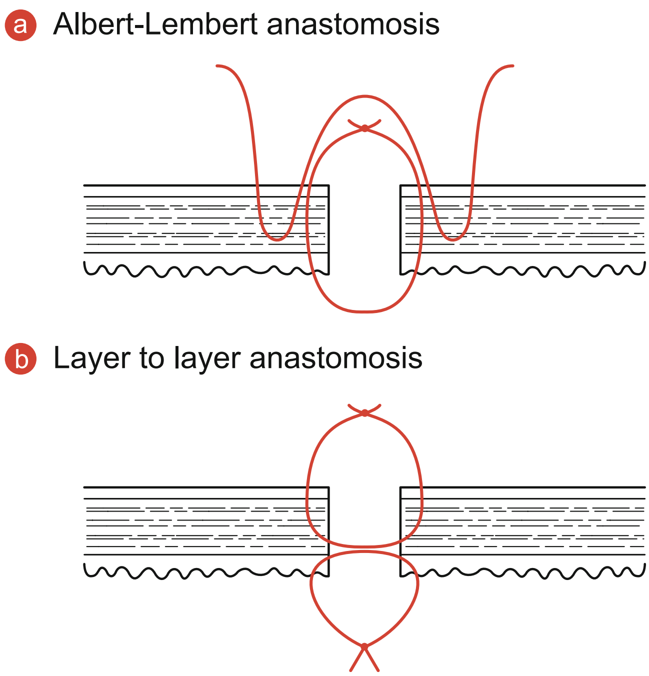

Fig. 8.2 Double-layer suture. (**a**) Albert-Lembert anastomosis. (**b**) Layer-to-layer anastomosis

Double-layer suture can be used for thick intestines in infants or childhood.

8.2.2 Interrupted Suture and Continuous Suture

In the interrupted suture, each stitch is made with a separate piece of material, and in the continuous suture, a continuous, uninterrupted length of material is used. Interrupted suture requires more time to perform, but it is suitable for adjustment of suture interval and axis of bowel when size of bowel wall to be anastomosed differs in both sides of the intestine. In addition, it can keep anastomosis diameter and leads to good vascular supply and less leakage of anastomosis. In childhood, physical growth should be taken in mind. In general, in the neonates or infants, interrupted suture would be recommended, because relative narrowing of anastomotic site due to growth would be less than continuous suture.

8.3 Anastomotic Method

8.3.1 End-to-End Anastomosis (Fig. 8.3)

This is commonly used technique for intestinal anastomosis. As usual procedure, posterior edges of the bowel are united with interrupted sutures tied on the mucosal aspect.

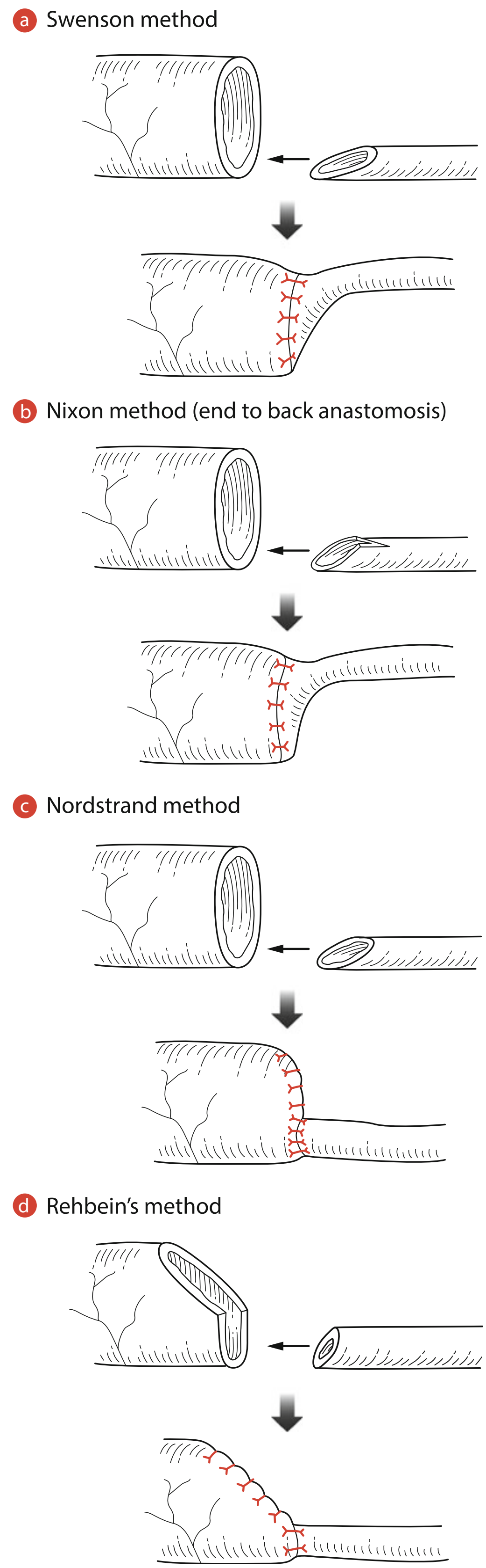

Fig. 8.3 Special anastomosis for intestinal atresia with great discrepancy between the proximal and distal bowel lumens [2]. (**a**) Swenson's method. (**b**) Nixon's method (end-to-back anastomosis). (**c**) Nordstrand's method. (**d**) Rehbein's method

Then anterior edges are united by similar sutures tied on the serosal surface.

Where there is a size discrepancy greater than 4:1 between the proximal and distal bowel lumens, an end-to-back anastomosis may be fashioned [3]. Other methods for cases with size discrepancy include Swenson's method, Nordstrand's method, and Rehbein's method [2].

8.3.2 End-to-Side Anastomosis

This anastomosis is performed at jejunojejunal anastomosis at the time of biliary reconstruction in congenital biliary dilatation or Kasai portojejunostomy. To prevent upward regurgitation of bowel content toward the liver, side-to-side attachment can be added 1–2 cm long between oral jejunal wall and Roux-en-Y limb.

8.3.3 Side-to-Side Anastomosis

A stapled side-to-side anastomosis is acceptable in most situations in adult surgery. A stapled side-to-side ileocolic anastomosis is preferable following a right hemicolectomy for cancer and Crohn's disease.

In the pediatric surgery, this anastomosis is performed by GI stapler in case of Duhamel-GIA technique for Hirschsprung disease. A stapled functional end-to-end anastomosis can be also performed for small infant. Gastrojejunal bypass is occasionally performed after Ladd's procedure due to difficulty of duodenal passage with uncorrectable kinking of the duodenojejunal junction in patients with atypical malrotation. But blind loop syndrome should be avoided by meticulous follow-up especially in pediatric age group.

8.4 Suture Materials

Absorbable compound is used for suture threads. Either monofilament or braided is suitable in most situations. Atraumatic needle with thread is commonly used. Selection of shape, curve, and size of needle and control release or not can be decided based on age and size and condition of the bowel. Both-sided needle can be used for extremely thin and small-sized bowel to secure the mucosal layer. 5-0 or 6-0 threads are used for neonate and infant, and 4-0 or 5-0 threads are used for children over 1 year old, but flexible application would be important according to the situation.

8.5 Postoperative Complications

Postoperative complications include dehiscence, peritonitis from leakage or necrosis, bleeding, ileus, recurrence of clinical disease, short bowel syndrome, and would infection. Anastomotic leakage is more likely to be associated with interrupted sutured anastomosis, preexisting peritonitis, or hypoalbuminemia.

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9 Repair and Anastomosis of the Blood Vessel

Yukihiro Inomata and Shintaro Hayashida

Abstract

As the preoperative preparation, the targeted lesion should be evaluated precisely in relation to the vascular configuration. For repair or hemostasis of fine or fragile vessels, fine instruments should be prepared and used. For effective hemostasis in unexpected bleeding, accurate recognition of the bleeding point is the first step. Nonabsorbable fine sutures, like 5-0 or 6-0, are usually used. Z-shaped or continuous suture is commonly used for hemostasis. Tear of the vessels should be prevented with control of the needle holder very smoothly and lightly. In case of major bleeding from large vessels, effective usage of vascular clamp is necessary. Temporary hemostasis by such a clamp will make the operator calm down to face the difficult bleeding. If there is a major defect in the large veins, autologous vein graft, like saphenous vein, ovarian vein, or inferior mesenteric vein, is conventionally used. In case of vascular anastomosis, matching of the alignment is the most important. Control of the alignment can be done referring the direction of the vascular clamps. Interrupted suture may be better unless the diameter of the vessel is less than 5 mm. Discrepancy of the diameter can be overcome in the case of end-to-end fashion. Anticoagulation is not necessary in case of the repair or anastomosis of large vessels. If necessary, warfarinization with INR around 2.0 is applied.

Keywords

Bleeding • Hemostasis • Vascular anastomosis • Vascular clamp • Calm down

9.1 Preoperative Management

In this chapter, how to do in cases of unexpected bleeding, repair of the intraoperative injury of major vessels, and the way of the vascular resection and anastomosis will be described. Reconstruction of the small arteries will be described elsewhere.

When repair or anastomosis is expected in advance in some operative procedures, precise evaluation of the anatomy of the targeted vessels should be done before the surgery. If it is the case of tumor resection, location of the vessels in relation to the tumor, possibility of the invasion, possibility of the vascular replacement, and availability of the suitable graft vessels should be all considered. In these days, contrast-enhanced computed tomography (CT), and

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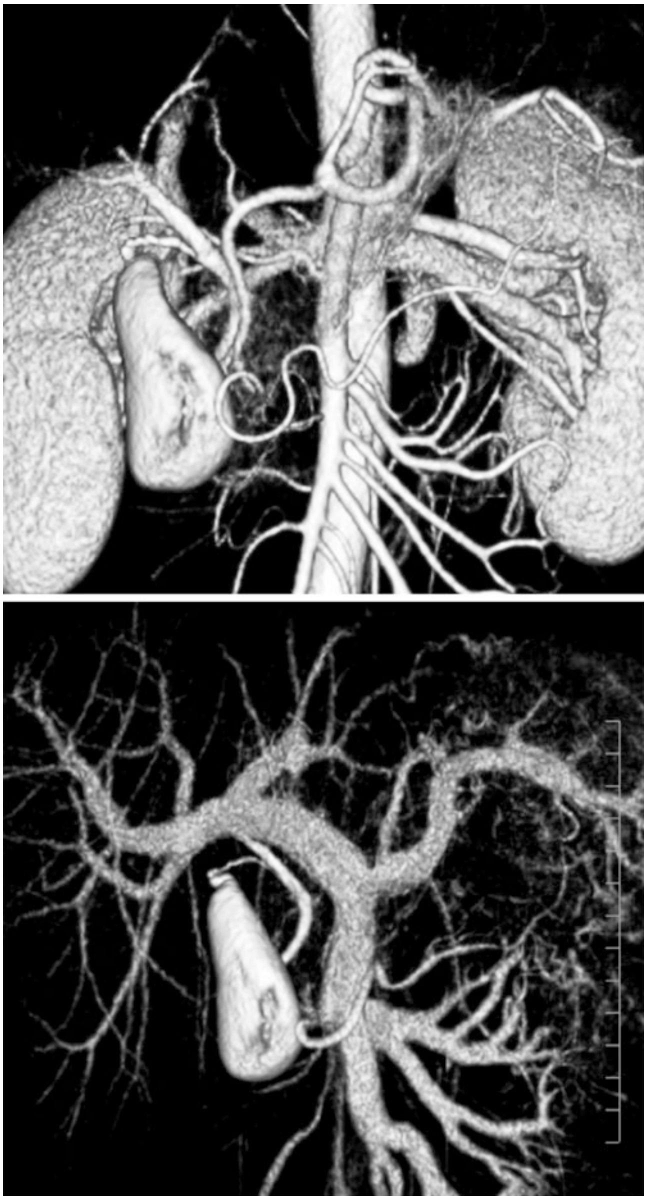

Fig. 9.1 Imaging of 3D CT

the three-dimensional evaluation using the data obtained by this CT, is the best way for such objectives (Fig. 9.1). If there is a possibility of the allergy to the contrast medium, magnetic resonance imaging (MRI) is also effective.

9.2 Preparation of Suture Material or Instruments

For the repair or anastomosis of the blood vessels, monofilament stitches should be prepared. The size of the stitches depends on the size of the aimed vessels, but 5-0 or 6-0 is used commonly. Absorbable or nonabsorbable is not a major

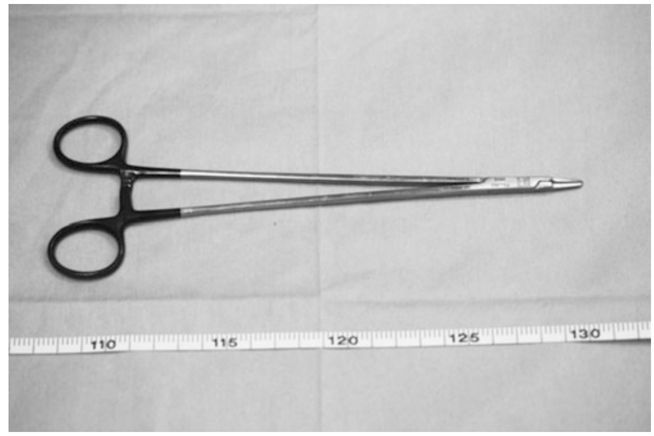

Fig. 9.2 Ryder needle holder for fine stitches

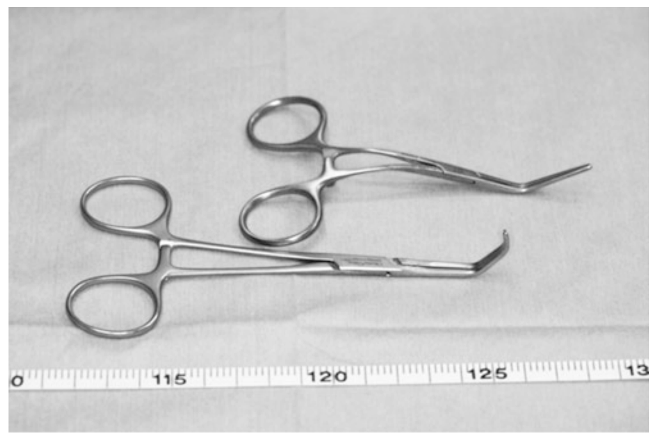

Fig. 9.3 DeBakey clamps for vascular clamping

issue, although in cases of pediatric patients, absorbable material is preferred. Nonabsorbable material is easier for handling in tying. If 6-0 or thinner material is used, fine needle holder is better for handling (Fig. 9.2). As for the vascular clamps, Satinsky-type clamp is popular, but in the case of small vessels, more fine clamps are preferred (Fig. 9.3). We call this (Fig. 9.3) as a “Baby Potts clamp,” and it is commercially available as a “DeBakey clamp.” To hold the fine suture material, small clamps with the tip covered by rubber sheath are used to prevent the injury of the material.

For the secure hemostasis, accurate recognition of the bleeding point is essential. Magnifying loupe is very useful in this setting. Pediatric surgeons should be familiar with the usage of such type of magnification devices in ordinary surgery. Magnification of 2.5 times will be enough.

Usage of artificial vessels is quite rare, in the case of pediatric surgical cases, especially for fine veins. However, innovation in this field should be paid attention in the near future.

9.3 Operations

9.3.1 In Cases of Vascular Injury or Necessity of Vascular Replacement

The first step for hemostasis is to recognize the injury or bleeding site accurately. For the pinpoint or small injury of the vessels, z-shaped repair with nonabsorbable monofilament material (like Prolene®) is useful (Fig. 9.4). For the thinner vessel, the thinner suture is suitable. If the vessel is very small, suturing with the surrounding connective tissue is done. If it is major vessels and the bleeding hole is visible, repair of the wall without the surrounding tissue is better. To prevent the additional injury to the vessels, smooth rotation of the needle along with the curve of the needle is necessary (Fig. 9.5). To close the hole of the vascular wall, some mobility of the wall is necessary. If the dissection of the vessel is not enough while suturing, the wall may be more injured. To face such condition, additional dissection with transient hemostasis by finger compression should be followed by definite hemostasis.

9.3.2 In Cases of Injury of Major Veins

For the secure repair of major vessels, hemostatic condition with application of the vascular clamp is the best circumstance. However, this is not always possible because there is no space for the application of the clamp. If you have to repair while the blood is coming from the injured site, continuous flushing of the saline by the assistants is necessary to keep the field visible. If it is the canal veins, this procedure is very important to prevent the air emboli. Effective aspiration of the blood is also important, and multiple aspirators are effective in bloody operations.

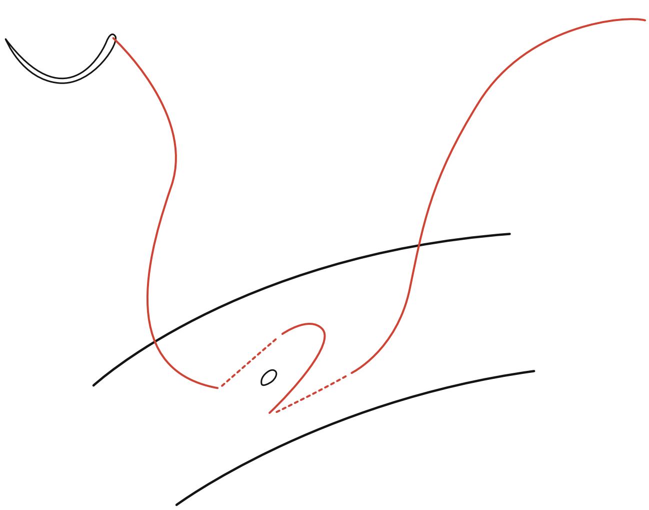

Fig. 9.4 Z-figure suture for repair of vascular injury

Even though the later reconstruction may be necessary in cases of unexpected bleeding, temporary hemostasis for the time being and following evaluation is the better way with better result.

9.3.3 Use of Autologous Venous Graft

In cases that need the replacing of autografts for the vascular reconstruction, selection and harvesting should be done case by case. If you take out the tumor with some organ(s), vessels in that organ might be useful. For example, if the kidney is extirpated, the renal vein in or around the organ can be used if there is no invasion of the tumor. Other usable autografts for vascular reconstruction (mainly for venous system) are inferior mesenteric vein, ovarian vein in female, and saphenous vein. However, of course, in pediatric patients, these are too small. The external iliac vein and internal juggler vein can be harvested. The external iliac vein can be harvested via the abdominal cavity in cases of the operations of the lower abdomen. If it is for the upper

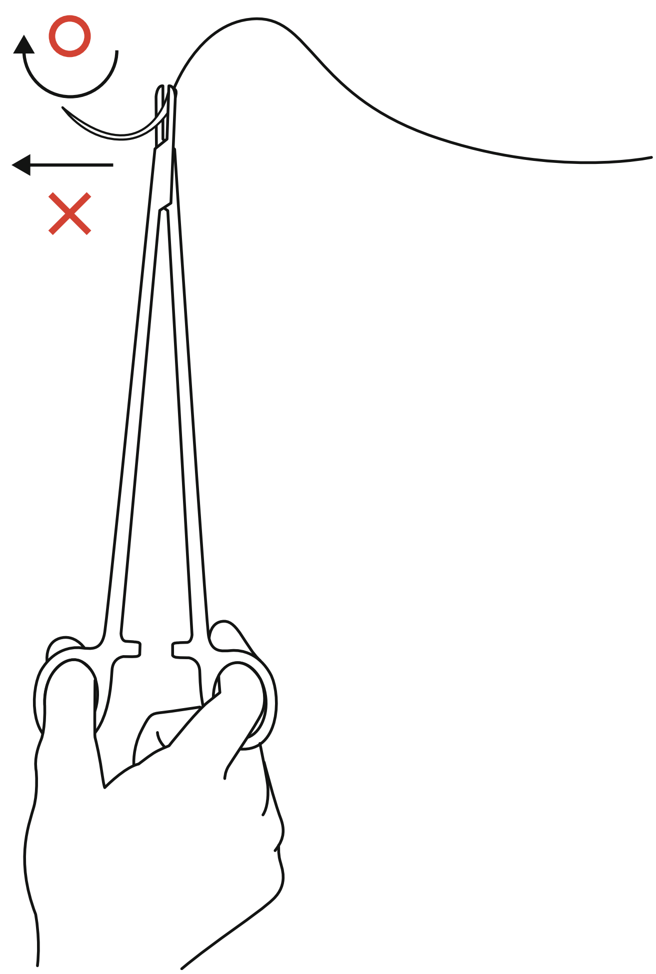

Fig. 9.5 Rotation of the needle along its curve will not cause the tear of the vascular wall

abdominal surgery, extra-peritoneal approach with lower oblique skin incision is possible for harvesting. The stump after harvesting of these major veins should be closed by running suture of 6-0 or 5-0 monofilament stitches.

9.3.4 When It Is Difficult to Close the Injury of the Vascular Wall Itself

In case of the bleeding from the venous plexus like presacral or peri-bladder area, rough and repeated suturing might extend the injury and bleeding. Temporary compression by fingers is effective in many cases. After some time of compression and thinking with calming down of the operator, direct and complete hemostasis is possible in many cases. Packing with temporary closure may be effective, but it is not necessary in most of the cases.

9.3.5 How to Close the Vascular Stumps

There are two ways of the closure; one is by suturing and the other is tying. The selection depends on the size and the quality of the vessel. Tying is timesaving but has the possibility of slippage. If the cuff of the stump is not long enough, suturing is safer. In the case of the closure of major vessels, even if it is already clamped, stay suture is placed at each side of the vessel to prepare the accidental slippage of the clamp. For the closure by running suture, coming from one side to the other side, called "from-and-back" method, is the most secure way (Fig. 9.6). After completion of the suture, cutting of the stitches should be done after the release of the clamp. If there is a bleeding point left, that point is closed by z-shaped suturing. In the case of major vessels, the stitches should be left 1 cm or more for the possible slip of the knot.

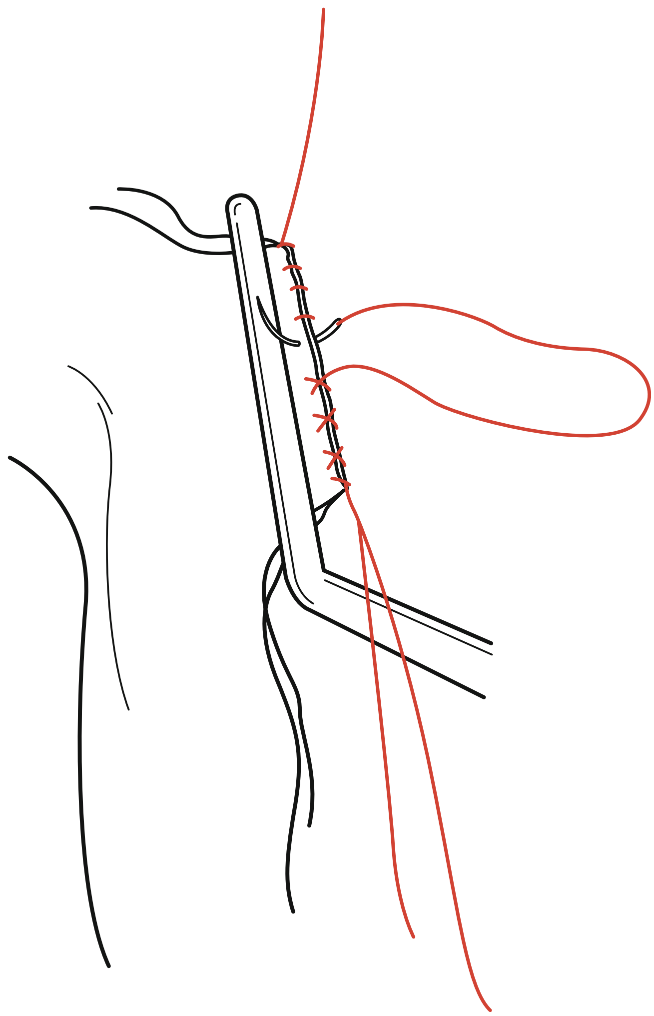

Fig. 9.6 From-and-back running suture for the closure of vascular stump

9.4 Techniques of Vascular Anastomosis

9.4.1 End-to-Side Anastomosis

Alignment of the blood vessel is important for good anastomosis. In case of end-to-side anastomosis, location and size of a hole on the wall of the vessel will mostly decide the outcome of the anastomosis. When the vessel is large enough, this hole can be made using a stay stitch to pull up the wall so that resection of the wall can make a hole, not a simple incision (Fig. 9.7).

Anastomosis of the blood vessel can be done with eversion technique. Typically, the stitch passes from outside to the inside and then inside to the outside. In case of interrupted suture, the procedure is exclusively this eversion technique. However, in case of running suture, and under the condition that the blood vessel cannot be turned 180°, intraluminal suture has to be applied (Fig. 9.8). In this technique, first, stay suture with doubly armed suture at each end is placed, with direction of outside-inside-inside-outside. At one end, the suture is tied with the knot outside, and one arm is passed into the inside. Then, this arm is used for the intraluminal running suture to the other end, where the arm is passed outside. Then the stay suture of the other side is also tied, and the one arm passed outside is tied with one arm of the stay suture. After fixation of this side, one arm is used for the anastomosis of the other wall with running suture, comes back to the initial end, and be tied with the other arm of the stay suture (Fig. 9.9).

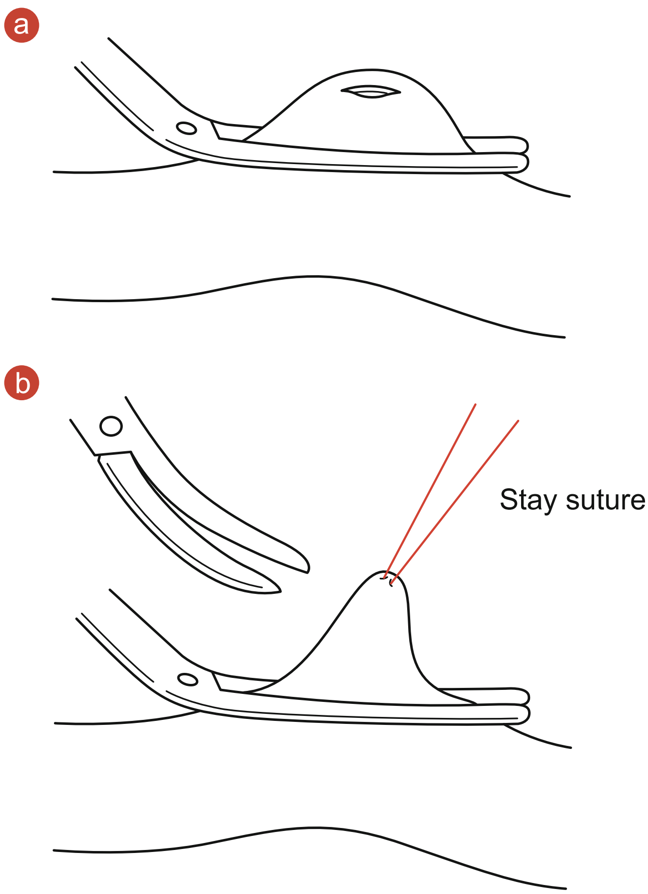

Fig. 9.7 How to make a hole on the wall of the large vessel. (**a**) Incision with sharp knife. (**b**) Small excision of the wall with the aid of stay pulling suture

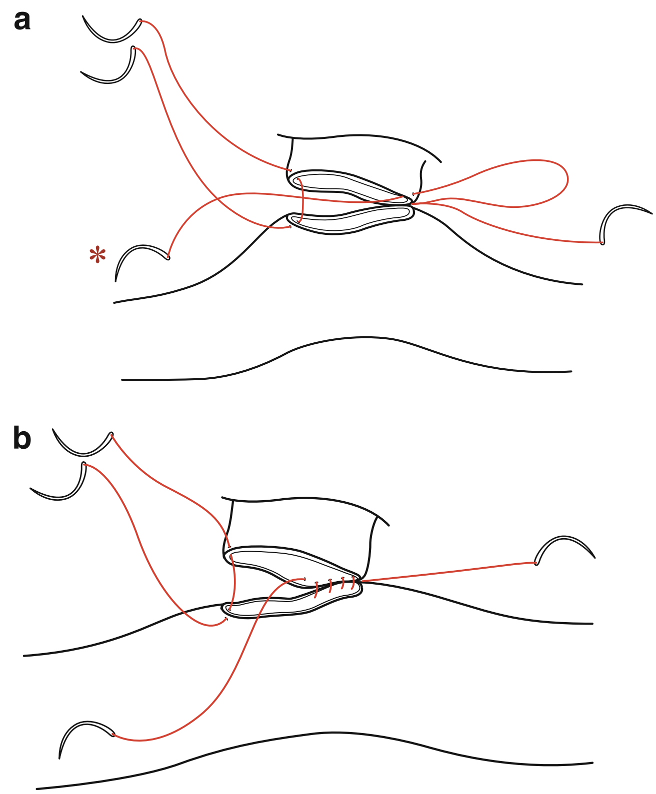

Fig. 9.8 Anastomosis of the blood vessel (1). (**a**) Start of the intraluminal running suture after placing two stay sutures at both ends of the orifice. One arm of the double-armed stitch at one end is brought to the inside of the lumen for the start of the running suture of the posterior wall. (**b**) The running suture goes on and the arm is brought to outside at the other end

9.4.2 Interrupted or Running

If the diameter of the blood vessel is less than 5 mm, interrupted suture is mandatory, if possible. In cases of running suture, constriction at the anastomotic site by the suture should be prevented. For this purpose, there are two ways. One is with the so-called growth factor, and the other technique is pulling both ends tightly while suturing (Fig. 9.10).

9.4.3 After Completion of the Suture

After completion of the anastomosis, the clamp of the proximal side is first released, and then the distal clamp is released later. Again, cutting of the suture should be done after release of the clamps. Even if there is bleeding at the anastomotic site, expansion of the blood vessel may cause the spontaneous hemostasis after a while.

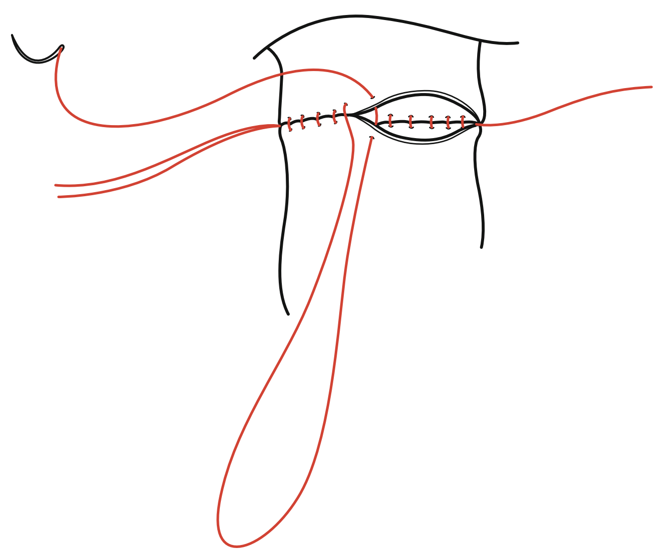

Fig. 9.9 Anastomosis of the blood vessel (2). The running suture of the anterior wall is done with the needle, going outside-inside-inside-outside

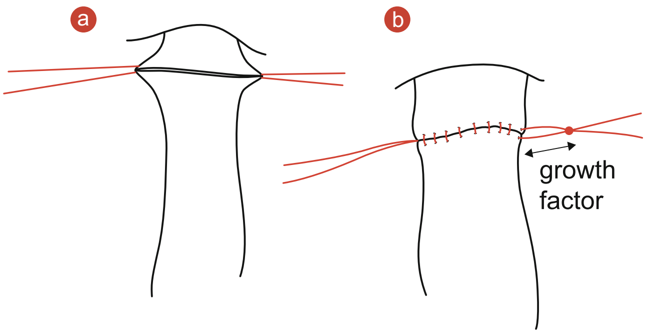

Fig. 9.10 How to prevent the constriction of the suturing. (**a**) Both stay sutures are pulled with good tension in both directions while the running suture is going on. (**b**) Leaving the so-called growth factor for the possible expansion of the lumen after de-clamping

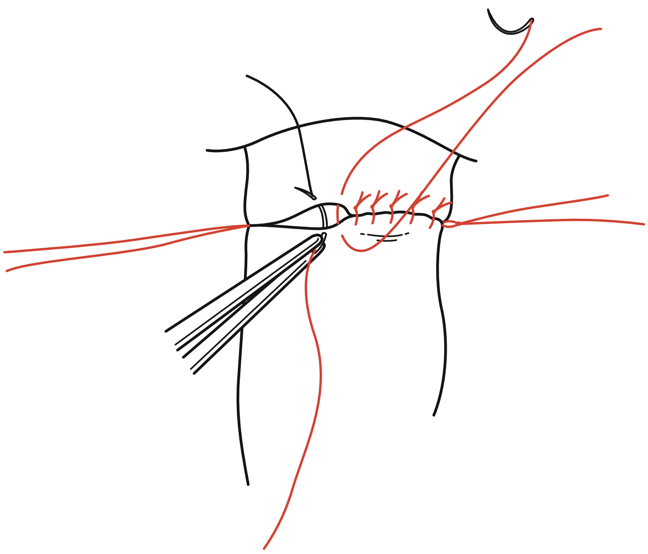

Fig. 9.11 Interrupted suture is also effective for the prevention of the constriction

9.4.4 End-to-End Anastomosis

Both ends should be prepared with minimum tension for approximation. The alignment of both ends is again most important. If the eversion technique is applicable, stay sutures at 4 points will make the anastomosis easier only from the outside. If it is not possible, the posterior wall is anastomosed with running suture using the intraluminal technique, and the anterior wall is anastomosed in ordinary eversion. If the vessel is not large enough in this setting, anterior wall can be done with interrupted (Fig. 9.11). Adjustment of the difference of the diameter is possible by modification of the interval of stitches at each side.

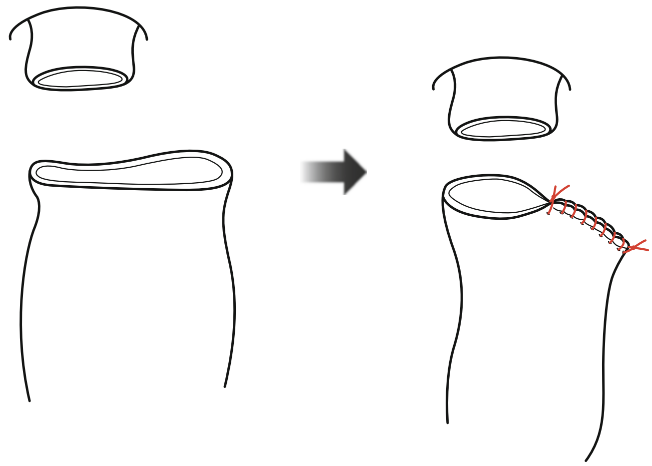

Fig. 9.12 In case of much discrepancy between the two ends of the vessel. The sider one is tapered with partial closure by a running suture

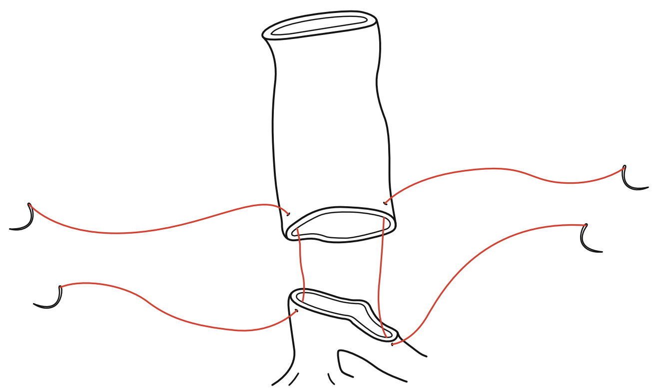

Fig. 9.13 Interposition of a vascular graft

Difference within 1.5 times of the diameter can be overcome with simple modification of the interval. If the difference is more, tapering of the bigger side can be done (Fig. 9.12).

9.4.5 Reconstruction with Interposition or Patch Graft

In case of interposition graft, stay suture with doubly armed suture is first placed at each edge of the stump of the host vessel. Then, each edge of the graft vessels is fixed using the stay sutures by the technique similar to the abovementioned end-to-end anastomosis (Fig. 9.13).

The patch graft is used for the augmentation of the host vessel, when it is narrow or kinking at the curve. In the case

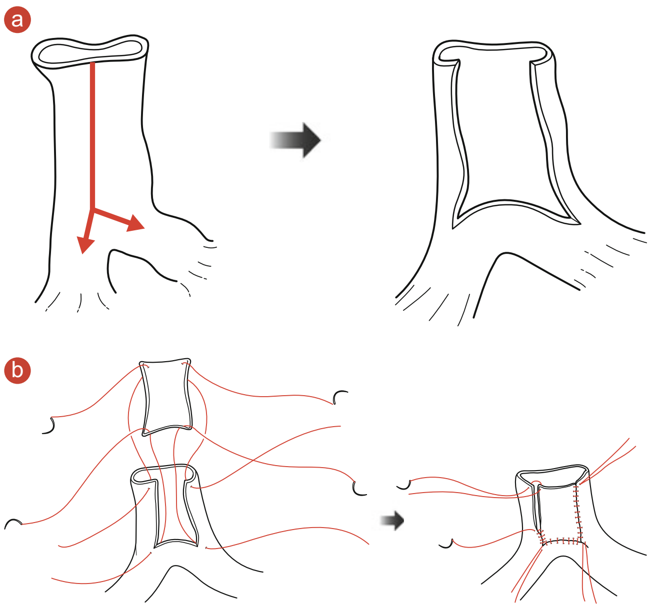

Fig. 9.14 Patch graft. (**a**) Anterior wall of the sclerotic vein (showing the case of portal vein augmentation) is longitudinally incised. (**b**) The incised and exposed vein graft is placed at the defect of the wall and applied with four stay sutures. Each margin is sutured with running

of the patch graft technique (Fig. 9.14), the graft vessel is cut open and extended on the wet sponge. Using the stay sutures with doubly armed suture at 3 or 4 points around the defect of the host vessel, the patch is approximated to cover the defect. The size of the patch should be large enough because bites for suturing are necessary and it will expand after perfusion of the blood. The suture material should be thin enough. For example, it should be 5-0 in the vena cava and 6-0 or 7-0 in the portal vein or peripheral veins.

9.5 Postoperative Management

Anticoagulation is not always necessary. In reconstruction of major vessels, it is not necessary. In the case of the portal vein, if there is a positive history or strong possibility of thrombosis, anticoagulation using heparin followed by warfarinization should be considered. Control of the anti-coagulation level should be modified case by case, because it should be balanced with the possibility of bleeding.

Biopsy of Tumor

10

Takaharu Oue

Abstract

Various biopsy procedures such as core needle biopsy, laparoscopic/thoracoscopic biopsy, and excisional/incisional open biopsy are selected according to the purpose, tumor site, and condition of the patient. Tumor biopsy is performed not only for pathological diagnosis but for evaluation of the chemotherapy effects, confirmation of the remaining of the viable malignant cells, and analysis of tumor biology. Biopsy specimens should be divided and appropriately stored for each analysis, for example, formalin fixation-paraffin embedding for histological diagnosis, sterile tissue culture medium for chromosomal analysis, and snap frozen deep freezer storage for DNA/RNA analysis. After biopsy, confirmation of hemostasis is most important.

Keywords

Tumor biopsy • Laparotomy • Laparoscopic • Hemostasis • Children

10.1 Preoperative Management

10.1.1 Check the Purpose and Minimum Requirement of the Samples

Ordinary, the purpose of tumor biopsy is to confirm the pathological diagnosis. But in some cases, tumor biopsy is performed not only to identify the pathological diagnosis but for other purposes, such as the evaluation of the chemotherapy effects, confirmation of the remaining of the viable malignant cells, and analysis of tumor biology. Therefore, surgeons should recognize the purposes of the biopsy before operation to obtain the appropriate biopsy samples.

Pathologists and oncologists analyze the various biomarkers such as chromosomal anomalies, gene mutations, and surface markers, so that surgeons should discuss with pathologists and oncologists before biopsy to obtain the sufficient amount of the tumor specimen. And the samples should be divided and appropriately stored for each analysis, for example, formalin fixation-paraffin embedding for histological diagnosis, sterile tissue culture medium for chromosomal analysis, and snap frozen deep freezer storage for DNA/RNA analysis (Fig. 10.1).

10.1.2 Check the Image Analysis and Decide the Site and Route of Biopsy

Before biopsy, surgeons should check carefully the image analysis such as CT scan, ultrasonography, and MRI to discuss which part of the tumor should be cut and route should be chosen to approach the tumor. Generally, large vessels and organs should be evaded.

The suitable biopsy site should contain the viable tumor tissue and not contain the necrotic nor hemorrhagic tissue.

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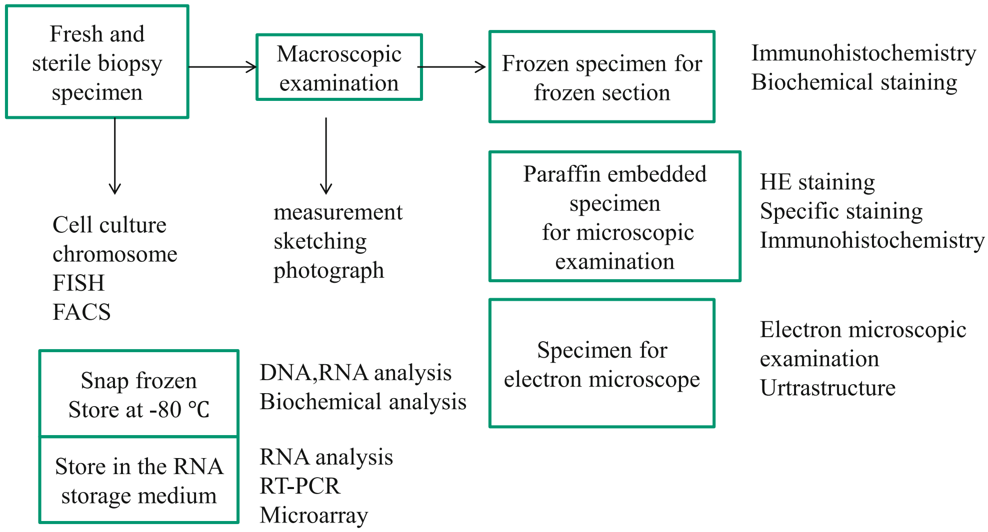

Fig. 10.1 Managements of the biopsy specimen

Biopsy site does not represent the whole of the tumor. If the image analysis shows that the tumor is heterogeneous, biopsy specimens should be obtained from the several different parts.

10.1.3 Select the Procedure

The decision of the procedure depends on the required amount of the biopsy specimen and biopsy site. The condition of the patients, schedule of chemotherapy, and cosmetic results should also be considered to decide the suitable procedure. In the malignant cases, biopsy procedure should not disturb the schedule of chemotherapy; therefore surgical complication should be minimized. Followings are various biopsy procedures from lower surgical stress to higher. Surgeons will choose the suitable procedure in case by case.

10.1.3.1 Core Needle Biopsy

Core needle biopsy uses needles which remove a small cylinder of tissue. Ordinary, biopsy is performed using the disposable biopsy needles such as "Tru-Cut™" under the guide of ultrasonography. The main advantages are that it does not require general anesthesia and an incision. It therefore often selected in cases general anesthesia is difficult, such as the cases with huge mediastinal tumor. If the tumor is deep inside the body and cannot be felt, the needle is guided by imaging test such as an ultrasound or CT scan.

In children, pathological diagnosis of the tumors is sometimes very difficult. The specimens of needle biopsy are very small so that sometimes insufficient for the pathological diagnosis. Therefore the indication of needle biopsy is limited in the pediatric cases.

10.1.3.2 Laparoscopic/Thoracoscopic Needle Biopsy

Needle biopsy is performed under the monitoring of laparoscopy or thoracoscopy. Although general anesthesia is required, this method enables to check the gross appearance of the tumor, and needle biopsy can be performed more accurately and safely.

10.1.3.3 Laparoscopic/Thoracoscopic Incisional Biopsy

Laparoscopic/thoracoscopic biopsy is less invasive and achieves the good cosmetic results than open biopsy. However it is difficult when the tumor is too large because working space maybe too small. If hemostasis is not achieved, it should immediately be changed to the open surgery.

10.1.3.4 Open Biopsy

Biopsy is performed under laparotomy or thoracotomy. A surgeon removes the entire tumor (called an excisional biopsy) or a small part of a large tumor (called an incisional biopsy) (Fig.10.2). Surgical stress and operative wound will be large, but sufficient amount of the specimen can be obtained certainly and safely.

10.1.4 Operations

10.1.4.1 Open Biopsy via Laparotomy

1. Laparotomy should be performed via a part of the estimated surgical incision of the tumor resection surgery in the future to reduce the surgical scar (Fig. 10.3).

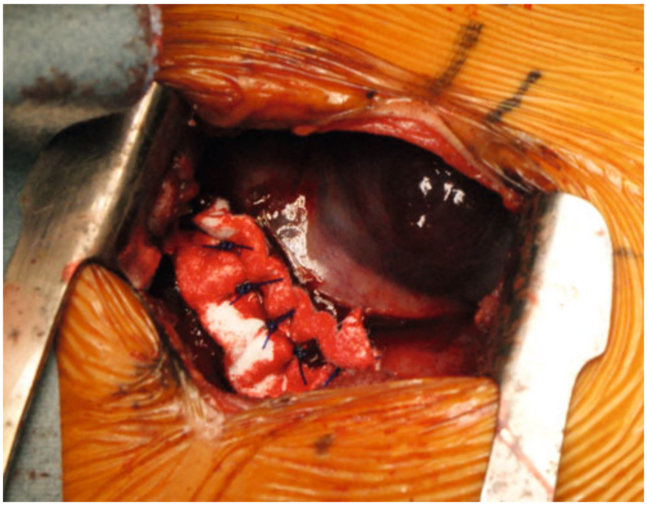

Fig. 10.2 Open incisional biopsy for intrathoracic tumor via thoracotomy. The tumor was soft and vascular rich, so that felts were used to press the biopsy site for hemostasis

Fig. 10.3 Laparotomy was performed via a part of the estimated surgical incision of the liver resection surgery in the future

2. After laparotomy, search and palpitate the whole of the abdomen to evaluate the tumor extension and metastasis.
3. Dissect the organs in front of the tumor and sufficiently disclose the tumor surface.
4. Biopsy specimens may be damaged by the heat of the electric scalpel or energy devices. Therefore tumor had better be cut sharply by scalpel or surgical scissors to obtain the specimen (Fig. 10.4). Biopsy should be performed quickly to reduce the hemorrhage and hemostasis should be performed immediately. The biopsy specimens should be gently treated to avoid the compression injury.
5. Before biopsy, state the suture for hemostasis using a large surgical needle. If the tumor is soft, put the felts or pledgets beside the biopsy sites to avoid cutting of the tumor by the threads (Fig.10.5). Hemostasis is performed using electric scalpel and compresses the tumor tissue by ligating the suture (Figs. 10.2 and 10.6a). When the hemostasis is difficult, fill the biopsy site with hemostatic materials such as Surgicel™ or TachoSil™ and tie over the bleeding site using the suture (Fig. 10.6b).
6. During the hemostasis, intraoperative pathological examination will be performed using the frozen sections to

Fig. 10.4 Biopsy specimens may be damaged by the heat of the electric scalpel or energy devices. Therefore, the tumor had better be cut sharply by scalpel or surgical scissors

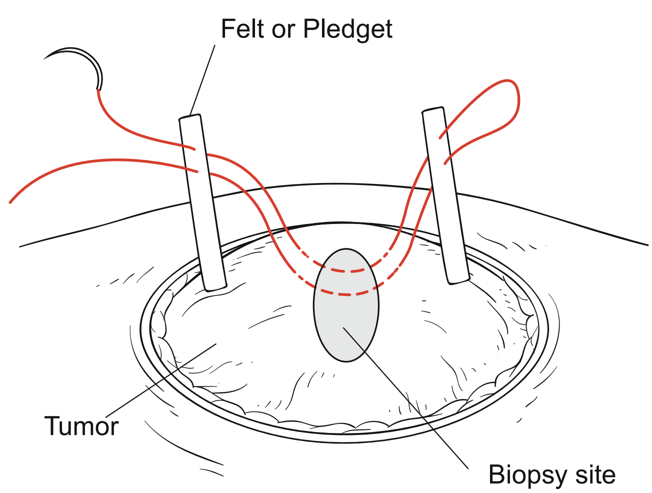

Fig. 10.5 Open incisional biopsy for hepatoblastoma via laparotomy. Expose the surface of the tumor sufficiently. Before biopsy, state the suture for hemostasis using a large surgical needle. If the tumor is soft, put the felts or pledgets beside the biopsy sites to avoid cutting of the tumor by the threads. Cut the tumor sharply using surgical scalpel or scissors to avoid the crushing of the specimen

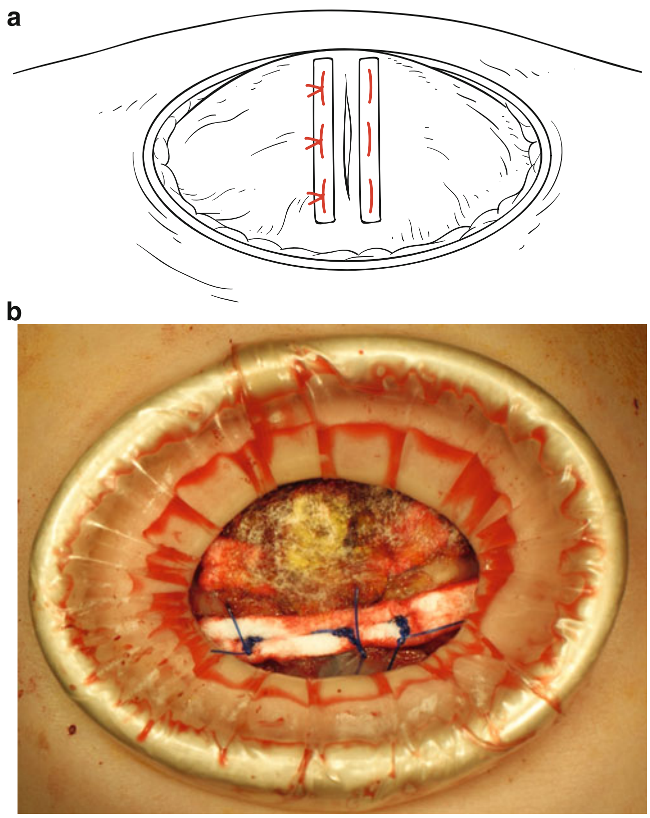

Fig. 10.6 Hemostasis. (**a**) Hepatoblastoma is soft and vascular rich, to state the suture and put the felts beside the biopsy sites. Hemostasis is performed by filling the biopsy site with hemostatic materials and ligating the suture to tie over the biopsy site. (**b**) Hemostasis is performed using electric scalpel. When the hemostasis is difficult, fill the biopsy site with hemostatic materials such as Surgicel™ or TachoSil™ and press the bleeding site using the suture

confirm that appropriate tumor tissue was included in the specimen.

10.1.4.2 Laparoscopic/Thoracoscopic Biopsy (Figs. 10.7 and 10.8)

1. Decide the port site according to the location of tumor and biopsy route. Ordinary, three ports, one camera port and two working ports, are inserted before biopsy (Fig. 10.7a).
2. Thoracoscopic biopsy is ordinary performed under differential lung ventilation. When the differential lung ventilation is difficult, make the artificial pneumothorax by carbon dioxide gas using the laparoscopic trocar (Fig. 10.8). Search the whole of the abdominal/thoracic space to evaluate the tumor invasion and metastasis.
3. Dissect the organs in front of the tumor and sufficiently disclose the tumor surface.

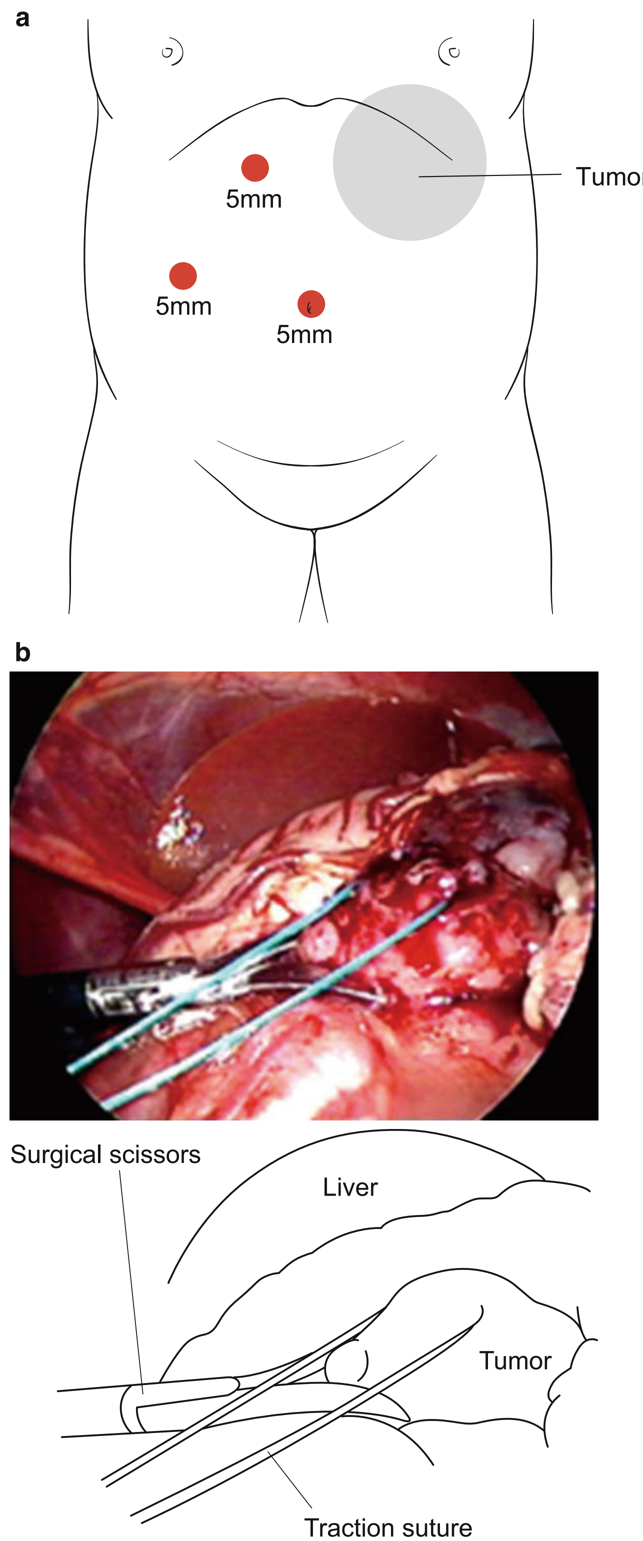

Fig. 10.7 Laparoscopic biopsy for left adrenal neuroblastoma. (**a**) Three ports, one camera port and two working ports, are inserted before biopsy. (**b**) Sufficiently disclose the tumor surface. Put the traction suture and cut the tumor sharply by surgical scissors. Hemorrhage from the biopsy site could be controlled by raising the intra-abdominal pressure to 12 cm H_2O. The biopsy specimens were put in the plastic bag to collect

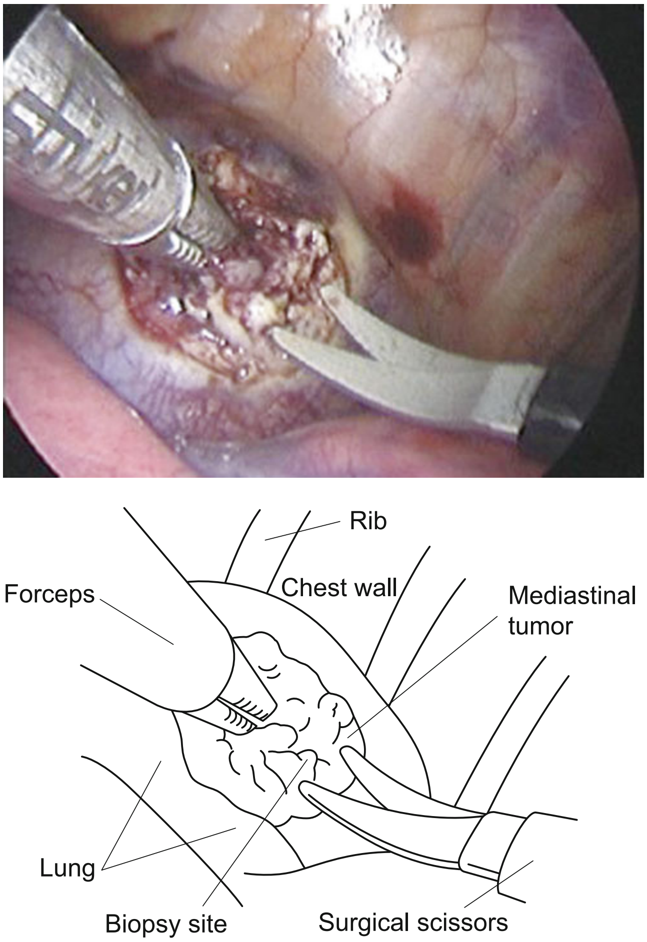

Fig. 10.8 Thoracoscopic biopsy for the right mediastinal Ewing sarcoma. Three ports, one camera port and two working ports, are inserted. Biopsy was performed under differential lung ventilation and artificial pneumothorax. Disclose the tumor surface sufficiently and cut the tumor sharply by surgical scissors. Hemorrhage from the biopsy site could be controlled by raising the intrathoracic pressure to 12 cm H_2O

4. Tumor had better be sharply cut by surgical scissors instead of energy devices to avoid the heat damage of the biopsy specimen. Biopsy should be performed quickly to reduce the hemorrhage. After the biopsy, hemostasis should be performed immediately. Small hemorrhage from the biopsy site can be controlled by raising the intrathoracic pressure to 10 cm H_2O or more (Figs. 10.7b and 10.8). If hemostasis is difficult, do not hesitate to convert to the open surgery.
5. The biopsy specimens will be put in the plastic bag to collect.
6. During the hemostasis, intraoperative pathological examination will be performed using the frozen sections to confirm that appropriate tumor tissue was included in the specimen.

10.2 Postoperative Management

The most important point is hemostasis. Hemorrhage at the biopsy site will be sometimes observed after surgery, therefore watch carefully the hemodynamics and blood count. If hemorrhage is suspected by low-output syndrome or anemia, immediately confirm imaging analysis such as ultrasonography and CT scan.

11 Rectal Biopsy

Ryuichiro Hirose

Abstract

The histopathological examination of rectal biopsy is the most definitive method for diagnosing Hirschsprung's disease (HD). The absence of ganglion cells in the submucosal and myenteric plexuses and hypertrophic nerve bundles with proliferated irregular cholinergic nerve fibers in the mucosal layer are the definitive findings. The level of aganglionosis is synchronous in the submucosa and myenteric plexus; therefore, the mucosal biopsy can be substituted for the full-thickness biopsy in most cases. Rectal mucosal biopsy is a bedside procedure that requires no general anesthesia or suturing, so this has become the first step before a full-thickness rectal biopsy is planned. Nowadays, a combination of rectal mucosal biopsy and acetylcholinesterase staining has been most frequently used for the diagnosis of HD.

Keywords

Hirschsprung's disease • Rectal mucosal biopsy • Suction biopsy • Punch biopsy • Full-thickness biopsy

11.1 Introduction

It is recommended that all biopsies are taken only from the posterior or lateral walls of the rectum to avoid injury of the urethra or other surrounding structures. In addition, the anal canal composed of squamous cells and normal hypoganglionic zone should be avoided because biopsy of the anal canal region is painful and providing inadequate specimens. Therefore the biopsy should be taken at least 1–2 cm above the dentate line.

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11.2 Rectal Mucosal Biopsy

11.2.1 Preparation and Caution

For the rectal mucosal biopsy, the rectum is cleansed with a glycerin enema before biopsy and the biopsy is performed with no anesthesia. The neonate or infant patient is placed in lithotomy position, while the left lateral position is for older children.

The overall quality and the depth of the mucosal biopsy specimens are essential to allow a precise diagnosis. If the biopsy specimen may not include sufficient submucosa for histological examination, repeat biopsy or full-thickness rectal biopsy should be performed. Usually two to three samples are obtained to avoid repeat biopsy due to inadequate specimen.

In the rectal mucosal biopsy, bleeding from the biopsy site occurs but is usually minimal and ceases spontaneously. However, post-biopsy bleeding may be recognized, so the staff should check about 30 min after the procedure if there

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is persistent bleeding. A plain gauze packing into the anus for 20–30 min will secure a hemostasis in most cases.

11.2.2 Rectal Suction Biopsy (RSB) [1]

Suction biopsy has been broadly employed to obtain the rectal mucosal specimens of newborn infants and young children with suction biopsy instruments. The advantage of this technique is low risk of perforation or bleeding and can be performed at the bedside.

The RSB instruments are basically composed of a suction cylinder with a small side hole which contains a cutting blade and an air-tightly connected syringe for applying negative pressure (Fig. 11.1). Recently, instead of multipurpose instruments, specifically designed RSB instruments using a single-use disposable sharp blade have become commercially available.

The cylinder with side hole is inserted approximately 2–3 cm proximal to the anal verge.

The operator adjusts the position of the cylinder to be sure of the complete adhesion of the hole to the mucosa. An adequate suction is applied by withdrawing onto the syringe. The negative pressure draws mucosal tissue into the side hole and a running inner blade cuts off the samples. The samples are retrieved from the cylinder following the procedure and sent to a laboratory to be examined by a pathologist.

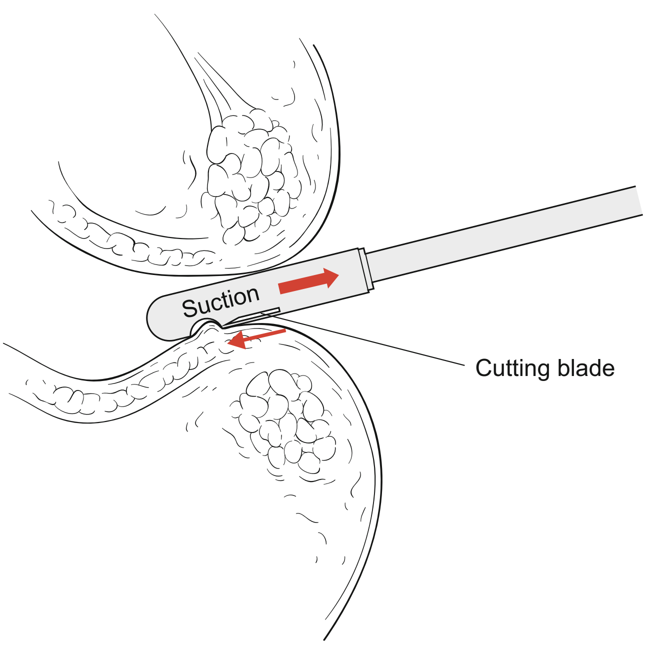

Fig. 11.1 Rectal suction biopsy

11.2.3 Punch Biopsy

11.2.3.1 Punch Biopsy (Forceps Biopsy) of Rectal Mucosa

A view of the rectum is obtained using with anoscopy (or nasal speculum for neonate). Using the laryngeal cup biopsy forceps, a site of the midline of the posterior rectal mucosal surface, 2–3 cm above the dentate line, is gently bitten by jaws under direct vision (Fig. 11.2a). While keeping the jaws firmly closed, the instrument is sharply withdrawn. The mucosal specimen remains inside the jaws and partly around them. The demerit of forceps punch biopsy is difficulty to control the depth or width of the collected samples, containing the risk of obtaining unintended muscular layers inducing perforation, scarring, and bleeding.

11.2.3.2 Punch Biopsy Using a Test Tube [2]

In order to reduce such risks, the method to obtain the punch biopsy specimens through a small hole is described. A small hole of about 6 mm in diameter is drilled at the edge of the curved tip of a polypropylene translucent test tube. A biopsy tube is inserted into the rectum with the side hole facing the posterior wall of the rectum. Slight lateral pressure should be applied so that the side aperture rests firmly against the mucosal surface. The rectal mucosa protruding from the hole can be seen in the biopsy tube using a penlight as a source of light. The protruded mucosa is grasped by laryngeal biopsy forceps and pulled off (Fig. 11.2b). The edge of the hole acts as the traction fulcrum, therefore making a small specimen of the mucosa easily obtainable.

Thereafter, the biopsy tube is turned so that pressure is applied to the biopsy site by the wall of the tube for purposes of hemostasis. Additional biopsy can be performed immediately on another portion of the exposed rectal mucosa. When the all biopsies are finished, a plain gauze pack is inserted into the anus for hemostasis, for 20–30 min.

11.3 Full-Thickness Biopsy of the Rectum

In cases where the rectal mucosal biopsy yields an inadequate specimen, full-thickness biopsies providing deeper tissues should be used.

11.3.1 Procedures

The patient is placed in the lithotomy position under general anesthesia. The anal orifice is digitally dilated. Two small anal

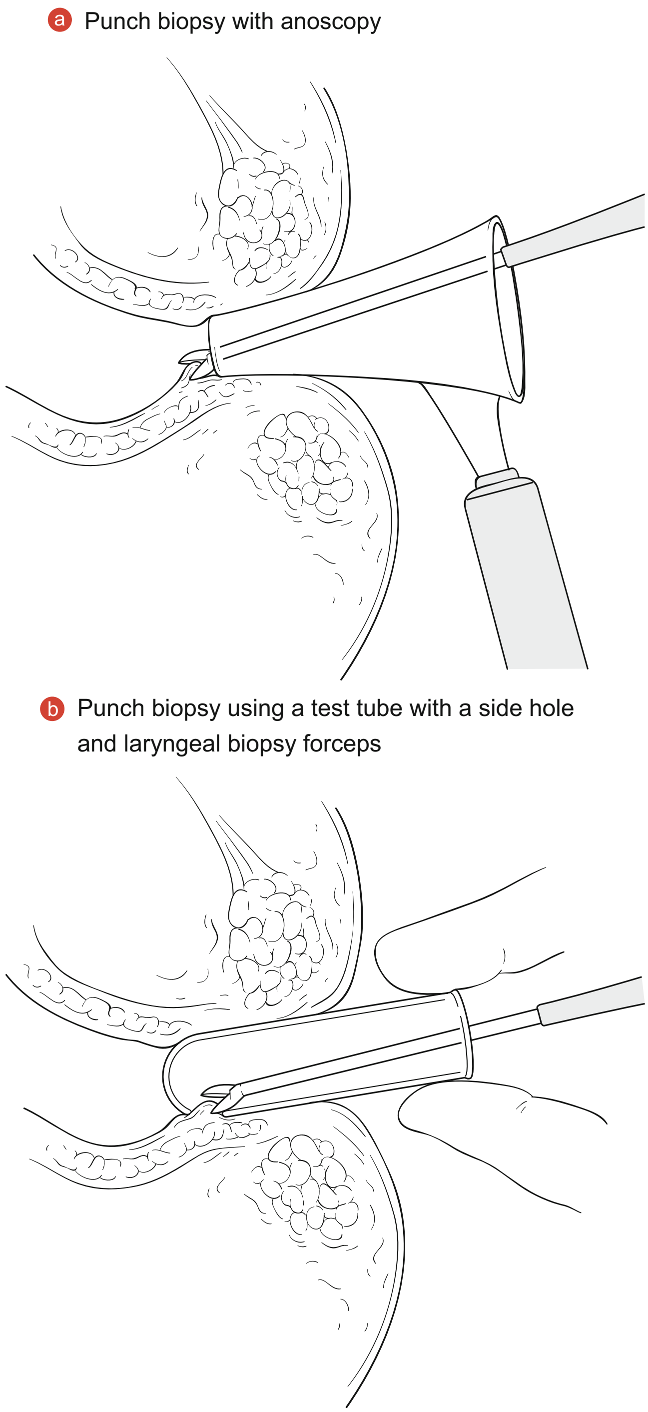

Fig. 11.2 Punch biopsy

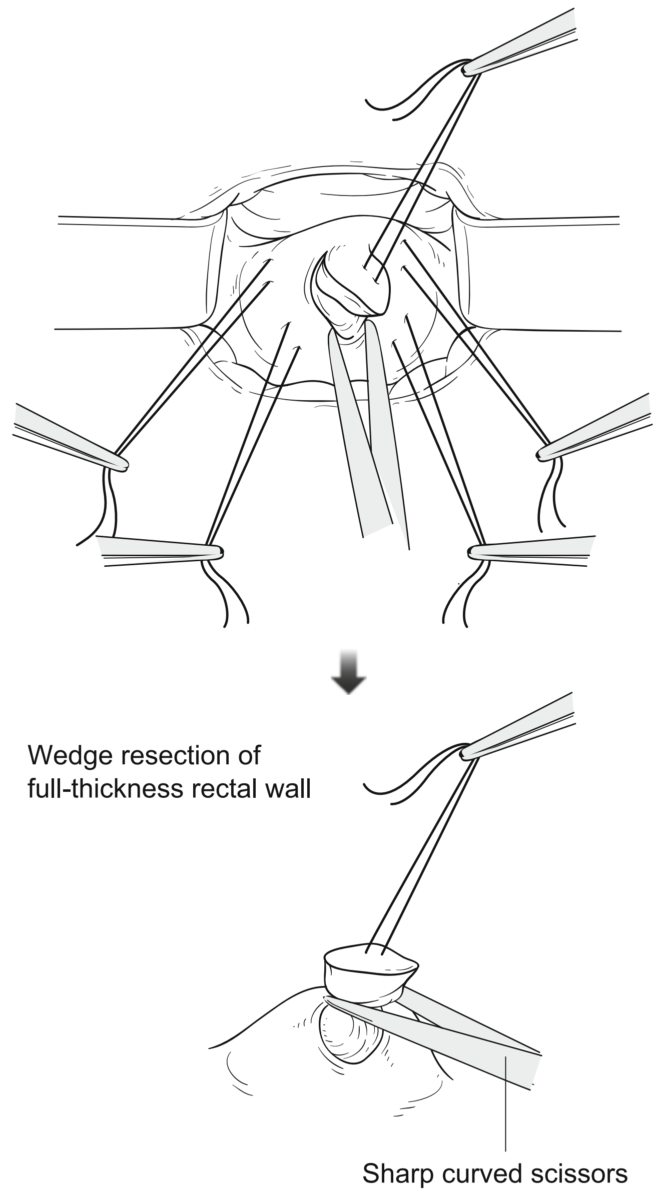

Fig. 11.3 Full-thickness biopsy. A full-thickness specimen is taken with a pair of sharp curved scissors under the prolapsed field with traction sutures

retractors are placed and hold the posterior aspect of the dentate line. The posterior rectal wall 2–3 cm above the dentate line is prolapsed into the field with traction sutures. If the prolapse is not enough to perform the procedures, additional traction sutures are needed. Using a sharp curved scissors, a full-thickness specimen is taken with traction of marking suture between the traction sutures (Fig. 11.3). The biopsy must include the circular and longitudinal muscle layers to examine the Auerbach's plexus. Hemostasis may be achieved with coagulation and by suturing. The rectal defect is closed with interrupted or running absorbable sutures.

11.4 The Intraoperative Preliminary Biopsy

In the transanal approach operation, the colonic biopsy cannot be done until the time that a point of caliber change is pulled down to the anus. Operators must wait for the frozen

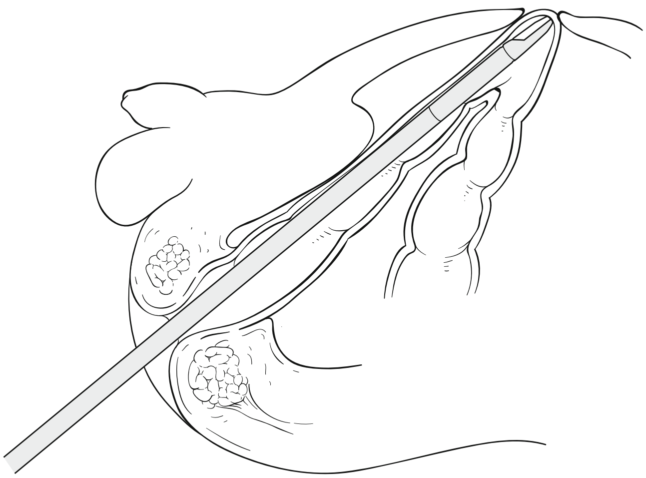

Fig. 11.4 The intraoperative preliminary biopsy through the umbilicus. A transanally inserted Hegar dilator or grasping forceps can deliver the sigmoid colon through the umbilical incision

section documenting ganglion cells and occasionally need additional repeated biopsies.

The preliminary biopsy can be done through a single small umbilical incision. The sigmoid colon is easily delivered using transanally inserted lubricated Hegar dilator or grasping forceps (Fig. 11.4). The entire colon can be accessed through the umbilical incision to obtain multiple biopsies in the case of longer-segment HD using single-incision laparoscopic operation technique, if needed [3].

Colonic biopsies are extracorporeally taken by either seromuscular or full-thickness wedge resection.

Laparoscopic seromuscular biopsies might be an excellent alternative; however, transumbilical biopsies are easier and may reduce the risk of spill and late-onset perforation after biopsies.

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Part II

Head and Neck

Head and Neck Sinus and Mass

12

Hiroaki Kitagawa

Abstract

Cervical mass and sinus of the neck represent a wide variety of anomalies, both congenital and acquired. Each branchial arch and its components can be traced to the formation of future anatomic structures. The most common lesions arise from the thyroglossal duct or branchial structures, particularly from the second branchial cleft. The third and fourth clefts form the pharynx below the hyoid bone and these anomalies from these clefts enter into the pyriform sinus. In general, thyroglossal duct or cyst lesions lie close to the midline, whereas branchial remnants present more laterally in the neck.

Keywords

Preauricular pits • Thyroglossal duct • Cleft anomalies • Branchial anomalies

12.1 Introduction

Cervical mass and sinus of the neck represent a wide variety of anomalies, both congenital and acquired. Each branchial arch and its components can be traced to the formation of future anatomic structures. The most common lesions arise from the thyroglossal duct or branchial structures, particularly from the second branchial cleft. The third and fourth clefts form the pharynx below the hyoid bone and these anomalies from these clefts enter into the pyriform sinus. In general, thyroglossal duct or cyst lesions lie close to the midline, whereas branchial remnants present more laterally in the neck.

12.2 Preauricular Pits, Sinuses

12.2.1 Diagnosis and Clinical Presentation

Preauricular sinus is related to embryonic ectodermal mounds that form the auricles of the ear. The sinuses are often short and end blindly. They are lined with stratified squamous epithelium. These cysts and sinuses are commonly noted at birth and are more common on the right side although many of them are bilateral. If the sinuses remain asymptomatic, excision is not required. Presentation with infection and/or drainage or abscess formation is an indication for surgical excision (Fig. 12.1).

12.2.2 Operations

Under general anesthesia, the pit anterior to the helix is prepped and draped in the standard fashion. If the sinus is easily identified, then blue dye is injected into the sinus using a 27-gauge angiocatheter. If a lacrimal probe can be passed through the sinus, then the sinus is easy to follow. Local anesthetic containing 0.5 % lidocaine with 0.01 mg

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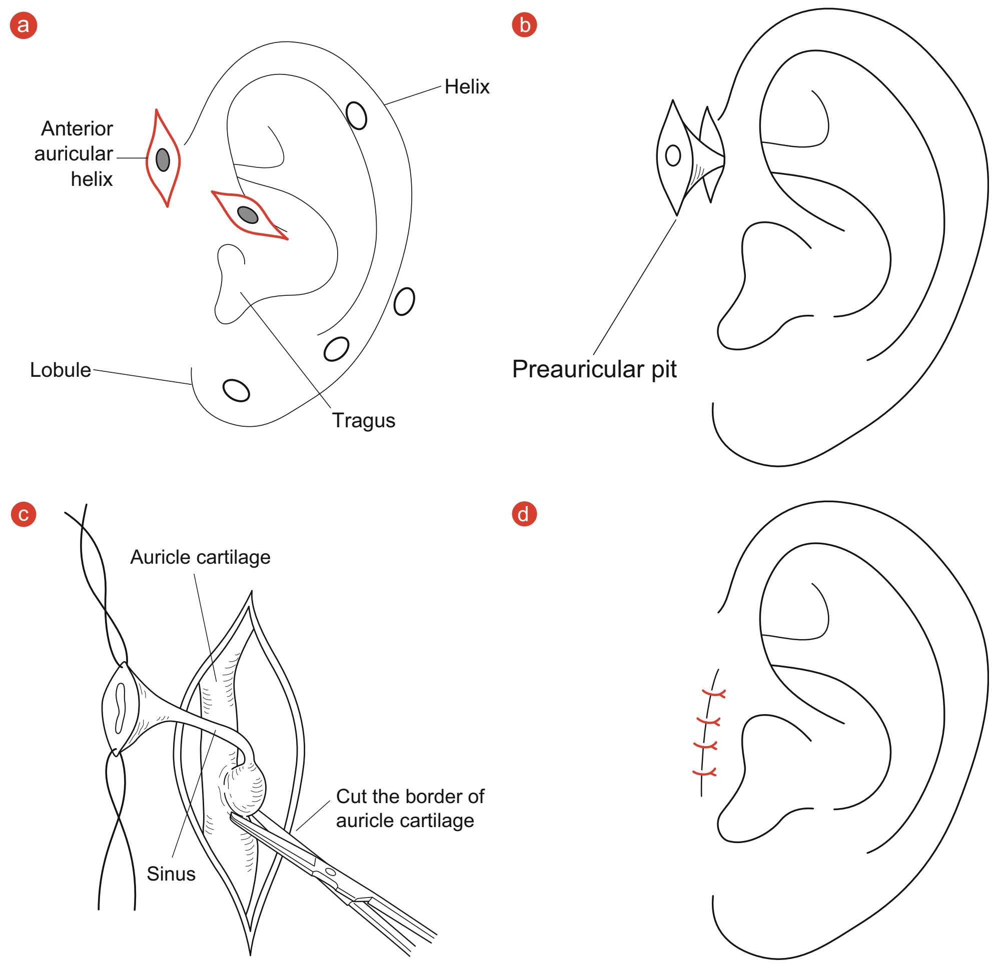

Fig. 12.1 Excision of preauricular pits and sinus. (**a**) More than 70 % of the preauricular pits and sinuses are seen in the anterior auricular helix. (**b**) An elliptical skin incision is made around the preauricular pit. (**c**) Removal of a small bit of the adjacent cartilage reduces the risk of missing one of these branching tracts. (**d**) The wound is closed in layers with a continuous suture of absorbable monofilament material. The skin is also closed with 5-0 absorbable monofilament suture

epinephrine (1:100,000) is injected around the sinus before the incision to reduce bleeding.

A fusiform skin incision is made around the sinus. Complete surgical excision of the sinus tract to the level of the temporalis fascia is the best option in an uninfected draining sinus. It is important to avoid rupture of the sinus and to perform a complete excision to decrease the risk of recurrence. Removal of a small bit of adjacent cartilage reduces the risk of missing one of the branching tracts. The skin and subcutaneous tissue is sutured using monofilament absorbable suture and oral antibiotics are prescribed for a week.

12.3 Thyroglossal Duct Cysts

12.3.1 Embryology and Diagnosis

The foramen cecum is the site of the development of the thyroid diverticulum. In the embryo, this structure develops caudal to the central tuberculum impar, which is a thickening in the floor of the primitive pharynx and is one of the embryonic pharyngeal structures that lead to the formation of the tongue. The migration is usually started from 4 weeks and completed by 7 weeks of gestation, at which point the thyroglossal duct is obliterated. The proximal remnant of this pathway is the foramen cecum at the base of the tongue, whereas the distal remnant is represented by the pyramidal lobe of the thyroid gland. The remnants usually lie in close proximity to the hyoid bone. Usually, the thyroglossal duct does not communicate with the ectoderm during development, but a sinus can result from infection or spontaneous rupture or a drainage procedure. Ultrasonography is the best diagnostic tool and this appears to be very accurate and avoid the need for irradiation. The incidence of ectopic thyroid tissue being misdiagnosed as a thyroglossal cyst is 1–2 %. If the ultrasound image demonstrates a solid mass, then a thyroid scan is essential to ensure the lesion is not thyroid tissue.

12.3.2 Surgical Management

The patient is positioned supine with the neck slightly hyperextended. A transverse cervical incision is made above the thyroglossal cyst and the cyst is exposed through the wound (Fig. 12.2). The underling hyoid bone is divided 1.5 cm from the midline on either side after dividing the attachments of the mylohyoid and hyoglossus muscles from its superior border (Fig. 12.3). En bloc resection is completed with suture ligation of the proximal tract (Fig. 12.4). The core-out dissection above the hyoid bone should not extend too far, and the tract should be a single duct above the hyoid bone as described by Horisawa and colleagues. The base of the floor of the mouth is ligated with an absorbable suture (Fig. 12.5). The dissection sometimes requires the placement of the surgeon's finger at the base of the patient's tongue to identify the cephalad extent of the dissection. The wings of the hyoid bone are not approximated and the incision is irrigated and the wound is closed in layers. A Penrose drain is inserted below the hyoid bone, and antibiotics are used perioperatively and for several days postoperatively.

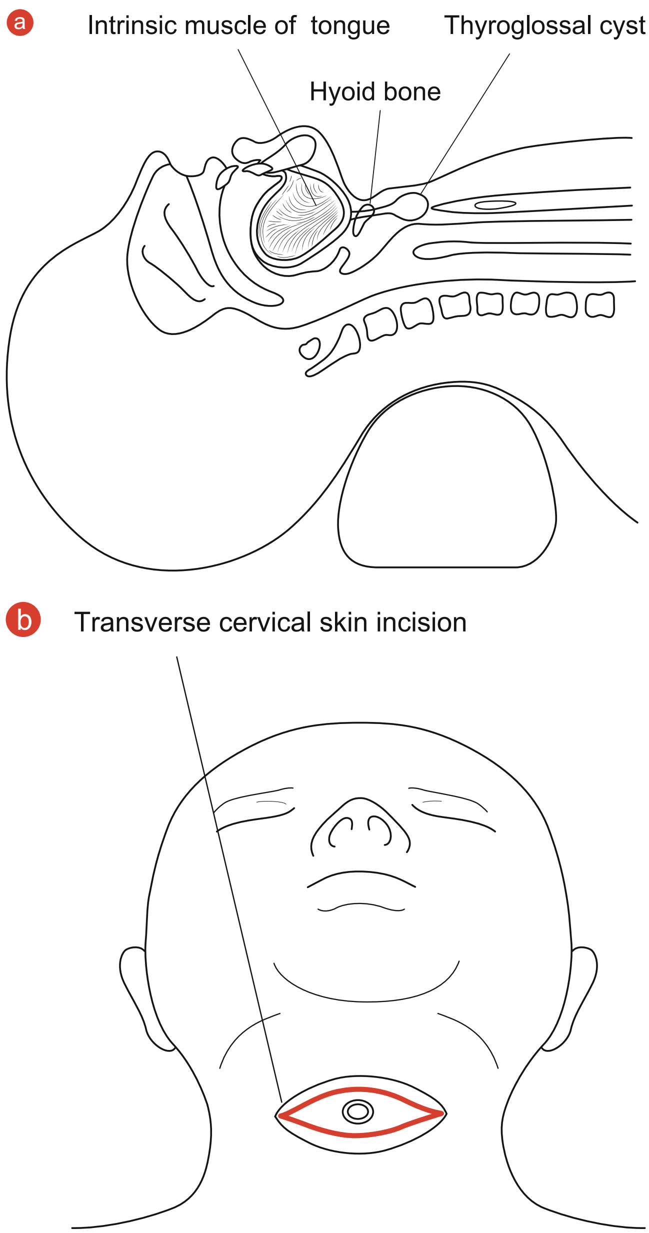

Fig. 12.2 A positioning of a child for a thyroglossal duct cyst and/or branchial remnant. (**a**) Hyperextension of the head with support under the shoulders keeps the child in a stable position and facilitates exposure. (**b**) A transverse cervical skin incision is made around the thyroglossal duct cyst

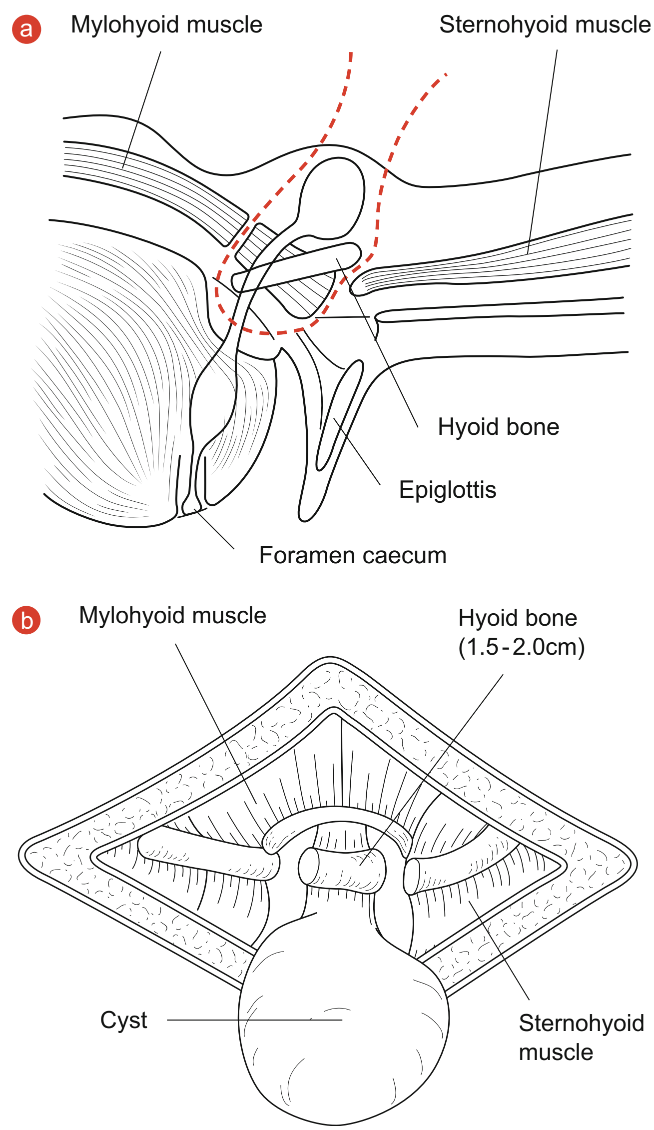

Fig. 12.3 Carefully mobilizing the cyst along with its tract. (**a**) The underlying hyoid bone is divided, and the depth of core-out toward the foramen cecum in a thyroglossal duct cyst is not too deep into the tongue muscle. (**b**) The underlying hyoid bone is divided about 15–20 mm after dividing the attachment of the mylohyoid and hyoglossus muscles from its superior border

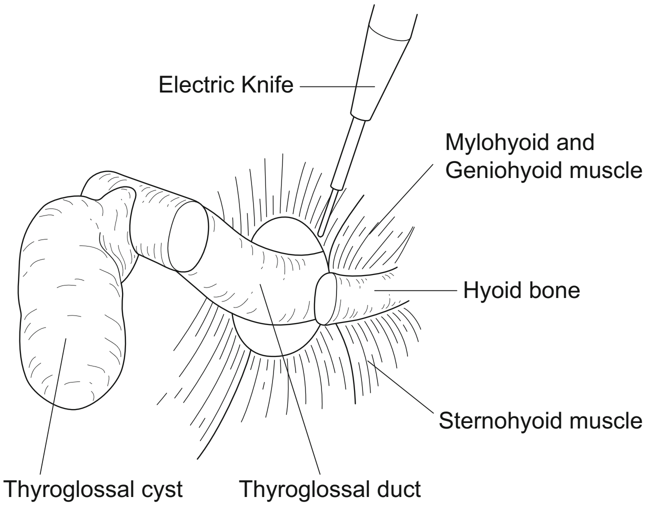

Fig. 12.4 Remove mylohyoid muscle and geniohyoid muscle from hyoid bone. Diathermy is used to divide sternohyoid, mylohyoid, and hyoglossus muscles from superior and inferior borders of hyoid bone

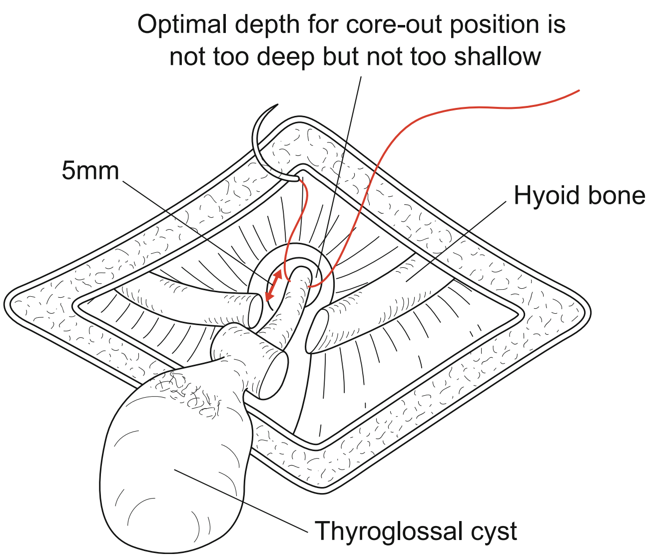

Fig. 12.5 The optimal depth to core out toward the foramen cecum in the thyroglossal duct cyst is not too deep into the tongue. The length of the single duct above the hyoid bone is the optimal depth

12.4 Remnants of Embryonic Branchial Apparatus

12.4.1 Embryology and Diagnosis

During the sixth week of gestation, four pairs of branchial arches dominate the lateral cervicofacial area of the human embryo. Each branchial arch and its components can be traced to the formation of future anatomic structures as outlined. The first branchial arch forms the mandible and contributed to the maxillary process of the upper jaw. The anomaly location in the parotid gland has no connection to the external auditory canal (type I). Type II anomaly connects with the external auditory canal and extends deep into the parotid gland. The first cleft anomalies often lie in close association to the parotid gland and the facial nerve.

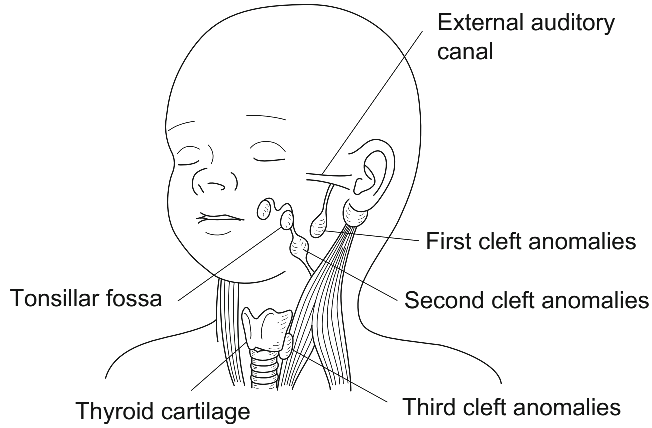

Fig. 12.6 Locations and sinus tract routes for the first to third branchial anomalies

The second arch forms the hyoid bone and the cleft of the tonsillar fossa. Second arch branchial cleft sinuses typically lie between the lower anterior border of the sternocleidomastoid muscle and tonsillar fossa of the pharynx. The cleft sinus or fistula tract may be in close proximity to the glossopharyngeal and hypoglossal nerves as well as carotid vessels as the tract travels through the carotid bifurcation and over the nerves to enter the lateral pharyngeal wall.

Third and fourth branchial anomalies are very rare and most present as sinuses or infected cysts rather than congenital fistulae and drain into the pyriform sinus (Fig. 12.6).

12.4.2 Treatment

The optimal management of congenital neck sinuses, cysts, and fistulas is usually complete excision done electively. Surgical resection is performed under general anesthesia with the patients positioned in hyperextension of the head with support under the shoulders. A small transverse elliptical incision is made around the external opening and deepened beneath the cervical fascia (Fig. 12.7).

First branchial anomalies are classified into type I and II. Type I lesions are considered to be duplications of the membranous external auditory canal. Type II lesions contain both ectodermal and mesodermal elements and may include

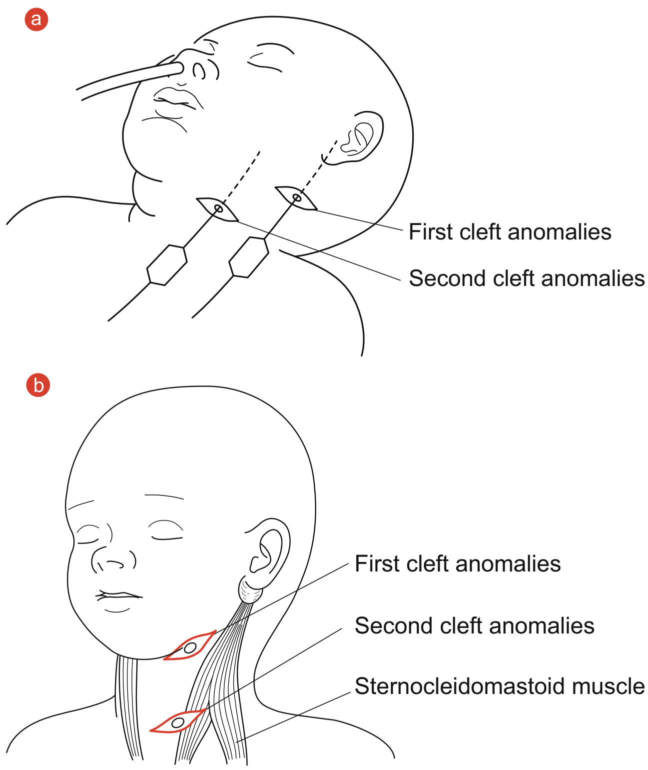

Fig. 12.7 Skin mark for first and second branchial anomalies. (**a**) Nasal intubation under general anesthesia. The patient is positioned with the neck hyperextended. Patient is prepped and draped around the neck and mouth. If a sinus is present, precise identification may be facilitated by gently inserting a probe or a length of nylon suture. (**b**) The skin incision is made around the sinus opening. This is usually an elliptical skin incision parallel to the skin creases

the cartilage. These anomalies pass medial to the facial nerve. A communication with the external auditory canal may be present. Great care must be taken given the proximity of the facial nerve (Fig. 12.8).

Second branchial cleft anomalies are the most common branchial anomalies. Drainage from a small cutaneous pit along the anterior border of the lower sternocleidomastoid muscle is the most common presentation. A transverse cervical incision in a skin crease is taken directly over the cyst or around the sinus opening. In a case of a fistula, precise identification may be facilitated by gently inserting a probe or a monofilament suture into the tract. Methylene blue has also been used to stain the tract and makes it easier to identify should it break during dissection. If the tract is long, exposure may be improved by a second incision along a skin crease more cephalad: the so-called stepladder

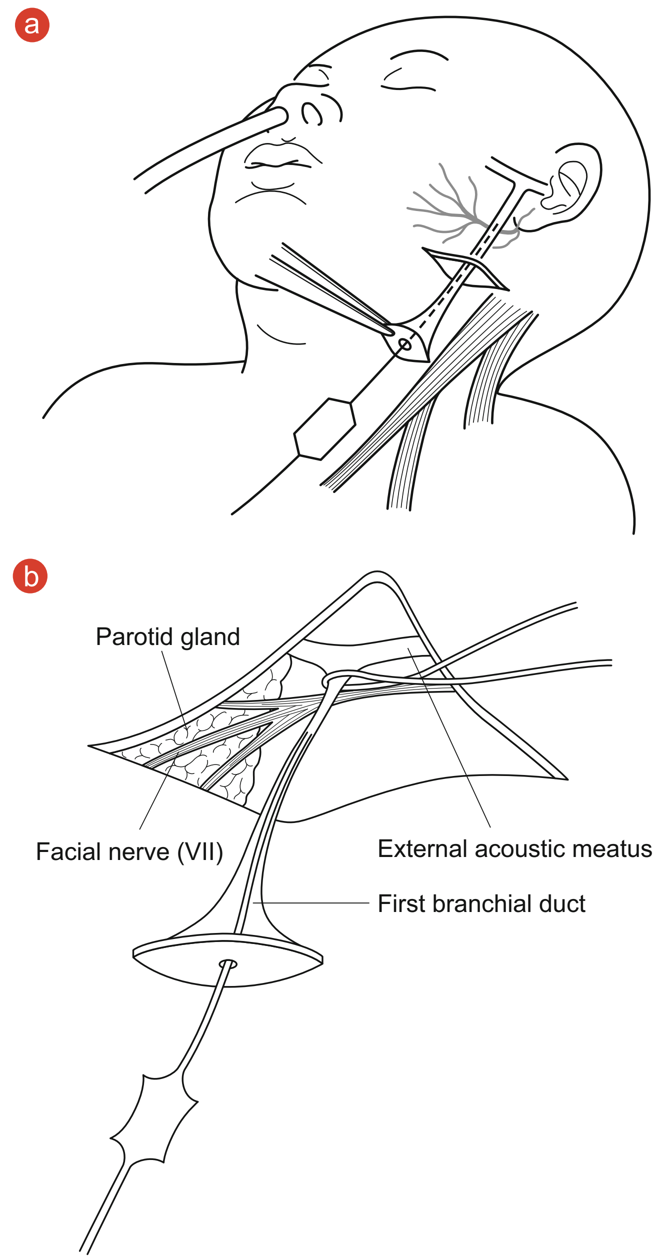

Fig. 12.8 Excision of first branchial anomalies. (**a**) Cysts are seen as swelling posterior or anterior to the ear or inferior to the earlobe in the submandibular region. (**b**) The tract may be intimately associated with the parotid gland. The sinus sometimes passes between the branches of the seventh cranial nerve making resection difficult, particularly in the patients who have a tract deep to the facial nerve

incision (Fig. 12.9). The second cleft tract penetrates the platysma and the cervical fascia to ascend along the carotid sheath to the level of the hyoid bone. The tract then turns

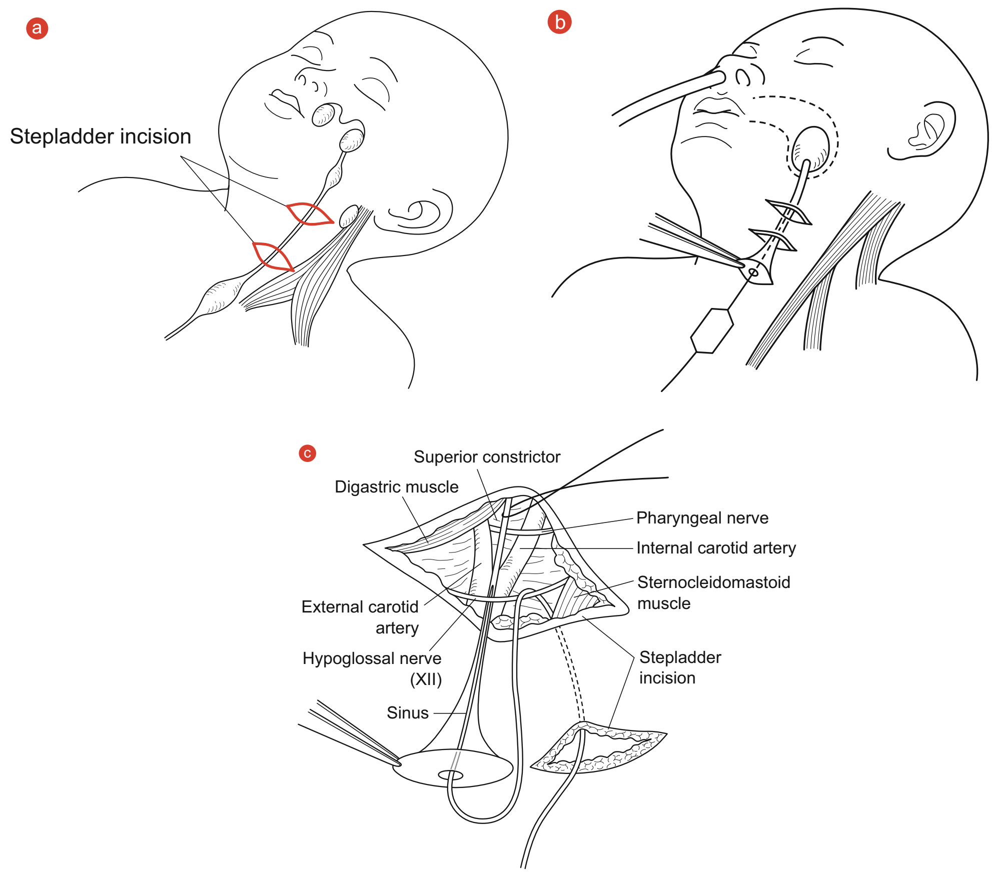

Fig. 12.9 Excision of second branchial anomalies. (**a**, **b**) If the branchial sinus is too long to safely dissect through the first incision, then stepladder cervical incision was made more cephalad to remove the fistula en bloc. (**c**) The sinus passes between the internal and external carotid arteries deep to the carotid sheath, ending in the tonsillar fossa

medially between the branches of the carotid artery, behind the posterior belly of digastric and stylohyoid muscles, and in front of the hypoglossal nerve to end in the tonsillar fossa. The internal opening can be anywhere in the nasopharynx or oropharynx. However, it is most commonly found in the tonsillar fossa. A finger or bougie in the oropharynx can help identify the opening in the tonsillar fossa. The tract must be carefully ligated at this point. The skin is closed with monofilament absorbable suture.

Pyriform Sinus Malformation

13

Masayuki Kubota

Abstract

Pyriform sinus fistulas are considered to consist of two different types of fistulas, which originate in the third and fourth branchial clefts. Fistulas corresponding to the former type run over the superior laryngeal nerve, while those corresponding to the latter type run under the superior laryngeal nerve (SLN) [1]. In our experience, there were only two patients whose fistula seemed to originate in the third branchial cleft because the orifice of the fistula was in the upper part of the pyriform sinus. These two cases similarly showed a huge cervical cystic mass. In the majority of the patients, the fistula originated from the apex of the pyriform sinus; thus, their origin was in the fourth branchial cleft. These cases showed a relatively long fistula running downward to the thyroid gland. The recurrence rate of pyriform sinus fistula is high, especially when the fistula originates in the fourth branchial cleft. The varying clinical characteristics, method of diagnosis, and operative techniques for these two types of fistula are described.

Keywords

Pyriform sinus fistula • Branchial cleft • Superior laryngeal nerve • Recurrence

13.1 Preoperative Managements

A pyriform sinus fistula has its orifice in the pyriform sinus, which is located at the entrance of esophagus. A majority of cases show left-sided fistulas. The origin of the fistula is considered to be the third or fourth branchial cleft. Fistulas that originate in the third branchial cleft have an orifice in the upper part of the pyriform sinus and run over the superior laryngeal nerve, while the fistulas of the fourth branchial cleft origin have an orifice at the base of the funnel-shaped pyriform sinus and run under the superior laryngeal nerve, downward to the thyroid gland (Fig. 13.1).

Imaging examinations of the upper esophagus, obtained with the swallowing of barium, are necessary for diagnosis. The washout of contrast medium from the fistula is relatively fast, and pharyngoesophageal cinematography is useful to confirm the presence of the fistula. In a fistula that originates in the third branchial cleft, the orifice is located in the upper part of the sinus and runs transversely (Fig. 13.2a), while a fistula that originates in the fourth branchial cleft begins in the apex of the funnel-shaped sinus and runs downward (Fig. 13.2b). Fistulas associated with huge cervical cysts are often found antenatally or early in the neonatal period. The periodic aspiration or the drainage of the cyst is often necessary for the cases in which the cyst shows a tendency to grow. In the present series of the patients with pyriform sinus fistula, the fistulas that were associated with cervical cysts were of the third branchial cleft origin. Fistulas of the fourth branchial cleft origin, which run downward to the thyroid

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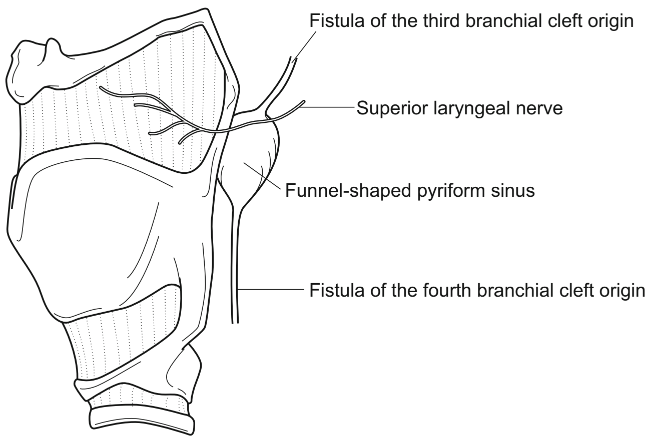

Fig. 13.1 The site of orifice and running of the fistulas which originate in the third and fourth branchial clefts

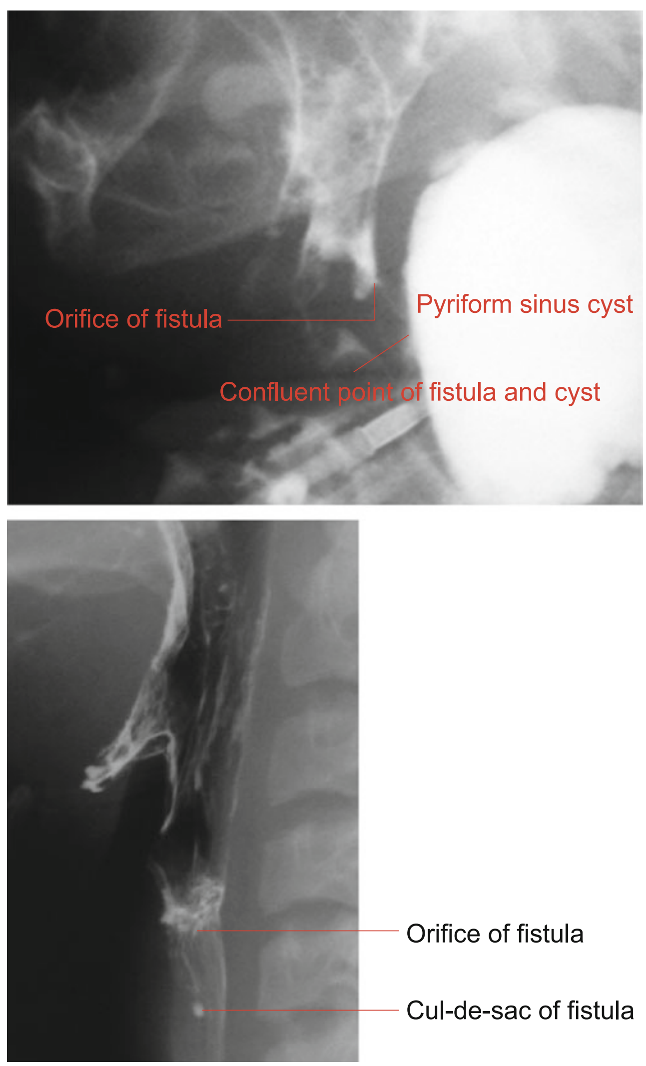

Fig. 13.2 Imaging studies of the fistulas. In a fistula of the third branchial cleft origin, the orifice is located in the upper part of the sinus and runs transversely, while a fistula of the fourth branchial cleft origin begins in the apex of the funnel-shaped sinus and runs downward. (**a**) The fistula of the third branchial cleft origin. (**b**) The fistula of the fourth branchial cleft origin

gland, often cause recurrent cervical abscesses or chronic suppurative thyroiditis. In these cases, preoperative antibiotics or abscess drainage is necessary.

13.2 Method of Operation

Operative position is similar to that in the operation of the thyroid gland with the cervical region elevated and extended using the soft mat or towel under the shoulder. Transverse skin crease incision at the middle level of the cervical region is a preferred skin incision, while transverse skin incision at the level of the abscess encircling its orifice is used in patients with cervical abscess (Fig. 13.3). In the operation of the fistula of fourth branchial cleft origin, intraoperative endoscopy is used to insert a guidewire through the pyriform sinus. A guidewire is inserted before placing the skin incision when the patient has a cervical orifice of the abscess, while it is during operation in patients without skin orifice.

Fistula is approached by dividing the platysma. Then, anterior cervical muscles were split along the anterior edge of the sternocleidomastoid muscle until the upper pole of the left thyroid gland is exposed. Then, the left upper thyroid vessels are ligated and divided. By lifting up the upper pole of the thyroid gland, operation field changes into the view where inferior constrictor muscle of the pharynx is well exposed (Fig. 13.4). When the patient has an outer orifice of the cervical abscess, this operative view is obtained by tracing back the inflammatory pseudo-fistula. At this stage of operation, a guidewire can be inserted into the pyriform sinus using the intraoperative endoscopy. Meticulous care should be taken for smooth insertion of the guidewire into the fistula. When a guidewire comes out by breaking the fistula, the remaining distal part of the fistula connecting to the thyroid gland should be carefully separated and removed. Then, vinyl tube of 4–6 Fr. size is introduced through a guidewire from the mouth to the fistula, which makes the dissection of the thin wall of fistula much easier.

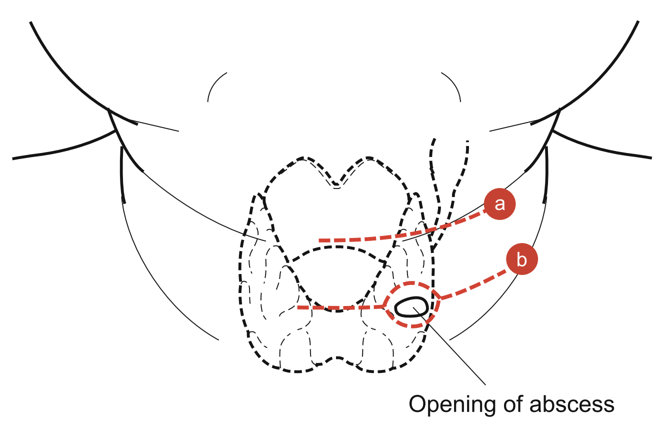

Fig. 13.3 Skin incision in the absence (**a**) or presence (**b**) of skin abscess

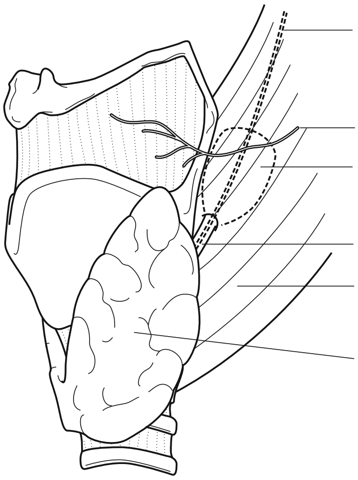

Fig. 13.4 Anatomical relationship of a fistula which originates in the fourth branchial cleft with inferior constrictor muscle of the pharynx, thyroid gland, and superior laryngeal nerves. A guidewire is inserted into the fistula. The apex of pyriform sinus locates at the level of the inferior constrictor muscle of the pharynx

The fistula should be traced into the inferior constrictor muscle of the pharynx and divided at this muscle level, which corresponds to the base of the pyriform sinus. The pyriform sinus is continuously under the strong positive pressure of swallowing, so the secure ligation of the fistula at the base of pyriform sinus is a most important procedure to prevent a recurrence. For that purpose, we first place a loose knot when the fistula has a stent tube. Then, a loose knot is tightened to make a firm knot as a stent tube is slowly pulled out. Then, a transfixing suture is placed a few millimeter distal to the firm knot for a doubly ligation of the fistula. Operation field is closed in layers leaving a continuous suction drain or a longitudinally trimmed Penrose drain.

In case of cervical cyst, the neck is rotated rightward to place the cyst in the middle of the operation field in the thyroid position. A skin incision of the compatible length to that of the cervical cyst is placed above the cervical cyst. Surface of the cyst is approached through the muscle splitting incision. The dissection of the cyst from surrounding tissue is carried out just on the plane of the cyst wall, which is most important to prevent the unnecessary injuries to the muscles and nervous tissue. Fistula connecting to the pyriform sinus can be identified at the inner side of the cyst. Because this type of fistula with cervical cyst is of the third branchial cleft origin, thyroid gland never appeared in the operation field. After dissecting the upper half of the cyst, a gentle pull-up of the cyst through the wound makes its exposure much easier. Aspiration of the cyst content at this stage of operation also makes dissection easier. The diameter of the fistula is similar to that of the thyroglossal cyst from the hyoid bone to the foramen of the tongue. When the content of the cyst is spilled over during dissection of the inner side of the cyst, there is a possibility that fistula connecting the cyst is divided. On such occasion, a careful search of the thin fistula is necessary. Base of the fistula should be doubly ligated as the fistula of the fourth branchial cleft origin.

Instead of a complete resection of the fistula, electrical or chemical cauterization of the internal opening of the fistula is reported [2, 3]. However, usefulness of these methods needs a long-term follow-up of the patients.

13.3 Postoperative Managements

In the recovery room, a careful checkup of drainage volume from the wound is important. Postoperative bleeding may induce a local swelling of the wound and inappropriate drainage may induce a compression of the trachea. In my experience of recurrent cases, a dirty, mucinous discharge is noted immediately after operation. Because a recurrent rate is the highest among the congenital cervical cyst, the secure primary operation is the most important for the patients.

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Accessory Ear and Cervical Ear

14

Miyuki Kohno

Abstract

Accessory ear is a fairly common congenital malformation of the external ear. However, cervical ear is uncommon. Surgical treatment is usually performed for cosmetic purposes. The important points for surgical treatment are optimal incision for the cartilage and excision without injuring important structures deep in the face and neck.

Keywords

Accessory ear • Cervical ear • Pharyngeal remnant • Congenital

14.1 Accessory Ear and Cervical Ear: Epidemiology

An accessory ear (accessory auricle, auricular appendage) is a fairly frequent skin bump lesion, occurring in 15 of 1,000 births. It commonly occurs in the vicinity of the tragus, additionally occurring in the malar part connecting the tragus and angulus oris; moreover, those occurring in the neck are also referred to as cervical ears. However, cervical ear is uncommon.

14.1.1 Accessory Ear (Anterior Part of the Ear, Malar Region Accessory Ear): Etiology

The majority is unilaterally present in the anterior of the tragus. In addition to the anterior of the tragus, it also occurs in the malar region connecting the tragus and the corner of the mouth, where such accessory ears are considered to be aberrant tissue derived from the first pharyngeal (branchial) arch during the developmental process. In many cases, abnormalities are only observed in the accessory ear and nowhere else; however, facial development abnormalities on the same side such as microtia, first or second pharyngeal (branchial) arch syndrome, etc. may develop as complications. Although the form varies, those that are larger often comprise cartilage (elastic cartilage), with continuity with the tragus cartilage frequently observed. It is sometimes slightly concaved in the accessory ear of the malar region, resembling the navel.

14.1.2 Cervical Ear (Cervical Chondrocutaneous Branchial Remnant, Cervical Auricle, Accessory Ear of the Neck): Etiology

Cervical ears are referred to by a variety of names, including cervical chondrocutaneous branchial remnant, cervical accessory auricles, cervical skin tags, etc.

Cervical ears are believed to be derived from the second pharyngeal (branchial) arch or the lower third or fourth pharyngeal (branchial) arch, occurring in the lower one-third of the anterior margin of the sternocleidomastoid muscle. Generally, they occur as small protrusions without a stem (Fig. 14.1). Larger protrusions may exhibit an auricle-like shape. A cartilage is contained inside; however, the

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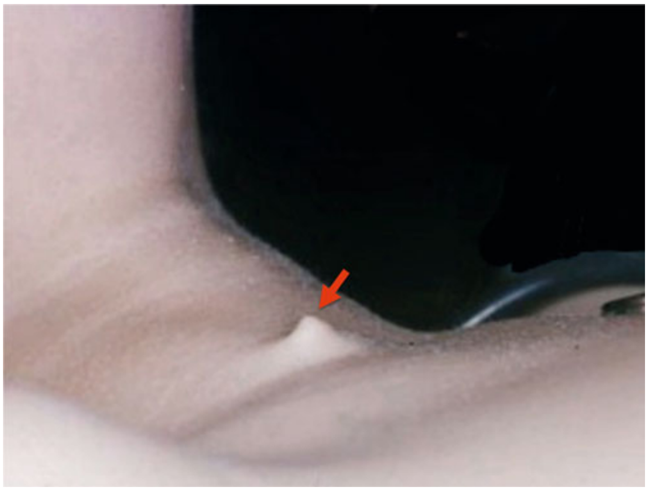

Fig. 14.1 Cervical ear. It is located in the lower one-third of the anterior margin of the sternocleidomastoid muscle

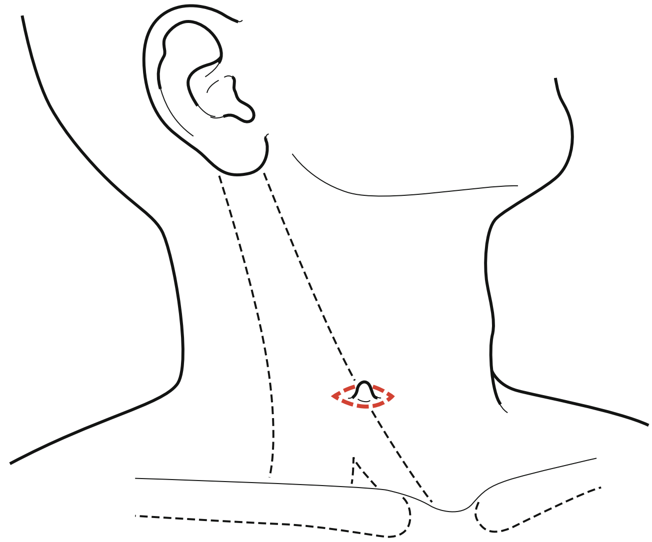

Fig. 14.2 Cervical ear skin incision (located in the lower one-third of the sternocleidomastoid muscle anterior margin). It becomes a spindle-shaped incision along the striae. Cartilage of the cervical ear is generally shallow, making excision easy

majority is shallow, making extraction easy. Generally, cartilage of the cervical ear is not continuous with deep tissue; however, there are reports of cases in which it was continuous with the auricular cartilage of the same side and/or cricoid cartilage.

14.2 Surgery

Surgery has slim to no functional significance and is carried out with the objective of cosmetic improvement. Consideration is given to the excision design such as size and shape such that unnatural bumps and depressions do not remain on the skin following surgery.

14.2.1 Simple Ligation

Regarding bumps of the skin not containing cartilage with a narrow stem, when the roots are ligated using silk thread at an early stage following birth, it sheds in 7–10 days due to necrosis. Ligation is applied by slightly pulling the accessory ear in order to prevent a skin bump from remaining at the base; however, an explanation must be provided to the guardian that cosmetic surgery may be required in the future due to a skin bump remaining at the base thereby preventing cosmetic results from being achieved.

14.2.2 Simple Excision

In many cases, elastic cartilage is found in the base; therefore, excision is carried out including the cartilage.

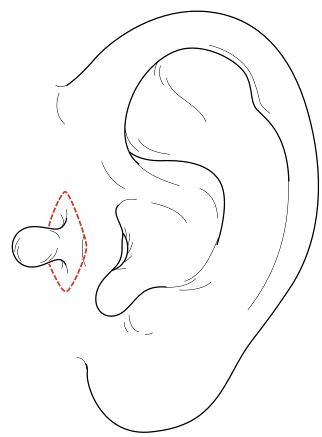

Fig. 14.3 Skin incision. The incision line of the accessory ear present in the anterior part of the ear is a vertical incision perpendicular to the preauricular margin

A spindle-shaped skin incision is designed from the rise of the stem. With cervical ears, a horizontal incision is made along the striae (Fig. 14.2). In the anterior part of the ear, a vertical incision is made parallel to the preauricular margin (Fig. 14.3). At this time, the incision is designed by closely observing the direction of the bump such that the suture line is kept from being too long, and a short natural line is made. When incision of the cartilage is insufficient, the remaining cartilage may cause a skin bump; therefore, the cartilage must be sufficiently excised such that it does not touch the skin surface. However, in the event the cartilage is continuous with the external auditory canal and/or the cartilage of the tragus, conversely, deformation of the tragus may be caused; therefore, the tragus cartilage must be preserved such that the

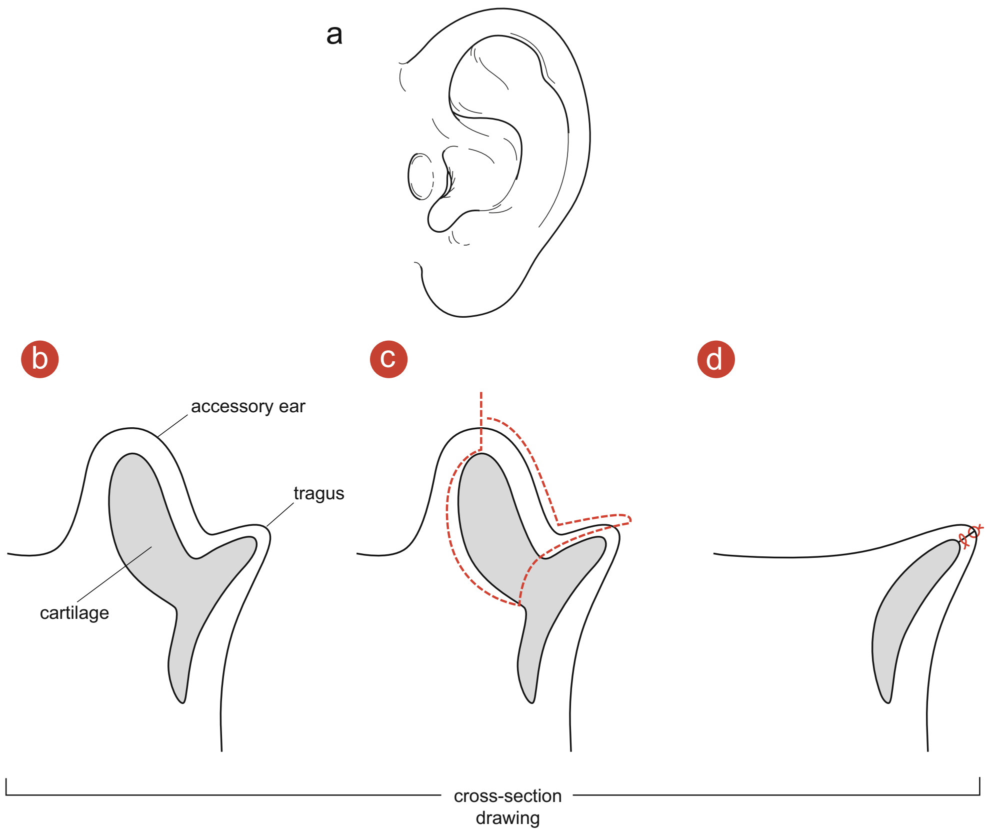

Fig. 14.4 Tragus plastic surgery. (**a**) Accessory ear close to the tragus. (**b**) The *red dotted line* depicts the location of the excision line. The *gray* area depicts the cartilage. (**c**) An incision line is made at the ridgeline of the accessory ear and tragus. New skin is made from the inner skin of the accessory ear and the skin on the tragus and external auditory canal side. (**d**) The suture site is located at the ridgeline of the new tragus

shape of the tragus is impaired, and attention must be paid not to excise too much. Subcutaneous fatty tissues should be closely gathered following excision using an absorbing thread.

In the case of accessory ears with a wide base, the skin bump in the vicinity of the base is used to advantage, and the skin excision width is made minimal, thereby achieving a natural finish with a short suture line.

14.2.3 Tragus Plastic Surgery

When the accessory ear is positioned close to the tragus or when it is partially adhered, reconstruction of the tragus may be carried out at times using part of the accessory ear. The excision site is designed so as to pass the ridgeline of the tragus and ridgeline of the accessory ear. Accordingly, a new tragus may be reconstructed in the skin on the external auditory canal side of the tragus, midline of the skin of the accessory ear, and part of the cartilage, and simultaneously, the sutured wound passes above the reconstructed tragus, thereby also being good for cosmetic reasons (Fig. 14.4).

14.2.4 Precautions During Surgery

Forced deep excision of the cartilage is accompanied by the risk of damaging branches of the superficial temporal arteries traveling the deep regions and facial nerves in the accessory ear of the malar region; therefore, sufficient attention must be paid.

Part III

Thoracic

Standard Operation for Esophageal Atresia

15

Tomoaki Taguchi

Abstract

The most popular type of esophageal atresia is esophageal atresia with a distal tracheoesophageal fistula (TEF), namely, Gross type C. Division of TEF and primary anastomosis of the esophagus are essential. One-layer stitch anastomosis with monofilament absorbable sutures (5-0 or 6-0 PDS) is the most standard procedure for end-to-end anastomosis. Muscle-sparing axillary skin crease incision achieved excellent motor and aesthetic outcomes. The patient is placed in the left lateral position. The uppermost right arm was extended to about 130°, drawn forward, and placed on an armrest. A pulse oximeter is applied on hand of the extended right arm for monitoring peripheral blood pulse and saturation of oxygen. During operation, blood pulse and saturation of oxygen have been kept in normal range in order to avoid transient arm paralysis caused by the hyperextension of arm or the hyperextension of wound.

Extrapleural approach through the fourth intercostal space allows the identification of azygos vein, TEF, and upper pouch. The azygos vein was identified and ligated with 4-0 silk and divided; then, the upper esophagus and TEF are exposed. Vagus nerve is present besides the upper esophagus. TEF is identified along the vagus nerve. TEF is encircled by tape and divided nearby trachea and closed by 5-0 PDS stitch sutures. Esophageal end-to-end anastomosis was followed. Thorax and skin wound is closed in layers.

Keywords

Esophageal atresia • Tracheoesophageal fistula (TEF) • Axillary skin crease incision • Transanastomotic tube • Pulse oximeter • Monofilament absorbable suture

15.1 Esophageal Atresia (Open)

The most popular type of esophageal atresia is esophageal atresia with a distal tracheoesophageal fistula (TEF), namely, Gross type C. Division of TEF and primary anastomosis of the esophagus are essential. Recently, bronchoscopy prior to operation is recommended to define the site of entry of TEF. Esophagoscopy will define the length of the upper pouch and exclude an upper pouch TEF that enters the side of the proximal pouch at some distance from its distal end.

15.2 Esophageal Anastomosis

One-layer stitch anastomosis with monofilament absorbable sutures (5-0 or 6-0 PDS) is the most standard procedure for end-to-end anastomosis (Fig. 15.1a). Classically, Haight

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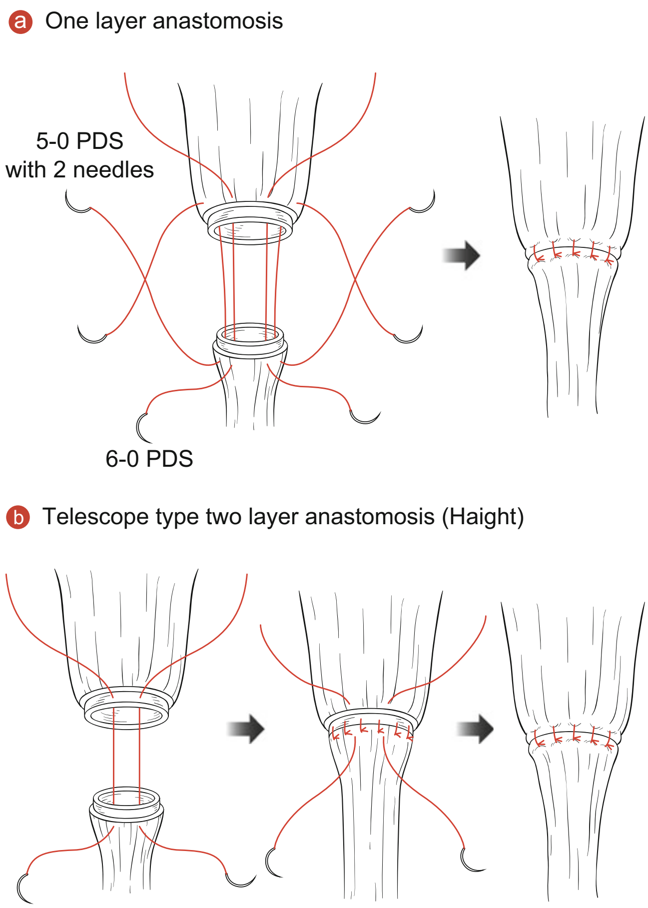

Fig. 15.1 Esophageal anastomosis. (**a**) One-layer anastomosis. (**b**) Telescope-type two-layer anastomosis

recommended two-layer stitch anastomosis with proximal mucosa to distal full layers and proximal muscle layer to distal muscle layer (Fig. 15.1b).

15.3 Classical Standard Incision

Right posterolateral incision has been the most common approach. The infant is positioned on the left side and stabilized. The right arm is extended above the head and fixed. A curved incision is made 1 cm below the inferior angle of the scapula extending from the midaxillary line to the paravertebral region posteriorly. The latissimus dorsi muscle is divided along the length of the incision. Serratus anterior muscle is retracted forward. The thorax is entered through the fourth or fifth intercostal space.

15.4 Muscle-Sparing Axillary Skin Crease Incision (MSASCI)

MSASCI for thoracic surgery was initially reported by Atkinson as "peraxillary approach" for dissection of the upper thoracic and stellate ganglia through the second ICS in adult in 1949 [1]. MSASCI was initially proposed for neonates by Bianchi et al. in 1998 [2], and then Kalman and Verebely extended this approach for children in 2002 [3], thus resulting in a good postoperative cosmetic result. However, they performed operations through the third or fourth intercostal space (ICS); therefore, the target organs were restricted in the upper two thirds of the thoracic cavity. Recently, we demonstrated that this approach could cover the whole thoracic cavity through from the third to eighth ICS [4]. As a result, most of patients achieved excellent motor and aesthetic outcomes.

15.5 Radical Operation for Esophageal Atresia

The patient is placed in the left lateral position. The uppermost right arm was extended to about 130°, drawn forward, and placed on an armrest. A pulse oximeter is applied on hand of the extended right arm for monitoring peripheral blood pulse and saturation of oxygen. During operation, blood pulse and saturation of oxygen have been kept in normal range in order to avoid transient arm paralysis caused by the hyperextension of arm or the hyperextension of wound.

A skin incision is made just on the axillary skin crease (Fig. 15.2), and the pectoralis major and latissimus dorsi muscles are retracted superiorly and medially, respectively. Either of these muscles can be partially incised in case. The incision is deepened and the axillary fat pad and lymph nodes are pushed upward. The long thoracic nerve was preserved in the posterior part of the wound (Fig. 15.3). The anterior serratus muscle is split along its fibers just on the fourth and fifth costa.

The fourth intercostal muscle is gently lifted up and opened (Fig. 15.4a); then, the extrapleural space is made between the chest wall and pleura (Fig. 15.4b). The dissection between the chest wall and the pleura was extended posteriorly; then, the posterior mediastinum is exposed.

The azygos vein was identified and ligated with 4-0 silk and divided (Fig. 15.5a); then, the upper esophagus and TEF

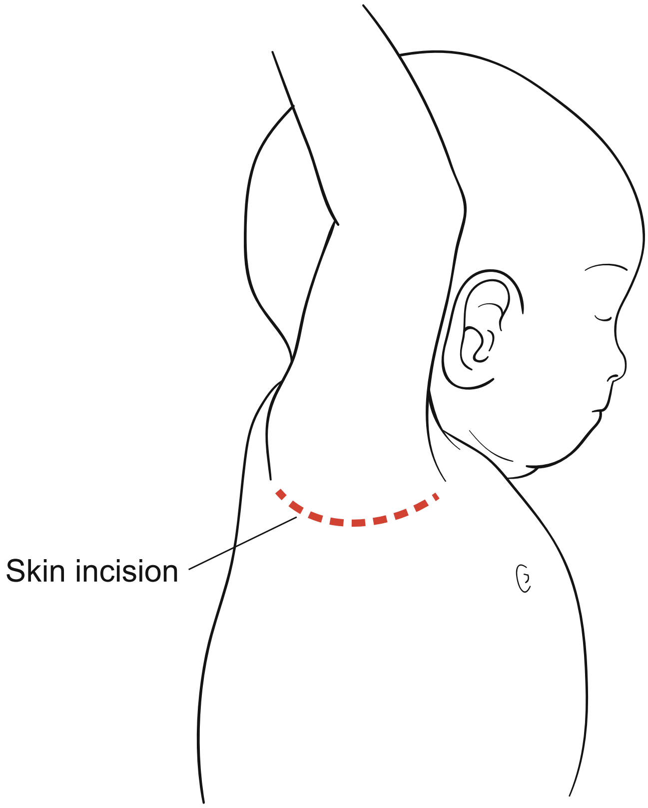

Fig. 15.2 Right axillary skin crease incision

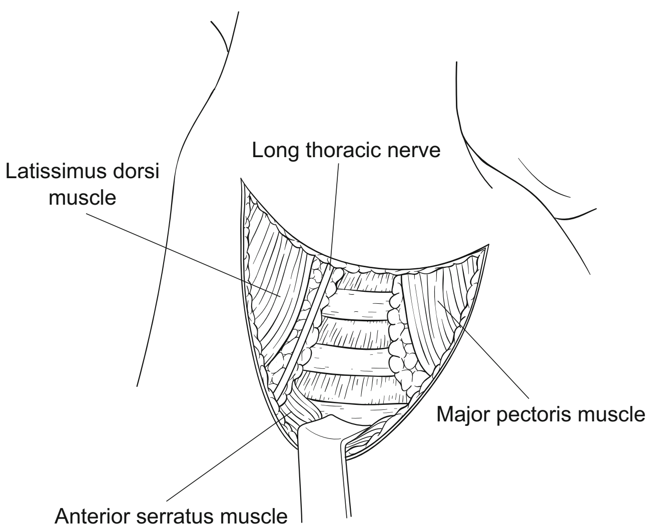

Fig. 15.3 Anatomy of muscles and costa

are exposed. Pushing a rubber tube through mouse, the upper esophagus is easily identified. Vagus nerve is present besides the upper esophagus. TEF is identified along the vagus nerve. Just in case, bronchoscopy is required to identify TEF. TEF is encircled by tape (Fig. 15.5b) and divided nearby trachea (Fig. 15.6a) and closed by 5-0 PDS stitch sutures (Fig. 15.6b). The stump of the upper esophagus is

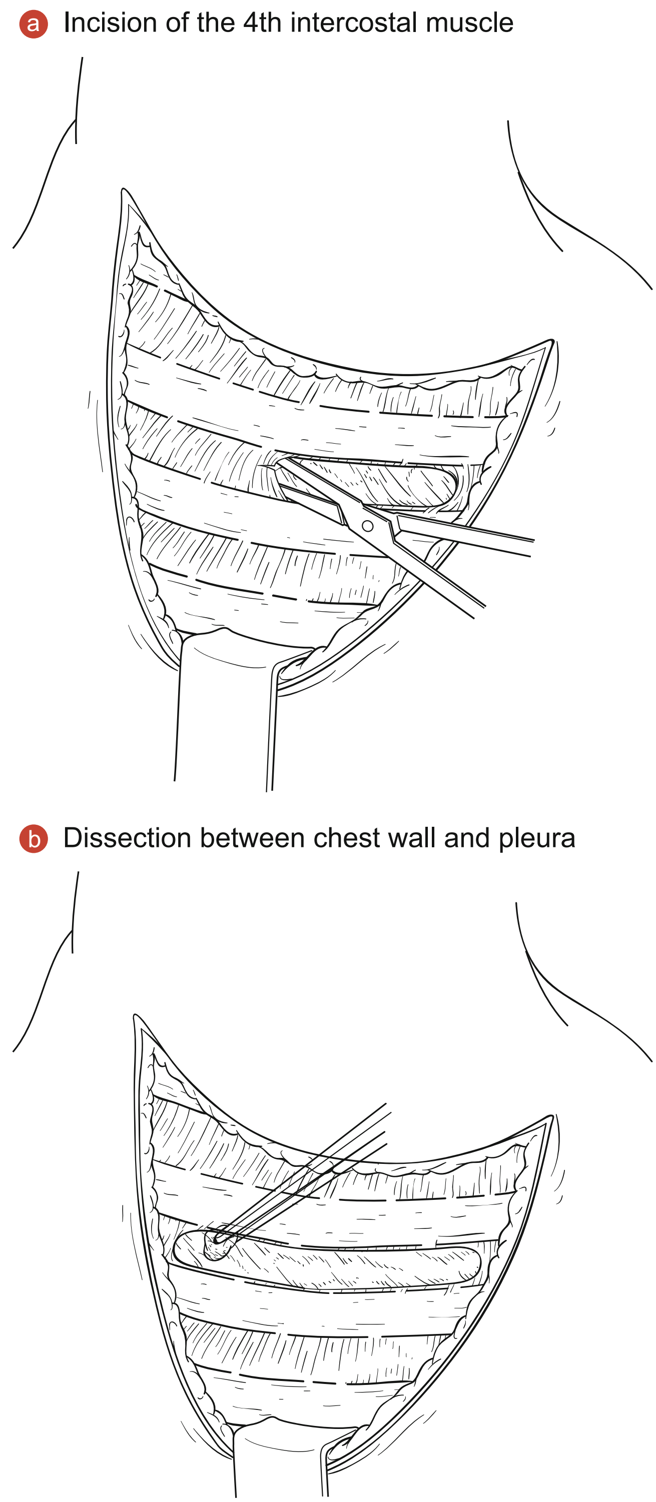

Fig. 15.4 Exploration [1]. (**a**) Incision of the fourth intercostal muscle. (**b**) Dissection between the chest wall and pleura

opened sharply, helped by pushing a rubber tube through mouse (Fig. 15.7a). Esophageal end-to-end anastomosis was performed with one-layer stitch sutures. Both lateral sides were approximated using 5-0 PDS (Fig. 15.7b), and a transanastomotic tube was inserted from the nose to the

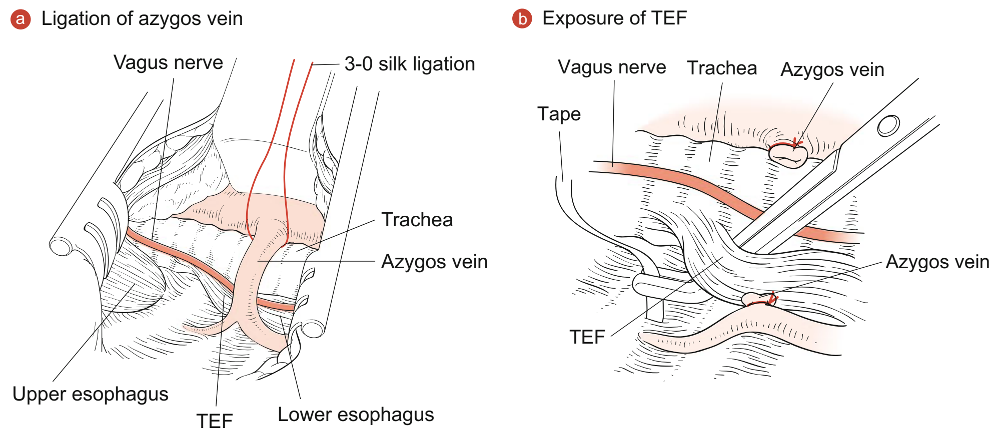

Fig. 15.5 Exploration [2]. (**a**) Ligation of azygos vein. (**b**) Exposure of TEF

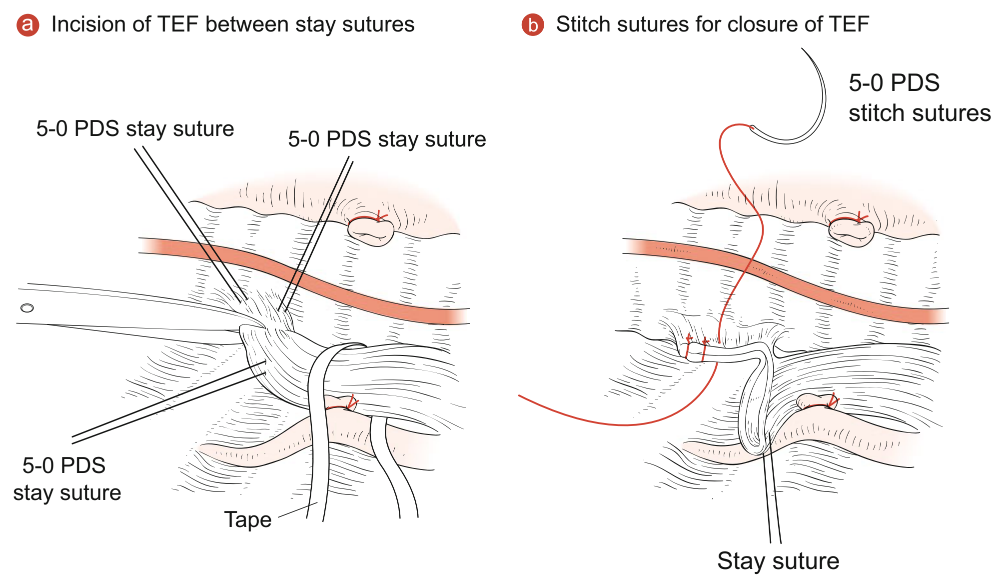

Fig. 15.6 Closure of TEF. (**a**) Incision of TEF between stay sutures. (**b**) Stitch sutures for closure of TEF

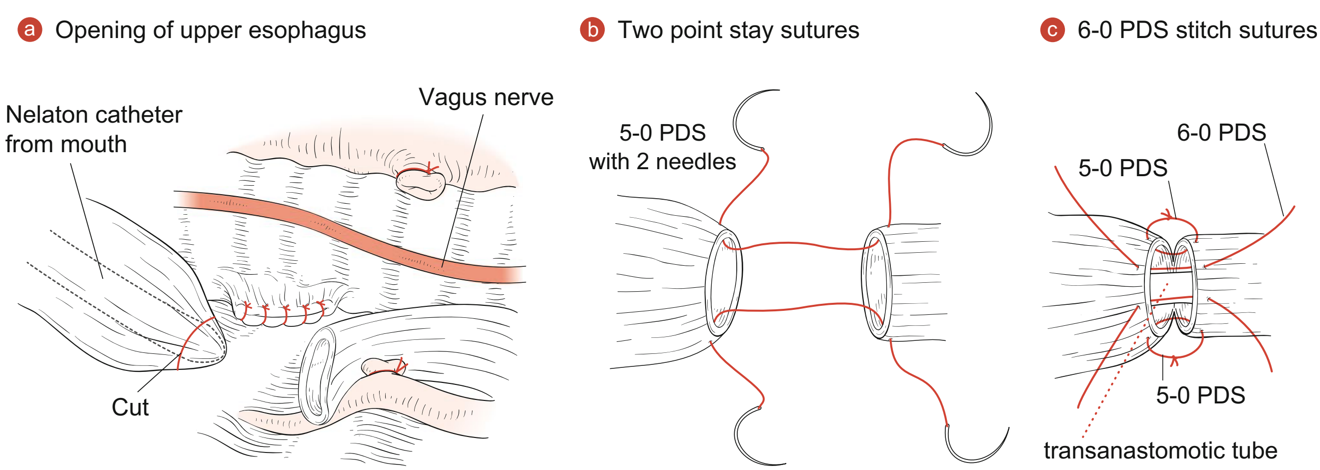

Fig. 15.7 Anastomosis of esophagus [1] standard. (**a**) Opening of upper esophagus. (**b**) Two-point stay sutures. (**c**) 6-0 PDS stitch sutures

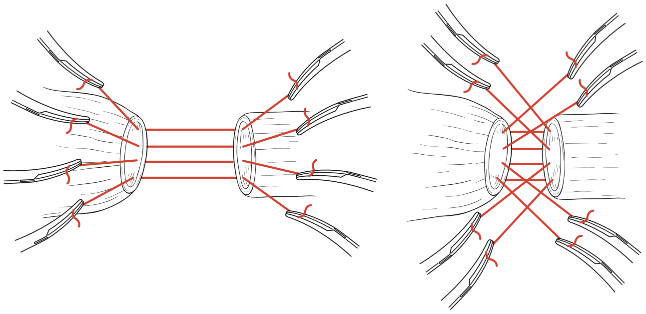

Fig. 15.8 Anastomosis of esophagus [2] in case of high tension

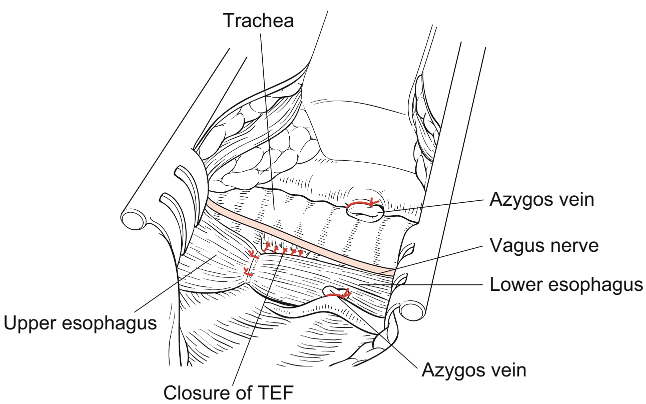

Fig. 15.9 Anastomosis of esophagus [3] completed

stomach through the anastomosis (Fig. 15.7c). The anterior and the posterior aspects were sutured with 6-0 PDS in stitch. If the tension is strong between proximal and distal esophagus, all sutures are tied after all stitches are finished, by approximation of both stumps (Fig. 15.8).

After completion of anastomosis, air leakage from closure of TEF is checked (Fig. 15.9). Thorax is loosely closed with a few absorbable stitch sutures, in order to avoid bony adhesion after closure. Both thoracic and subcutaneous tubes were inserted through both ends of wound; therefore, no additional wounds were necessary for tubes (Fig. 15.10). A skin wound is closed with subcuticular sutures.

15.6 MSASCI for Pulmonary Operation

MSASCI is also useful for pulmonary lobectomy for cystic lung disease, such as congenital cystic adenomatoid malformation (CCAM) and pulmonary sequestration.

One-lung ventilation was attempted in order to obtain adequate operational field for pulmonary lower lobectomy [5]. Briefly, bronchial blockade with a 4Fr or 5Fr Fogarty embolectomy catheter was attempted in each case. Children were initially intubated with a Fogarty embolectomy catheter

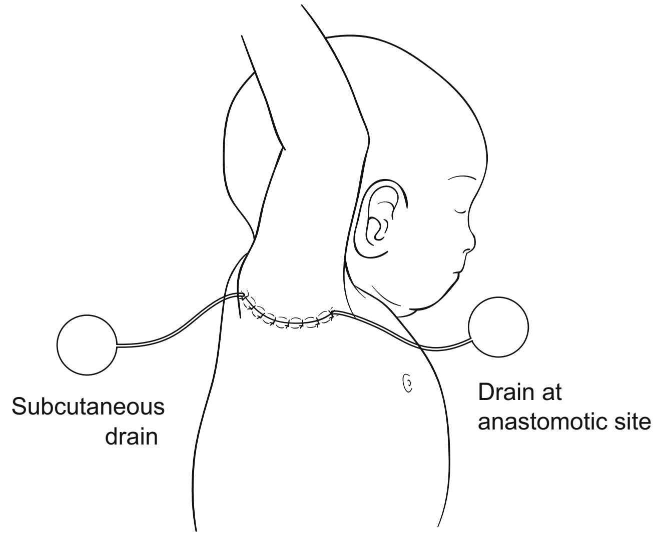

Fig. 15.10 Drains

under direct laryngoscopy. Then, immediately, an endotracheal tube was placed alongside the catheter in the trachea. After securing the tube, a pediatric fiber-optic bronchoscope (2.2 mm in diameter) was passed through to set a Fogarty embolectomy catheter to the mainstem bronchus. And then, bronchial blockade was performed with its balloon inflated with an appropriate volume of normal saline. Thoracotomy was done through the fifth or sixth ICS, and then the lung was deflated. The pulmonary arteries were ligated and cut and then the bronchus was cut and closed with 5-0 PDS sutures. Finally, the pulmonary vein was doubly ligated and cut, and the pulmonary ligament was dissected.

One-lung ventilation is also performed for pulmonary sequestration. Thoracotomy is performed via the seventh or eighth ICS in order to approach the abnormal artery in pulmonary ligament at first. One-lung ventilation allows the lower lobe to be easily lifted for the dissection of pulmonary ligament and the ligation of abnormal artery. This abnormal artery is ligated before ligation of pulmonary vein in order to avoid lung volume expansion. Thoracoscopic ligation of abnormal artery is also useful prior to thoracotomy.

15.7 Points of Postoperative Care

1. The patient is sedated under respirator control for 3 days, in order to avoid tension of anastomosis and atelectasis.
2. Enteral feeding using transanastomotic tube is started after extubation of endotracheal tube.
3. Esophagography is performed on the seventh day after surgery; then, the chest drain is removed.

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Esophageal Atresia with Long Gap

16

Tomoaki Taguchi

Abstract

The definition of "long gap" is generally more than two vertebrae. At first, the gap of the esophagus is tried to be shortened using some devices for extension of both the upper and lower esophagus. Foker' s method is reported to be effective. There are several options using alternative organs, such as gastric tube, jejunal interposition, colonic transposition, and gastric transposition. Gastric transposition is one of the alternatives for replacing the esophagus using the whole stomach. This procedure can be performed trans-hiatally via the posterior mediastinum without thoracotomy. There have been several reports showing good results compared with other procedures. This method has the advantage of involving only one anastomosis, which is well vascularized and is associated with a low incidence of leakage. Briefly, the greater curvature of the stomach is mobilized by ligating and dividing the vessels in the greater omentum and the short gastric vessels. These vessels should be ligated well away from the stomach wall in order to preserve the vascular arcades of the right gastroepiploic vessels. The highest part of the fundus of the stomach is identified and pulled up through the posterior mediastinum into the neck.

Keywords

Long gap • Esophageal atresia • Foker • Gastric transposition • Blood supply

Long gap esophageal atresia is seen in most cases of Gross A and B and some cases of Gross C. The definition of "long gap" is generally more than two vertebrae. If abdominal gas is absent in X-ray examination, the patient has no distal tracheoesophageal fistula. Tube gastrostomy is the first choice. Then, the gap between the upper and lower esophagus is evaluated.

At first, the gap of the esophagus is tried to be shortened using some devices for extension of both the upper and lower esophagus. Recently, Foker' s method (Figs. 16.1 and 16.2) is reported to be effective, and this method requires only 2 weeks to reduce gap appropriately [1–4].

If the original esophagus is too short to perform esophageal anastomosis, there are several options using alternative organs, such as gastric tube (Fig. 16.3) [5], jejunal interposition (Fig. 16.4) [6], and colonic transposition (Fig. 16.5) [5].

16.1 Gastric Transposition

One of the alternatives for replacing the esophagus is gastric transposition using the whole stomach [7]. This method has the advantage of involving only one anastomosis, which is well vascularized and is associated with a low incidence of leakage. Gastric transposition is currently the procedure of choice for esophageal replacement in adults with esophageal

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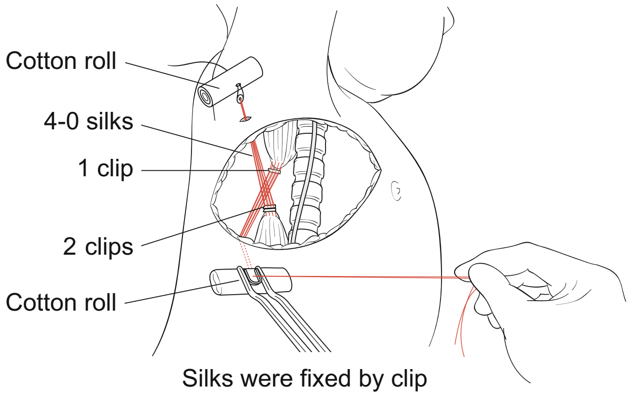


Fig. 16.1 Foker's method (original) (Cited from Ref. [1] with revisions)

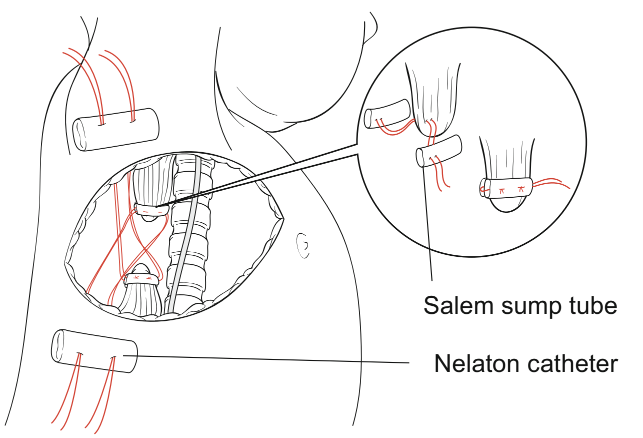


Fig. 16.2 Modified Foker's method (Cited from Ref. [2] with revisions)

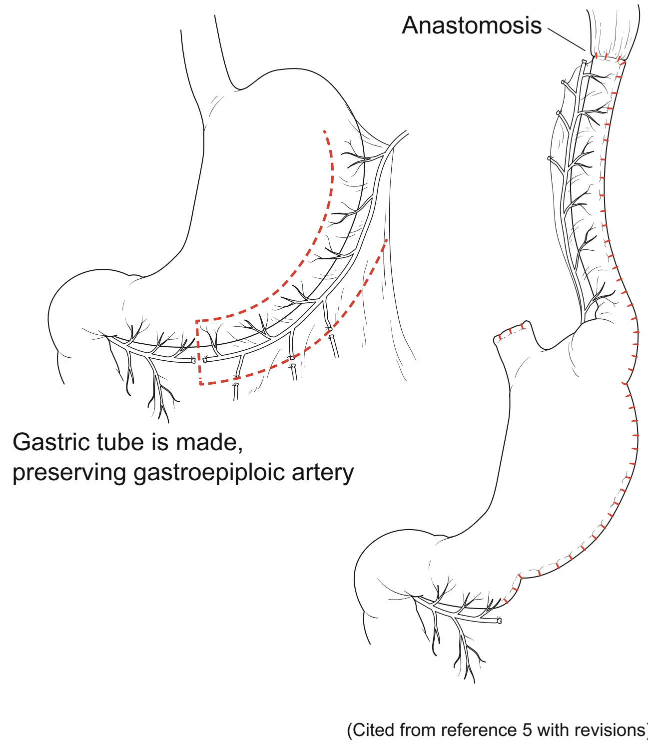


Fig. 16.3 Reversed gastric tube (Cited from Ref. [5] with revisions)

carcinoma. The procedure can be performed trans-hiatally via the posterior mediastinum without thoracotomy.

There have been several reports showing good results compared with other procedures [8,9].

The initial feeding gastrostomy should ideally have been sited on the anterior surface of the body of the stomach, well away from the greater curvature, in order to preserve the vascular arcades of the gastroepiploic vessels.

16.1.1 Abdominal Procedure

The patient is placed in a supine position with hyperextension of the neck.

Laparotomy is made via a midline upper abdominal incision or an upper abdominal transverse incision.

The gastrostomy is carefully mobilized from the anterior abdominal wall and the defect in the stomach closed with 4-0 PDS stitch sutures. Adhesions between the stomach and the left lobe of the liver are released, taking care not to damage any of the major blood vessels.

The greater curvature of the stomach is mobilized by ligating and dividing the vessels in the greater omentum and the short gastric vessels. These vessels should be ligated well away from the stomach wall in order to preserve the vascular arcades of the right gastroepiploic vessels. Meticulous care must be exercised to avoid damaging the spleen.

The lesser curvature of the stomach is freed by dividing the lesser omentum from the pylorus to the diaphragmatic hiatus. The right gastric artery is carefully identified and preserved, while the left gastric vessels are ligated and divided close to the stomach. The lower esophagus is exposed by dividing the phrenoesophageal membrane, and the margins of the esophageal hiatus in the diaphragm are defined (Fig. 16.6a).

The short lower esophagus is dissected out of the posterior mediastinum through the diaphragmatic hiatus. The anterior and posterior vagal nerves are divided during this part of the procedure. The body and fundus of the stomach are now free from all attachments and can be delivered into the wound.

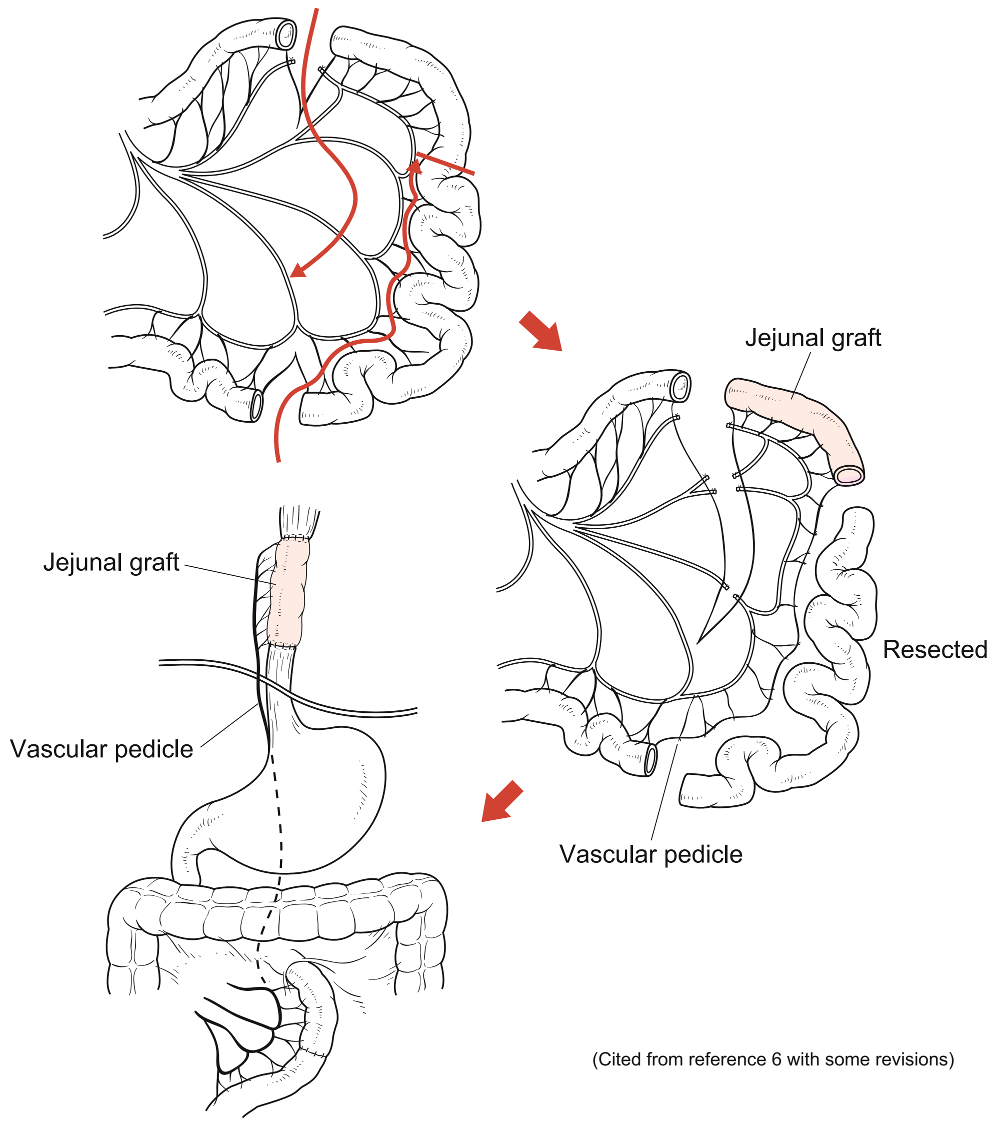


Fig. 16.4 Jejunal interposition (Cited from Ref. [6] with some revisions)

The esophagus is transected at the gastroesophageal junction and the defect closed by GIA staplers or 4-0 PDS sutures.

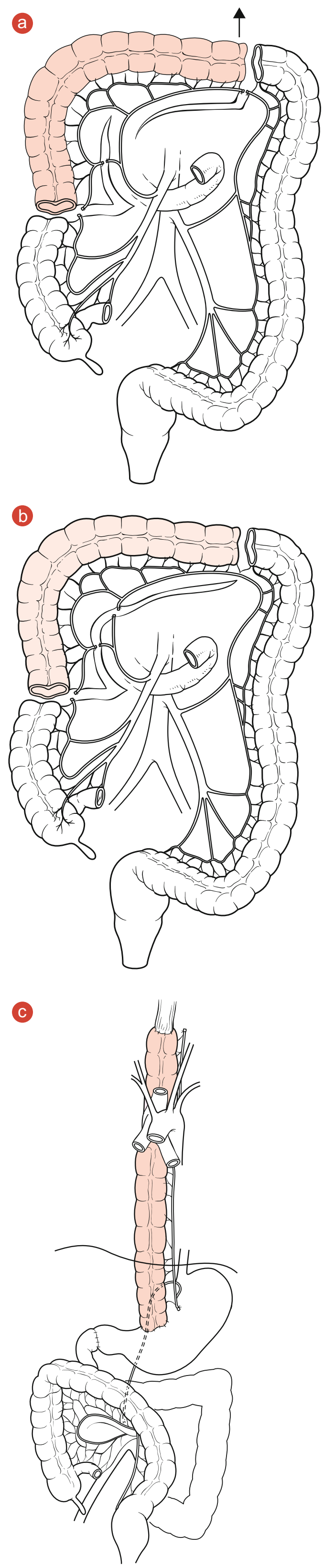
The second part of the duodenum is Kocherized to obtain maximum mobility of the pylorus. A pyloroplasty is performed, the longitudinal incision being closed transversely with 4-0 PDS sutures (Fig. 16.6b).

The highest part of the fundus of the stomach is identified and two or three stay sutures are applied to the left and the right of the area selected for the anastomosis. These sutures help to avoid torsion of the stomach occurring as it is pulled up through the posterior mediastinum into the neck (Fig. 16.6c).

16.1.2 Neck Procedure

A transverse incision is made on the left neck. The upper esophagus is mobilized (Fig. 16.7a, b). Esophageal tube inserted via the mouth is helpful to identify the upper esophagus. The recurrent laryngeal nerve coursing upward on the posterolateral surface of the trachea is identified and preserved (Fig. 16.7c). It is important to mobilize at least 1–1.5 cm full-thickness esophagus to allow a satisfactory anastomosis.

A plane of dissection between the membranous posterior surface of the trachea and the prevertebral fascia is established, and a tunnel is created into the superior mediastinum by blunt dissection using finger (Fig. 16.8a).



(Cited from reference 5 with some revisions)

Fig. 16.5 Colonic transposition. (**a**) Graft blood supply from middle colonic artery. (**b**) Graft blood supply from left colonic artery. (**c**) Completed (Cited from Ref. [5] with some revisions)

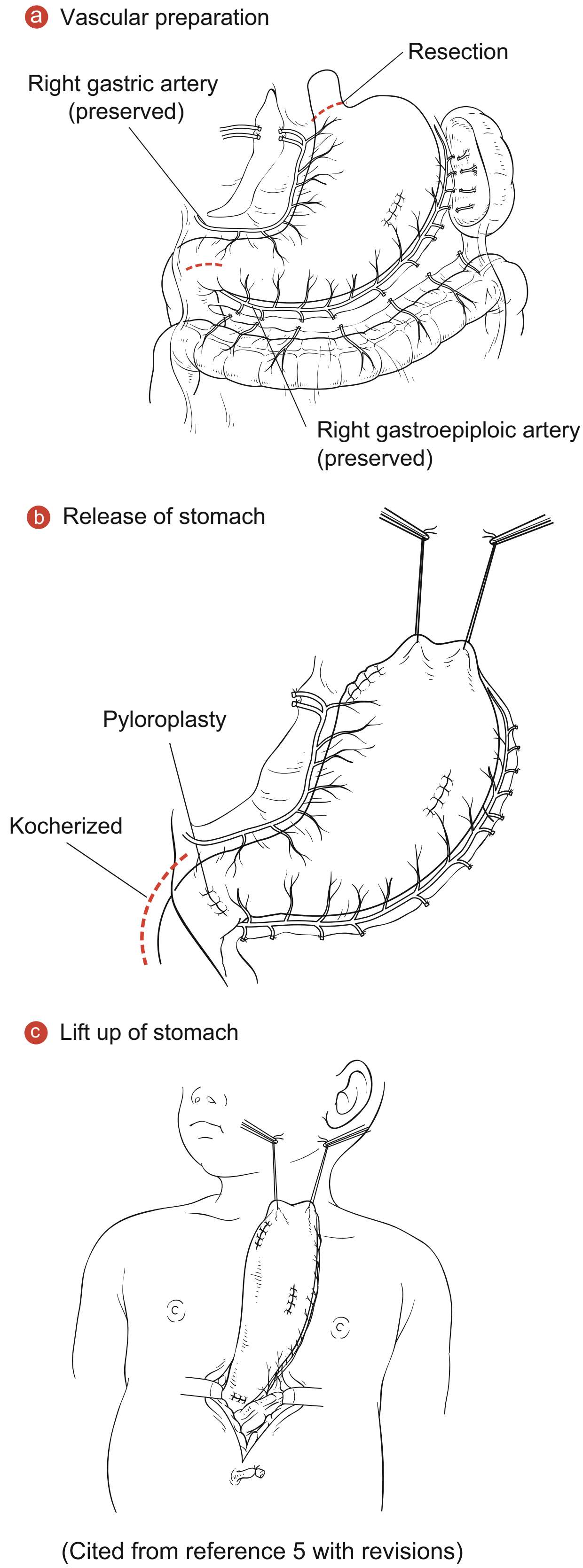


Fig. 16.6 Gastric transposition (1). (**a**) Vascular preparation. (**b**) Release of stomach. (**c**) Lifting up of stomach (Cited from Ref. [5] with revisions)

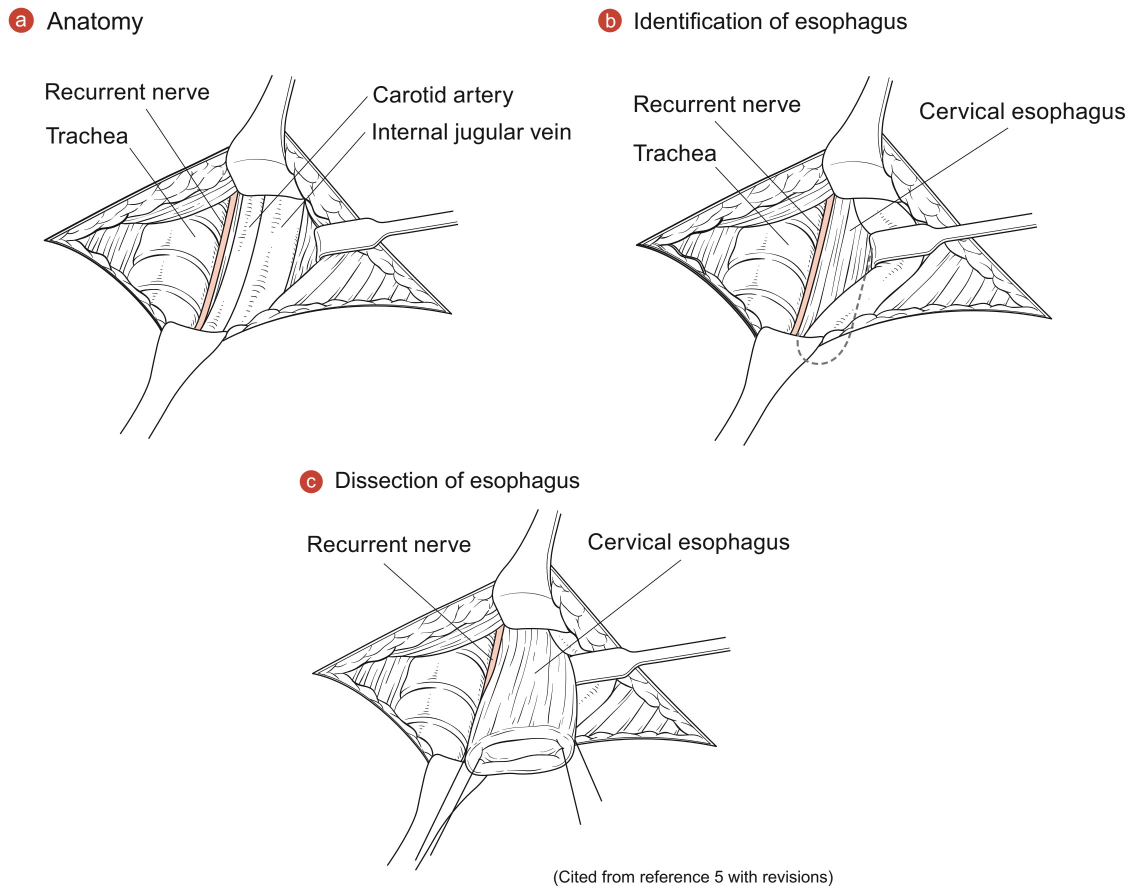


Fig 16.7 Gastric transposition (2): Dissection of cervical esophagus. (**a**) Anatomy. (**b**) Identification of esophagus. (**c**) Dissection of esophagus (Cited from Ref. [5] with revisions)

A similar tunnel is created by means of blunt dissection through the esophageal hiatus in the posterior mediastinal space posterior to the heart and anterior to the prevertebral fascia, using finger (Fig. 16.8a).

When continuity of the both tunnels has been established by fingers, the space to be occupied by the stomach is developed into a tunnel of two to three fingers' breadth.

Then long-size clamp is inserted from the cervical incision and is passed through the posterior mediastinum tunnel to appear via esophageal hiatus into the abdominal wound (Fig. 16.8b). The two or three stay sutures on the fundus of the stomach are gently pulled up through the tunnel. An adequate spacing of the tunnel is important for preventing poor blood supply and the twisting of stomach should be avoided (Fig. 16.8c).

Anastomosis between the cervical esophagus and the highest part of the stomach is performed using a single layer of 5-0 PDS stitch sutures (Fig. 16.9a). Transanastomotic nasogastric tube is inserted into the intrathoracic stomach before completing the anterior aspect of anastomosis (Fig. 16.9b).

A silicon drain is placed at the site of anastomosis, and the neck wound is closed in layers.

The margins of the diaphragmatic hiatus are sutured to the antrum of the stomach with a few 5-0 PDS stitch sutures. So, the pylorus lies just below the diaphragm. A tube jejunostomy is created for early enteral feeding.

The abdominal wound is closed in layers.

16.2 Points of Postoperative Care for Gastric Transposition

1. The patient is sedated under respirator for a few days, in order to avoid airway obstruction around the trachea near the lifted stomach.
2. Enteral feeding using transanastomotic tube is started after confirmation of bowel movement.
3. Esophagography is performed on the seventh day after surgery, and then the chest drain is removed.

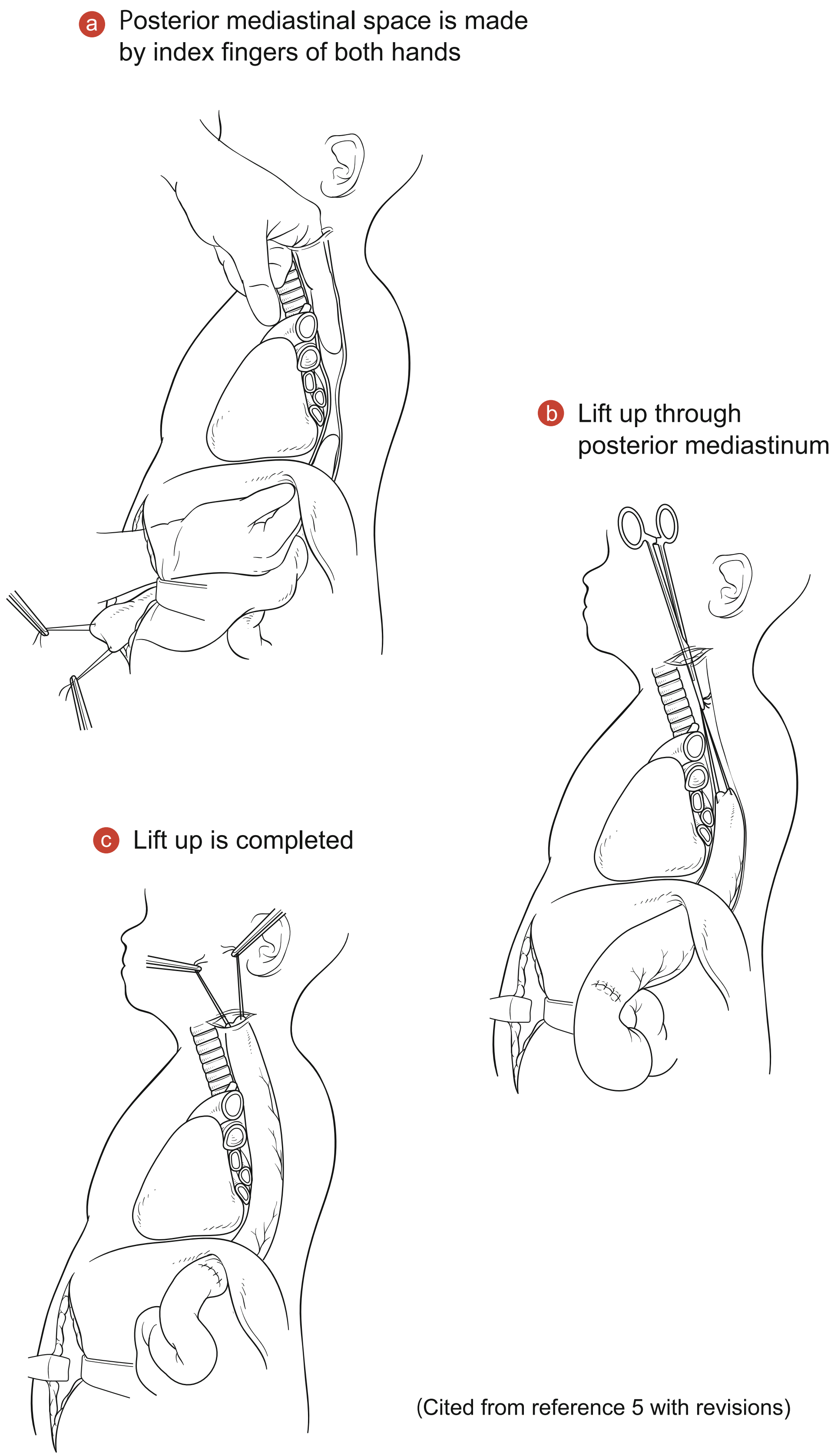


Fig. 16.8 Gastric transposition (3): Creation of posterior mediastinal space. (**a**) Posterior mediastinal space is made by index fingers of both hands. (**b**) Lifting up through posterior mediastinum. (**c**) Lifting up is completed (Cited from Ref. [5] with revisions)

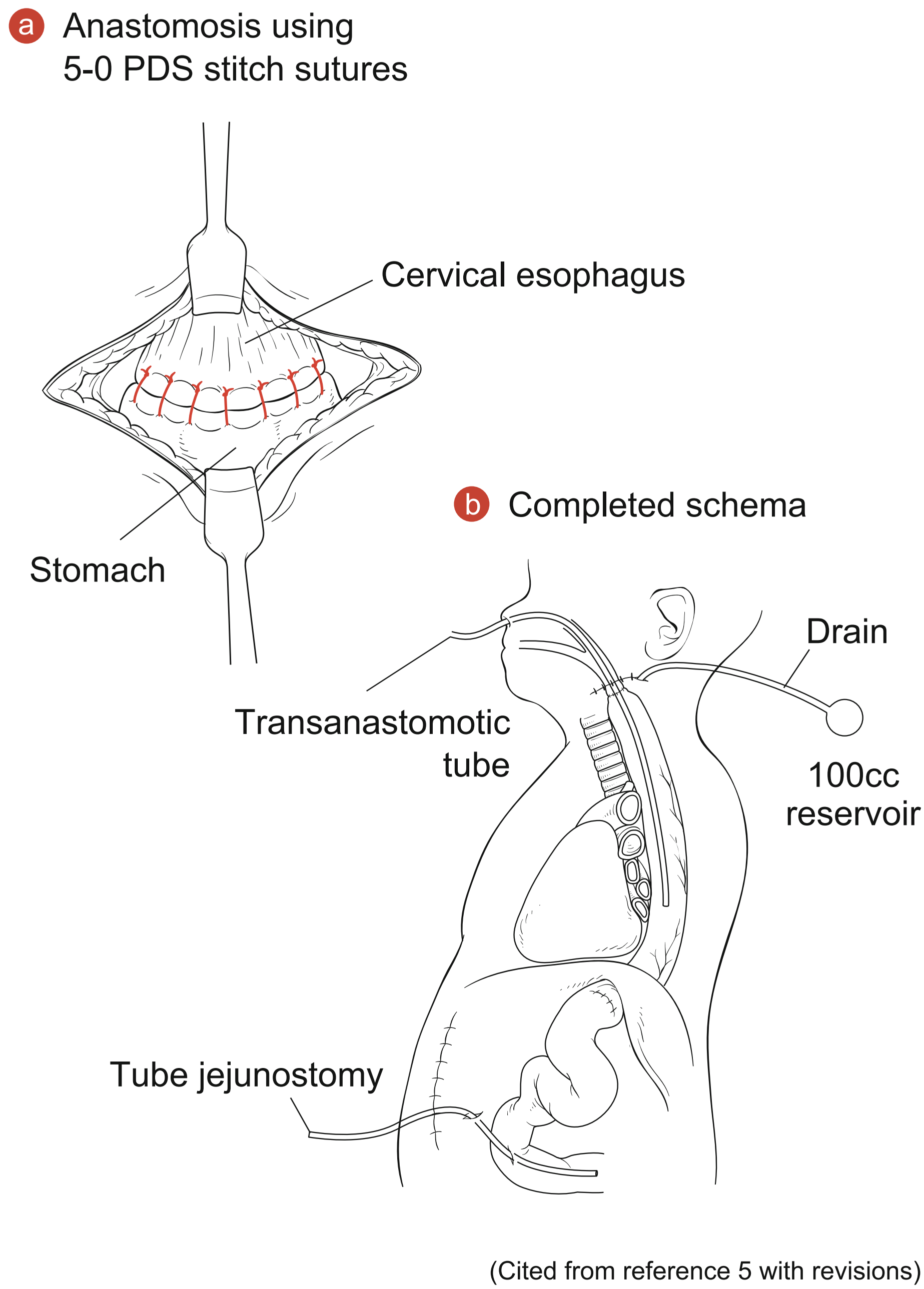


Fig. 16.9 Gastric transposition (4). (**a**) Anastomosis using 5-0 PDS stitch sutures. (**b**) Completed schema (Cited from Ref. [5] with revisions)

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17 Thoracoscopic Operation for Esophageal Atresia

Kyoichi Deie and Tadashi Iwanaka

Abstract

We describe primary thoracoscopic repair of type C esophageal atresia. We illustrate the procedure performed in a neonate whose birth weight was ≥2000 g who had no severe cardiac anomalies or respiratory complications. Intratracheal intubation is performed under spontaneous breathing. The patient is placed in a near-prone position with the right side slightly elevated. The surgeon and the assistant hold the camera stand on the right side of the patient. The first port is inserted into the intercostal space on the caudal side of the angulus inferior scapulae, and two working ports are inserted on the right and left sides of the first port. After identifying the azygos vein and the vagus nerve, the lower pouch is dissected and the fistula is ligated. After the upper pouch is adequately mobilized, its distal tip is resected. An anchoring suture is placed on the back wall of the upper pouch to anchor it on the caudal side of the upper pouch. Anastomosis is performed using 5-0 absorbable sutures. After anastomosis of the back wall, a transanastomotic nasogastric tube is inserted into the lower esophagus. After completing anastomosis, a chest drain is inserted through the camera port. The postoperative management after thoracoscopic repair of esophageal atresia is similar to that after conventional thoracotomy.

Keywords

Esophageal atresia • Thoracoscopy • Tracheoesophageal fistula

17.1 Introduction

In selecting the method and timing for surgical treatment of esophageal atresia (EA), it is essential to consider the presence of a tracheoesophageal fistula (TEF), the length of the gap, the severity of cardiac anomalies or respiratory complications, and the patient's birth weight. In this chapter, we describe primary thoracoscopic repair of type C EA. We illustrate the procedure with a neonate whose birth weight was ≥2000 g who had no severe cardiac anomalies or respiratory complications.

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17.2 Preoperative Management and Anesthesia

The preoperative setup for thoracoscopic repair of EA is similar to that for conventional thoracotomy. Until starting the procedure, the patient should be kept in the prone position and intraoral suction performed to prevent aspiration of saliva.

Because the anesthesia is very difficult and risky, it is essential that the pediatric surgeons and anesthesiologists carefully discuss the procedures before commencing surgery. First, when starting general anesthesia, positive pressure ventilation must not be performed with a muscle relaxant. Intratracheal intubation is performed under spontaneous breathing to prevent anesthetic gas from flowing into the stomach through the TEF. Then, bronchofiberscopy is performed to determine where the fistula is located.

In one method, the TEF is temporarily closed using a Fogarty catheter by rigid bronchofiberscopy under positive pressure ventilation. However, as it is essential to ligate the fistula, the patient should be moved out of the prone position as soon as possible. In addition, as mentioned in the Chap. 3, "Laparoscopy and Thoracoscopy," the operative field should be kept clear by maintaining an artificial pneumothorax. Therefore, differential lung ventilation, such as intubation of the left bronchus or temporary occlusion by placing a Fogarty catheter in the right bronchus, is not recommended.

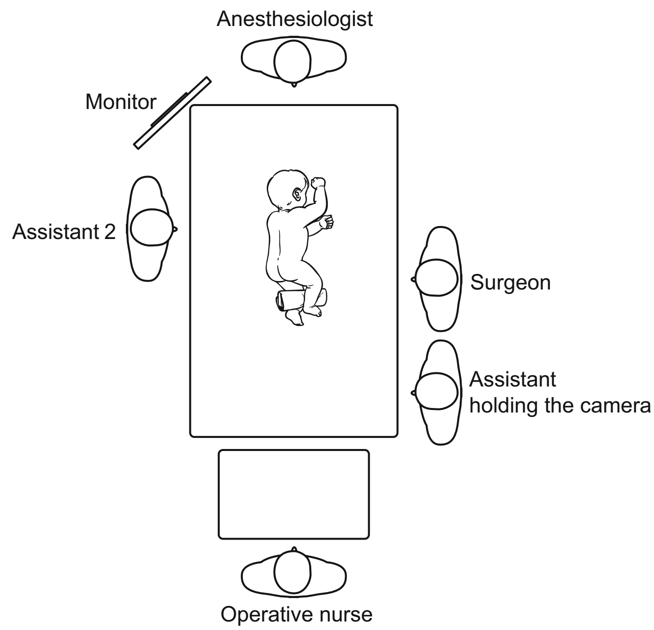

Fig. 17.1 Staff positions. All staff perform the operation while watching a monitor placed over the patient's head. Another monitor is prepared for the anesthesiologist, to enable close cooperation between the surgeon and anesthesiologist

17.3 Operations

17.3.1 Positioning

Intratracheal intubation is performed under general anesthesia with spontaneous breathing. The patient is placed in a near-prone position, with the right side slightly elevated. The surgeon and the assistant hold the camera stand on the right side of the patient (i.e., on the left side of the operating table) (Fig. 17.1).

17.3.2 Port Placement

After minithoracotomy with Pean forceps, the first port for a 5-mm thoracoscope is inserted into the intercostal space on the caudal side of the angulus inferior scapulae. To collapse the right lung, the thoracic cavity is insufflated with carbon dioxide to a pressure of 8 mmHg. The operator then inserts two working ports with a diameter of 3–4 mm on the right and left sides of the first port, under thoracoscopic vision. The right working port is placed near the axillary region and may be 5 mm in diameter, sufficient for the introduction of a clip applier. However, because carbon dioxide is likely to leak from the pneumothorax if a 3-mm instrument is inserted into the 5-mm port, additional devices may be required to maintain a clear surgical field.

17.3.3 Dissection of the Lower Pouch and Ligation of the TEF

After the azygos vein, the vagus nerve, and the descending aorta are identified and the surgical field is sufficiently large, the pressure of the carbon dioxide in the artificial pneumothorax is lowered to 4 mmHg (Fig. 17.2). The azygos vein is divided using an electrosurgical device. If postoperative bleeding is a concern, ligation or a vessel sealing system may be used. Recently, we have started to preserve the azygos vein because some reports have suggested that its retention decreases the risk of leakage and the incidence of

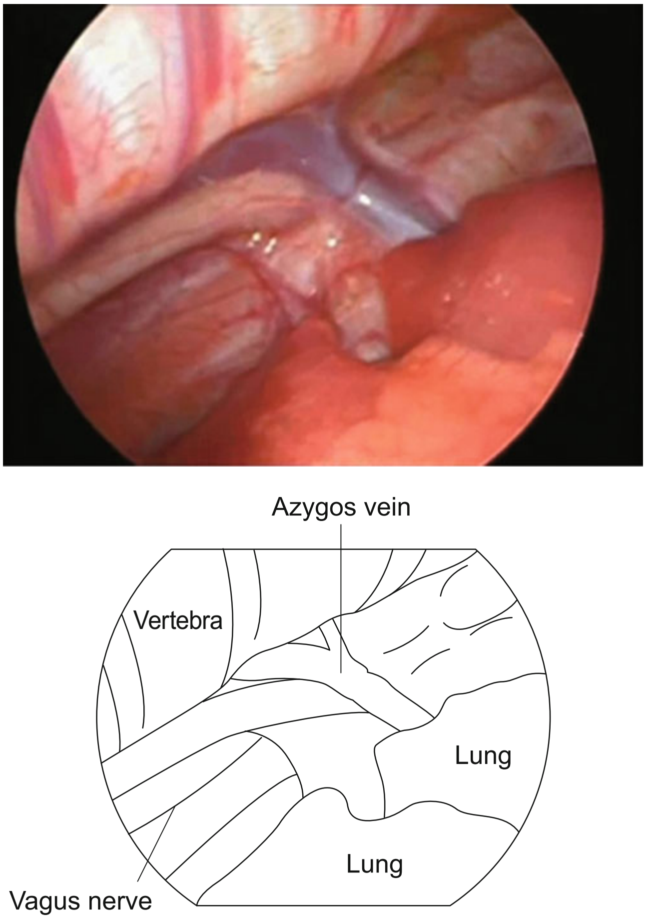

Fig. 17.2 The surgical field. The azygos vein and the vagus nerve are the main features used to guide dissection. An artificial pneumothorax induced by carbon dioxide at 4 mmHg collapses the lung and maintains an adequate surgical field

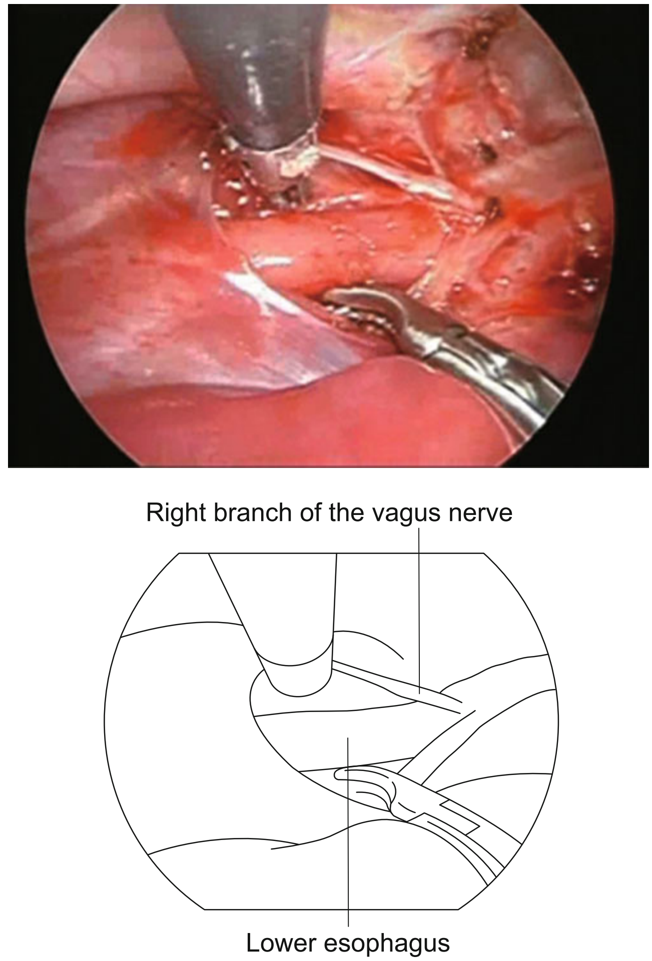

Fig. 17.3 Dissection of the lower esophagus. The lower pouch is easy to find just under the right branch of the vagus nerve

recurrent TEF, thus improving the postoperative management. After making an incision on the pleura near the vagus nerve on the caudal side of the azygos vein, the lower pouch can be easily found just under the dissected right branch of the vagus nerve (Fig. 17.3). After dissecting the lower pouch along its entire circumference, the fistula is ligated as closely to the trachea as possible using 4-0 absorbable sutures (Fig. 17.4). The TEF is resected just before starting esophagoesophagostomy. After ligating the TEF, a muscle relaxant is administered and controlled ventilation is started. The ventilation pressure is lowered to maintain the surgical field with an artificial pneumothorax, and the frequency of the ventilation is increased to prevent hypercapnia.

17.3.4 Dissection of the Upper Pouch

The upper pouch can be identified if the anesthesiologist places some pressure on the esophageal stethoscope. An incision is made in the parietal pleura and the upper pouch is dissected with a hook-shaped electrosurgical device. The upper pouch is mobilized as far as the thoracic inlet, but the surgeon must be careful to avoid damaging the membranous part of the trachea (Fig. 17.5). The distal tip of the upper pouch is resected after achieving adequate mobilization. Because it is necessary to anchor the caudal side of the upper pouch, one anchoring suture is placed on the back wall. The suture thread is taken outside the thoracic wall, and the assistant pulls it with a moderate force (Fig. 17.6).

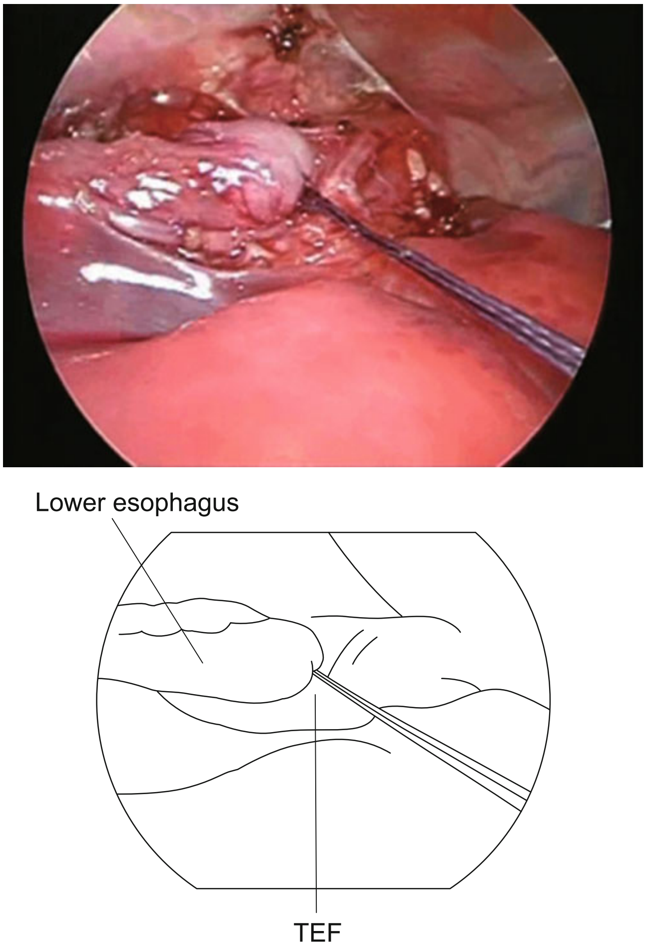

Fig. 17.4 Ligation of TEF. The fistula is ligated using 4-0 absorbable sutures. After completing esophagoesophagostomy, one or two additional sutures may be placed on the TEF stump, if necessary

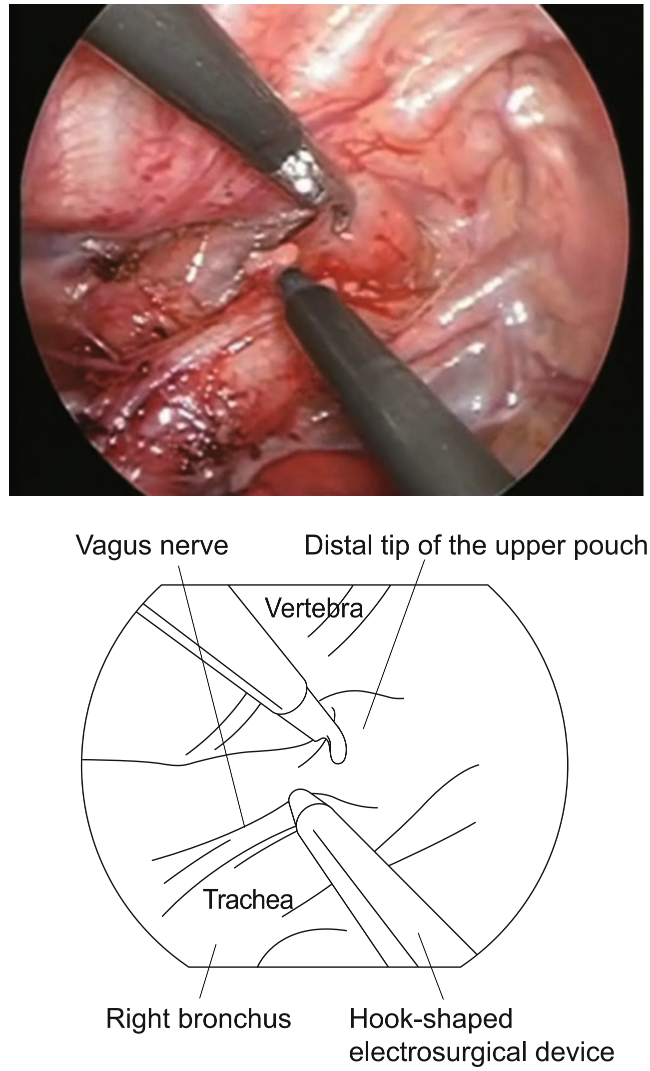

Fig. 17.5 Dissection of the upper pouch. The surgeon must be careful to avoid damaging the right branch of the vagus nerve and the membranous part of the trachea

17.3.5 Resection of TEF and the Anastomosis

When dividing a TEF, part of the back of the TEF should be left, which makes it easier to identify the small lumen of the esophagus and to place the first suture (Fig. 17.7). For anastomosis, it is easier to place the first suture in the center of the back wall, and subsequent sutures can be sequentially placed on each side of the first suture (Fig. 17.8). In conventional thoracotomy, the first and second sutures are placed at both ends, and additional sutures are placed sequentially from the back wall, but this method is not recommended in thoracoscopic surgery. Because there is no support from an assistant, it is sometimes unclear whether all layers are adequately sutured. Once anastomosis of the back wall is completed, the anesthesiologist inserts a transanastomotic nasogastric tube into the lower esophagus. Anastomosis of the anterior wall is also performed. It is important that adequate sutures that include the esophageal mucosa are placed under thoracoscopic vision (Fig. 17.9). Anastomosis is performed using a 5-0 monofilament absorbable suture with a total of about eight stitches, including four or five in the back wall and three or four in the anterior wall. Full cooperation between the surgeon and the anesthesiologist is essential during the procedure because the best results are obtained if the anesthesiologist slightly hyperventilates the

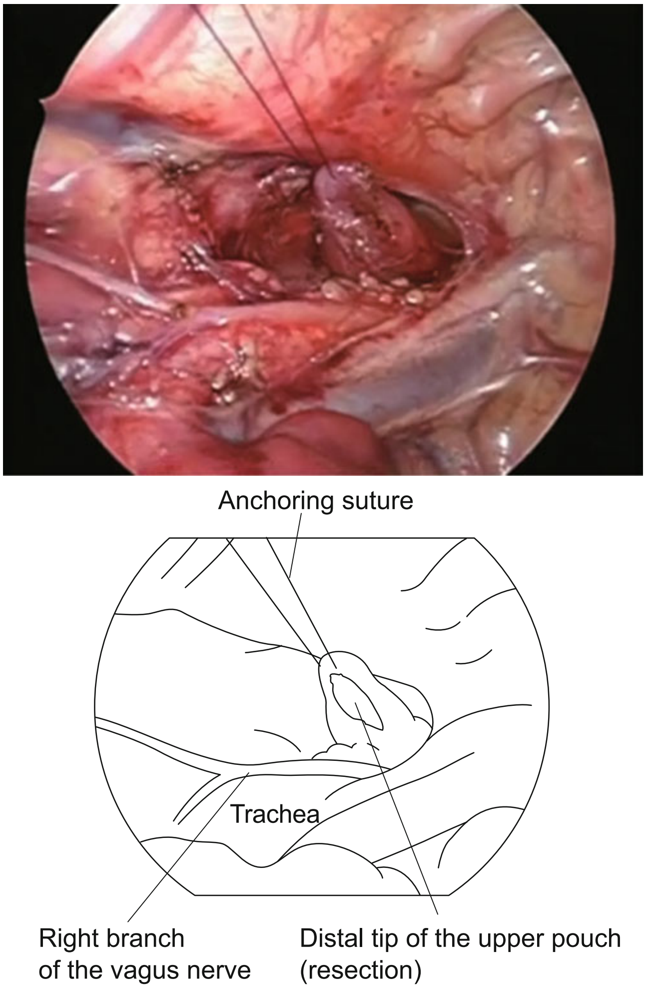

Fig. 17.6 Anchoring the caudal part of the upper pouch. After one anchoring suture is placed on the back wall, the tip of the upper pouch is cut open, and the thread is pulled to the caudal part outside the thoracic wall

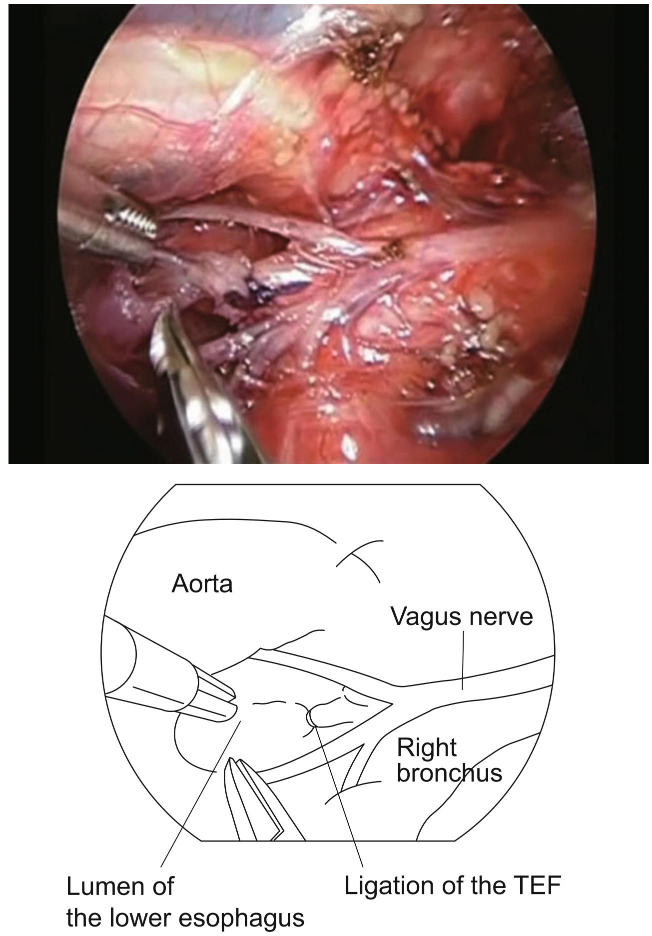

Fig. 17.7 TEF resection. After dividing the TEF, part of the back of the TEF should be left in place. After placing the first suture, the TEF can be completely separated

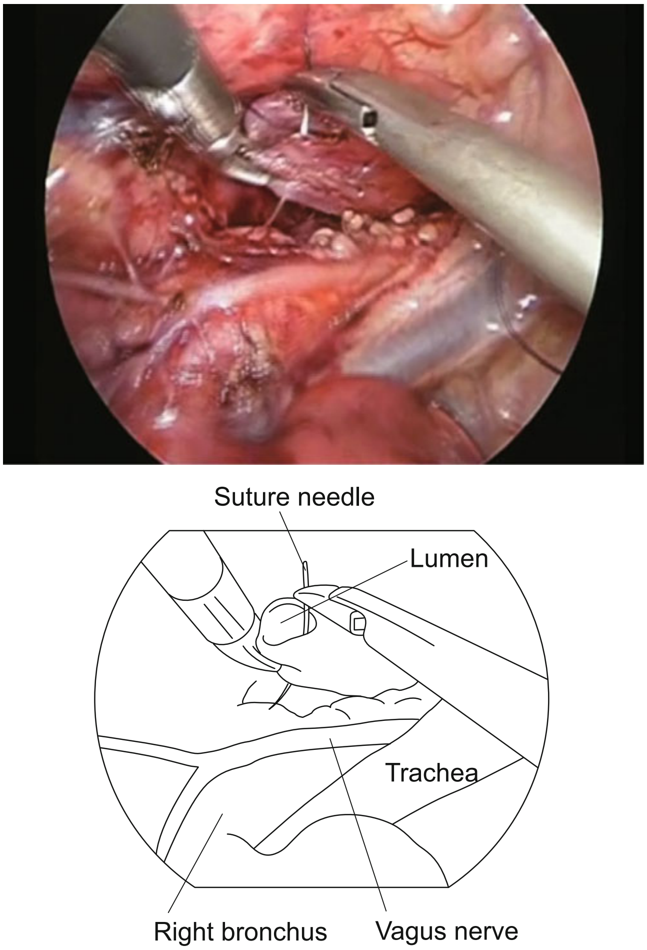

Fig. 17.8 Esophagoesophagostomy. Esophagoesophagostomy is performed using sequential 5-0 monofilament absorbable sutures. Internal ligation or extracorporeal ligation may also be performed. The surgeon must be careful to avoid splitting the lower esophagus

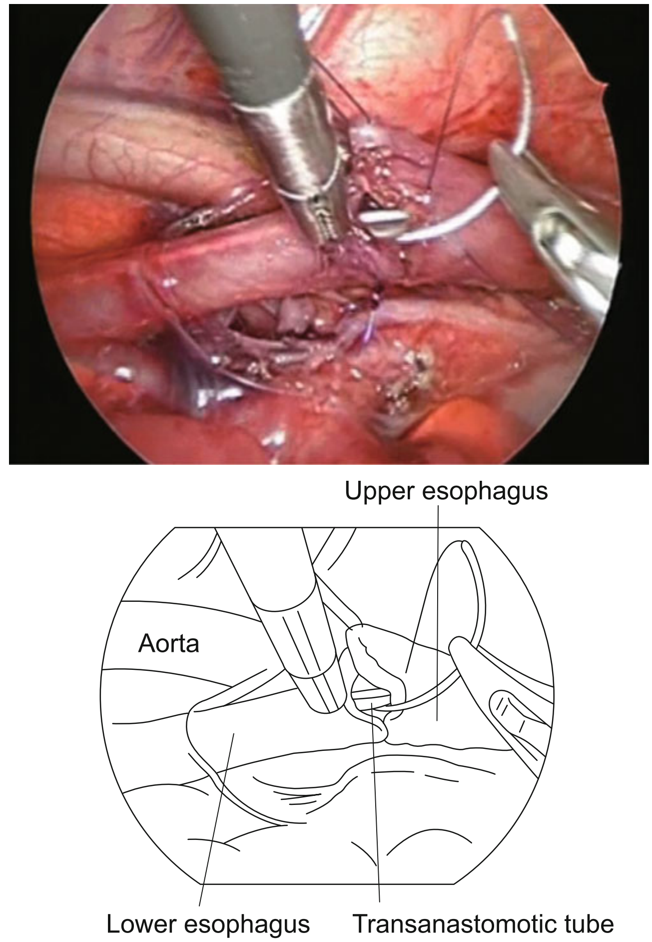

Fig. 17.9 Anastomosis of the anterior wall after inserting a transanastomotic nasogastric tube. It is important that adequate sutures that include the esophageal mucosa are placed. Sutures may be placed on the anterior wall, from the exterior surface to the interior surface of the esophagus

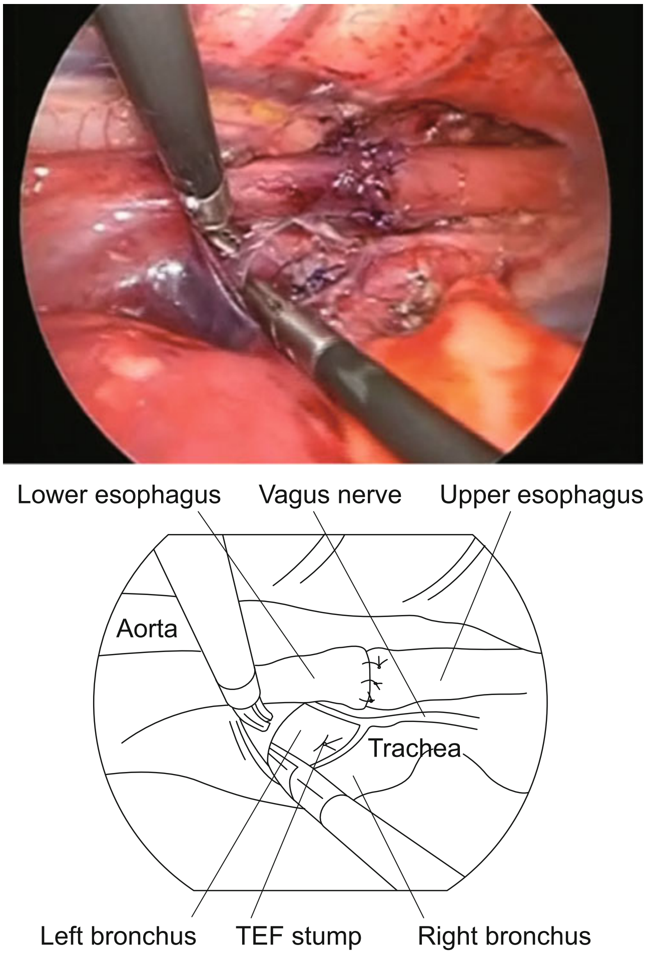

Fig. 17.10 Image obtained after completing anastomosis. The vagus nerve near the back wall of the trachea, the bronchus, and the TEF stump after placing additional sutures is easily seen

patient just before placement of each suture and then suspends respiration for approximately 10 s while the suture is placed.

17.3.6 Additional Sutures on the TEF Stump

Once the anastomosis is completed, one or two additional sutures are placed on the TEF stump using 6-0 monofilament absorbable sutures (Fig. 17.10). After washing the thoracic cavity, a chest drain is inserted through the camera port. We do not perform gastrostomy in patients who have no other anomalies.

17.4 Postoperative Management

Because thoracoscopic EA repair is a minimally invasive procedure, the muscle relaxant is stopped and the respiratory apparatus is removed if the tension of the anastomosis is low.

If postoperative contrast-enhanced X-ray fluoroscopy reveals no anastomotic stricture or leakage, oral feeding is started soon after surgery. Postoperative management following thoracoscopic EA repair is similar to that after conventional thoracotomy for EA.

Lung Surgery

18

Seiichi Hirobe

Abstract

The principles of lobectomy are similar in children and adults although technical precision is required for pulmonary surgery of small infants. In general, a lobectomy includes several basic steps as follows: the handling of the fissure, vascular system, and bronchus. In most instances it is better to dissect out and control the pulmonary arterial branches first, venous drainage second, and the bronchus last.

Keywords

Lobectomy • Lung surgery • Axillary skin crease incision

18.1 Optimal Timing of Operation

The management of asymptomatic congenital lung malformations remains controversial, and the optimal timing of surgery for these lesions continues to be debated. Human lung development after birth consists of three stages: stage I, the alveolar proliferation stage from birth to 1 or 2 years of age when alveolar number increases quickly, then slows after 4 years of age, and stops at 10 years of age; stage II, the stage of microvascular maturation and proliferation of the vascular bed at 2–3 years of age; and stage III, the stage of late alveolarization, which continues up to the alveolar period of maturity.

The mechanisms that affect lung function after lobectomy in children are compensatory alveolar multiplication and overinflation of the remaining lung. Alveolar multiplication of the remaining lung mainly occurs after lobectomy in patients who are younger than 1 year at the time of operation, whereas overinflation of the remaining lung mainly occurs after lobectomy in patients who are 1 year or older at the time of operation. Based on the result of postoperative lung function tests, we suggest that lung resection be performed before the age of 1 year.

18.2 Anesthesia and Position of Patient

Many lung operations in children can be successfully performed using a standard endotracheal tube without single-lung ventilation. But the single-lung ventilation can reduce expansion of the lung excessively; it is convenient for surgical exposure. Single-lung ventilation can be accomplished in infants by the use of bronchial blockers.

Thoracotomy is performed with the patient in a lateral decubitus position (Fig. 18.1). An axillary roll is used and appropriate padding of the legs is done to avoid pressure damage. The upper arm is allowed to lie on the same side with support to prevent excessive stretching of the arm as well as the brachial plexus.

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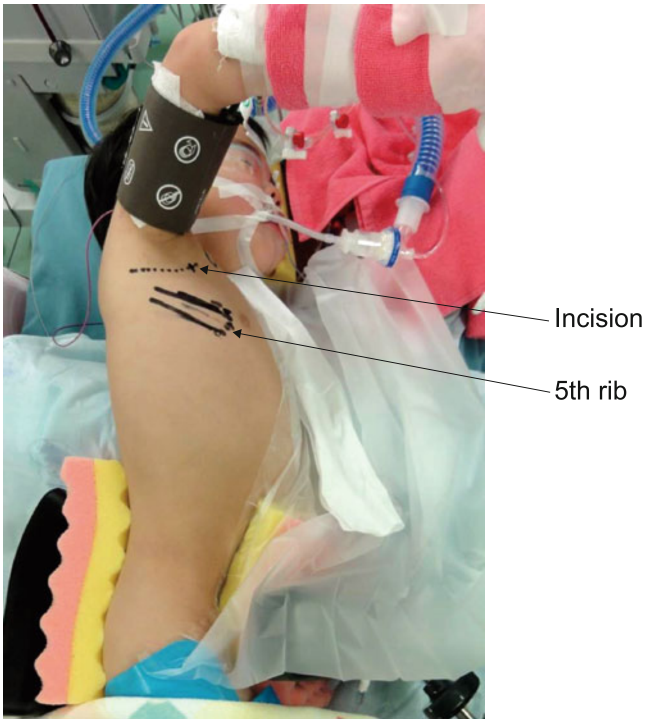

Fig. 18.1 Surgical position

18.3 Incision and Thoracotomy

With the great interest in minimally invasive techniques for treating various pathologies, we have widely applied an integrated surgical approach that combines muscle-sparing minithoracotomy and video assistance using mainly direct visualization of the lung resection.

In 1998 Bianchi et al. published their work on axillary skin crease incision. Operative access to the axilla is achieved with the infant in the lateral position. The incision follows the course of an axillary skin crease, preferably the highest possible (Fig. 18.1). The dissection carried between the pectoralis major and latissimus dorsi keeps both muscles intact. The serratus anterior is split along the line of its fibers to expose the ribs, and the intercostal muscles are divided along the upper border of the sixth rib for thoracotomy via the fifth intercostal space.

18.4 Visual Field for Lobectomy (Fig. 18.2)

The intercostal muscles are opened and the pleural space is entered. A small retractor is used to spread the ribs and incision of the intercostal space is completed anteriorly and

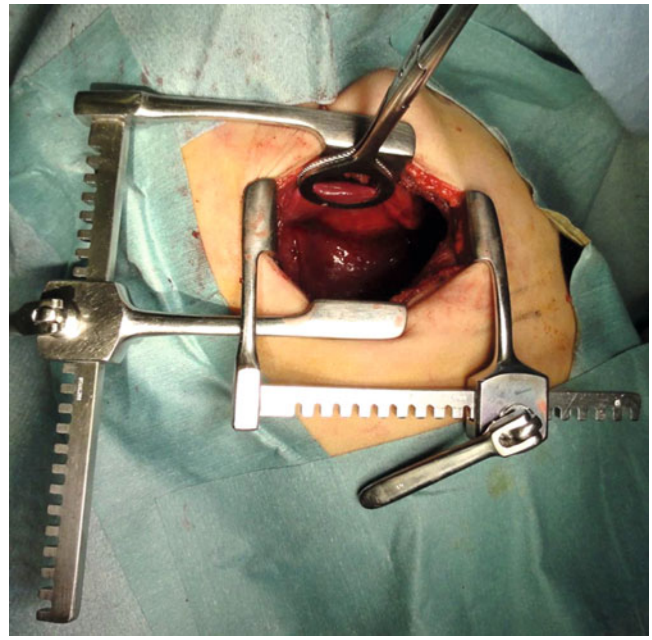

Fig. 18.2 Visual field for lobectomy

posteriorly. To optimize the surgical exposure, a second spreader is placed at right angles to the first to retract the skin anteriorly and the latissimus dorsi posteriorly. Splendor tends to press an axillary artery; we placed pulse oximeter on a fingertip for monitoring O_2 saturation.

A dimension of the incision is about 6 cm and we could not insert a hand but only four fingers. So, to optimize the surgical exposure, the operator puts on the headlight, and single-lung ventilation may be recommended to reduce expansion of the lung excessively. To get the visual field, the lung could not be pulled outside a wound, affected lobe is held by a gripping forceps, and normal lobe is spread by spatula gently.

18.5 Principles of Lobectomy

The principles of lobectomy are similar in children and adults although technical precision is required for pulmonary surgery of small infants. In general, a lobectomy includes several basic steps as follows: the handling of the fissure, vascular system, and bronchus (Figs. 18.3, 18.4, 18.5, and 18.6). In most instances it is better to dissect out and control the pulmonary arterial branches first, venous drainage second, and the bronchus last. Some of the pulmonary arterial vessels in the lobe pass along the fissure. The purpose of the handling of the fissure is to clarify the directions of the

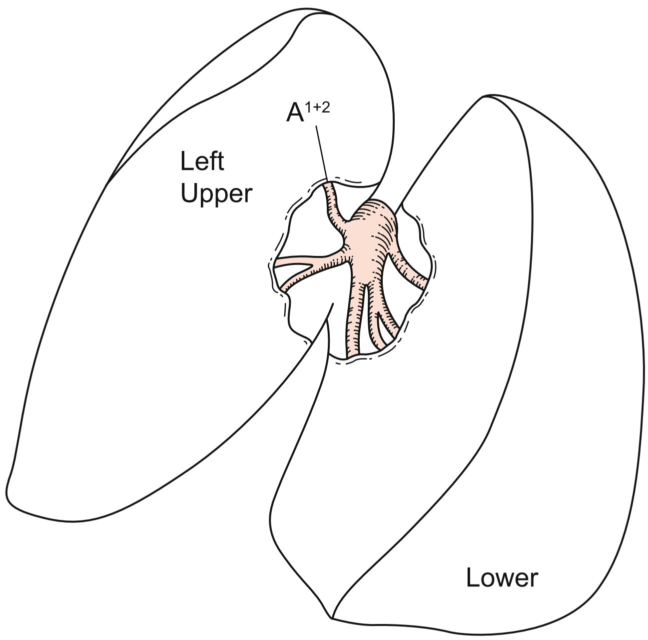

Fig. 18.3 Left lower lobectomy: the interlobar fissure is exposed

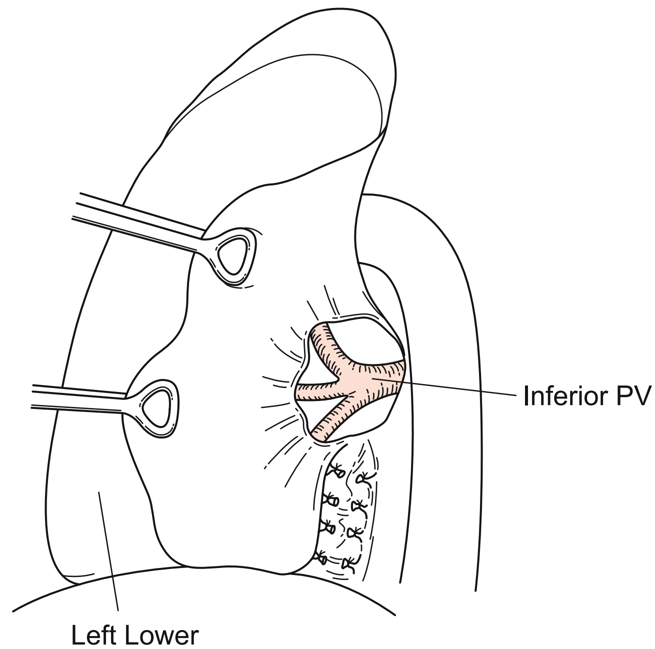

Fig. 18.5 Exposure of the inferior pulmonary vein

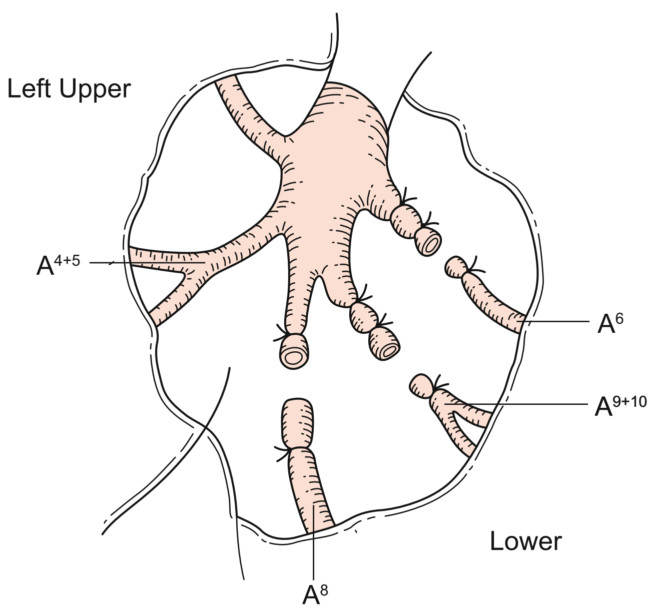

Fig. 18.4 Ligation of A^6, A^{9+10}, and A^8

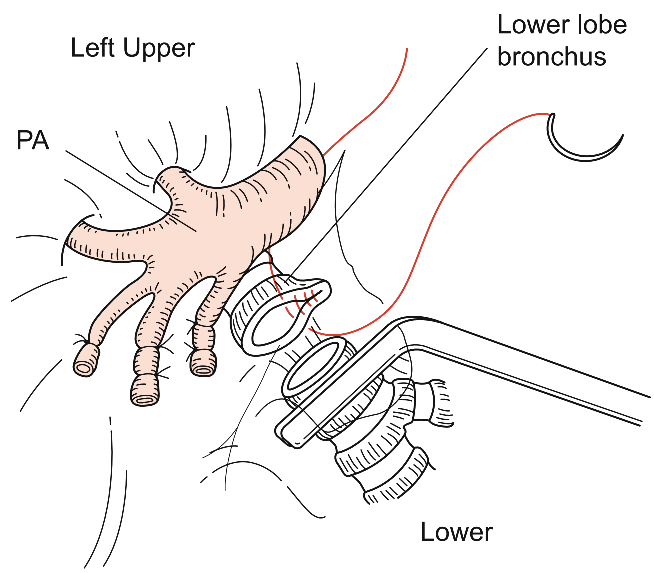

Fig. 18.6 Handsewn bronchial closure

pulmonary artery branches in the lobe to be resected and to separate the fused lung tissue between the adjacent lobes (Figs. 18.3 and 18.4). For patients with a well-developed fissure, the separation can be performed with an electric surgical knife or even scissors. Blunt and sharp techniques are combined for the separation. The pleura and the adhesions are loosened to prepare for the hilar dissection.

For patients with a partially or completely fused fissure, an artificial fissure is created to expose all of the blood vessels and bronchi in the lobe, which is followed by the lobectomy (Figs. 18.7, 18.8, and 18.9). The key of the first approach for the creation of an artificial fissure within the lung parenchyma is separating a channel in the lung parenchyma with a Kelly forceps or small forceps. The separated lung tissue can be sutured mechanically or manually. A continuous stitching with 4-0 Prolene thread is used to suture

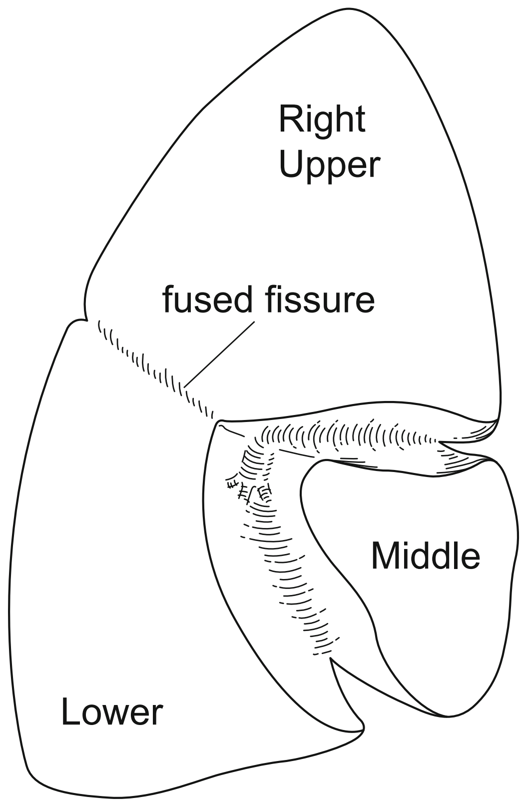

Fig. 18.7 Right upper lobectomy: fused fissure

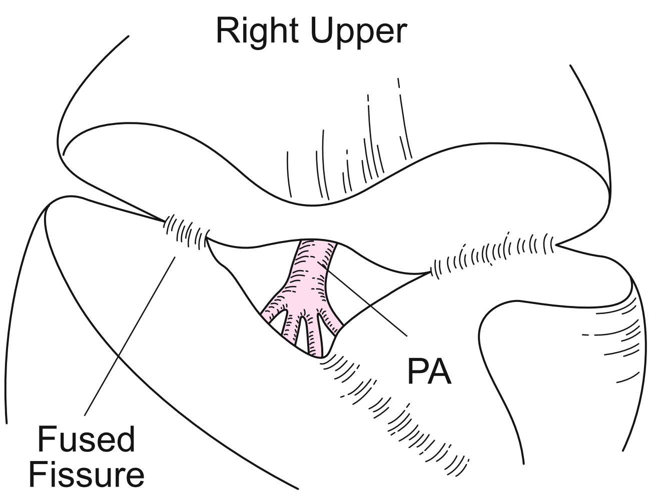

Fig. 18.8 Right upper lobectomy: the interlobar fissure is exposed

the cut edges of the lung tissue. If the fissure is poorly developed and the tissue adjacent to the fissure is essentially fused, a cutting stapler can be used to cut open some tissue at the location of the fissure. After getting close to the pulmonary vein, the cutting stapler can be guided by the previously separated channel and then triggered to completely cut open the fissure.

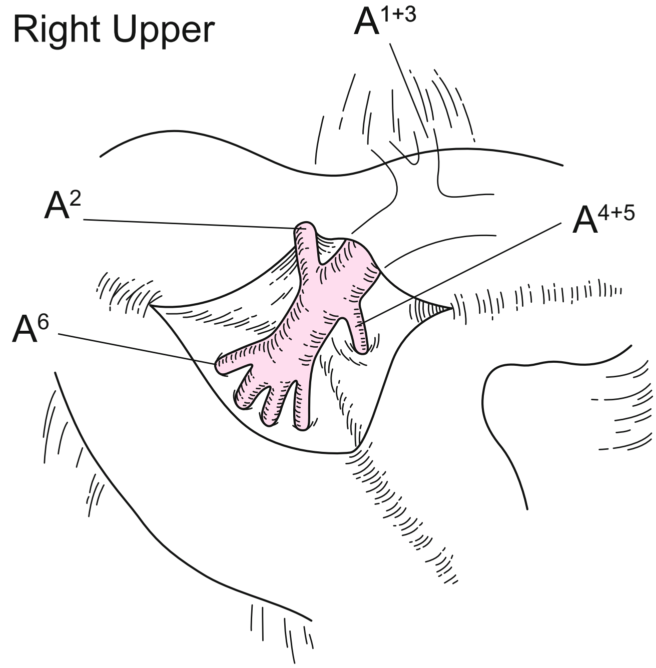

Fig. 18.9 Exposure of the pulmonary artery

18.6 Left Lung Lobectomy (Figs. 18.3, 18.4, 18.5, and 18.6)

The left upper pulmonary artery is located at the upper pole and behind the hilum and is divided into the A^3 and A^{1+2}. The former is in front of the left upper pulmonary bronchus, and the latter is behind the left upper pulmonary bronchus, while the lingual segment (A^4, A^5) is in the middle of the fissure.

The left lower pulmonary artery is divided into A^6 in the back of the oblique fissure and A^{9+10} and A^8 in the front middle of the oblique fissure. The left upper pulmonary vein is located in front of the left hilum, and the left lower pulmonary vein is located at the lower pole of the left hilum.

Left lower lobectomy is illustrated in Figs. 18.3, 18.4, 18.5, and 18.6. The interlobar fissure is exposed by retraction of the upper lobes superiorly and the lower lobe inferiorly. The branches of the interlobar portion of the pulmonary artery are exposed carefully. The thickness of the wall of the pulmonary arteries is smaller than one-half the average arteries; on the other hand, the blood flow volume is much. So, meticulous dissection of the individual arterial brunches, ligation, and division are indicated. We used to separate vessels using two small spatulas with both hands, which is safe for deep detachment (Fig. 18.11). Along the front-up edge of the pulmonary artery, the arterial sheath is cut open, and the lung parenchyma is stripped for approximately 1 cm toward the distal end of the artery along the sheath, which

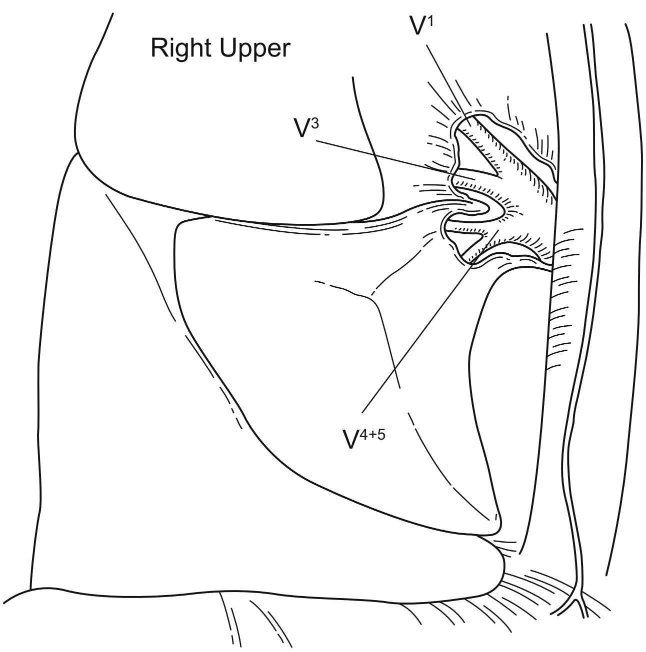

Fig. 18.10 Exposure of the superior pulmonary vein

then exposes the branching of the artery from the left pulmonary artery trunk. When a sufficient length of artery is freed, it can be ligated. All the vessels are best managed by ligation with nonabsorbable suture as well as suture ligation proximally. For left lower lobectomy, vessels (A^6, A^{9+10}, A^8) are identified and ligated (Fig. 18.4). Peripheral placement of the ligatures is particularly important in small infants to avoid compromise of the arterial supply to the remaining upper lobe.

The lobe is then retracted anteriorly to expose the posterior hilum. The inferior pulmonary vein is exposed by opening the inferior pulmonary ligament and carrying the pleural dissection upward to isolate and facilitate ligation of the inferior pulmonary vein (Fig. 18.5).

After division of the arterial and venous branches of the left lower lobe, adventitial tissue surrounding the lower lobe bronchus is cleared away and the accompanying bronchial artery is ligated and severed. The bronchus only needs to be cleared to show its origin, as further dissection may compromise the blood supply and delay healing of the bronchial stump (Fig. 18.6).

Bronchial stump closure is easily and reliably done in adults and older children with commercial surgical stapling devices. In infants and small children, this is undesirable

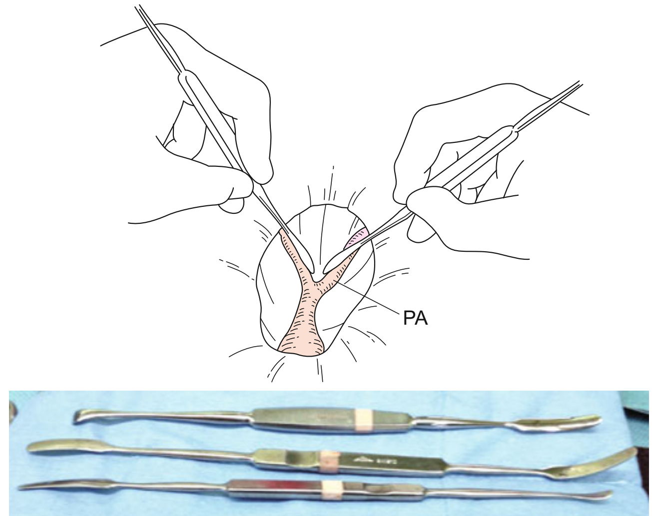

Fig. 18.11 The appearance of two small spatulas with both hands

because the size of the instrument may make its application insufficiently precise. When working with small airways, the difference between an acceptable and compromised residual bronchus can be exceedingly small. For these reasons, a carefully handsewn bronchial closure is preferable in infant and small children.

18.7 Right Lung Lobectomy

Right upper lobectomy is illustrated in Figs. 18.7, 18.8, 18.9, and 18.10. The oblique fissure is opened between the upper and lower lobes. This permits the dissection and isolation of A^2, which ordinarily comes off the pulmonary artery after the middle lobe branches (Fig. 18.9). The superior lobe vein is identified and dissected laterally, usually exposing three segmental pulmonary veins (Figs. 18.10 and 18.11). The middle lobe veins entering the superior pulmonary vein must be identified and preserved. It is often easier and safer to ligate the individual venous branches peripherally. These are visualized by retraction of the lung posteriorly in order to gain wider exposure of the anterior hilum.

After division of the arterial and venous branches of the right upper lobe, adventitial tissue surrounding the bronchus is cleared away. After division of the bronchus, the stump is closed with interrupted sutures of nonabsorbable material.

19 Thoracic Empyema

Toshihiro Muraji

Abstract

Video-assisted thoracoscopic decortication is an effective treatment for empyema of the chest cavity, if it is done during the exudative phase in various aspects, such as technical difficulty, incidence of postoperative complications, time to apyrexia, duration of drainage, and length of hospitalization. Only two ports are suffice, one for a telescope and the other for working forceps. The working space is established by pushing the telescope itself into the cavity. Decortication is made by ripping off the fibrous peel from the surface of the lung with forceps.

Keywords

Empyema • Decortication • VATS

19.1 Pathophysiology

Empyema is a well-recognized complication of pneumonia. Approximately 25 % of these patients are less than 1 year of age. The causative organisms include *S. pneumoniae*, *S. aureus*, *H. influenzae*, and anaerobic bacteria.

There are three phases of manifestation:

Stage 1 (the exudative phase): Thin fluid accumulates in the pleural space of the affected side of the chest.

Stage 2 (the fibropurulent phase): It is characterized by accumulation of large quantities of pus with many polymorphonuclear leucocytes and fibrin in the chest cavity. As the fluid thickens, loculation begins and the lung is progressively less expandable.

Stage 3 (the organizing phase): Fibroblasts grow into the exudate on both the visceral and parietal pleural surface, producing membranous peel. The lung is firmly fixed.

19.2 Historical Background

Traditionally, nonoperative treatment with chest drainage and intravenous antibiotic administration had been the standard, while it was sometimes complicated with thick fibrous thickening of the pleura compressing the affected side of the lung. Surgical intervention, namely, "decortication" used to be considered only in stage 3, after an active inflammation was controlled. However, this surgical management was made through a standard thoracotomy often with a lot of blood loss requiring blood transfusion.

Two new treatment modalities have been described since the 1990s. These are an early intervention with video-assisted thoracoscopic surgery (VATS) and the other nonoperative therapy with fibrinolysis. VATS has been prevailing in pediatric population since 1993, when thoracoscopic procedure for empyema was first reported [1].

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19.3 Diagnosis

Diagnosis is made under the condition of worsening pneumonia with symptoms of fever, tachypnea, shortness of breath, cough, and even cyanosis. Chest X-ray films show pleural effusion, laterally and posteriorly in an early phase and later a solid mass of fibrin, which does not shift with a postural change. Ultrasonography is especially important to locate pleural fluid loculation when performing diagnostic thoracentesis for culture and sensitivity. CT scan is recommended only when the location of fibrin mass is not surely identified with US (Fig. 19.1).

19.4 Principles of Treatment

Appropriate antibiotic therapy with an adequate drainage for maintenance of lung expansion is the first-line management. VATS is more effective, if it is done within 4 days after diagnosis. Such an early surgical intervention allows to minimize technical difficulty, incidence of postoperative complications, time to apyrexia and duration of drainage, and length of hospitalization [2]. However, use of fibrinolysis is also considered as an effective adjunctive management for drainage in empyema that was first introduced by Stringel [3] in a pediatric population in 1994. He used urokinase 1,000 IU/ml, instilled 20 ml four times a day. The chest tube was clamped for 2 h after instillation. In Avansino's meta-analysis paper of primary VATS or nonoperative management [4], primary VATS was superior in any aspects, such as hospital mortality, re-intervention rate, length of tube thoracostomy, and duration of antibiotics. More recently, it was reported that instillation of urokinase 1,000 Iu/ml, 56 ml/m^2 for 1 h with a postural change, is highly successful, and only 9.8 % required operative intervention out of 41 children [5].

The diagnosis and management is summarized as follows: first of all, take two X-ray films of the chest, one supine and the other upright position to determine the stage of the patient. A shift of fluid collection by the postural change suggests that the patient is in stages 1–2. In stage 1, start antibiotics with chest tube drainage, followed by fibrinolysis if the condition is worsening. However, one had better to consider surgical intervention within 4 days of diagnosis. For the patients in stage 2, primary VATS is recommended to avoid open decortication which is maximally invasive.

19.5 Operations

General rule of posture of the patient for thoracoscopy is to lean a patient posteriorly to clear off the lung out of the way to approach to anterior part of the chest and lean anteriorly to

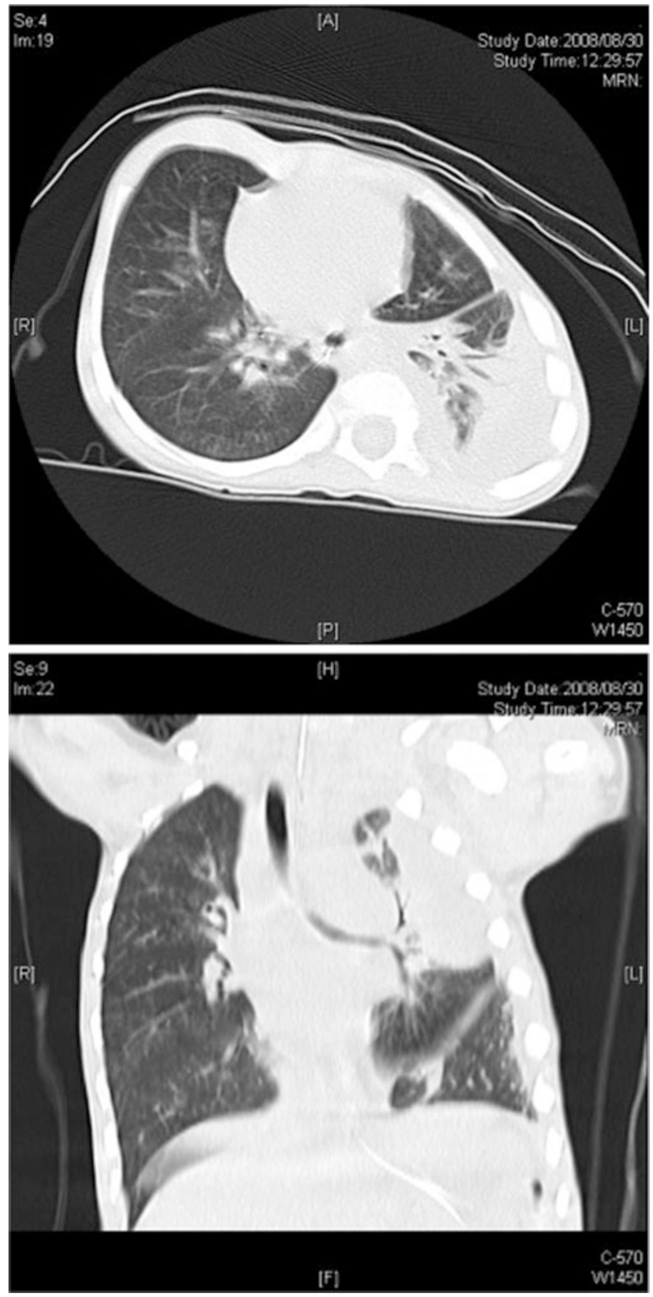

Fig. 19.1 CT scan: Loculation of thick pleural fluid in the chest cavity is well recognized with CT scan, suggesting the site of the first port

approach to the posterior (Fig. 19.2). But it is not mandatory for VATS when various positionings are difficult in a patient with cerebral palsy with scoliosis.

Appropriate intercostal space (ICS) should be selected for the first port by careful observation of chest X-ray film and ultrasonography. A usual loculation occurs around the sixth ICS on the midaxillary line. The first trocar is inserted with a telescope insufflating the CO_2. The working space is established by pushing the telescope itself into the cavity (Fig. 19.3), allowing the site of the second port to be decided

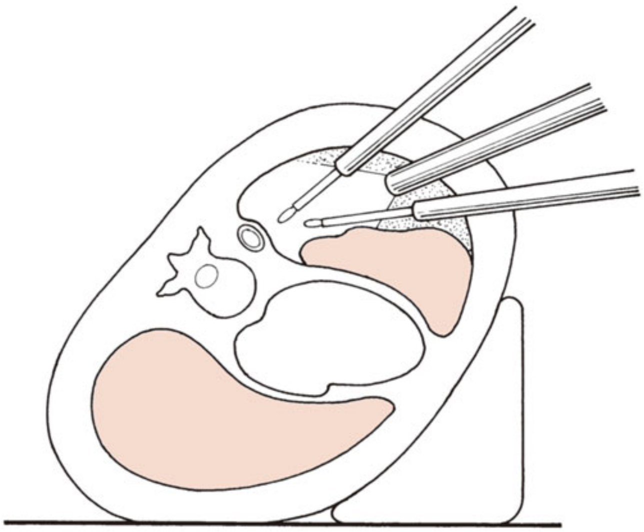

Fig. 19.2 Posture of the patient: When the pus is loculated in the posterior part, the semi-prone position is recommended to allow the lung go down out of the way

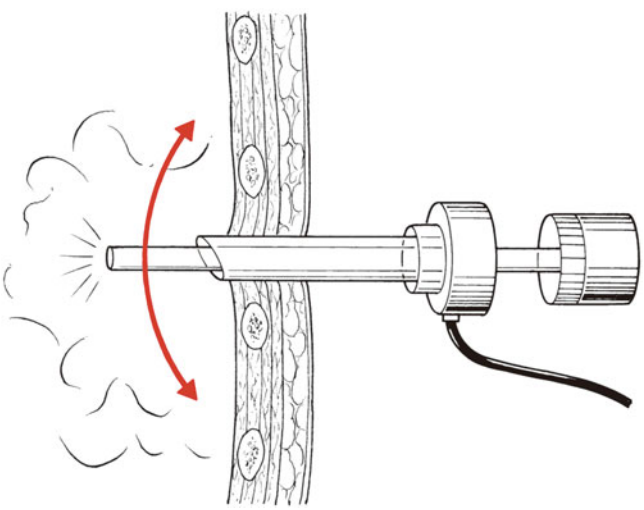

Fig. 19.3 The first port is preferably a transparent disposable trocar, allowing the location of the tip of the port and scope visible in the chest cavity. The working space is established by pushing the telescope itself into the cavity

for the best functional ICS by telescopic guidance along the anterior axillary line. Decortication is performed by ripping off the fibrous peel from the surface of the lung with forceps (Fig. 19.4). Irrigation followed by an insertion of a bore chest tube completes the procedure. Postoperatively, the chest tube is removed when fever subsided. Antibiotics are used given orally for 1 week after discharge. Opacity in the affected site of the lung field on the chest X-ray film continues for several days. However, remaining small amounts of fibrous exudates are going to be cleared by macrophages.

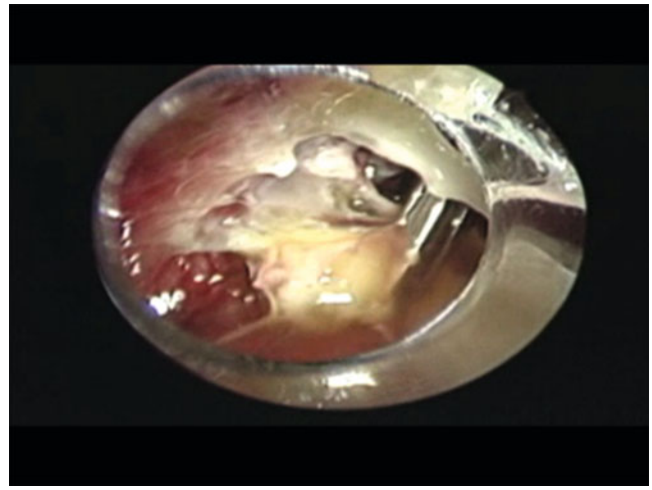

Fig. 19.4 The fibrous peel is ripped off from the surface of the lung with forceps

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20 Congenital Diaphragmatic Hernia and Diaphragmatic Eventration

Tatsuo Kuroda

Abstract

Surgical procedures for representative pediatric diaphragmatic diseases, congenital diaphragmatic hernia and diaphragmatic eventration, are described in this chapter. In congenital diaphragmatic hernia, a repair through laparotomy under direct vision is the most common procedure. Patch repair is sometimes required for huge diaphragmatic defect. Recently, thoracoscopic repair is applied more often especially for the patients with stable respiratory state. Diaphragmatic reconstruction using abdominal muscle flap can be an option for huge defect in consideration of growth. In diaphragmatic eventration, plication to avoid paradoxical movement of the diaphragm is performed.

Keywords

Congenital diaphragmatic hernia • Direct suture repair • Patch repair • Thoracoscopic repair • Abdominal muscle flap • Diaphragmatic eventration • Plication

20.1 Congenital Diaphragmatic Hernia

20.1.1 Preoperative Management

In the neonatal patients presenting critical respiratory distress, stabilization of respiratory state and hemodynamics for 24–48 h usually precedes surgical intervention in order to avoid pulmonary artery spasm during peri-surgical period. Surgery on ECMO immediately after birth may be an optional strategy. Consideration should be paid in case of applying a less conventional surgical procedure such as an endoscopic repair and a repair using the native muscle flap, regarding (1) how large the diaphragmatic defect is, and (2) if the general condition permits the procedures.

Whatever the procedure is, placement of nasogastric tube at the proper position for drainage of gastric content and glycerin enema to reduce meconium in intestines and to empty the bowel are mandatory before operation.

20.1.2 Operations

20.1.2.1 Direct Suture Repair Through Laparotomy

Skin Incision and Operative Field (Fig. 20.1)

Left subcostal incision approximately 1.0 cm below the costal margin provides an excellent exposure of the left diaphragm and the defect. Left lobe of the liver may be retracted rightward or upward to visualize whole diaphragmatic defect. In order to retract the liver, skin incision reached to the midline may be more convenient. Attention should be paid that the lateral end of the skin incision is often very close to the lateral edge of the diaphragmatic defect. Incision should not be elongated in the lateral direction further beyond the anterior axillary line.

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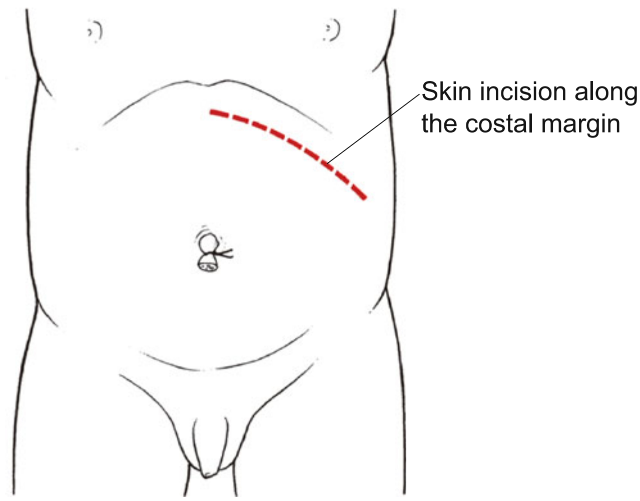

Fig. 20.1 Skin incision

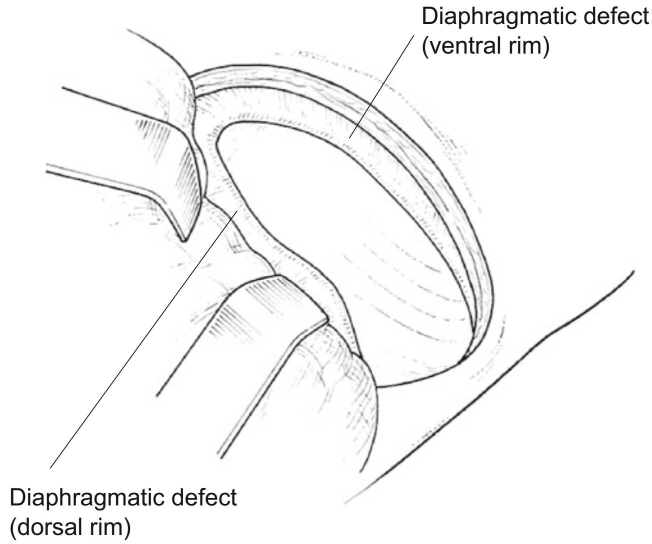

Fig. 20.2 Identification of diaphragmatic defect

Reduction of the Visceral Organs

Visceral organs herniated into the pleural cavity should be pulled down to the peritoneal cavity with the most gentle maneuver. Especially, splenic injury must be avoided, because opportunity to apply ECMO for severe respiratory distress is lost under incomplete control of hemorrhage. Spleen and the stomach should be pulled out together. Sometimes gauze wrapping makes holding of the organs a lot easier.

Identification of Diaphragmatic Defect (Fig. 20.2)

The ventral rim of the diaphragmatic defect is then identified and grasped with Allis clamp. By lifting these clamps, the median edge of the diaphragmatic defect can be well visualized. In case of huge defect, identification of the dorsal rim of the defect is often difficult. Sometimes, adrenal gland and kidney locate in the chest cavity. Compression of the retroperitoneal space and retraction of the adrenal gland and the kidney in the caudal direction using an intestinal spatula are useful to identify the dorsal rim and are also beneficial to protect adrenal gland from injury.

Direct Suture Repair (Figs. 20.3 and 20.4)

3-0 atraumatic needles are usually used to repair the defect. Knot horizontal mattress suture may be preferable. Knot suture should be started from the median side; thus, the lateral edge of the defect would be more easily identified. In case that dorsal lateral rim is not well developed, the ventral rim can be sutured directly with the chest wall.

Additional Procedure

Ladd operation is added in case that the patient has malrotation.

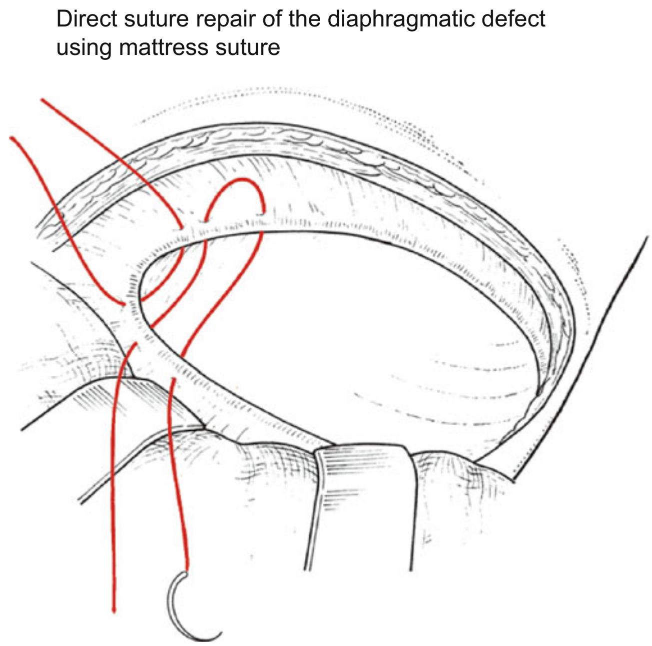

Fig. 20.3 Direct suture repair

20.1.2.2 Patch Closure of the Diaphragmatic Defect

Dorsal Suture (Fig. 20.5)

When the diaphragmatic defect is so huge that direct suture is not feasible or may cause a major deformity of the thorax, Dacron or Teflon patch is used to close the defect. First, the patch material is trimmed to fit the dorsal rim of the diaphragmatic defect; thereafter, the patch and dorsal rim are sutured with knot mattress sutures. Similarly to the direct rerepair, median suture should be preceded.

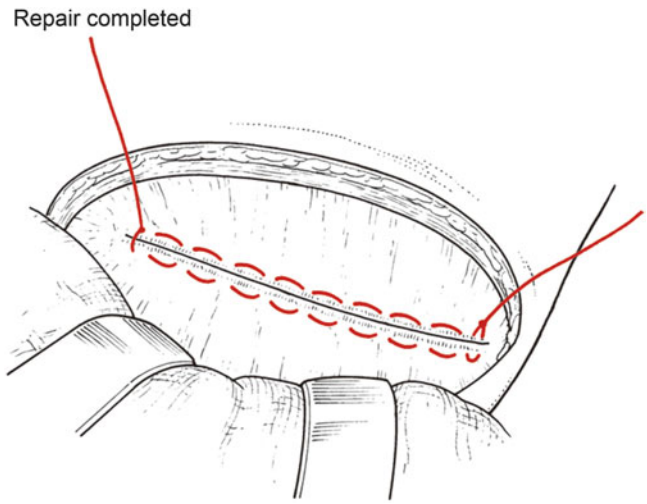

Fig. 20.4 Repair completed

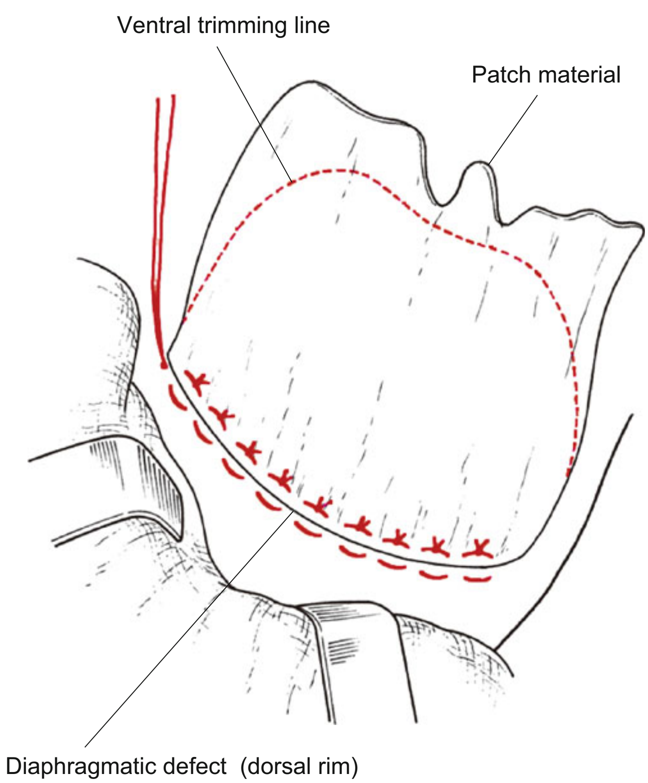

Fig. 20.5 Patch repair, dorsal suture

Ventral Suture (Fig. 20.6)

Subsequently, the ventral rim and the patch are sutured with the loosest tension to avoid relapse of hernia. Diaphragm is reconstructed to form a high dome using the patch. Flat and tensioned patch repair should be avoided. Figure 20.6 shows the actual way of the patch holding and the diaphragmatic dome figuration.

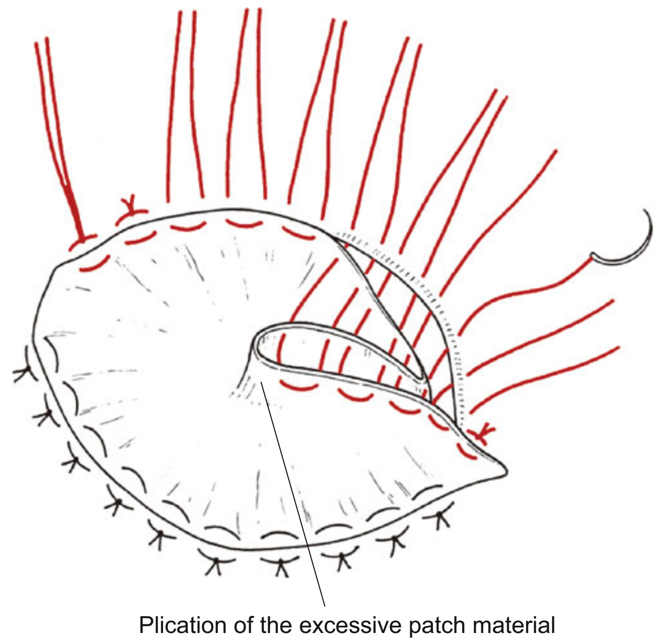

Fig. 20.6 Patch plication and ventral repair

20.1.2.3 Thoracoscopic Repair

Position and Port Design (Fig. 20.7)

CDH repair using either thoracoscope or laparoscope is reported recently in several literatures. Pushing the herniated organs into the peritoneal cavity seems technically easier than pulling the organs down out of the pleural cavity. Thoracoscopic repair is presented in the current chapter.

The patient is placed on the lateral position.

The first port is inserted either in the third intercostal space on the middle axillary line or just beneath the scapula on the posterior axillary line. Intrapleural pressure is then gradually increased up to 5 mmHg for pneumothorax.

The working ports are then inserted through the fifth and the sixth intercostal spaces.

Reduction of the Herniated Organs and Repair of the Diaphragmatic Defect

The operator should stand on the cranial site of the patient so that the operator can look down the diaphragmatic defect. Then, the herniated organs are reduced into the peritoneal cavity gently by using cherry dissector and other devices. Diaphragmatic defect is then visualized and repaired with direct suture. Patch repair is also feasible; however, many literatures recommend applying endoscopic repair only for less severe cases.

20.1.2.4 Diaphragmatic Reconstruction Using Abdominal Muscle Flap

Patch repair is sometimes associated with late complications such as relapse of the diaphragmatic hernia, because the patch does not grow and become intolerable, as the patient

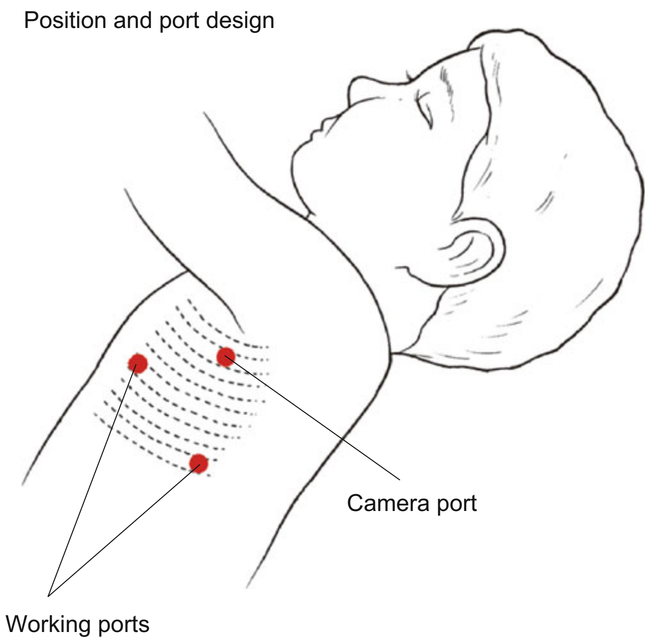

Fig. 20.7 Position and port design

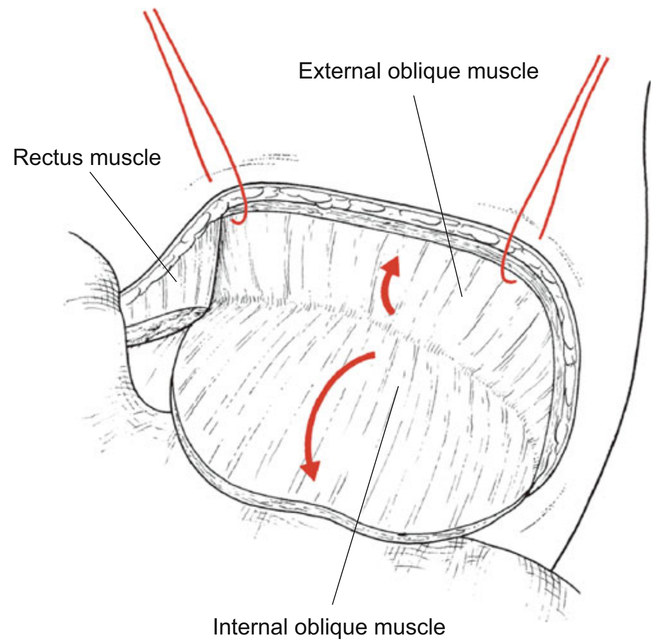

Fig. 20.9 Plasty of internal oblique muscle flap

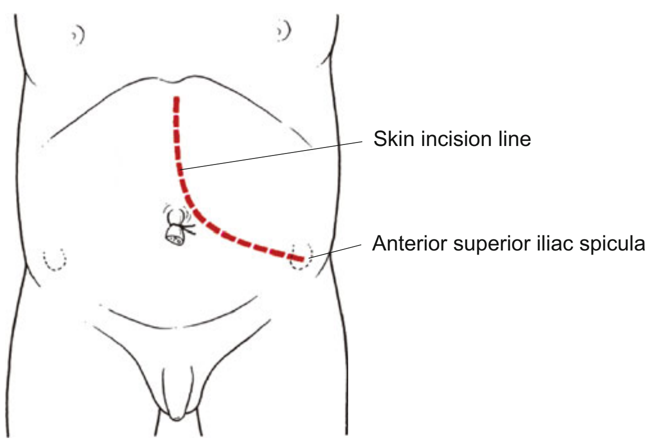

Fig. 20.8 Skin incision for repair using abdominal muscle flap

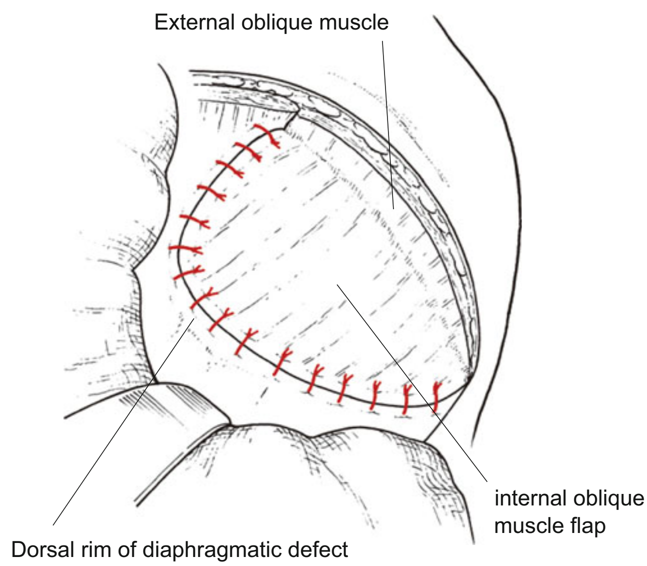

Fig. 20.10 Repair of the defect using abdominal muscle flap

grows bigger. Therefore, diaphragmatic reconstruction using native tissues such as internal oblique muscle of the abdominal wall has been proposed [1, 2].

Skin Incision (Fig. 20.8)
In order to make the muscle flap, skin incision is placed from median subcostal point to anterior superior iliac spine as shown in Fig. 20.8.

Plasty of Internal Oblique Muscle Flap (Fig. 20.9)
External and internal oblique muscle is dissected in the cranial direction, and internal muscle is mobilized. Finally, internal muscle is separated from the lateral edge of the rectus muscle, and the flap is formed.

Repair of the Defect (Fig. 20.10)
The flap is replicated and sutured with the edge of the diaphragmatic defect.

20.1.3 Postoperative Management

Hypoplasia of the lung and pulmonary hypertension are the most critical problems of congenital diaphragmatic hernia, which determine the prognosis. Usually for the critical cases presenting respiratory distress immediately after birth, intensive cardiopulmonary management is required.

Since the hypoplastic pulmonary artery is very irritable, pulmonary arterial spasm and pulmonary hypertensive attack due to surgical stress or postoperative intervention are often experienced. The patient must be managed and handled carefully with minimal manipulation in order to avoid triggering the severe pulmonary arterial attacks. Immediately after operation, surgical drapes should be removed most gently.

When general condition and respiratory state are stabilized enough, tube feeding may be started. Gastroesophageal reflux disease is frequently associated with congenital diaphragmatic hernia; therefore, it is recommended that an enteral feeding tube is inserted and placed at the upper jejunum during laparotomy.

20.2 Diaphragmatic Eventration

20.2.1 Preoperative Management

Diaphragmatic eventration develops both by congenital and acquired etiologies. Congenital defect or hypoplasia of muscular component of the diaphragm and the nerve injury during delivery are the most frequent etiologies. Major pathophysiology of the disease is respiratory insufficiency because of the paradoxical movement of the paralyzed and elevated diaphragm; therefore, the surgical procedures for diaphragmatic eventration are directed to immobilize the relaxed diaphragm by plication. The most patients are not on respirator, but require mild oxygen therapy and precise monitoring for hypoxemia and hypercapnia. In case of progressive hypercapnia, urgent operation is needed. Emptying of the bowel makes the surgery safer; therefore, no per oral feeding and glycerin enema are recommended preoperatively.

20.2.2 Operations

20.2.2.1 Diaphragmatic Plication

Approach to the Diaphragm

Eider transthoracic approach or transabdominal approach is useful to reach the diaphragm. Transthoracic approach may be more popular in order to avoid the possibility of ileus. Technically, pushing down the elevated diaphragm is often easier than pulling down the diaphragm separately from the lung. In transthoracic approach, the chest is opened through the sixth or lower intercostal space. If the chest was opened through too low intercostal space, the elevated diaphragm occupies the most of the operative field and disturbs the surgical procedures more.

In the case of transabdominal approach, lower subcostal incision is used to reach the diaphragm similarly to the skin incision for congenital diaphragmatic hernia repair.

Plication of the Diaphragm (Fig. 20.11)

In the case of transthoracic approach, the top of the elevated diaphragm is first grasped with Allis forceps and lifted (Fig. 20.11); then, the abdominal organs right behind the diaphragm are pushed down and squeezed out. Thereafter,

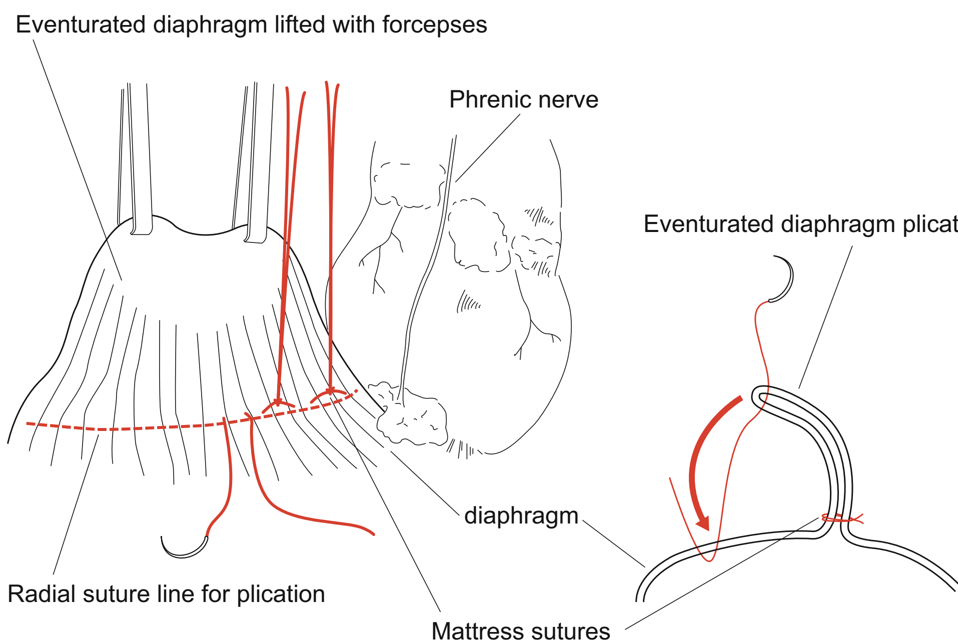

Fig. 20.11 Plication of the diaphragm

the isolated diaphragm is plicated by knot mattress sutures at the lowest line as shown in Fig. 20.11. Phrenic nerve spreads through the diaphragm in the radial directions from the median root. Therefore, attention must be paid that the suture line should be placed in the radical direction in order to avoid phrenic nerve injury. Thereafter, the plicated diaphragm is sutured and fixed with the diaphragm itself (Fig. 20.11 right). The chest was then closed usually without placing a chest tube.

In the case of transabdominal approach, the diaphragm is pulled toward the peritoneal cavity and then plicated similarly.

Recently, endoscopic plication of the diaphragm by insertion of the specific needle to the chest cavity is also reported.

20.2.3 Postoperative Management

Usually, respiratory state improves dramatically after plication of the diaphragm. Unlike congenital diaphragmatic hernia repair, it is rather rare that the patient still needs to be on respirator for long after plication. Per oral feeding is restarted as soon as intestinal movement recovers.

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For Further Reading

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Part IV

Abdominal Wall

Inguinal Hernia: Standard Procedure

21

Hitoshi Ikeda and Kazunori Tahara

Abstract

Inguinal hernia repair is usually performed after 3 months of age. The principle of repair is high ligation of the hernia sac or the patent processus vaginalis (simple high ligation). Open inguinal hernia repair by simple high ligation of the sac is called "Potts' procedure," although the principle had already been documented in the early nineteenth century. In Potts' operation, a skin crease incision, approximately 2–2.5 cm in length, is made just above the internal inguinal ring. After the external oblique fascia is incised and the inguinal canal is exposed, the cremaster muscles (the internal oblique muscle in female patients) are bluntly spread apart, and the spermatic cord structure (the round ligament in female patients) and the hernia sac are identified. Then, in male patients, the vas and the testicular vessels are freed from the sac which is then transected. The presence of the round ligament is confirmed in female patients. The proximal part of the sac is freed as high as possible at the level of the internal inguinal ring, and it is doubly ligated by transfixation with unabsorbable sutures. When sliding hernia is present, the involved viscus is reduced to the abdomen, and the sac is doubly ligated distally to the viscus.

The selective sac extraction method (SSEM) is a hernia repair in which only the hernia sac is selectively extracted and doubly ligated through a small skin incision. Although finer skills are required, SSEM is a cosmetically excellent method with high patient satisfaction.

Postoperative complications include hemorrhage, wound infection, recurrence, male testicular dislocation, and testicular atrophy.

Keywords

Inguinal hernia • Potts' operation • Selective sac extraction method (SSEM)

Although direct inguinal hernia and femoral hernia are present at incidences of 0.5–2.6 % and 1–2.6 %, respectively, inguinal hernia in children usually refers to indirect inguinal hernia which results from the persistent presence of a patent processus vaginalis [1]. It is difficult to make an accurate diagnosis of direct inguinal hernia preoperatively, and its presence is often unrecognized during the operation. Femoral hernia, on the other hand, can be diagnosed preoperatively by careful examination because the bulging is present laterally compared to indirect inguinal hernia (lateral to the inguinal ligament). In this chapter, the treatment of indirect inguinal hernia is described

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and inguinal hernia hereafter refers to indirect inguinal hernia.

21.1 Timing of Surgery and Preoperative Management

Hernia repair is usually performed after 3 months of age under general anesthesia without risks of major complications. An early operation is performed in patients in whom a risk of incarceration is deemed high. In premature infants, hernia is repaired when the adjusted age is 3 months based on due date or just before discharge from NICU by considering the general condition of the baby. Particular attention should be paid to postoperative respiration because general anesthesia may cause postoperative apnea in premature babies.

In patients with incarceration, in particular in those with the symptoms of bowel obstruction or the signs of local inflammation, an emergency operation should be urgently performed. However, when manual reduction of the incarcerated viscera is successful, hernia repair can be delayed until the local edema resolves. When the hernia contains an ovary, it is safe to perform operation within 24–48 h without an attempt at reduction if Doppler ultrasonography demonstrates blood flow of the ovary. Tenacious manual reduction may cause torsion of the ovary. When blood flow of the ovary is not observed or decreased, an emergency operation is performed. In patients with unreducible hernia of the omentum, it can be managed electively unless the signs and symptoms of strangulation are present. Unsuccessful reduction of the incarcerated bowel, the presence of redness or tenderness of the groin that indicates strangulation of the incarcerated viscera, and hernia with an irreducible, non-movable ovary are indications for an emergency operation.

Preoperative management includes restriction of oral intake, fluid infusion, premedication for general anesthesia, enema, and so on. The surgeon should mark the side of hernia repair with the patient's family and medical staffs in charge of the patient, to prevent any mistake between the right and left. In cases of emergency operation, the time from the last oral intake should be checked. Dehydration and electrolyte imbalance should be revised preoperatively.

21.2 Operations

The principle of inguinal hernia repair in children is high ligation of the hernia sac or the patent processus vaginalis (simple high ligation of the sac). Procedures used in inguinal hernia repairs in adults, i.e., tightening of the internal inguinal ring or reinforcement of the posterior wall of the inguinal canal, are unnecessary. Open inguinal hernia repair by simple high ligation of the sac is called "Potts' procedure" in Japan. However, the principle was first documented by Hamilton R. Russell in the early nineteenth century [1]. Therefore, the procedure rather should be called "the Russell procedure." He was the first surgeon who suggested that simple high ligation of the sac was sufficient to cure inguinal hernia in children. In Japan, Toyoo Yatsushiro described simple high ligation of the hernia sac in children in the early 1900s.

21.2.1 Simple High Ligation of Inguinal Hernia (Potts' Operation)

21.2.1.1 Skin Incision and Approach to the Inguinal Canal

Under general anesthesia, the spermatic cord structure, which is thickened and silky to the touch in patients with inguinal hernia, is located by palpation to determine the site of skin incision. A skin crease incision, approximately 2–2.5 cm in length, is made just above the internal inguinal ring so that the approach to the neck of the sac would be closest (Fig. 21.1). The superficial fascias, Camper's and Scarpa's fascias, are bluntly separated, and the external oblique fascia is identified by its shiny, inferomedially

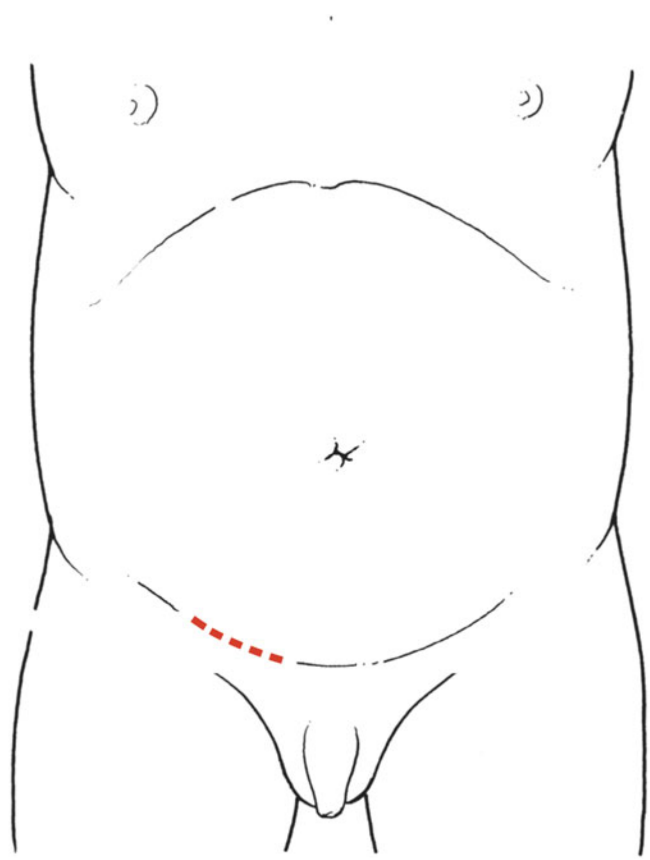

Fig. 21.1 Skin incision in Potts' operation (simple high ligation of inguinal hernia). A skin crease incision is made just above the internal inguinal ring

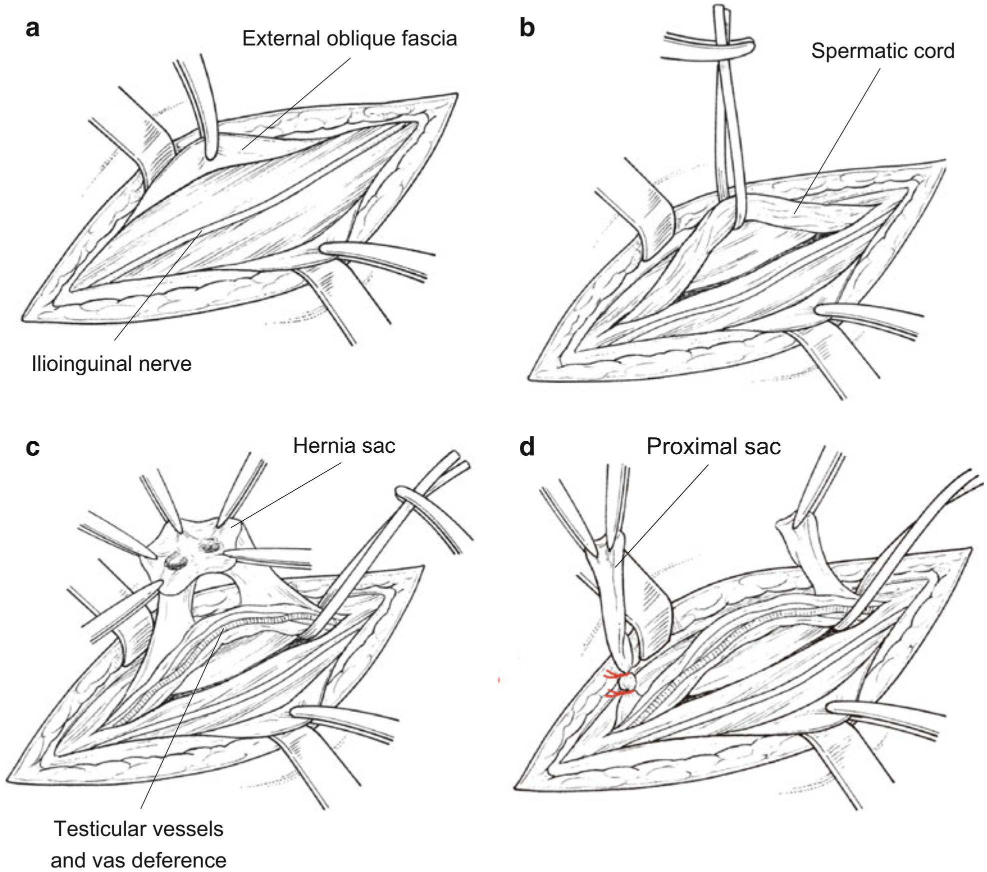

Fig. 21.2 Operative procedure of Potts' operation in male patients. (**a**) The inguinal canal is exposed, and the internal oblique muscle, the cremaster muscle, and the ilioinguinal nerve are identified. (**b**) Elevation of the spermatic cord by taping. (**c**) The vas and the testicular vessels are freed from the sac which is transected. (**d**) The neck of the proximal sac is doubly ligated

oriented oblique fibers and a feeling of tension specific to the fascia. The external oblique fascia is incised along the line of its fibers and the incision is extended to approximately 2 cm in length by spreading with scissors. Exposure of the inguinal canal leads to identification of the internal oblique muscle (caudal end is the cremasteric fibers) and the ilioinguinal nerve on the surface of the muscle (Fig. 21.2a). If the incision of the fascia is mistakenly medially shifted, the anterior sheath of the rectus abdominis muscle would be incised. This is recognized by an identification of the longitudinal muscle fibers of the rectus abdominis and the absence of the ilioinguinal nerve.

21.2.1.2 Elevation of the Cord Structure (or the Round Ligament)

The cremaster muscles (the internal oblique muscle in female patients) are bluntly separated from the shelving edge of the inguinal ligament. Then muscle fibers are bluntly spread apart, and the spermatic cord structure (the round ligament in female patients) is identified. If the spermatic cord (or the round ligament) is dorsally separated from the transversalis fascia and elevated by taping, the subsequent procedures will be easy (Fig. 21.2b).

21.2.1.3 Identification and Opening of the Sac

In male patients, the internal spermatic fascia which loosely covers the spermatic cord is incised, and the white, glistening sac of the hernia is identified by dissecting the fascia anterocranially. In female patients, the round ligament is covered by thin fasciae, and the hernia sac is connected proximally to the round ligament. Then, the sac is grasped with hemostats, opened and checked for contents. In male patients, the vas and the testicular vessels which are attached to the posterior wall of the sac are freed, and the sac is transected (Fig. 21.2c). In female patients, transection of the sac is unnecessary, but the presence of the round ligament on the wall of the sac has to be confirmed. When the round ligament is not identified, this is a clue for a diagnosis of testicular feminization, a disorder of sexual development. If a testis-like gonad is present, a small tissue sample is obtained by wedge resection and examined histologically to confirm the diagnosis.

21.2.1.4 Dissection and High Ligation of the Sac

The proximal part of the sac is freed as highly as possible at the level of the internal inguinal ring where the preperitoneal fat tissue is identified. If dissection is sufficient, the inferior epigastric vessels are identified medially to the internal inguinal ring. After the neck of the sac is freed highly enough, it is doubly ligated by transfixation with unabsorbable sutures (Fig. 21.2d). In female patients, the presence or absence of sliding of the ovary or fallopian tube is inspected. The ovary, fallopian tube, and cecum with their peritoneal attachments can be part of the hernia sac (sliding hernia). When sliding hernia is present, the involved viscus is reduced to the abdomen, and the sac is doubly ligated distally to the viscus. Then the external oblique fascia and superficial fascias are closed by absorbable sutures, and the skin is closed by subcuticular stitches with an absorbable suture.

In an emergency operation in patients with incarcerated hernia, the approach is the same as described above, except that the skin incision is somewhat longer and the inguinal canal is exposed by incising the external oblique fascia all the way to the external inguinal ring (Lucas-Championniére's operation). When strangulation of the hernia contents is reversible, they are reduced back into the peritoneal cavity and the sac is doubly ligated in a standard fashion.

21.2.2 Selective Sac Extraction Method (SSEM)

The selective sac extraction method (SSEM) is a hernia repair in which only the hernia sac is selectively extracted and doubly ligated through a small skin incision, approximately 5–6 mm in length. Although finer skills are required, SSEM is a cosmetically excellent method with high patient satisfaction [2, 3].

21.2.2.1 Skin Incision and Approach to the Inguinal Canal

Because the skin incision of the SSEM is very small, the incision has to be located at the skin just above the internal inguinal ring. In children with inguinal hernia, the spermatic cord or the round ligament is easily located by palpation. They are thickened and feel as if two pieces of silky cloth are being rubbed. A small skin crease incision is made where the spermatic cord or the round ligament overlies the pectineal line of the pubic bone lateral to the pubic tubercle.

21.2.2.2 Dissection and High Ligation of the Sac

In male patients, the entire cord structure is not pulled out of the wound. The cremaster muscles are partly elevated, and the internal spermatic fascia is identified. The hernia sac is identified by dissecting the fascia. By pushing back the muscular and fascial tissues into the wound, the hernia sac can be selectively extracted from the small wound. Then, the sac is opened and transected, and only the proximal part of the sac is extracted (Fig. 21.3a). The vas and the testicular vessels can be seen at the bottom of the proximal sac without exposing their entire length. In female patients, the hernia sac is identified and selectively extracted from the wound and is opened to confirm the round ligament. The neck of the proximal sac is doubly ligated without transecting the hernia sac.

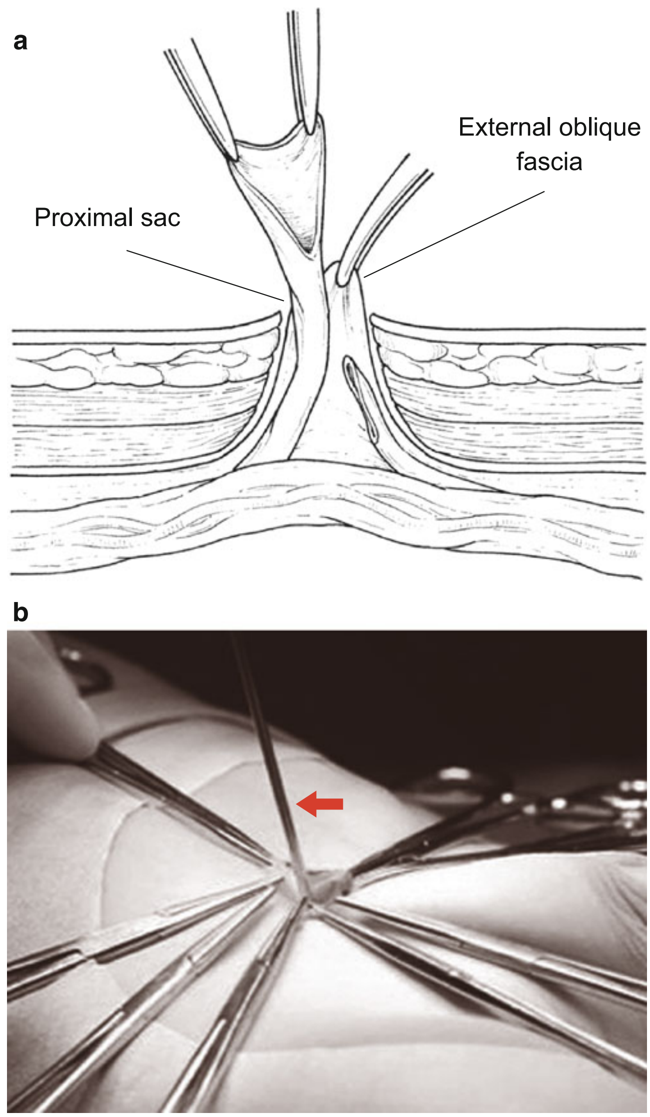

Fig. 21.3 Selective sac extraction method (SSEM). (**a**) Only the proximal part of the sac is extracted. The vas and the testicular vessels can be seen at the bottom of the proximal sac. (**b**) After the proximal sac is freed highly enough, a probe inserted into the proximal sac (*arrow*) indicates that the internal inguinal ring is just beneath the wound

The level where the sac is highly ligated is determined by identifying the preperitoneal fat tissue. After the neck of the sac is freed highly enough, a probe inserted into the proximal sac points in the direction of the pelvis (stands perpendicularly) and indicates that the internal inguinal ring is just beneath the wound (Fig. 21.3b).

21.3 Postoperative Management

General anesthesia-related complications may occur during the first 24 h after hernia repair. Large hematoma of the inguinoscrotal region or continuous oozing from the wound occurs rarely, but may be a first manifestation of hemophilia in male patients. After that, postoperative complications include wound infection, hernia recurrence, male testicular dislocation, and testicular atrophy.

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22 Inguinal Hernia: Laparoscopic Repair

Hiroomi Okuyama

Abstract

Laparoscopic percutaneous extraperitoneal closure (LPEC), an extracorporeal approach, is the most common procedure in the Japanese pediatric surgeons. After a 30° 5 mm laparoscope is inserted through the umbilical trocar, 2 mm grasping forceps is inserted via the lateral abdominal wall to manipulate the peritoneum near the internal inguinal ring. The contralateral side is observed not to overlook a slit-type or covered internal inguinal ring. The internal orifice of the inguinal canal is closed with purse-string suture of 2-0 nonabsorbable suture thread using a special needle with a wire loop to hold the suture thread at the tip. After dissection of the testicular vessels and vas deferens, the suture thread is released from the tip of the needle, the direction of the needle turned medially to put the purse-string suture on the medial half of the internal inguinal ring using the same technique. Before ligation, we have to confirm that there is no gap or skip lesion of the suture and that there is no involvement of the testicular vessels or vas deferens. The purse-string suture is tied extracorporeally. Contralateral PPV is closed using the same approach.

Keywords

Inguinal hernia • Children • Extracorporeal • Laparoscopic repair

22.1 Background

Laparoscopic repair of inguinal hernia is getting more common because of better cosmetic results, contralateral exploration and treatment. There are two procedures: intraperitoneal and extraperitoneal approaches to close the internal inguinal ring. Because intraperitoneal approach needs three ports (one camera, two working ports), intracorporeal suturing technique, and longer time compared to extracorporeal approach, laparoscopic percutaneous extraperitoneal closure (LPEC) is the most common procedure in the Japanese pediatric population. The principle of LPEC is same as that of open procedure such as Potts. Because LPEC does not need any artificial patches (large foreign body), it is well acceptable for children. In contrast, transabdominal preperitoneal (TAPP) approach and totally extraperitoneal (TEP) approach using a nonabsorbable artificial mesh are not preferred in the pediatric population. The indication of LPEC includes almost all children with indirect inguinal hernia regardless of age and sex. Incarcerated hernia is a good indication for LPEC because the incarcerated organs can be evaluated after reduction by laparoscope. LPEC is also applied for hydrocele as well as inguinal hernia. LPEC is useful for the diagnosis of recurrent inguinal hernia, femoral hernia, and direct hernia in which a definite preoperative diagnosis is difficult.

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22.2 Preoperative Management

Decompression of the intestine and the bladder is very important to gain an enough working space especially in small infants and children. After induction of anesthesia, the rectum should be decompressed by transrectal catheter, and the bladder should be emptied by urethral catheter routinely.

22.3 Patient's Position, Operation Room Layout, and Port Design (Fig. 22.1)

The patient is placed in a supine position and received general anesthesia with tracheal intubation. The surgeon stands right or left side of the patients, and the camera operator stands on the opposite side. The laparoscopic monitor is placed on the foot side of the patient.

22.4 Operations

22.4.1 Evaluation of the Ipsilateral and Contralateral Internal Inguinal Ring

After placing a 5 mm trocar via the umbilicus, pneumoperitoneum with a pressure ranging 8–10 mmHg is established. The patient is placed in the Trendelenburg position. A 30° 5 mm laparoscope is inserted through the umbilical trocar. A 2 mm trocar is placed via the lateral abdominal wall and 2 mm grasping forceps is inserted to manipulate the peritoneum near the internal inguinal ring. The contralateral side should be observed using the grasping forceps not to overlook a slit-type or covered internal inguinal ring. Although the incidence of contralateral PPV is as high as 30–50 %, we routinely close the internal inguinal ring regardless of the size, to prevent the contralateral hernia.

22.4.2 Dissection the Lateral Half of the Internal Inguinal Ring

The internal orifice of the inguinal canal is closed with purse-string suture of 2-0 nonabsorbable suture thread using Lapaherclosure™ (Hakko Medical), a special needle with a wire loop to hold the suture thread at the tip (Fig. 22.2). This needle with an outer diameter of 1.5 mm is inserted through the abdominal wall together with a 2-0 nonabsorbable suture at the closest point to the internal inguinal ring.

One half of the purse-string suture is begun extraperitonealy from the anterior to the posterior edge on one lateral half of the internal inguinal ring (Fig. 22.3).

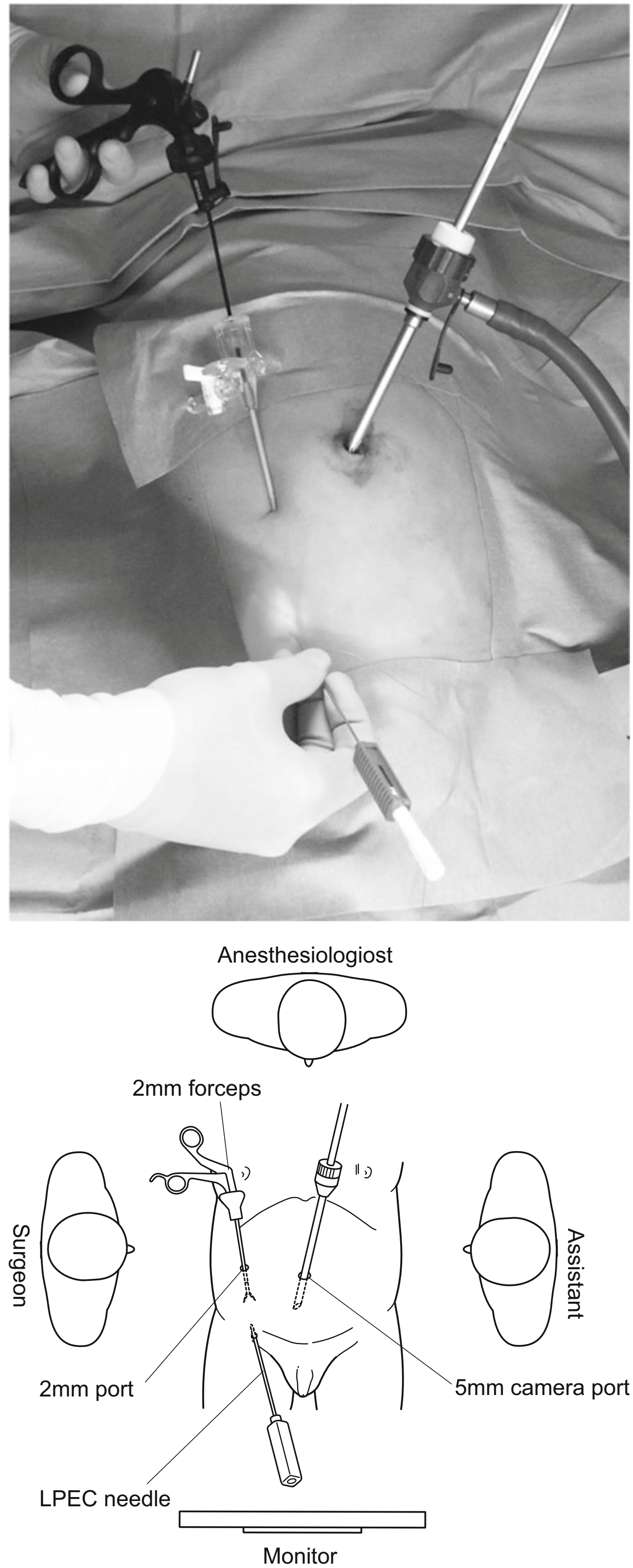


Fig. 22.1 Patient's position, operation room layout, and port design

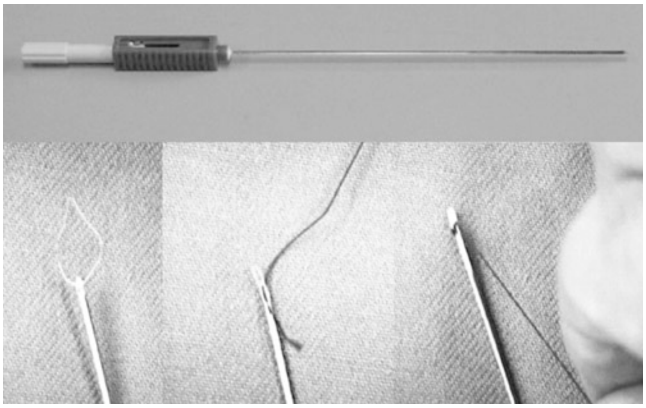


Fig. 22.2 LPEC needle (Lapaherclosure™, Hakko Medical)

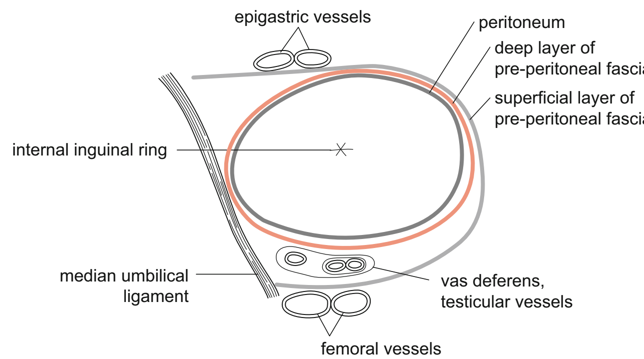


Fig. 22.4 Three layers of the membranous structure around the internal inguinal ring

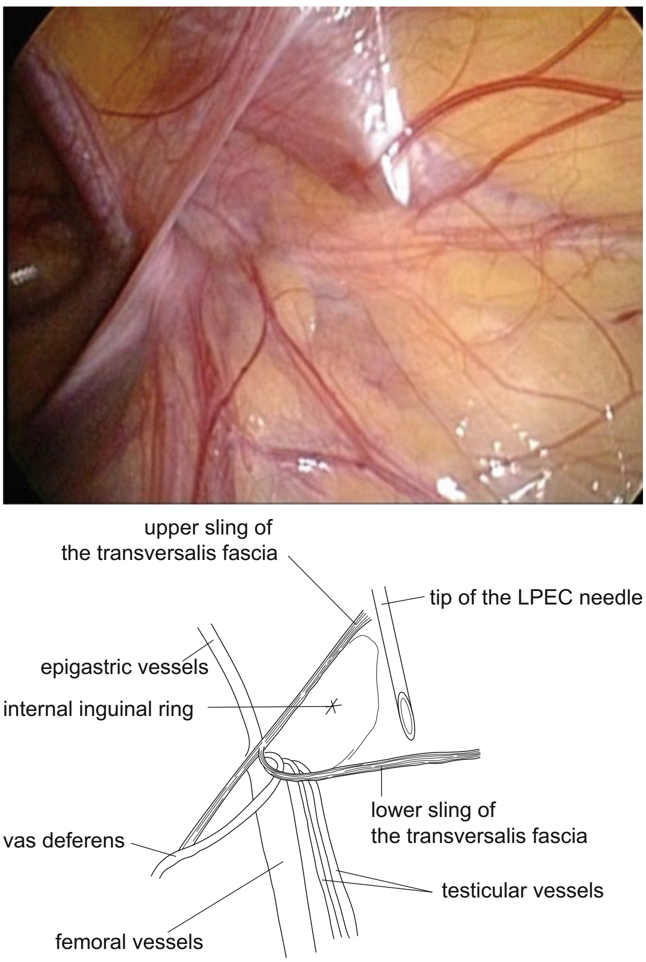


Fig. 22.3 Dissection of the lateral half of the internal inguinal ring using LPEC needle

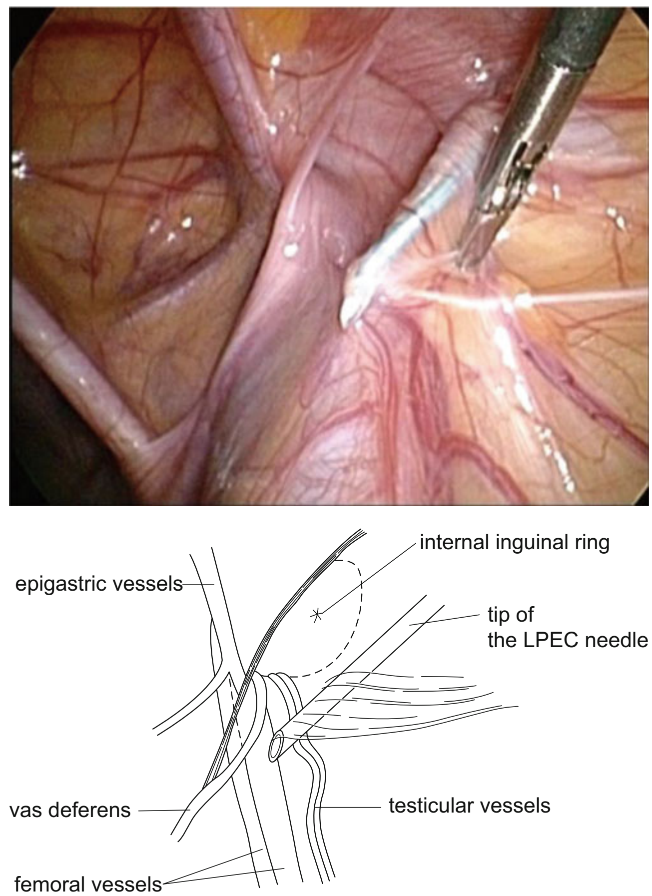


Fig. 22.5 Dissection of the testicular vessels

22.4.3 Dissection of the Testicular Vessels and Vas Deferens

The membranous structure around the internal inguinal ring has three layers in turn from the inside of the abdominal cavity: (1) peritoneum, (2) deep layers of preperitoneal fascia, and (3) superficial layers of preperitoneal fascia (Fig. 22.4). Because the testicular vessels and the vas deferens are located between the deep and superficial layers of preperitoneal fascia, the Lapaherclosure needle should go between the peritoneum and the deep layers of preperitoneal fascia to avoid the injury of the testicular vessels (Fig. 22.5) and the vas deferens (Fig. 22.6).

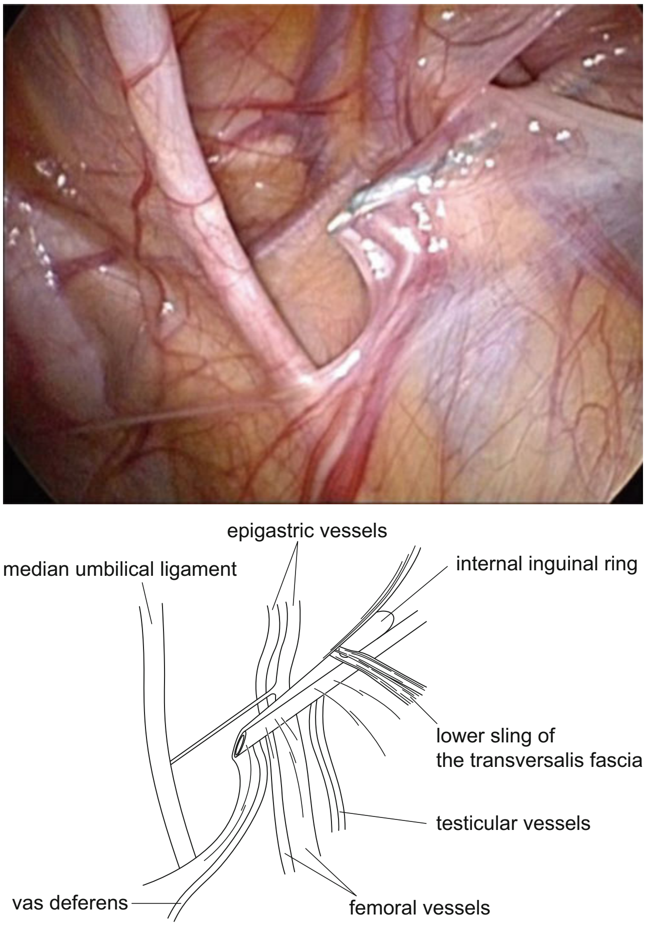


Fig. 22.6 Dissection of the vas deferens

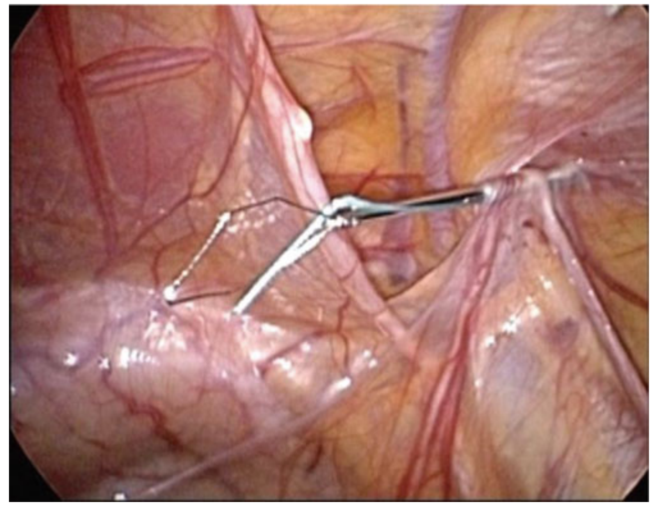


Fig. 22.7 Insertion of the LPEC needle into the abdominal cavity

22.4.4 Dissection of the Medial Half of the Internal Inguinal Ring

After dissection of the testicular vessels and vas deferens, the suture thread is released from the tip of the needle (Fig. 22.7). Then, the LPEC needle is pulled back to the insertion point, and the direction of the needle is turned medially to put the purse-string suture on the medial half of the internal inguinal ring using the same technique. The insertion point of the median suture should be close to that of the lateral suture to avoid a recurrence (Fig. 22.8). The Lapaherclosure is then removed from the abdomen together with the suture thread.

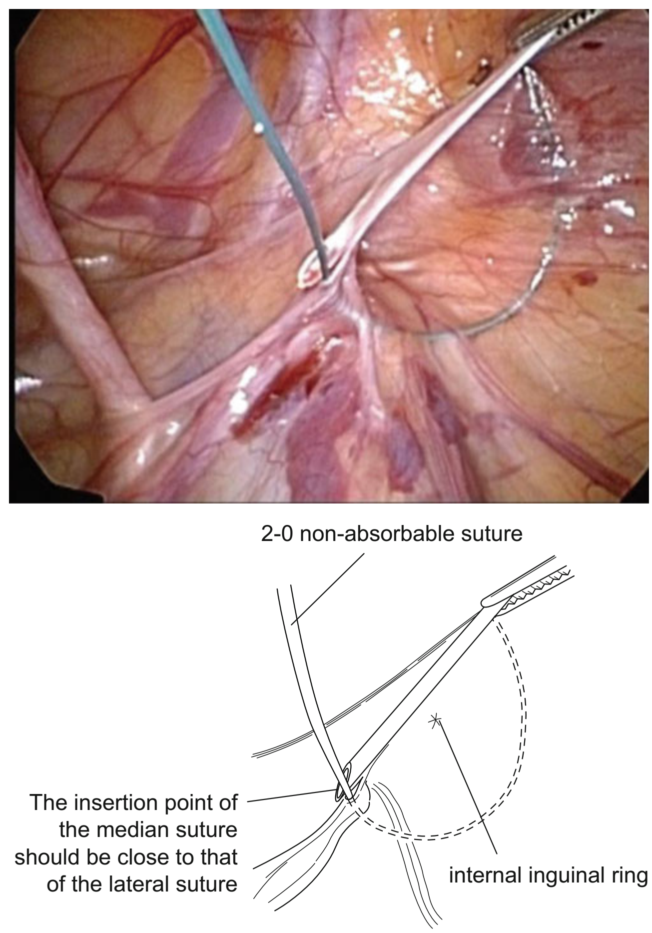
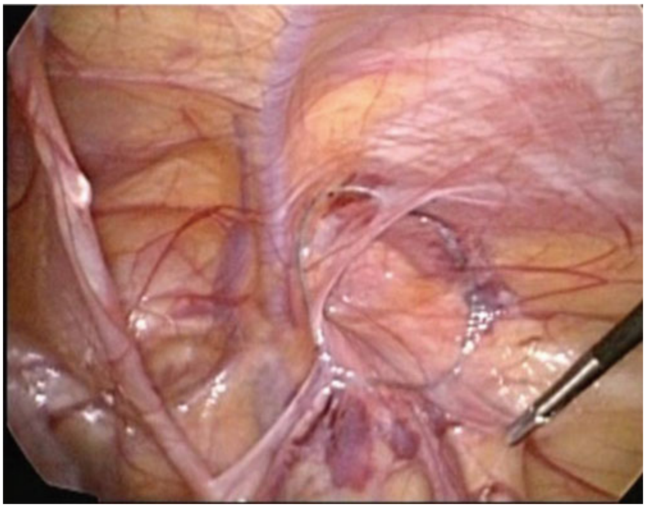


Fig. 22.8 Dissection of the median half of the internal inguinal ring

22.4.5 Ligation

Before ligation, we have to confirm that there is no gap or skip lesion of the suture and that there is no involvement of



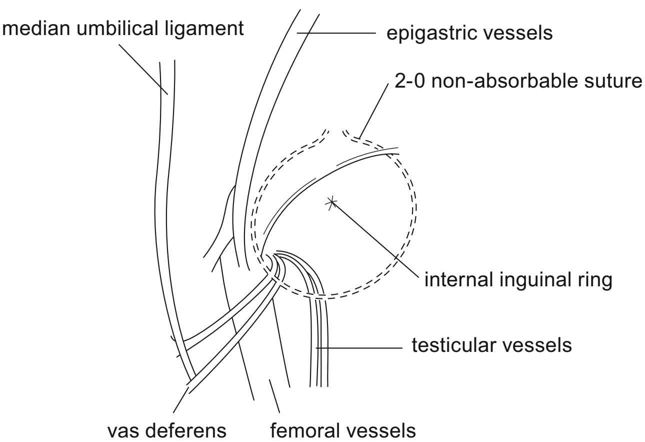


Fig. 22.9 No gap or skip lesion of the suture. No involvement of the testicular vessels or vas deferens

the testicular vessels or vas deferens (Fig. 22.9). The purse-string suture is tied extracorporeally, and the internal inguinal ring is completely closed (Fig. 22.10). Contralateral PPV is closed using the same approach. Usually one suture is enough to close the internal ring. However, if a thread loosens even a little, it is necessary to put another suture and ligate it.

22.5 Postoperative Management

A paraumbilical block is useful to reduce the postoperative pain. No special postoperative management is necessary in patients with LPEC.

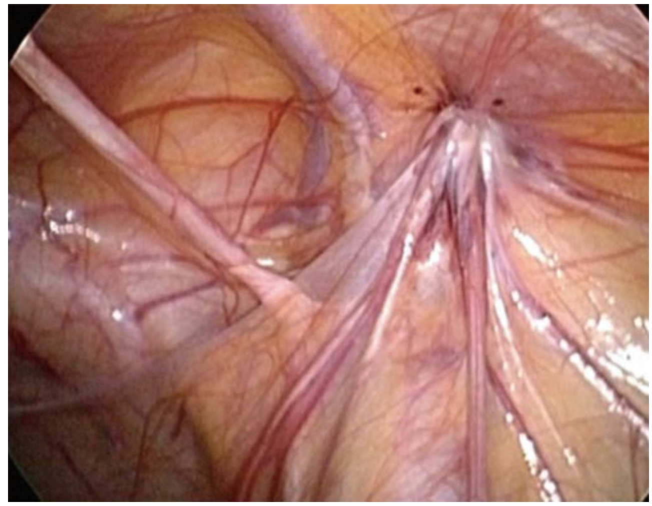


Fig. 22.10 The internal inguinal ring is completely closed extracorporeally

Patients are admitted in the morning and discharged in the afternoon of the same day (day care surgery).

22.6 Outcomes

The operation time of LPEC is longer in unilateral cases and shorter in bilateral cases compared to open procedure [1, 2]. The recurrence rate is less than 1 % in large series of LPEC procedures, which is comparable to those of open procedures [1, 2]. The incidence of metachronous contralateral inguinal hernia in patients with LPEC is significantly lower than that in patients with open procedure.

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23 Direct Inguinal Hernia and Femoral Hernia

Minoru Kuroiwa

Abstract

Direct inguinal and femoral hernias rarely develop in children. Direct hernia is caused by weakness of the posterior inguinal wall within the Hesselbach triangle and femoral hernia by femoral ring enlargement. The principle of surgery is excision of the hernia sac and reinforcement of the posterior inguinal wall for direct hernia and sac excision and closure of the femoral ring for femoral hernia. The anatomical differences between direct and femoral hernias should be well understood. Pediatric direct inguinal and femoral hernias are rare but require greater accuracy in performing the operation. The most suitable operation for direct hernia is iliopubic tract repair and that for femoral hernia is McVay repair.

Keywords

Direct inguinal hernia • Femoral hernia • McVay repair • Iliopubic tract repair

23.1 Introduction

The decreased strength of the posterior wall within the Hesselbach triangle and the enlarged size of the femoral ring in the groin are strongly correlated with the occurrence of direct inguinal and femoral hernias in childhood. The mechanism of these hernias is similar to that of adults. Therefore, the transversalis fascia and the surrounding structures, never touched during indirect inguinal hernia repair, have to be used for complete healing from these hernias.

On the other hand, even pediatric surgeons who have operated on a lot of indirect inguinal hernias have rarely experienced these hernias because of the rarity of direct and femoral hernias. It is potentially difficult for a pediatric surgeon to be prepared for rare disorders at all times.

In this section, the anatomy of the inguinal region and clinical features of the direct and femoral hernias are first discussed, followed by operative procedures for treating these hernias. Laparoscopic hernia repair and operative therapy using prosthetic material are excluded because there is poor verification about these operations in children.

23.2 The Anatomy of the Inguinal Region and Groin Hernia [1, 2]

The posterior wall of the inguinal canal is exposed if the external oblique aponeurosis is opened followed by picking up the spermatic cord. The area is a weak point in the posterior inguinal structure, what is called the "Hesselbach triangle" surrounded by the inferior epigastric vessels, the transversus abdominis arch, and the iliopubic tract (Fig. 23.1a, b and 23.2a). The triangle is constructed by the peritoneum and transversalis fascia without the internal oblique muscle and the transversus aponeurosis. The

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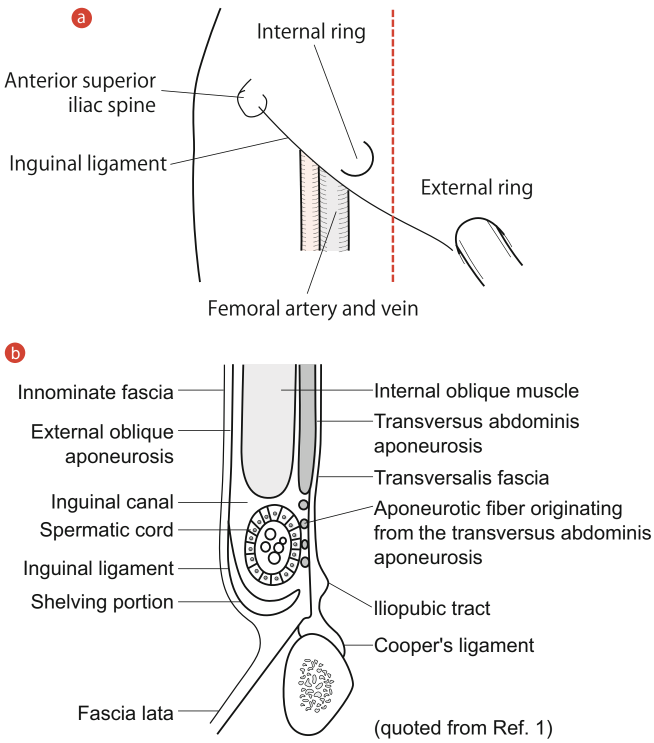
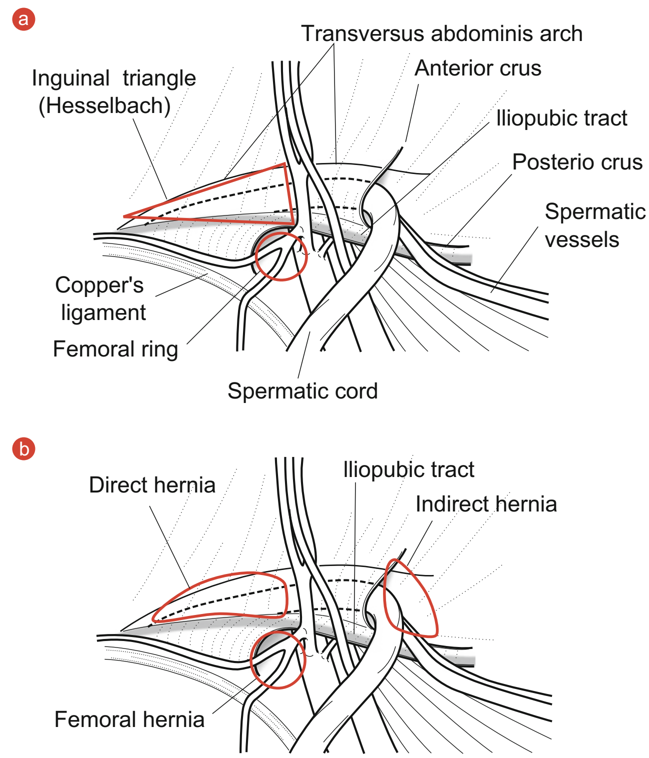


Fig 23.1 Anatomy of the right groin. (**a**) Land marks. (**b**) A parasagittal section on a *dotted line* in (**a**)



(modified from Ref. 2)

Fig 23.2 Anatomic structures contained within the posterior inguinal wall. (**a**) Local anatomy. (**b**) Sites of common groin hernia

transversalis fascia is thickened at the medial half of the fascia behind the inguinal canal (namely, the iliopubic tract) and attached to the Cooper ligament, forming an anterior part of the femoral sheath (Fig. 23.2a). The Cooper ligament represents the strongly reinforced periosteum of the superior ramus of the pubis and forms the inferior part of the femoral sheath. The external iliac artery and vein enters the femoral sheath by passing between the iliopubic tract and the Cooper ligament (Fig. 23.3). The Hesselbach triangle is reinforced by the transverse fascia and the fiber of the transversus abdominis aponeurosis (Fig. 23.1b). Decreased strength of the triangle leads to the occurrence of direct inguinal hernia, while femoral hernia develops due to the weakness and enlargement of the femoral ring (Figs. 23.2b and 23.3).

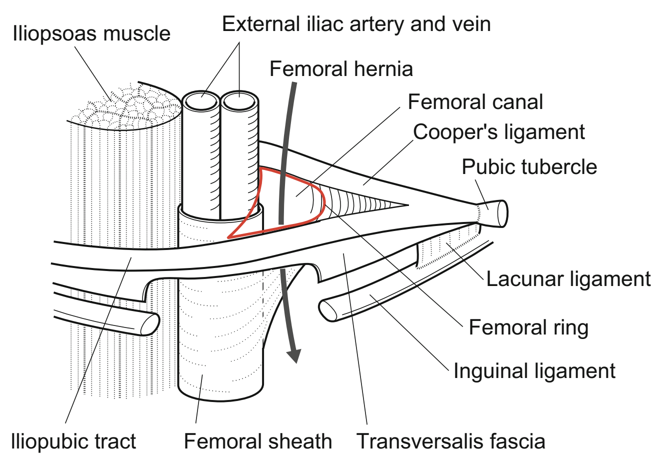


Fig 23.3 Three-dimensional diagram of the inguinal and femoral region (*right side*)

23.3 Clinical Features in Direct Inguinal and Femoral Hernia

Vast majority of groin hernias are indirect inguinal hernias, and direct inguinal hernias and femoral hernias rarely occur in childhood. Their incidence in pediatric groin hernia is 0.2–0.3 % for direct hernia and 0.2–0.9 % for femoral hernia. There is no difference in sex ratio and occurrence ratio of the affected side. The hernia is difficult to diagnose preoperatively, and patients with these hernias sometimes have a history of an indirect hernia repair. The site of occurrence in a direct hernia is medial, and the hernia content is easily reducible in comparison with indirect hernia. A history of a direct hernia repair also strongly suggests another direct hernia. These facts teach us that the existence of a direct inguinal hernia has to be kept in mind when treating recurrences after indirect hernia repair. In femoral hernias, the hernia usually presents as a soft mass caudal to the inguinal ligament, but it rarely develops superior to the ligament. Patients with femoral hernias also often have a history of hernia repair, but the incidence of a history is less frequent in comparison to patients with direct hernias.

The occurrence of incarceration in both hernias occurs less frequently; however, there is a predilection for incarceration in girls, and the ovary and the intestine can be intrusive organs in femoral hernia. Magnetic resonance imaging (MRI) and computed tomography (CT) scans are effective in diagnosing an incarcerated hernia.

23.4 Operations

In emergency and elective surgery, preoperative management is similar to that of indirect inguinal hernia.

23.4.1 Direct Hernia [3]

23.4.1.1 Skin Incision and Confirmation of Hernia Sac

Handling from the skin incision and opening of the anterior wall of the inguinal canal is performed as that in indirect inguinal hernia. A hernia sac is exposed by mobilization of the spermatic cord. The hernia bulges through the posterior wall of the inguinal canal. It has to be confirmed that there is a hernia sac inside the spermatic cord or the inferior epigastric vessels. At first surgery, the processus vaginalis should be investigated and has to be ligated if the processus is patent.

23.4.1.2 Incision in the Posterior Wall of the Inguinal Canal and Excision of the Hernia Sac (Fig. 23.4)

The initial incision in the transversalis fascia is performed at the top of the hernia bulge. All redundant and weakened tissue (hernia sac) in the posterior wall of the inguinal canal is to be excised after two suture ligatures. There is usually a broad-based hernia without a neck on the sac; therefore, the hernia sac is occasionally inverted to the peritoneal cavity or is dorsally plicated at times. The transversus abdominis arch and the upper margin of the transversalis fascia are grasped with a hemostat (at the medial edge of the posterior wall). These structures are grasped together in principle because they are usually indiscrete in structure. The lateral edge (flap) of the posterior wall (transversalis fascia including the iliopubic tract) has to be held by a clamp.

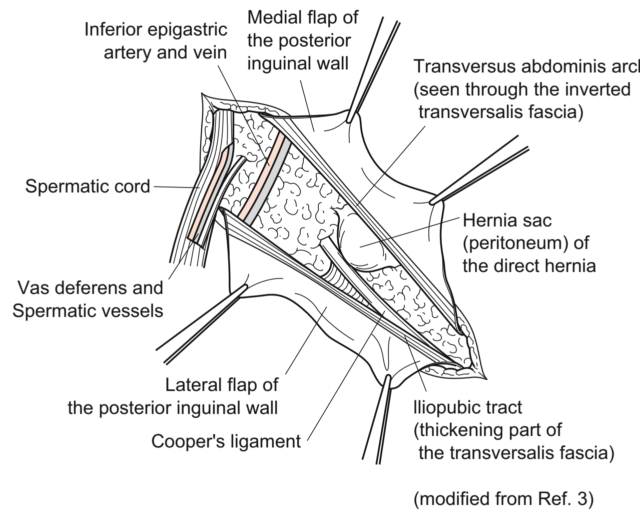


Fig 23.4 Illustration of the posterior inguinal wall after opening the transversalis fascia (*right side*)

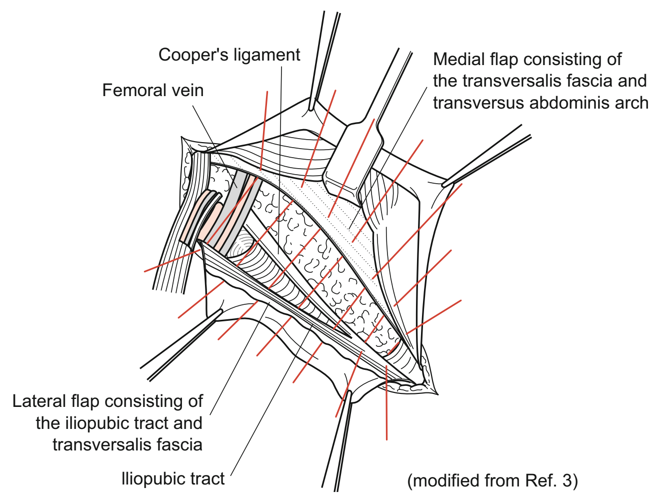


Fig 23.5 Technique of iliopubic tract repair for direct hernia

23.4.1.3 Reinforcement of the Posterior Wall of the Inguinal Canal (Fig. 23.5)

The iliopubic tract, which is the thickened transversalis fascia in the lateral fascial segment, is identified. Nonabsorbable suture is used for the repair of the posterior wall of the inguinal canal with reinforcement. Sutures are placed, beginning at the pubic tubercle and progressing laterally, to the approximate transversus abdominis arch above and to the Cooper ligament and the iliopubic tract below. It should be begun from the internal inguinal ring to the pubic tubercle to tie sutures because the size of the internal ring and compression of the spermatic cord have to be checked. In children, no relaxing incision is needed [4].

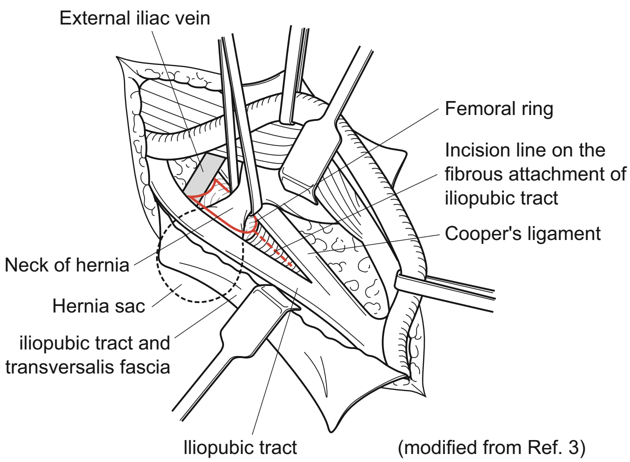


Fig 23.6 Exposure of the hernia neck in femoral hernia. The femoral sac passing between two structures (Cooper ligament and iliopubic tract) protrudes medial to the femoral vein below the inguinal ligament

23.4.1.4 Reconstruction of the Anterior Wall of the Inguinal Canal

Repair of the inguinal canal is performed the same way as for an indirect inguinal hernia.

23.4.2 Femoral Hernia [2, 3]

23.4.2.1 Skin Incision to Opening of the Posterior Wall of the Inguinal Canal

The procedure for the femoral hernia is similar to that in direct inguinal hernia. It is very important to confirm the existence of the hernia sac just below the inguinal ligament.

23.4.2.2 Confirmation of the Hernia Sac and Conversion of the Femoral Hernia (Fig. 23.6)

After the incision of the posterior wall, the Cooper ligament is dissected free and its deeper portion is cleaned. Then, starting lateral to the pubic tubercle, the Cooper ligament and iliopubic tract are visible. Working laterally, the femoral sac passing between the two structures (the Cooper ligament and iliopubic tract) which protrudes medial to the femoral vein below the inguinal ligament is identified. After taping to the neck of the sac, any femoral sac is converted to an inguinal one by manual manipulation that consists of traction at the neck and pressing upward on the bottom of the sac. The fibrous attachment of the iliopubic tract to Cooper ligament is incised when a femoral sac cannot be converted to a direct inguinal one. In rare cases, the inguinal ligament is cut off.

In incarcerated hernia, it should be kept in mind that careless dissection of the sac leads to an adverse effect on investigating the hernia content. The hernia sac is opened and explored to evaluate any intra-abdominal pathology. The hernia content without necrosis is reduced into the abdomen, and the sac has to be removed because of the risk of recurrence of femoral hernia. Laparoscopic examination is useful in diagnosing femoral hernia when there is any doubt about the existence of the hernia.

23.4.2.3 Suture Closure of the Femoral Ring with Reinforcement of the Posterior Wall of the Inguinal Canal (Fig. 23.7)

Starting lateral to the pubic tubercle, a layer of interrupted nonabsorbable sutures is placed between the medial flap and the Cooper ligament, including the iliopubic tract (Fig. 23.7a-①) going as far laterally as the medial edge of the femoral vein. The femoral ring is closed by three or four transition sutures between the Cooper ligament and the anterior femoral fascia (the lower part of transversalis fascia below the iliopubic tract) (Fig. 23.7a-②). The lateral one or two is placed just lateral to the last suture placed in the Cooper ligament (Fig. 23.7a-③). All of the sutures are tied from medial to lateral, and it should be confirmed that the internal inguinal ring is sufficiently narrow. Pediatric femoral hernia needs no relaxing incision.

The Cooper ligament and the iliopubic tract are initially sutured in terms of operability and reliability, followed by closure of the posterior wall of the inguinal canal (Moschcowitz repair and Ruggi repair as a modified McVay repair) (Fig. 23.7b, c) [4]. The anterior wall of the inguinal canal is reconstructed in accordance with that of an indirect inguinal hernia. There are many reports that do not recommend the femoral approach because of operative difficulty and poor reliability on closing the femoral ring [3].

The McVay repair, including a modified one, has been widely carried out for one-third of patients as the most reliable surgery; however, around one-half of patients are treated with other procedures, such as a femoral approach, iliopubic tract repair, or simple high ligation of the hernia sac [5, 6].

We should precisely understand the differences between direct hernia and femoral hernia and know that the most suitable operation for a direct hernia is iliopubic tract repair, which can reinforce the posterior wall of the inguinal canal, and that for a femoral hernia is the McVay repair, which can close the enlarged femoral ring.

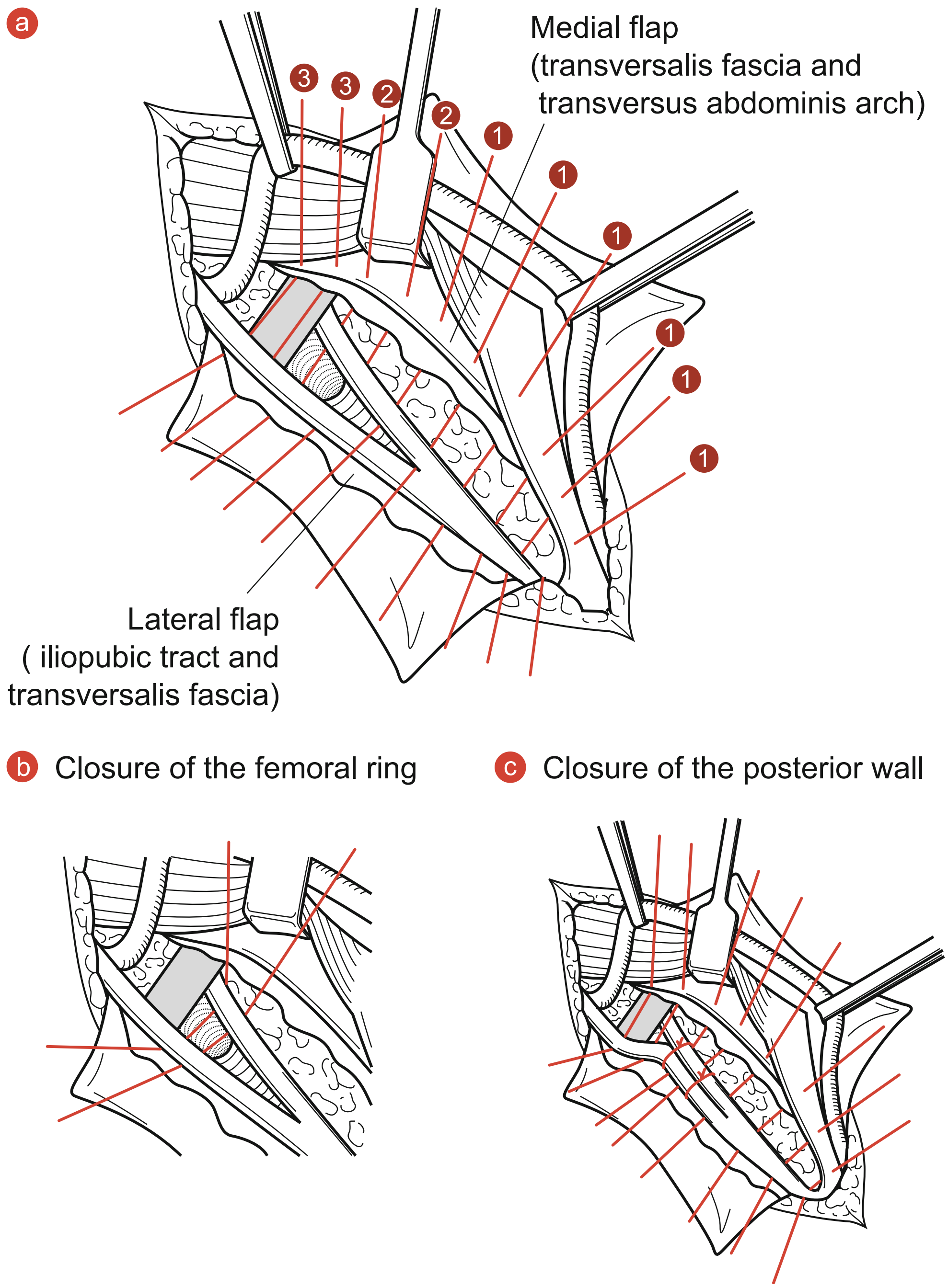


Fig 23.7 McVay repair and its modification. Local anatomy after excision of the femoral sac is similar to that of direct inguinal hernia (**a**). A small number of sutures are placed for closure of the posterior inguinal wall (**a**-①), for that of the femoral ring and posterior wall (transition suture) (**a**-②), and for that of the internal (deep) inguinal ring (**a**-③)

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24 Hydrocele, Nuck Hydrocele: Standard Procedure

Hitoshi Ikeda and Kazunori Tahara

Abstract

Congenital hydroceles are classified into communicating and noncommunicating according to the presence of a macroscopic communication between the hydroceles and free abdominal cavity. Simple high ligation of the hydrocele or patent processus vaginalis is effective treatment. Surgery is performed in patients whose hydroceles persist beyond 2 or 3 years of age and in patients with new hydrocele development after this period.

The principle of hydrocele surgery is to block the flow of ascites from the abdominal cavity to hydroceles. To achieve this, the hydrocele is ligated as high as possible at the level of the internal inguinal ring in communicating hydroceles, while the patent processus vaginalis is ligated as high as possible in noncommunicating hydroceles. The procedure of hydrocele surgery is basically the same as surgery for inguinal hernia repair. However, hydroceles or the patent processus vaginalis is thinner than the hernia sac, and it may be occasionally difficult to identify the patent processus vaginalis in hydrocele patients. Generally, hydrocele surgery is more difficult than hernia repair, and, therefore, meticulous and delicate skills are required. Late postoperative complications include wound infection and hydrocele recurrence.

Keywords

Congenital hydrocele • Testicular (scrotal) hydrocele • Hydrocele of the cord • Nuck hydrocele • Hydrocele surgery

Testicular hydrocele (scrotal hydrocele) and hydrocele of the cord in male patients and Nuck hydrocele in female patients are congenital hydroceles in which fluid is collected in the patent processus vaginalis or in the space surrounding the testis between the layers of the tunica vaginalis. The fluid originates from the abdominal cavity (ascites), and hydroceles are classified into communicating and noncommunicating according to the presence of a macroscopic communication between hydroceles and the free abdominal cavity (Fig. 24.1). In noncommunicating hydroceles, it is thought that there are microscopic communications between hydroceles and the abdominal cavity. Simple high ligation of the patent processus vaginalis is therefore effective in resolving hydroceles in patients with noncommunicating hydroceles.

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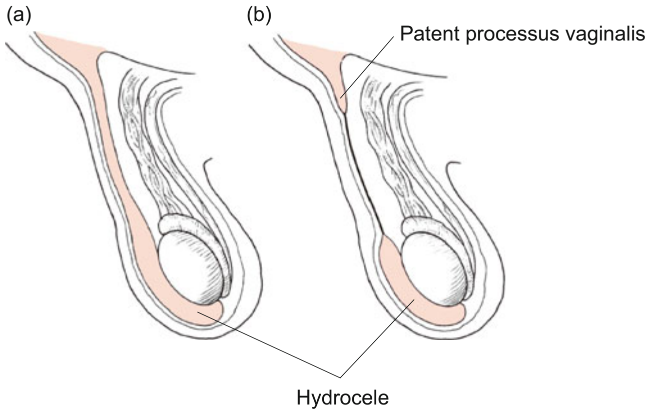

Fig. 24.1 Congenital hydroceles. (**a**) Communicating hydrocele. (**b**) Noncommunicating hydrocele

24.1 Timing of Surgery and Preoperative Management

In most patients with congenital hydroceles, hydroceles spontaneously resolve by the age of 12 months as a result of obliteration of the patent processus vaginalis. Therefore, surgical treatment is not indicated for infants younger than 12 months of age. Surgery is usually performed in patients whose hydrocele persists beyond 2 or 3 years of age and in whom spontaneous resolution of the hydrocele seems to be unlikely. Surgical treatment is also indicated in patients with new hydrocele development after this period.

Preoperative management is the same as that in inguinal hernia repair. In particular, the side to be surgically treated has to be marked preoperatively as in hernia repair, in order to prevent medical incidents or accidents.

24.2 Operations (Simple High Ligation)

The principle of hydrocele surgery is to block the flow of ascites from the abdominal cavity to the hydrocele. To achieve this, the hydrocele is ligated as high as possible at the level of the internal inguinal ring in communicating hydroceles, while the patent processus vaginalis is ligated as high as possible in noncommunicating hydroceles. The surgical procedure is basically the same as that for inguinal hernia repair. However, hydroceles or the patent processus vaginalis is thinner than the hernia sac, and it may be occasionally difficult to identify the patent processus vaginalis in hydrocele patients. Generally, hydrocele surgery is more difficult than hernia repair, and, therefore, meticulous and delicate skills are required. For hydroceles, the standard operation is open surgery, and laparoscopic surgery is rarely performed.

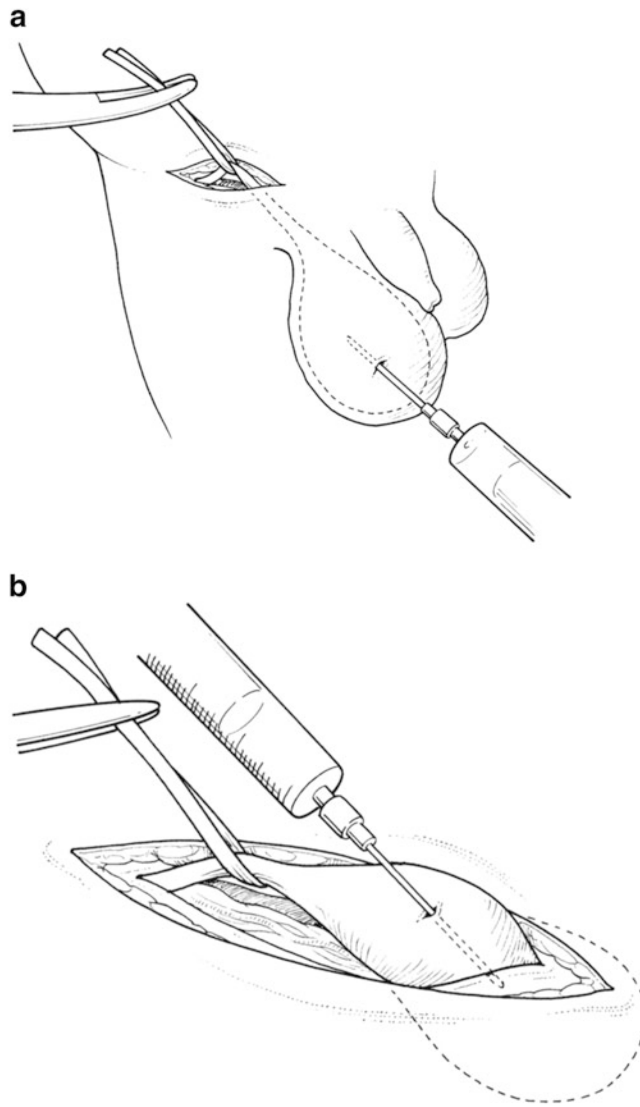

Fig. 24.2 Aspiration of the hydrocele. (**a**) Percutaneous or scrotal puncture. (**b**) Inguinal approach

24.2.1 Skin Incision and Approach to the Inguinal Canal

A skin crease incision, approximately 2–2.5 cm in length, is made just above the internal inguinal ring, which is similar to skin incision in inguinal hernia repair. Superficial fascias are bluntly separated, the external oblique fascia is incised, and the inguinal canal is exposed. The spermatic cord (the round ligament in female patients with Nuck hydrocele) is identified and elevated by taping. When the elevation of the spermatic cord is difficult due to the presence of a large hydrocele, the accumulated fluid in the hydrocele is aspirated by puncture and then the cord is pulled out of the wound (Fig. 24.2).

24.2.2 High Ligation of Hydrocele or Patent Processus Vaginalis

Blocking the channels of fluid flow from the abdominal cavity to hydrocele can be achieved by ligating the hydrocele or the patent processus vaginalis as high as possible at the level of the internal inguinal ring. The hydrocele is doubly ligated by transfixation with unabsorbable sutures in communicating hydroceles, and the patent processus vaginalis is similarly ligated in noncommunicating hydroceles. In male patients, the vas and testicular vessels are freed from the posterior wall of the hydrocele, and the hydrocele is transected before its proximal part is ligated (Fig. 24.3). In female patients, ligation is completed without transecting the hydrocele or patent processus vaginalis.

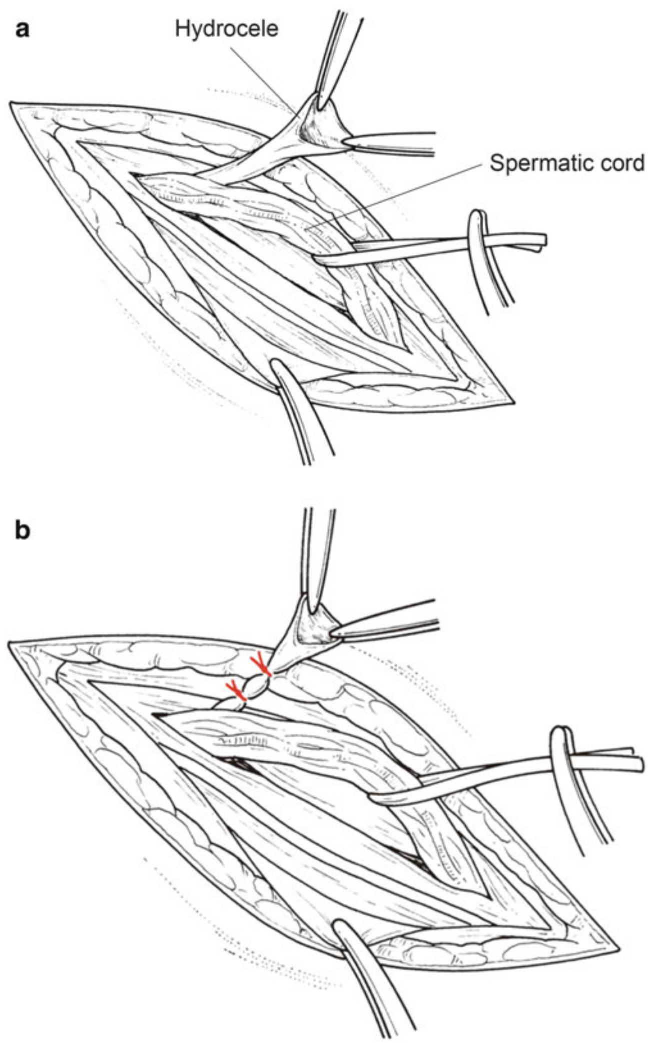

Fig. 24.3 Hydrocele surgery in male patients. The hydrocele or patent processus vaginalis is transected and doubly ligated at the level of the internal inguinal ring. (**a**) Identification and dissection of the hydrocele. (**b**) Double ligation of the hydrocele

24.2.3 Special Attention to Dissection

Hydrocele surgery is more delicate than hernia repair because the thin hydrocele or small, thin processus vaginalis has to be dissected. In particular, the thinnest part of the processus vaginalis where the vas is attached is easy to tear. Therefore, attention should be paid when dissecting the vas from the patent processus vaginalis. Actually, similar attention should be paid in inguinal hernia repair, because dissection of the vas from the hernia sac is not easy. If the hydrocele or patent processus vaginalis is torn near or beyond the internal inguinal ring, the deep end of the tear is grasped with a hemostat and then repaired by interrupted 5-0 absorbable sutures (Fig. 24.4).

24.2.4 Drainage of Distal Hydrocele

Since fluid flow from the abdominal cavity to hydrocele is blocked by high ligation, the distal fluid will disappear postoperatively by absorption without drainage. However, in order to meet parents' expectations that all hydroceles should be removed, the distal hydrocele is opened and the

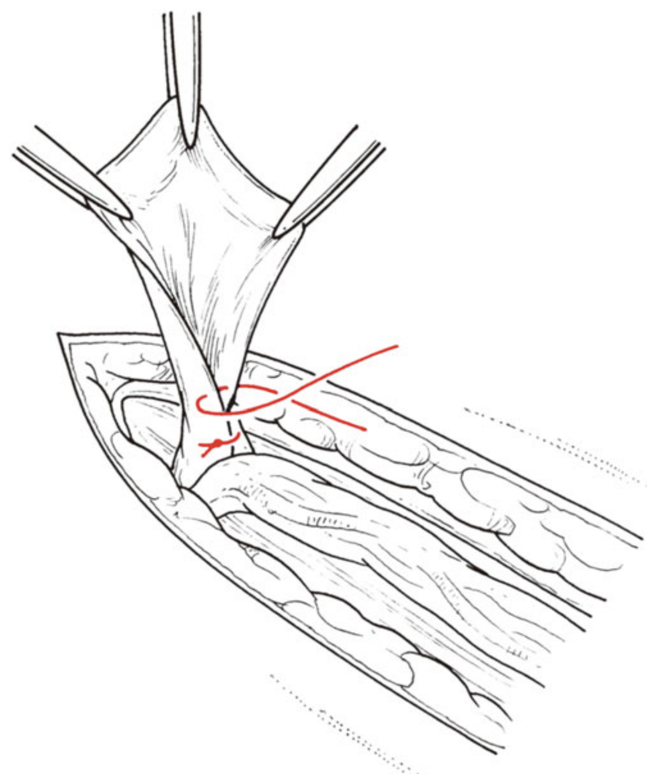

Fig. 24.4 Repair of the hydrocele (or patent processus vaginalis). Particularly the thinnest part of the processus vaginalis where the vas is attached is easy to tear. The tear can be repaired by interrupted sutures with 5-0 absorbable sutures

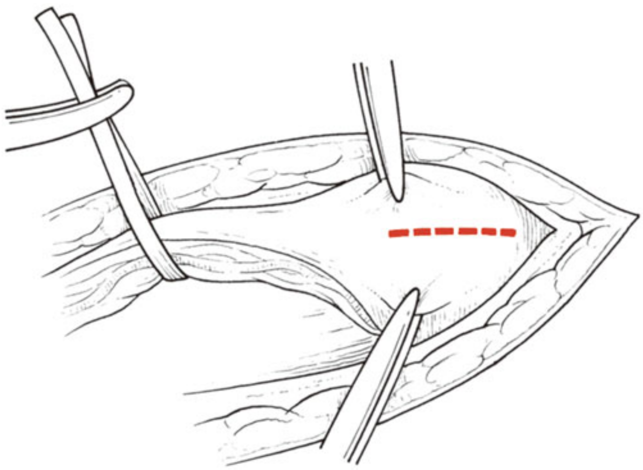

Fig. 24.5 The distal hydrocele is pulled out of the wound, grasped with hemostats, and opened to drain the fluid

accumulated fluid is drained before the wound is closed. In a noncommunicating hydrocele, the distal hydrocele is pulled out of the wound and grasped with hemostats. Then, it is opened by an incision and the fluid is drained (Fig. 24.5).

When a distal hydrocele is large and it is difficult to pull it out of the wound, the volume of distal fluid is decreased by a percutaneous puncture or puncture through the scrotal skin. After that, it can be approached and opened under direct vision through the wound. Because there are many tiny vessels in the walls of hydroceles, bleeding from the incisional site of the hydrocele should be stopped by coagulation or ligation. When the cavity of the hydrocele is separated by necks or septa, multiple incisions may be necessary to drain the accumulated fluid. Fluid aspiration instead of multiple incisions can be performed.

24.2.5 Wound Closure

The external oblique fascia and superficial fascias are closed by interrupted absorbable sutures. The skin is closed by subcuticular absorbable sutures.

24.3 Postoperative Management

General anesthesia-related complications and hemorrhage may occur during the first 24 h after hydrocele surgery. Late postoperative complications include wound infection and hydrocele recurrence.

Umbilical Hernia, Umbilical Plasty, and Linea Alba Hernia

25

Akira Toki

Abstract

Umbilical hernia is a common disease that we encounter daily as pediatric surgical disease. The surgical procedure has been established. However, the surgical procedure for the giant umbilical hernia or the hernia with redundant skin has not been established yet. In this chapter, I described mainly typical umbilical plasty and atypical umbilical plasty for special hernias such as giant umbilical hernia and hernia with redundant skin. I described perioperative management and the surgical procedure for typical umbilical hernia. And, I described diamond resection, Onizuka method, modified Onizuka method, and four skin flap method for these atypical umbilical hernias. Also, I mentioned treatment for linea alba hernia.

Keywords

Umbilical hernia • Umbilical plasty • Onizuka method

25.1 Preoperative Management

A hospital stay of two nights and 3 days is planned for the surgery, with the patient admitted to the hospital on the day before the procedure. Preoperatively, no tests or treatment are performed except for necessary anesthesia-related tests.

25.2 Operations

25.2.1 Surgical Indications

Surgical indications state that the patient must be at least 2 years old, the hernia orifice must be open, and distension must be observed in the umbilical region. Recently, it has been found that if fixation with sponge pressure is performed soon after the appearance of the umbilical region distension, early spontaneous healing occurs in 90 % of cases or more. Therefore, our policy does not advocate proactive surgical treatment.

25.2.2 Umbilical Plasty (Figs. 25.1 and 25.2)

1. Surgery is performed with the patient in the supine position under general anesthesia.
2. The skin incision is made in a half arc in the inferior margin base of the protruding umbilical region.
3. The entire circumference of the hernia sac is isolated and a tape is passed through it.
4. The hernia sac is resected, and after confirming its contents, the entire circumference of the hernia sac is removed.
5. A sufficient amount of the margin of the abdominal rectus muscle needed to construct the hernia orifice is exposed.
6. The hernia sac is closed with continuous suture using 4-0 absorbable strings; either vertical or horizontal

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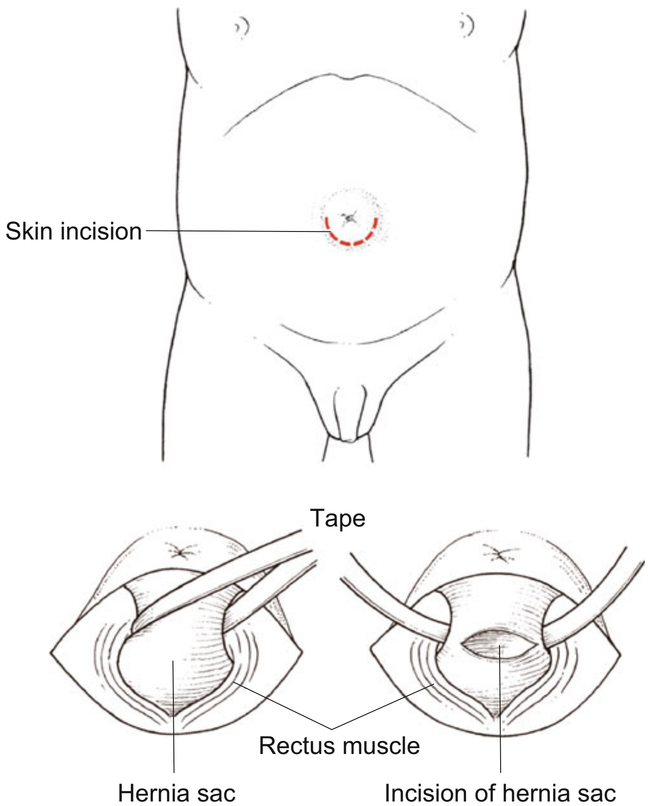


Fig. 25.1 Umbilical plasty

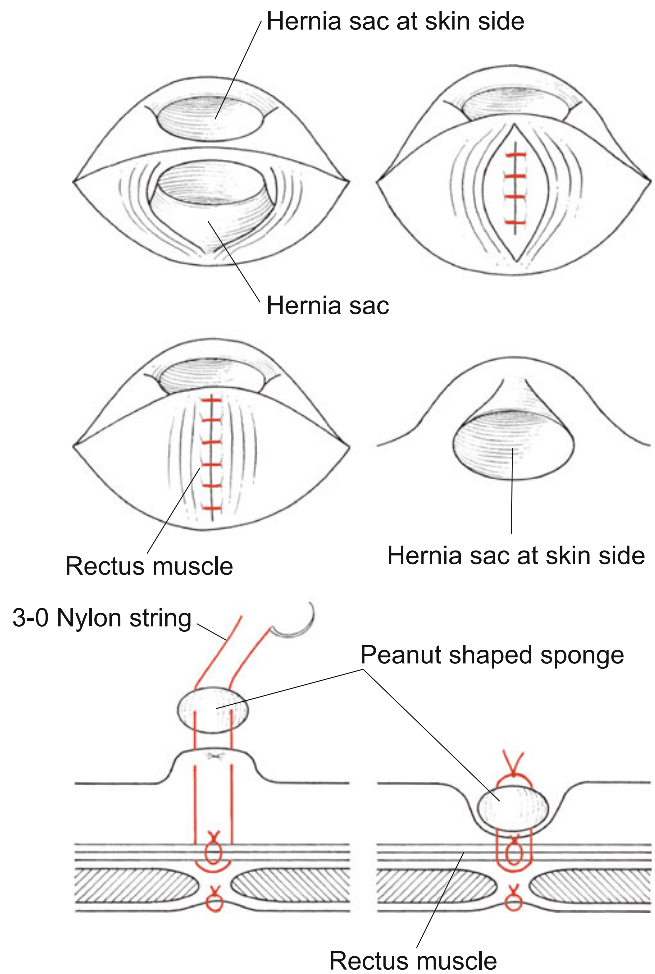


Fig. 25.2 Umbilical plasty

sutures may be used. The hernia sac does not need to be excessively resected.

7. The margin of the abdominal rectus muscle needed to construct the hernia orifice is vertically closed with interrupted suture using 4-0 absorbable strings.
8. The hernia sac remaining in the umbilical skin side is resected as much as possible to prevent the thickening of the skin in the umbilical region.
9. The umbilical region is fixed at the abdominal rectus muscle margin suture site. A number of fixation methods are available, but we will discuss our technique.
10. To make the umbilical fossa concave, a 3-0 nylon suture is looped around the center of the skin to become the umbilical fossa. The suture is brought around the rectus sheath or linea alba region, and the nylon suture is then brought out from the center of the skin to become the umbilical fossa. A peanut-shaped gauze ball is passed through the suture to prepare for pressure application.
11. It is considered best to give the umbilicus a cuplike shape that is caudally concave. However, when this is performed with too much pressure, the cranial side of the skin is pulled toward the umbilical region, creating conspicuous wrinkles. Therefore, it is important to determine an appropriate position for the umbilical fossa.
12. Deep subcutaneous tissue is fixed with 6-0 monofilament absorbable strings. Next, the subcutaneous tissue is also closed with 6-0 monofilament absorbable strings with reversed knotted suturing.
13. After covering the wound with surgical glue, the umbilical fossa is ligated with a nylon string and pressure is applied to the umbilical fossa region with a peanut-shaped sponge ball.

25.3 Points Regarding Postoperative Management

The patient is discharged from the hospital on the day after the surgical operation. After being discharged, the patient may take a shower at home. They are instructed to disinfect the wound area after showering (once a day). In the first postoperative week, the patient is examined on an outpatient basis and the nylon suture is removed, along with the peanut-shaped gauze ball. We also examine patients again on an outpatient basis at 1 month postoperatively.

25.4 Umbilical Plasty for Giant Umbilical Hernia or Excess Skin

As a rule, we are careful not to leave any of the skin incision wound outside the umbilicus. When excess skin is resected too much during umbilical plasty, even if the umbilical shape is satisfactory immediately after the operation, it may shrink over time. Taking into account the fact that excess skin contracts, we do not resect too much skin and make sure to construct the umbilicus that will become more satisfactory over time.

The Onizuka method is a technique typically used for umbilical plasty. However, we prefer to use the diamond resection method.

25.4.1 Diamond Resection (Fig. 25.3)

With this method, excess skin on the caudal side of the umbilical hernia is resected in a diamond shape to reduce the amount of excess skin:

1. As shown in the figure, the skin is resected by making a diamond-shaped incision in the excess skin on the caudal side of the umbilical hernia. The umbilical fossa region is preserved with this procedure.
2. After this incision, the hernia sac is treated as the typical umbilical hernia.
3. The diamond resection surface is vertically sutured.
4. Next, as mentioned above, the umbilical fossa region is determined to not cause wrinkles due to abnormal pulling by the surrounding skin. The peanut-shaped gauze ball is then used to apply pressure on the umbilical region as mentioned above.

With this procedure, excess skin can be easily resected and superior cosmetic outcomes can be achieved because the entire incision wound is inside the umbilicus.

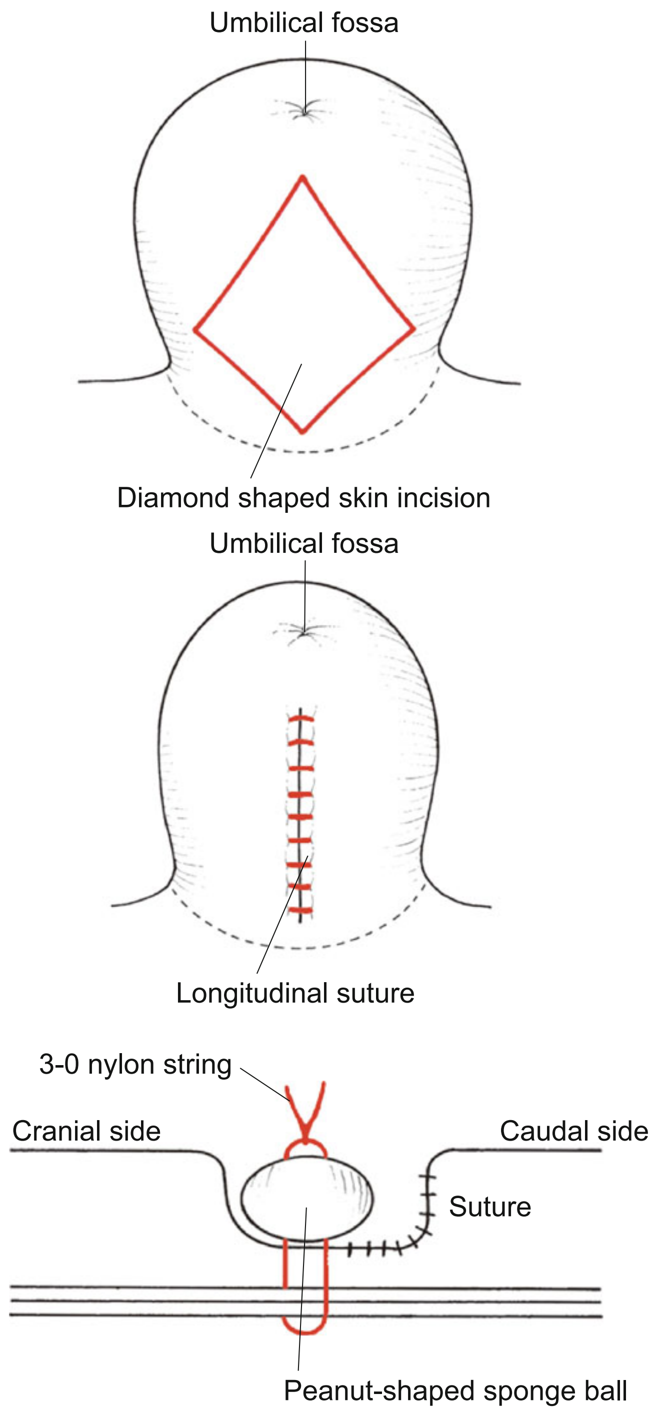


Fig. 25.3 Umbilical plasty (diamond-shaped skin incision method)

25.4.2 Onizuka Method

1. A skin incision design like that shown in the figure is used for the umbilical hernia protrusion region (Fig. 25.4).
2. The tip of the umbilicus is resected and the hernia sac is treated as the typical umbilical hernia.

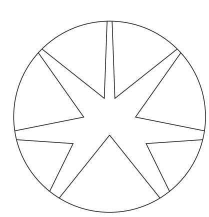


Fig. 25.4 Design of skin incision (Onizuka method) [1]

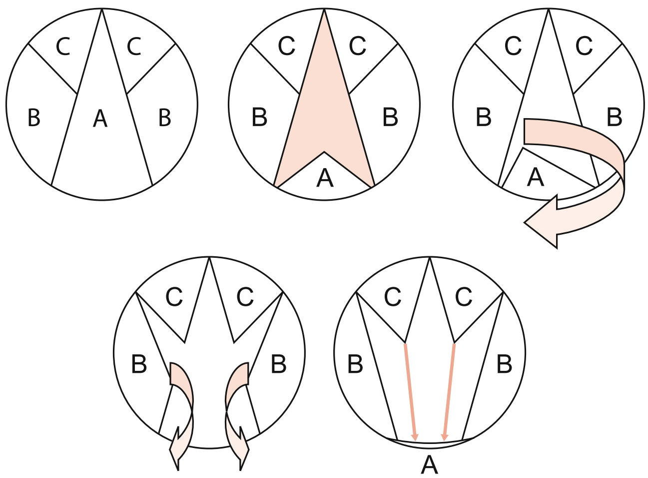


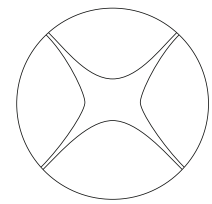
Fig. 25.5 Umbilical plasty (modified Onizuka method) [2]

3. The central caudal side skin flap is flipped inwardly and downward, the lower wall of the umbilicus is constructed, and sutures are directly stitched from the abdominal wall to fix the area with mattress suturing.
4. A number of other skin flaps are sutured together, the pattern of the base of the navel is constructed, and the upper part and lateral wall of the umbilicus are shaped.
5. A hard surgical swab is used to apply pressure to shape the umbilical fossa until the sutures are removed.

25.4.3 Modified Onizuka Method (Fig. 25.5)

1. The skin incision design shown in the figure is used.
2. After this incision, the hernia sac is treated as the typical umbilical hernia.
3. The gray part of skin flap A is resected, then inverted to fold in the rectus sheath and the caudal rectus sheath with the umbilical fossa, and fixed to the caudal rectus sheath to form the lower wall of the umbilical fossa. Skin flap B is fixed to both sides of the rectus sheath to which the skin flap A was fixed to form the lateral walls of the umbilicus. Skin flap C is fixed to the rectus sheath on the top of the skin flap A.
4. Lastly, these skin flaps are sutured.

Fig. 25.6 Design of skin incision (four skin flap method) [3]



25.4.4 Four Skin Flap Method

1. This uses a skin flap design using petal-shaped skin flaps of about 1 cm that are taken from the upper, lower, left, and right areas within a circle following umbilical margins (Fig. 25.6).
2. Excess skin is resected along with the hernia sac and the hernia orifice is closed.
3. After suturing the cranial side flap and left and right flaps, the skin flaps are sutured to the rectus sheath. Next, the top of the caudal side flap and top of the cranial side flap are sutured, and the left and right skin flaps are also sutured.
4. The umbilical region undergoes pressure fixation for 1 week.

25.5 Lina Alba Hernia

As a rule, this becomes less pronounced over time; thus, surgery is rarely required.

25.5.1 Surgical Method

A semiarch incision is made at the top of the umbilicus and isolated to the cranial side. Knotted suturing is performed at the linea alba site forming the hernia.

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Vitellointestinal Fistula and Urachal Remnant 26

Noritoshi Handa

Abstract

Vitellointestinal Fistula (Patent Omphalomesenteric Duct)

Failure of obliteration of the vitelline duct results in various anomalies such as umbilical enteric fistula, umbilical sinus, vitelline cyst, Meckel's diverticulum, umbilical polyp, and obliterated omphalomesenteric duct. In a case of the patent vitelline duct (vitellointestinal fistula), the drainage of ileal contents to the umbilicus or the ileal mucosal prolapse through the umbilical sinus is recognized in the newborn period. The diagnosis of the patent vitelline duct is confirmed by a fistulography which demonstrates the direct communication between the umbilicus and the ileum. Treatment of this condition consists of the excision of the fistulous tract and closure of the ileal wall which communicates the fistula via transumbilical approach.

Urachal Remnant (Urachal Sinus/Cyst)

Although the urachus extends from the anterior dome of the bladder toward the umbilicus in early gestation, the lumen of the urachus is gradually occluded and becomes cordlike structure during fetal development. Failure of obliteration of the urachus results in patent urachus, urachal sinus, urachal cyst, urachal diverticulum, and alternating sinus. Completely patent urachus is usually recognized in the neonates due to drainage of the urine through the umbilicus. Surgical repair is accomplished through the subumbilical transverse incision or the infraumbilical U-shaped incision with excision of the urachal sinus. On the other hand, umbilical urachal sinus is recognized by periumbilical erythema, tenderness, and transumbilical purulent discharge, and urachal cyst is detected by tender lower midline mass in general. Excision of sinus or cyst with the rest of the urachal tract should be performed.

Keywords

Vitelline duct remnants • Omphalitis • Urachal remnant • Pyourachus

26.1 Vitellointestinal Fistula (Patent Omphalomesenteric Sinus)

26.1.1 Preoperative Management

26.1.1.1 Symptoms [1, 2]

1. Drainage of ileal contents to the umbilicus
2. Ileal mucosal prolapse through the umbilical sinus (Fig. 26.1)

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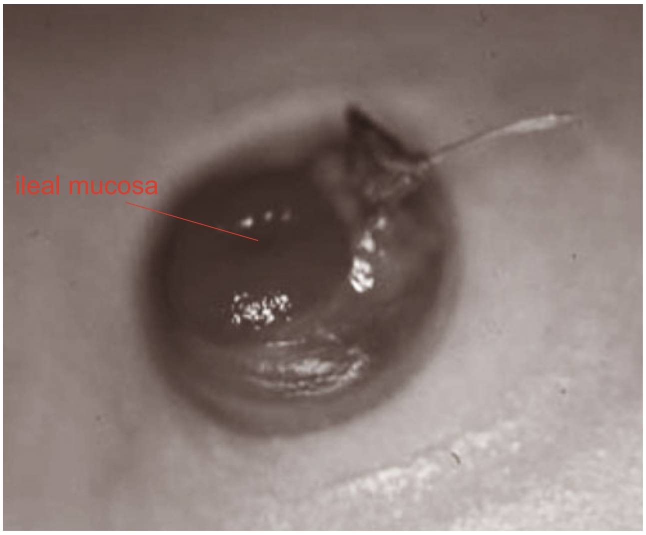

Fig. 26.1 Vitellointestinal fistula. Ileal mucosal prolapse through the umbilical sinus

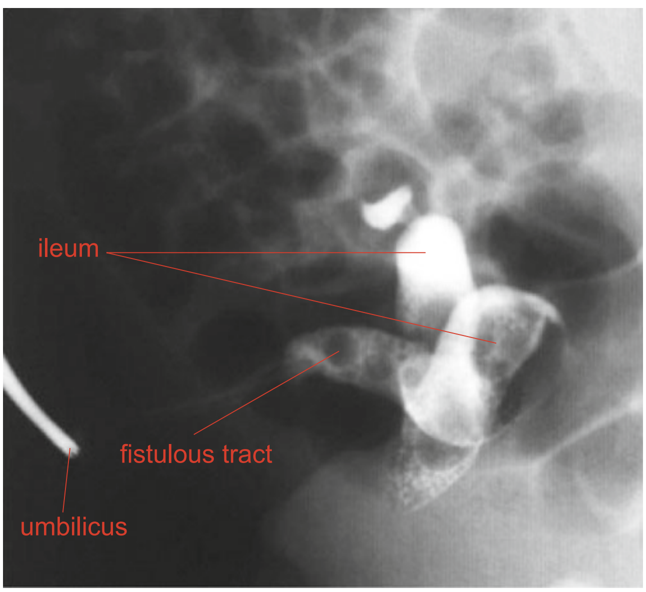

Fig. 26.2 Vitellointestinal fistula: fistulography. Fistulography demonstrates the communication between the umbilical sinus and ileum

26.1.1.2 Diagnosis

A fistulography demonstrates the direct communication between the umbilicus and the ileum (Fig. 26.2) [3].

26.1.2 Operations

26.1.2.1 Skin Incision (Fig. 26.3)

1. Supra- or infraumbilical transverse incision

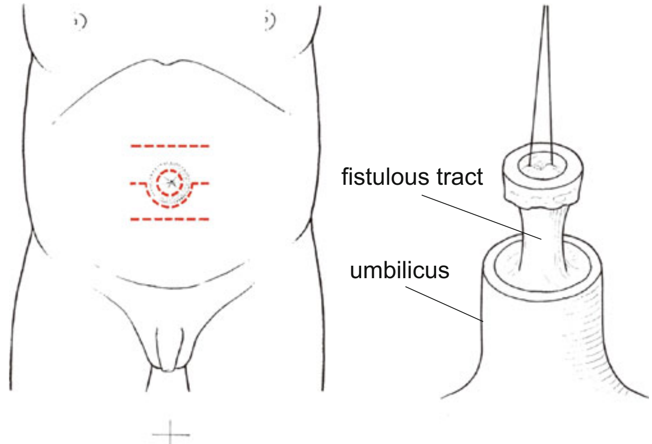

Fig. 26.3 Vitellointestinal fistula: skin incision, dissection of the fistula

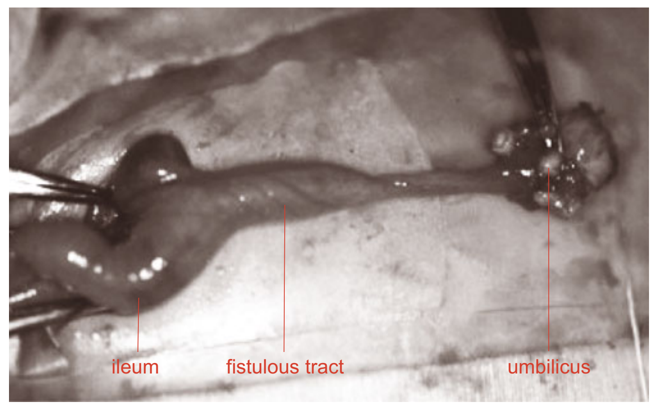

Fig. 26.4 Vitellointestinal fistula. Communication between the umbilicus and ileum via patent canal

2. U-shaped or inverted Ω incision around the umbilicus
3. Circular incision within the umbilicus at the mucocutaneous junction (Fig. 26.3, right) [4]

26.1.2.2 Dissection, Resection of the Fistulous Tract, and Anastomosis

A circular incision between the umbilical skin and the ileal mucosa is made (Fig. 26.3, right), and dissection of the fistulous tract from the surrounding tissue is continued into the peritoneal cavity. Upon entering the peritoneal cavity, the ileum which is connected to the fistula is mobilized (Fig. 26.4). After a division of the mesodiverticular band, a wedge resection of the

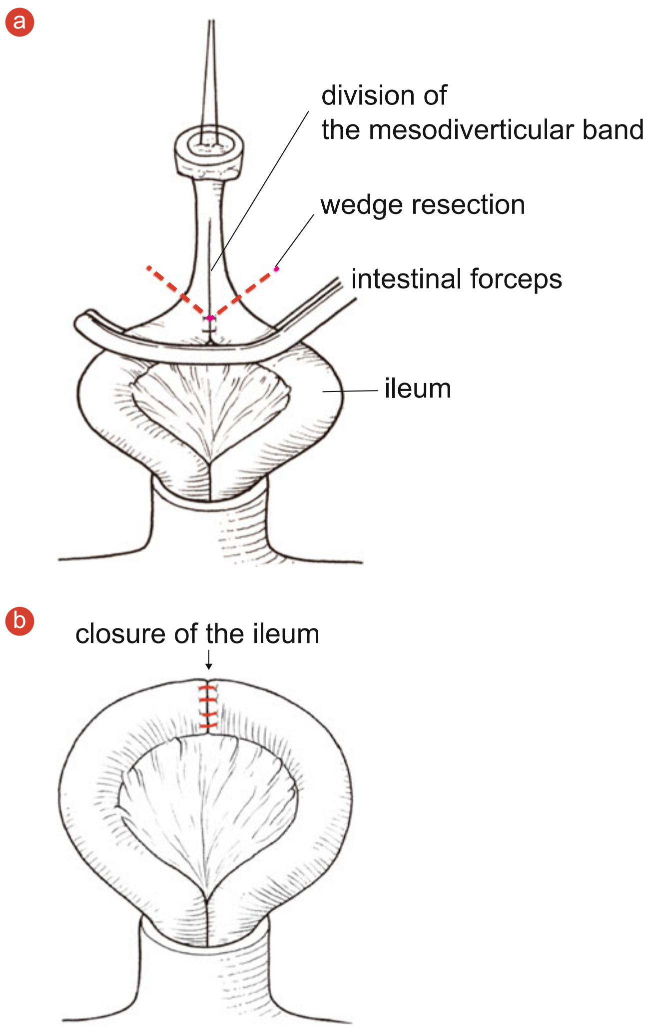

Fig. 26.5 Wedge resection of the vitellointestinal fistula and closure of the ileum. (**a**) mesodiverticular band. (**b**) closure of the ileum

vitellointestinal tract is done and the ileum is closed in one or two layers with absorbable sutures (Fig. 26.5).

26.1.2.3 Wound Closure

The defect in the umbilical ring is sutured and the umbilical skin is closed by a subcuticular purse-string suture with absorbable suture.

26.1.3 Postoperative Management

1. Feeding is started when flatus or stool passed.
2. Postoperative complications: anastomotic leakage, anastomotic stenosis, wound infection, and adhesive intestinal obstruction.

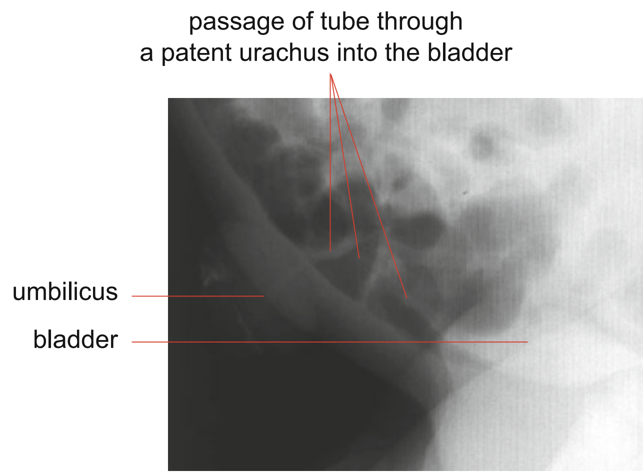

Fig. 26.6 Patent urachus: fistulography. Demonstration of a patent urachus and the bladder through injection of an umbilical sinus

26.2 Urachal Sinus/Urachal Cyst

26.2.1 Preoperative Management

26.2.1.1 Symptoms [5–7]

1. Drainage of the urine through the umbilicus (completely patent urachus)
2. Omphalitis: periumbilical erythema, tenderness, and transumbilical purulent discharge (umbilical urachal sinus)
3. Tender lower midline mass (urachal cyst, pyourachus)

26.2.1.2 Diagnosis [7]

1. Fistulography (Fig. 26.6)
2. Retrograde cystography (Fig. 26.7)
3. Ultrasonography (Fig. 26.8)
4. CT scan (Fig. 26.9)
5. MRI

In case of a completely patent urachus, immediate surgery is needed, whereas operation should be performed after the infection subsides by antibiotic therapy or drainage in case of the pyourachus.

26.2.2 Operative Procedures

26.2.2.1 Skin Incision (Fig. 26.3)

1. Subumbilical transverse incision (Fig. 26.10a)
2. Lower abdominal midline incision (Fig. 26.10b)
3. Infraumbilical U-shaped (Fig. 26.10c) or Y-shaped incision (Fig. 26.10d)

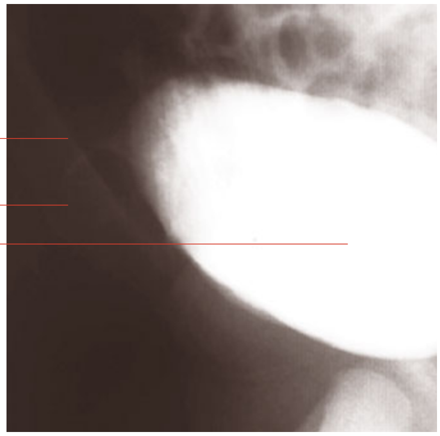

Fig. 26.7 Patent urachus: retrograde cystography. Demonstration of the thin tract (patent urachus)

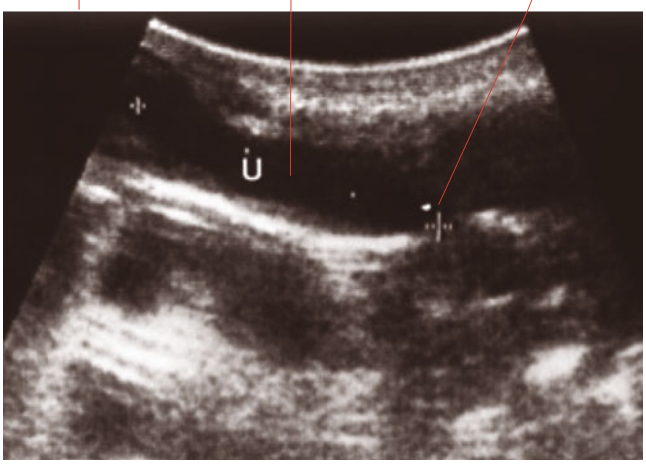

Fig. 26.8 Umbilical urachal sinus: ultrasonography. Demonstration of the extraperitoneal blind-ending hypoechoic structure from the umbilicus

In case of a completely patent urachus and urachal cyst, the subumbilical transverse incision or the lower abdominal midline incision is suitable, whereas in case of the umbilical urachal sinus, the infraumbilical U-shaped or Y-shaped incision is excellent.

26.2.2.2 Dissection of the Urachus

After an adequate skin incision is made and the separation of the rectus fascia is done, the urachus is dissected away from the peritoneum. The urachus extends from the anterior dome

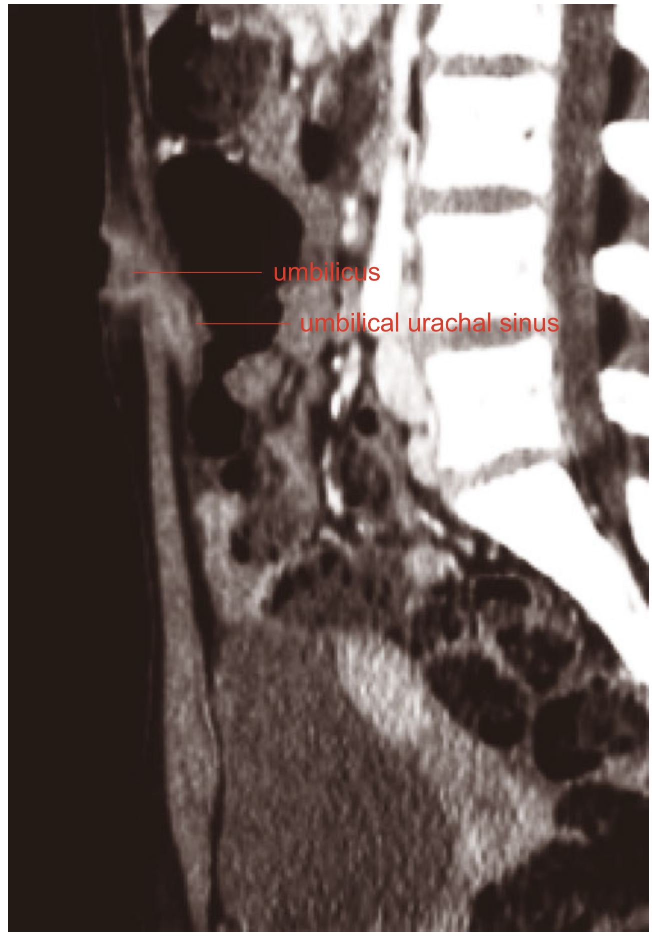

Fig. 26.9 Umbilical urachal sinus: CT scan. Demonstration of the blind-ending tubular structure from the umbilicus

of the bladder toward the umbilicus, adjacent to the medial umbilical folds (Fig. 26.11). In case of the umbilical urachal sinus, to probe from the umbilical orifice to the sinus facilitates the dissection.

26.2.2.3 Excision of the Urachus

Although the extraperitoneal excision of the urachal remnant is desirable, the urachus is resected with the peritoneum if the inflammatory adhesion is dense.

26.2.2.4 Closure of the Bladder and Excision of the Median Umbilical Fold

In case of a patent urachus, total excision of the urachal sinus with a cuff of bladder is required. The bladder is closed in two layers with absorbable sutures. In case of the umbilical

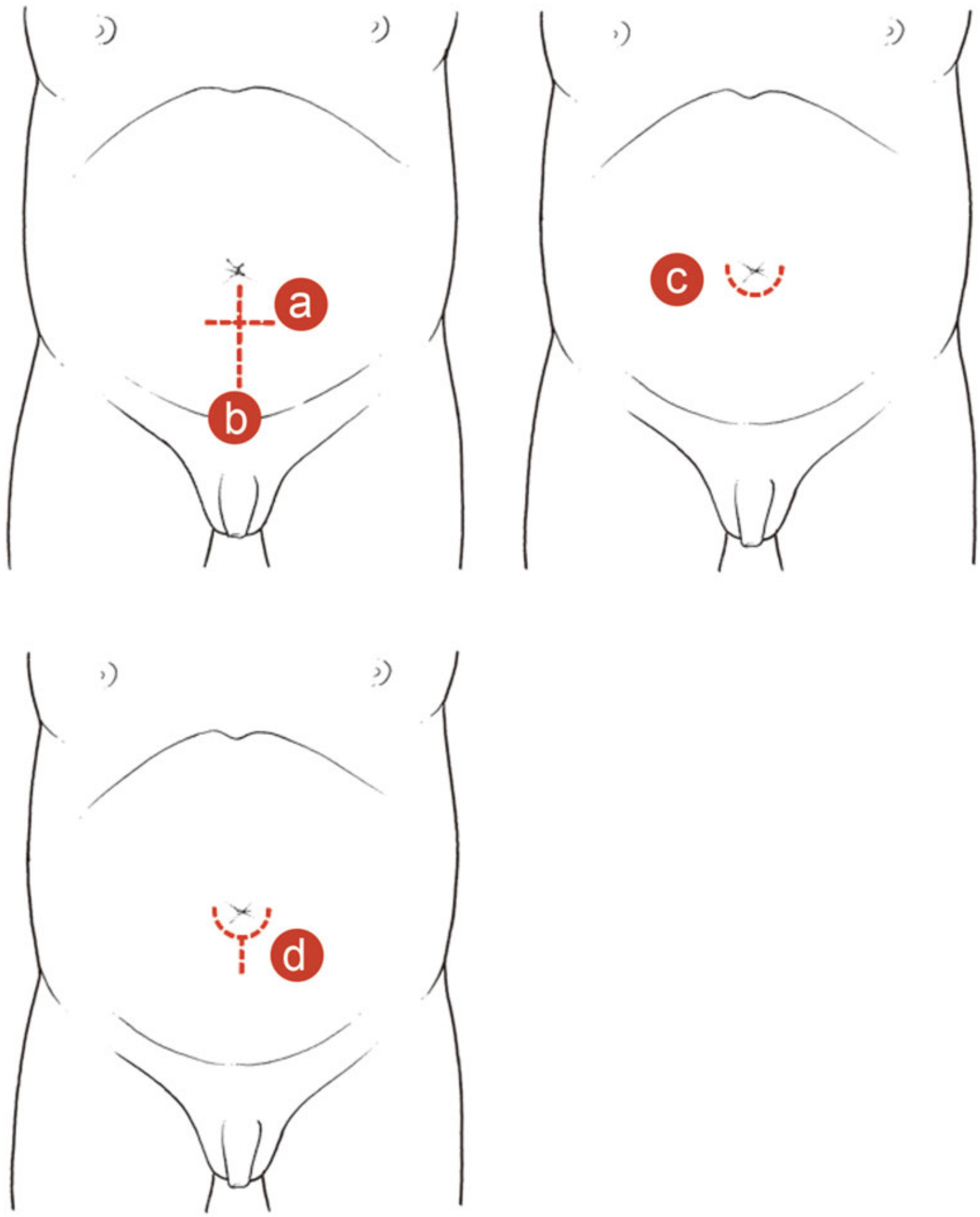

Fig. 26.10 Excision of the urachal remnants: skin incision. (**a**) Subumbilical transverse incision. (**b**) Lower abdominal midline incision. (**c**) Infraumbilical U-shaped incision. (**d**) Infraumbilical Y-shaped incision

sinus, the proximal sinus and the distal medial umbilical fold are resected.

26.2.2.5 Wound Closure

The defect in the umbilical ring is sutured and the abdominal wall is closed as usual fashion.

26.2.3 Postoperative Care

1. Early postoperative feeding is possible in case of the extraperitoneal excision of the urachus, but in case of laparotomy, feeding is started when the flatus or the stool passed.
2. Postoperative complications: wound infection and adhesive intestinal obstruction (in a case of laparotomy)

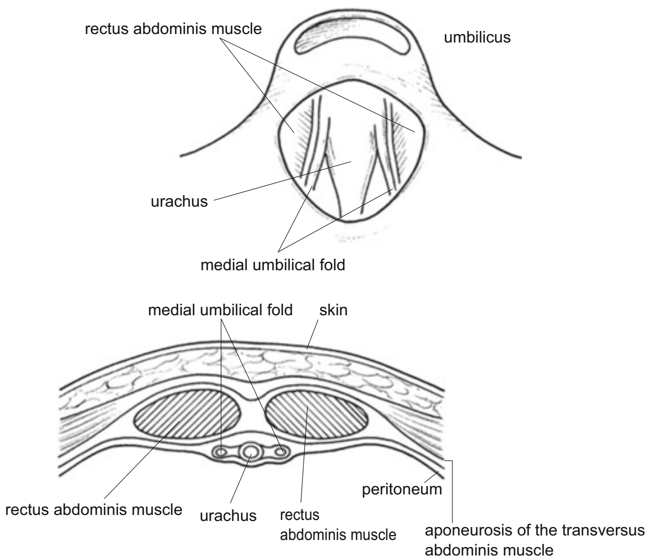

Fig. 26.11 Anatomy of the urachus

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Gastroschisis and Omphalocele

27

Yutaka Kanamori

Abstract

Gastroschisis is not usually complicated with other severe anomalies, and if the prolapsed intestine is not edematous, it should be reduced into the abdominal cavity and primary closure of the abdominal wall could be possible. But if the prolapsed intestine is very edematous because of prolonged stimuli by the amniotic fluid and congestion of the mesenteric veins, multistage closure of the abdominal wall is recommended. We recently use the wound retractor Alexis^R to construct silo. More recently sutureless closure of the abdominal wall is reported.

Omphalocele is often complicated with some severe congenital anomalies such as severe cardiac disease or chromosomal anomaly. If the hernia is very small, named as hernia into the umbilical cord, the abdominal wall is closed soon after birth. But if the hernia size is large and liver parenchyma prolapsed, the primary closure of the abdominal wall is impossible, and multistage closure should be chosen. Silo is first constructed using Alexis^R to cover the prolapsed organs, and within 7–10 days, silo is squeezing so as to put into the prolapsed organs into the abdominal cavity. Finally the abdominal wall is closed. Recently more severe cases of omphalocele have come to be saved because of the progress of the respiratory care.

Keywords

Omphalocele • Gastroschisis • Abdominal wall defect

27.1 Gastroschisis

The patient usually has an abdominal wall defect at the right side of the umbilicus whose diameter is 2–3 cm. The prolapsed organs may include the intestine, stomach, reproductive organs, and bladder. The important points to keep in mind when we treat gastroschisis are as follows: (1) The size of the abdominal wall defect is usually not so large, (2) the intestine is a main prolapsed organ, and (3) intestinal problems such as prominent edema, atresia, and perforation are often seen.

27.1.1 Preoperative Management

In order to prevent severe dehydration and hypothermia, prolapsed organs should be covered by the Saran Wrap as soon as possible after birth. Also in order to protect the patient from bacterial infection, clean technique should be utilized to handle the patient using clean gauze, towels, and gloves.

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27.1.2 Operations

27.1.2.1 The Case with the Prolapsed Organs Being Not Edematous (Fig. 27.1a)

When the prolapsed organs are not edematous, one-stage operation to close the abdominal wall defect should be tried. But if general condition and respiro-circulatory status are not stable, one-stage operation should be abandoned and a multistage operation be considered.

One-stage operation is usually performed under general anesthesia. The intestine should be carefully examined before reducing them into the abdominal cavity whether it has an atresia or a perforation. If the abdominal cavity is too small to reduce the prolapsed organs, the technique to distend the anterior abdominal wall using figure tip of the operator may be effective to gain enough cavity. Subcutaneous tissues around the abdominal wall defect are dissected well and abdominal muscular layer around the defect should be disclosed. The umbilical cord is preserved in situ in this stage to make the umbilical hollow. 3-0 absorbable sutures or nonabsorbable sutures are used to close the abdominal defect. The sutures cannot be stitched on the umbilical cord; instead the intimate sutures are stitched near the cord not to leave the space in the suture line (Fig. 27.1b). Skin closure is archived by the purse-string suture to create the circular umbilical scar.

27.1.2.2 The Case with Severe Edematous Intestine (Fig. 27.1c)

In some case, the intestine and other prolapsed organs have long been exposed in amniotic fluid in fetal life, which causes very severe inflammation and edematous change of the organs. And furthermore the abdominal wall defect is so small that the prolapsed organs are sometimes squeezed by the edge of the abdominal wall and it causes severe congestion and resultant edema. In these cases, multistage abdominal closure should be considered. One-stage operation is to construct the abdominal silo by the wound retractor Alexis^{R} XS or XXS (Applied Medical Co. USA) (Fig. 27.2a). If the size of the abdominal wall defect is too small to create the silo in case the intestinal edema is very severe, we do not hesitate to enlarge the defect size to double by cutting the cranial side of the abdominal wall.

When keeping the prolapsed organs in the bag, the blue ring of the wound retractor was inserted into the abdominal cavity after *cutting a falciform ligament and a round ligament*. The opened side of the bag is closed by rotating the white rings and ligated by the suture material (Fig. 27.2a, b). The skin edge around the defective abdominal wall should be covered by the appropriate material (we usually use Karayahesive® (Alcare Co. Tokyo Japan) to prevent the bacterial infection).

After the silo creation, the edema of the intestine gradually subsides by the improvement of the blood flow and the prolapsed intestine starts to put into the abdominal cavity naturally. The operator squeezes the bag so as to push the prolapsed organs into the abdominal cavity once a day. Within 7–10 days, prolapsed organs are put into the cavity. Intestinal ischemia and the excessive increase of the intra-abdominal pressure must be avoided during these procedures by careful monitoring. Under general anesthesia, the final operation to close the abdominal wall defect should be performed (Fig. 27.2c). Remove the wound retractor and close the abdominal muscle layer according to the same way described in the one-stage operation. Skin closure is also done by the purse-string suture. After the operation, respiratory support is usually needed for a few days (Fig. 27.2d).

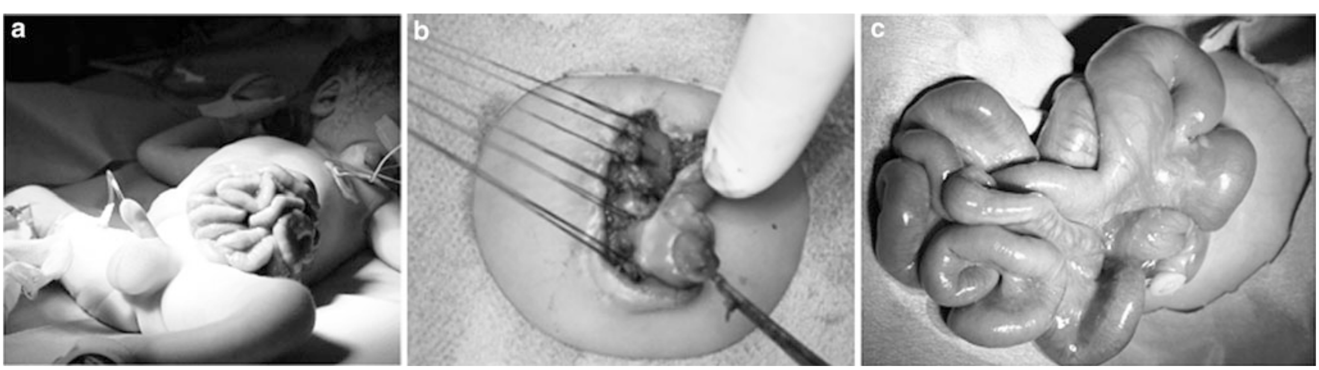

Fig. 27.1 Gastroschisis (1). (**a**) A case with no edema in prolapsed intestine. (**b**) One-stage closure of the abdominal wall was performed in this case after the prolapsed intestine was pushed into the abdominal cavity. When the umbilical cord is preserved, the sutures to close the abdominal muscle cannot be stitched at the umbilicus, then the sutures are stitched near the umbilicus to adjust the left and right rectal muscles. (**c**) A case with prominent edema in prolapsed intestine. In this case, one-stage closure of the abdominal wall is difficult

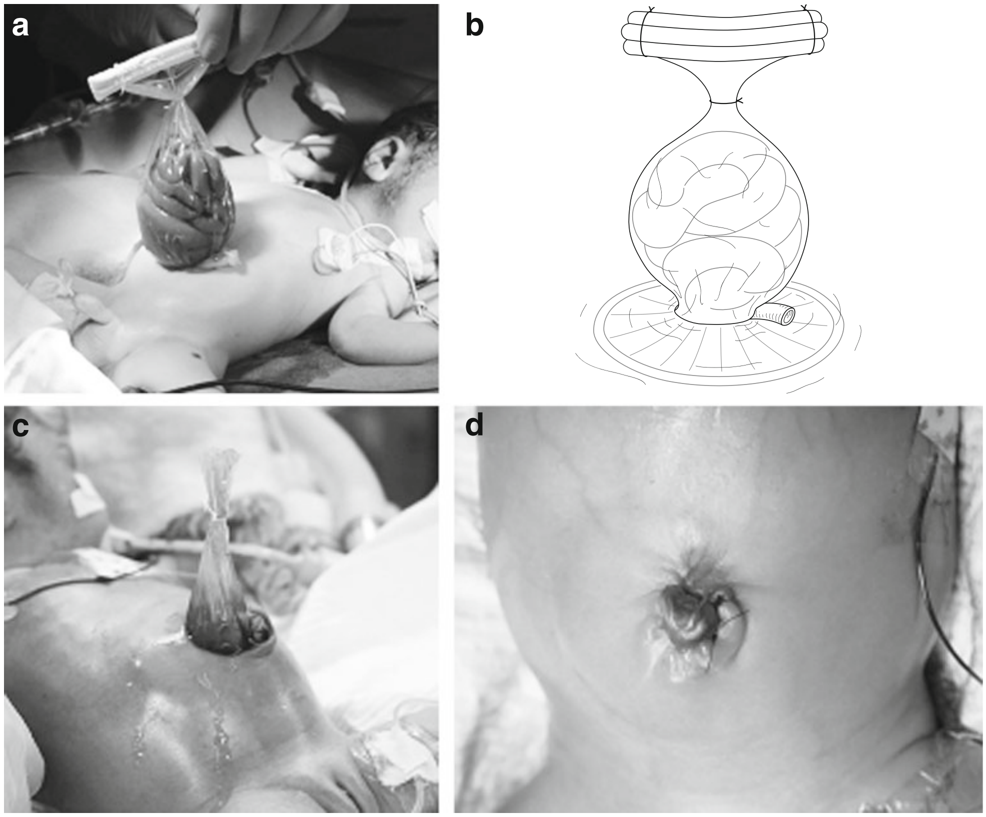

Fig. 27.2 Gastroschisis (2). (**a**) In this case, the wound retractor Alexis^{R} XS was inserted into the abdominal cavity to make a silo. The general condition in this case was poor and one-stage repair was abandoned. Outer side of the wound retractor is closed by the ligation. (**b**) The schema of the silo formation using wound retractor Alexis^{R} XS. (**c**) The silo was squeezed day by day for a few days and the prolapsed intestine was put into the abdominal cavity. (**d**) After the abdominal muscle layer is closed, the skin defect is closed by the purse-string suture to form the umbilical pit

27.1.2.3 The Case Being Complicated with Intestinal Atresia or Intestinal Perforation

If the intestinal atresia is apparent at birth, intestinal stoma is created first, and after decompressing the intestinal distension, primary closure or multistage closure of the abdominal wall defect should be selected. If the intestinal perforation exists and abdominal cavity is contaminated with meconium, silo creation should be selected at birth with appropriate drainage of the abdominal cavity.

27.1.2.4 Sutureless Method to Close the Abdominal Wall Defect (Fig. 27.3)

This method has attracted attention because of its easy procedure. Instead of abdominal wall closure by suture materials, the skin edge is covered by Tegaderm™ and waits to close the muscle layer by itself.

Fig. 27.3 Sutureless closure of the abdominal wall. In this case after the prolapsed intestine was put into the abdominal cavity, the skin defect is closed by the tape fixed on the skin without using any suture materials. Abdominal wall close naturally in this method

27.2 Omphalocele

Omphalocele is often complicated with other congenital anomalies such as cardiac disease or chromosomal anomaly, which sometimes define the prognosis of the patients. The classification of omphalocele is as follows: (1) supraumbilical, (2) umbilical, (3) infraumbilical, and (4) umbilical cord hernia.

27.2.1 Preoperative Management

Almost the same as gastroschisis

27.2.2 Operations

27.2.2.1 Umbilical Cord Hernia

Some bowels prolapsed into the umbilical cord. This type of hernia is less severe and primary closure is easy. It is recommended that the primary closure should be done under general anesthesia. First hernia sac should be removed and check whether some congenital anomalies such as omphalomesenteric remnants or urachal remnants exist. The prolapsed bowels are easily reduced into the abdominal cavity and close the abdominal wall by a few sutures.

27.2.2.2 Giant Hernia Containing Liver Parenchyma (Figs. 27.4 and 27.5)

(a) After dissecting widely, the subcutaneous tissue around the hernia sac and abdominal wall defect is covered with freed skin. Defective abdominal muscle is left open and it will be closed later in life. This method is now rarely adopted in Japan.

(b) Silo formation by wound retractor Alexis^R.

One method is a direct suture of a retractor ring to abdominal muscle layer after dissecting subcutaneous tissues around the hernia. This method effectively pulls up the abdominal muscle and dilates the abdominal cavity but may cause the injury of the muscle layer by sutures when squeezing the prolapsed organs into the abdominal cavity.

Another method is almost the same way as gastroschisis. This method should be applied to the omphalocele with relatively mild liver prolapsed (Fig. 27.4a). After removing the hernia sac, the blue ring of the wound retractor is inserted into the abdominal cavity (Fig. 27.4b). This method is less effective to dilate the abdominal cavity and the ring may be slipped out by the tension.

When the hernia is large and abdominal wall is so hypoplastic (Fig. 27.4c), the blue ring of the wound retractor is directly sutured to the skin edge of the hernia

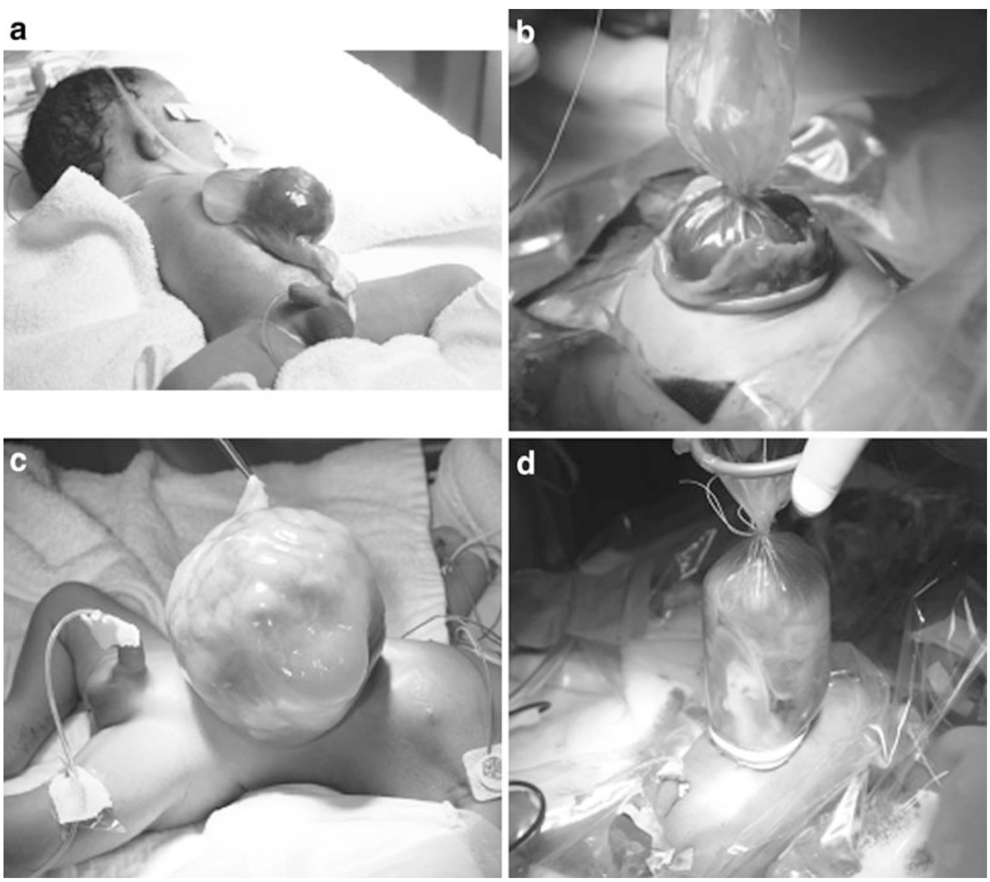

Fig. 27.4 Omphalocele (1). A case of moderate-size omphalocele (hernia content includes only the liver). (**a**) Cyst formation in the Wharton jelly is ascertained. (**b**) Wound retractor Alexis^R XS is inserted into the abdominal cavity after removing the hernia sac. A case of giant omphalocele (hernia contents include the liver and intestine). (**c**) This hernia is very large in size and anticipated much difficulty to put the herniated organs into the abdominal cavity. (**d**) Wound retractor Alexis^R XS was directly sutured to the edge of the defected skin to form a silo

Fig. 27.5 Omphalocele (2). (**a**) A case presented in Fig. 27.4c, d. In 7 days, the almost all prolapsed organs were reduced into the abdominal cavity by squeezing the silo day by day. (**b**) The abdominal wall is closed by the muscular layer after the hernia sac was removed. The muscle layer is stretched with the strong tension in this case. (**c**) The skin defect is longitudinally sutured and the skin at the caudal end is plicated as rectangular shape to form a skin roll that is imitated as an umbilical pit

leaving hernia sac in situ (Fig. 27.4d). This method may be possible under local anesthesia. As hernia sac is left intact, ascites does not overflow from the wound and it is easy to squeeze the prolapsed organs into abdominal cavity. In 7–10 days, the prolapsed organs should be pushed into the abdominal cavity because the skins will be torn by the sutures with the tensions (Fig. 27.5a). If the hernia sac adheres to intra-abdominal organs, hernia sac is partly resected and the adhesion is released before constructing the silo. The abdominal wall is closed by muscular layer after the prolapsed organs are reduced into the abdominal cavity by silo squeezing (Fig. 27.5b). In this method, the hernia sac is intact in situ and we first dissect the hernia sac from the skin and the abdominal muscle is closed by the absorbable sutures. The skin cannot be closed as the gastroschisis because the skin defect is large enough to close by purse-string suture. We close the skin longitudinally and at the caudal end, the skin is cut rectangle and make a skin roll to form the umbilical pit (Fig. 27.5c).

(c) Recently survival cases of a more complicated and severe omphalocele have been reported because they are well cared in fetus and intensively cared after birth with the up-to-date respiratory support. In such severe cases, the defect of the abdominal wall is so severe and the development of abdominal muscle is so poor. In order to close the abdominal wall, the skin graft is applied or Karayahesive^{R} (Alcare Co. Tokyo, Japan) is applied on the hernia sac to induce skin elongation to cover the defect. In some case, component separation technique is applied to close the abdominal muscle: the fascia of the external oblique muscle is longitudinally cut and it makes the transverse widening of the muscle to gain enough abdominal cavity. In another case, the tissue expander is inserted into the abdominal cavity to make enough space to reduce the prolapsed organs.

Part V

Abdominal

28 Laparoscopic Nissen's Fundoplication

Hirotsugu Terakura and Osamu Segawa

Abstract

Nissen's fundoplication is performed for patients with gastroesophageal reflux. In this chapter, the author describes laparoscopic Nissen–Rossetti fundoplication. This method is simple, safe, and highly effective, with few complications or recurrences.

Keywords

GER (gastroesophageal reflux) • Nissen's fundoplication • Nissen–Rossetti • Laparoscopic fundoplication

28.1 Points of the Operation

The procedure of the operation by using endoscope would be best if the procedure itself would be as simple as possible, with few complications and fewest chances of recurrence. My operative method of laparoscopic fundoplication is Nissen–Rossetti, with no or minimum division of the short gastric vessels, loose plication of esophageal hiatus in one stitch, 360° full wrap with three stitches, and the fixation of the wrap to the diaphragmatic crus in one stitch. The total number of stitches in my operative method is only 5 and the operating procedure itself is as simple as possible.

28.2 Preoperative Management

The most important point of preoperative preparation is to reduce enteric gas as much as possible in order to keep a wide view of the operative field during operation. Oral intake is prohibited and a laxative (such as magnesium citrate) is injected through nasogastric tube in the afternoon of the day before operation. An enema is also necessary in the evening of the day before operation and in the morning of the day of surgery.

28.3 Operations

28.3.1 Position of the Patient (Fig. 28.1)

There are a lot of patients with severe motor and intellectual disabilities who undergo the fundoplication. Although some elder children have scoliosis and deformity of a soma, it is necessary to devise a posture so that the surgeon can stand at pedal extremities of the patient, with an assistant on either side.

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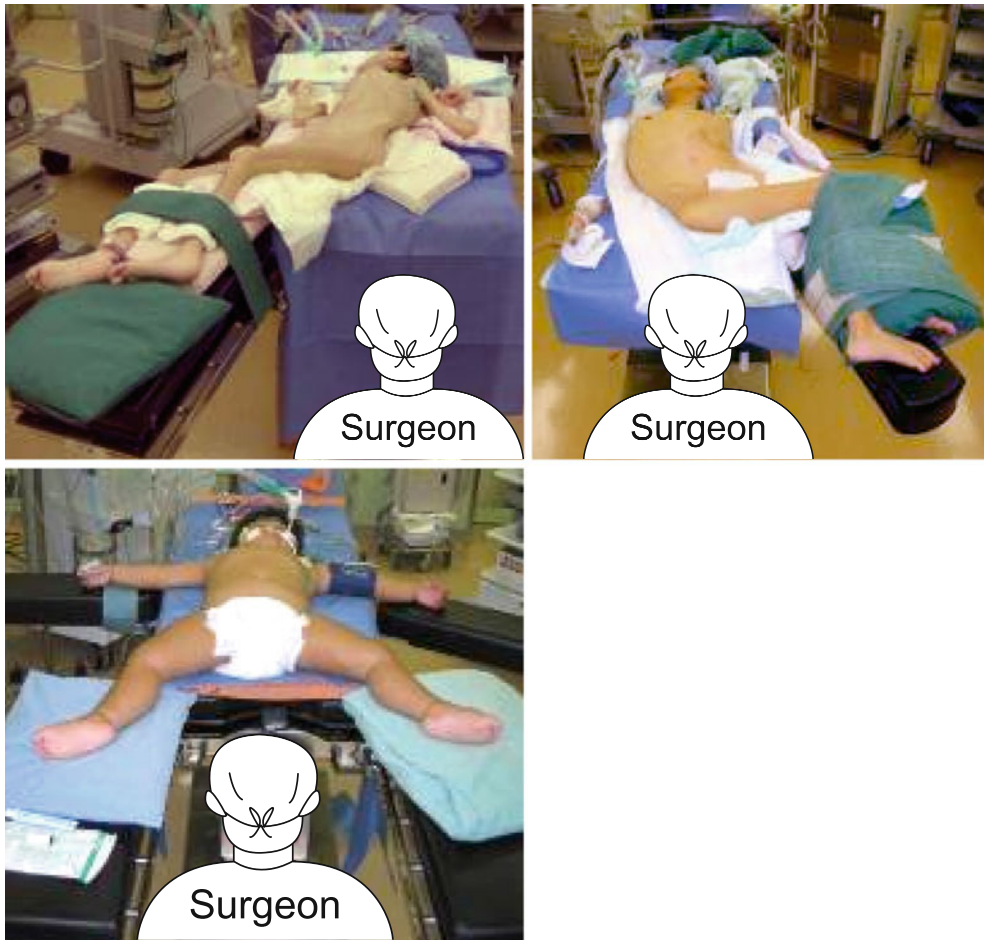

Fig. 28.1 Position of the patients

28.3.2 Securing of the Space of Operative Field (Fig. 28.2)

It is very difficult to make enough space of operative field even by pneumoperitoneum in the patient with flat thorax. The operation itself is quite difficult especially in the case of a patient with severe scoliosis and deviation of the stomach. The thorax and abdominal wall is lifted up and we can establish a wide space of the operative field by lifting a thread by using a lift device, which is stitched at the left hypochondrium.

Fig. 28.2 Securing of the space of operative field. Lifting a thread by using a lift device

28.3.3 Port Placements and Liver Retraction (Fig. 28.3)

The operation is performed with four ports. The initial port for the telescope (5 or 12 mm Hasson) is usually placed above the umbilicus. Pneumoperitoneum is created by pressure of 8 mmHg. A 5 or 10 mm scope with a 30° lens is then placed through the umbilical port, and two 5 mm ports for instruments of surgeon are placed in the right and left upper quadrant of the abdomen under direct vision. It is important to insert these ports quite laterally so that the wide angle creates the facilities of the intracorporeal suturing. One

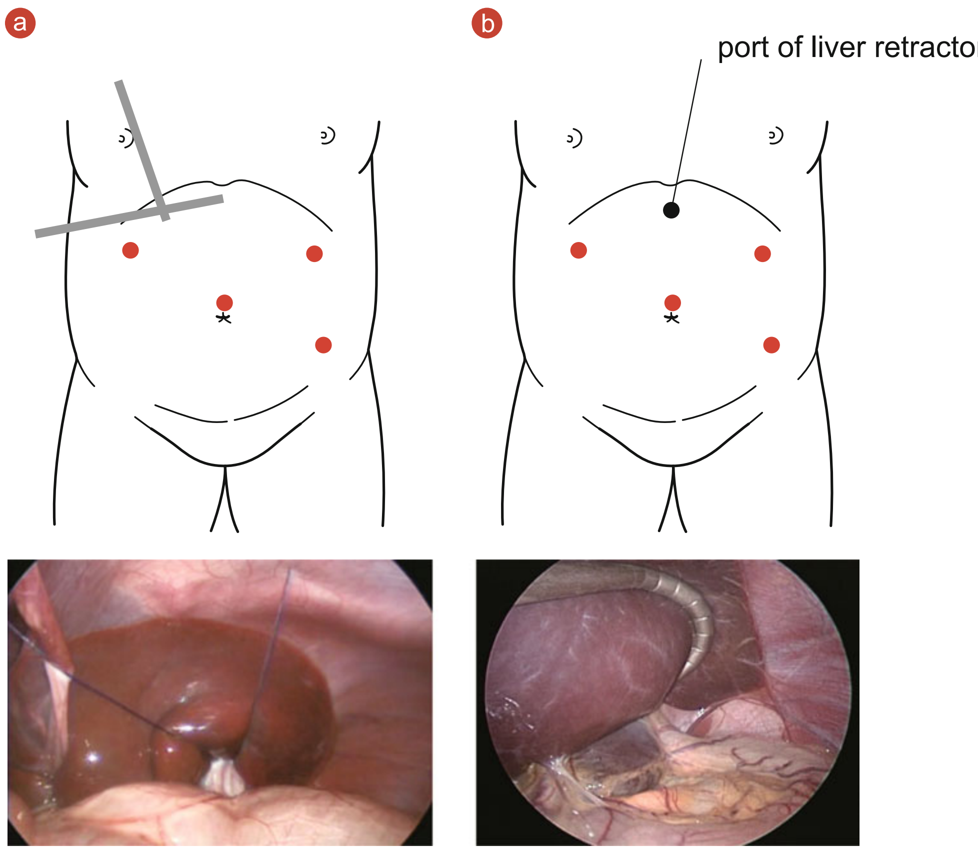

Fig. 28.3 Port placements and liver retraction. (**a**) Lifting the left lobe of the liver by thread. (**b**) Liver retractor

5 mm port for the assistant's grasping forceps is placed in the left under quadrant. When using the liver retractor, one port is added in the midline of the epigastrium (gastrostomy potion). It's better to fix the liver retractor to the operating table with a forceps holder. Recently, I insert thread (2-0 Vicryl, ETHICON®) through the abdominal wall at the epigastrium to the abdominal cavity and pull out extracorporeally at the right hypochondrium, after stitching to the top of the esophageal hiatus and lifting the left lobe of the liver. The epigastric port for liver retraction is not necessary in this method.

28.3.4 Exposure of the Esophageal Hiatus and Detachment of the Esophagus

After inserting all ports and elevating the lateral segment of the left lobe, the table is then turned in reverse Trendelenburg position to allow the colon and the small intestine to fall away from the area of dissection. The surgeon starts to operate on the left hand with Maryland-type forceps or intestine-grasping forceps and then on the right hand with an ultrasonic coagulation-lancing device Harmonic Ace (Johnson & Johnson (LCS)). The assistant pulls the gastric fundus using Endo Babcock.

At first, I cut the gastrohepatic ligament toward the esophagus while being careful not to cut vagal hepatic branches. A good view will be obtained after separating the gastrohepatic ligament on the head side of vagal hepatic branches (Fig. 28.4). Next, I cut the phrenoesophageal ligament from the front to the left side of the esophagus, and the detachment of the esophagus from esophageal hiatus is started from the left side. I dissect between the hiatal crus and esophagus at the left side and the dissection of the back of the esophagus is performed as much as possible at the same time. Afterward, I exfoliate the front of the esophagus from the diaphragm and move to the right and dissect between the hiatal crus and esophagus at the right side and move to detachment of the back of the esophagus. When I dissect the back of the esophagus, it is safe for me to insert the tip of the cherry dissector (Johnson & Johnson) at the deep site of the mediastinum and pull to lift the esophagus in the foreground of the operative field. Dissection of the posterior side of the esophagus is performed being careful of injury of posterior trunk of vagal nerve. The use of blunt tip forceps as grasping for the bowel is much safer when we thread forceps from the right to the left through the back of the esophagus (Fig. 28.5). After dissection of the posterior side of the esophagus completely, the tape is passed through the dorsal space of the esophagus. The assistant holds the

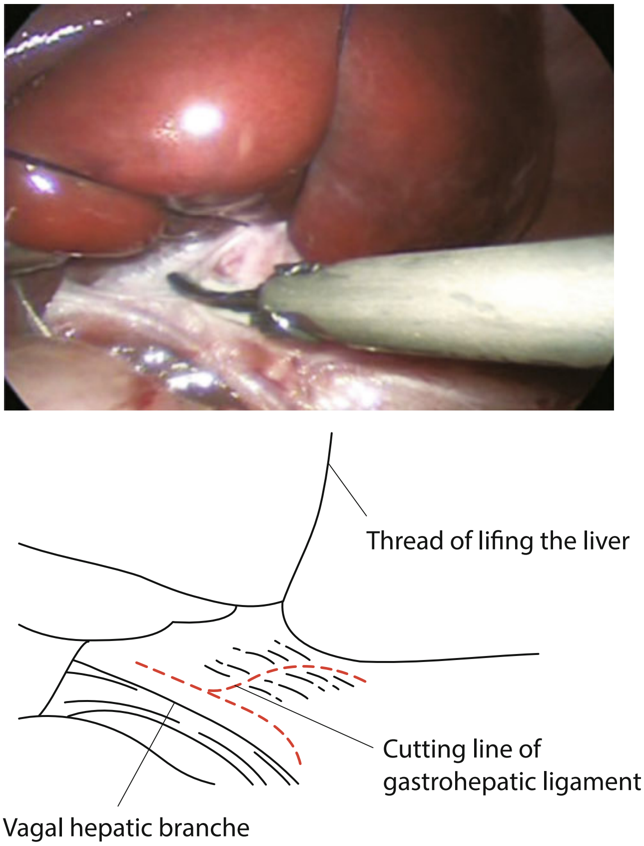

Fig. 28.4 Separating the gastrohepatic ligament on the head side of vagal hepatic branches

Fig. 28.5 Blunt tip forceps

knot of the tape with double ligation by the forceps inserted from the port of the left under quadrant and pulls the tape toward the abdominal wall. Further full dissection around the esophagus in the mediastinum is carried out, while the assistant pulls the esophagus out of the mediastinum by the traction of the tape. The left membranous tissues on the gastric side of the tape are cut thoroughly on the posterior

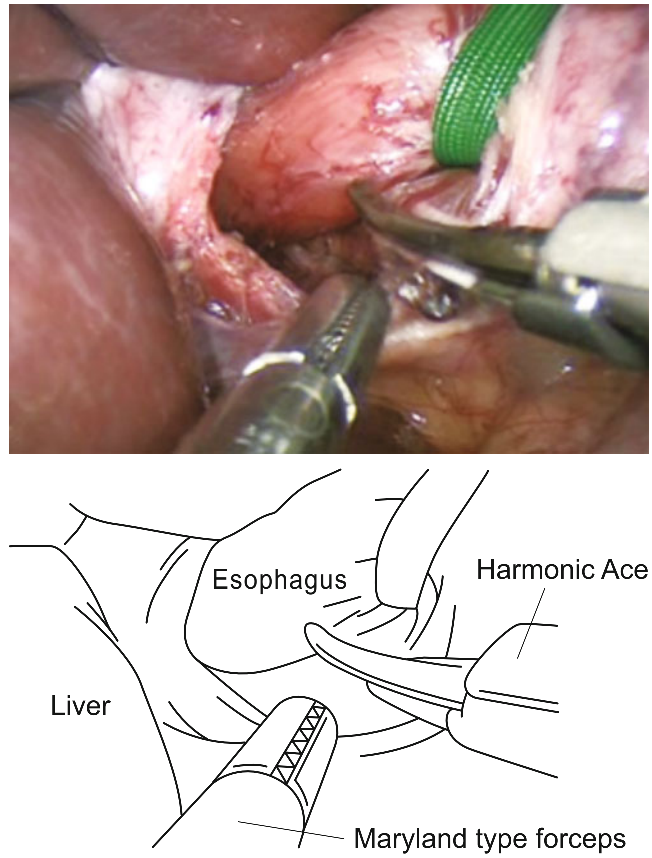

Fig. 28.6 Cutting of the membranous tissues

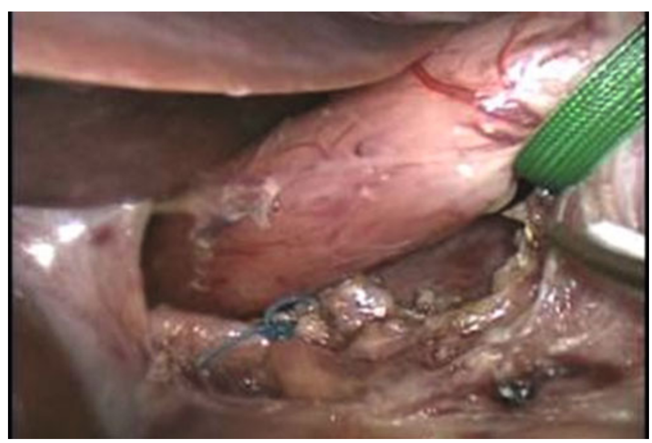

Fig. 28.7 Wide window

side of the esophagus (Fig. 28.6). If the window of the posterior side of the esophagus is not wide enough, the wrap will be too tight to pull at the formation of the wrap (Fig. 28.7). The esophagus is lifted toward the abdominal wall, and the posterior trunk of vagal nerve is identified. It is not a problem that the posterior trunk of the vagal nerve is detached or undetached from the esophagus. As it is usually detached and free from the esophagus, it is located at the back of the knot for the crural repair after full detachment.

Traction of the stomach by the assistant is important when the esophagus is dissected fully. The assistant pulls the fundus of the stomach toward the left and dorsal side at the time of dissection on the right side. The fundus of the stomach is pulled toward the reversed direction and ventral side on the back of the esophagus at the time of dissection on the left side. It is important for the assistant to change the direction of traction depending on the dissecting operative field.

28.3.5 Division of the Short Gastric Vessels

Although I have not dissected the posterior wall of the gastric fundus and not divided the short gastric vessels as my basic policy for the prevention of recurrence, dissection and/or division will be necessary if the wrap cannot be formed loosely. The tight wrapping by force will lead to smaller wrap in the back of the esophagus, unbalance-shaped wrap, and twist of the wrap. In the case of performing the division of the short gastric vessels as Nissen's method, we exfoliate the gastric fundus following the division of the short gastric vessels. Then we can dissect in a correct layer between the hiatal crus and esophagus at the left side of esophageal hiatus. In terms of the energy device for the division of the short gastric vessels, LigaSure (COVIDIEN) and ENSEAL (Johnson & Johnson) are much safer than LCS because of minimum lateral thermal injury in case of contact with spleen. As gastrosplenic ligament is very narrow especially in the upper pole of the spleen, energy devices such as LigaSure and ENSEAL are quite useful.

28.3.6 Crural Repair (Plication of the Diaphragmatic Crus) (Fig. 28.8)

The crura are approximated loosely at the back of the esophagus with one interrupted suture of 2-0 nonabsorbable stitch. The space around the esophagus is necessary, in which 5 mm forceps is inserted easily. The posterior trunk of the vagal nerve which is free from esophageal posterior wall is positioned at the back of the suture for plication.

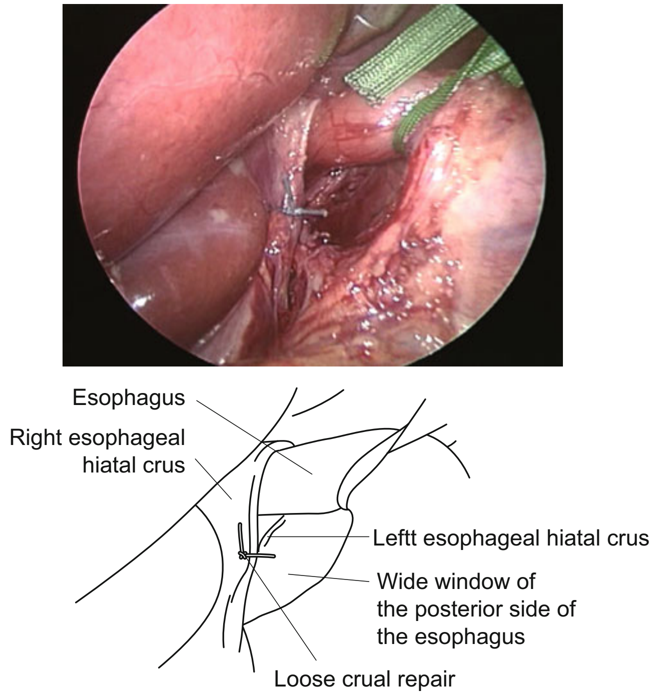

Fig. 28.8 Crural repair

28.3.7 Formation of the Wrap (Fig. 28.9)

There is no bougie into the esophagus during operation, and 360° full wrap is formed around the abdominal esophagus basically. The stitches of wraps are lined at 10–11 o'clock of the abdominal esophagus. The fundus is grasped and pulled through the retroesophageal space and the so-called "shoeshine" maneuver is performed to pull an adequate amount of the stomach for the loose wrap. It is very important to simulate before the actual suturing (Fig. 28.10). Most suitable points of stitches at bilateral wraps for short and loose wrap are decided with good balance and not too tight of wraps. The suture of wrap for the fundoplication is then performed using three interrupted 2-0 nonabsorbable sutures

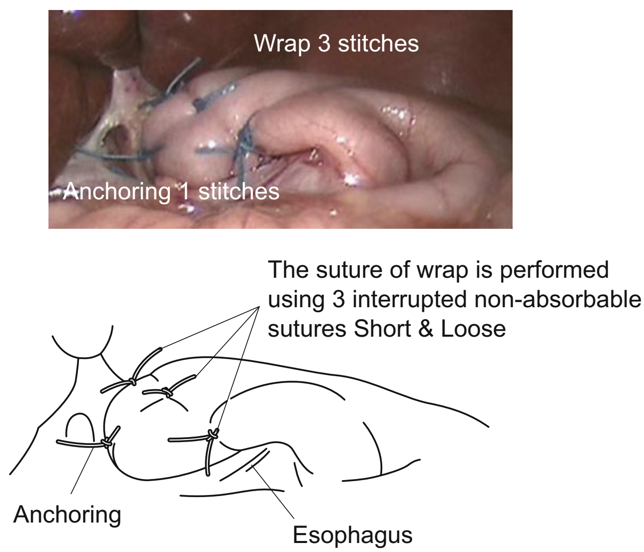

Fig. 28.9 Formation of the wrap and anchoring

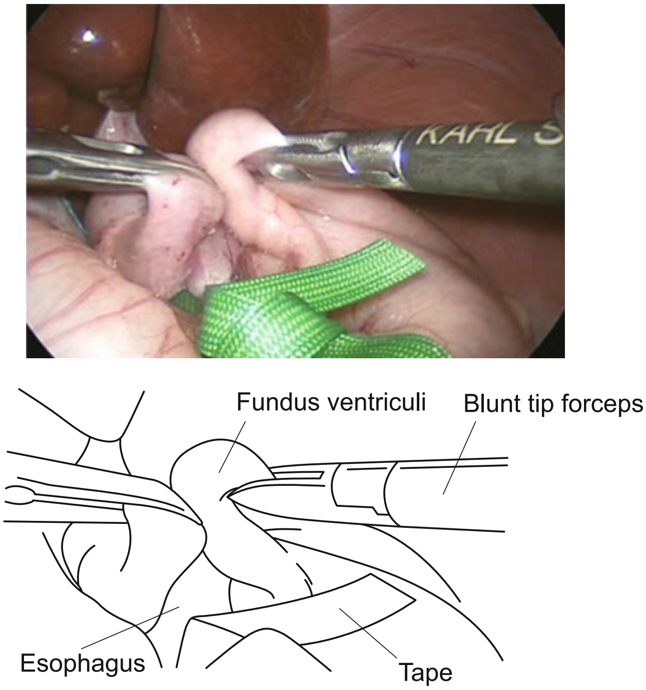

Fig. 28.10 Simulation of the wrap

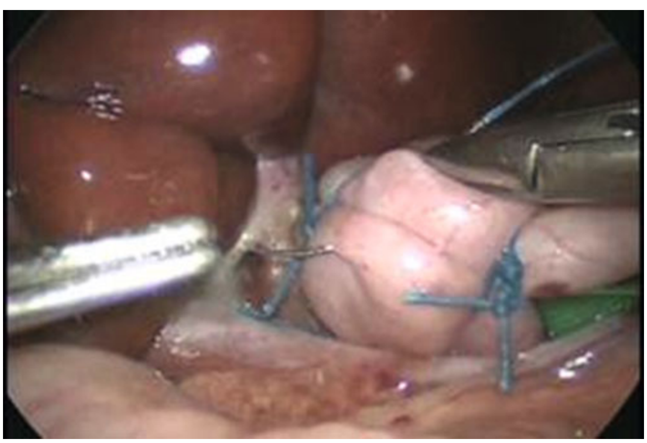

Fig. 28.11 The third stitch only as for the tripe

from gastric to diaphragmatic side. Serous membrane and muscle layer of the esophagus are also sutured in two stitches of diaphragmatic side. It is important that seam allowance of gastric full-thickness suture is wide enough to prevent disruption of the wrap. Furthermore, I add another one stitch of only wrap during these two stitches (Fig. 28.11). Previously, I shaped the wraps for fundoplication by only two stitches. However, three stitches are necessary now because of my experience of recurrent cases due to wrap disruption.

Fig. 28.12 The case with the existing gastrostomy

After completing the fundoplication, the suture for fixation between right wrap and right hiatal crus is performed as shoulder stitch. Nonabsorbable stitches (Ness Pau Ren 2-0) are used for all the sutures. All ports are removed after confirmation of hemostasis without irrigation and drain.

28.3.8 The Case with the Existing Gastrostomy (Fig. 28.12)

Even though the gastrostomy has already established, it is not necessary to be detached from the abdominal wall for fundoplication basically. As the operative field for fundoplication is the head side of the gastrostomy, usual fundoplication can be performed without any problems if the scope is inserted through the right side of the gastrostomy. Although it is slightly difficult to insert the forceps between the gastrostomy and falciform ligament especially by the left hand, deep insertion of the port will make it easy.

28.4 The Points of Postoperative Management

The nasogastric tube should be left for the decompression of the stomach overnight and removed the following day.

If the gastrostomy tube has been inserted, the nasogastric tube is removed at the end of the operation and the gastrostomy tube is left for the decompression.

I inject 20–50 ml of gastrografin through the gastrostomy tube or the nasogastric tube at 9:00 a.m. on the following day of the operation and take the abdominal X-ray 2 h later. I can confirm that there is no damage of vagal nerve if gastrografin has flowed out from the stomach to the duodenum, and oral intake of clear water without nasogastric tube or gastrostomy tube feeding will be started in the afternoon. It will be possible for infants and the patients with gastrostomy tube feeding to be discharged from the hospital after 3–5 days of the fundoplication operation.

In the case of the patients who eat normal diet, it takes more than 1 week for the hospital to discharge them because of a step-by-step increase of the amount and contents of food.

Pyloromyotomy

29

Hizuru Amano, Hiroshi Kawashima, and Tadashi Iwanaka

Abstract

Hypertrophic pyloric stenosis (HPS) is one of the most common surgical diseases associated with vomiting in infants. Vomiting is due to obstruction caused by hypertrophy of the muscular layers of the pylorus. Most patients present with nonbilious projectile vomiting with associated dehydration and metabolic alkalosis. The hypertrophied pylorus, known as an "olive," is palpable in the upper abdomen in most cases. Ultrasonography is the standard diagnostic test for HPS. Although there are reports of medical therapy with atropine, HPS is generally treated with surgery because atropine therapy requires a long hospitalization and is sometimes ineffective. Ramstedt's pyloromyotomy is currently the standard treatment for HPS. Although an open surgery provides a large operative field, which makes the procedure safe and easy, laparoscopic pyloromyotomy has grown in popularity recently. Its popularity is due to several benefits including better cosmesis, faster recovery with earlier return to full feeding, and shorter length of hospital stay compared with an open procedure. In addition, there are several reports showing no difference in complication rate between open and laparoscopic procedures. We describe the technique of pyloromyotomy using the open procedure as well as the laparoscopic procedure.

Keywords

Hypertrophic pyloric stenosis • Pyloromyotomy • Ramstedt's pyloromyotomy • Laparoscopic pyloromyotomy

29.1 Clinical Features and Diagnosis

Hypertrophic pyloric stenosis (HPS) is characterized by the development of nonbilious projectile vomiting in an infant at 3–5 weeks of age followed by dehydration and metabolic alkalosis due to hypochloremia and hypokalemia. A pyloric mass is palpable in upper abdomen and is referred to as an "olive."

Ultrasonography is the standard imaging technique for the diagnosis of HPS. A muscle thickness of ≥4 mm and a pyloric channel length of ≥16 mm are the criteria for diagnosis of HPS (Fig. 29.1). If the ultrasonographic findings are equivocal, an upper gastrointestinal study can be helpful. A positive study shows a "string sign" indicating the narrow elongated pyloric channel and a "mushroom sign" caused by the mass effect of the hypertrophied pylorus on the duodenal cap (Fig. 29.2).

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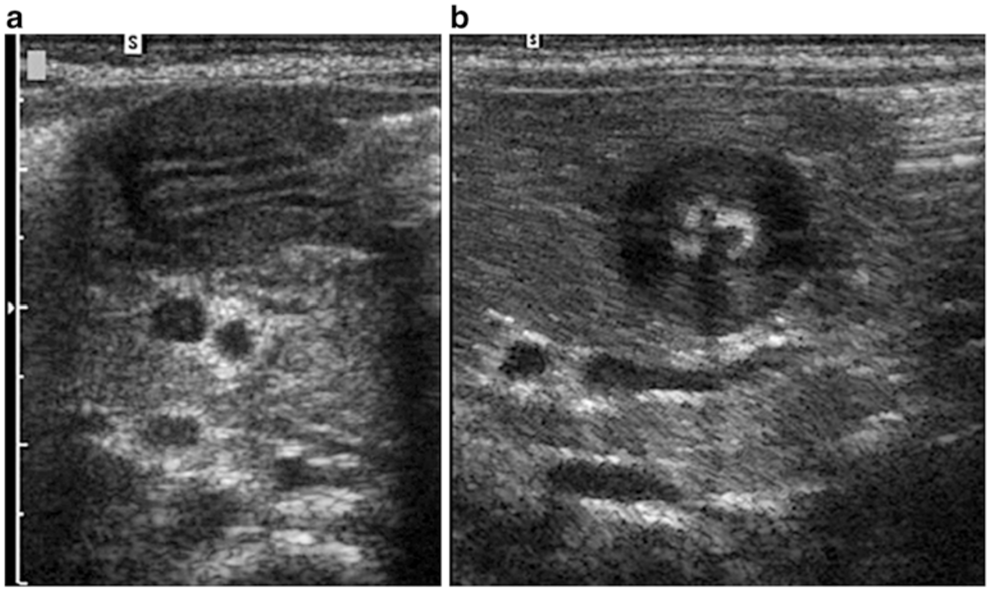

Fig. 29.1 Ultrasonographic images showing pyloric muscle thickness measuring 5 mm. Longitudinal view (**a**) and transverse view (**b**)

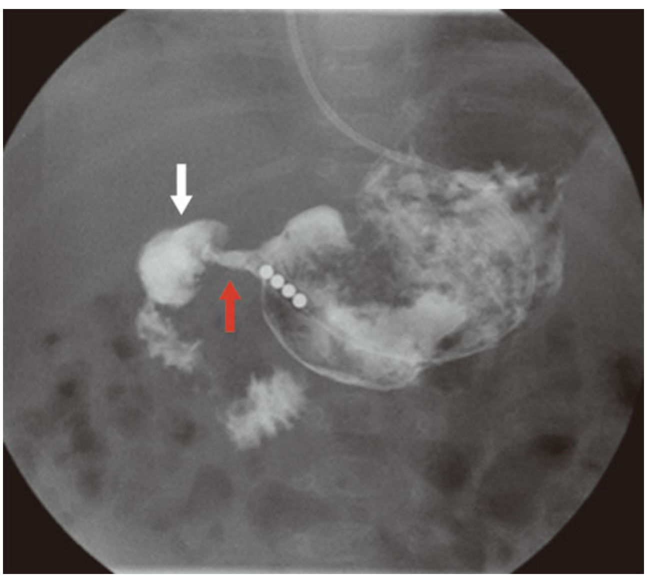

Fig. 29.2 An upper gastrointestinal study illustrating the string sign (*red arrow*) and mushroom sign (*white arrow*)

29.2 Preoperative Management

Frequent vomiting causes dehydration, loss of electrolytes, and hypoproteinemia. Before surgery, dehydration and metabolic alkalosis must be adequately corrected according to the level of severity (Table 29.1).

A nasogastric tube is placed prior to surgery to prevent accidental vomit-induced aspiration.

Table 29.1 Fluid resuscitation for dehydration and electrolyte abnormalities

Severity	Base excess (mmol/L)	Electrolyte composition Na:Cl:K (meq/L)	Resuscitation regimen normal saline: 5 % dextrose, 1 mmol potassium chloride (ml)	Volume (ml/kg/day)
Severe	≥10	100:120:20	200:100:12.5	150
Moderate	10> BE ≥5	75:95:20	100:100:10	150
Slight	<5	75:95:20	100:100:10	120

Before laparoscopic surgery, the umbilicus should be meticulously cleaned to prevent wound infection. This should be performed with extreme care especially in neonates whose umbilical cords have just fallen off.

Catheterization of the bladder is mandatory for the laparoscopic procedure to prevent injury of the bladder during insertion of the port.

29.3 Operations

Ramstedt's pyloromyotomy is the standard operation for HPS today.

29.3.1 The Open Procedure

The open procedure provides a large operative field, which makes procedures safe and easy especially for pylorus delivering.

29.3.1.1 Incision (Fig. 29.3)

For the open procedure, various incisions have been reported.

The Right Upper Quadrant Transverse Incision

A transverse incision approximately 3 cm long is made just above the palpable pyloric mass in the right upper quadrant of the abdomen. After making a cut in the fascial layer, the rectus muscle is bluntly split longitudinally in the direction of its fibers for laparotomy. Delivery of the pyloric mass through the incision is easy as it is lying immediately beneath it. The incision can be easily extended when needed.

The Omega-Shaped or Semicircular Incision Around the Upper Half of the Umbilical Ring

The omega-shaped or semicircular incision is made along the upper half of the umbilical ring. The muscles and fascia are divided longitudinally in the midline. These incisions have often been used for a better cosmetic result, and they also provide a large operative field to deliver the pyloric mass [1, 2].

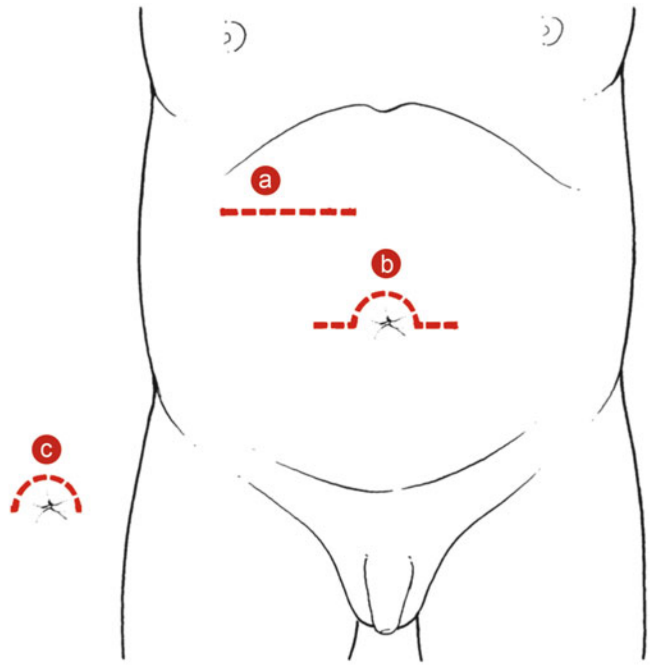

Fig. 29.3 Incisions of the open procedure. The right upper quadrant transverse incision (**a**), Omega-shaped incision (**b**), and semicircular incision around the upper half of the umbilical ring (**c**)

29.3.1.2 Identification of the Pylorus and Delivery and Stabilization of the Pyloric Mass

After opening the peritoneum, the edge of the liver is retracted cranially allowing identification of the omentum and greater curvature of the stomach. The pyloric mass is delivered through the incision by grasping the less vascularized portion of the anterior gastric wall. Grasping the pyloric mass directly with forceps can result in injury of the serosa, so the gastric wall should be grasped instead of the pyloric mass at exteriorization (Fig. 29.4). When exteriorization of the pyloric mass is considered difficult due to its size, extension of the incision or traction suture is helpful. The pyloric mass can be stabilized by steadily holding the middle finger behind it with the thumb on the anal side and the index finger on the oral side as shown in Fig. 29.5a. When the incision is held this way, the entire pyloric channel can be seen, and the duodenal-pyloric junction (a point highly susceptible to mucosal perforation) can easily be confirmed (Fig. 29.5b, c).

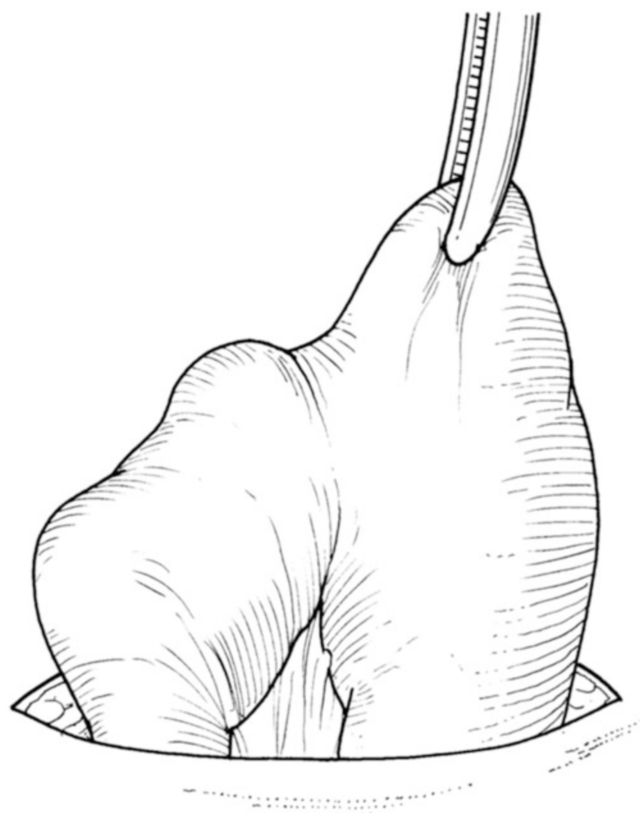

Fig. 29.4 Delivery of the pylorus. The pylorus can be easily delivered through the incision by grasping the stomach

29.3.1.3 Incision of the Pylorus

Following exteriorization, the area and length of the incision should be determined properly.

The serosal incision is made in the avascular area in the middle of the anterior surface of the pylorus between the greater curvature and the lesser curvature, extending orally for approximately 5 mm from the pyloric mass and just oral to the pyloric vein on the duodenal side (Figs. 29.6 and 29.7a). Ultrasonography is helpful to determine the muscle thickness before surgery. The depth of the incision is

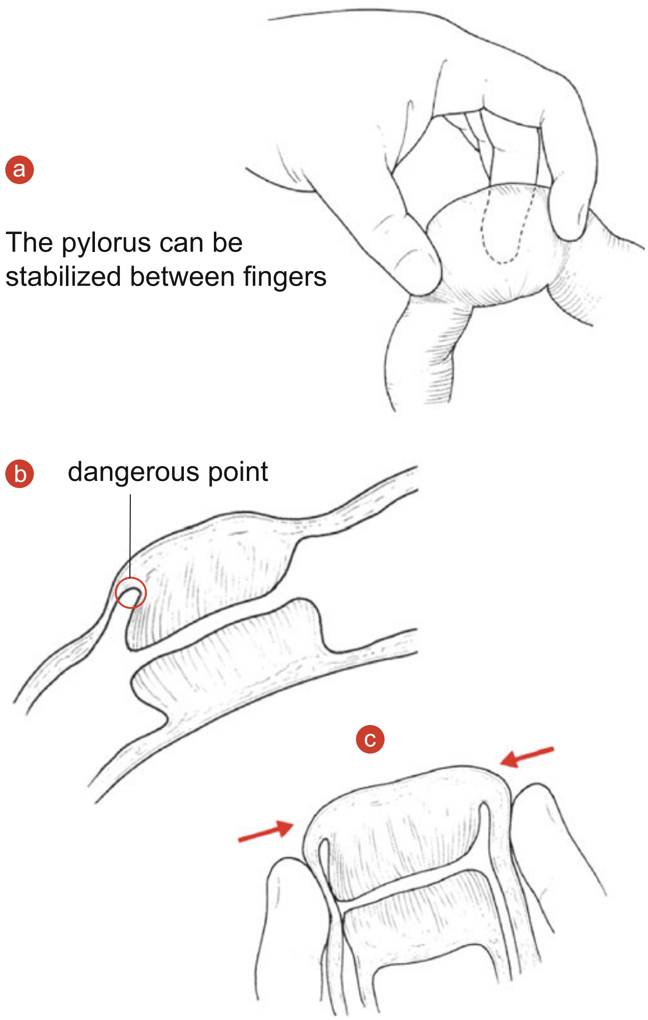

Fig. 29.5 Stabilization of the pylorus. The pylorus can be stabilized between fingers (**a**). The duodenal-pyloric junction is a dangerous point for mucosal perforation (**b**). The entire pyloric channel and duodenal-pyloric junction can be easily identified to avoid perforation during incision of the pylorus (**c**)

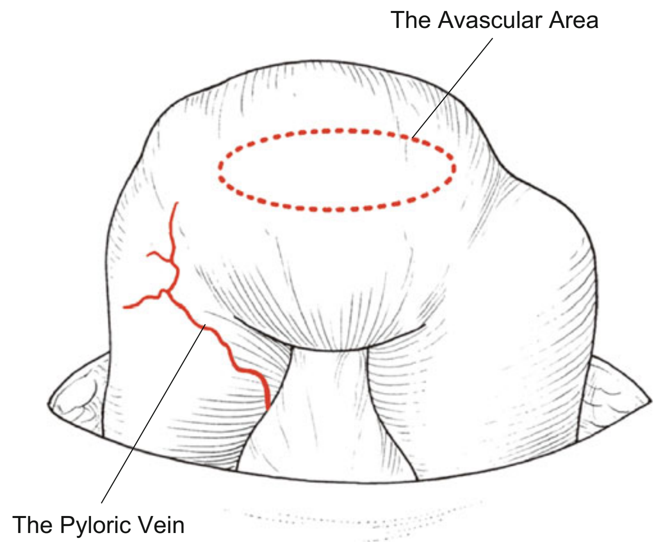

Fig. 29.6 The avascular area on the anterior surface of the pyloric mass

determined by ultrasonographic image. An incision 2–3mm deep is sufficient in most cases.

The pyloric hypertrophied muscle fibers are bluntly divided down to the submucosa with a blunt instrument such as the back of a scalpel handle (Fig. 29.7b). Then, division of the muscles along the submucosa using a Benson pyloric spreader is continued little by little taking care not to press the submucosa until its bulging is recognized (Fig. 29.7c). Division of the muscles must be started from the middle of the pyloric mass proceeding toward the normal gastric wall and then toward the duodenal side. The most dangerous point of mucosal perforation exists at the duodenal-pyloric junction. Meticulous technique is mandatory. In most cases of incomplete myotomy, division of the muscles on the proximal side does not go far enough, and it should be continued until normal gastric mucosa is in view. Division of the muscles must be done completely without leaving any residual fibers forming a bridge over the underlying submucosa because residual muscle fibers can impair the submucosal bulging.

After muscle spreading, approximately 50 ml of air is insufflated through a nasogastric tube to determine if the split of muscles is adequate and to detect mucosal perforation. Bleeding from serosa is less when the incision occurs in the avascular area. Though minor bleeding from the pyloric muscle edges may be seen, it can be stopped by applying slight pressure with the forceps. During exteriorization of the pyloric mass, bleeding due to venous congestion is present, but hemostasis is obtained by replacing it in the abdominal cavity.

Then the incision is closed in layers.

29.3.2 The Laparoscopic Procedure

The laparoscopic procedure does not necessitate exteriorization of the pyloric mass; hence this is a minimally invasive surgery with limited effect on the stomach and pylorus. Furthermore, this technique is beneficial economically because it is associated with shorter time to full feeding and shorter hospital stay compared with the open procedure [3–5]. Favorable cosmetic results are obtained as well [6]. Recent reports have shown no difference in the complication rate between open and laparoscopic procedures [4–7]. Currently the laparoscopic procedure is widely

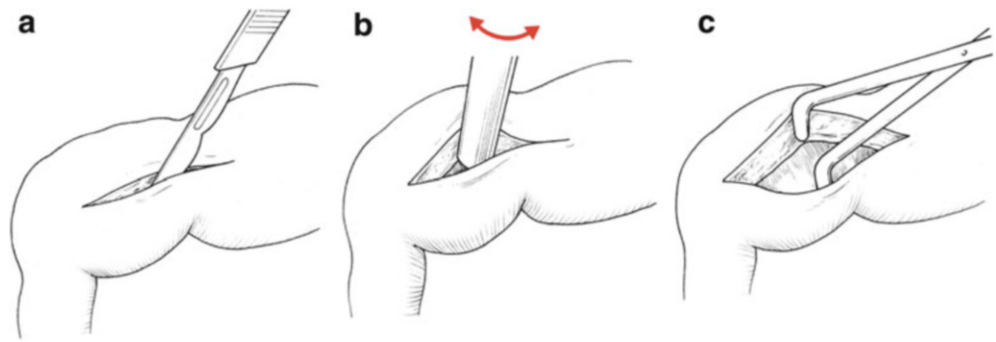

Fig. 29.7 Incision of the pylorus. A serosal incision (**a**). Blunt dissection of the pyloric hypertrophied muscle fibers with a blunt instrument such as the back of a scalpel handle (**b**). Spreading the pyloric hypertrophied muscle fibers using a Benson pyloric spreader until the bulging submucosal layer comes into view (**c**)

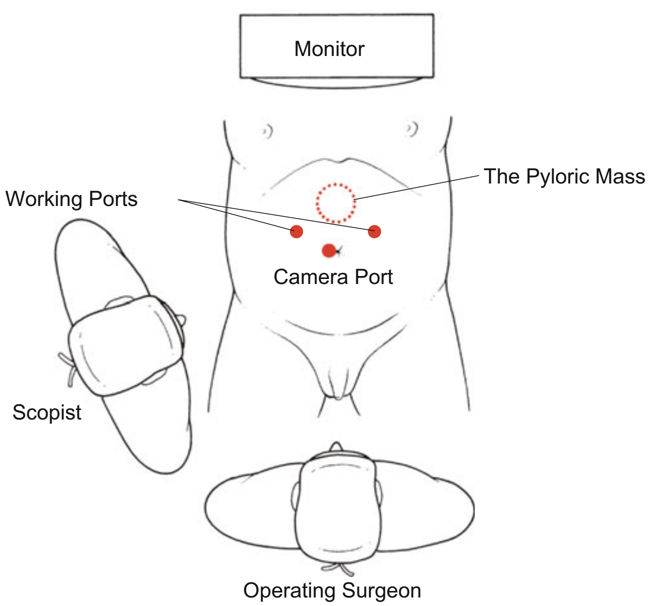

Fig. 29.8 Patient positioning, surgeon positioning, and port placement

accepted and is replacing the open procedure. The technique of pyloromyotomy is similar to the open procedures.

29.3.2.1 Port Placement and Surgeon Position

A 5-mm camera port is placed through a small longitudinal incision in the umbilicus as shown in Fig. 29.8. The abdomen is insufflated with CO_2 to a pressure of 8 mmHg. On each side of the upper quadrant of the abdomen, a 4-mm working port is placed. These ports must be placed caudal to the pyloric mass or the instruments will be inserted vertically, which makes grasping and incising the pylorus difficult.

The surgeon stands at the patient's feet, and the scopist stands on the patient's right side with the monitor positioned at the patient's head facing the surgeon.

29.3.2.2 Delivery and Stabilization of the Pyloric Mass

The extent of the pyloric hypertrophied muscle fibers is confirmed by touching the pylorus with the forceps using both hands. The duodenum is grasped by the atraumatic bowel grasper forceps in the left hand just distal to the pyloric mass, and the gastric wall is grasped by the forceps in the right hand. The pylorus is rotated with both forceps until the avascular area comes into view. Then stabilization of the pyloric mass must be confirmed using only the left forceps prior to incision of the pylorus. The duodenum should be grasped gently to avoid injury.

29.3.2.3 Incision of the Pylorus

A serosal incision is made in an avascular area from just proximal to the duodenal bulb toward the anterior gastric wall as in the open procedure (Fig. 29.9a). A Tan Endotome (KARL STORZ, Tuttlingen, Germany) is useful for making the serosal incision because its controllable edge length is less likely to injure the mucosa. Making a slightly deeper incision in the middle portion facilitates later handling of the pyloric spreader.

The pyloric hypertrophied muscle fibers are bluntly divided by introducing one side of the pyloric spreader into the middle of the incision (Fig. 29.9b). Then both sides of the pyloric spreader are inserted in the middle portion. The pyloric hypertrophied muscle fibers are spread by slowly opening the pyloric spreader until the bulging submucosal layer comes into view (Fig. 29.9c). Spreading of the muscles is extended toward the anterior gastric wall and then toward the duodenal wall taking care not to press the pyloric spreader on the submucosa (Fig. 29.9d, e). A Tan Pyloric Spreader (KARL STORZ, Tuttlingen, Germany) is useful for spreading the muscles placing the grooves on the outside of the distal end of the forceps, so the muscles spread without slipping.

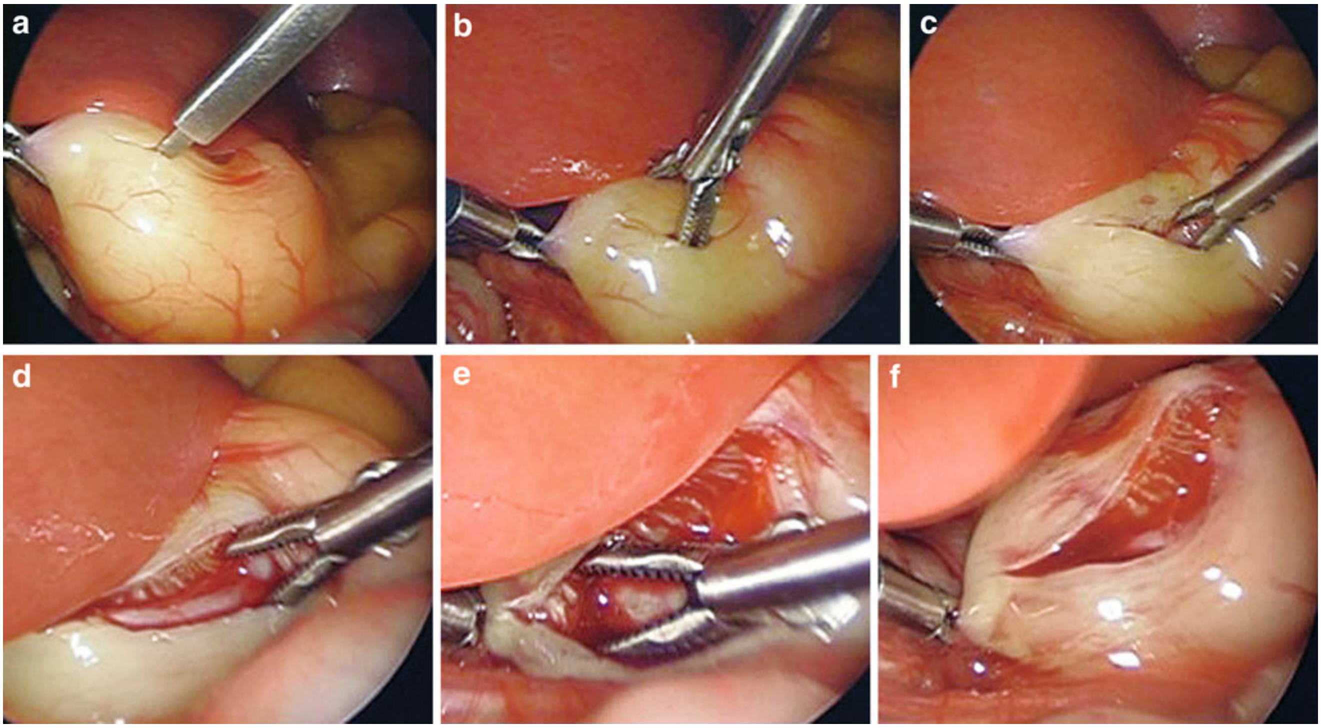

Fig. 29.9 The laparoscopic procedure. Serosal incision of the hypertrophied pylorus with the knife (**a**). The pyloric hypertrophied muscle fibers are bluntly divided using one side of the forceps (**b**). The pyloric hypertrophied muscle fibers are spread by widening both sides of the forceps (**c**). Incision is extended onto the anterior gastric wall (**d**). Incision is extended onto the duodenal wall (**e**). Hypertrophied pyloric muscle after being split with the spreader until the bulging submucosal layer comes into view (**f**)

29.3.2.4 Testing for Perforation

Before checking for mucosal perforation, the pylorus is stabilized with the forceps so the mucosa can be seen. After reducing the CO_2 pressure to 3 mmHg, approximately 50 ml of air is insufflated through a nasogastric tube (Fig. 29.9f). Increasing the intragastric pressure above the abdominal pressure allows the surgeon to check the leakage of gastric fluid or bile caused by mucosal perforation.

29.3.3 Strategy for Perforation

The major complication of pyloromyotomy is mucosal perforation, which can be prevented by meticulous manipulation. Once it has occurred, however, perforation must be repaired immediately.

In the case of an open procedure, the mucosal perforation defect is closed using one or two direct mucosal sutures with 6-0 absorbable suture and covered with a patch of omentum sutured to the mucosa. Postoperatively, no feeding is allowed for 24–48 h and placement of a nasogastric tube for suction is required. Alternatively, a new myotomy is made on the opposite side of the turned pylorus after closing the mucosal perforation with a suture in the seromuscular layer.

In the case of a laparoscopic procedure, the strategy is the same as in open surgery. However, if the surgeon is not very experienced and skilled in suturing, conversion to an open operation under direct vision is mandatory.

29.4 Postoperative Management

After an open procedure, feeding of small amounts of milk can be started 12–24 h after the procedure and advanced to full feeding in 3–4 days.

Patients who undergo a laparoscopic procedure are able to initiate feeding of small amounts of milk as early as 3 h postoperatively and advance to full feeding in 3–4 days. Postoperative emesis is not unusual. If frequent emesis persists, feeding should be stopped for approximately 12 h and then restarted.

Patients can be discharged when full feeding is tolerated.

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Duodenal Atresia and Stenosis

30

Hiroomi Okuyama

Abstract

Duodenal atresia and stenosis are classified into intrinsic and extrinsic obstruction. Intrinsic obstruction includes congenital duodenal atresia and stenosis, and extrinsic obstruction includes malrotation and SMA syndrome. Because of high incidence of associated anomalies, an evaluation of associated diseases is mandatory before operation. The most common classification of duodenal atresia divides these anomalies into three categories based on the type of the obstruction: membrane, fibrous cord, and complete separation. A proximal transverse to distal longitudinal (diamond-shaped) duodenoduodenostomy is the most common procedure regardless of the type of obstruction. When there is continuity of the muscular coats of the bowel, the best surgical approach is membranectomy because of the physiologic anatomy after operation. The surgeon should identify the location of the papilla Vater by compression of the gallbladder to see where the bile enters the duodenum before and after anastomosis. A trans-anastomotic feeding tube is passed down to the level of the proximal jejunum to detect another obstruction caused by a second duodenal mucosal web. This tube can help an early establishment of enteral feeding postoperatively.

Keywords

Congenital • Duodenal atresia • Duodenal stenosis • Diamond shaped

30.1 Congenital Duodenal Atresia and Stenosis

Congenital duodenal atresia and stenosis are classified into intrinsic and extrinsic obstruction. Intrinsic obstruction includes congenital duodenal atresia and stenosis, and extrinsic obstruction includes malrotation and SMA syndrome. In this section, we describe the operative procedures for the intrinsic obstruction including congenital duodenal atresia and stenosis.

30.2 Preoperative Management

More than 50 % of patients with congenital duodenal obstruction have associated anomalies. The incidences of major anomalies are 30 % in Down syndrome, 30 % in cardiac anomalies, and 25 % in anomalies of alimentary tract such as esophageal atresia and anorectal anomalies. Because of high incidence of associated anomalies, an evaluation of these diseases is mandatory before operation. A preoperative management includes infusion therapy aiming to correct dehydration and decompression of the stomach via nasogastric tube. Since emergent operation is not necessary except extrinsic obstruction due to mid-gut volvulus, an

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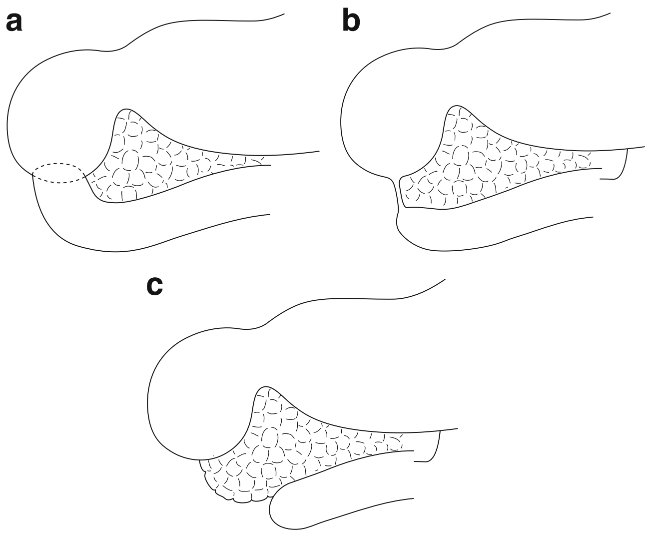

Fig. 30.1 The most common classification of duodenal atresia divides these anomalies into three groups. (**a**) Membrane. (**b**) Fibrous cord. (**c**) Complete separation

elective operation should be scheduled after enough preoperative evaluation and management.

30.3 Classification

The most common classification of duodenal atresia divides these anomalies into three groups based on the type of the obstruction: membrane, fibrous cord, and complete separation (Fig. 30.1). The most common type represents a mucosal membrane with an intact muscle wall. Membranous type with incomplete obstruction is considered a stenosis. Occasionally an intact membrane in the shape of a wind sock may be noted. The site of the origin of the wind sock should be identified at the time of anastomosis (Fig. 30.2). In a case of the presence of intestinal gas in the small intestine, an incomplete obstruction or a complete obstruction with Y-shaped duodenal opening of the pancreatobiliary system should be considered (Fig. 30.3).

30.4 Operations

30.4.1 Proximal Transverse to Distal Longitudinal (Diamond-Shaped) Duodenoduodenostomy [1]

This procedure can be performed in most cases of duodenal obstruction regardless of the type. Short-term and long-term results are reported to be better than the other procedures

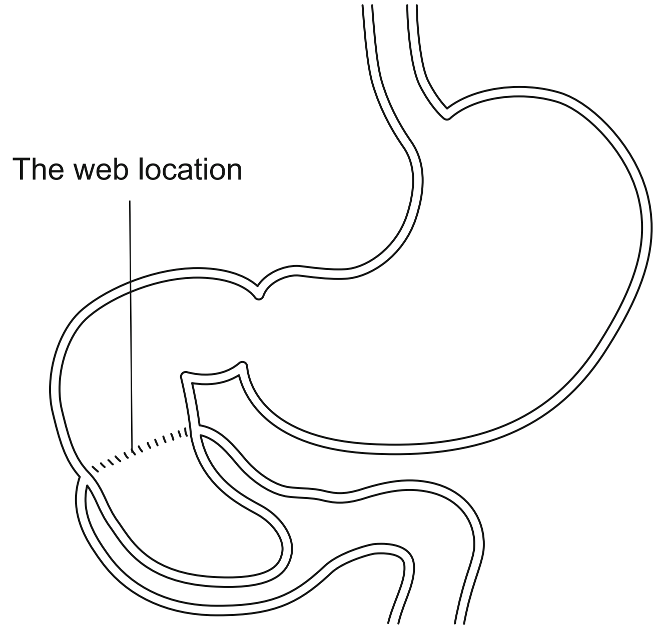

Fig. 30.2 Wind sock web variant. The origin of the web locates at the site of indentation of the wall of the duodenum proximal to the level of obstruction

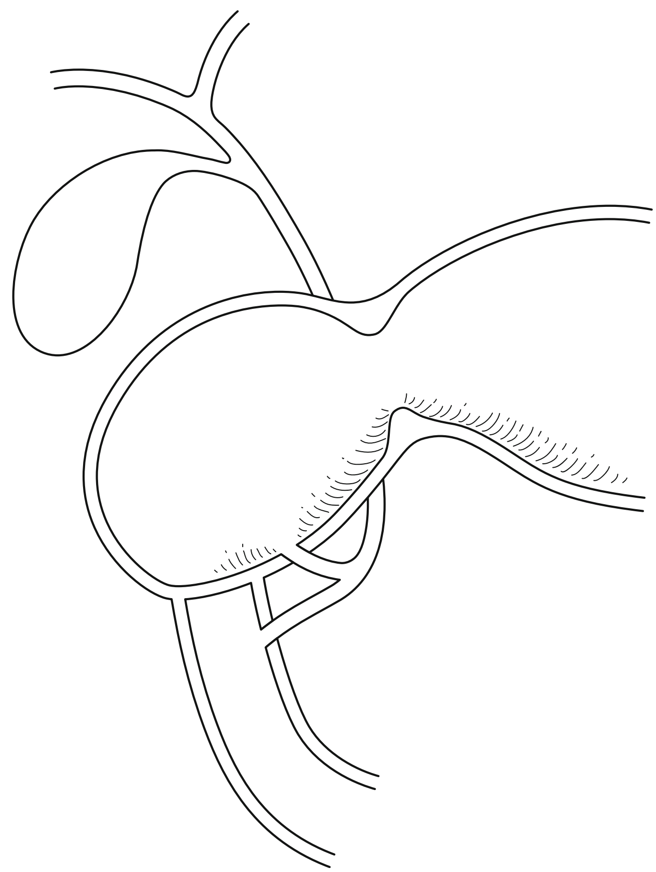

Fig. 30.3 Y-shaped duodenal opening of the pancreatobiliary system

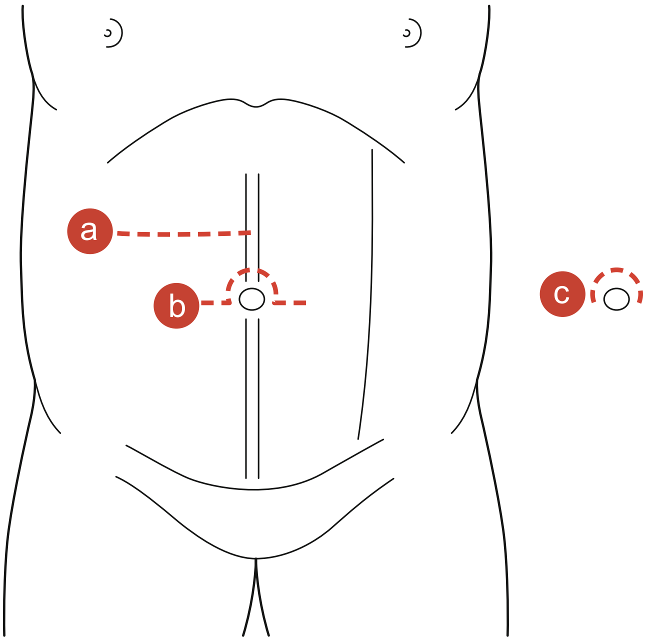

Fig. 30.4 Skin incisions: (**a**) Transverse right upper abdominal incision. (**b**) Supraumbilical omega-shaped incision. (**c**) Intraumbilical semicircular incision

such as gastrojejunostomy and duodenojejunostomy because of physiologic reconstruction without a blind loop.

The abdomen is entered through a transverse right upper abdominal incision from the midline to the lateral edge of the rectal muscle. Recently, several trans-umbilical approaches such as an omega-shaped incision are preferred for a better cosmetic result (Fig. 30.4). The first portion of the duodenum is usually thickened and dilated. Associated anomalies such as malrotation and annular pancreas are evaluated. After taking down the lateral attachments, the right colon is reflected medially and inferiorly to allow access to the transverse limb of the duodenum (Fig. 30.5). An extended Kocher's maneuver is performed to evaluate the type of the duodenal atresia. In membrane and fibrous cord-type atresia, distal duodenum can be found in this maneuver because the two ends are usually in proximity (Fig. 30.6). In complete type with discontinuity in the muscular wall, the distal duodenum is sometimes difficult to locate. In such a case, retrograde approach from the Treitz ligament is necessary to find the distal end. A sufficient length of the duodenum distal to the atresia is mobilized to allow for a tension-free anastomosis. Stay sutures on both ends of the proximal transverse incision and midpoints of the distal longitudinal incision can help the following anastomosis (Fig. 30.7). A transverse incision is made on the anterior wall of the proximal dilated duodenum. The incision should be 1.5–2.0 cm long and 1 cm apart from the obstruction site to avoid the injury of the ampulla of Vater. A longitudinal incision of the comparable size is made on the

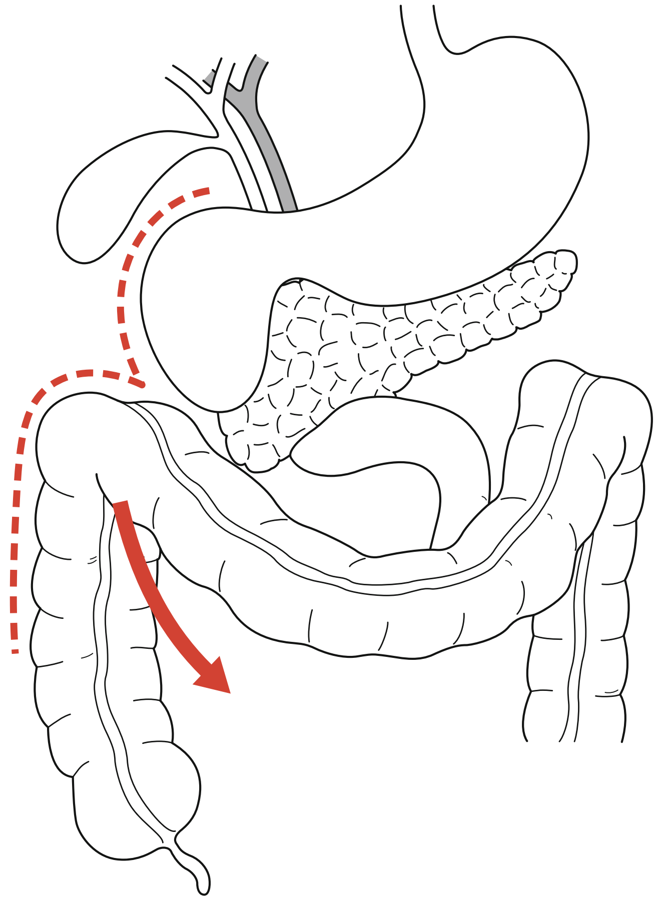

Fig. 30.5 An extended Kocher's maneuver is performed to evaluate the type of the duodenal atresia

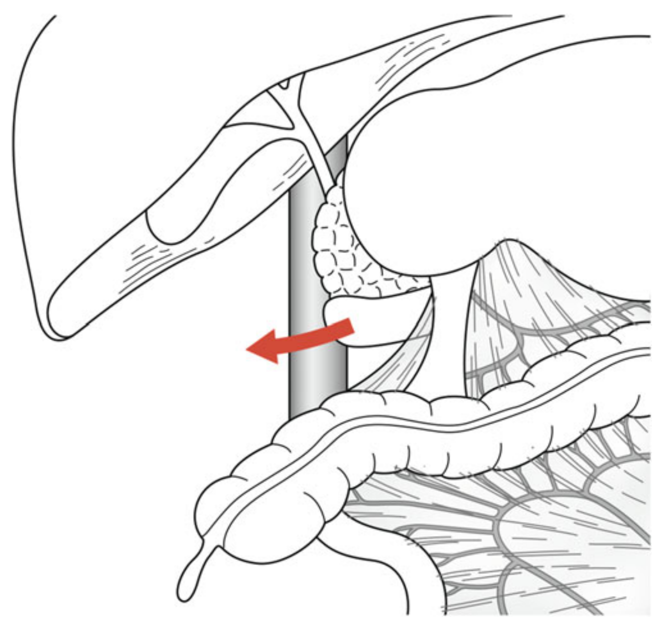

Fig. 30.6 A sufficient length of the duodenum distal to the atresia is mobilized to allow for a tension free anastomosis (*arrow*)

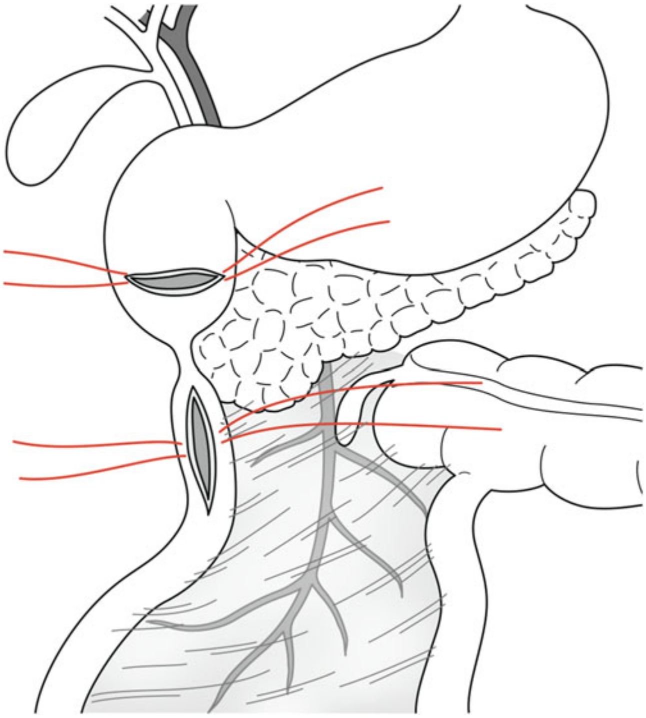

Fig. 30.7 After placing stay sutures, transverse and longitudinal incisions are made on both ends of the obstructed duodenum

antimesenteric border of the distal duodenum. A proximal transverse to distal longitudinal (diamond-shaped) anastomosis is performed using interrupted 5-0 or 6-0 absorbable sutures. The anastomosis is then fashioned by approximating the end of each incision to the appropriate midportion of the other incision (Fig. 30.8). The surgeon should identify the location of the papilla Vater by compression of the gallbladder to see where the bile enters the duodenum before and after the posterior wall anastomosis. A trans-anastomotic feeding tube is passed down to the level of the proximal jejunum to detect another obstruction caused by a second duodenal mucosal web. This tube can help an early establishment of enteral feeding postoperatively. Tapering of the dilated proximal duodenum is rarely needed as the proximal duodenal dilatation usually resolves after relief of the obstruction.

30.4.2 A Standard Side-to-Side Anastomosis

A standard side-to-side anastomosis may be performed using the same incision of the proximal and distal wall of the duodenum. Gaining a sufficient length of the duodenum distal to the atresia is important to achieve a tension-free anastomosis. Both interrupted and continuous 5-0 or 6-0 absorbable sutures can be used.

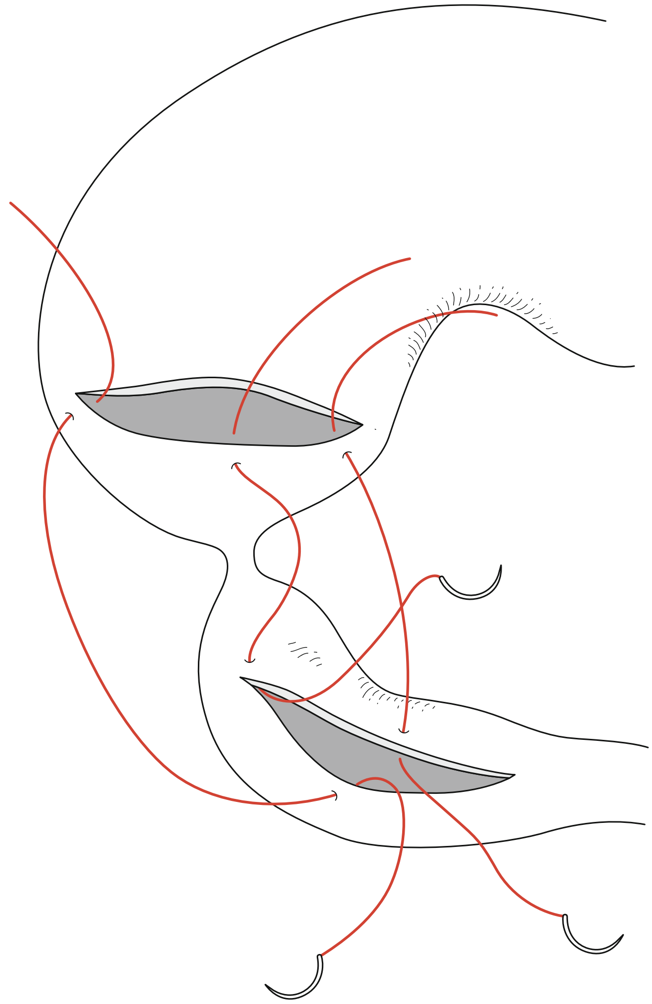

Fig. 30.8 The anastomosis is then fashioned by approximating the end of each incision to the appropriate midportion of the other incision

30.4.3 Membranectomy

When there is continuity of the muscular coats of the bowel, the best surgical approach is membranectomy because of the physiologic anatomy after operation. After an extended Kocher's maneuver, the duodenum is entered via an anterior longitudinal incision in the dilated duodenum, and the web can simply be excised (Fig. 30.9). A longitudinal incision down to the distal duodenum removing the membrane with Heineke-Mikulicz-type duodenoplasty may also be used (Fig. 30.10). The ampulla of Vater should be identified before excising the membrane. The web can be carefully opened along the lateral side because in most cases the papilla is

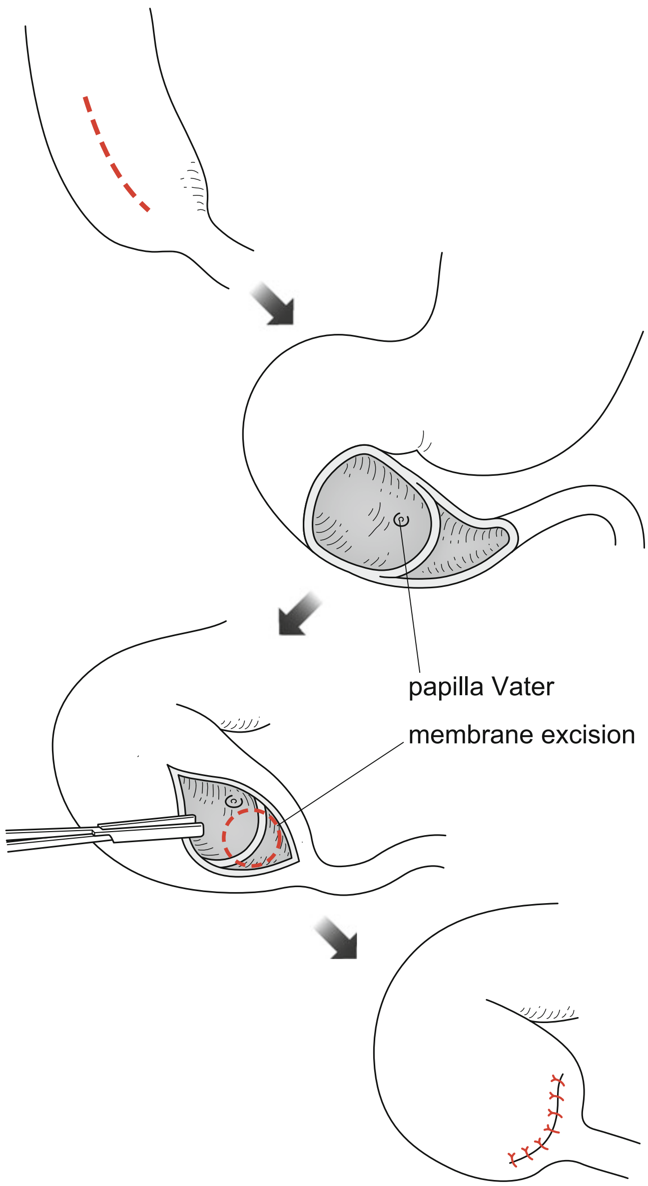

Fig. 30.9 The duodenum is entered via an anterior longitudinal incision, and the web can simply be excised

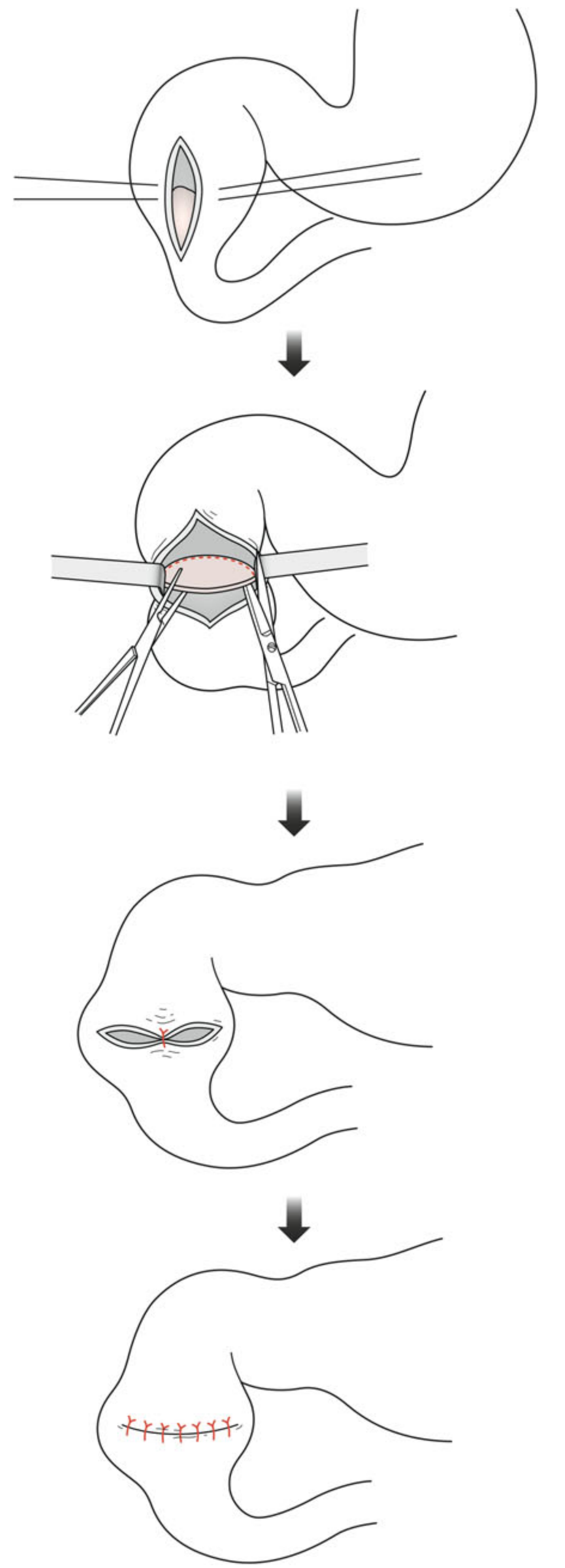

Fig. 30.10 A longitudinal incision down to the distal duodenum removing the membrane with Heineke-Mikulicz-type duodenoplasty may be used

located in the medial portion of the web. The web should be partially excised to avoid an injury of the papilla Vater. The proximal and distal mucosal edges may be approximated by fine absorbable sutures. The surgeon should identify the location of the papilla Vater by compression of the gallbladder to see where the bile enters the duodenum before and after the membranectomy. Transverse closure of the longitudinal duodenotomy incision guards against further narrowing of the duodenum. In patients with wind sock web variant, the origin of the web can be identified by passing the nasogastric tube down to the level of the obstruction to detect a site of indentation of the wall of the duodenum proximal to the level of obstruction (Fig. 30.2). After documenting that there is no distal obstruction, simple closure of the duodenotomy is possible in these patients.

30.4.4 Endoscopic Procedures

As endoscopic equipment and instruments have been improved, the indication for endoscopic procedures has been extended in infants with duodenal obstruction. In cases of membrane obstruction or stenosis, endoscopic membranectomy using a hook knife or balloon dilatation can be performed, although the safety and efficacy is still questionable in the neonatal period.

30.5 Postoperative Management

At the end of operation, another nasogastric tube with side holes is placed to decompress the stomach. The patient is kept without oral intake until stool is passed and limited clear gastric drainage is noted. It usually takes 7–10 days postoperatively. A trans-anastomotic feeding tube can allow an early establishment of the enteral feeding in the postoperative period. As total parenteral nutrition can be safely performed even in the newborn period, gastrostomy placement is rarely needed. The position of the nasogastric tube and the trans-anastomotic tube should be confirmed by X-ray film to avoid an injury of the anastomotic site. Late occurrence of megaduodenum can be treated by a re-anastomosis or a tapering duodenoplasty or a plication. As various anomalies of the pancreatobiliary system such as annular pancreas, pancreas divisum, and pancreatobiliary maljunction are often associated with duodenal obstruction, the patients should be carefully followed up for a long term.

Reference

1. Kimura K, Mukohara N, Nishijima E, et al. Diamond-shaped anastomosis for duodenal atresia; an experience with 44 patients over 15 years. J Pediatr Surg. 1986;21:1133–6.

Intestinal Atresia and Stenosis

31

Hiroomi Okuyama

Abstract

Congenital atresia and stenosis of the small intestine are classified into the four groups.

Type I: The obstruction is caused by a membrane or web.
Type II: Blind-ending proximal loop connected by a fibrous cord.
Type III(a): The atresia ends blindly with no fibrous connecting with a mesenteric defect.
Type III(b): "Apple peel-type" atresia consists of a proximal jejunal atresia and the absence of the superior mesenteric artery.
Type IV: Multiple-segment atresia.

Access to the entire intestine is necessary to evaluate the type and location of the intestinal atresia. The first step is to determine the continuity of the distal segment by injection of sterile saline into the distal bowel lumen. The bulbous hypertrophied proximal end should be resected. If there is not enough length, plication of this portion may be effective in improving peristalsis. End-to-end and end-to-back anastomosis is preferred between bowel ends of different size. A one-layer interrupted inverted technique using fine monofilament absorbable sutures is the most preferred technique to adjust the diameter difference. When a primary anastomosis is contraindicated in cases of severe discrepancy of the diameter or unstable patient's condition, a staged operation is considered as a safer strategy.

Keywords

Small intestine • Atresia • Stenosis

31.1 Congenital Atresia and Stenosis of the Small Intestine

Operative procedures for congenital atresia and stenosis of the small intestine are classified into two categories: a primary operation and a staged operation. A surgical management of intestinal atresia is selected based on the type of the atresia, the location of the lesion, the associated conditions, and the presence of peritonitis due to perforation. In most cases except for unstable conditions, primary operation is chosen.

31.2 Preoperative Management

Although the incidence of associated anomalies in infants with intestinal atresia is not as high as that in patients with duodenal atresia, the preoperative evaluation of associated anomalies is mandatory. A preoperative management

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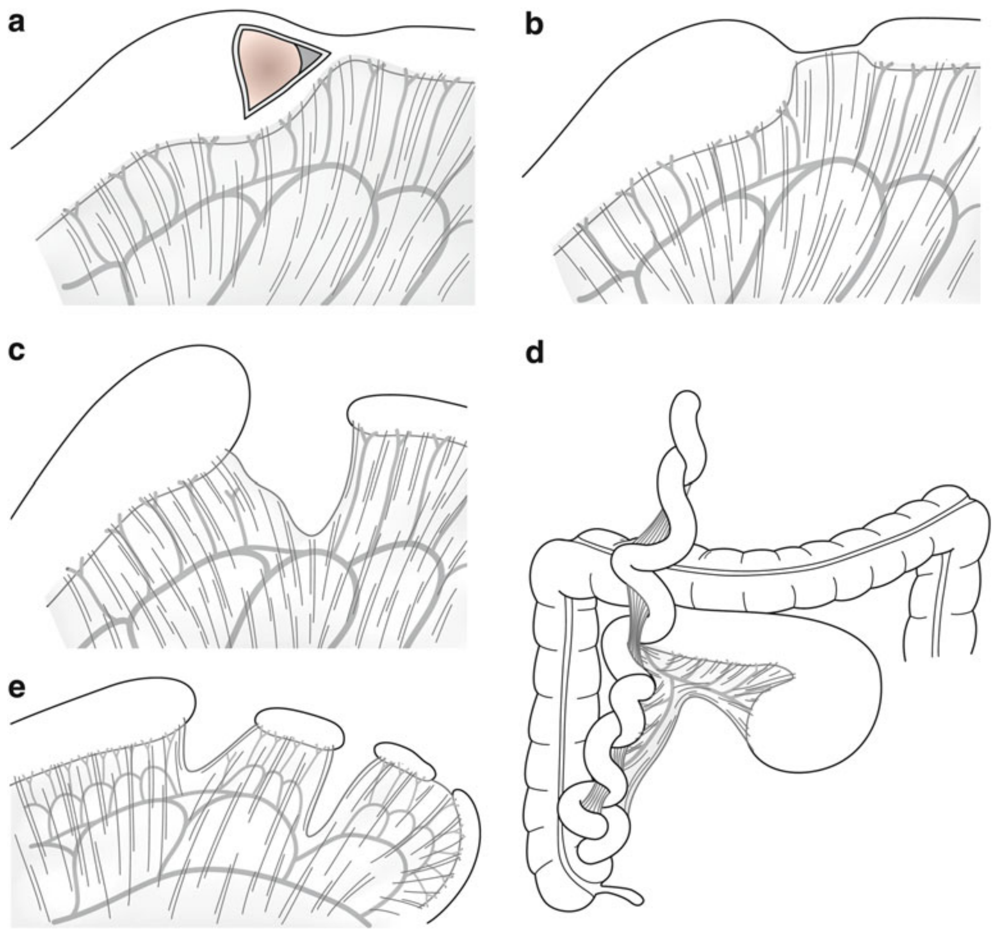

Fig. 31.1 Classification. Membranous (**a**), fibrous cord (**b**), complete separation (**c**), apple-peel (**d**), multiple-segment atresia (**e**)

includes infusion therapy aiming to correct dehydration and decompression of the stomach via nasogastric tube. Because lower intestinal obstruction is at high risk of perforation, semi-emergent operation should be scheduled in patients with ileal atresia. Preoperative contrast enema is useful to evaluate the colon abnormality such as atresia or stenosis.

31.3 Classification

Congenital atresia and stenosis of the small intestine are classified into the following four groups based on the type of atresia (Fig. 31.1):

(a) Type I: The obstruction is caused by a membrane or web formed of both mucosa and submucosa while the muscularis and serosa remain intact.
(b) Type II: Blind-ending proximal loop connected by a fibrous cord to the collapsed distal bowel with an intact mesentery.
(c) Type III(a): The atresia ends blindly with no fibrous connecting cord to the distal intestine. A V-shaped mesenteric defect of varying size is present between two ends of intestine.
(d) Type III(b): "Apple-peel" or "Christmas tree-type" atresia consists of a proximal jejunal atresia, the absence of the superior mesenteric artery beyond the origin of the middle colic branch, agenesis of the dorsal mesentery, significant loss of intestinal length, and a large mesenteric defect.
(e) Type IV: Multiple-segment atresia.

31.4 Operations

31.4.1 Primary Anastomosis

31.4.1.1 Approach

The abdomen is entered through a transverse upper abdominal incision. Recently, several trans-umbilical approaches are preferred for a better cosmetic result (Fig. 31.2).

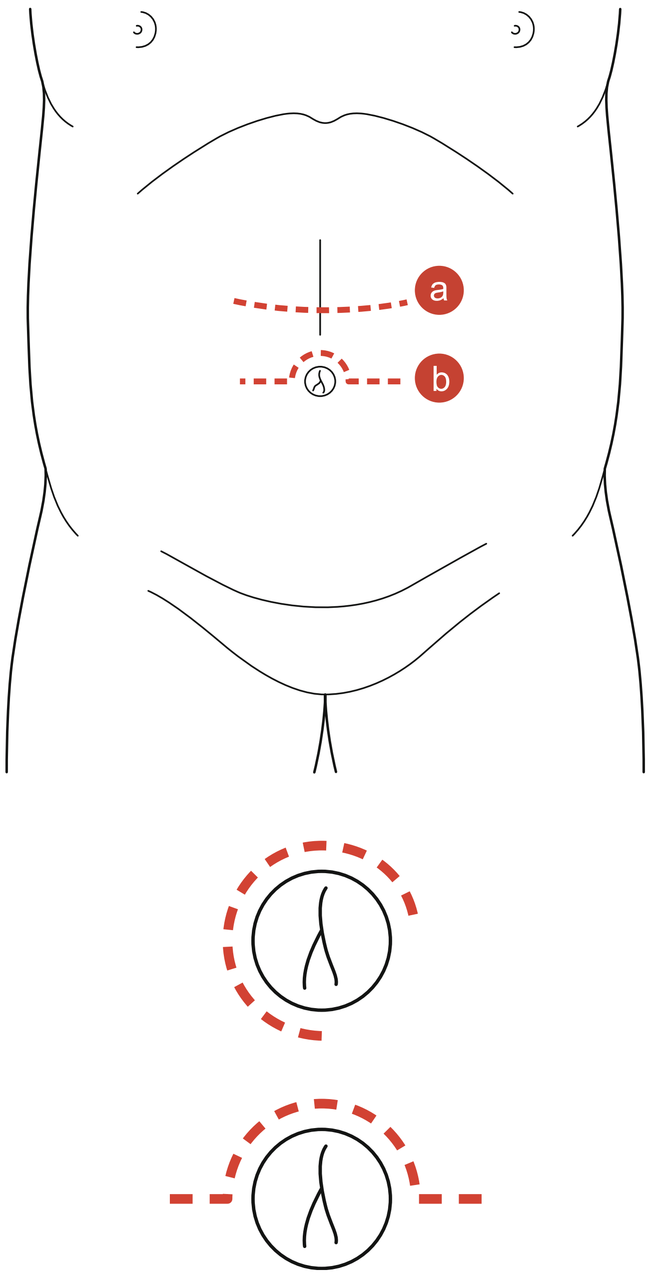

Fig. 31.2 Skin incisions. (**a**) Standard transverse upper abdominal incision. (**b**) Omega-shaped incision

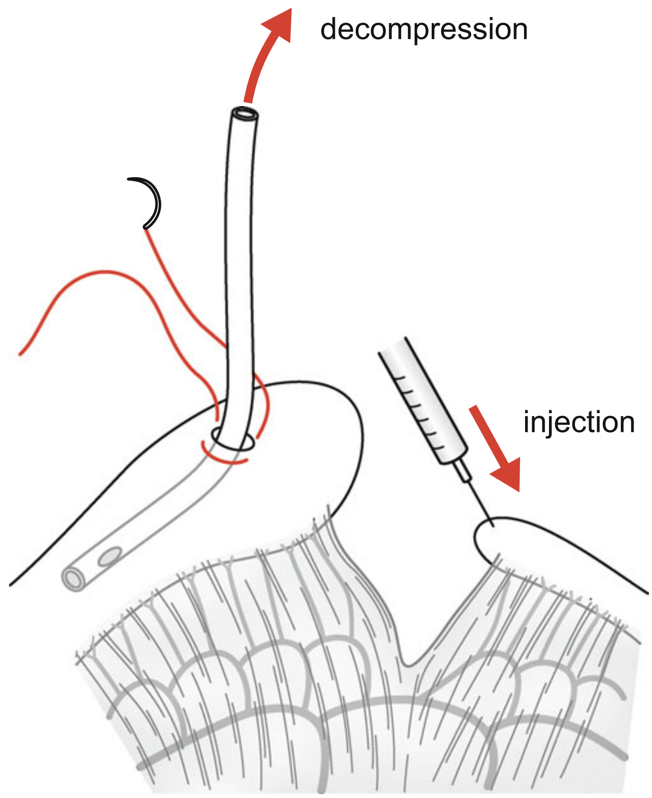

Fig. 31.3 Evaluation of the both end of the atresia

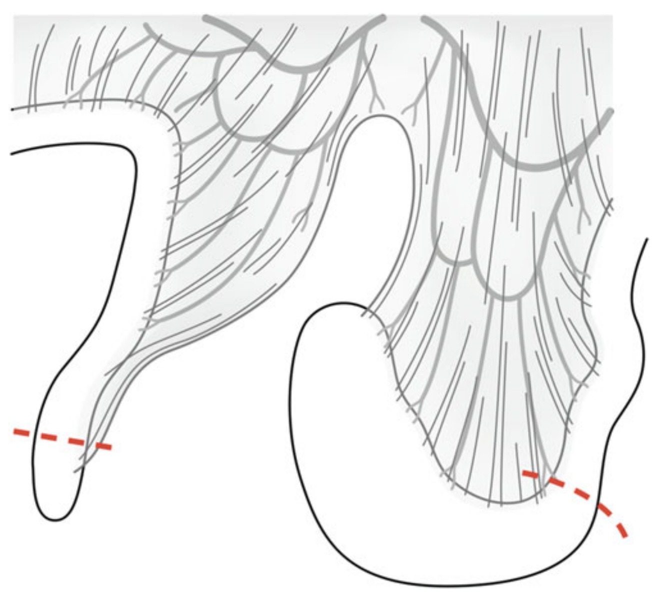

Fig. 31.4 End-to-end anastomosis. Proximal dilated end (10–20 cm in length) should be resected if possible

31.4.1.2 Inspection and Evaluation (Fig. 31.3)

Regardless of the approach, access to the entire intestine is necessary to evaluate the type and location of the intestinal atresia. The evaluation of the distal bowel is important because we should rule out the apple peel-type or a multiple atresia. The first step is to determine the continuity of the distal segment. This is accomplished by injection of sterile saline into the distal bowel lumen. The contents are then "milked" through the distal bowel to ensure that the lumen is patent to the cecum. Continuity of the colon can be established preoperatively by a contrast enema. Next step

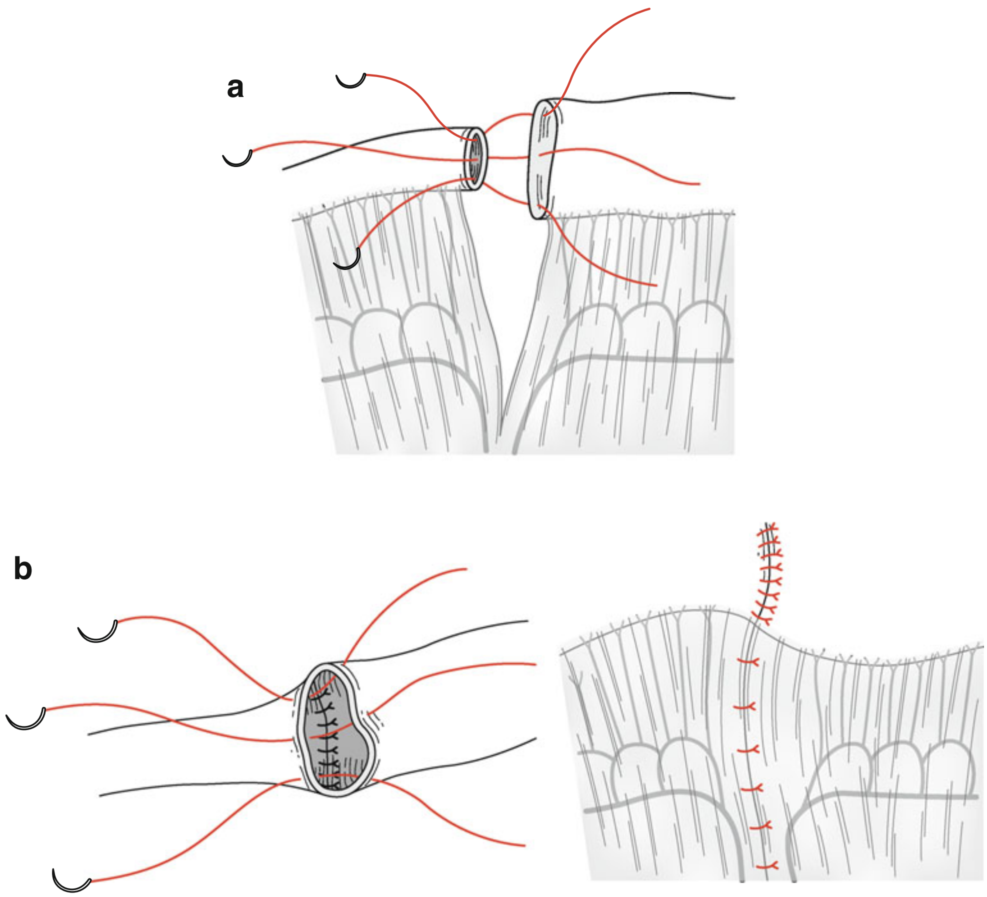

Fig. 31.5 End-to-end anastomosis. A one-layer interrupted inverted technique using 5-0 or 6-0 monofilament absorbable sutures

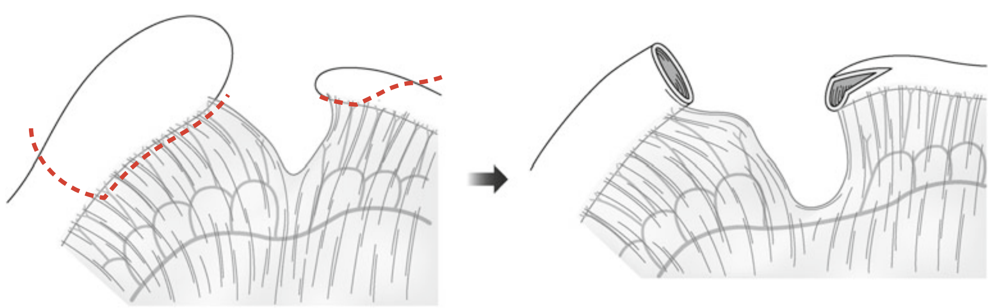

Fig. 31.6 End-to-back anastomosis. The distal end is removed obliquely, leaving the mesenteric side longer than the antimesenteric aspect. An incision made down the antimesenteric border may be needed to create an adequate distal enterostomy for anastomosis

is to decompress the proximal dilated bowel by placing a catheter into the bowel lumen.

31.4.1.3 Anastomosis (End-to-End and End-to-Back Anastomosis)

End-to-end and end-to-back anastomosis is preferred between the bowel ends of different size. Side-to-side and side-to-end anastomosis is not recommended in congenital intestinal atresia because of postoperative persistent functional obstruction. The bulbous hypertrophied proximal end should be resected (usually 10–20 cm length) if there is adequate length of the remaining gut (Fig. 31.4). If there is not enough length, plication of this portion may be effective in improving peristalsis. A one-layer interrupted inverted technique using 5-0 or 6-0 monofilament absorbable sutures is the most preferred technique to adjust the diameter difference (Fig. 31.5). In a case in which an end-to-end anastomosis is difficult because of severe diameter difference, the distal end is removed obliquely, leaving the mesenteric side longer than the anti-mesenteric aspect (Fig. 31.6). An incision made down the anti-mesenteric border may be needed to create an adequate distal enterostomy for

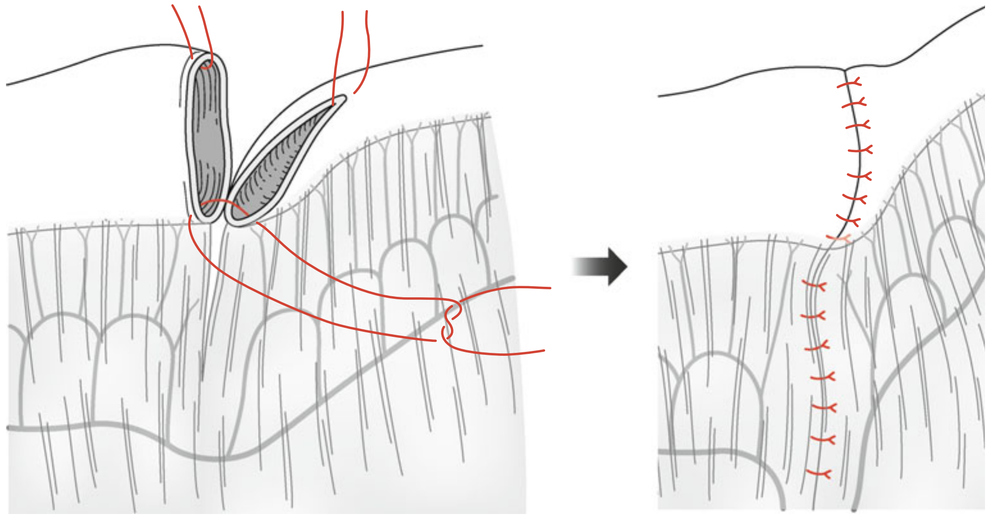

Fig. 31.7 End-to-back anastomosis: one-layer interrupted sutures

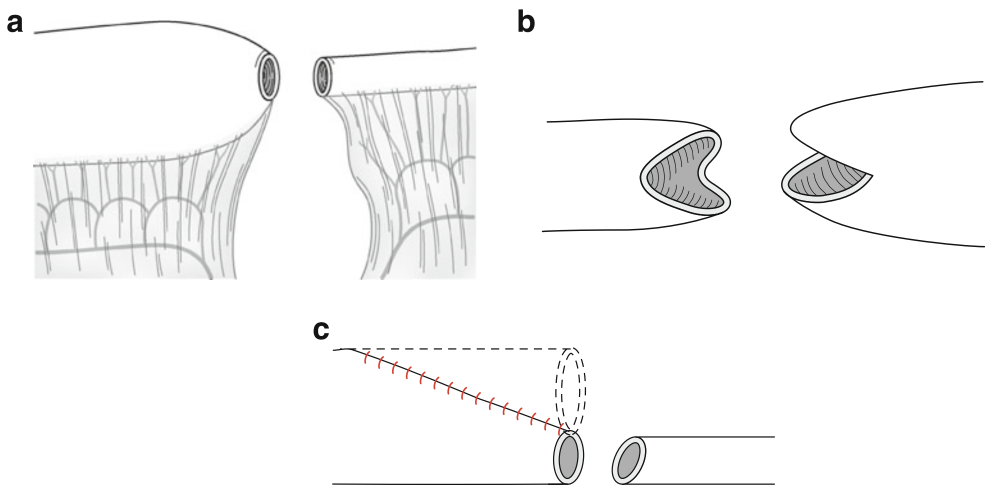

Fig. 31.8 Other anastomotic techniques to adjust the diameter without bowel resection. (**a**) End-to-end linear anastomotic technique (Patil et al.). (**b**) “fish mouth,” “wing-shaped” end-to-end anastomosis (Yoshino et al.). (**c**) Longitudinal tapering enterostomy (Grosfeld et al.)

anastomosis; the length of this incision should equal the circumference of the proximal gut at the chosen line of anastomosis (Fig. 31.7). The mesenteric defect is repaired with careful attention to avoid rotation or kinking of the anastomosis or injury to the blood supply.

31.4.2 Other Anastomotic Techniques to Minimize the Length of the Intestinal Resection (Fig. 31.8)

31.4.3 Functional End-to-End Anastomosis Using Stapler (Fig. 31.9) [1]

Although the functional end-to-end anastomosis using auto-stapler is common in adult patients, it is rarely used in newborn with intestinal atresia. An endo-stapler with a small anvil can be used to make a functional end-to-end anastomosis even in neonates. Once the small anvil is inserted to the distal segment, a functional end-to-end anastomosis is possible regardless of the difference of the diameter between both ends of the bowel. The side-to-side anastomosis is performed on anti-mesenteric sides of the proximal and distal segments. The open ends are closed with another stapler. Triple stapling should be avoided by sliding the side-to-side suture lines. Both ends of the side-to-side suture line and the triple stapling point should be sawn using interrupted absorbable sutures to prevent anastomotic leakage. Bleeding from the suture line should be carefully checked.

31.4.4 Multiple Atresia

If there is sufficient length of the remaining intestine, the segments of the multiple atresia may be resected and

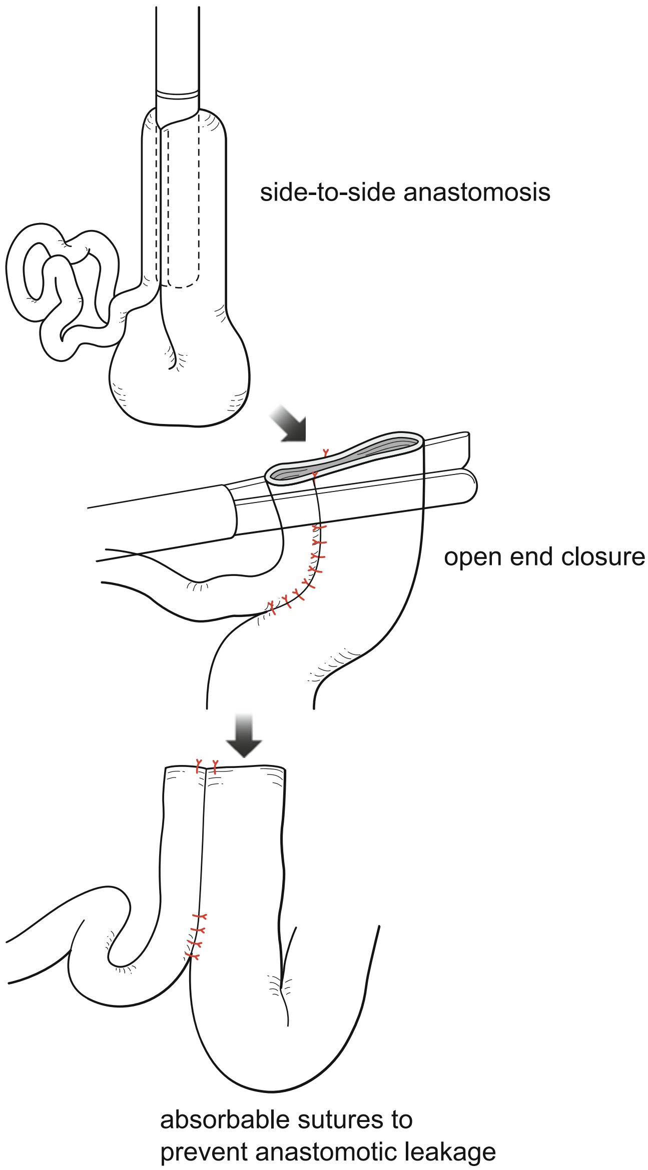

Fig. 31.9 Functional end-to-end anastomosis using a stapler

one or two anastomosis created. However, if there is a need to preserve most of the intestine, multiple anastomosis should be performed to keep the bowel length as long as possible.

31.4.5 Staged Operations

A primary anastomosis may be contraindicated in cases of severe discrepancy of the diameter or unstable patient's condition. In those cases, a staged operation is considered as a safer strategy of the treatment.

31.4.5.1 Double-Barreled Enterostomy

Exteriorization of both ends of the atresia is the safest procedure. A tube enterostomy of the distal end can be used to evaluate and avoid unused atrophy of the distal intestine.

31.4.5.2 Bishop Koop (Fig. 31.10a)

Bishop Koop is a proximal end-to-distal side anastomosis with a decompression ileostomy. This allows for extraperitoneal closure of a single stoma once bowel function returned.

31.4.5.3 Santulli (Fig. 31.10b)

Bringing the proximal segment out as a stoma and performing an end-to-side anastomosis using the distal segment. A feeding tube can be left in the distal segment through the anastomosis.

These procedure can be used for not only intestinal atresia but also bowel obstruction caused by other etiology such as meconium-related ileus.

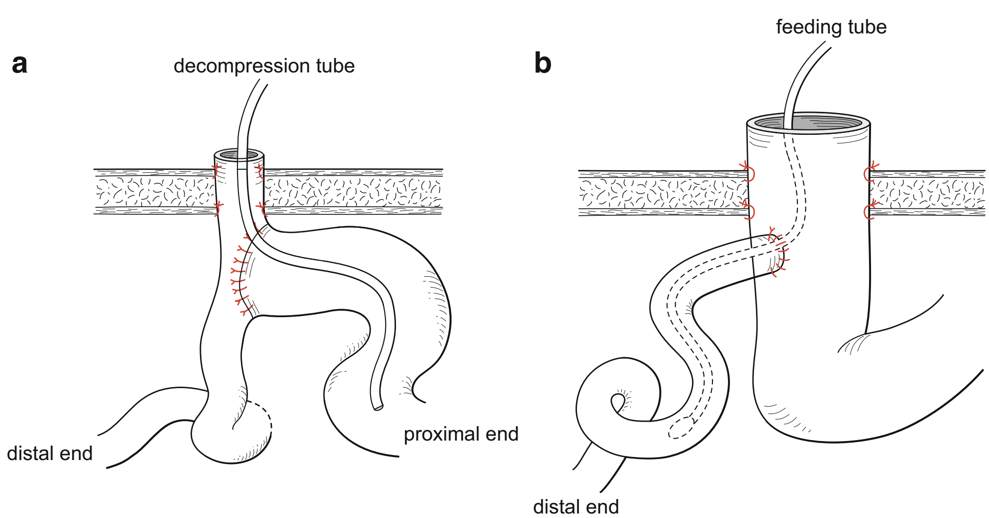

Fig. 31.10 (**a**) Bishop Koop. (**b**) Santulli

31.5 Postoperative Management

At the end of operation, a nasogastric tube is placed to decompress the stomach. The patient is kept without oral intake until stool is passed and limited clear gastric drainage is noted. A trans-nasal long intestinal tube may be useful to decompress the dilated proximal bowel. A trans-anastomotic feeding tube can be used only for high type of atresia. In cases of lower atresia, a retrograde trans-anastomotic decompression tube may be inserted via an appendix.

Reference

1. Mitchell IC, Barber R, Fischer AC, Schindel DT. Experience performing 64 consecutive stapled intestinal anastomosis in small children and infants. J Pediatr Surg. 2011;46:128–30.

32 Intestinal Malrotation

Hirotoshi Yamamoto

Abstract

In cases of intestinal malrotation, the origin of the jejunum is very close to the ileocecum, and the pedicle-shaped mesenteric base undergoes midgut volvulus, which is likely to result in strangulation obstruction and thus requires urgent surgery.

The entire bowel is held en bloc carefully and is everted out of the wound. If volvulus is present, it needs to be lifted immediately. The Ladd ligament is dissected sharply and completely at the lateral side of the duodenum, followed by Kocher mobilization of the duodenum, and freeing of the ileocecum and ascending colon from the retroperitoneum toward the left. The duodenum and cecum/ascending colon are freed, and the mesenteric base is dilated maximally. If done properly, a state of nonrotation is created in which the duodenum runs down almost straight from the second part to the right peritoneal cavity, and the entire right half of the colon is moved to the left of the abdomen, with the ileocecum located in the left hypogastric region. If membranous closure is seen in the duodenum or the upper part of the jejunum, radical surgery is simultaneously performed. If the patient's general condition is favorable, aseptic appendectomy is additionally performed. For prevention of postoperative adhesion, careful hemostasis and sufficient washing with warm saline are needed. In the end, the duodenum and small bowel are returned into the right of the peritoneal cavity, with the colon placed on the left.

Keywords

Intestinal malrotation • Ladd procedure • Aseptic appendectomy

32.1 Introduction

Ceased rotation of the intestine during the fetal period is called malrotation. There are various types of this condition. In cases of intestinal malrotation, the origin of the jejunum is very close to the ileocecum, and the pedicle-shaped mesenteric base undergoes midgut volvulus, which is likely to result in strangulation obstruction and thus requires urgent surgery.

32.2 Preoperative Management

A frequent initial symptom is intense bilious vomiting due to disturbed duodenal passage within several days after birth. The symptoms of dehydration associated with vomiting need to be alleviated immediately. A nasogastric tube is inserted for decompression through sufficient aspiration of gastroduodenal contents, to prevent volvulus aggravation. Diuresis with sufficient fluid therapy is desirable before the operation

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is started. However, if volvulus is intense, the bowel may soon become necrotic due to disturbed circulation, and the pediatric patient may develop shock. Urgent surgery is required in such cases. Preoperative treatment with antibiotics is needed in cases of suspected volvulus.

32.3 Operations

The Ladd procedure is the standard operative procedure [1].

32.3.1 Laparotomy and Intestinal Eversion

Usually, laparotomy is performed with a right upper quadrant transverse incision. Recently, an umbilical approach, which is esthetically superior, has also been used (Fig. 32.1). The cranial side is incised in a Ω-like shape along the umbilical ring, and the subcutaneous tissue, linea alba, muscular tissue, and peritoneum are incised as much as possible to open the abdomen. A better operative field can be secured if a wound retractor is used (Fig. 32.2). After laparotomy, the presence or property of ascites is checked first. Ascites is often transparent but occasionally looks like chyle because of lymphoduct retention. If ascites is bloody, intestinal necrosis is suspected; if it is contaminated by bile or feces, intestinal perforation is suspected, requiring submission of an ascite sample for bacterial culture. The dilated small bowel loop is often ischemic and dark red, and its necrosis or perforation is not uncommon. The entire intestine is held en bloc carefully and is everted out of the wound, followed by observation of the mesenteric base to check for volvulus. Volvulus mostly involves the intestine from the duodenum to the middle of transverse colon, often showing torsion by 360–720° in a clockwise direction (Fig. 32.2).

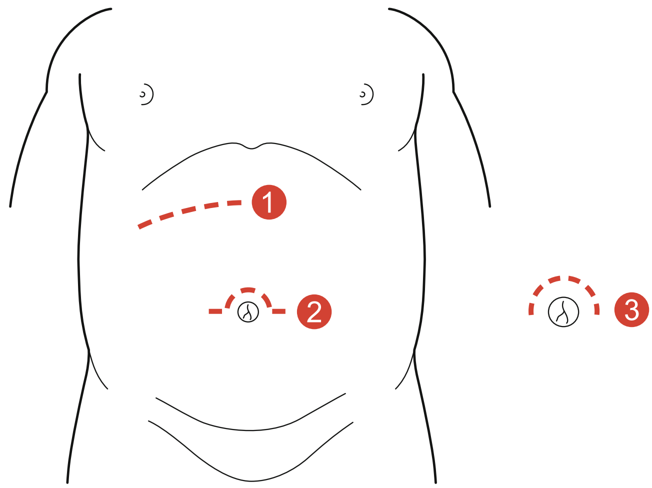

Fig. 32.1 Skin incision: (*1*) Right upper quadrant transverse incision; (*2*) small Ω-form incision along the umbilical ring; and (*3*) arch-shaped incision along the umbilical ring

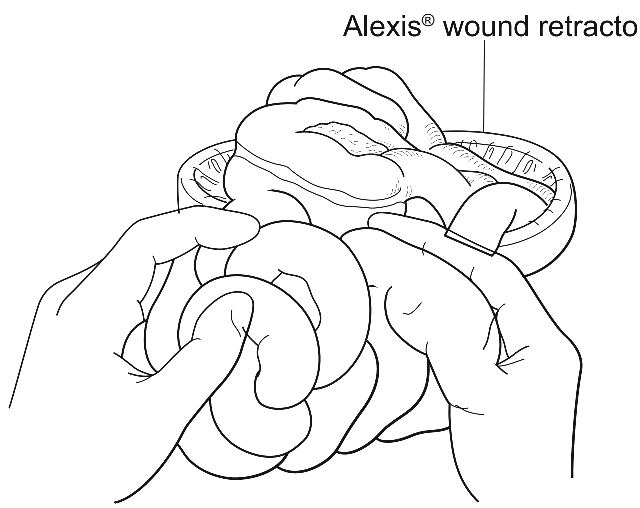

Fig. 32.2 Lifting of the volvulus with an umbilical approach. The Alexis® wound retractor (XS size) is applied. The entire midgut, with developed volvulus, is pulled out of the incised wound and rotated slowly along a clockwise axis to lift the volvulus

32.3.2 Torsion Lifting

If volvulus complication is seen, it needs to be lifted immediately. The entire intestine after eversion is held with both hands and is slowly rotated counterclockwise in 90-degree steps to lift the torsion (Fig. 32.2). If the patient is a neonate, each manipulation should be made very carefully to avoid injury, because the neonate's intestine is fragile. Repair is made completely until the duodenum is located on the right side, and the transverse colon and cecum are located in front of the mesentery. As the torsion is lifted, the color of the intestine gradually normalizes. If the intestinal color does not improve, the ischemic intestine needs to be wrapped with a gauze preimmersed in warm saline to improve intestinal circulation, and the condition should be checked again 20–30 min later. If a narrow range of intestinal necrosis is present, the necrotic part of the intestine is resected, followed by end-to-end anastomosis. If poor intestinal color is wide ranging, the abdomen is closed after lifting of strangulation. The abdomen is then opened again 12–24 h later, and any intestine restoring normal color is preserved to prevent postoperative short bowel syndrome (second look).

32.3.3 Paraduodenal Band (Ladd Ligament) Dissection

After the volvulus is lifted, the paraduodenal band (Ladd ligament) needs to be checked. The Ladd ligament is a

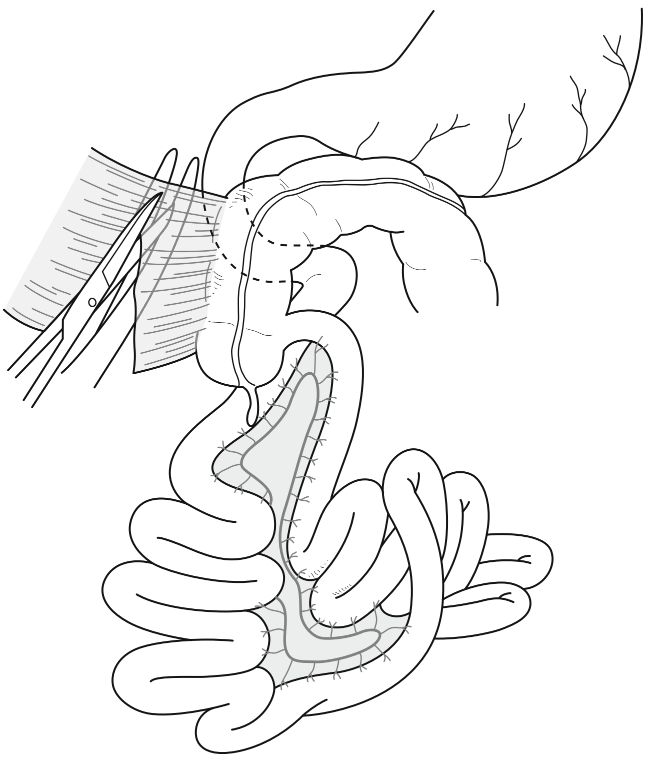

Fig. 32.3 Ladd ligament dissection

fibrous membrane-like structure running from the right abdominal wall beyond the duodenum-jejunum junction to the cecum and right colon located near the superior mesenteric artery/vein. This membranous structure is dissected sharply and completely at the lateral side of duodenum, followed by Kocher mobilization of duodenum (Fig. 32.3), and then freeing of the ileocecum and ascending colon from the retroperitoneum toward the left to expose the superior mesenteric artery/vein.

32.3.4 Mesenteric Base Extension

Manipulation to free the duodenum and cecum/ascending colon and dilate the mesenteric base maximally is important in preventing volvulus recurrence. The duodenum-jejunum transition area needs to be freed carefully (raising the intestine from the mesenteric side), attempting to form a straight line as far as possible, because this part is often tortuous and curved, showing edematous adhesion with the mesentery, and because the superior mesenteric vessels have short branches likely to remain curved (Fig. 32.4). Next, pushing the cecum/ascending colon toward the patient's left side, the manipulation is made to also expose the superior mesenteric artery/vein branches so that the superior mesenteric artery/vein runs almost at the center of the dilated mesentery. Sufficient care needs to be taken to avoid pancreas and

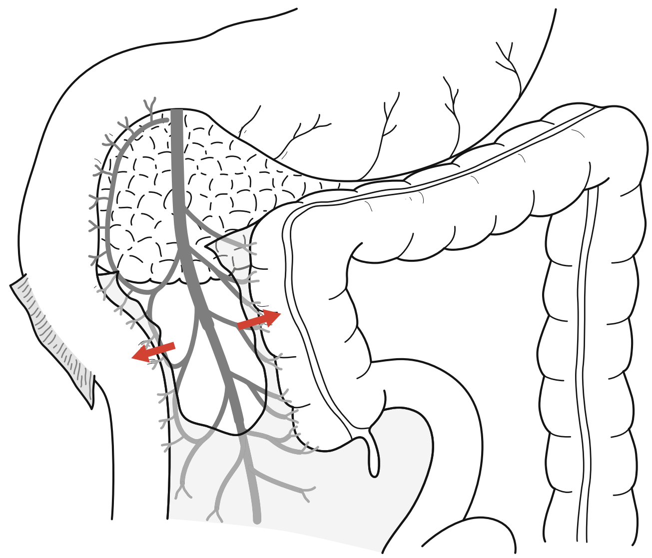

Fig. 32.4 Mesenteric base stretching: freeing of the duodenum-jejunum transition area

superior mesenteric artery/vein injury. Following this manipulation, the duodenum runs almost straight down from the second part to the right peritoneal cavity, and the entire right part of the colon is moved to the left abdomen, with the ileocecum located in the left hypogastric area (state of nonrotation) (Fig. 32.5).

32.3.5 Endogenous Obstruction

In cases where this condition develops immediately after birth, intraoperative assessment for membranous closure of the duodenum or the upper part of jejunum is needed. Air is supplied via the catheter inserted into the stomach to confirm that the air easily moves into the duodenum and distal parts of the small bowel. If obstruction or stenosis is found, it needs to be treated radically at the same time.

32.3.6 Aseptic Appendectomy

After surgical treatment of this condition, it is not possible to precisely identify the location of the appendix within the peritoneal cavity. To avoid difficulty in diagnosing appendicitis in the future, an appendectomy is additionally performed unless the operation time is limited by the presence of shock. Because the Ladd procedure is a noncontaminated surgery, appendectomy also uses an aseptic procedure (inversion appendectomy). The mesoappendix is ligated and dissected, followed by eversion, and insertion of the appendix toward the colon while pushing the appendix

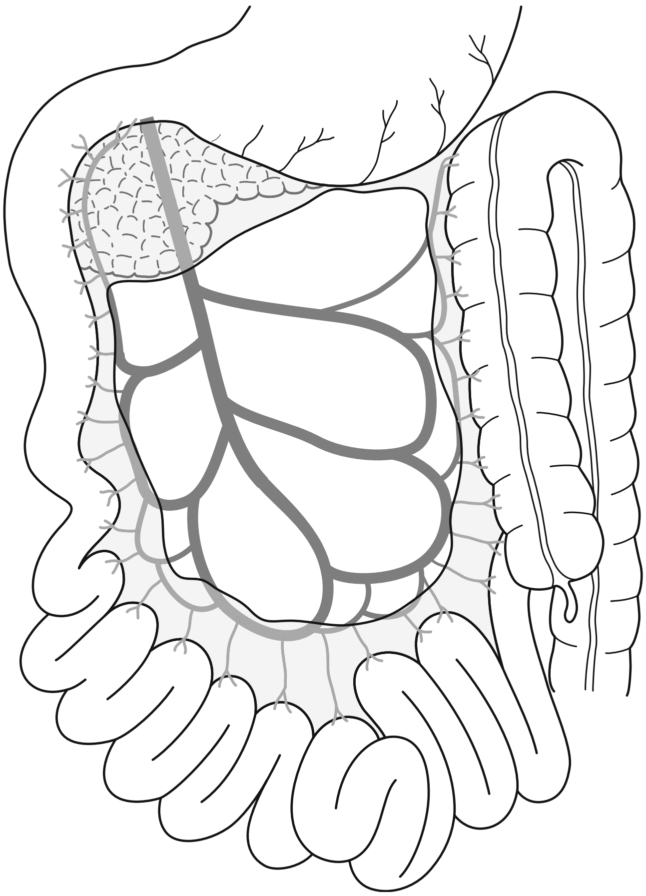

Fig. 32.5 Completion of mesenteric base stretching: a state of nonrotation

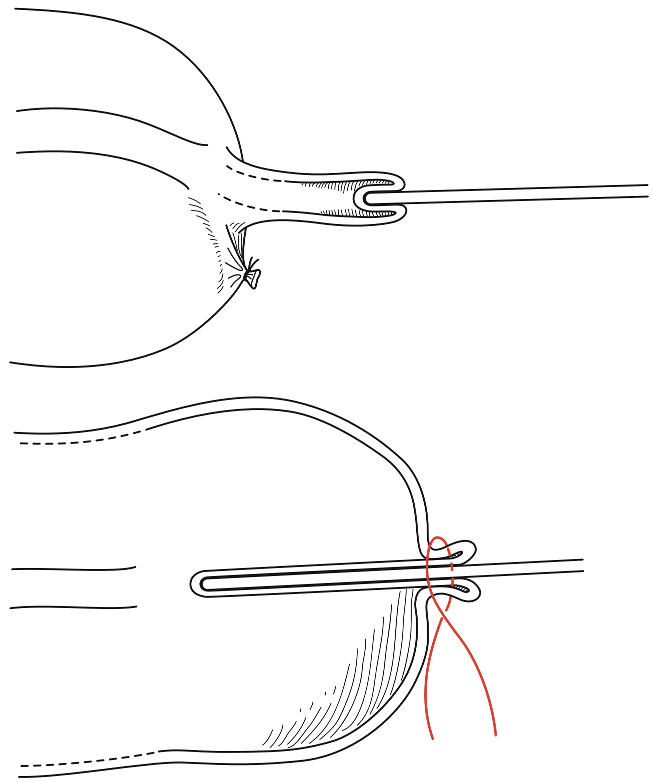

Fig. 32.6 Inversion appendectomy (*1*): eversion and insertion of the appendix toward the colon

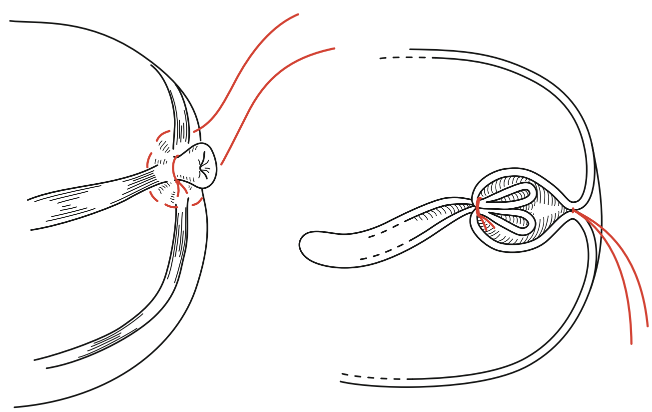

Fig. 32.7 Inversion appendectomy (*2*): ligation of the appendix and purse-string suturing of the tissue around the appendix base

tip with a probe (Fig. 32.6). The appendix is not inserted completely into the colon; its base is slightly left not inserted, and the appendix is ligated at this site. Next, purse-string suturing is made on the tissue around the base, which is then pushed into the cecum (Fig. 32.7). The appendix undergoes necrosis and soon sloughs away completely. If an appendectomy is skipped, the patient's family needs to be informed that the location of the appendix is different from the general one.

32.3.7 Peritoneum Defect Disposal

Upon completion of the manipulation to expand the mesentery base maximally, an extensive defect of the peritoneum is seen, possibly resulting in complication by postoperative adhesive ileus in 3–5 % of all cases. To prevent adhesion, hemostasis should be carefully performed and the area sufficiently washed with warm saline.

32.3.8 Returning the Intestine into the Peritoneal Cavity

The duodenum and small bowel are finally returned into the right side of the peritoneal cavity and the colon to the left side of the cavity. The volvulus recurrence rate after this operation has been reported to be 5 % or less. For volvulus prevention, the duodenum or colon is sometimes fixed to the lateral abdominal wall (Bill fixation [2]), but this

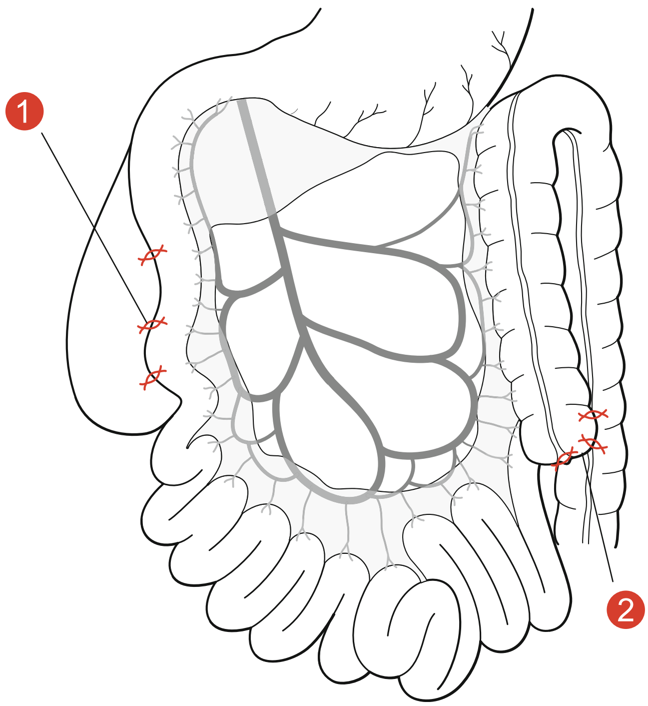

Fig. 32.8 Bill fixation: the duodenum to the origin of duodenum is fixed to the retroperitoneum (*1*). The cecum is fixed to the descending colon (*2*)

manipulation is currently viewed as unnecessary by many surgeons (Fig. 32.8).

32.4 Postoperative Management

Aspiration with a nasogastric tube is continued for 24 h after surgery, and bodily fluids are replenished with fluid therapy. In cases where extensive bowel resection results in short bowel syndrome, intravenous alimentation is needed until adaptation (increase in absorbing area and function) takes place. Care needs to be taken due to the high incidence of postoperative intussusception as compared with other types of open abdominal surgery.

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Meckel's Diverticulum

33

Hirotoshi Yamamoto

Abstract

Meckel's diverticulum is indicated for surgical treatment if complicated by ileus, diverticulitis, intussusception, ulcer/gastrointestinal bleeding, intestinal perforation, or diverticulum torsion. When Meckel's diverticulum is resected due to gastrointestinal bleeding, ectopic gastric mucosa responsible for ulcers also needs to be resected completely. Recently, Meckel's diverticulum has often been investigated laparoscopically. If the diverticulum is long, ectopic gastric mucosa is present at its tip, and its laparoscopic resection with an automated anastomosing device is also selected. However, in cases where the diverticulum has a broad base, ectopic gastric mucosa can be present anywhere within the diverticulum, thus requiring extra-abdominal wedge resection of the ileum (including the diverticulum) to avoid any ectopic gastric mucosa being left unresected. Ileectomy and end-to-end anastomosis are performed in cases where inflammatory Meckel's diverticulum has formed a mass and in cases of severely disturbed circulation through the ileum due to intussusception, diverticulum torsion, or ileus.

Keywords

Meckel's diverticulum • Ectopic gastric mucosa • Laparoscopic diverticulectomy

33.1 Embryology and Clinical Presentation

The omphalomesenteric duct joins the midgut and yolk sac during the fetal period and usually disappears at gestational age of 6 weeks. If the vitelline duct or fetal vessel remains between the intestine and the umbilical cord, diverse congenital anomalies may arise. Meckel's diverticulum is an ileal diverticulum formed by an omphalomesenteric duct remnant near the small intestine. It is a common gastrointestinal malformation seen in 1–2 % of the entire population. Most patients with Meckel's diverticulum remain symptom-free, but 15–33 % develop acute abdomen (ileus, diverticulitis, intussusception, ulcer/gastrointestinal bleeding, intestinal perforation, or diverticulum torsion) requiring surgical intervention.

33.2 Preoperative Managements

When dealing with a case of ileus, a nasogastric tube is inserted to achieve sufficient decompression of the intestine preoperatively. If dehydration due to vomiting is seen, fluid therapy is applied to correct electrolyte balance. In cases of gastrointestinal bleeding, the nasogastric tube discharge is checked to rule out bleeding from the stomach and duodenum. In cases of infection or perforation, antibiotics are administered by drip infusion.

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33.3 Operations

An essential point during resection of Meckel's diverticulum causing intestinal bleeding is to resect the ectopic gastric mucosa responsible for ulceration completely.

33.3.1 Incision

In preoperatively diagnosed cases of Meckel's diverticulum causing bleeding or inflammation, right lateral transverse incision or right paramedian incision has been used to begin the operation. In cases of ileus with an unidentified site of obstruction, a right upper quadrant transverse incision has been used. An umbilical incision, which achieves excellent cosmetic results, has also been used. The cranial side is incised in a Ω-like shape along the umbilical ring, and the subcutaneous tissue, linea alba, muscular tissue, and peritoneum are incised as much as possible to open the abdomen (Fig. 33.1). In recent years, Meckel's diverticulum is often explored laparoscopically, and this approach is well indicated in cases where the source of bleeding is unknown. Under observation with a 5-mm diameter laparoscope inserted through the incision created at the lower edge of the umbilical ring, the diverticulum is explored from the distal end of ileum to the oral side using bowel forceps inserted through the 3-mm or 5-mm port on both sides of the abdomen (Fig. 33.2). Meckel's diverticulum is often located within 100 cm oral to the ileal terminal.

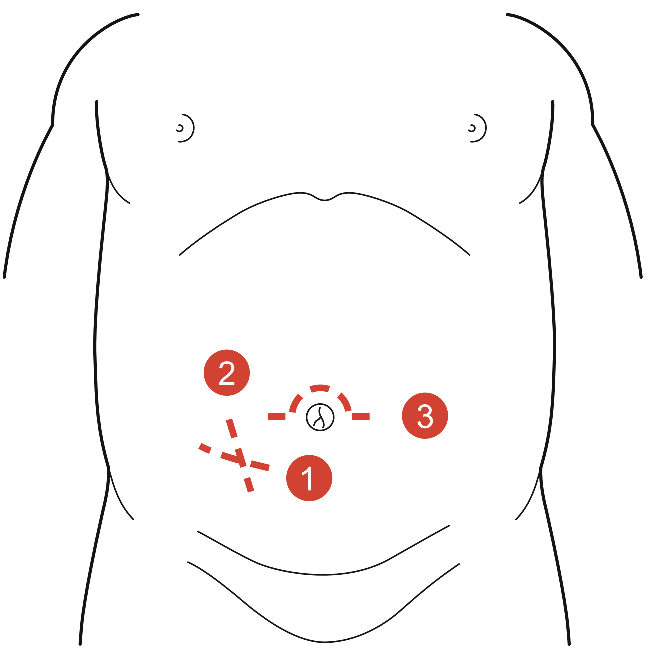

Fig. 33.1 Skin incision: (*1*) Right lateral transverse incision; (*2*) right paramedian incision; and (*3*) small Ω-form incision along the umbilical ring

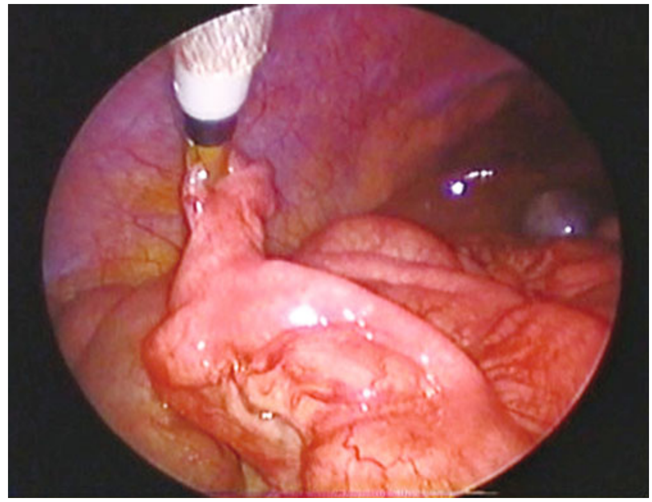

Fig. 33.2 Laparoscopic findings: Meckel's diverticulum is explored from the distal end of the ileum to the oral side with the use of bowel forceps inserted through the 3-mm or 5-mm port on both sides of the abdomen

33.3.2 Excision of Diverticulum

There are two techniques for laparoscopic diverticulectomy: in one the diverticulum is laparoscopically excised within the body employing an autosuture device, while in the other a diverticulum is exteriorized through the umbilical incision and excised. The former has the merits of less invasiveness, shorter time to postoperative recovery of bowel motility, lower adhesion incidence, and so on, because the intestine is not exteriorized. However, in cases where the diverticulum has a broad base, ectopic gastric mucosa can be present anywhere within the diverticulum, thus requiring extra-abdominal wedge resection of the ileum (including the diverticulum) to ensure that all ectopic gastric mucosa is resected. The camera port at the umbilical ring is removed, and the incision is extended along the umbilical ring to cover approximately two-thirds of the circumference. Then, the subcutaneous tissue of the umbilical ring, the linea alba, and the peritoneum are incised as extensively as possible to pull the diverticulum out of the incision (Fig. 33.3). After completion of the extracorporeal resection and anastomosis, it may be difficult to reduce the intestine into the peritoneal cavity due to congestion in the operated intestine. Therefore, it is important to initially make a slightly larger umbilical incision.

First, outflow and blood flow are blocked with intestinal forceps placed several centimeters from the planned site of dissection. Four-point supportive sutures are applied in all directions of the planned resection line. While pulling these

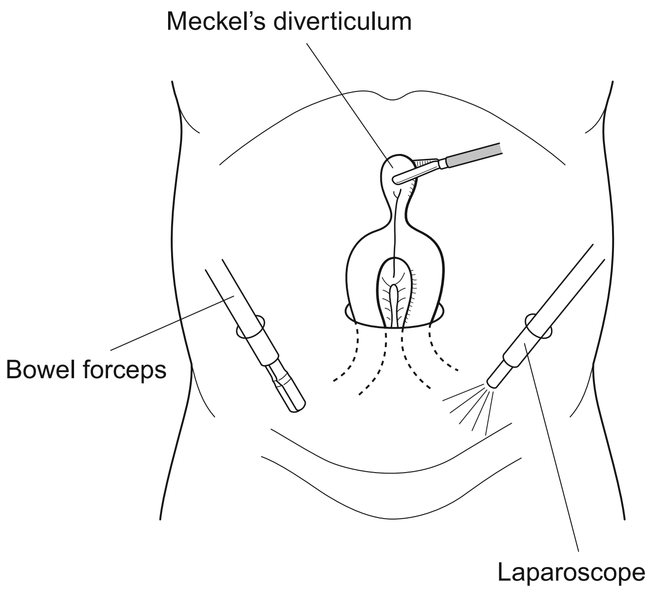

Fig. 33.3 Laparoscope-assisted surgery: the diverticulum is held under laparoscopic guidance and is pulled out of the peritoneal cavity via the port (created at the umbilical ring) for resection

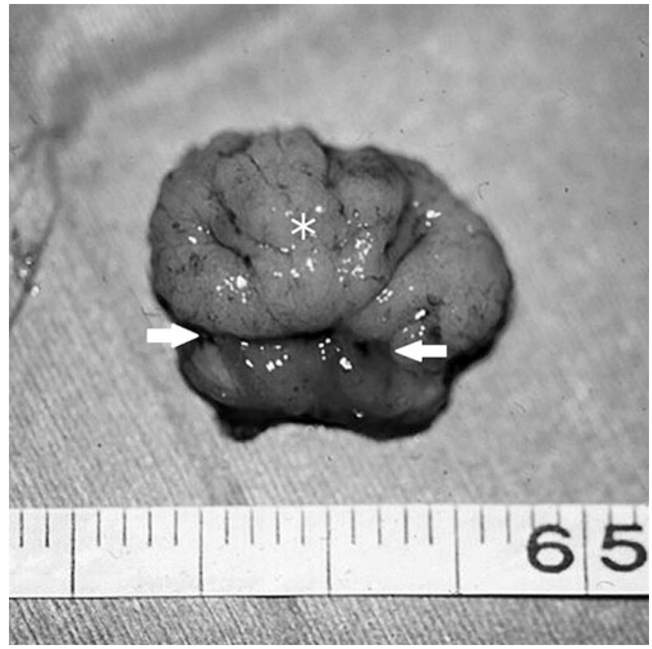

Fig. 33.5 Resected specimen: ectopic gastric mucosa is present even at the diverticulum base (*asterisk*), with ulcer bleeding noted in the small bowel (between *arrows*)

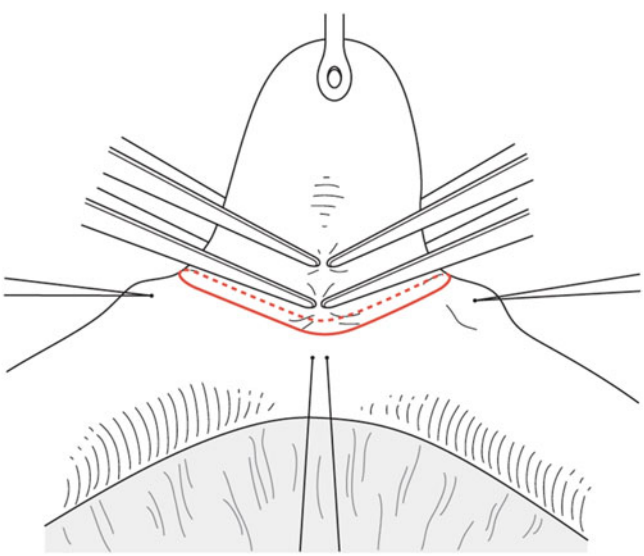

Fig. 33.4 Diverticulum resection: if the diverticulum has a broad base, it is resected in a wedge shape, including the base

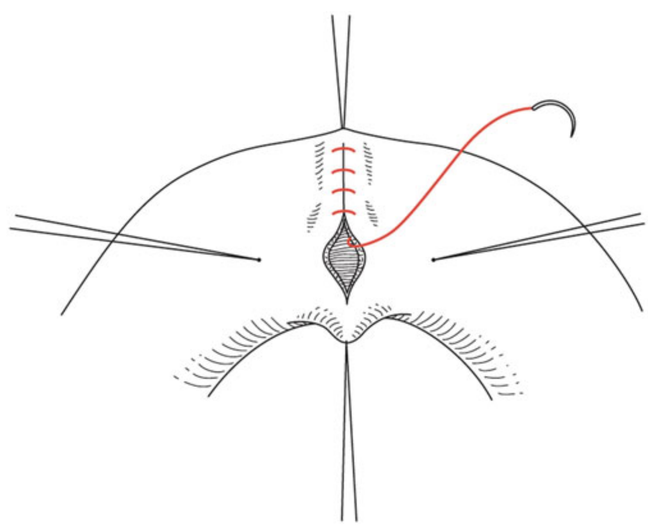

Fig. 33.6 Closure of intestinal incision: the wound created by incision is closed by suturing perpendicular to the major axis of bowel

sutures, the part closer to the small bowel is compressed in a wedge shape with two pairs of hemostatic forceps, and the diverticulum is resected with the forceps closer to the small bowel (Fig. 33.4). The small bowel lumen is checked for the presence of ectopic gastric mucosa through the incised wound, and any ectopic gastric mucosa found is resected (Fig. 33.5). The incised wound of the bowel is closed by suturing perpendicularly to the major axis of bowel while pulling the supportive sutures in a horizontal direction (Fig. 33.6). If the diverticulum is long, ectopic gastric mucosa is present at its tip, and laparoscopic resection with an automated anastomosing device is also an option. During this procedure, resection and suturing are performed while applying the automated suturing device obliquely to the diverticulum base (approximately 45° to the major axis of bowel). In cases where the long diverticulum is resected extra-abdominally, resection is performed with two pairs of hemostatic forceps applied to the diverticulum base

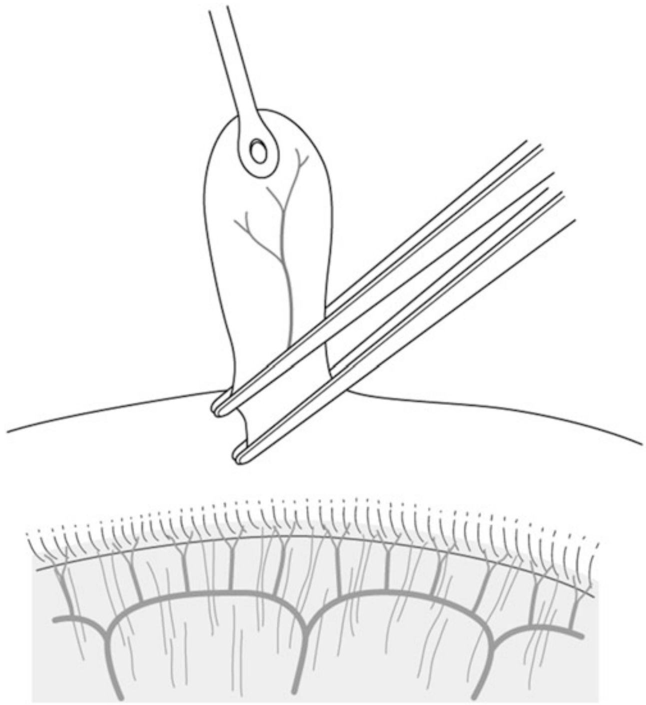

Fig. 33.7 Resection of a long diverticulum: in cases with a long diverticulum, resection is performed with the forceps applied obliquely to the diverticulum base

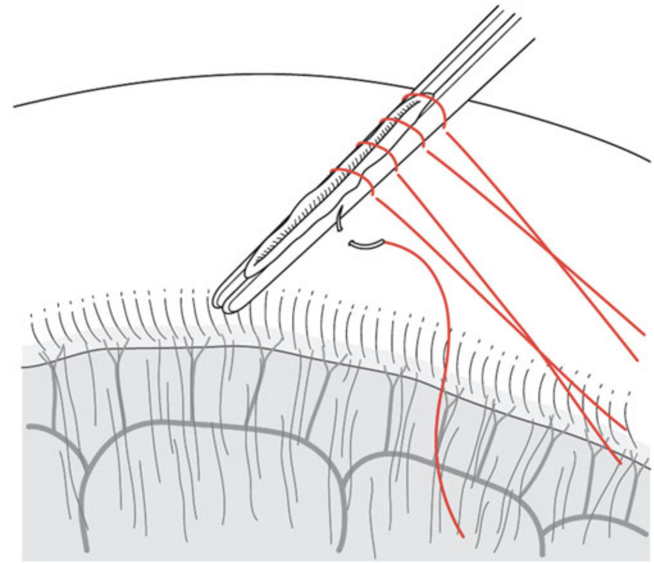

Fig. 33.8 Closure of wound in cases of a long diverticulum: the wound is closed by mattress suturing while applying the forceps to the intestinal side

obliquely in the same manner as mentioned above (at the same angle to the major axis of the bowel) (Fig. 33.7), followed by mattress suturing while applying the forceps to the part closer to the bowel to avoid intraperitoneal contamination (Fig. 33.8).

Ileectomy and end-to-end anastomosis are performed in cases where inflammatory Meckel's diverticulum has formed a mass and in cases of severely disturbed circulation through the ileum due to intussusception, diverticulum torsion, or ileus.

33.3.3 Postoperative Management

Postoperatively, the bowel is decompressed with a nasogastric tube and fluid therapy is continued until normal gastrointestinal motility is resumed. Antibiotics are administered until wound infections can be avoided.

34 Internal Hernia

Masahiko Sugiyama and Tomoaki Taguchi

Abstract

Internal hernia is defined as "intestine enters into the large fossa, cystic space, or defect and causes closed-loop bowel obstruction." Internal hernias are classified into two types: peritoneal fossa and peritoneal defect. The former includes paraduodenal hernia, paracecal hernia, sigmoid fossa, and foramen of Winslow, and the latter includes defects of mesentery, omentum, and uterus band.

Internal hernia appears with symptoms of bowel obstruction such as abdominal pain, bilious vomiting, and abdominal distension. This condition can rapidly progress to bowel ischemia. Preoperative definitive diagnosis is difficult. Currently, due to the progress of imaging, such as color Doppler ultrasonography and CT scan, some cases can be diagnosed preoperatively. Emergent operation is recommended in cases of strangulation.

Keywords

Internal hernia • Paraduodenal hernia • Mesenteric defect hernia • Paracecal hernia

34.1 Skin Incision

Large-size skin incision is required for emergent operation in order to obtain enough operational view. Small incision just on the affected lesion can be possible in the case of definitive preoperative diagnosis by imaging. Laparoscopic surgery is recommended in case of good systemic condition. Laparoscopy can provide definitive intraoperative diagnosis and may proceed the reduction of hernia and closure of hiatus.

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34.2 Operations

Intraoperative observations of the intestine from the ileocecal valve to the Treitz band provide the condition of intestine and the place of hiatus. Gentle pullout of the herniated intestine and estimation of the intestine are essential. The ischemic bowel is warmed and the mesenteric arterial palpation is confirmed. Then, necrotic bowel is resected and end-to-end anastomosis is performed. The bowel should be remained as much as possible. Hiatus of hernia is closed or extended widely.

34.3 Small Intestinal Mesenteric Defect Hernia

The intestine enters into the mesenteric defect (Fig. 34.1a). If the reduction is difficult, the defect can be extended (Fig. 34.1b). Operators should pay attention not to injure mesenteric vessels during closure of the hiatus.

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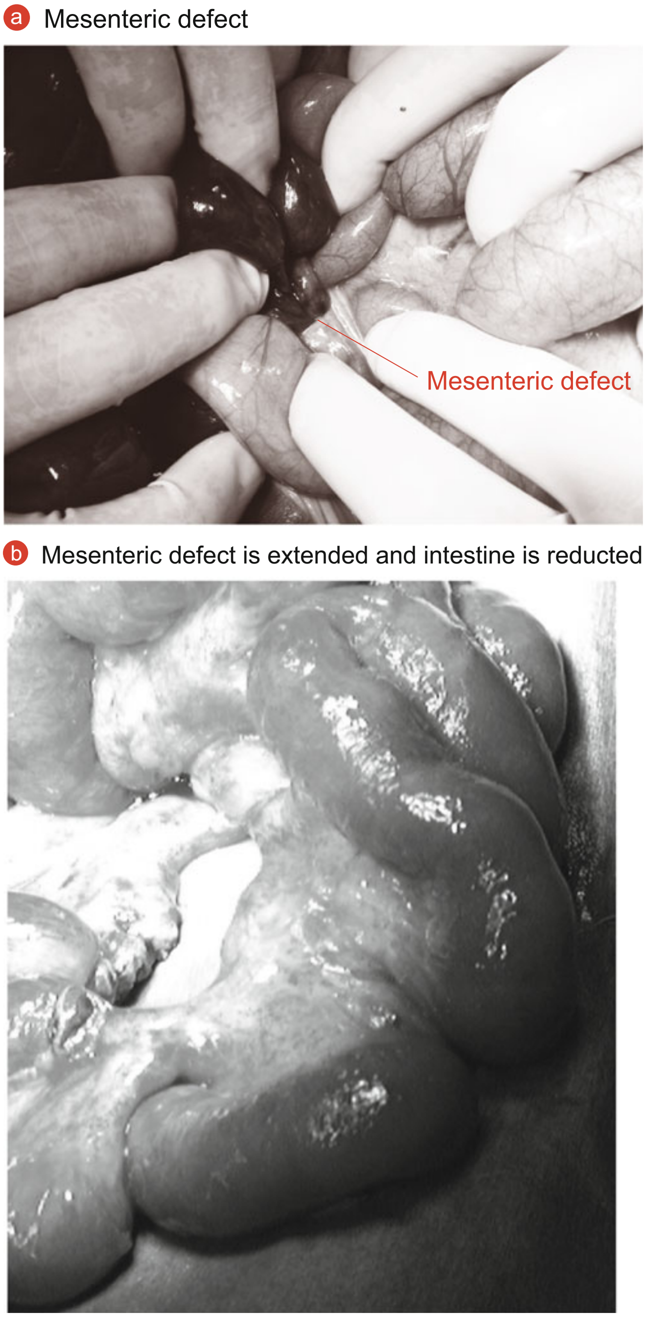

Fig 34.1 Mesenteric defect hernia

34.4 Paraduodenal Hernia

Left type is much common than right type.

Right type: small intestinal rotation is stopped at 90°, and the colon only continues to rotate. The small intestine is placed at the right side of superior mesenteric artery. And the cecum is fixed to right upper abdomen by Ladd band. Then, small intestine is wrapped by mesenterium of right colon (Fig. 34.2a). The Ladd band is cut and dissection is extended and then hernia sac is opened (Fig. 34.2b).

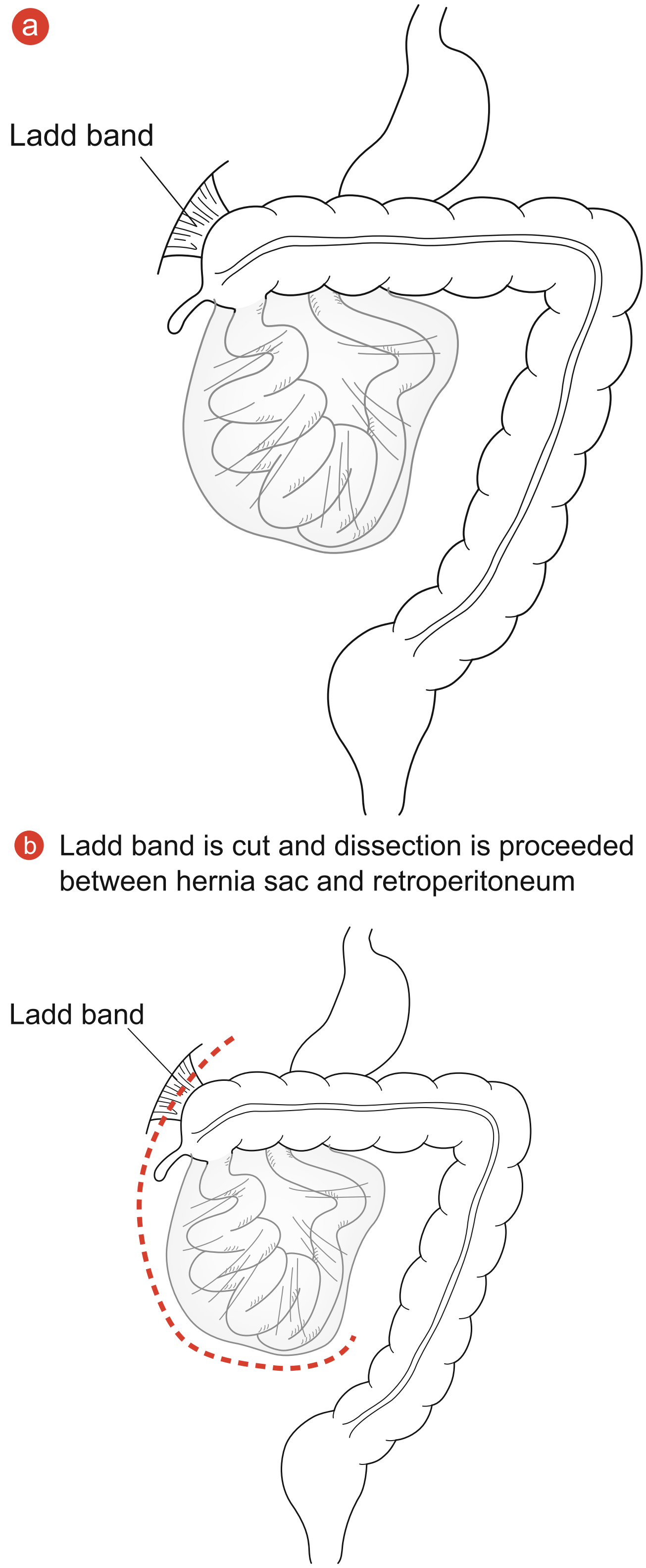

Fig 34.2 Right paraduodenal hernia

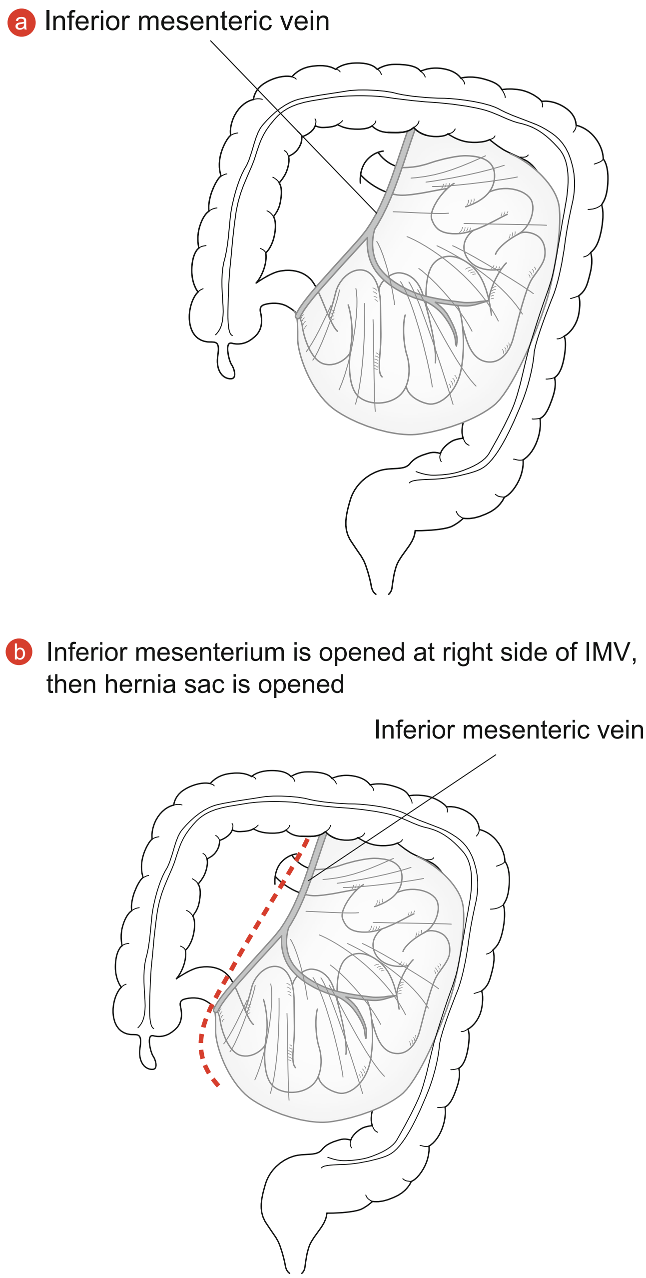

Fig 34.3 Left paraduodenal hernia

Left type: small intestinal rotation is completed; however, the small intestine enters the posterior space of the inferior mesenteric vein and dorsal of the inferior mesenterium. And the inferior mesenterium is fixed to the retroperitoneum; the hernia sac is created (Fig. 34.3a). At first, the intestine is reduced, and hernia hiatus is extended at the right side of the inferior mesenteric vein (Fig. 34.3b).

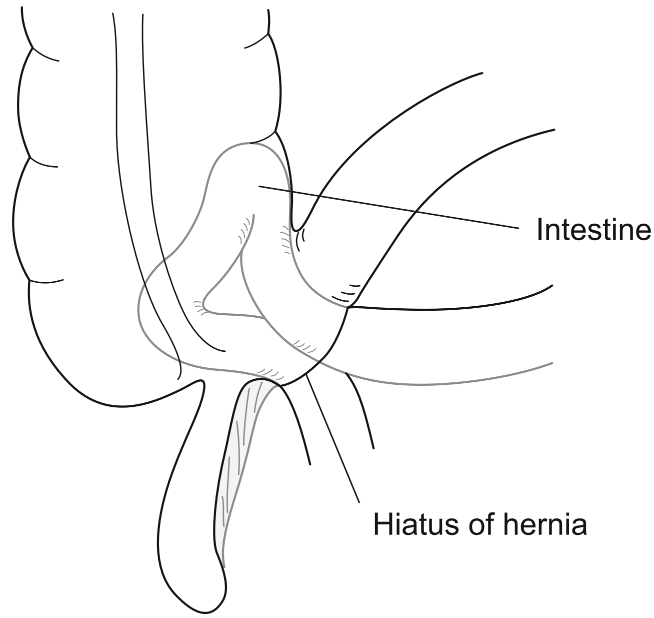

Fig 34.4 Paracecal hernia

34.5 Paracecal Hernia

Paracecal fossae are cause of this internal hernia. There are four fossae: superior ileocecal fossa, inferior ileocecal fossa, retrocecal fossa, and retroappendiceal fossa. Usually fossa shows funnel appearance, and it is difficult to enter. However, when the orifice is small and the depth is long, internal hernia happens (Fig. 34.4). At first, the intestine is reduced and hiatus is closed or is extended widely.

34.6 Sigmoid Fossa Hernia

There are three types of sigmoid fossa hernia: intersigmoid fossa, mesosigmoid defect, and mesosigmoid internal hernia. The intestine is reduced and hiatus is closed.

34.7 Foramen Winslow Hernia

The size of foramen of Winslow is large, and the length of mesenterium is extended, or poor fixation of mesenterium causes foramen of Winslow hernia. The intestine is reduced and fixed.

Intussusception

35

Masahito Sato

Abstract

Intussusception is one of the most commonly encountered conditions in pediatric surgery. It is defined as the peristaltic invagination of a section of the bowel (the intussusceptum) into a more distal segment of the bowel (the intussuscipiens). Surgical treatment is indicated if nonoperative reduction by hydrostatic or pneumatic methods under fluoroscopic or ultrasonographic guidance fails. Conventional manual reduction is widely recognized to be a basic technique by pediatric surgeons.

Keywords

Intussusception • Intussusception reduction • Laparoscopic surgery

35.1 Diagnosis

Intussusception is diagnosed using ultrasonographic or radiological examinations.

35.1.1 Classification

Diagnosis of the severity of pediatric intussusception.

1. Severe
   In seriously ill children that require intensive resuscitation and children who exhibit clinical or radiological evidence of peritonitis or perforation, nonoperative reduction is generally considered to be inappropriate.
2. Moderate
   In moderate cases, patients usually exhibit a good general condition; however, intestinal perforation can occur in infants with a history longer than 48 h after the onset of intussusception, in infants under 3 months, in patients with ileoileocolic intussusception, and in patients with suspected intestinal ischemia due to leukocytosis. Therefore, nonoperative reduction should be attempted while paying sufficient attention to the choice of contrast medium, the reduction pressure, and the reduction frequency.
3. Mild
   In mild cases involving patients that are in a good general condition, nonoperative reduction by hydrostatic or pneumatic methods under fluoroscopic or ultrasonographic guidance is the optimal method.

35.1.2 Nonoperative Reduction

The success rate of nonoperative reduction is considered to be approximately 90 %. Nonoperative reduction can be performed using various methods including ultrasonographic reduction using gas or normal saline solution and fluoroscopic reduction. Nonoperative reduction using barium is not recommended because of the risk of peritonitis due to intestinal perforation.

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35.2 Surgical Reduction (Manual Reduction: Hutchinson's Maneuver)

35.2.1 Preoperative Management

No special preoperative bowel preparations are required. Children with a long history of intussusception, in whom peritonitis, gangrenous bowel tissue, and/or septicemia are likely to be present, would benefit from a regime of intravenous fluids, antibiotics, and nasogastric decompression.

35.2.2 Operations

35.2.2.1 Positioning and Incision (Fig. 35.1)

Surgery is performed with the patient in the supine position. A right transverse skin incision is made above the umbilicus. A surgical procedure that is performed via a circumumbilical incision was also recently developed.

35.2.2.2 Reduction of the Intussusception (Figs. 35.2, 35.3, and 35.4)

The bowel section involved in the intussusception, which feels like a mass during palpation, is pulled out of the wound. If this proves difficult, a portion of the cecum toward the ascending colon can be mobilized from the retroperitoneum. The apex of the intussusception is then located in the cecum or ascending colon.

Next, the intussusceptum is pinched between the surgeon's fingers and pushed toward the proximal side over the intussuscipiens. Reduction is achieved by squeezing the intussusceptum back to the proximal side as if the surgeon was squeezing a tube of toothpaste (Hutchinson's maneuver). During manual reduction, resistance is felt when the intussusceptum passes through the ileocecal valve toward the proximal side. The surgeon uses both thumbs to push the intussusceptum back to the proximal side while using

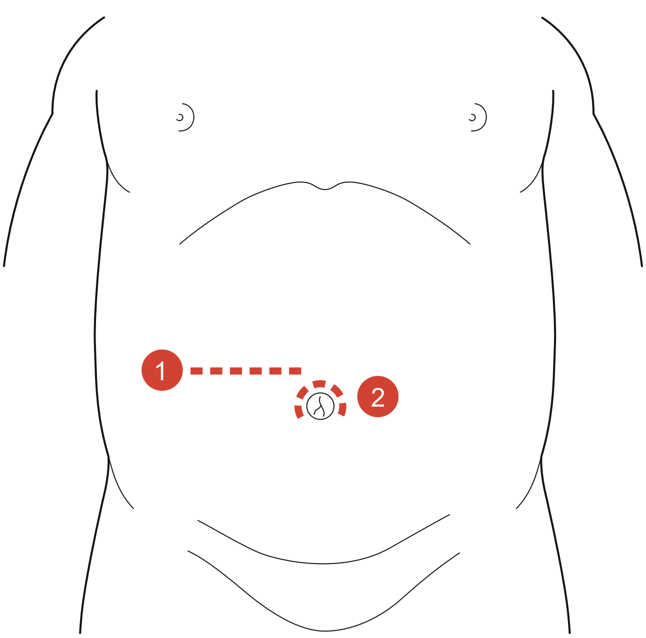

Fig. 35.1 Incision (*1*) A right transverse skin incision. (*2*) The umbilical approach

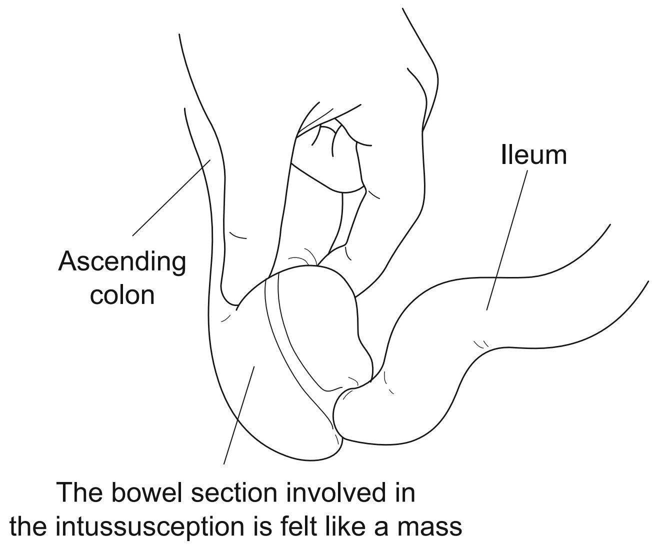

Fig. 35.2 Identification of the section of bowel involved in the intussusception. The section of the bowel involved in the intussusception, which feels like a mass during palpation, is pulled outside of the wound

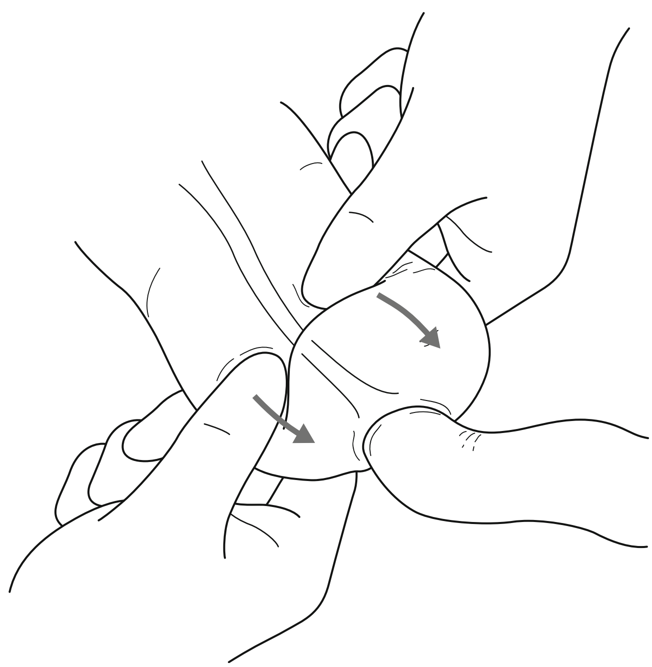

Fig. 35.3 Intussusception reduction (*1*). The intussusceptum is squeezed between the surgeon's fingers and pushed toward the proximal side

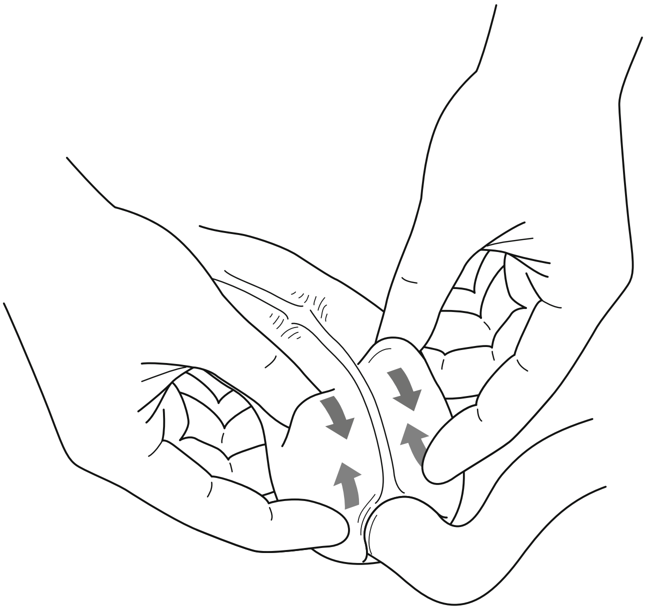

Fig. 35.4 Intussusception reduction (*2*). At the end of the reduction procedure, the intussusceptum is pushed toward the proximal side with both thumbs, while the intussuscipiens is pulled toward the surgeon using both index fingers

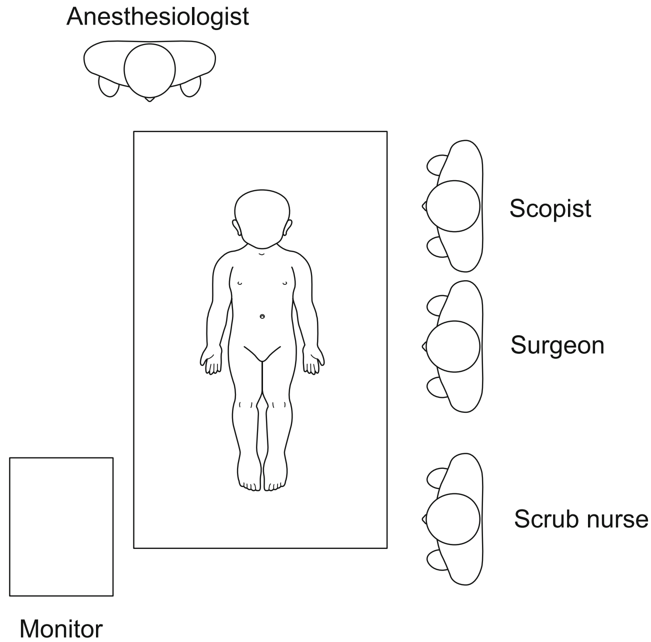

Fig. 35.5 Positioning of the patient, surgical team, and equipment

their index fingers to pull the cecal wall toward the distal side. After the reduction procedure, the intussuscipiens is checked for serosal injuries and perforations.

35.2.2.3 Resection

Bowel resection is necessary when the intussusception cannot be manually reduced, or necrotic bowel tissue is observed after the reduction of the intussusception or a pathological lead point, such as small intestinal polyps, Meckel's diverticulum, an ectopic pancreas, or intestinal duplication is encountered. It is occasionally necessary if manual reduction has caused serious damage to the ascending colon or cecal wall (intussuscipiens), which is stretched by the intussusceptum. However, the extent of bowel resections should be minimized as much as possible. Appendectomy is not contraindicated if the adjacent cecal wall is normal.

35.2.3 Postoperative Management

Oral nutrition is restarted once intestinal peristalsis has recovered. This is based on the postoperative management strategy for patients who undergo intestinal resection.

35.3 Laparoscopic Intussusception Reduction

Laparoscopic reduction is indicated for cases of intussusception in which nonoperative reduction is unsuccessful, complete reduction of the intussusception cannot be confirmed, or complications involving a pathological lead point, such as small intestinal polyps, Meckel's diverticulum, an ectopic pancreas, or intestinal duplication, are suspected.

The success rate of laparoscopic intussusception reduction is particularly high in cases of ileocecal intussusception. In cases that are complicated by a pathological lead point, laparoscopic-assisted bowel resection can be performed. In children who suffer peritonitis or perforation or require intensive resuscitation, the conventional open approach is preferable.

35.3.1 Operations

35.3.1.1 Positioning of the Patient, Medical Staff, and Monitor (Fig. 35.5)

Surgery is performed with the patient in the supine position. The surgeon stands on the left side of the patient, and an assistant stands on the right side of the surgeon. The monitor is placed on the right side of the patient. After general anesthesia has been induced, a urinary catheter is inserted.

35.3.1.2 Port Positions and Laparoscopic Reduction (Figs. 35.6, 35.7, and 35.8)

A semicircular umbilical incision for a camera port is made in the left side of the umbilicus using an open laparoscopic technique. Pneumoperitoneum is maintained at 8–10 mmHg. Two working ports of 5 mm in size are inserted through a right-subcostal mid-clavicular incision and a suprapubic

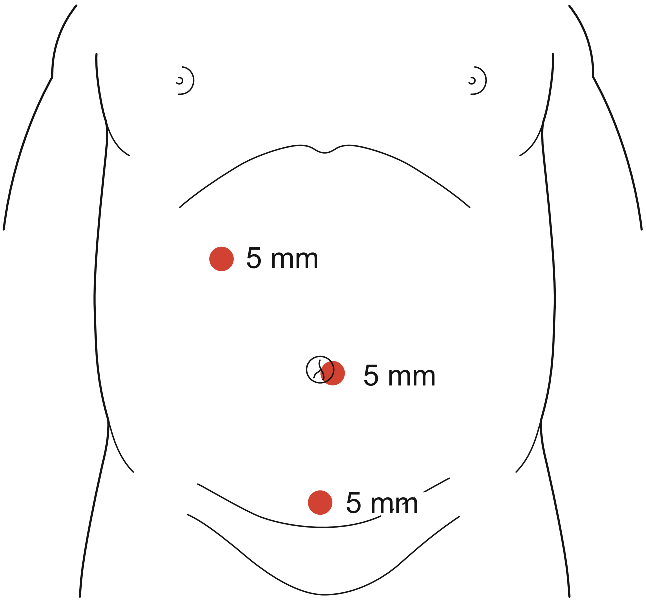

Fig. 35.6 Positions of the trocar sites

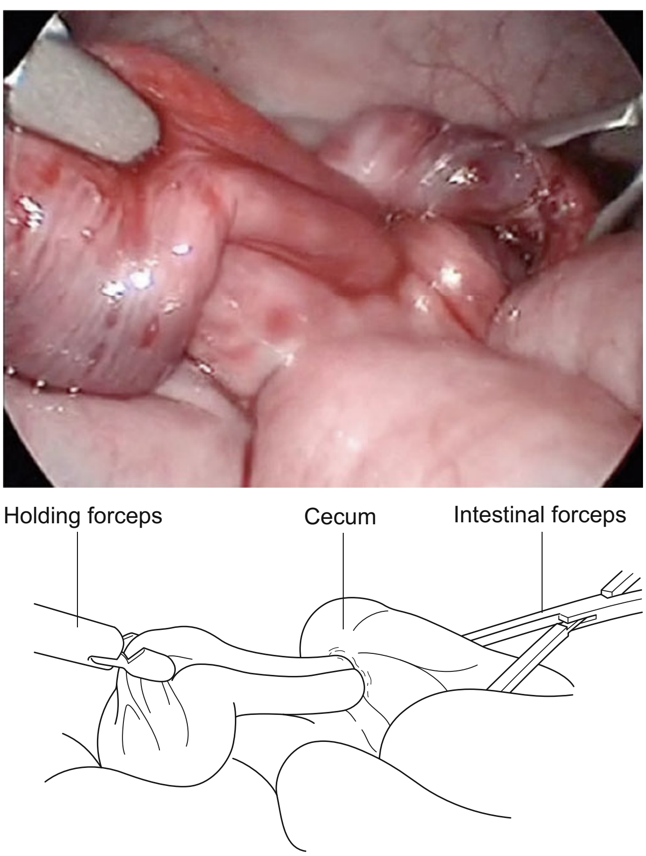

Fig. 35.7 Laparoscopic intussusception reduction (*1*). Once the intussusceptum has been identified, intestinal forceps are used to push the intussusceptum back toward the proximal side. To prevent re-invagination, the distal end of the intussuscipiens is pulled toward the proximal side with intestinal forceps

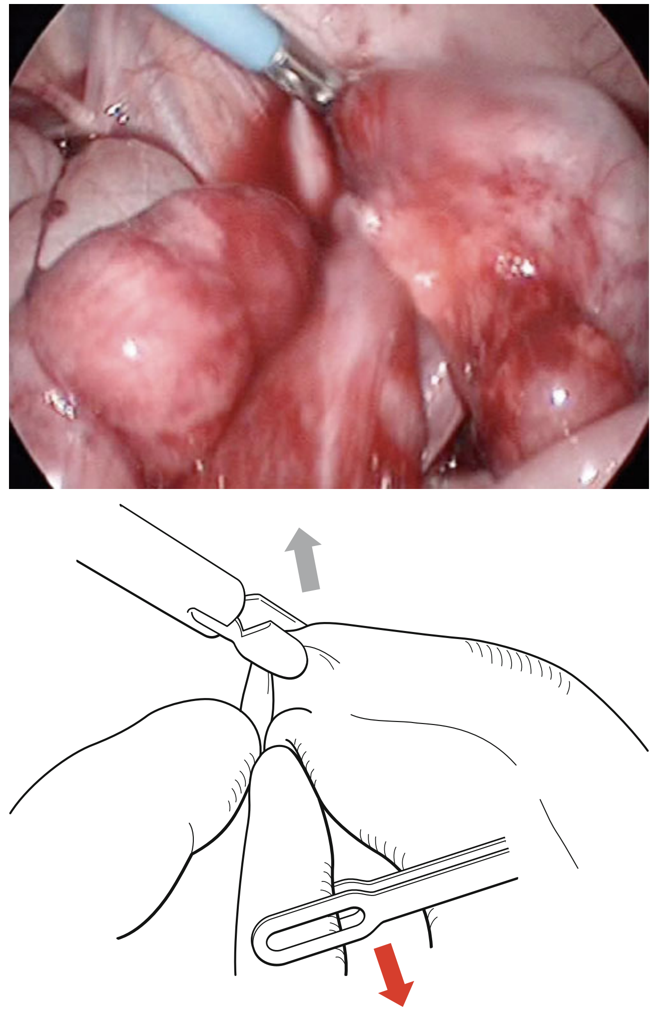

Fig. 35.8 Laparoscopic intussusception reduction (*2*). The cecum is pushed to the right and out of the patient's body, while the end of the intussusceptum is pulled toward the proximal side

incision, respectively. The patient is placed in the Trendelenburg position, and the operation table is inclined to the left to move the small intestine away from the ileocecal region. An additional trocar, for retraction, is inserted through a left lower incision when the dilated intestine obscures the surgeon's view.

Sometimes the intussusception reduces spontaneously before the surgeon reaches it. If this occurs, the patient's anatomy is checked, and the procedure is terminated.

Otherwise, laparoscopic intestinal forceps are used to gently squeeze the ascending colon toward the distal side to identify the intussusceptum. Once the intussusceptum has been identified, the intestinal forceps are used to push the intussusceptum back toward the proximal side. If the intestinal forceps are released during this procedure, the intussusceptum will reinvaginate toward the distal side; hence, to prevent reinvagination, the distal end of the intussuscipiens is pulled toward the proximal side with intestinal forceps. This maneuver is repeated until the intussusceptum has been pushed back to the cecum; after which the cecum is pushed to the right and outside of the patient's body, while the end of the intussusceptum is pulled toward the proximal side. In many cases, this technique results in the complete reduction of the intussusception. After the reduction procedure, the intussuscipiens is checked for serosal injuries or perforations.

35.3.1.3 Laparoscopic-Assisted Resection

If necrotic bowel tissue or a pathological lead point is encountered after the reduction of the intussusception, the umbilical incision is extended, and bowel resection is performed extracorporeally.

35.3.1.4 Conversion to Open Surgery

The laparoscopic procedure should be immediately converted to an open procedure in cases in which laparoscopic reduction is difficult, the patient develops intestinal perforation or peritonitis, or intestinal damage occurs during the laparoscopic reduction.

36 Appendectomy

Masahito Sato

Abstract

Appendicitis is one of the most common medical conditions affecting children. It is usually treated with open or laparoscopic appendectomy, which is probably a basic surgical procedure for young pediatric surgeons to perform. Appendicitis is common in older children, but care must be taken in younger children because it can be difficult to diagnose, and children are prone to perforated peritonitis.

Keywords

Appendectomy • Laparoscopic surgery • Appendicitis

36.1 Open Appendectomy

36.1.1 Preoperative Management

Patients that are complicated by peritonitis, such as those with perforated appendicitis, should be given sufficient fluid transfusions before surgery to stabilize their hemodynamics. Antibiotics should also be administered from the preoperative period onward.

36.1.2 Operations

36.1.2.1 Incision (Figs. 36.1 and 36.2)

The most common incision employed during open appendectomy is a transverse right lower quadrant skin crease incision through or below McBurney's point.

The external oblique muscle is split in the direction of its fibers. Then, the internal oblique muscles and the transverse muscle are cut in the direction of their fibers to reach the peritoneum. The peritoneum is grasped and then opened with a scalpel. The resultant peritoneal opening is enlarged with scissors.

36.1.2.2 Exposure of the Appendix (Fig. 36.3)

When the greater omentum or small intestine is located below the incision, it should be moved to the cranial side. Next, the teniae coli are grasped and followed to the proximal side to reach the appendix. If the appendix cannot be identified easily, the cecum and appendix are dissected from the retroperitoneum using blunt or sharp dissection. Once the appendix has been identified, the mesoappendix or the appendix itself is held with Pean or Babcock forceps, and the appendix is pulled out of the incision. If the appendix cannot be identified, the muscle-splitting incision should be enlarged by medially transecting the rectus muscle in order to achieve adequate exposure of the operative field.

36.1.2.3 Appendectomy (Figs. 36.4 and 36.5)

The traction provided by Babcock forceps makes it easy to control the appendix. The mesoappendix is divided using hemostats and ligated in sequence. Once any blood vessels have been dealt with, the appendix is crushed approximately

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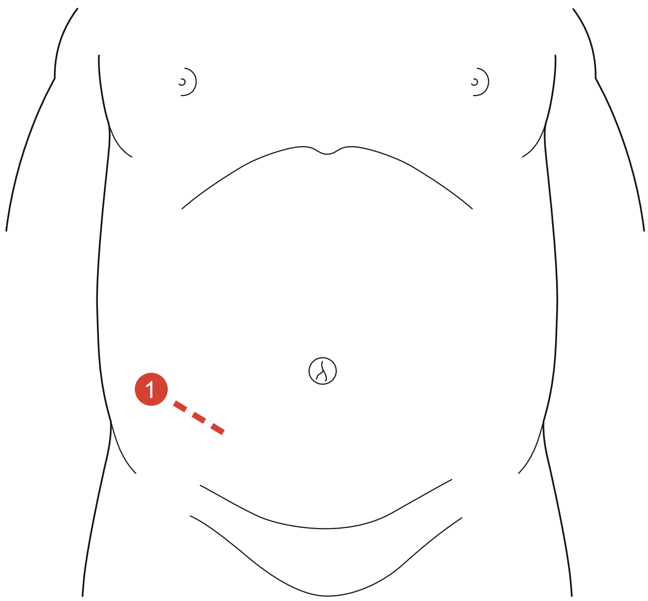

Fig. 36.1 Incision. A transverse right lower quadrant skin crease incision through McBurney's point

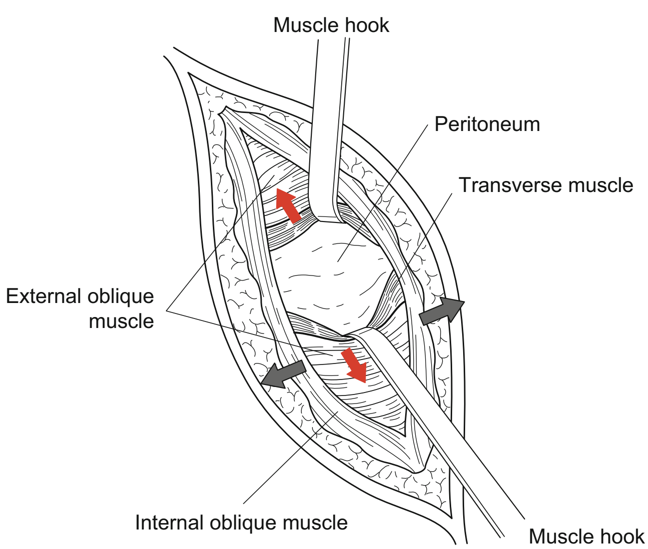

Fig. 36.2 Muscle-splitting incision to expose the peritoneal cavity

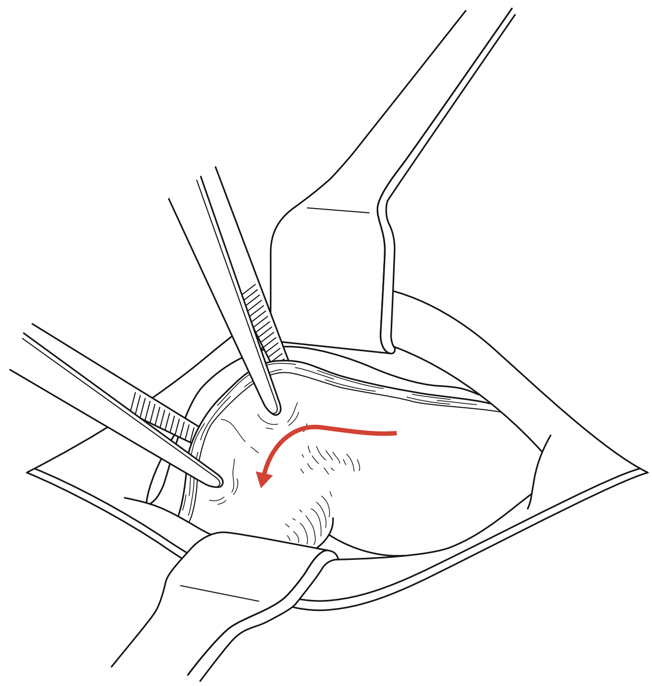

Fig. 36.3 Exposure of the appendix. The teniae coli are grasped and followed to the proximal side to reach the appendix

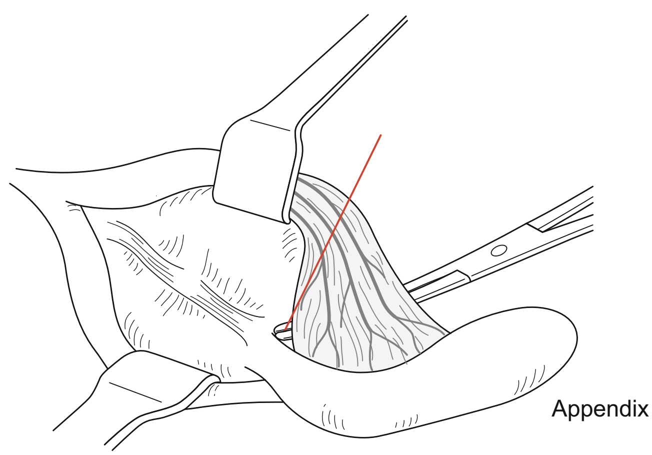

Fig. 36.4 Division of the mesoappendix

5 mm above its origin, and a clamp is attached a few millimeters distal from the crushed tissue. Next, the appendix is tied off in the crushed region and removed via sharp division just proximal to the clamp. The resected stump of the appendix is often buried within the cecum using a purse-string suture, but stump inversion is not always necessary.

36.1.2.4 Suction and Irrigation

In patients that develop perforated appendicitis or abscesses, the pelvis and right paracolic spaces are suctioned and irrigated with saline. In cases involving pan-peritonitis, pediatric patients are placed in the reverse Trendelenburg position, and irrigation is performed with a sufficient amount of saline so that the solution pools in the pouch of Douglas. Closed drains can be placed in the pouch of Douglas and/or at any abscess sites.

36.1.2.5 Wound Closure

After closing the peritoneum with sutures, the wound site is cleaned. Subsequently, the muscle layer is closed with sutures, and the skin is sutured so as not to leave any dead space.

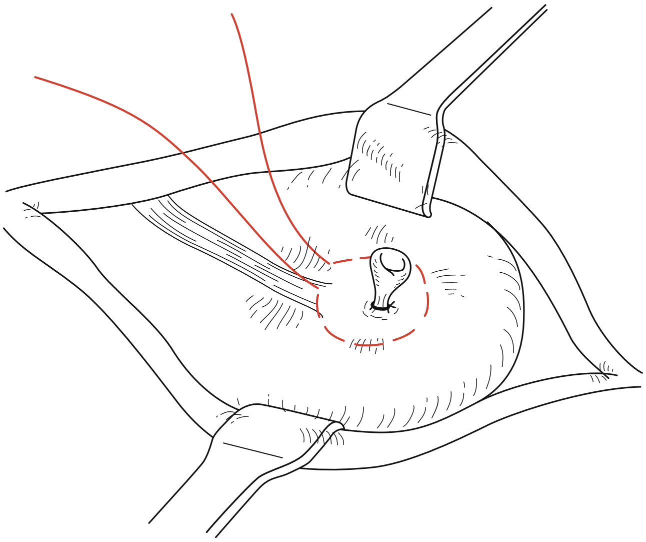

Fig. 36.5 Use of a purse-string suture. The resected stump of the appendix is buried within the cecum with a purse-string suture

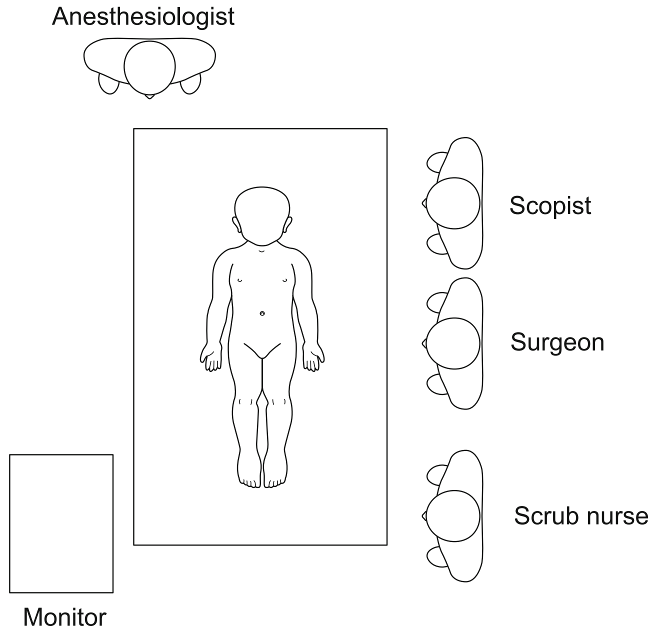

Fig. 36.6 Positioning of the patient, surgical team, and monitor

36.1.2.6 Postoperative Management

Oral intake is restarted once intestinal peristalsis has returned. The use of postoperative antibiotics varies depending on the extent of the patient's appendicitis. Postoperatively, care must be taken to prevent wound infection and residual abscess formation.

36.2 Laparoscopic Appendectomy

Laparoscopic appendectomy is indicated for mild to serious cases of appendicitis involving pan-peritonitis. As observation, suction, and irrigation of the peritoneal cavity are often employed in patients with appendicitis complicated by peritonitis, such patients are considered to be good candidates for laparoscopic appendectomy. However, in children with a poor general status, such as those who require intensive resuscitation after developing shock, the conventional open approach is preferable.

36.2.1 Preoperative Management

The preoperative management strategies employed before laparoscopic appendectomy are the same as those used before open appendectomy.

36.2.2 Operations

36.2.2.1 Positioning of the Patient, Surgical Team, and Monitor (Fig. 36.6)

The patient is put in the supine position with both arms alongside their body on the operating table. A nasogastric tube is installed, and a urinary catheter is inserted to prevent bladder injuries. The surgeon stands on the left side of the patient, and the scopist stands on the cranial side of the surgeon. A monitor is placed at the patient's right foot. The operation table is tilted in the Trendelenburg position and to the left. Thus, the right colon and small intestine shift to the left.

36.2.2.2 Port Positions (Fig. 36.7)

A semicircular intraumbilical incision for a 10-mm camera port is made on the left side of the umbilicus using an open laparoscopic technique. Pneumoperitoneum is maintained at 8–10 mmHg. Two working ports of 5 mm in size are inserted through a right subcostal mid-clavicular incision and a suprapubic incision, respectively. An additional 5-mm working port can also be inserted in the left abdominal region. The number, position, and diameter of the second and third trocars are decided based on the technique used, as well as the position and appearance of the appendix, and the experience of the surgeon.

36.2.2.3 Exposure of the Appendix and the Laparoscopic Appendectomy (Figs. 36.8, 36.9, and 36.10)

In cases in which peritonitis develops before the mobilization of the appendix, the abdominal cavity should be rinsed with saline. In cases involving an appendicular infiltrate or abscess formation, care should be taken to avoid spreading pus or injuring the bowel. If the greater omentum or small intestine covers the appendix, they should be gently moved

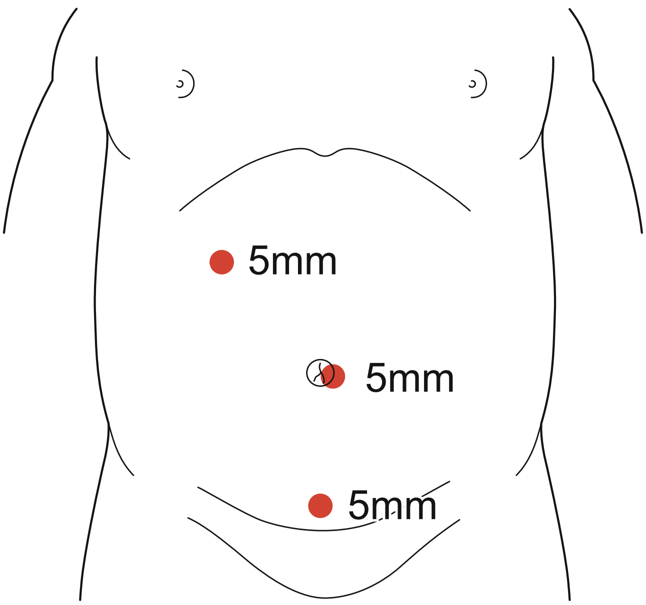

Fig. 36.7 Port positions. The number, position, and diameter of the trocars are decided based on the technique used, as well as the position and appearance of the appendix, and the experience of the surgeon

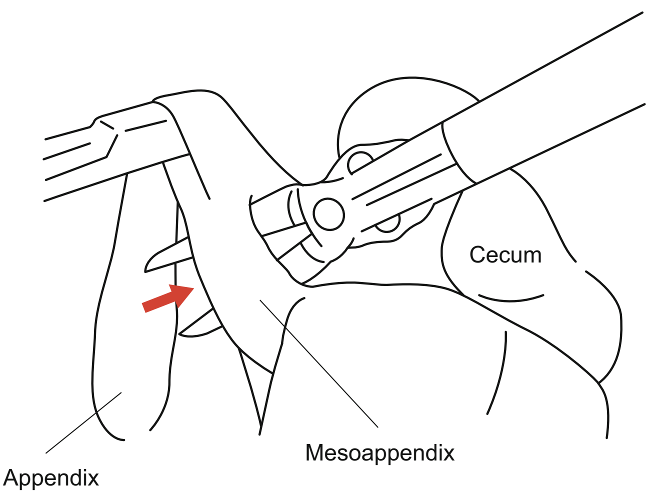

Fig. 36.8 Treatment of the mesoappendix (*1*). A window is constructed in the mesoappendix

away. In particular, the greater omentum must be handled carefully to avoid unnecessary bleeding. In cases involving a retrocecal appendix, the retroperitoneum is dissected, and the appendix or cecum is mobilized. In cases involving gangrenous/necrotic appendicitis, grasping the appendix itself might damage the appendix or cause its contents to leak; thus, care must be taken to grasp the mesoappendix.

The mesoappendix can be divided using cautery, laparoscopic coagulation shears, clips, or a vascular/gastrointestinal stapler. When using laparoscopic coagulation shears, care must be taken regarding the direction of the

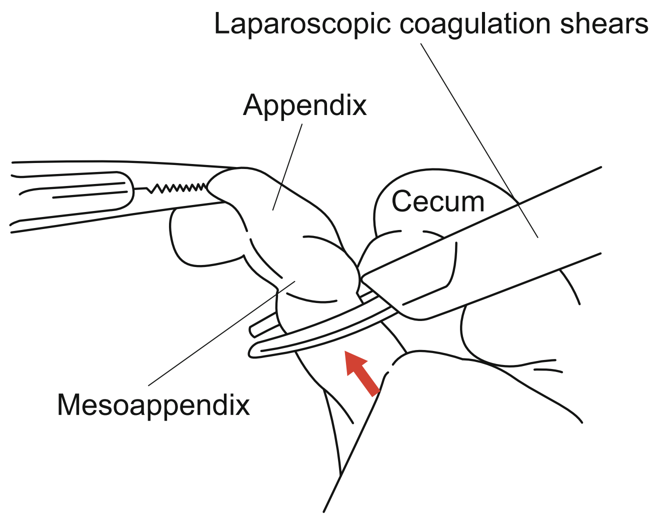

Fig. 36.9 Treatment of the mesoappendix (*2*). The mesoappendix is dissected using laparoscopic coagulation shears

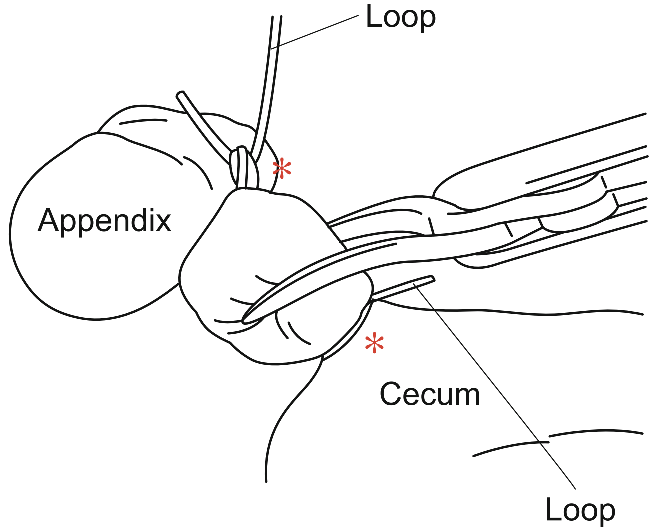

Fig. 36.10 Treatment of the appendiceal stump. The appendiceal stump is ligated with two loops and resected between two sites (a single ligature is acceptable)

active blade to avoid damaging the surrounding organs due to cavitation of the tip.

After being pedicled on the cecum, the appendiceal stump is ligated using two loops or a laparoscopic gastrointestinal stapler. If a fecalith is suspected to be present at the root of the appendix, it should be guided to the resected side. The appendix is then resected between the two loops.

Next, the appendix is removed through the sheath of the umbilical trocar so that the infected appendix does not touch the anterior abdominal wall. If the appendix is large, it is stored in a sterile bag and removed through the umbilical incision following the removal of the trocar.

When the basis of the appendix is severely inflamed, it is safer to use a laparoscopic gastrointestinal stapler to amputate the appendix and part of the cecum wall. To make the use of a laparoscopic stapler possible, one port has to be enlarged to 10/12 mm in size.

36.2.2.4 Suction and Irrigation

In cases of perforated appendicitis or peritonitis, suction and irrigation are performed with a sufficient amount of saline. Irrigation is carried out while observing the entire peritoneal cavity below the right diaphragm from the pouch of Douglas to the ileocecal region and the region extending from the lower surface of the liver to below the left diaphragm. Residual abscess formation commonly occurs in the pouch of Douglas and ileocecal area; thus, these regions must be thoroughly checked.

In cases involving peritonitis, drainage can be carried out in the pouch of Douglas.

36.2.2.5 Wound Closure

The laparoscope and trocars are removed, and the umbilicus is closed with fascial sutures.

36.2.2.6 Postoperative Management

The preoperative care strategy employed after laparoscopic appendectomy is the same as that used after open appendectomy.

37 Gastrointestinal Perforation

Naoto Urushihara

Abstract

Neonatal intestinal perforation often represents a serious condition, and prognosis remains poor in low-birth-weight infants. Tissue is fragile with little reserve for invasion; therefore, it is important to always practice extreme caution and perform surgery that is rapid and precise. The primary objective of the surgery is to save the life of the infant; thus, a simple surgery should be performed that is minimally invasive and completed in the shortest possible time. For patients in whom suture failure is likely and postoperative long-term enteral feeding is anticipated to be difficult, it is safer to perform enterostomy.

Keywords

Neonatal intestinal perforation • Gastric rupture • Idiopathic perforation • Necrotizing enterocolitis

37.1 Neonatal Intestinal Perforation

Neonatal intestinal perforation, particularly gastric perforation and necrotizing enterocolitis, often represents a serious condition. Prognosis remains poor for intestinal perforation in low-birth-weight infants, the number of which has been recently increasing. The preoperative condition of such infants strongly influences the prognosis; therefore, it is important that preoperative tests and treatment are rapid and thorough.

37.1.1 Preoperative Management

First, we insert a nasogastric tube for intestinal decompression, then correct dehydration and acidosis, and administer antibiotics. If necessary, circulatory support and a diuretic are administered with dopamine hydrochloride. In the event of respiratory disturbance caused by abdominal distension, abdominal paracentesis drainage under local anesthesia is required. As a general rule, a rapid infusion is administered in 1–2 h, and surgery is performed after diuresis is achieved. However, if diuresis is not achieved, surgery is performed after 3–4 h to avoid waiting in vain.

The infant should be kept warm to prevent hypothermia before the start of surgery. The primary objective of the surgery is to save the life of the infant; thus, a simple surgery should be performed that is minimally invasive and completed in the shortest possible time. Particularly in low-birth-weight infants, tissue is fragile with little reserve for invasion; therefore, it is important to always practice extreme caution and perform surgery that is rapid and precise.

37.1.2 Operations

In neonatal intestinal perforation, the perforation site is often unknown; thus, laparotomy is often performed with a

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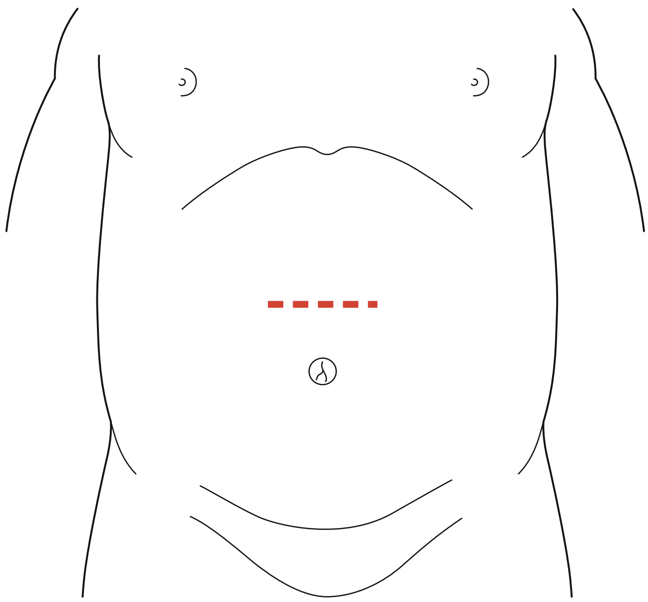

Fig. 37.1 Skin incision for neonatal intestinal perforation

transverse incision slightly above the umbilical region to enable the treatment of perforations at any site (Fig. 37.1). The surgical procedure involves a primary closure or anastomosis for patients in good general condition and in whom it is deemed, based on laparotomic findings, that suture or anastomosis can be successfully completed. For patients in whom suture failure is likely and postoperative long-term enteral feeding is anticipated to be difficult, it is safer to perform enterostomy.

37.2 Gastric Rupture

37.2.1 Incision

A transverse incision above the umbilical region is made. The peritoneal cavity is washed with warm saline. Ascites fluid is submitted for bacterial and fungal culture. Thereafter, the peritoneal cavity is examined. In low-birth-weight infants with bleeding tendency, there is a risk of subcapsular liver hematoma and mesenteric hematoma; therefore, the procedure should be performed with extreme caution. If subcapsular liver hematoma occurs, it will be difficult to stop the bleeding; it can be life-threatening. There is no requirement to remove strongly adhered purulent ascites. If gastric perforation is observed on examination of the peritoneal cavity, the incision is extended toward the upper left. Gastric perforation is often observed in the anterior wall of the greater curvature extending from the gastric fundus to the gastric corpus; thus, the perforation may not be clearly observed unless an incision is made in the gastrocolic ligament, and the omental bursa cavity is exposed. Furthermore, in some cases, the oral side of the lesion extends to the esophagogastric junction.

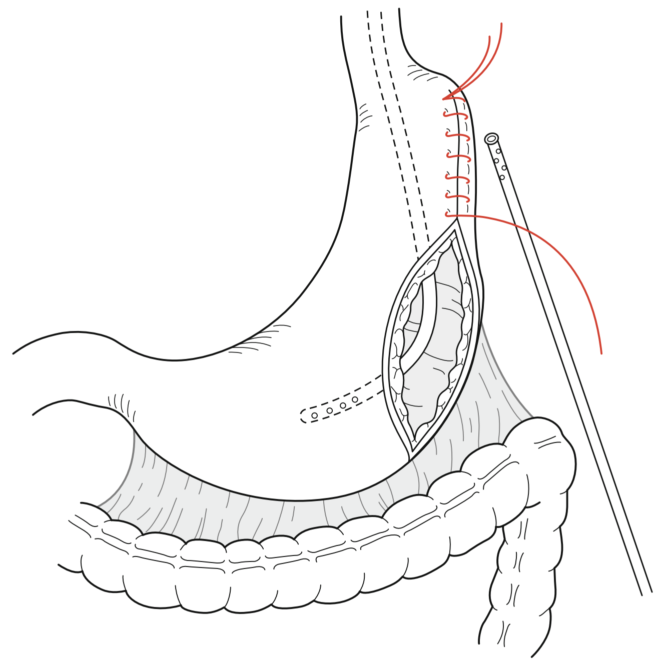

Fig. 37.2 Closure of the gastric perforation site. Debridement of the necrotic tissue and mucous membrane at the site of muscular layer loss is unnecessary. Using an absorbable suture, the perforation is closed using continuous sutures through all layers or interrupted sutures

37.2.2 Closure of the Perforation

The gastric wall surrounding the perforation can defect its muscular layer and develop necrosis. Debridement of the necrotic tissue and mucous membrane at the site of muscular layer loss is unnecessary because it will only prolong the duration of surgery, increase blood loss, and has no benefits. While devoting due attention to the spleen, the gastrocolic ligament connected to the greater curvature is dissected. A nasogastric tube is placed. Using a 3-0 or 4-0 absorbable suture, the perforation is closed using continuous sutures through all layers or interrupted sutures (Fig. 37.2). If required, additional sutures will be made through the serosa muscular layer. Although the gastric volume will be reduced after suture closure, microgastria will not be a problem postoperatively. There is no requirement for gastrostomy.

37.2.3 Intraperitoneal Lavage and Drainage

After completion of suturing of the stomach, the absence of other abnormalities must be verified. Occasionally, gastric perforation will be caused by intestinal atresia or intestinal malrotation; therefore, it should be verified that there is no obstruction of the lower gastrointestinal tract. Thereafter, the peritoneal cavity is thoroughly washed using warm saline, and a drain is placed under the diaphragm on the left and in the pouch of Douglas. There is no requirement to remove all purulent ascites and strongly adhered substances to avoid hemorrhage.

The abdominal wall is closed with absorbable sutures through all three layers.

37.2.4 Postoperative Management

Many patients require artificial respiration management immediately following surgery. In severe cases, septicemia can lead to disseminated intravascular coagulation (DIC) and severe renal failure, for which anti-DIC therapy is administered, and in severe renal failure, continuous hemofiltration and peritoneal dialysis are performed.

37.3 Idiopathic Intestinal Perforation (Focal Intestinal Perforation)

Idiopathic intestinal perforation in neonates is occasionally occurred, especially in very low-birth-weight infants. Punched-out perforation of the ileum is usually seen, and the prognosis is relatively good compared with necrotizing enterocolitis. In some cases, it is difficult to distinguish perforations caused by the meconium plug. In low-birth-weight infants, only drainage is first performed in some cases. However, if the general condition of the patient is not poor, it is better to perform laparotomy so that enteral feeding can be initiated earlier. If possible, suturing of the perforation or resection and intestinal anastomosis are performed. However, because of the possibility of reperforation and delayed postoperative enteral feeding, enterostomy is often performed.

37.3.1 Skin Incision

Laparotomy is often performed with a transverse incision above the umbilical region to enable treatment of perforation in any site. Recently, laparotomy has also been performed with a small median incision (Fig. 37.1).

37.3.2 Perforation Suture and Intestinal Resection/Anastomosis

In the case of a simple punched-out perforation, the perforation is closed with interrupted sutures or purse-string sutures, using 5-0 or 6-0 absorbable sutures (Figs. 37.3 and 37.4). If

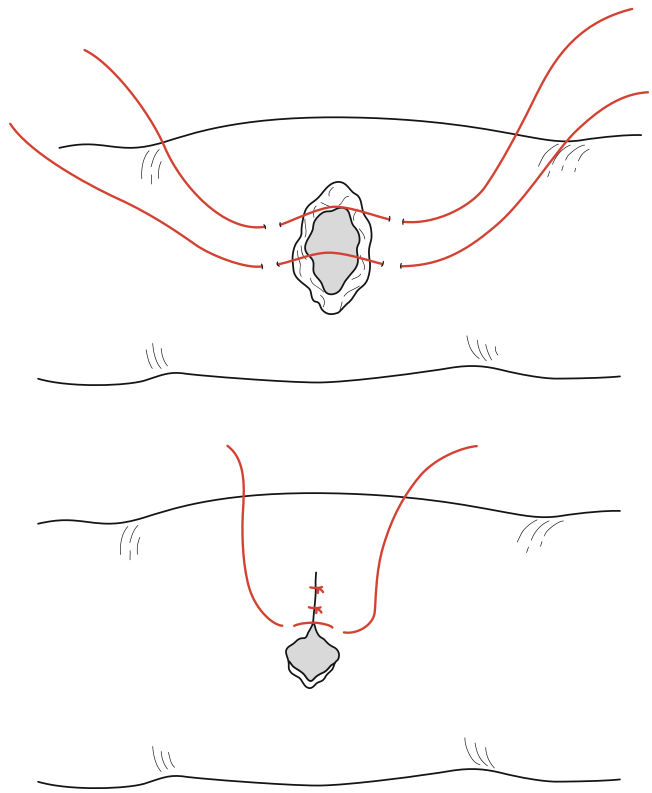

Fig. 37.3 Closure of the perforation. In the case of a simple punched-out perforation, the perforation is closed with interrupted sutures using absorbable sutures

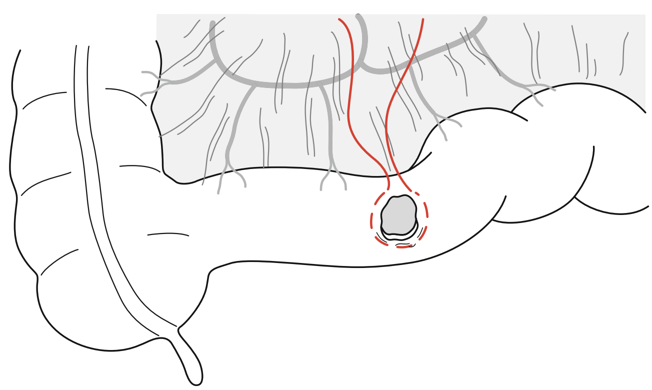

Fig. 37.4 Purse-string sutures. In the case of a small perforation, the perforation is closed with purse-string sutures

the suture site is weak and there is a risk of suture failure, the nearby intestinal tract is used as a patch on the suture site (Fig. 37.5).

37.3.3 Tube Enterostomy

In the case of perforations caused by the meconium plug or when intestinal resection and anastomosis have been

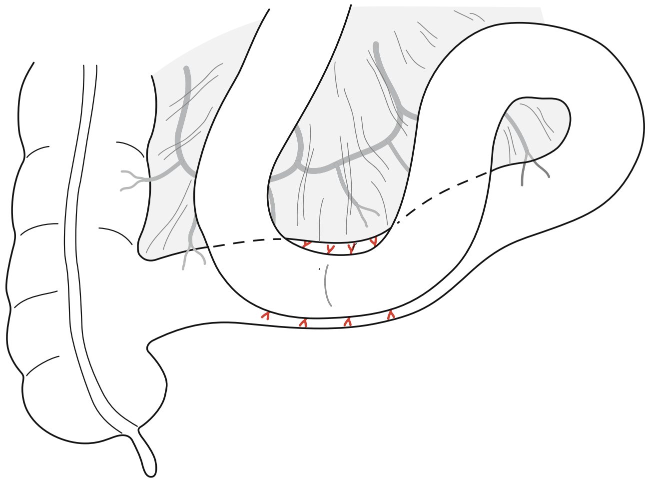

Fig. 37.5 Patch on the suture site. If the suture site is weak and there is a risk of suture failure, the nearby intestinal tract is used as a patch on the suture site

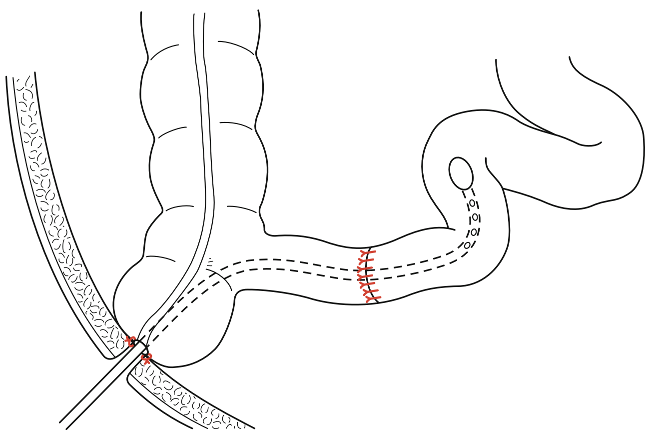

Fig. 37.6 Retrograde tube enterostomy. A transanastomotic tube is placed in a retrograde manner after appendectomy

performed, a transanastomotic tube is useful. This includes tube enterostomy with a tube inserted in a retrograde manner after appendectomy and tube enterostomy with a Witzel-type tube placed in an anterograde manner. We have preferably used tube enterostomy with a tube placed in a retrograde manner after appendectomy to facilitate lavage of the thick meconium and the intestinal decompression after surgery (Fig. 37.6).

T-tube ileostomy, which does not require enterostomy closure, is a technique that involves placement of a T-tube at the ileal perforation site or intestinal distension site.

37.3.4 Enterostomy

There are various types of enterostomy. When intestinal resection is not performed, loop enterostomy is used; when intestinal resection is performed, a single- or double-barreled enterostomy is used. The enterostomy and abdominal wall are sutured with several stitches. In end enterostomy, attention must be devoted to necrosis as a result of vascular insufficiency, and enterostomy is created at a sufficient height from the abdominal wall. T-tube ileostomy, which does not require enterostomy closure, is a technique that involves placement of a T-tube at the ileal perforation site or intestinal distension site. In enterostomies created at a high position, a considerable amount of intestinal fluid is lost, and in cases in which weight gain cannot be achieved, early closure of the enterostomy should be considered.

37.4 Necrotizing Enterocolitis

Necrotizing enterocolitis is common in low-birth-weight infants and in infants with heart disease. In many cases, the preoperative condition of patients is poor, and the timing of surgery poses a problem. In general, surgery is performed for cases involving perforation, and cases involving suspected intestinal necrosis that is unresponsive to conservative treatment. First, the decision regarding whether to perform intraperitoneal drainage alone or with laparotomy differs depending on the institutional policy. There are various types of necrotizing enterocolitis, including extensive necrosis, necrosis in several sites, and localized necrosis in the ileum and colon.

37.4.1 Operations

There are various surgical procedures depending on the extent of necrosis in the intestinal tract. In general, resection of the necrotic intestinal tract and creation of an enterostomy is performed. The degree and extent of the lesion are assessed, and after verifying the length of the preservable intestinal tract and whether the ileocecum can be left, the most suitable surgical procedure is selected. When extensive necrosis in the intestinal tract is seen, a second-look operation is performed with intraperitoneal drainage only. The second surgery is performed after ≥48 h, and the patient is evaluated according to their general condition and the presence of compartment syndrome caused by an increase in abdominal pressure. In cases of localized necrosis in the intestinal tract, the necrotic intestinal tract is removed, and an enterostomy is created at the mouth and anus side. To ensure intestinal blood flow, the intestinal tract and fascia are sutured with several stitches at sufficient height from the abdominal wall. When multiple necroses occur in the intestinal tract and produce skip lesions, the necrotic intestinal tract is removed, and an enterostomy is created at both ends (mucous fistula).

Furthermore, in cases with extensive or multiple lesions, extensive intestinal resection, enterostomy at a high position, and multiple enterostomies may be required, and complications associated with the enterostomy and postoperative management will be challenging to treat. Therefore, “the patch, drain, and wait method” [1] as well as “the clip and drop back method” [2] have been reported.

37.4.2 Patch, Drain, and Wait Method

A central venous line is inserted, and broad spectrum antibiotics are administered. Laparotomy is performed with

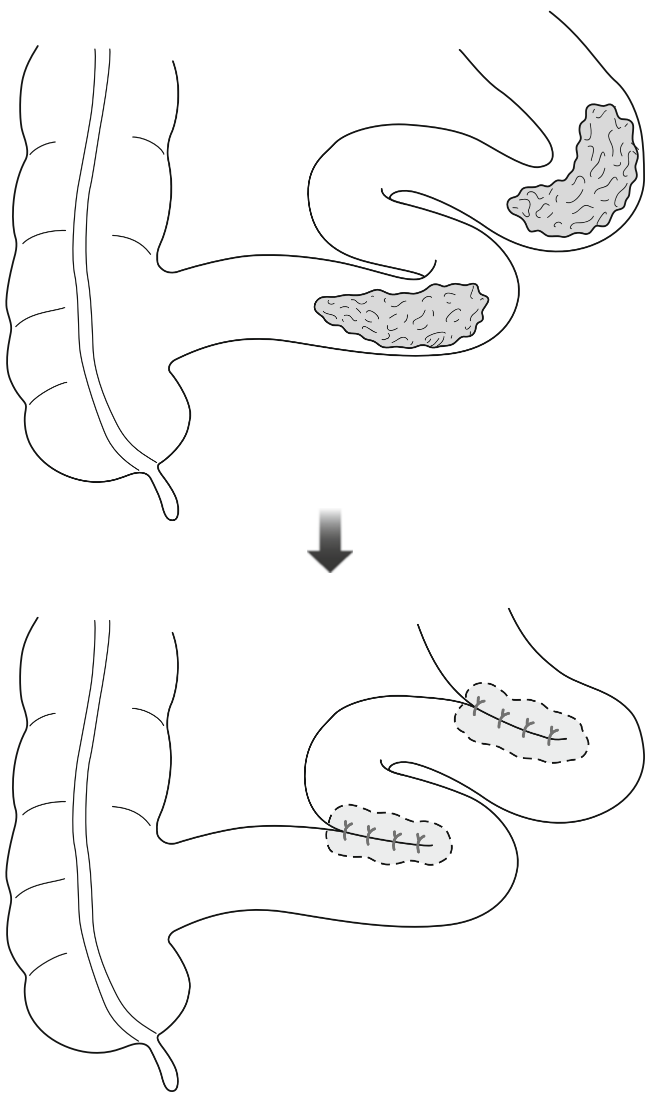

Fig. 37.7 Patch, drain, and wait method. Transverse sutures are made by patching the mouth side and anus side of the intestinal tract at the site of perforation

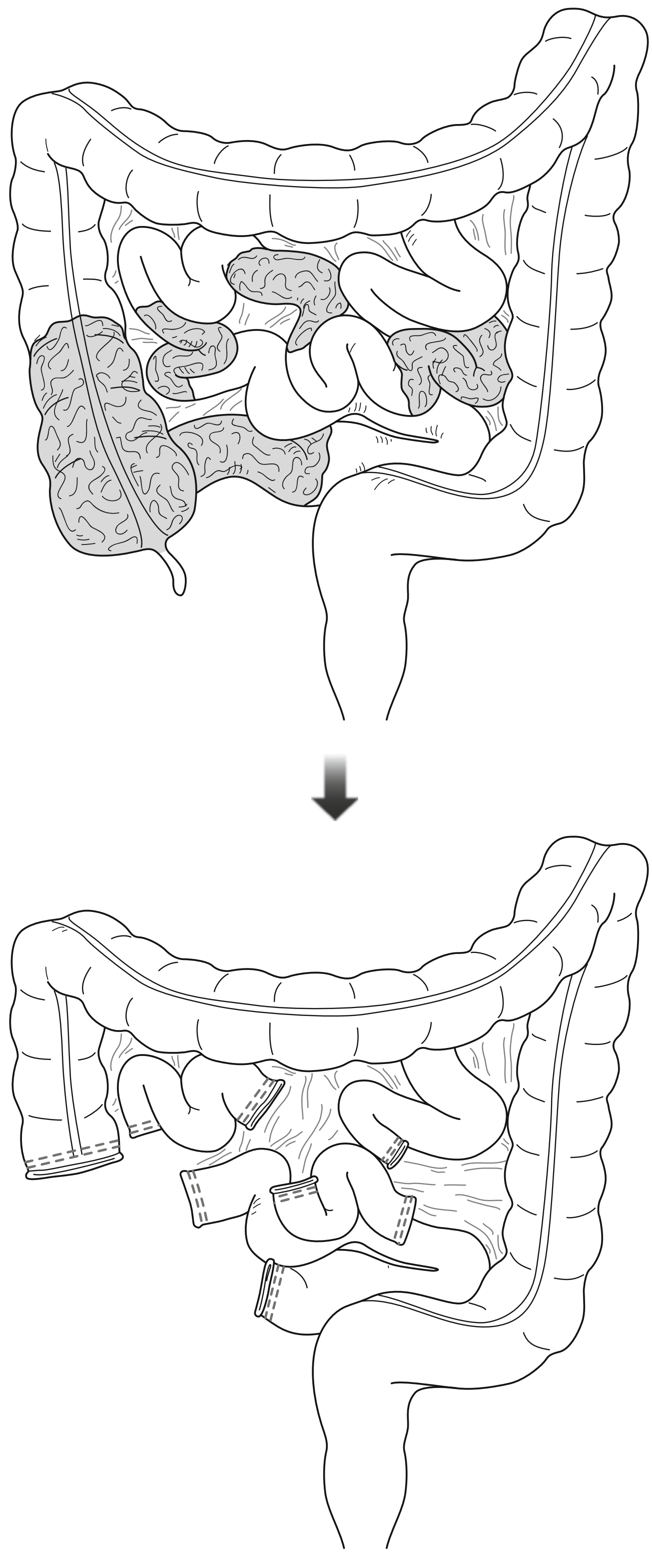

Fig. 37.8 Clip and drop back method. After removal of the necrotic intestinal tract, the intestinal stump is clipped and closed with autosutures to return to the abdominal cavity. Second-look operation is performed 48–72 h later

a midline incision in the upper abdominal to enable rapid laparotomy with minimal blood loss. A gastrostomy is then created. Transverse sutures are made by patching the mouth side and anus side of the intestinal tract at the site of perforation, without any removal of the intestinal tract or creation of an enterostomy (Fig. 37.7). The adjacent greater omentum and intestinal tract may be used. In cases with multiple perforations or extensive necrosis, intestinal pressure is only reduced without patching. Thereafter, Penrose drains are placed in the pelvic cavity from the left and right upper abdomen. Following surgery, a high-calorie transfusion is given, and the Penrose drain insertion site creates a natural enterostomy. A second surgery is subsequently performed.

37.4.3 Clip and Drop Back Method

After removal of the necrotic intestinal tract, rather than creating an enterostomy, the intestinal stump is clipped and closed with autosutures to return to the abdominal cavity (Fig. 37.8). The peritoneal cavity is then washed and closed. Subsequently, 48–72 h later, the abdomen is reopened for evaluation, and anastomosis is performed, if possible. When resection of necrosis in the intestinal tract is required, additional resection of the intestinal tract is performed, and a third look surgery is performed.

37.4.4 Enterostomy Closure

Prior to enterostomy closure, barium enema examination is performed to verify that there is no intestinal stenosis. If required, surgery is performed for intestinal stenosis.

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Hirschsprung's Disease

38

Ryuichiro Hirose

Abstract

Surgical management of Hirschsprung's disease (HD) consists of removal of the aganglionic segment of the rectum and colon and reconstruction of the intestinal tract by pulldown and anastomosis of the normally innervated bowel just above the anus while preserving the normal sphincter function.

The most commonly performed operations are the Swenson, Duhamel, and Soave procedures:

1. The Swenson procedure (Swenson and Bill. Surgery 24:212–20, 1948) involved complete rectal resection and primary end-to-end anastomosis just above the anal sphincter (Fig. 38.1).
2. The Duhamel operation (Duhamel. Arch Dis Child 35:38–39, 1960) brings the normal bowel through the avascular retrorectal plane, with a crushing clamp or a stapled anastomosis joining both the lumen of the normoganglionic pulled-down bowel and native aganglionic rectum (Fig. 38.2).
3. The Soave procedure (Soave. Surgery 61:503–508, 1967) involves a mucosectomy of the rectum and an endorectal pull-through into the aganglionic rectal muscular cuff (Fig. 38.3).

These principal techniques were already established in the mid-twentieth century. Recent minimally invasive techniques using laparoscopy (Georgeson et al. J Pediatr Surg 30:1017–1021, 1995; Morikawa et al. J Pediatr Surg 33:1679–1681, 1998) or transanal approach (De la Torre-Mondragon and Ortega-Salgado. J Pediatr Surg 33:1283–1286, 1998; Langer et al. J Pediatr Surg 34:148–1451, 1999; Albanese et al. J Pediatr Surg 34:377–380, 1999) have dramatically changed the concept of the definitive operation for HD; however, the same perineal techniques are basically employed as one of three common traditional operations.

Keywords

Hirschsprung's disease • Swenson operation • Duhamel operation • Soave operation • Duhamel-Ikeda operation • Laparoscopic surgery • Georgeson's operation • Morikawa's prolapsing method • Transanal endorectal pull-through operation

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38.1 Introduction

In this chapter, we take up three procedures (Figs. 38.1, 38.2 and 38.3):

1. Duhamel-Ikeda "Z-shaped anastomosis" procedure [4] mostly had adopted by pediatric surgeons in Japan.
2. Laparoscopic endorectal pull-through operation (Soave-Denda) using Morikawa's prolapsing technique [6]. The most popular Georgeson's laparoscopic operation employs the same perineal procedures with transanal operation as described later.
3. Transanal endorectal pull-through operation [7–9].

38.2 Preoperative Management

Historically, HD is treated by a multistage surgical approach with a diverting colostomy over 6–12 months. Currently, the one-stage pull-through procedures have been commonly accomplished by laparotomy at an earlier age. The recent introduction of minimally invasive pull-through techniques may accelerate the primary definitive operation to be performed at further earlier period.

Rectal and colonic decompression and irrigation with a transanally inserted tube is widely used in the preoperative management until primary pull-through, not only for the cases with short-segment HD but with longer segment

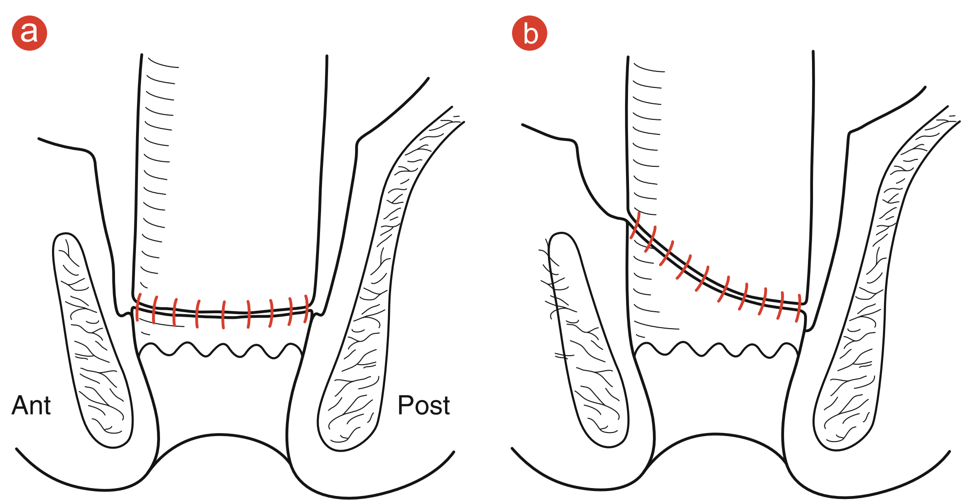

Fig. 38.1 Swenson's operation. (**a**) Swenson (original). (**b**) Swenson (modified – oblique anastomosis)

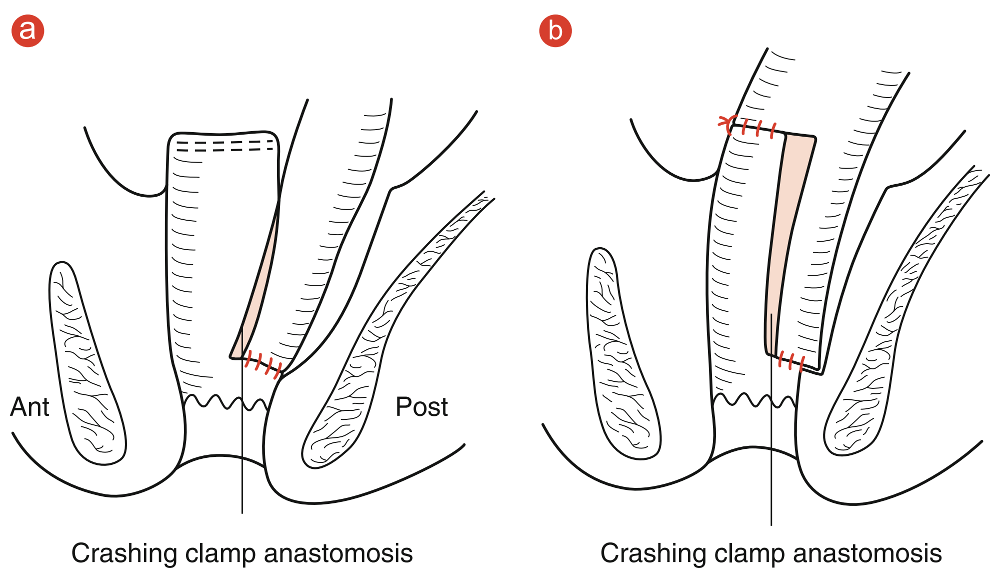

Fig. 38.2 Duhamel's operation. (**a**) Duhamel. (**b**) Duhamel-Ikeda

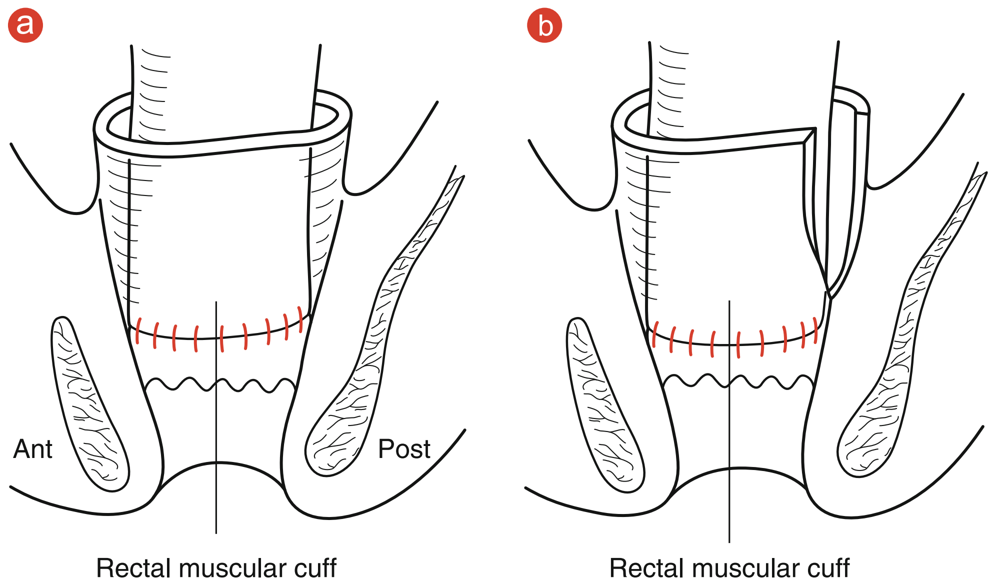

Fig. 38.3 Soave's operation. (**a**) Soave. (**b**) Soave-Denda

aganglionosis. However, severe enterocolitis, suspected perforation, malnutrition, and poor general condition are still accepted indications for a prior colostomy. Immediate operation should be undertaken if irrigations are ineffective.

38.3 Definitive operative procedures

38.3.1 Duhamel-Ikeda (Z-shaped anastomosis) [4]

The child is placed in the lithotomy position (Fig. 38.4a). Under laparotomy, the aganglionic segment is resected after leveling biopsies. The ganglionated bowel is mobilized to ensure adequate length for the pull-through, by preserving the reminder of the arcades.

The rectum is divided near the peritoneal reflection using a linear stapling device. A retrorectal space is created with blunt dissection in the midline preferably using sponge peanut dissector, so that an assistant's finger can be felt at the dentate line (Fig. 38.4b).

With the use of cautery, a full-thickness curvilinear incision is made 0.5–1 cm proximal to the dentate line posteriorly. A proximal ganglionated bowel is pulled down through the retrorectal space to the intraanal orifice. The surgeon should make certain that pulled-down bowel is not twisted and the mesentery of this bowel is located posteriorly so it will not be injured during the firing of the stapler done later (Fig. 38.4c).

Once the bowel is pulled through, the excessive portion of the pulled-down bowel is excised, and the posterior half anastomosis between the rectum and pulled-down bowel is completed above the dentate line from the anal side. The anterior wall of the pulled-down bowel is anastomosed to the upper edge of the posterior intraanal orifice with the interrupted sutures to make the caudal anastomosis of septum, and some of these sutures are used for traction.

Thereafter, at the peritoneal floor, anchoring sutures are placed between bilateral wall of the rectal stamp and the pulled-down bowel from the abdominal approach. At this level, a transverse wound is then made in the anterior wall of the pulled-down bowel, and the rectal stamp is transected. Interrupted sutures are placed between the posterior wall of rectum and the anterior wall of pulled-down bowel to make the cranial anastomosis of the septum. A stapling device is placed with one arm into the native anal canal and the other into the pulled-down bowel. The stapler is fired directly in the midline. In general, two or three times of 3.5 mm staples are needed. The anastomosis suturing between the anterior wall of the rectum and pulled-down bowel is completed, and this procedure completely relieve the blind pouch.

The advantage of this operation is easiness of assembling procedures, less pelvic dissection, the large anastomosis decreasing the risk for stricture, and the presence of a reservoir which is helpful for children with longer aganglionic segments.

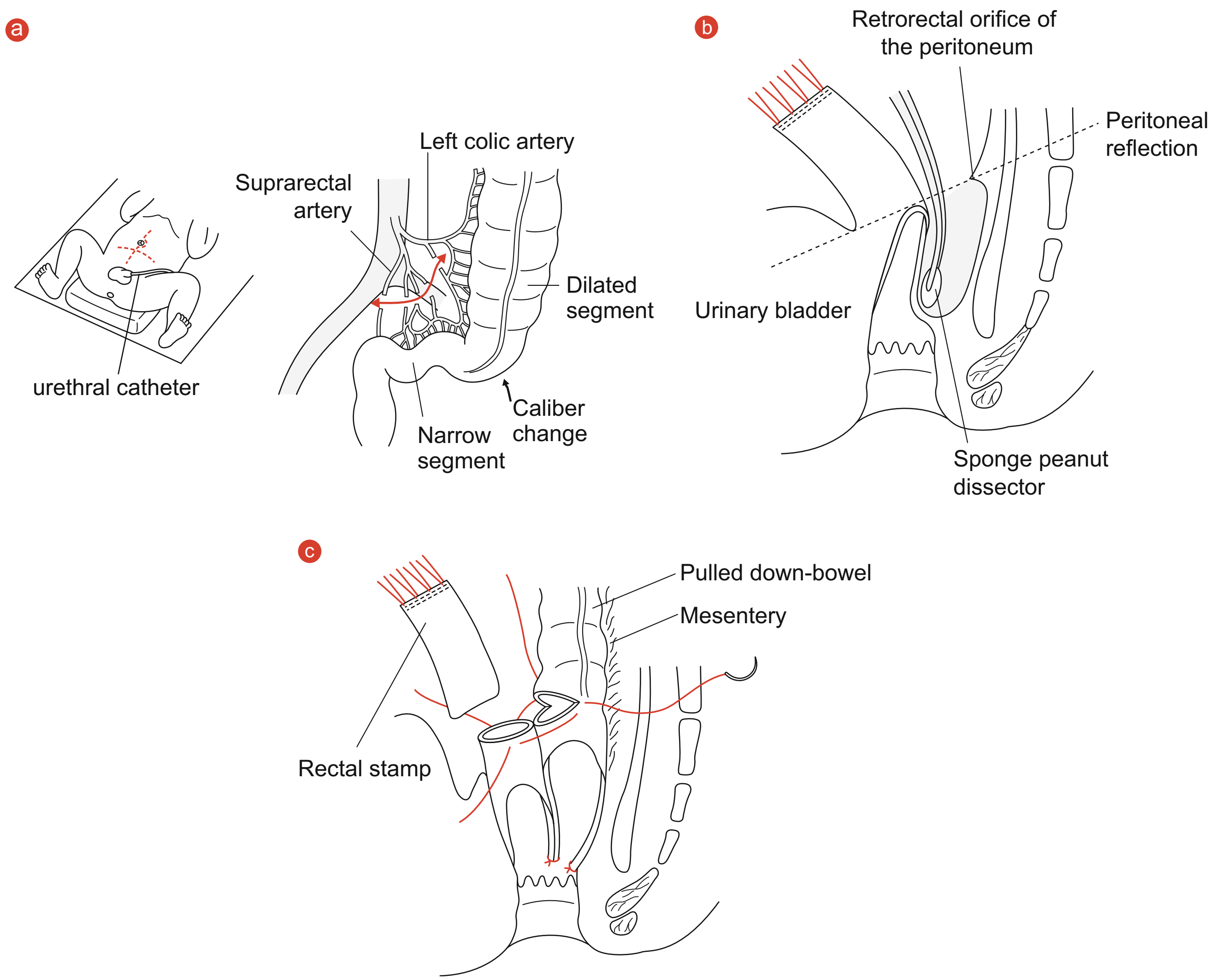

Fig. 38.4 Z-shaped anastomosis (Duhamel-Ikeda). (**a**) The child is placed in lithotomy position at the end of the table with buttock pillow. (**b**) A retrorectal space is created with blunt dissection in the midline preferably using sponge peanut dissector, so that an assistant's finger can be felt at the dentate line. (**c**) Procedure at the peritoneal floor. Anchoring sutures placed between the rectal stamp and the pulled-down bowel. A transverse incision is made in the anterior wall of the pulled-down bowel, and the rectal stamp is transected

38.3.2 Laparoscopy-Assisted Endorectal Pull-Through (Soave-Denda) [5]

Induction of the laparoscopic techniques for the definitive operation of HD has dramatically changed the concept of the operative approach. The Soave, Swenson, and Duhamel procedures have been contemporaneously reported using laparoscopic assistance. The endorectal pull-through operation using Soave-Denda method has become the most popular method. Georgeson adopted the transanal mucosectomy, while Morikawa described extra-anal mucosectomy using prolapsing technique.

In this section, Morikawa's prolapsing method with extra-anal mucosectomy is described.

38.3.2.1 Morikawa's Prolapsing Method with Extra-Anal Mucosectomy [6]

The patient is placed in the lithotomy position. A three trocar technique is usually used with the first trocar placed through the umbilicus. Two working trocars are added in the right upper and lower quadrant. A transanal-inserted Hegar dilator or forceps can act as a substitute of an additional port by control of the sigmoid colon and rectum.

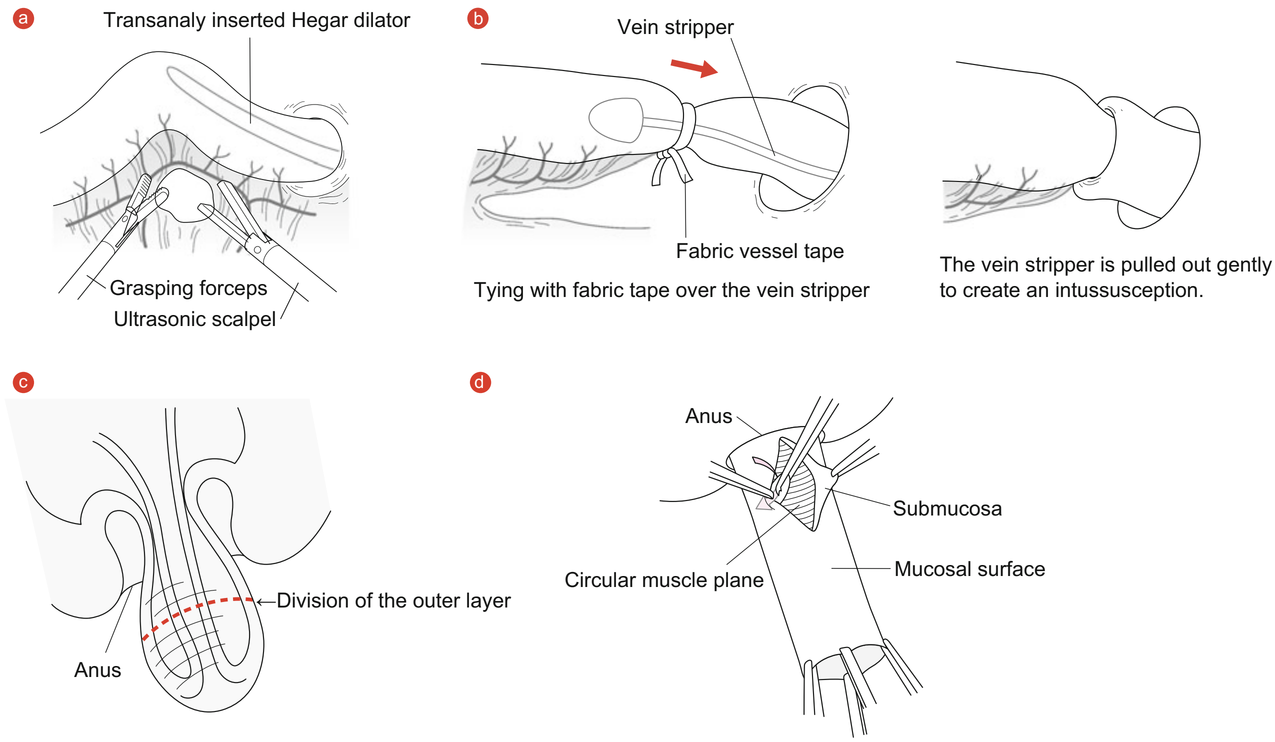

Fig. 38.5 Prolapsing technique with extra-anal mucosectomy (Morikawa). (**a**) Fenestration of the sigmoid mesentery. (**b**) Prolapsing of the rectum. (**c**) Division of the outer layer of the prolapsed rectum achieved the rectal transection outside the anus. (**d**) Extra-anal mucosectomy under direct observation. Rectal mucosa is separated from the circular muscle plane

After identification of the caliber change point, an Allis clamp is inserted through the anus to grab the anterior wall of the rectum, and the rectum is pulled out of the anal canal creating a rectal prolapse. If this method shows any difficulty, after fenestration of the sigmoid mesentery, a vein stripper is inserted into the rectum through the anus up to the caliber change, then the rectum or sigmoid colon is tied with fabric tape over the vein stripper, and the vein stripper is pulled out gently to create a rectal prolapse (Fig. 38.5).

The everted rectum is then divided, and a full-thickness biopsy specimen is taken for frozen section. The proximal cut end is closed by sutures and returned into the pelvic cavity.

As the rectal mucosa exposed outward, normal saline is injected into the submucosa of rectum, and the mucosectomy is performed circumferentially under direct observation. Along with the extra-anal mucosectomy, rectal mucosa is separated from the circular muscle plane to the level of the dentate line.

The posterior wall of the muscular cuff is split to the level of the anastomotic line, and the remaining muscle coat is put back after trimming of its surplus part. The colon is pulled down through the muscular coat and transected at the level of normal ganglion cells after the vessels were dissected close to the bowel wall. The anastomosis is made circumferentially between the pulled-down bowel and the anus.

38.3.3 Transanal Endorectal Pull-Through Operation [7–9] (Fig. 38.6)

The hooks of a circumferential retractor system are placed initially just inside the anal canal at the level of the mucocutaneous junction. A circumferential mucosal incision is made 0.5–1 cm above the dentate line using mono-polar electrocautery. When all around outer edge of the mucosa is raised, interrupted sutures are placed the floated mucosal edge and tied to provide uniform traction. The hooks are then replaced deeper, just proximal to the dentate line for the better view. Using traction sutures, a submucosal dissection is continued proximally by blunt ablation and precise coagulation of vessels with the tip of electrocautery.

When the submucosal dissection reached near the peritoneal reflection, the muscular layer of the colon is slackened. The slack rectal muscle is incised circumferentially and the dissection continued on the outer rectal wall. Each encountered membranous structures and blood vessels is one by one

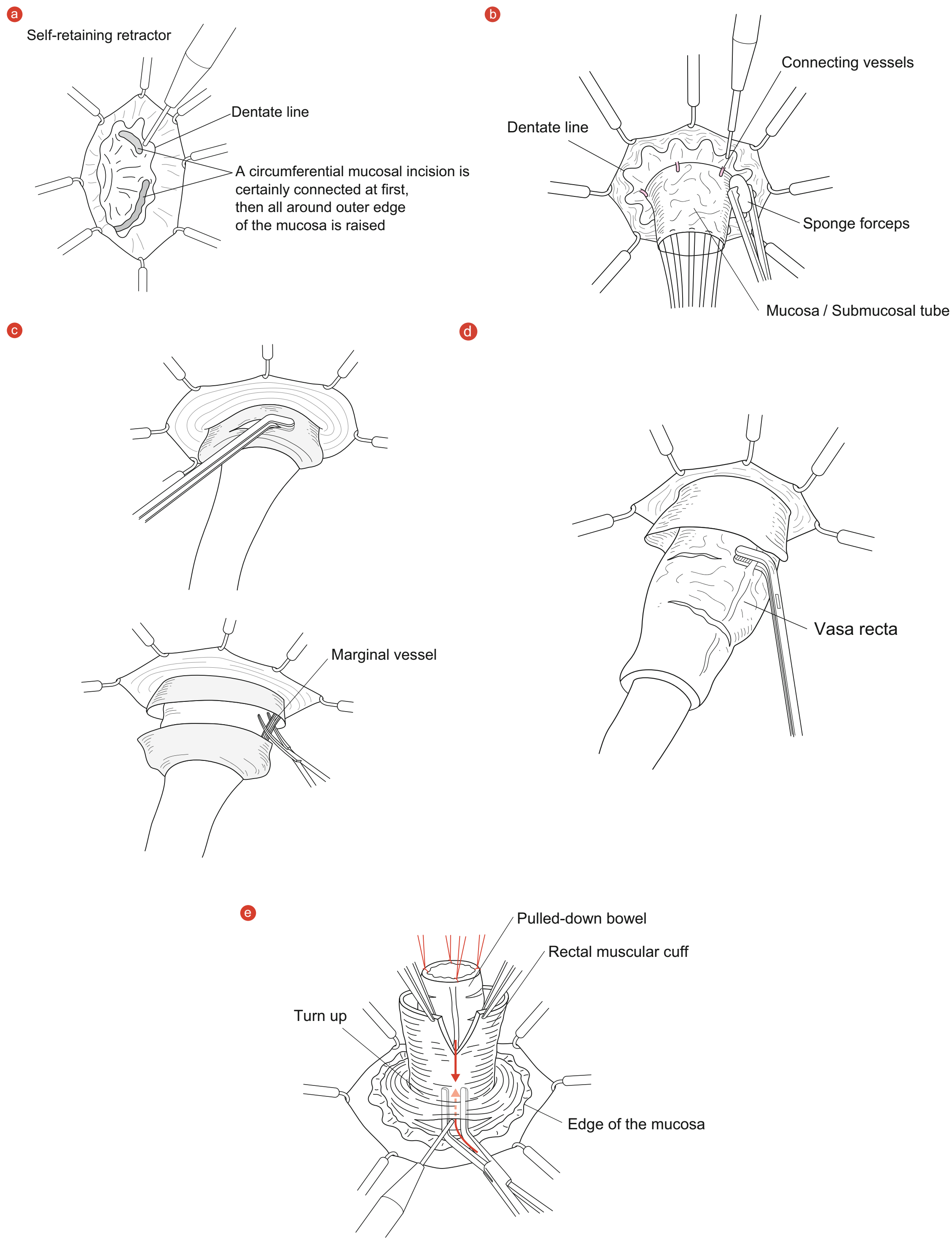

Fig. 38.6 Transanal approach. (**a**) Circumferential mucosal incision above the dentate line. (**b**) Using traction sutures, a submucosal dissection is continued proximally by blunt ablation and precise coagulation of vessels. (**c**) The sluck rectal muscle is incised circumferentially and the dissection continued on the outer rectal wall. (**d**) Each membranous structures and vasa recta is divided near the serosal surface. The entire rectum and most of the sigmoid colon can be gradually delivered through the anus. (**e**) Split of the muscular cuff in the posterior midline

divided just outside the serosal surface, thereafter the entire rectum and the most part of the sigmoid colon can be gradually delivered through the anus. In patients with a more proximal transitional zone, transabdominal mobilization can be achieved either laparoscopically or through mini-laparotomy at umbilical incision.

The posterior wall of the muscular cuff is split at the midline and is put back after trimming of its surplus part. Thereafter, the colon is pulled through the anus and divided at the level of ganglionated bowel. A single-layered, full-thickness anastomosis is created with interrupted, absorbable sutures. As there is discrepancy in diameter between pulled-down colon and anus, care is taken not to make residual slit between mucosal folds at the anastomotic line.

38.4 Provision for Trouble Shooting

Along the rectal mucosectomy, adhered parts of the internal transverse muscle strips tend to attract to the dissected mucosa/submucosal tube and prone to mislead to the inadequate layer dissection. As the muscular layers of neonate and small infant are very thin, the dissection will easily stray into out of the muscular layer or adventitia. This is the deep pelvic dissection same as Swenson's procedure, including presumed risks of the nerve, blood vessel, and urethral injury.

Great care is taken to keep the adequate dissection layer and notice the misdirection immediately.

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39 Imperforate Anus: Low Type

Shigeru Ueno

Abstract

The first step to treat a patient with imperforate anus is to make diagnosis of the type correctly. Newborn babies with low-type anomaly mostly have a fistula opening. Cutback operation can be a radical operation for a newborn baby with low-type, but it may not be enough for incising the external sphincter muscle to prevent postoperative constipation. The author prefers to manage bowel movements with glycerin enemas via the opening until around 6 months of age. The radical anoplasty is cutting the muscle backward for most boys with low type and when the opening is near the anal pit in girls. Anal transplantation is another anoplasty for girls with anovestibular fistula or anovulvar fistula and boys with a fistula away from the anal pit. For rare low type, covered anus complete, perineal anoplasty using endoscopy can be an option. Postoperative management includes daily enemas with dilatation just after surgery. Because constipation is the major concern for patients with low-type anomaly, care should be continued for a long time preferably by the time they go to school.

Keywords

Imperforate anus • Low-type anomaly • Perineal anoplasty

39.1 Preoperative Management

39.1.1 Diagnosis

The first step to treat a patient with the imperforate anus is to diagnose the type correctly. Most desirable postoperative bowel function is expected by choosing an appropriate procedure based upon correct diagnosis. In this chapter, the type is described based on the international classification of 1970 adopted in Japanese Study Group of Anorectal Malformations [1, 2].

39.1.1.1 Boys

Most are classified to have covered anal stenosis or anocutaneous fistula. The former subtype is with a “bucket handle”, or excessive skin fold, with a stenotic orifice at the anal site. In the latter subtype, an orifice is located in the perineum anterior to the anal pit. Clinically, both subtypes can be treated with similar fashion. The anus appears normal at a glance, but the anal pit does not have an opening and the fistula opens just near the pit (covered anal stenosis) or in the perineum (anocutaneous fistula).

The fistula may extend anteriorly up to the scrotum or may be covered with thin membrane and be filled with meconium. It is sometimes difficult to find the extremely small orifice just after birth. Careful inspection of the

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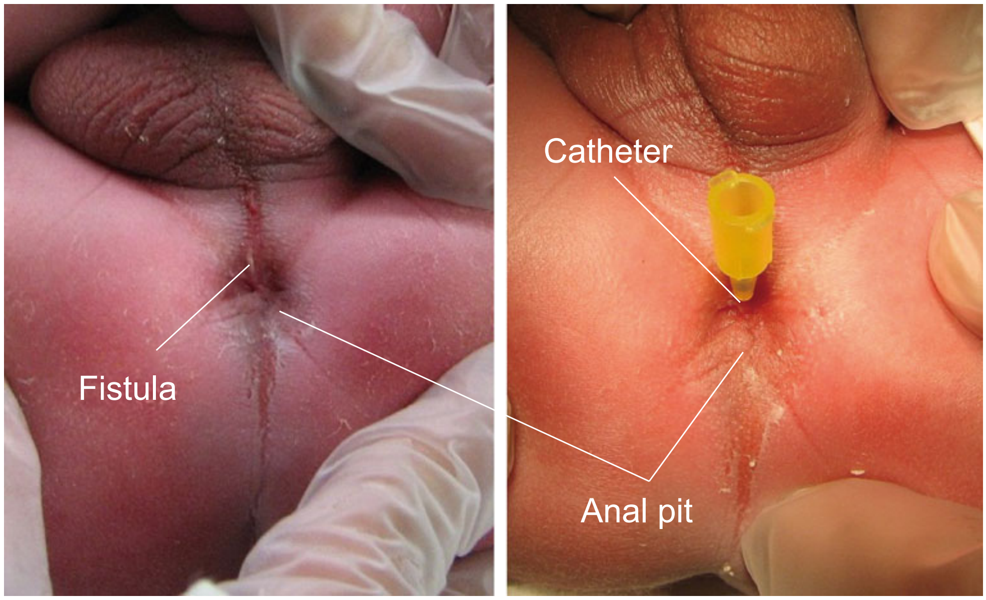

Fig. 39.1 Finding an extremely small orifice of a boy

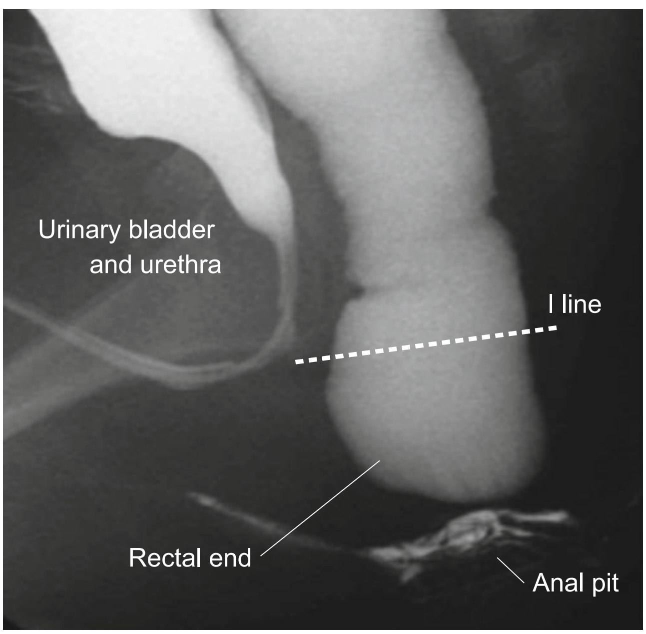

Fig. 39.2 Colonography and cystourethrography demonstrate the anatomy of covered anus complete in a boy. The rectal end extends beyond I line to reach just beneath the anal pit

perineum and probing with a thin soft catheter will succeed to find the opening (Fig. 39.1).

Covered anus complete is an uncommon subtype of the low-type imperforate anus. The anorectum ends without fistula, but the blind pouch is beyond I line, which could be demonstrated by an invertogram, or Wangensteel-Rice's radiography, and ultrasonographic study through the perineum (Fig. 39.2).

If there is some distance between the pouch and the anal pit, it is preferable to make colostomy as in cases with high or intermediate type.

39.1.1.2 Girls

In a baby girl with low-type imperforate anus, a fistula opens at the vestibule, the vulva, or the perineum. In most prevalent anovestibular fistula, the orifice is within the vaginal vestibule, which is different from anovulvar fistula, where a fistula opens at the vulva, which is just posterior to the vestibule.

In a girl with anovestibular fistula, there does not seem to be any opening at a glance. However, a type without fistula including a cloacal-type anomaly is infrequent. Careful inspection is necessary not to overlook the opening with probing the vestibule toward the posterior direction (Fig. 39.3).

Diagnostic methods of other rather rare low-type anomalies in a girl, such as covered anal stenosis, anocutaneous fistula, and covered anus complete, are similar to those of a boy with the same type.

39.1.2 Neonatal Treatment

When a fistula is found open in newborn period, the baby can pass meconium. Cutting the opening posteriorly to pass the stool, or "cutback," can be a radical operation for a newborn baby with low-type imperforate anus. But the author does not prefer radical operation at newborn period regardless of the gender.

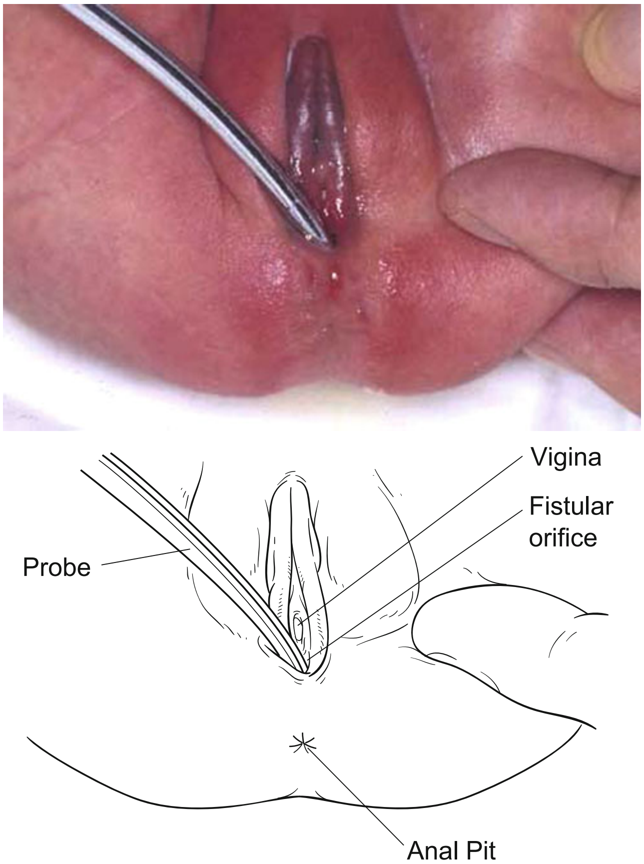

Fig. 39.3 In a girl with anovestibular fistula, the fistula is probed around the vaginal vestibule and the vulva. A probe can be inserted posteriorly through the orifice

A cutback operation at newborn period may not be enough for incising the external anal sphincter muscle to prevent constipation, which is the major postoperative concern in a patient with low-type.

When a fistula is narrow in a boy, it is necessary to cut it open posteriorly just enough to pass the stool followed by an everyday "bougie" or dilatation with dilators for a week. In a girl, the backward incision from the fistula is not necessary, but only bougie is enough as an initial treatment.

If stool passage is secured by the dilated fistula, bowel movements are managed with the twice-a-day glycerin enemas (3 ml/kg/time) afterward, and family can learn the procedure and the baby can be at home until the radical operation.

39.1.3 Preoperative Management

The radical operation is planned at around 6 months of age. Contrast enema, cystography, and sometimes electromyography are required as preoperative investigations to precisely investigate distribution of the muscle and the associated urological anomalies.

Fig. 39.4 Contraction of the muscle is confirmed by electrical stimulation and mark at the center of the anal pit

When there is any other lesion such as spina bifida, perineal mass, or presacral tumor, distribution of the muscle complex and the location of the lesion need to be confirmed by MRI to plan the appropriate operation. The bowel was evacuated by preoperative enemas.

39.2 Operations

39.2.1 Choice of the Operative Method

For the low-type imperforate anus, since the anorectum goes through the puborectalis muscle, perineal anoplasty is the only necessary procedure.

The aim of the operation is to form an anorectum which passes the center of the external sphincter muscle which can squeeze but not disturb evacuation. In addition, it is important to bring appearance from the genitalia to the anal orifice as normal as possible. Therefore, if the opening is near the anal pit, anoplasty by cutting the external sphincter backward is chosen, and if it is far off the pit, in particular, in a girl, the anal transplantation (Potts method) is chosen.

39.2.2 Positioning and Confirming the Muscle Distribution

After introducing a urethral catheter, patient is placed in lithotomy position. In infants, it is good to make "sitting cross-legged" position where lower limbs are folded in front of the belly. Contraction of the muscle (mainly external sphincter muscle) is confirmed by electrical stimulation and mark at the center of the anal pit (Fig. 39.4).

39.2.3 Surgical Procedures

39.2.3.1 Anoplasty by Cutting the (External Sphincter) Muscle Backward

This procedure is chosen in most boys with low type and when the opening is near the anal pit in girls with anocutaneous fistula. Skin is incised semicircularly around the posterior rim of the fistula, and the posterior skin flap is made by subcutaneous undermining (Fig. 39.5). The skin flap is extended posteriorly enough about 10 mm beyond the center of the muscle, which is confirmed by electrical stimulation. Posterior wall of the fistula including the mucosal layer and the muscle is incised longitudinally (Fig. 39.6).

The length of the incision is beyond the contractile center of the muscle, and the mucosa is also incised as deep as the muscle so that the opening is wide enough to pass the little finger of the surgeon without resistance.

The skin is approximated with the mucosa with knotted sutures and the little finger can be inserted before the operation is over (Fig. 39.7). Additional vertical incision is made posteriorly if the opening is narrow. A stent tube (flexible catheter 14 Fr.) is placed through the opening.

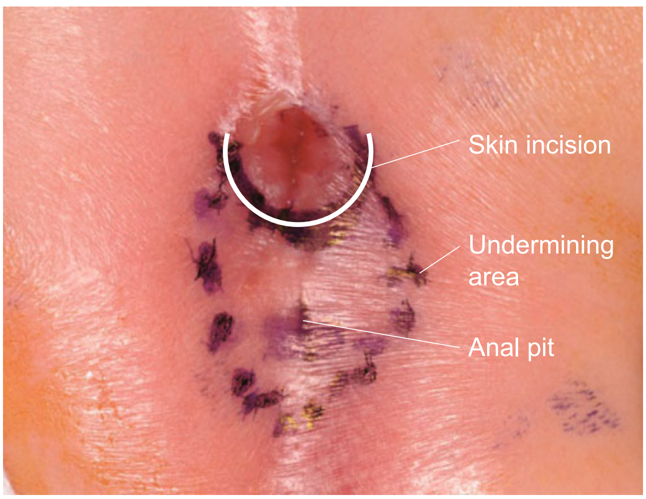

Fig. 39.5 Skin marking for the anocutaneous fistula

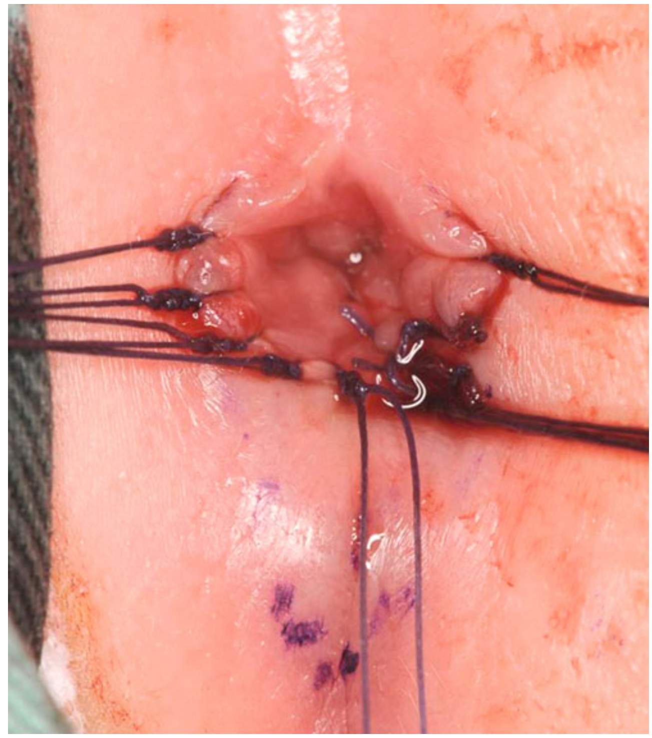

Fig. 39.7 The skin is approximated with the mucosa with knotted sutures

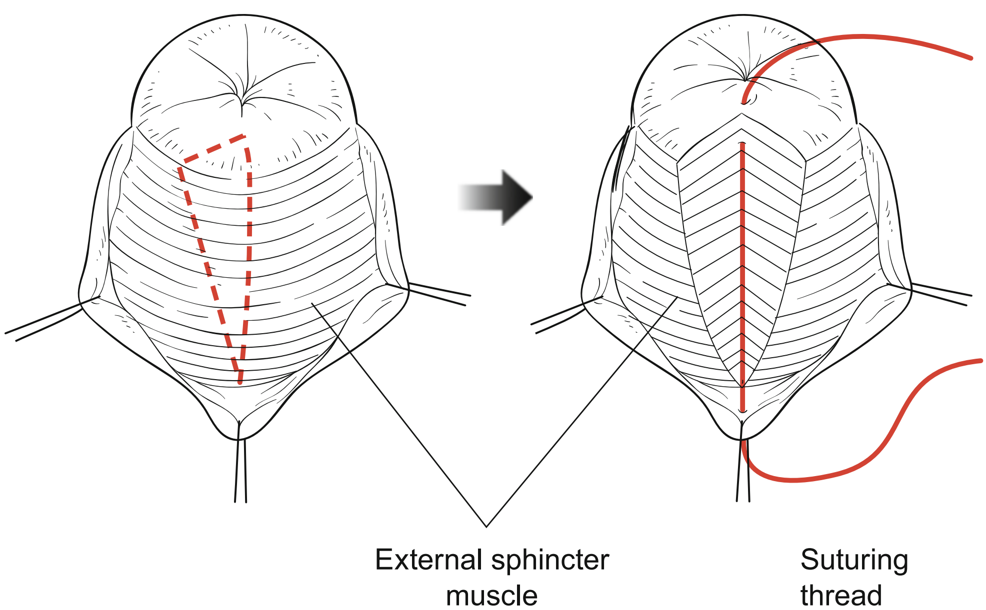

Fig. 39.6 Anoplasty by cutting the (external sphincter) muscle backward

39.2.3.2 Anal Transplantation (Potts Method)

When a fistula opening is at the perineum, or outside the external sphincter muscle in boys, and in girls with ano-vestibular fistula or anovulvar fistula, anal transplantation is chosen for radical operation. The fistula edge with some skin is cut circumferentially, and it may be sewn up closed with 4-0 threads. Surrounding tissue is dissected from the fistula (Fig. 39.8). The boundary between the fistula and the muscle or the vaginal wall is separated with a scalpel. Because the fistula wall tightly connected with the tissue transits into the rectal wall surrounded with the loose tissue, dissection can be done bluntly at around 1 cm from the tip of the fistula. After having secured enough distance for anoplasty, contraction of the muscle by electrical stimulation can demonstrate the exact position of the puborectalis muscle and the external sphincter muscle. The puborectalis muscle is behind the rectum, and the external sphincter muscle contraction can squeeze the center of the anal pit.

Y-shaped skin incision is made at the anal pit with the wing of approximately 1 cm from the center, and the edges of the skin are undermined. After having reconfirmed the center of the sphincter by stimulation, a short tunnel is made from the distal end of the puborectalis muscle to the center with curved forceps (Fig. 39.9). The muscle complex is not cut open.

After having widened the tunnel, the anorectum is pulled through with the forceps grasping the tip of the fistula or the threads. The pulled-through rectal wall is fixed with four stitches to the external sphincter followed by suturing the trimmed rectal wall and the skin. A stent tube (flexible catheter 10 Fr.) is placed after sutures. The perineal wound is approximated in a layer-to-layer fashion with absorbable sutures (Fig. 39.10).

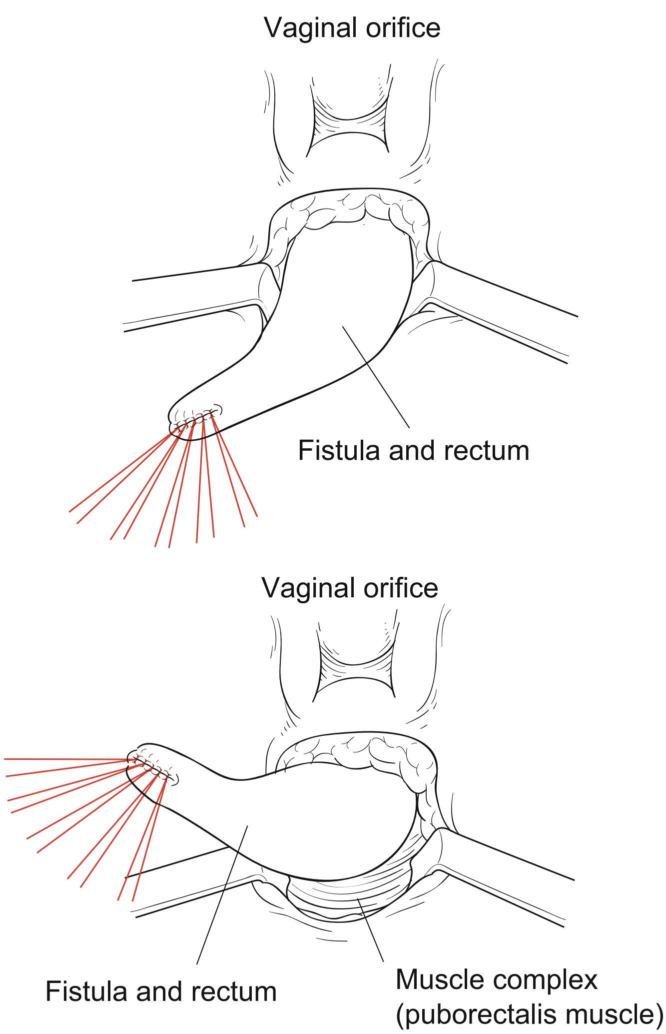

Fig. 39.8 Anal transplantation (Potts method): dissection of the anovestibular fistula in a girl

39.2.3.3 Operation for Covered Anus Complete (Endoscopy-Assisted Anoplasty)

Covered anus complete is an uncommon subtype and the anorectum ends without fistula beyond I line (Fig. 39.2). If there is some distance between the pouch and the anal pit, colostomy is made in a newborn period.

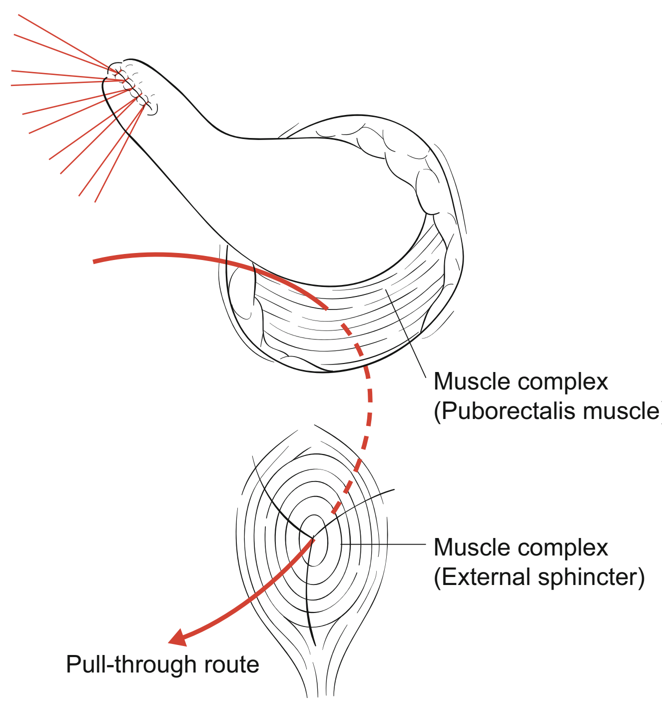

Fig. 39.9 Pull-through route for anovestibular fistula

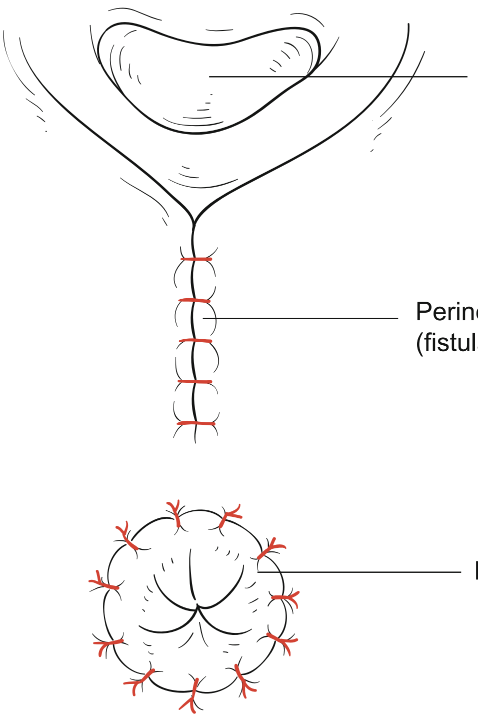

Fig. 39.10 Appearance after anal transplantation (Potts method)

When the rectal end greatly surpasses I point in preoperative colonography via colostomy (Fig. 39.2), perineal anoplasty can be done with an aid of endoscope.

With the patient in a lithotomy position, the center of the anal pit is determined with electrical stimulation. An endoscope is inserted from the stoma and the rectal end is observed to have mucosal convergence (Fig. 39.11a).

Under endoscopic observation, a catheter is inserted from the center of the anal pit into the rectal end followed by fixing the catheter to the skin. Circumferential incision is made around the catheter, and the sphincter muscle is dissected to reach the rectal end with guide of the catheter. The rectal end is dissected along the wall deep enough to be approximated to the skin.

Then the rectum is opened to reach the lumen and trim the end to make a wide orifice. The skin is approximated with the rectal wall with knotted sutures and confirm that the little finger can be inserted before the operation is over (Fig. 39.11b). Additional vertical incision is made if the opening is narrow. A stent tube (flexible catheter 14 Fr.) is placed through the opening. The postoperative care is similar to the management of the patient with colostomy.

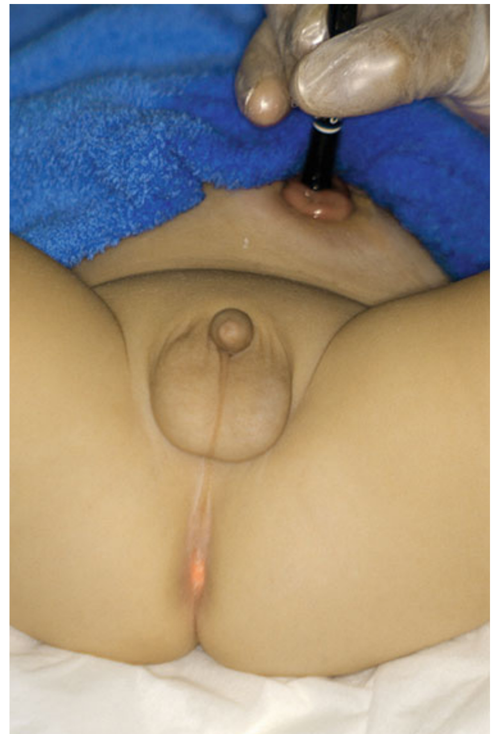

Fig. 39.11a An endoscope is inserted from the stoma to see the rectal end

39.3 Postoperative Management

39.3.1 Care Just After Surgery

1. Stent tube to a newly formed anus is left in place. To protect the wound, it may be necessary to have the patient's lower limbs fixed for a week.
2. Antibiotics are provided to prevent wound infection for a week.
3. Diet can be started next day if the colostomy is present.
4. When the wound is intact 2 weeks after surgery, dilatation with Hegar dilators can be started to prevent stenosis of the wound.
5. The dilatation should be carried out carefully with gentle manner. It would start from 10-size in cases with cutback anoplasty and from 8-size in cases with circumferential anoplasty. The neo-anus is enlarged little by little to reach 14-size before discharge. If there is bleeding, the size-up should not be done.

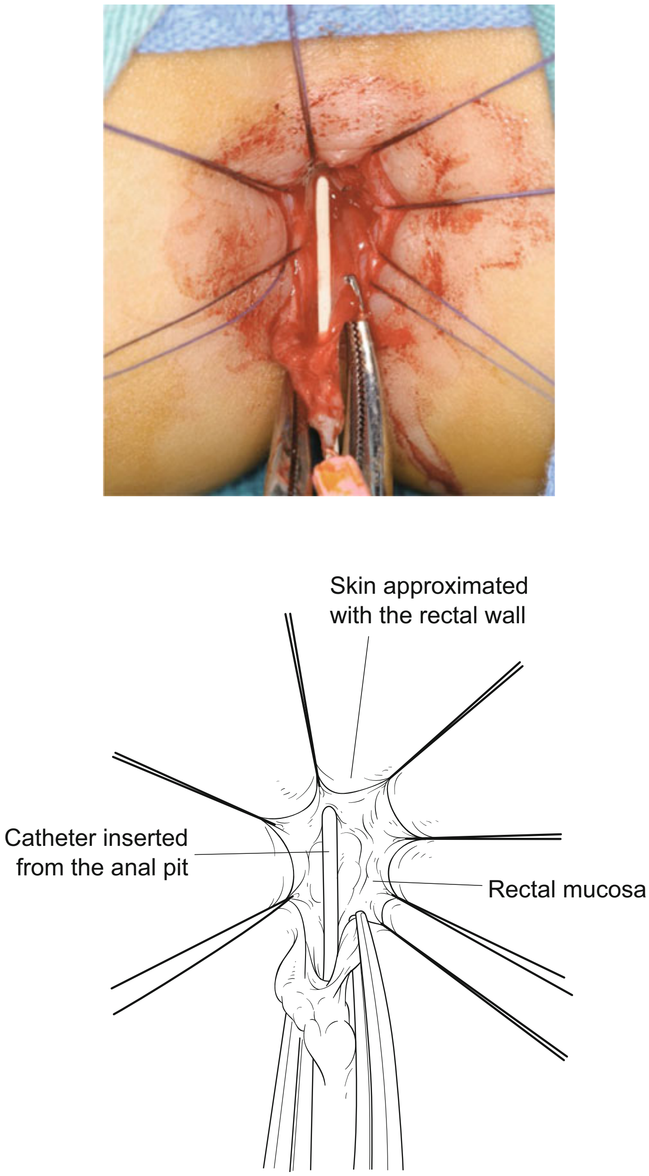

Fig. 39.11b The sphincter muscle is dissected to reach the rectal end with guide of the catheter. The rectum is opened and the skin is approximated with it

6. If there is any wound infection or dehiscence of the wound, the stent should be in place and the wound dilatation should not be started until complete healing of the wound.
7. The bowel management with the twice-a-day glycerin enemas (3 ml/kg/time) is started 2 weeks after anoplasty.
8. After dilatation of the wound is completed up to 14-size, the patient can be discharged after the family become able to manage bowel movements by daily enemas.
9. A rubber stent tube can be removed at discharge in a patient with cutback anoplasty.

39.3.2 Long-Term Care After Discharge

1. At outpatient visits once in a week or two, a surgeon should check the anal lumen digitally to see if the newly made anus is stenotic. If it is stenotic, daily digital dilatations by family or placing a stenting tube should be continued until enough lumen is maintained and the wound gets soft.
2. Stent tube can be placed for about 3 months to secure the enough anal lumen. The surgeon should check the lumen from time to time at outpatient visits.
3. Long-term bowel management by daily enemas should be continued until a patient becomes continent.
4. It is preferable to do twice-a-day enemas for 6 months after anorectoplasty and then a daily enema afterward.
5. Enemas can be reduced after confirming the spontaneous bowel movements.
6. It is said that a child can acquire fecal continence after 4 years of age. However, children with low-type anomaly frequently need long-term bowel management to prevent constipation. Enough amount of dietary fiber with water should be recommended to soften the stool. Laxatives should be prescribed if the patient tends to be constipated. Usually, bowel management can be discontinued by the time the patient goes to school.

References

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2. Smith ED. Classification. In: Stephens FD, Smith ED, editors. Anorectal malformations in children: update 1988. New York: Alan R. Liss; 1988. p. 211–22.

40 Imperforate Anus: Intermediate and High Type

Shigeru Ueno

Abstract

Newborns with intermediate- or high-type imperforate anus mostly have no anal opening. Invertography can suggest the level of the rectal end and a stoma is constructed. It is necessary to determine the correct subtype by contrast studies of the colon and the urinary tract before anorectoplasty. Full understanding of the muscle anatomy is necessary for desirable anorectoplasty, and the procedure includes approach to the rectum, transection of the fistula, rectal mobilization, construction of the pull-through route, and anoplasty.

The rectum can be mobilized by sacral approach after minimal incision of the posterior muscle and the fistula is transected. If the rectum ends up high, abdominal or laparoscopic approach is necessary to transect the fistula. Tunnel is made from the anterior aspect of the puborectalis muscle to the anal pit with angulation while confirming muscle contraction by electrical stimulation. By posterior-sagittal anorectoplasty, long vertical sacroperineal incision is made, and the muscle complex is divided sharply in the midline to reach the rectum. The mobilized rectum is pulled through or placed at the center of the muscle complex while making an anterior angulation. The rectum is anchored to the external sphincter muscle, and its end is sutured to the skin flap.

Postoperative management includes dilatation immediately after anorectoplasty and daily enemas for a long period. Enemas can be reduced after achieving fecal continence. Laxatives are prescribed if necessary to prevent constipation. For children with high type, care should be focused to prevent an accident in public and be multidisciplinary and sometimes would be necessary beyond the adult life.

Keywords

Imperforate anus • Intermediate-type anomaly • High-type anomaly • Sacral rectoanoplasty • Bowel management

40.1 Preoperative Management

40.1.1 Diagnosis and Stoma Construction

The first step to treat a patient with the imperforate anus is to make diagnosis of the type correctly. Most desirable post-operative bowel function is expected by choosing an appropriate procedure based upon correct diagnosis. In this chapter, the type is described based on the international classification

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of 1970 adopted in Japanese Study Group of Anorectal Malformations [1, 2].

40.1.1.1 Boys

Except for rare subtypes, anorectal stenosis (intermediate) and rectal atresia (high), there is no anal opening (Fig. 40.1). In patients with the above-mentioned subtypes, the anal pit has an opening, but the stoma should be constructed since stools cannot come out from the opening due to stenosis or atresia.

In a patient with low-type anocutaneous fistula, where it appears to have no opening but has actually a very fine fistula, the stoma is not necessary (see Chap. 39, Fig. 39.1). In a newborn baby without an anal opening, Wangensteel-Rice's radiography or invertography can suggest the level of the blind end of the rectum. When the pouch ends below I line, infrequent subtype, covered anus complete, is the diagnosis, but a stoma should be constructed when there is distance from the anal pit (see Chap. 39, Fig. 39.2).

A stoma is constructed usually at the sigmoid colon, but when the position of rectal end is high and rectovesical fistula is suspected, it can be made at the transverse colon.

40.1.1.2 Girls

A baby girl with intermediate or high type of imperforate anus needs a stoma construction at newborn period. She has a fistula connection to the vagina or the vestibule. Rare subtypes of anomalies, namely, rectovaginal fistula high and low, where a fistula opens to the vagina, should be differentiated with the cloacal type.

In a patient with a fistula opening at the vestibule, rectovestibular fistula should be differentiated from similar but distinctive anovestibular fistula. The latter is more common and stools can be passed through the fistula and there is no need of colostomy, but a stoma is necessary in the former type.

Fig. 40.1 Appearance of a boy with high-type imperforate anus

40.1.1.3 Diagnosis of the Subtype and Preoperative Management

It is necessary to determine the correct subtype before anorectoplasty. Contrast study of the colon and cystourethrography can diagnose subtype, and distribution of the external sphincter muscle can be determined by the electromyography. If the patient is associated with other anomaly (ies), the operative timing should be modified after consulting with other specialties.

When there is any other perineal lesion such as spina bifida, perineal mass or presacral tumor, distribution of the muscle complex, and the location of the lesion need to be confirmed by MRI to plan the appropriate operation.

Particularly, when the Currarino syndrome is suspected with a lesion before the sacrum, operative method can be complicated.

40.2 Operations

40.2.1 Intermediate and High Type and Anatomy of the Pelvic Floor

The pelvic floor muscle is responsible for fecal continence. Desirable anorectoplasty for a patient with imperforate anus, particularly for one with intermediate or high type, needs a full understanding of the muscle anatomy of the pelvic floor and defecation physiology.

Stephens emphasized distinction of the levator muscle, the puborectalis muscle, and the external sphincter muscle, which form the pelvic floor [1, 2]. These muscles support the anorectum and function as sphincter mechanics of the anal canal (Fig. 40.2). On the other hand, Pena commented that it is difficult to distinguish these muscles during surgery and named the muscle as complex which is composed of parasagittal and vertical fibers, and he proposed posterior-

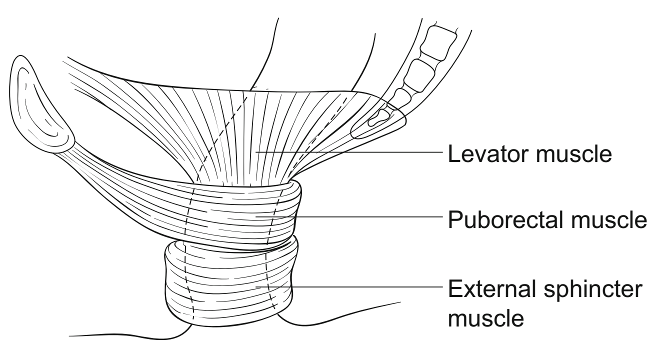


Fig 40.2 Muscle anatomy of the pelvic floor (Stephens 1971)

sagittal anorectoplasty [3, 4]. The anorectum goes through the center of the pelvic muscle and the muscle supports the rectum from behind like a hammock around the assumed plane from the pubic bone and the coccygeum (PC line). Below that line, the muscle is shaped like a horse's hoof and pulls the rectum forward and then forms a flexure (anterior angulation) while enveloping the anal canal.

The internal sphincter is formed at the end of the rectum as thickened wall and functions as effector of anorectal reflex, which relaxes after expansion of the rectum by its content. The most distal part of the muscle is the external sphincter muscle, which can be voluntarily contracted and relaxed.

In children with high or intermediate type, the rectum terminates blindly and mostly communicates either with the bladder, urethra, vagina, or vestibule through a fistula. Poor development of the muscle is common, and it is thin anteroposteriorly at the level of the puborectalis muscle and narrow at the level of external sphincter muscle. Reflective relaxation response, however, is attributed in the rectal end similar to that of the internal sphincter. It is very important to construct the structure as normal as possible with the anatomical and functional understanding of the muscles in anorectoplasty.

In this chapter, the muscle is described dividedly as puborectal muscle and external anal sphincter according to Stephens' concept, while admitting that we are not able to definitely distinguish them on surgery.

40.2.2 Choice of the Operative Method

It is necessary to pull through the anorectum at the right position as possible, which means that it goes through the center of the muscle structure while preserving anterior angulation. Procedures include approach to the rectum, transection of the fistula, rectal mobilization, construction of the pull-through route, and anoplasty. Route construction can be done by the posterior approach, but abdominal or laparoscopic approach is necessary if the rectum ends up high with or without a fistula.

40.2.3 Surgical Procedures

40.2.3.1 Operative Posture and Marking of the Anal Pit

A urethral catheter is placed and the patient is positioned as prone jackknife posture. Contraction of the external sphincter muscle is confirmed by electrical stimulation over the skin and mark at the center of the anal pit. For an intermediate type, skin incision is a Y-shaped one with a leg of approximately 1 cm from the center of the muscle contraction (Figs. 40.3. Assuming that the rectal end is to be sutured to the skin in the depth for a high type, skin flap is created by Nixon's method. Namely, a central vertical skin incision of 2 cm is made at the anal pit, and the incision is spread out to four directions from both ends. And then resect pieces of diamond-shaped skin at the anteroposterior part (Fig. 40.4).

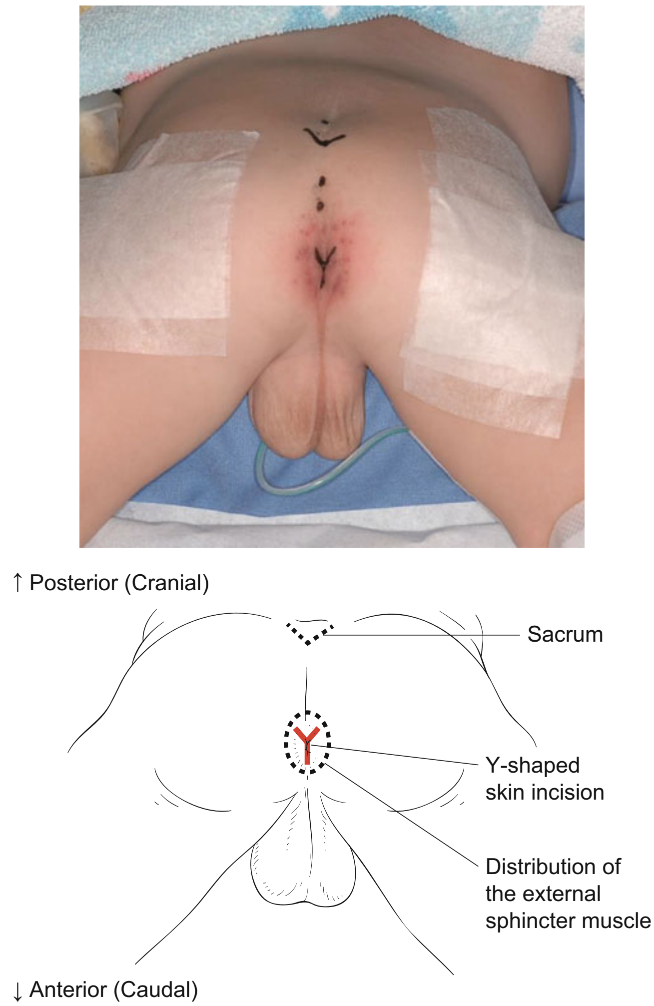


Fig 40.3 Prone position and marking of the anal pit (intermediate type)

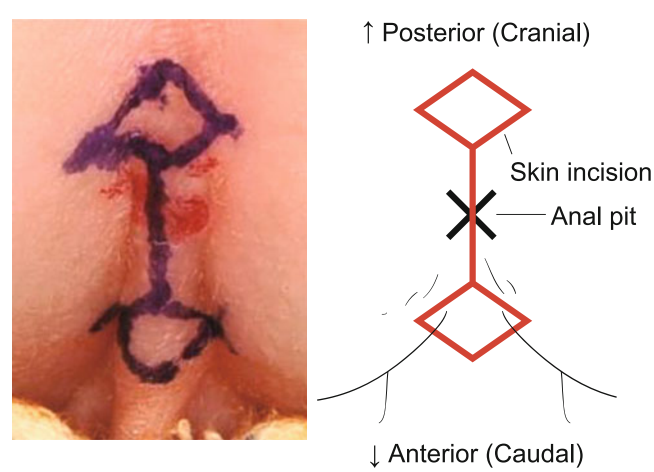


Fig 40.4 Marking of the anal pit by Nixon's method

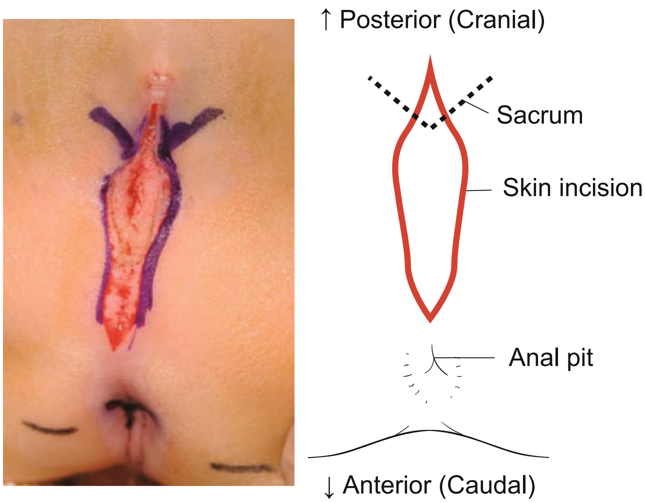


Fig 40.5 Midline sacral skin incision (prone)

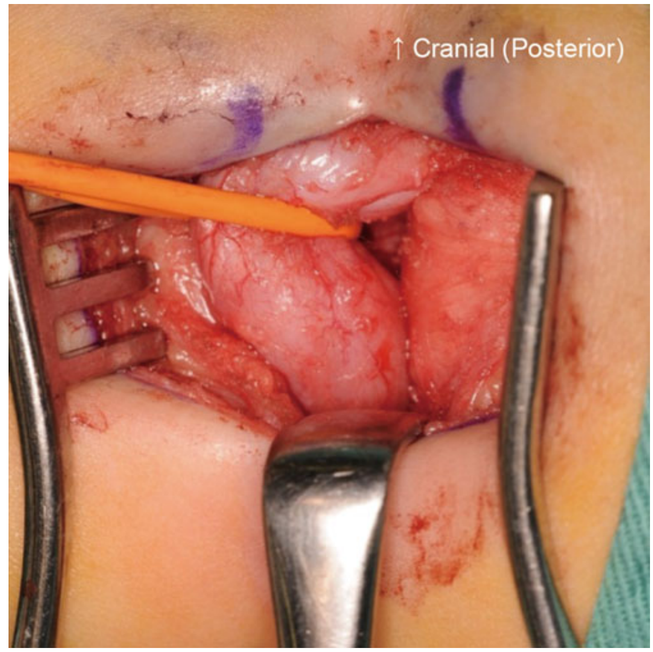


Fig 40.6 Approach to the rectum: the rectum is mobilized and scooped with a tape

40.2.3.2 Approach to the Rectum from the Sacral Incision

Midline skin incision is made at the sacrococcygeal region approximately a few centimeters away from the anal pit (Fig. 40.5). After reaching dorsal surface of the sacrococcygeal bones, a triangular incision is made to remove the coccygeal bone or cartilage. Anococcygeal ligament is incised vertically in the midline, and the presacral membrane is opened to reach the posterior rectal wall.

40.2.3.3 Mobilization of the Rectal Pouch and Division of the Fistula

The rectum is mobilized from the surrounding tissue along the adventitial membrane to reach the anterior wall and is scooped with a tape (Fig. 40.6). This step may be difficult when the rectum is dilated remarkably. Preoperative adequate irrigation of the colon could be helpful to make it easy.

The anterior rectal wall is bluntly or sharply dissected from the urethra in a boy and from the vagina in a girl. The muscle posterior to the rectum is minimally incised and the rectum is mobilized down to the fistula if present or to the blind end of the rectum in patients without fistula. The fistula may have a common wall with the urethra. The rectal wall can be sharply separated from the surrounding tissue, while the urethral catheter is palpated from behind to confirm the junction. Then the urethral fistula is divided at the junction after placing the transfixing suture (Fig. 40.7). In a girl with the rectovestibular fistula, a narrow fistula runs to the opening, but, unlike an anovestibular fistula, the fistula could not be separated completely. In the case without fistula, the rectum is separated from the neighboring tissue down to the end and divided after placing the transfixing suture as one with fistula. The distal end of the rectum is elevated, and the rectum is mobilized further enough to reach the anal pit for anoplasty (Fig. 40.9).

40.2.3.4 Tunneling the Pull-Through Route

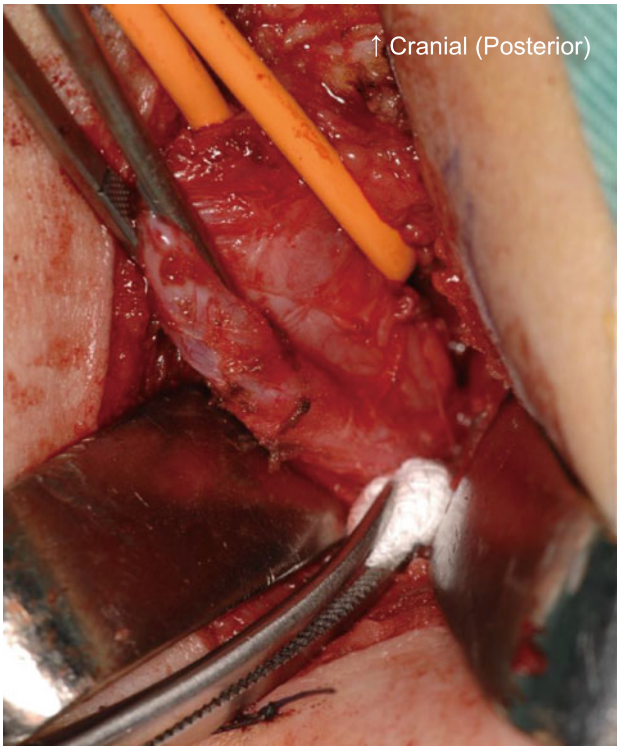
The skin is incised as marked at the anal pit. Approximately 1 cm skin flap is made by undermining surrounding subcutaneous tissue. External sphincter muscle can be identified by electrically stimulated contraction. The center of the muscle contraction should be at the anal end of the pull-through route (Fig. 40.8).

The other end of the pull-through route is at the anterior aspect of the puborectal muscle, which is located at the pelvic floor and can be reached from the sacral wound. Muscle contraction towards anterior direction is confirmed by electrical stimulation. In a boy with recto-prostatic urethral fistula, the puborectalis muscle is located more anal than the fistular junction. In a boy with recto-bulbar urethral fistula, the rectal end and the fistula are located anterior to the puborectal muscle.

The rectum should be located just posteriorly to the central tendon, which is the convergence of the pelvic floor muscles from both sides and anterior to the puborectalis muscle. Therefore, the pull-through route of the rectum begins just anterior to the contraction and behind the urethra and ends at the center of the anal pit (Fig. 40.9).

By the above-mentioned operation, both ends of the route are determined. A right-angled clamp is inserted into the cranial end of the route pointing at the anal end (Fig. 40.10).

a



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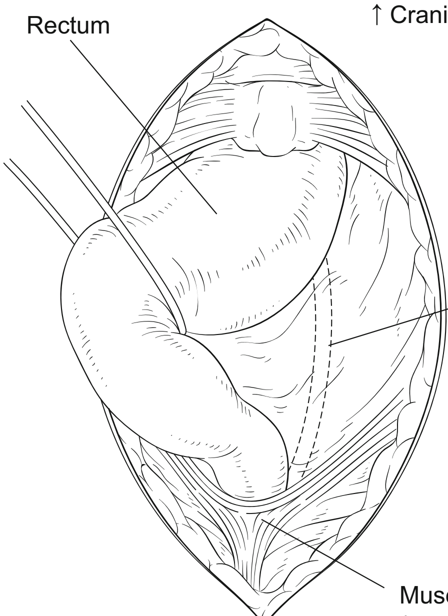

Fig 40.7 Rectum is mobilized down to the fistula

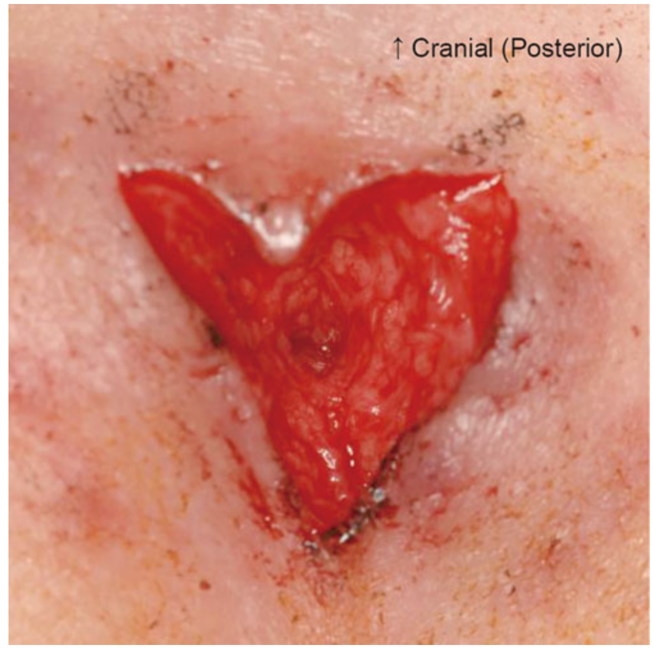

Fig 40.8 Skin incision at the anal pit (Y shaped)

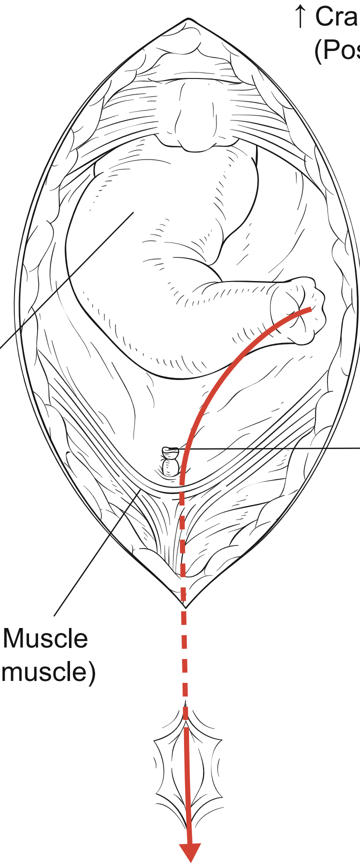

Fig 40.9 The fistula is divided after placing the transfixing suture. The pull-through route of the rectum begins just anterior to the contraction and behind the urethra and ends at the center of the anal pit

A Penrose drain is then put into the route, which should be placed anterior to the puborectalis muscle (Fig. 40.11). The tunneled route is dilated with Hegar dilators covered by a Penrose drain wide enough to pass the rectum (Figs. 40.12a, 40.12b).

Fig. 40.10 A right-angled clamp is inserted from the cranial end of the route to the anal end to make a tunnel

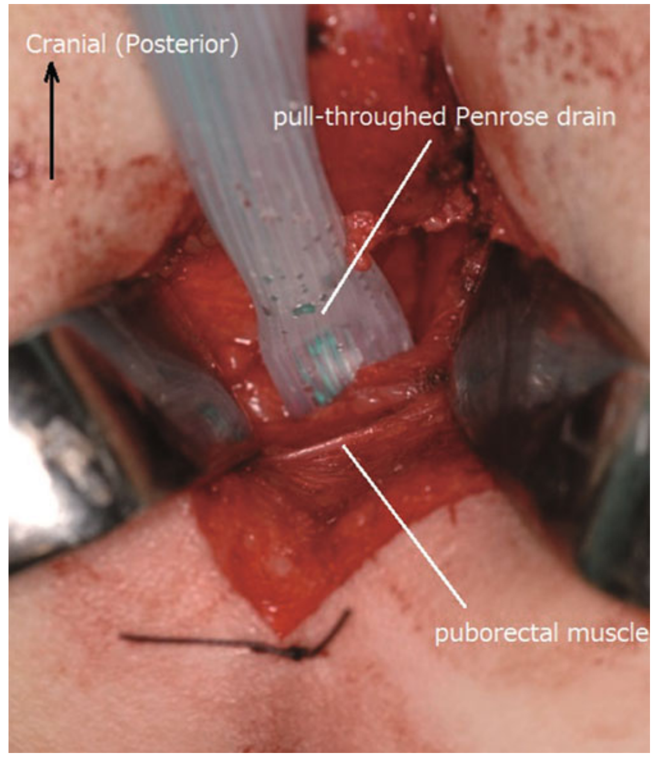

Fig. 40.11 Penrose drain is placed into the tunnel, which should be anterior to the puborectalis muscle

In posterior-sagittal anorectoplasty (Pena's technique), long vertical incision is made from the sacrum to the anal pit. The muscles are divided sharply in the midline to reach the posterior rectal wall. After mobilizing the rectum, it is placed at the center of the muscle complex while making an anterior angulation. The muscle is re-approximated instead of tunneling.

The author does not have an experience of this technique, but it is considered to be vital to place the rectum as close as possible to the desired anatomy. To accomplish it, the muscle complex should be sutured after identifying the central tendon, which is the most anterior position of the rectum and the muscle around the anal pit, which is the posterior end and responsible for the voluntary contraction of the anus.

40.2.3.5 Anoplasty

The rectal stump is grabbed with a clamp through the drain tube and the rectum is pulled through to the anal side (Fig. 40.13). The rectal wall is anchored to the external sphincter muscle with four stitches (Fig. 40.14). After trimming the rectal end, it is sutured to the skin flap (Fig. 40.15). When the Nixon's method is used, the skin flap is sewed up to 3–4 stitches at the top and bottom, and then the rectum is fixed (Figs. 40.4 and 40.16a, 40.16b).

The sacral wound is closed by suturing layer-to-layer fashion. A flexible catheter of 8 Fr is placed as a trans-anastomotic stent and fixed to the skin by adhesives (Figs. 40.17a, 40.17b).

40.2.3.6 Surgery for the Rectovesical Fistula (Sacro-Abdominoperineal Anoplasty)

For a boy with rectovesical fistula or blind end of the rectum is in the abdominal cavity, it is necessary to mobilize the rectum and to transect the fistula by laparotomy or laparoscopically. After having made the pull-through route in jackknife position, the rectum is pulled through after the patient is placed in the lithotomy position, and then the rectum is sutured to the anal pit.

The rectum cannot be mobilized from the sacral wound because the rectal end is high above the operative field. Therefore, after identifying the urethra posteriorly and the puborectal muscle contraction, the pull-through route is created similarly as in boys with other type. A right-angle

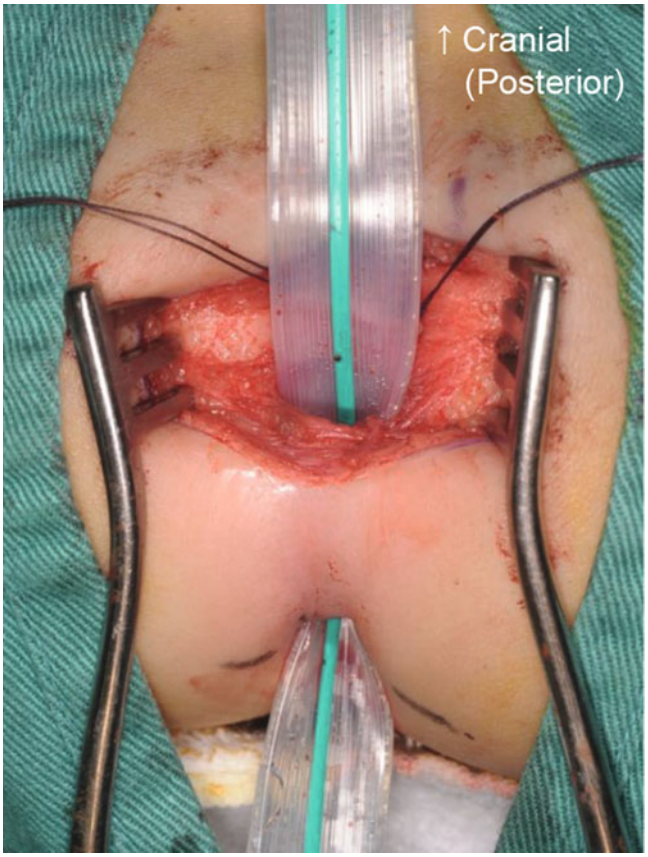

Fig. 40.12a A Penrose drain is in the route

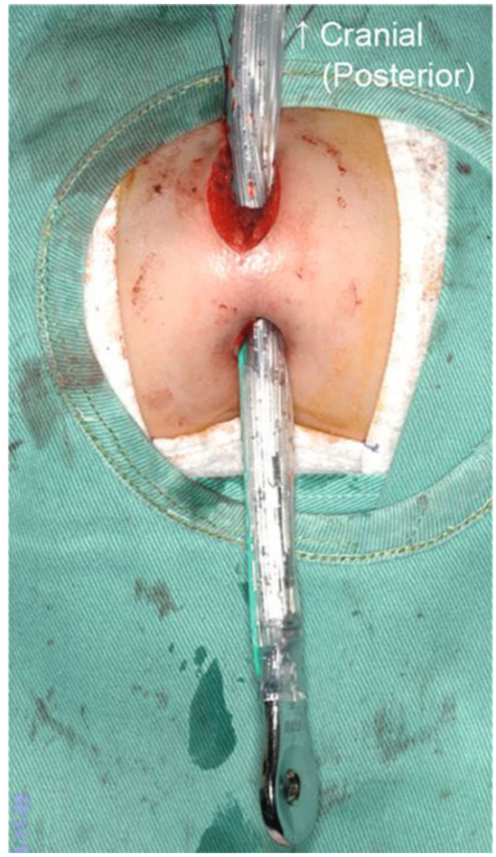

Fig. 40.12b Tunneled route is dilated with Hegar dilators covered by the drain

clamp is used to tunnel the pull-through route from the sacral wound to the anal pit. The pull-through route is dilated wide enough to pass the rectum, and Penrose drain as a guide is left in place. And the sacral wound is closed and the patient is placed in the lithotomy position.

From a laparotomy wound, the rectal end is mobilized after incising the peritoneal reflection. The rectum is dissected toward the vesical fistula if present and it is divided. The rectum is then fully mobilized on its vascular pedicle in order to get mobility to reach the perineal wound. The truncus of the inferior mesenteric artery may be divided for that purpose.

After confirming that the rectum is mobilized long enough to reach the perineal wound, the blind end of the rectum is sutured to the Penrose drain previously left in place from the sacroperineal wound. Then the Penrose drain is gently pulled through with the rectum along the tunneled route to the anal pit. Anchoring of the rectum and anastomosis of the rectal wall to the perineal skin is made as the same fashion as sacroperineal anorectoplasty.

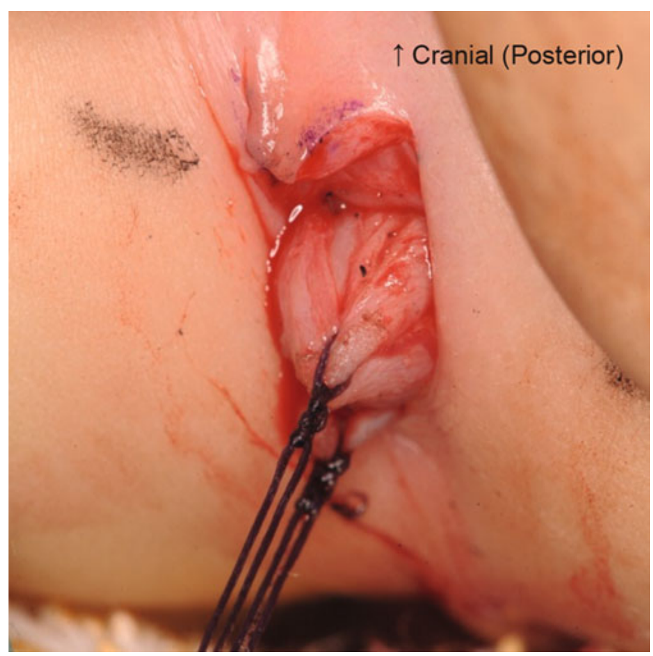

Fig. 40.13 The rectal stump is pulled through to the anal side

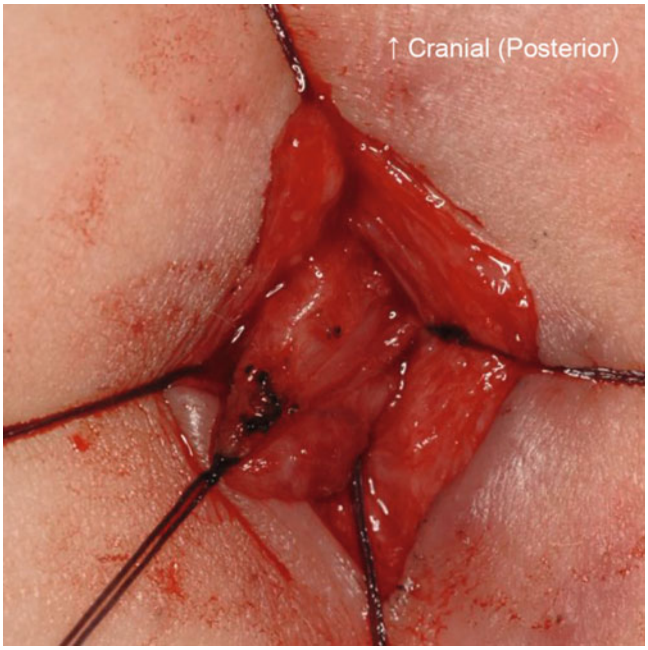

Fig. 40.14 The rectal wall is anchored to the external sphincter muscle

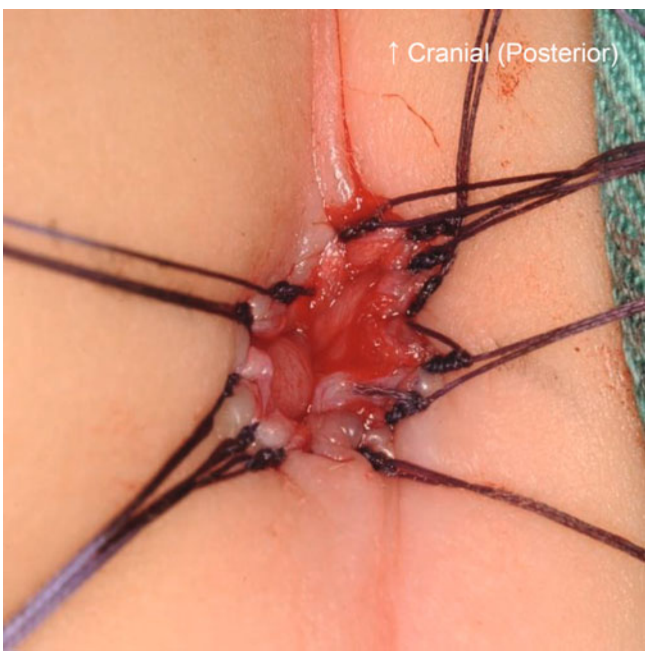

Fig. 40.15 Trimmed rectal end is sutured to the Y-shaped skin flap

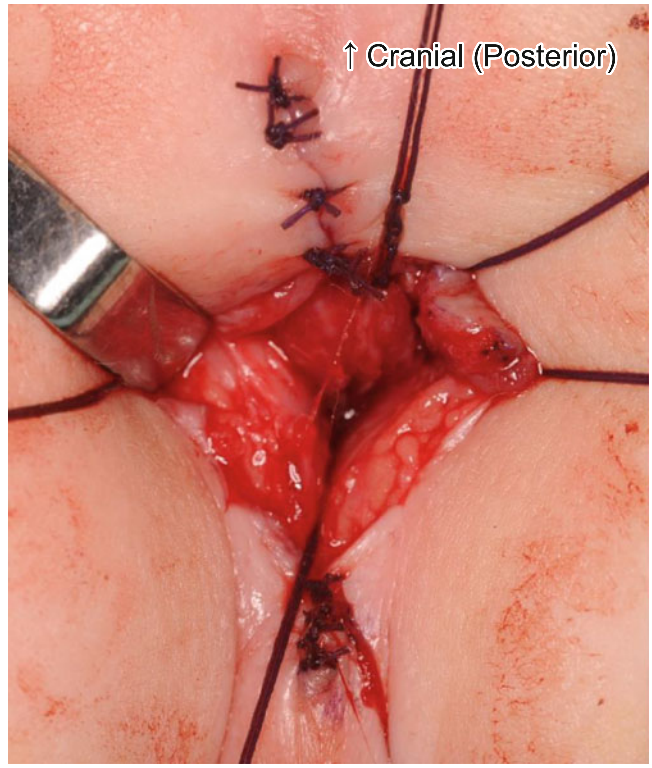

Fig. 40.16a The skin flap is sewed up three to four stitches at the *top* and *bottom* in Nixon's method

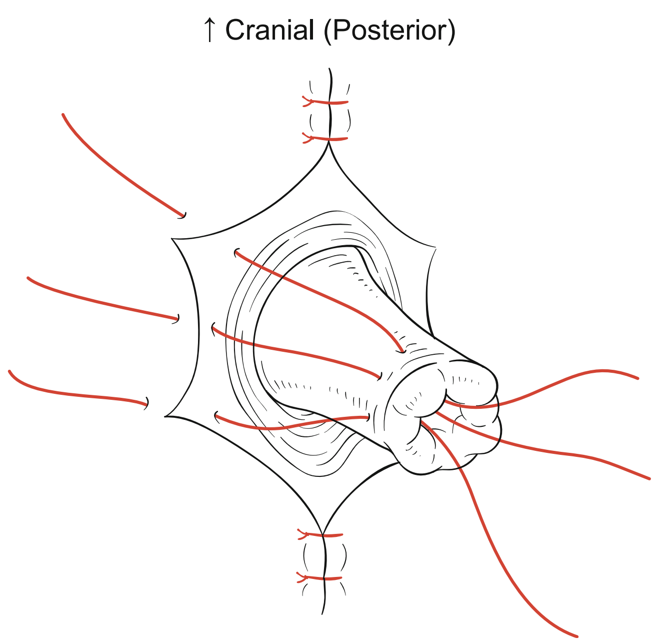

Fig. 40.16b Fixation of the rectum in Nixon's method

40.3 Postoperative Management

40.3.1 Care Just After Surgery

1. Stent tube to a newly formed anus is left in place. To protect the wound, it may be necessary to have the patient's lower limbs fixed for 1 week.
2. Antibiotics are provided to prevent wound infection.
3. Diet can be started the next day.
4. When the wound is intact 2 weeks after surgery, dilatation with Hegar dilators can be started to prevent stenosis of the wound.

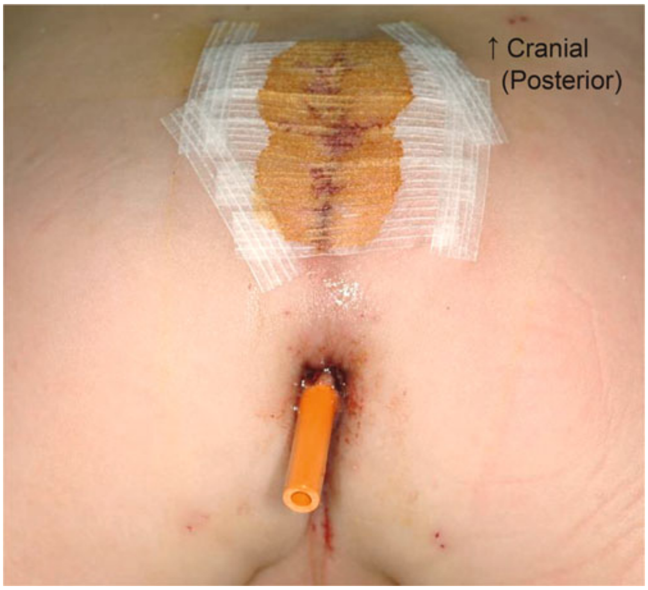

Fig. 40.17a Postoperative appearance. A flexible catheter of 8 Fr is placed (Y-shaped incision)

Fig. 40.17b Postoperative appearance 1 year after anorectoplasty (Nixon's method)

5. Dilatation should be carried out carefully with slow and gentle manner. It would start from 8-size and the anus is enlarged little by little to reach 14-size before discharge. If there is bleeding, the size-up should not be done.
6. If there is any wound infection or dehiscence of the wound, the stent should be in place without dilatation. Wound dilatation should not be started until the wound is healed.
7. Colostomy can be closed after dilatation of the wound is completed up to 14-size and a satisfactory anal lumen is secured.
8. The bowel management with the twice-daily glycerin enema (3 ml/kg/time) is started 1 week after colostomy closure.

40.3.2 Long-Term Care After Discharge

1. At outpatient visits once in a week or 2, a surgeon should check the anal lumen digitally to see if the newly made anus is stenotic. If it is stenotic, daily digital dilatations by family or placing a stenting tube should be continued until enough lumen is maintained and the wound gets soft.
2. Stent tube can be placed for about 3 months to secure the enough anal lumen. The surgeon should check the lumen from time to time at outpatient visits.
3. Bowel management with enemas should be given for a long period. It is preferable to twice-a-day enemas for 6 months after anorectoplasty and then a daily enema afterward.
4. Enemas can be reduced while confirming the spontaneous bowel movements.
5. It is said that a child can become continent after 4 years of age. However, children with high- or intermediate-type anomalies may suffer from constipation or fecal incontinence and frequently need long-term bowel management before obtaining fecal continence.
6. The bowel management with enemas should be continued for a long period.
7. To prevent constipation, enough amount of dietary fiber with water should be recommended to soften the stool. Laxatives should be prescribed if the patient tends to be constipated.
8. For children with a high-type imperforate anus, an accident in a school or in public can have a grave psychological backlash. Care should be focused to prevent any accident due to incontinence out in a society.
9. In some special social events, such as stay-over without family or school excursion, care should be focused for the patient not to be embarrassed with such accident.

40.3.3 Support by the Team

1. Care for children with imperforate anus should be a teamwork including caregivers, nurses, social workers, and physicians/surgeons surrounding the patient.

2. Consideration of factors affecting the patient care such as family's background, home environment, and social services is sometimes necessary to deal with the problems.
3. Transitional and multidisciplinary cares beyond the adult life are sometimes necessary since the patients with imperforate anus tend to have long-lasting health problems including genitourinary and reproductive dysfunctions.

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41 Rectovestibular Fistula Without Imperforate Anus (Perineal Canal)

Noritoshi Handa

Abstract

Rectovestibular fistula without imperforate anus (perineal canal) is a relatively rare condition which is classified into miscellaneous deformities in the international classification of anorectal anomalies. In female neonates or early infants with this condition, a passage of feces or flatus from the vaginal vestibule or vulvitis is observed because of a fistulous tract which communicates between the anterior wall of the lower rectum and the vaginal vestibule with the normal anus. The fistula can be determined by inserting with a probe, and the fistulous tract is also confirmed by barium enema, fistulography, or stomatography. Treatment should be surgical and various surgical approaches have been described. The vestibulo-anal pull-through method which is one of perineal fistulectomy is recommended for this disease because of its simple, easy, and less invasive procedures. The role of colostomy in treating this condition is still controversial, but colostomy is greatly helpful in preventing wound infection or wound disruption.

Keywords

Rectovestibular fistula • Perineal canal • Double termination of the alimentary tract • Anorectal anomaly

41.1 Preoperative Management

41.1.1 Symptoms

1. Passage of feces from the vaginal vestibule (Fig. 41.1)
2. Vulvitis (Fig. 41.1)

41.1.2 Diagnosis

1. Barium enema (Fig. 41.2)
2. Fistulography
3. Stomatography (Fig. 41.3)

41.2 Suitable Age of Operation

Infancy is suitable, because rectovestibular fistula is commonly found soon after birth.

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Fig. 41.1 Vulvitis. Passage of stool per vaginal vestibule (*arrow*) associated with redness of the external genitalia

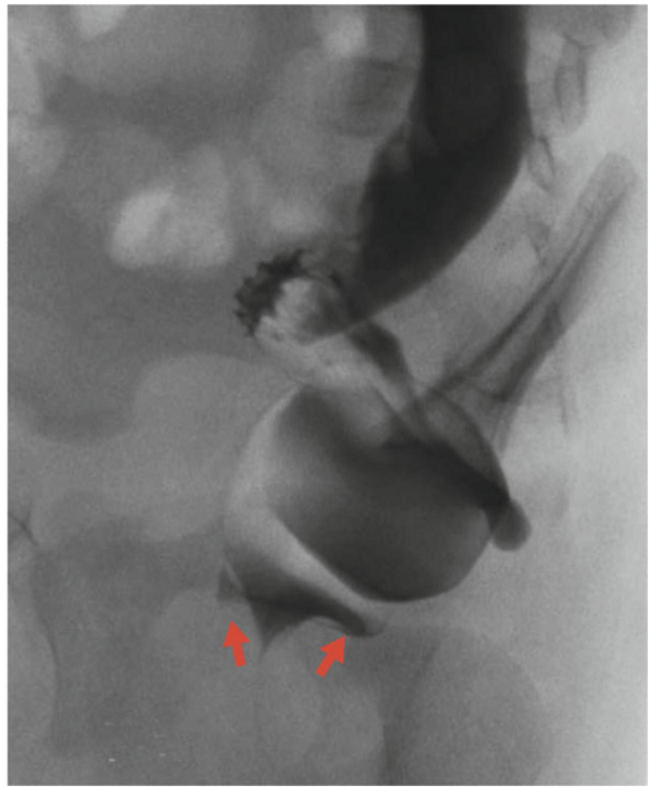

Fig. 41.2 Barium enema. A thin fistulous tract is visualized (*arrow*)

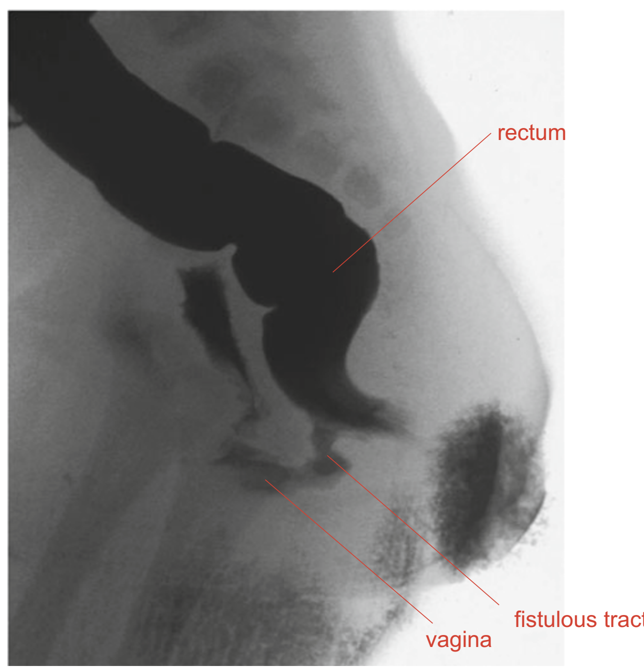

Fig. 41.3 Stomatogram

41.3 With Colostomy or Without Colostomy [1, 2]

Although a temporary colostomy is advantageous for control of vulvitis in neonate or early infancy, for treatment of postoperative wound infection or wound disruption and for easier management for fistula recurrence, fistulectomy is generally underwent without a diverting colostomy.

If an excision of fistula is underwent without stoma, preoperative colon preparation is essential by no oral intake with intravenous infusion or oral feeding of elemental diet and rectal irrigation with normal saline.

Fig. 41.4 Rectovestibular fistula. A probe run through from the vestibular orifice to anterior wall of lower rectum just above anal verge

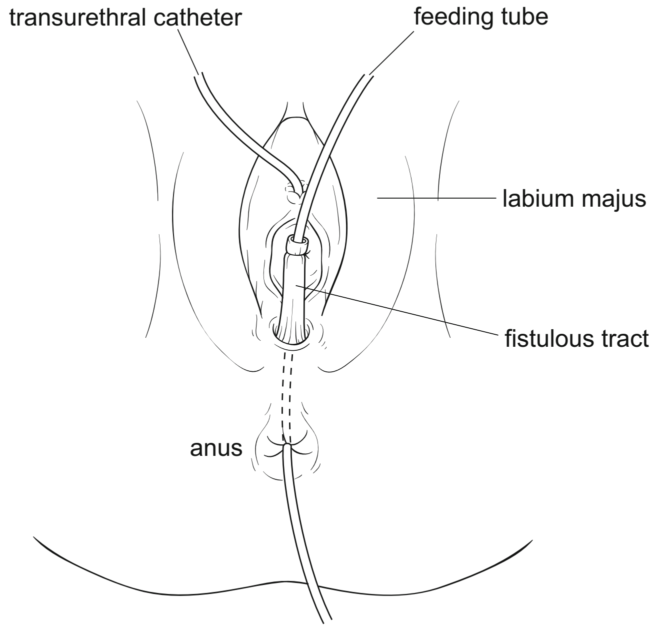

Fig. 41.5 Dissection of the fistulous tract

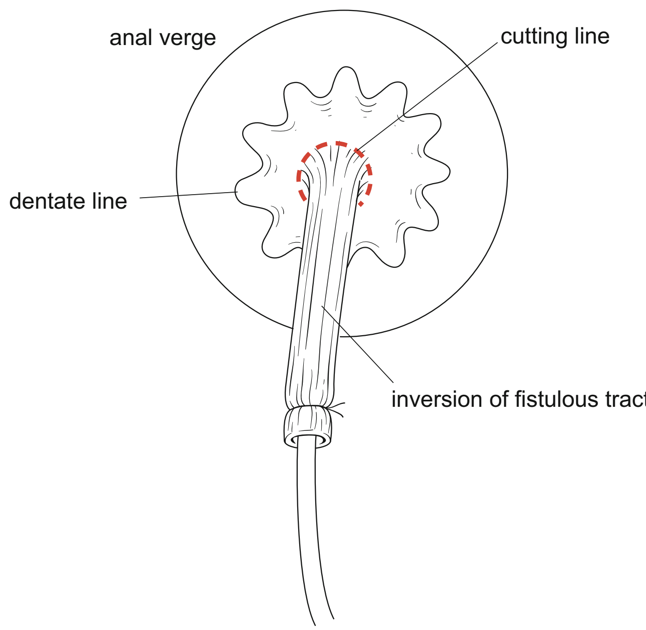

Fig. 41.6 Inversion of the fistulous tract

41.4 Operations: Vestibulo-anal Pull-Through Method [3, 4]

41.4.1 Exploration of the Fistulous Tract

After a transurethral catheter is placed under lithotomy position, a fistulous tract is explored using probe which is inserted through the vestibular orifice (Fig. 41.4).

41.4.2 Dissection, Inversion, and Resection of the Fistulous Tract

After a feeding tube is inserted through the canal, a circular incision is made around the vestibular orifice, and dissection of the fistula from the surrounding tissue is continued toward the rectal orifice (Fig. 41.5). The dissected tract is ligated with silk suture and is pulled through from the anterior wall of the rectum. Then, the inverted tract is transected at the rectal orifice (Fig. 41.6).

41.4.3 Closure of Wound

After the dead space is irrigated with normal saline, the vestibular orifice and the rectal orifice are closed, respectively, with absorbable sutures.

41.5 Postoperative Management

In case without colostomy, wound irrigation with normal saline is necessary whenever the perineal wound is contaminated by stool.

Postoperative complications: wound infection, wound disruption, recurrence of fistula.

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Anal Fistula

42

Tatsuya Suzuki

Abstract

A perianal abscess is caused by inflammation due to bacterial infection of the anal gland, which is located in the anal crypts along the dentate line, and is formed by tunneling under the skin of the anus. An anal fistula is formed when pus is discharged from an opening of the abscess to the skin (Fig. 42.1). The symptoms are more common in breastfed male infants aged less than 6 months. Abscesses and external fistulae (secondary openings) are more likely to be located to the side of the anus (at 3 and 9 o'clock). Abscess symptoms rapidly improve and are relieved by incision and drainage, but symptoms are likely to recur after some time. However, an anal fistula in infants generally resolves before 1 year of age. When the fistula is palpable and the symptoms recur, even at 1 year of age or older, radical surgery for the anal fistula is indicated.

Keywords

Anal fistula of infant • Perianal abscess of infant • Radical surgery for anal fistula

42.1 Preoperative Management

42.1.1 Incision of a Perianal Abscess

There are no special preoperative preparatory procedures, other than verifying the last feeding time to prevent vomiting associated with crying. In general, we perform the procedures during hospitalization to confirm postoperative hemostasis and provide instructions for sitz baths and anal cleansing to parents (Fig. 42.1).

42.1.2 Radical Surgery for Anal Fistula

If there are atypical symptoms, the fistula location and surrounding area should be evaluated by fistulography in advance. The patients should not be fed after breakfast on the day before surgery and should be administered a 50 % glycerin enema according to body weight (2 mL × weight in kg) in the afternoon and evening on the same day to promote defecation.

42.2 Operations

42.2.1 Incision of a Perianal Abscess

A scalpel is inserted into the dome of the abscess, and an approximate 5-mm incision is made in parallel to the anal folds and spread radially under local anesthesia. The tip of a mosquito clamp is inserted into the abscess, and purulent

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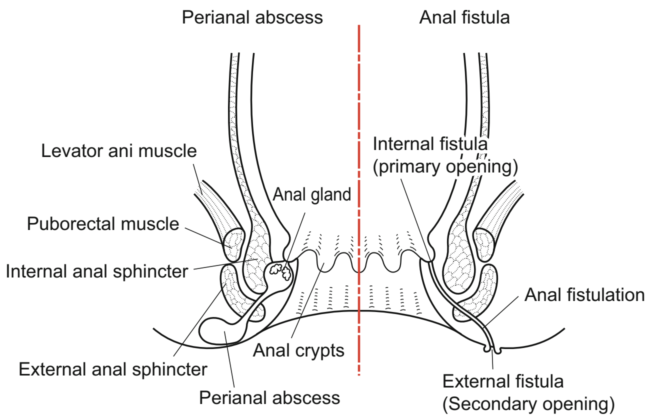

Fig. 42.1 Anatomy of rectum/anus and perianal abscess and anal fistula

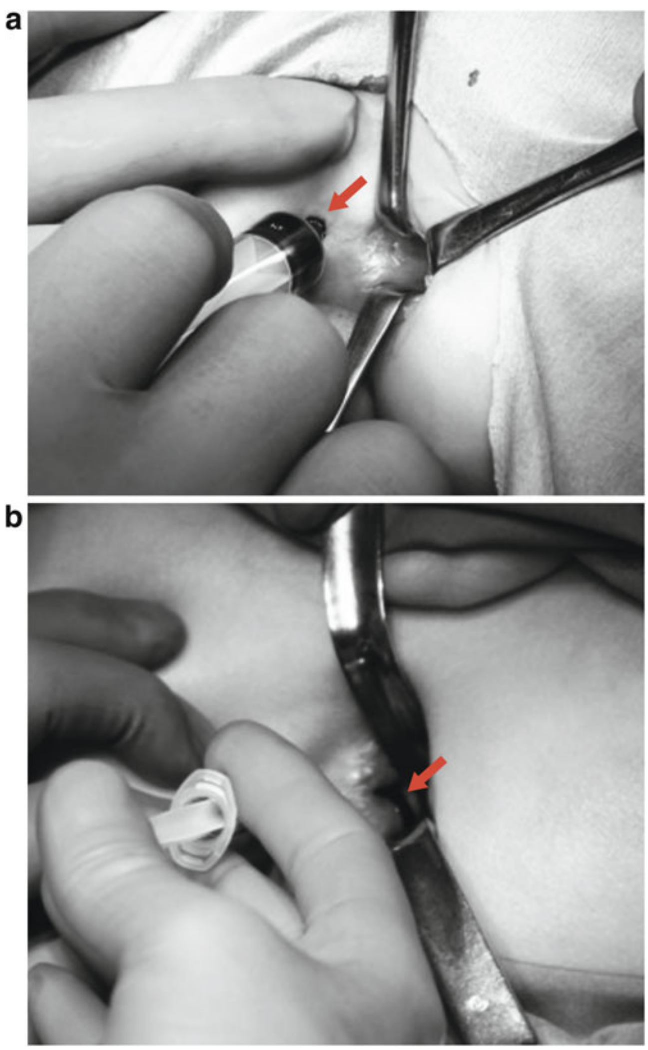

Fig. 42.2 Check the internal fistula (primary opening) by injecting the dye into the external fistula (secondary opening). (**a**) Directly inject the dye into the secondary opening using a needleless syringe. (**b**) Check the drainage of the dye from the primary opening

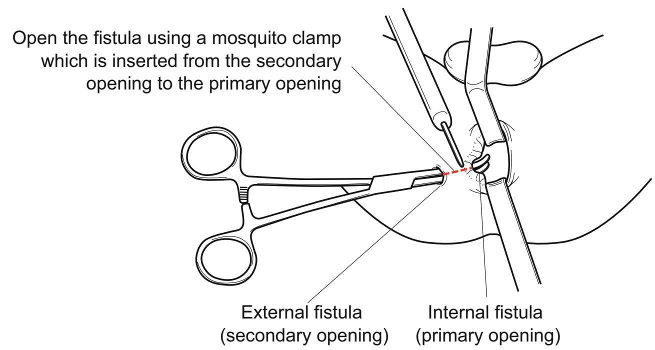

Fig. 42.3 Opening of the fistula

discharge is promoted. The abscess cavity is filled with ribbon gauze.

42.2.2 Radical Surgery for Anal Fistula

The procedures are performed in the lithotomy position under general anesthesia (if a fistula is located in the ventral region, the procedure can be performed in the jackknife position). Approximately 2 mL of indigo carmine is transferred to a 3-mL needleless syringe and injected into a secondary opening or forcefully instilled into the fistula to check for flow from a primary opening (Fig. 42.2) (use of an intravenous catheter trocar may allow excess leakage from the side of the trocar, with insufficient pressure). After confirmation of the location of the primary opening, a probe or mosquito clamp is inserted from the secondary opening to the primary opening to open the fistula (Fig. 42.3). Then, the primary opening is completely excised, and necrotic and diseased granulation tissue in the fistula is also excised. The margin is trimmed to make the open wound suitable for drainage, and complete hemostasis is performed using electrocautery (Fig. 42.4). Square gauze with Xylocaine® Jelly is then packed into the open wound.

A complex anal fistula in an older toddler should be treated by sphincter splitting fistulotomy or fistulectomy, as in radical surgery for anal fistulas in adult patients. It is important to completely remove primary openings (multiple anal crypts adjacent to the primary opening may sometimes be removed).

42.3 Important Points of Postoperative Management

42.3.1 Incision of a Perianal Abscess

If ribbon gauze spontaneously falls out, it is not necessary to repack the wound after completion of hemostasis. The ribbon gauze should be removed the next day if it remains in the

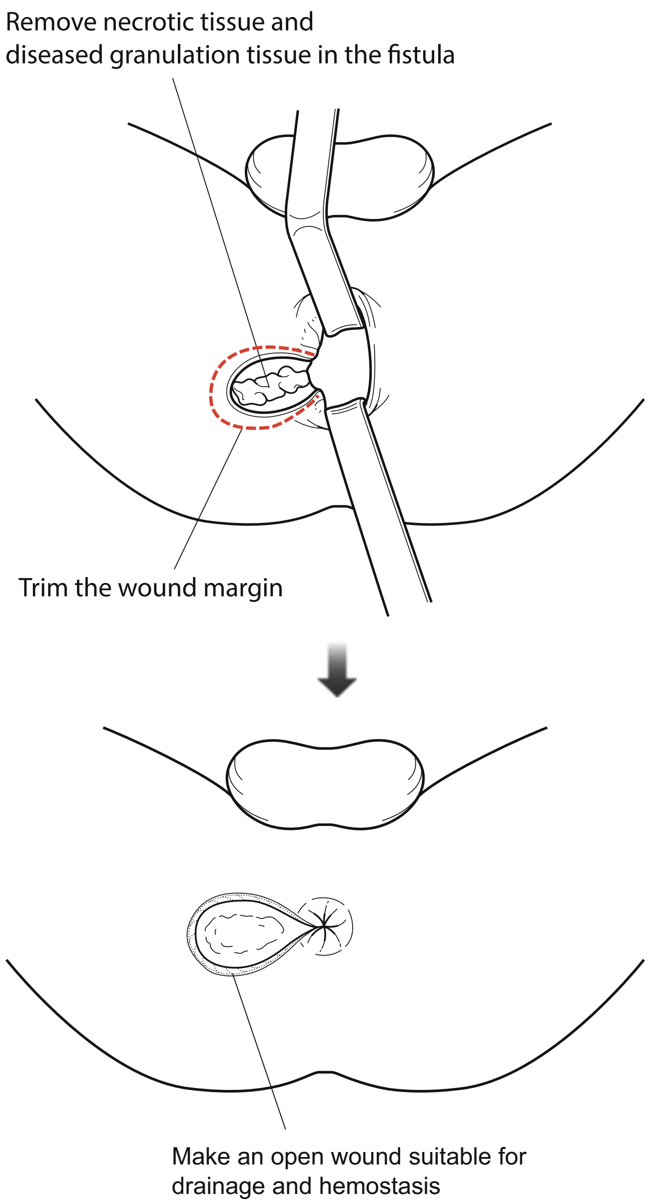

Fig. 42.4 Complete removal of the fistula and open wound formation

site. Sitz baths and anal cleansing in lukewarm water from postoperative day 1 are recommended. The incision is likely to close at an early stage, and the parents should be instructed in a method for drainage of pus at home. If the patient has fever, oral antibiotics are administered for a few days (as antibiotic administration may cause diarrhea, it is not always necessary if there is adequate purulent drainage).

42.3.2 Radical Surgery for Anal Fistula

If split gauze in the wound spontaneously falls out, it is not necessary to repack the wound after completion of hemostasis. The gauze should be removed the next day if it remains in the site. Water intake is allowed a few hours after surgery, and food intake is restarted the next morning. Antibiotics are routinely administered intravenously for three doses: immediately before surgery, the evening on the day of surgery, and in the morning on the day after surgery. Wound cleansing with lukewarm water is started from postoperative day 1, and instructions for the method of sitz baths and wound cleansing are given to the parents. The patient can be discharged from the hospital when sufficient oral intake, smooth defecation, and excellent wound healing are confirmed (in general, 3–4 days after the surgery). The parents provide sitz baths and wound cleansing for the patient after discharge, and the wound healing process is followed up in the outpatient department. When the wound size has decreased, an anal digital examination is performed in the outpatient department. Bougienage is also performed as appropriate, to prevent closure of the deeper aspect of the open wound, and appropriate wound closure and epithelialization are promoted.

Anorectal Prolapse

43

Satoshi Ieiri, Tatsuru Kaji, and Tomoaki Taguchi

Abstract

Rectal prolapse is defined as the state in which the rectal walls have prolapsed to a degree where they protrude out the anus and are visible outside the body.

Infants often suffer from this disease when they have severe chronic constipation and frequent watery diarrhea. Its peak incidence is between 1 and 3 years. Prolapse can be either partial or complete. Patients who undergo a radical procedure of anorectal malformation and Hirschsprung's disease often experience anorectal prolapse following pull-through operation (Rintala RJ, Pakarinen MP. 104 other diagnosis of the anus and rectum, anorectal function. In: Coran AG, Adzick NS, Krummel TM Laberge JM, Shamberger RC, Caldamone AA, editors. Pediatric surgery 7th ed. Philadelphia: Elsevier Saunders; 2012. pp. 1311–20). Neurological impaired patients also suffer from a similar state. These patients cannot recover with conservative treatment. A surgical procedure is the first-line choice of treatment. There are many types of procedures for the surgical treatment of anorectal prolapse, which includes more than 50 methods including modified ones. Surgical treatment for anorectal prolapse for pediatric patients should be selected to prevent injury of the pelvic floor muscle and anal sphincter in the presence or absence of the underlying disorders in regard to the quality of life. In this text, we introduce the perineal approach and laparoscopic approach.

Keywords

Anorectal prolapse • Perineal approach • Gant-Miwa • Laparoscopic approach • Rectopexy

43.1 Perineal Approach

43.1.1 Gant-Miwa Procedure

The patient is placed in the lithotomy position, and the perineal region and the anal canal are cleaned. The tip of the prolapsed rectum is grasped by Allis forceps to make a complete rectal prolapse (Fig. 43.1). Four points of the rectal mucosal membrane, 12, 3, 6, 9 o'clock positions, are sutured by a transfixing manner in order to make a tied 5 mm membrane ball. The best depth of needle driving is into the surface of the smooth muscle layer (Fig. 43.2). Similar ligatures are made forward to the dentate line forming the spiral shape. The prolapsed rectum is gradually reduced in

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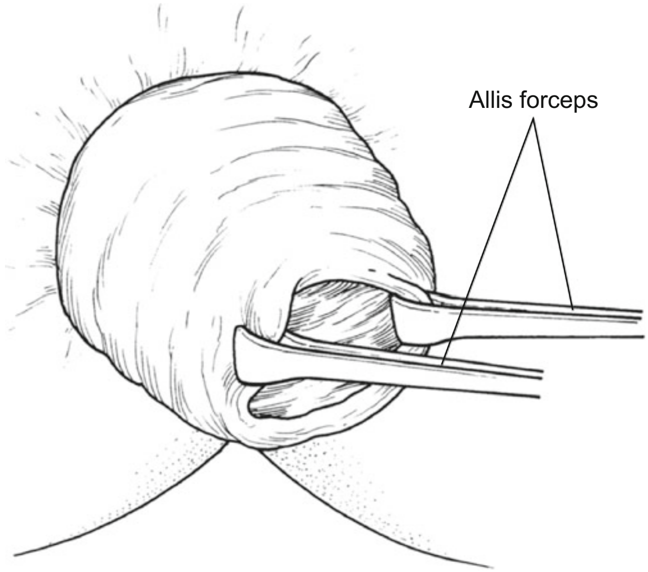

Fig. 43.1 Making a complete rectal prolapse

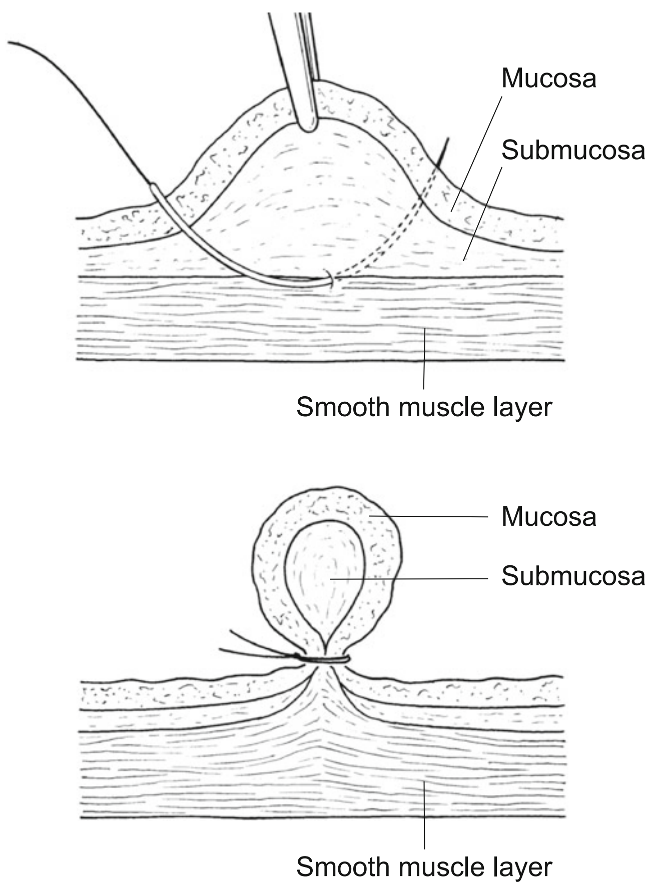

Fig. 43.2 Needle driving into the surface of the smooth muscle layer. (**a**) Penetrate the needle tip just the surface of smooth muscle layer. (**b**) The size of surgical knot is about 5 mm

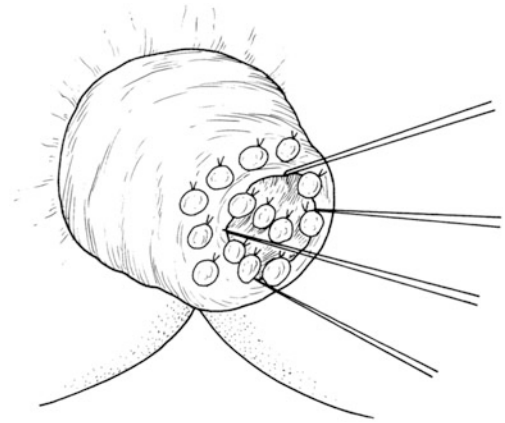

Fig. 43.3 Reduction in the anus with an increase of the membrane ligature

the anus with an increase of the membrane ligature (Fig. 43.3). The first four stay sutures are cut, and the next suture is left to secure the operative field. Finally, these transfixing membrane sutures are made near the dentate line [1, 2]. A digital examination is performed to confirm the presence or absence of stenosis.

43.1.2 Anal Encirclement (Thiersch Procedure)

The patient is placed in the lithotomy position, and the perineal region and the anal canal are cleaned. After reduction of the prolapse, two small radical incisions are made, each 2 cm from the anal verge, at 12 and 6 o'clock positions (Fig. 43.4). Using a fully curved aneurysm needle, a 2-0 or 3-0 monofilament nonabsorbable (Nylon, Prolene) suture is threaded from the posterior and anterior incisions around the anus just deep to the external sphincter muscle. The needle is rethreaded and the monofilament nonabsorbable suture is pulled anterior to posterior around the other side of the anal canal (Fig. 43.5). With an assistant's finger, or a No. 10 or 11 Hegar dilator held in the anal canal, the suture is pulled and tied inside the posterior incision. Fine and absorbable monofilament sutures (PDS, Monocryl) are used to close the two incisions [3].

This operation does not correct the prolapse itself; it merely supplements the anal sphincter, narrowing the anal canal with the aim of preventing the prolapse from becoming external, meaning it remains in the rectum.

43.2 Laparoscopic Approach

43.2.1 Laparoscopic Abdominal Rectopexy

The recovery time following laparoscopic surgery is shorter and less painful than traditional abdominal surgery. Instead of opening the pelvic cavity with a wide incision

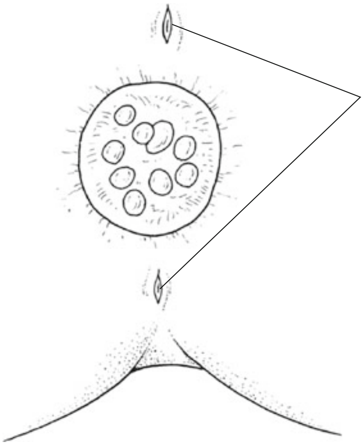

Fig. 43.4 Two small incisions at 12 and 6 o'clock positions

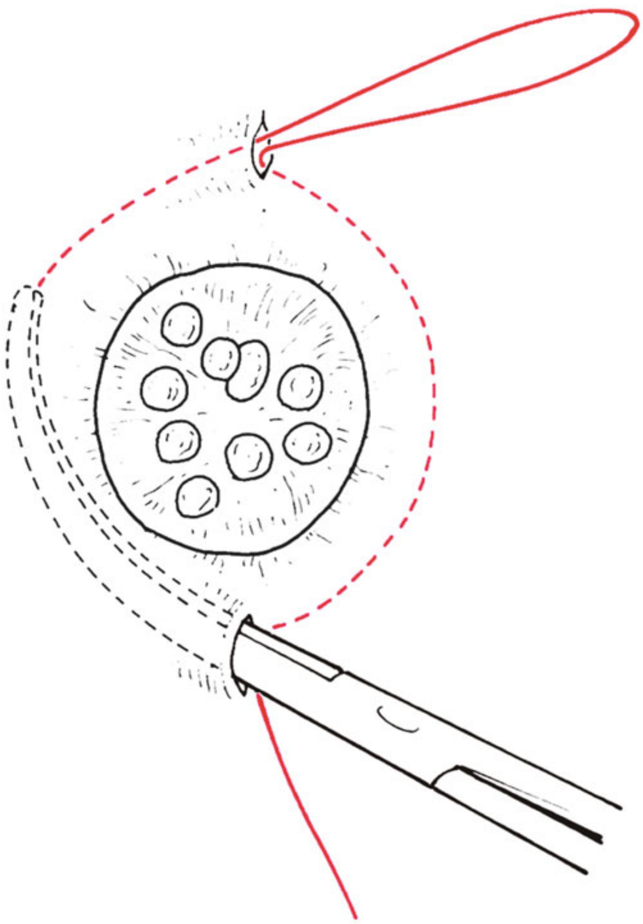

Fig. 43.5 Needle rethreaded anterior to posterior around the other side of the anal canal

(laparotomy), a laparoscope and surgical instruments are inserted into the pelvic cavity through small incisions [4].

The patient is placed in the lithotomy position. A pneumoperitoneum is established under direct vision by

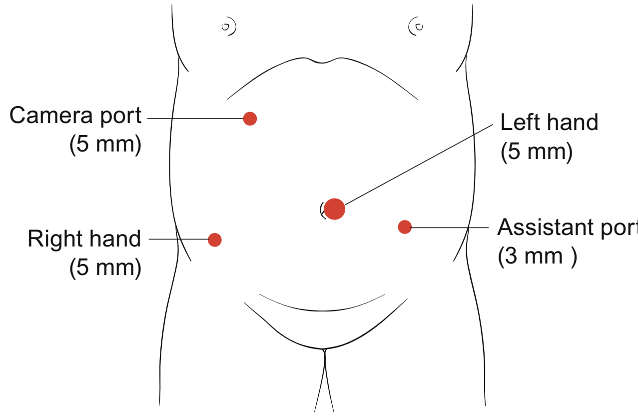

Fig. 43.6 Trocar placement

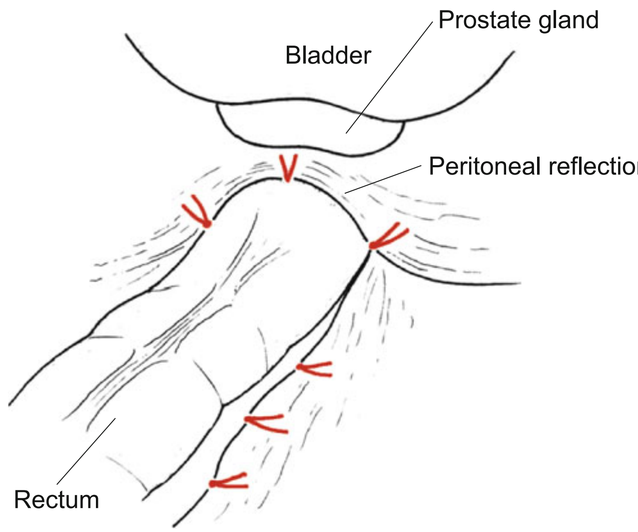

Fig. 43.7 Direct suture rectopexy to the sacral bone and promontory

placing a 5 mm Hasson trocar through the umbilical incision. A 5 mm 30° laparoscope is inserted to inspect the intra-abdominal contents. Two additional 5 mm trocars and one 3 mm trocar are then inserted under direct vision, two in the right paraumbilical region and one in the left paraumbilical region (Fig. 43.6). The laparoscopic technique includes retrorectal dissection, starting from the peritoneal reflection on the right side of the rectum extending from the sacral promontory to the pelvic muscular floor in the retrosacral bloodless plane. Great care is given to the identification of iliac vessels and the ureter. In the absence of pelvic floor laxity, direct suture rectopexy to the sacral bone and promontory are performed using nonabsorbable suture material without mesh (Fig. 43.7). In cases with laxity and weakness of the pelvic floor and in patients with neuropathic conditions (e.g., spina bifida and meningomyelocele), additional mesh is recommended [5].

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Biliary Atresia

44

Masaki Nio, Motoshi Wada, Hideyuki Sasaki, and Hiromu Tanaka

Abstract

Kasai portoenterostomy is still the first-line surgical treatment of biliary atresia (BA), and the maintenance of good QOL of native liver survivors is a very important issue in the era of liver transplantation. Currently we employ long Roux-en Y portoenterostomy with an antireflux intestinal spur valve as the standard procedure. Technical points of this procedure are described herein. With a small laparotomy, the diagnosis and the type of obstruction are confirmed by direct cholangiography. Dissecting the extrahepatic biliary remnant, the branches of the hepatic artery are identified. The fibrous common bile duct is also dissected and divided close to the duodenum. Small branches of the portal vein toward the caudal lobe through the fibrous remnant are carefully ligated and divided. The fibrous remnant is vertically divided in the middle using an electric cautery. The right and the left parts of the remnant are removed independently, paying careful attention so as not to injure the underlying liver capsule. The long Roux-en Y limb with the antireflux intestinal spur valve is prepared. The hepatic portoenterostomy is performed in the end-to-back fashion. Special care is taken during placing the lateral stitches close to the cut surfaces of the fibrous remnant so as not to involve the cut surfaces into the stitches.

Keywords

Biliary atresia • Kasai portoenterostomy • Cholangitis • Antireflux intestinal valve

44.1 Background

Since the development of Kasai portoenterostomy by Morio Kasai in 1950s, the outcome of surgical treatment for biliary atresia (BA) has greatly improved. Currently, most patients with BA survive after Kasai operation followed by liver transplantation if necessary. It is true that the impact of liver transplantation on the treatment outcome of BA is significant. However, Kasai portoenterostomy is still the first-line surgical treatment of BA, and the maintenance of good QOL of native liver survivors is a very important issue.

In Tohoku University Hospital, where Morio Kasai developed Kasai portoenterostomy, techniques of Kasai portoenterostomy have been modified for the past half century. Currently we employ long Roux-en Y portoenterostomy with an antireflux intestinal spur valve as a standard procedure. Technical points of this procedure are described herein.

44.2 Preoperative Management

In BA, early corrective surgery is essential to achieve good operative results. Preoperative evaluation and precise preparation are, of course, important. However, time wasting with

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unnecessary examinations before surgery should be refrained. If the correct diagnosis is difficult or BA cannot be excluded after routine examinations, a prompt direct cholangiography with laparotomy or laparoscopically is recommended. Vitamin K is intravenously administered for patients with cholestasis. Correction of hemorrhagic tendency is important for Kasai portoenterostomy as a preparation. Coagulopathy due to disturbed absorption of vitamin K in BA patients sometimes causes intracranial bleeding, and the surgery needs to be postponed in such situation. If the coagulopathy is appropriately corrected and the surgery is properly performed, no blood transfusion is usually required in ordinary cases. However, if the patient developed severe liver fibrosis associated with portal hypertension, unexpectedly much bleeding might be encountered. Thus, packed red blood cells should be prepared before surgery in such cases. Long-time fasting before surgery or preparation by oral administration of nonabsorbable antibiotics is not required. After induction of general anesthesia, broad-spectrum antibiotics are usually intravenously administered.

44.3 Operations

44.3.1 Cholangiography and Liver Biopsy

The surgery is performed using a ×2.5 loupe. In a supine position, the upper abdomen of the patient is elevated using a small pillow and a small incision is made for laparotomy (Fig. 44.1). The gallbladder is identified to perform cholangiography. In most cases the gallbladder is empty and atrophic. If the gallbladder contains any fluid, the fluid is aspirated and kept as a specimen after examining the volume and the color. Then a thin plastic tube is placed in the gallbladder through a small incision, and cholangiography is tried (Fig. 44.2). If the biliary tract from intrahepatic bile ducts to the duodenum is demonstrated during the cholangiography, BA is excluded. Otherwise the diagnosis is confirmed. The type of obstruction is classified according to the Japanese Society of Pediatric Surgeons' classification [1]. If the cholangiography is impossible due to extrahepatic biliary obstruction, the patient has type II (atresia of the hepatic duct) or III (atresia at the porta hepatis), mostly type III. In the patient showing the biliary tract from the gallbladder to the intrahepatic ducts, type I (atresia of the common hepatic duct) is diagnosed. If a cystic structure is associated in the type I BA, such type is called type I cyst. Once the diagnosis of BA is made, the wound is extended for the subsequent corrective surgery. While a hepaticoenterostomy is employed in some patients with types I/I cyst and II, Kasai portoenterostomy is indicated in the majority of the patients of all types. A liver biopsy is performed anytime during the surgery.

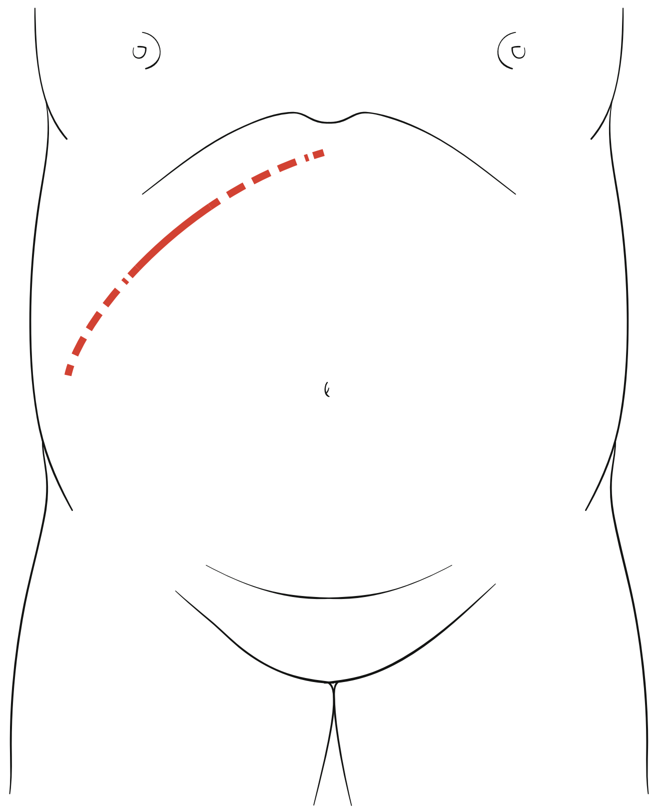

Fig. 44.1 Laparotomy. A small laparotomy is extended for Kasai portoenterostomy after confirming the diagnosis of biliary atresia by cholangiography

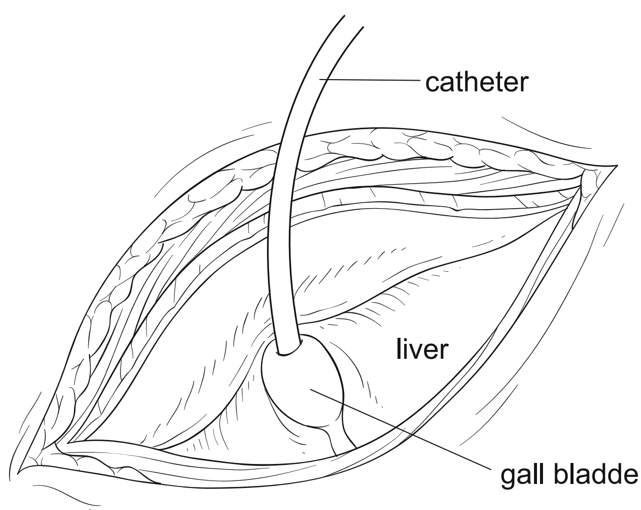

Fig. 44.2 Cholangiography. The content of the gallbladder is aspirated, if existing. A 4 Fr. venous catheter is cannulated from a small incision at the gallbladder and then cholangiography is performed

44.3.2 Dissection of the Extrahepatic Biliary Remnant

The dissection is started from the gallbladder and advanced toward the hepatoduodenal ligament. During the dissection of the hepatoduodenal ligament, the left and the right branches of the hepatic artery and the fibrous common bile duct are identified and taped (Fig. 44.3). The cystic artery is ligated and divided away from the hepatic artery. If dilated lymphatic vessels are encountered, they are ligated before division to prevent postoperative excessive ascites.

The fibrous common bile duct is dissected toward the duodenum, ligated, and divided close to the cranial margin of the duodenum. Subsequently, the dissection of the fibrous remnant is advanced toward the porta hepatis. If the hepatic parenchymal bridge exists between the lateral and medial segments covering the round ligament, it is separated using an electric cautery. This procedure helps better exposure of the fibrous remnant of the umbilical portion.

During the dissection of the fibrous remnant near the arterial branches, small branches to the fibrous remnant are carefully ligated or coagulated by an electric cautery and divided. While the left and right branches of hepatic artery must be preserved, the medial branch is usually ligated and divided because it becomes obstacles of safe and proper techniques of portoenterostomy. The anterior and posterior branches of the right hepatic artery are identified and taped. The dissection is further advanced toward the porta hepatis. During the dissection of around the bifurcation of the portal vein, three to five small branches from the portal vein to the caudate lobe through the fibrous remnant are carefully ligated and divided (Fig. 44.4). Division of these portal branches by an electric cautery is not recommended because of the risk of bleeding. Bleeding from even a small branch of the portal vein sometimes becomes troublesome and may take time for hemostasis. Enough exposure of the caudate lobe makes anastomosis much easier, which may lead to better bile drainage following the surgery.

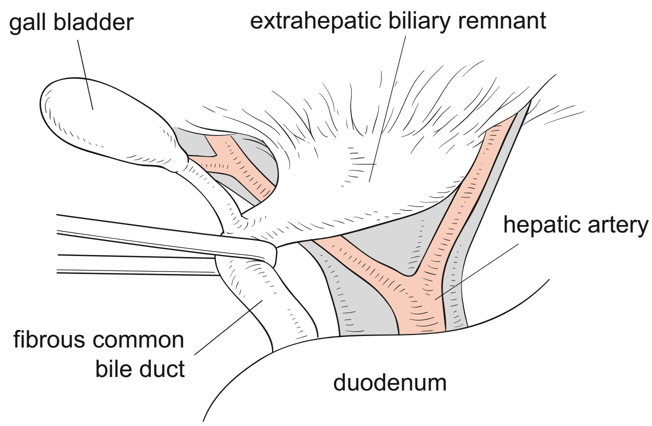

Fig. 44.3 Dissection of the extrahepatic biliary remnant. The left and the right branches of the hepatic artery are identified and taped. The fibrous common bile duct is also identified, taped, and dissected toward the duodenal side

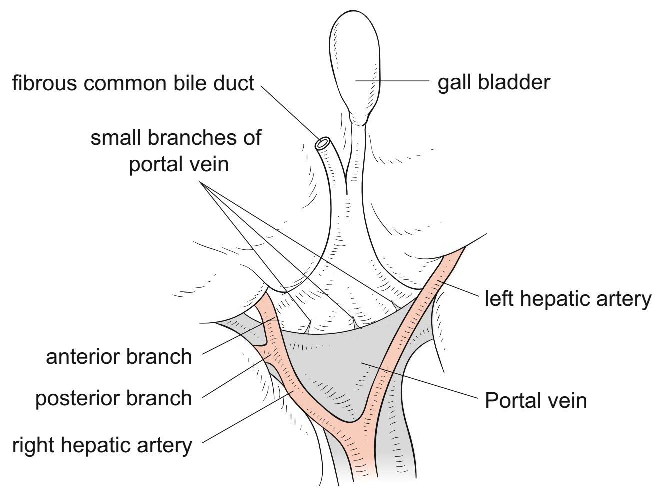

Fig. 44.4 The fibrous common bile duct is divided close to the cranial margin of the duodenum. The gallbladder is pulled up to the cranial side and the dissection of the fibrous remnant is continued. Small branches of the portal vein toward the caudal lobe through the fibrous remnant are carefully ligated and divided

44.3.3 Removal of the Extrahepatic Biliary Remnant

After completion of the dissection between the extrahepatic biliary remnant and its circumferential tissue at the porta hepatis, the fibrous remnant is totally removed. The fibrous remnant is vertically divided in the middle. Small incisions are made in the cranial and caudal sides of the border of the extrahepatic biliary remnant in the middle; tips of a pair of right angle forceps are placed between the fibrous remnant and the underlying capsule of the liver parenchyma (Fig. 44.5) and then the remnant is vertically divided between the tips of the forceps using an electric cautery (Fig. 44.6). The remnant is now separated into two parts, the right and the left parts. These two parts are removed independently using sharp scissors (Figs. 44.7 and 44.8). We never use an electric cautery at this point considering the risk of obstruction of the minute biliary openings exposing at the cut surface of the remnant due to thermal injury. The cut surfaces are located bilaterally just beside the main branches of the portal vein, and they are at the same level as the surrounding liver capsule (Fig. 44.9). If the blood supply from the surrounding vessels is well separated before transection, bleeding from the cut surface is minimal. Gauze packing following irrigation with enough amount of warm saline usually achieves hemostasis against the oozing from

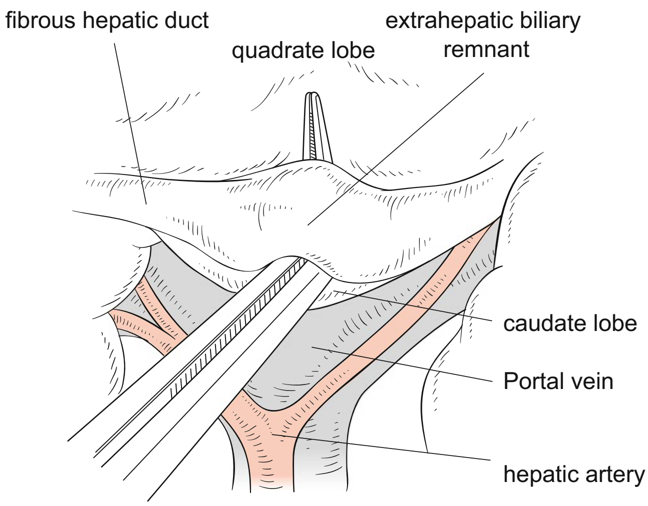

Fig. 44.5 Division of the extrahepatic biliary remnant (*1*). The tips of a pair of right angle forceps are placed between the remnant and the underlying capsule of the liver parenchyma

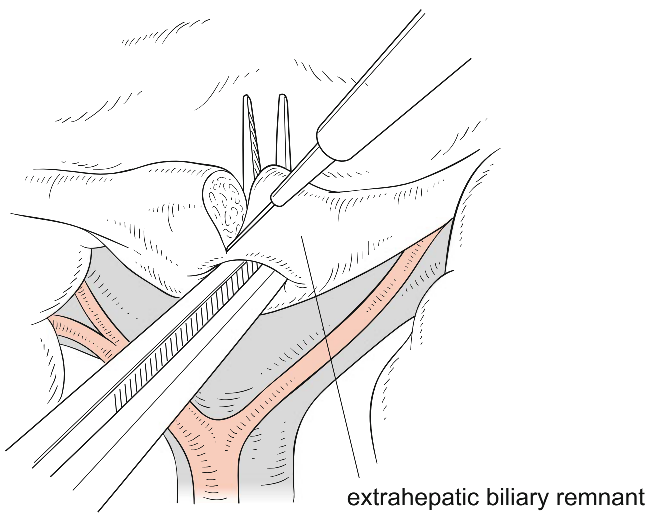

Fig. 44.6 Division of the extrahepatic biliary remnant (*2*). The fibrous remnant is vertically divided between the tips of the forceps using an electric cautery

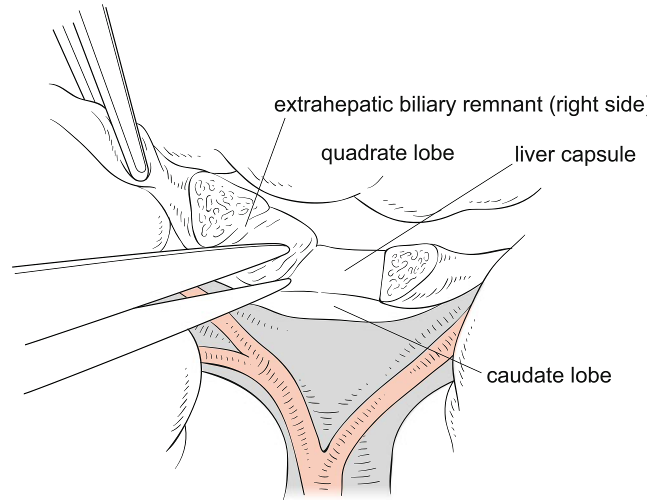

Fig. 44.7 Removal of the remnant (*1*). The right part of the remnant is removed using a pair of sharp scissors. The remnant is totally removed, paying careful attention so as not to injure the liver capsule

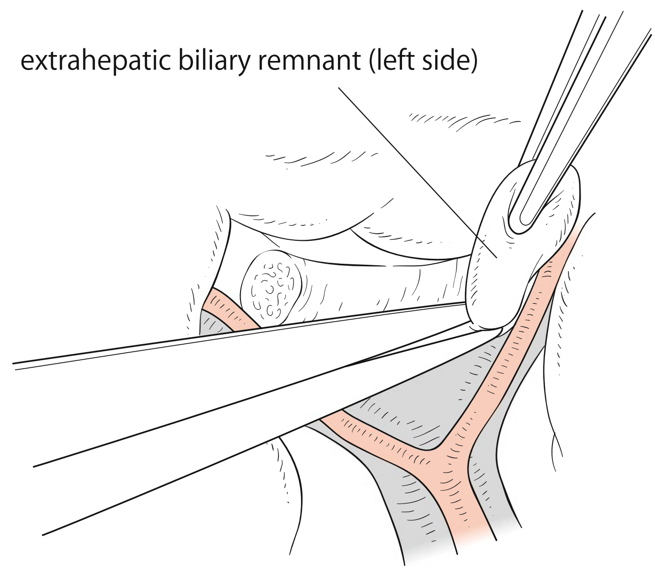

Fig. 44.8 Removal of the remnant (*2*). The left part of the remnant is removed in the same manner as the right side

the cut surface. The width of the cut surface is generally between 15 and 25 mm.

44.3.4 Preparation of the Roux-en Y Limb and the Antireflux Intestinal Spur Valve

The second branch of the jejunal vessels are dissected and divided taking care not to injure the vascular arcade along the jejunum, and the jejunum is transected approximately 10–20 cm away from the Treitz's ligament. Approximately a 50 cm (or 10 cm/kg weight) of the Roux-en Y limb is prepared, and the anastomosis between the oral end of the jejunum and the Roux-en Y limb is performed in the end-to-side fashion by interrupted single-layer stitches using 5-0 PDS II™.

The next step is creation of the antireflux intestinal spur valve [2]. The seromuscular layer of the Roux-en Y limb opposed to the jejunum is hemi-circumferentially removed as long as 2 cm from the Roux-en Y anastomosis. And then the exposed mucosal layer of the Roux-en Y limb is covered by the seromuscular layer of the confronting jejunal wall by several interrupted stitches using 5-0 PDS

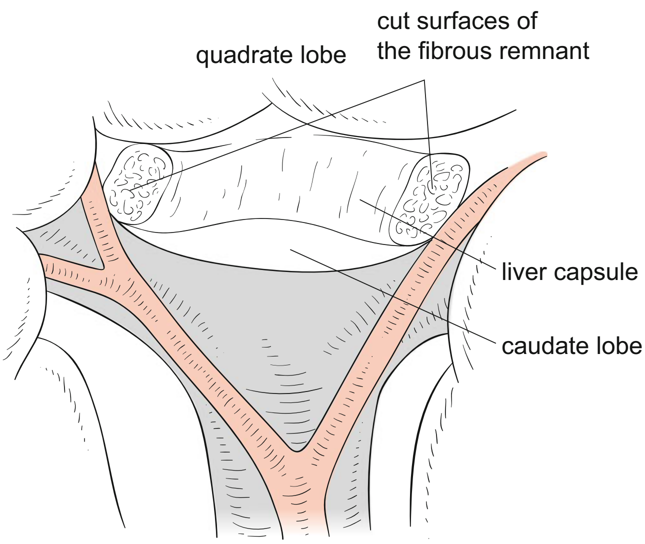

Fig. 44.9 Total removal of the fibrous remnant. The cut surfaces of the fibrous remnant are located bilaterally just beside the main branches of the portal vein. The liver capsule between the cut surfaces of the fibrous remnant is preserved

II™ (Fig. 44.10). After creating the spur valve, the valve function is confirmed at this stage. The space of the mesentery between the Roux-en Y limb and the jejunum is closed by several stitches. The end of the Roux-en Y limb is placed close to the porta hepatis through the retrocolic approach. The Roux-en Y limb is fixed to the mesocolon by several stitches at approximately 15 cm away from the end of the limb.

44.3.5 Hepatic Portoenterostomy

A catheter is cannulated into the Roux-en Y limb from the end and the limb is irrigated using enough amount of warm saline. The end of the limb is trimmed adjusting to the length between the main portal branches at the porta hepatis. The hepatic portoenterostomy is performed in the end-to-back fashion. The cut surfaces of the fibrous remnant are located bilaterally just beside the main branches of the portal vein. The anastomosis is performed to cover the cut surfaces by the end of the Roux-en Y limb by interrupted stitches using 5-0 PDS II™. Special care is taken during placing lateral stitches close to the cut surfaces of the fibrous remnant as not to involve the cut surfaces into the stitches. Small and shallow stitches are recommended in this area. On the other hand, during placing the stitches between the caudate lobe and the intestine, big bites are allowed because of no biliary structure existing in the central area. Relatively big and deep central stitches are placed intending to reinforce the anastomosis. After placing all stitches of the posterior row, they are tied. After confirming that the complete hemostasis at the porta hepatis is achieved and that the cut surfaces of the fibrous remnant are well exposed not involved in the stitches, stitches of the anterior row are placed in the same manner. A single-layer anastomosis is usually performed for portoenterostomy (Fig. 44.11). However, several additional stitches between the hepatic parenchyma and the intestine are placed if needed.

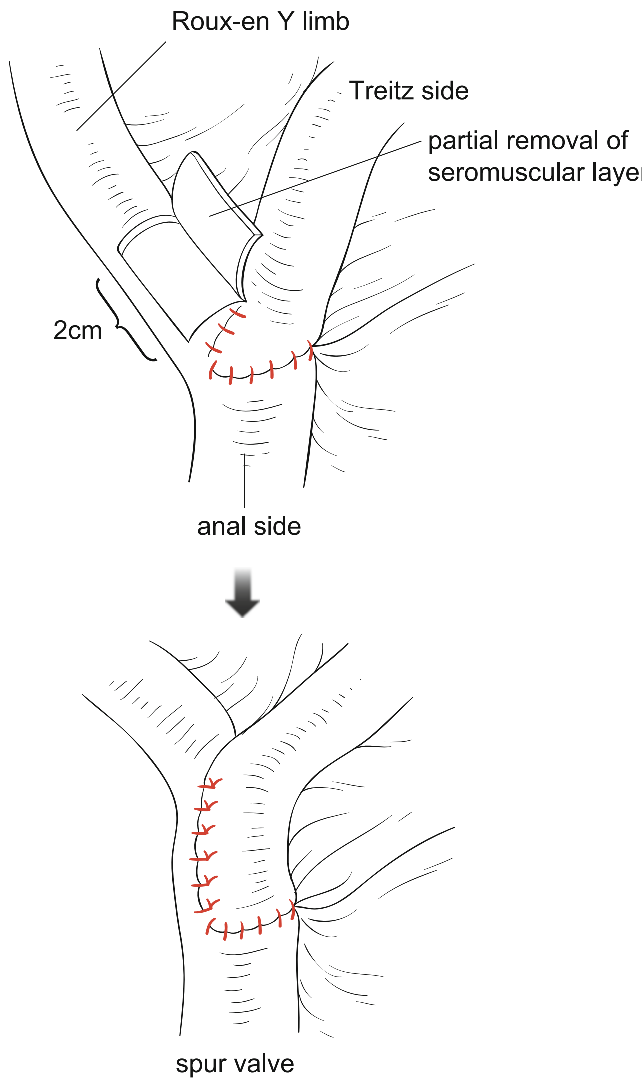

Fig. 44.10 Creation of the antireflux intestinal spur valve. The seromuscular layer of the Roux-en Y limb opposed to the jejunum is hemi-circumferentially removed as long as 2 cm from the Roux-en Y anastomosis. The exposed mucosal layer of the Roux-en Y limb is covered by the confronting jejunal wall by several interrupted stitches

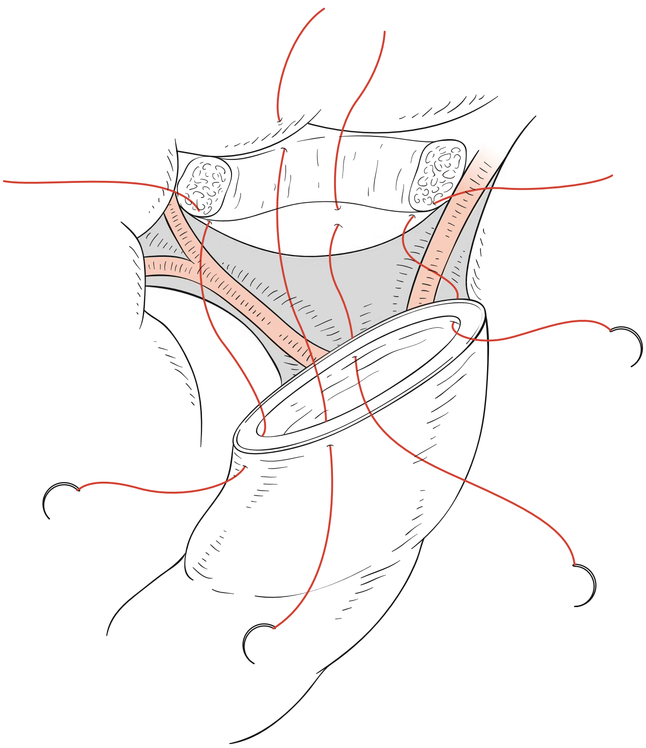

Fig. 44.11 Hepatic portoenterostomy. The hepatic portoenterostomy is performed in the end-to-back fashion. Special care is taken during placing the lateral stitches close to the cut surfaces of the fibrous remnant so as not to involve the cut surfaces into the stitches. Relatively big and deep central stitches are placed intending to reinforce the anastomosis

44.3.6 Abdominal Irrigation, Drainage, and Wound Closure

The abdominal cavity is irrigated using enough amount of warm saline and complete hemostasis is confirmed again. A small-sized closed drain is placed in the Winslow's foramen, the undersurface of the liver and the intestine facing to the abdominal wound are covered by Seprafilm®, and the abdomen is closed in the layer-to-layer fashion.

44.4 Postoperative Management

Major concerns are focused on the maintenance of bile drainage and prevention of the cholangitis. If the postoperative circulatory condition is well stabilized and urination is appropriately achieved, enough volume of IV fluid (120 ml/kg weight/day) is administered aiming maintenance of hepatic circulation and bile drainage. Antibiotics of broad spectrum are selected and given intravenously from the day 0. Oral feeding should be started when the intestinal function is well recovered. On the day 7, oral administration of 4 mg/kg weight/day of prednisolone is stated. Oral administration of 10–30 mg/kg weight/day of ursodeoxycholic acid is also started as early as possible after establishing oral feeding. Appropriate volume of fat emulsion and fatty soluble multivitamins are also given intravenously.

Recently, most patients pass acholic stools after Kasai portoenterostomy. However, some patients develop recurrence of jaundice with/without cholangitis postoperatively. In such patients, the indication of the redo-Kasai portoenterostomy is considered. The patient in whom excellent bile flow is once achieved after the Kasai portoenterostomy and the bile flow suddenly stops is believed to be the best candidate of the redo surgery. Before deciding the indication of the redo surgery, the condition of the hepatic functional reserve and the availability of liver transplantation should be well evaluated.

44.5 Comment on the Intestinal Valve

The employment of the intestinal valve procedure is still controversial. In Japan approximately 90 % of the patients currently undergo the Roux-en Y portoenterostomy, and the remaining 10 % of the patients undergo the Roux-en Y with the valve procedure according to the Japanese Registry of Biliary Atresia. The jaundice clearance rate of these two procedures is almost the same (61–62 %). However, the complication rate of the cholangitis is lower in the valve procedure (33 %) than in the Roux-en Y portoenterostomy without a valve (41 %), and for this reason we currently employ the valve procedure. An intussuscepted valve had been employed as well as a spur valve in the Tohoku University Hospital; it was abandoned due to the potential risk of complications such as the Roux-en Y obstruction in 2001.

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Choledochal Cyst

45

Minoru Yagi, Kimio Asagiri, and Suguru Fukahori

Abstract

Radical excision of the choledochal cyst and reconstruction by hilar hepaticojejunostomy are the optimal treatments for the choledochal cyst. This disconnects the pancreatic and biliary ducts.

Internal drainage of the cyst by cystenterostomy has a prohibitively high long-term morbidity from cholangitis, stone formation, and malignant change and should be avoided. Definitive surgical excision may be unsafe in a critically sick children with perforation or serious concomitant complications. In such cases, temporary external drainage such as cholecystostomy, and delayed surgery once the patient has improved and the anatomy has been defined, is safer.

Postoperative complications are relatively rare, but early problems may include an anastomotic bile leakage, bleeding, intra-abdominal sepsis, injury to adjacent structures, and wound complications. Late complications are anastomotic stricture of the hepatico-jejunostomy, hepatolithiasis, pancreatitis from residual abnormalities in the common channel, and adhesive ileus. Even after adequate cyst excision, malignancy may very rarely affect residual extrahepatic ducts.

Keywords

Choledochal cyst • Hepaticoenterostomy • Pancreatitis

Congenital bile duct dilatation is pediatric representative disease showing surgical jaundice ranged with biliary atresia. Choledochal cyst is the traditional term. There are generally categorized as cystic and fusiform types in the common bile duct. Todani's classification is most commonly used [1]. Actually, there are mild dilatation types of the common bile duct with or without intrahepatic bile duct dilatation. Collectively, they are called choledochal cyst or congenital bile duct dilatation.

There are frequently identified in Oriental children comparing to European children. Girls are affected more often than boys. The patients' age is ranged from fetus prenatally diagnosed by ultrasonography to adults. Most of the patients are below 10 years old.

It is the optimal treatment for the common types of choledochal cyst in principle to excise extrahepatic bile duct including choledochal cyst as possible and to separate bile flow and pancreatic juice flow. Hilar hepatico-jejunostomy is recommended as reconstruction.

Forty or fifty years ago, internal drainage of the cyst by cystenterostomy was performed in Japan. However, cyst-enterostomy has a prohibitively high long-term morbidity

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from cholangitis, hepatolithiasis, and malignant degeneration and should be avoided.

There are several reconstructive types of hepaticoenterostomy as following: hepaticojejunostomy with Roux-en-Y, hepaticoduodenostomy, and hepaticoduodenostomy with jejunal interposition. Hepaticojejunostomy with Roux-en-Y is a common procedure. In this section, we present hepaticojejunostomy with Roux-en-Y by laparotomy as reconstruction of choledochal cyst.

45.1 Preoperative Preparation

From the view point of complicated pathological etiology, modern imaging methods including ultrasound scan, MRCP, ERCP, and three-dimensional DIC-CT provide sufficient anatomical information for an accurate diagnosis.

The pathology of a choledochal cyst is principally the existence of pancreaticobiliary malunion, which is present in most. Consequently, it shows intra- and/or extrahepatic bile duct dilatation. The terminal common bile duct and pancreatic duct unite to form a common channel well outside the duodenal wall. As this common channel is not surrounded by the normal sphincter mechanism, pancreatic juice refluxes into the bile duct, and high concentrations of pancreatic juice are typically present in the bile. Bile refluxes into the pancreatic duct occasionally cause pancreatitis. Protein plugs within a common channel or pancreatic duct or proximal side of the choledochal cyst often elevates the pressure of biliary tract. Consequently, pancreatitis due to above pathology is sometimes intractable.

Radical operation may be unsafe in critically sick children with perforation or serious concomitant complications. In such cases, temporary external drainage such as cholecystostomy, and delayed surgery once the patient has improved and the anatomy has been defined after sufficient conservative therapy including nothing by mouth, protease inhibitor, antibiotics, and so on, is safer to avoid postoperative serious complications.

Glycerine enema (1 ml/kg) in the previous evening and the morning of the operative day is useful for the satisfactory operative procedure.

45.2 Operative Procedure

45.2.1 Positioning, Skin Incision, Laparotomy

A high-transverse incision gives excellent exposure in the supine position (Fig. 45.1).

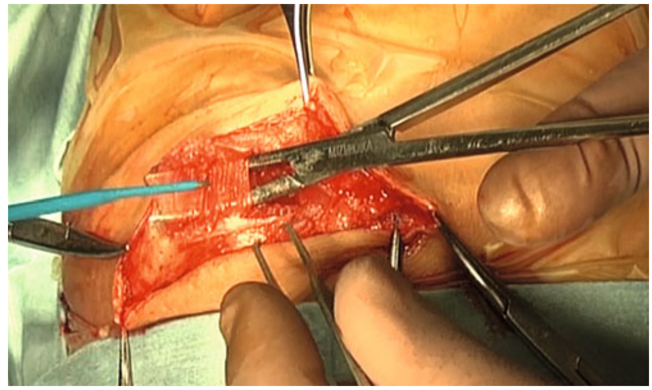

Fig. 45.1 A high-transverse skin incision

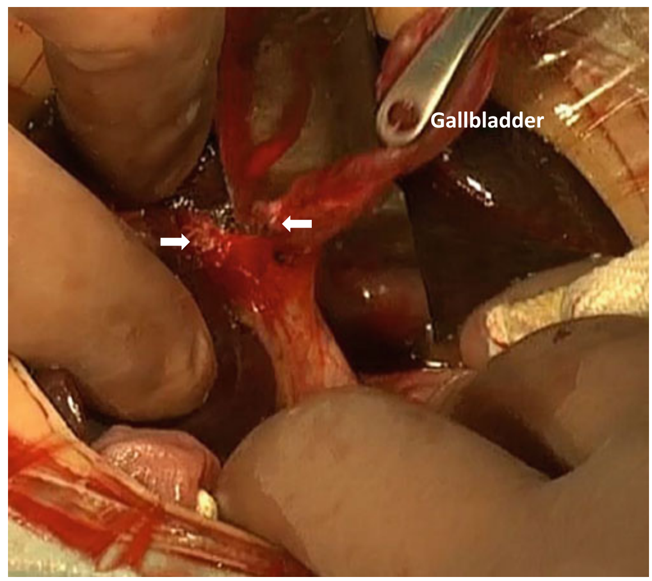

Fig. 45.2 After the gallbladder and cystic duct are mobilized and exposed from the liver bed, cystic artery is ligated and excised (→)

45.2.2 Gallbladder Mobilization from the Liver Bed

After the gallbladder and cystic duct are mobilized and exposed from the liver bed, cystic artery is ligated and excised. Cystic duct is ligated at the proximal infundibular site (Fig. 45.2, arrow).

Thereafter, bile is aspirated from the gallbladder and sent for culture and measurement of amylase/elastase-1 to examine regurgitation of the pancreatic juice.

45.2.3 Mobilization and Exposure of the Common Bile Duct (Choledochal Cyst)

The dissection extends inferiorly between the duodenum and the choledochal cyst and circumferentially keeps close to the choledochal cyst wall under careful identification of common hepatic artery and portal vein, while traction of choledochal cyst encircled with a vessel tape, using precise cautery to achieve safe and accurate hemostasis (Fig. 45.3). In this area, small vessels arising from the pancreas need careful cautery. Bile is aspirated from the choledochal cyst and sent for culture and measurement of amylase/elastase-1 to examine regurgitation of the pancreatic juice.

Thereafter, choledochal cyst is divided at just above cystic duct orifice (Fig. 45.4). The operative cholangiogram gives useful guide to the duodenal side of choledochal cyst transection. It is important to try to identify the junction of the pancreatic and bile ducts. Where the bile duct begins to narrow down inferiorly, it is dissected circumferentially and encircled. The duodenal side of choledochal cyst is dissected to just within the head of the pancreas and transected (Fig. 45.5). The duodenal side of the bile duct stump is managed with simple ligation and transfixing suture with 4-0 prolene (polypropylene monofilament suture) in the distal side (Fig. 45.6).

Protein plugs within a common channel or pancreatic duct or proximal side of the choledochal cyst should be washed out and removed using a combination of saline irrigation and catheters to prevent from postoperative pancreatitis before ligation of the duodenal side of choledochal cyst.

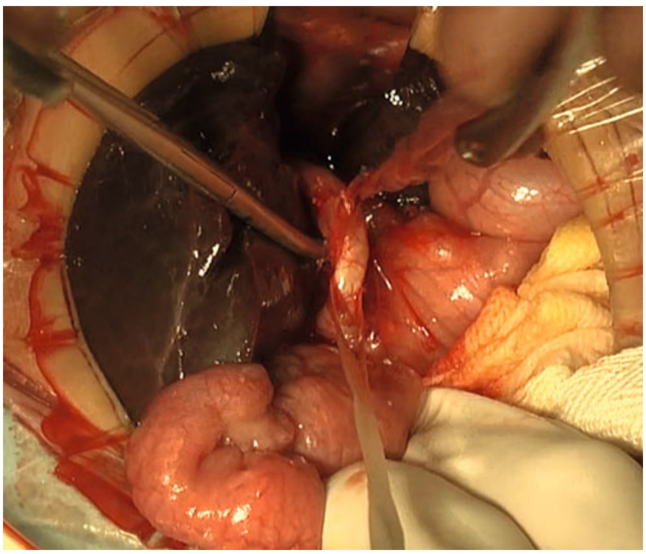

Fig. 45.3 Dissection and traction of choledochal cyst encircled with a vessel tape

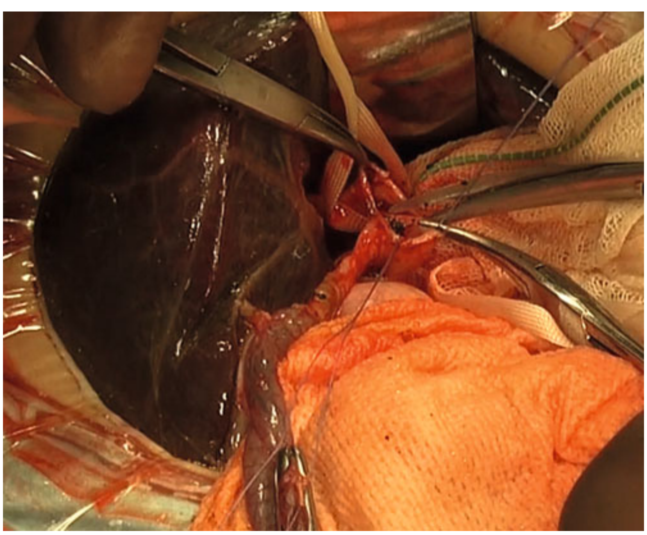

Fig. 45.4 Division of the choledochal cyst just above the cystic duct orifice

45.2.4 Dissection and Transection of the Common Hepatic Duct Including Choledochal Cyst in the Hepatic Hilum

After dividing of common hepatic duct just above cystic duct orifice, the hepatic side of the choledochal cyst is lifted forward and dissected (Fig. 45.7a). Under careful identification of common hepatic artery and portal vein, common hepatic duct should appear well vascularized.

The operative cholangiogram gives useful guide to the hepatic side of bile duct transection. It is important to transect the bile duct just under hepatic hilum as possible, not to leave remnants of the extrahepatic bile duct stenosis

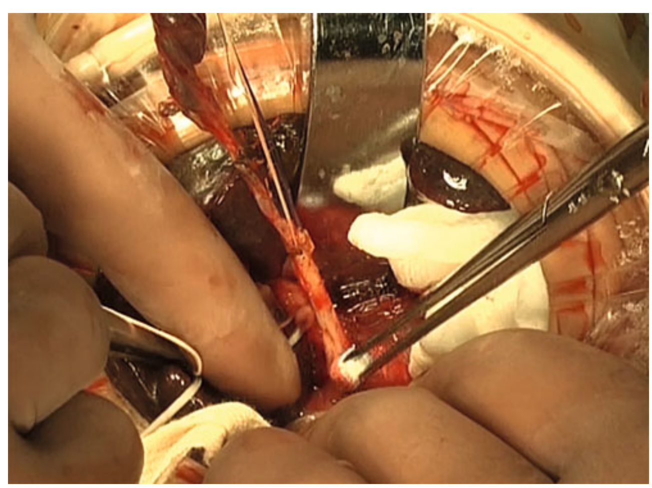

Fig. 45.5 Dissection of the duodenal side of the choledochal cyst just within the head of the pancreas

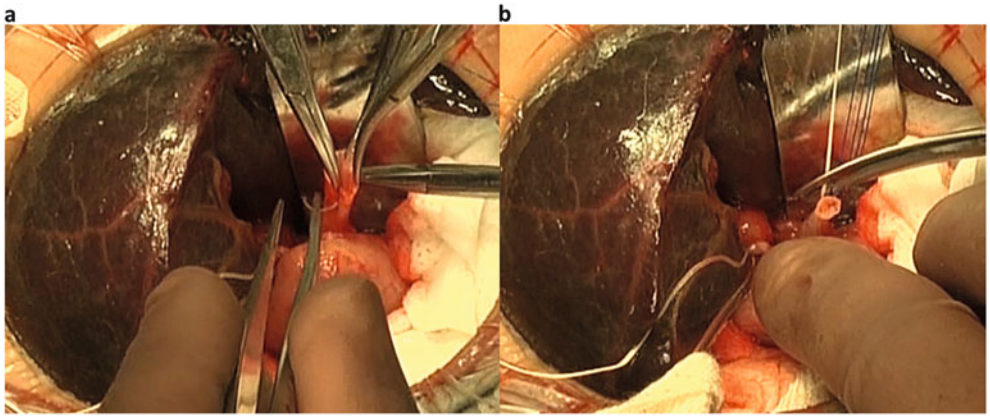

Fig. 45.6 Management of the duodenal side stump of the bile duct. (**a**) Ligation and transfixing suture in the stump of the intrapancreatic bile duct just above the common channel. (**b**) Excision of the remnant stump of the intrapancreatic bile duct

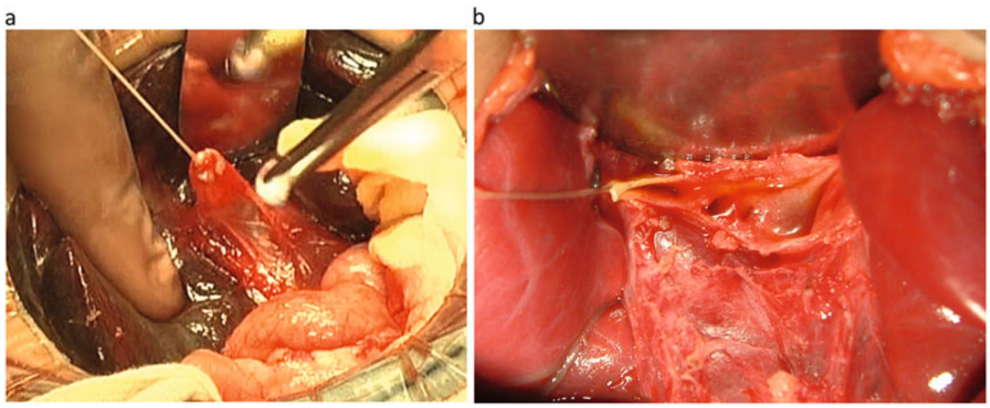

Fig. 45.7 Transaction of the common hepatic duct including choledochal cyst in the hepatic hilum. (**a**) The common hepatic duct including choledochal cyst in the hepatic hilum is lifted forward and dissected. (**b**) Transection of the common hepatic duct just under hepatic hilum as possible, not to leave remnants of the extrahepatic bile duct stenosis

(Fig. 45.7b). Remnants of the extrahepatic bile duct stenosis lead to hepatolithiasis in the long term. In this series, any dilated proximal intrahepatic ducts are cleared of debris by catheter irrigation with normal saline.

45.2.5 Liver Biopsy

It is essential to evaluate liver histology from the view points of cholestasis and fibrosis especially in the patients with prolonged jaundice. A wedge biopsy of the liver is performed at lower edge of right or left lobe.

45.2.6 Roux-en-Y Loop Construction

The duodenojejunal flexure is identified and the jejunum divided at approximately 30 cm downstream. At this point, there is a suitable vascular arcade to create a Roux-en-Y loop that will reach the hepatic hilum without tension. A 30 cm Roux-en-Y loop is adequate in infants. The proximal stump of jejunum is anastomosed in an oblique end-to-side fashion to the distal jejunum using Albert-Lembert's anastomosis with interrupted 4-0 absorbable sutures (Fig. 45.8, arrow). The distal end of the Roux-en-Y loop (Fig. 45.9, arrow) is passed through a window in the transverse mesocolon to the right of the middle colic vessels (retrocolic route) (Figs. 45.9 and 45.10).

45.2.7 Wide Hilar Hepaticojejunostomy

There are some dilatations of the intrahepatic bile duct in the first branch of the right or left hepatic duct in the most patients with choledochal cyst. It is important to anastomose without remnants of the extrahepatic bile duct stenosis at the hepaticojejunostomy [2]. In case of bile duct dilatation in the first branch of the right or left hepatic duct, it is easy to

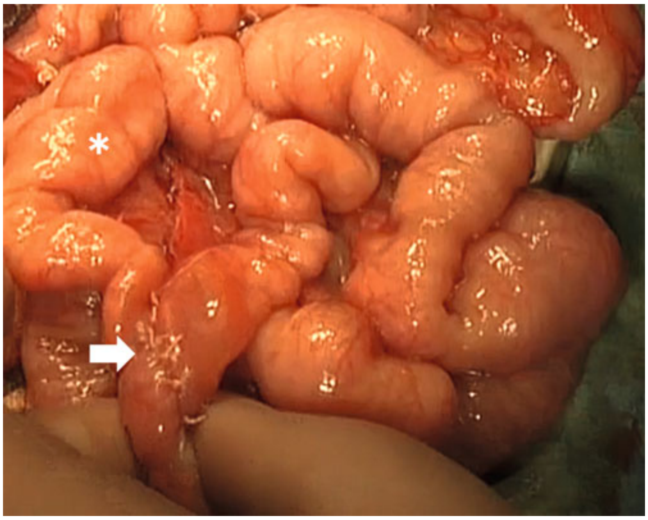

Fig. 45.8 The proximal stump of Roux-en-Y loop construction. End-to-side anastomosis between the proximal stump of jejunum and the distal jejunum (*white arrow*). *Roux-en-Y loop

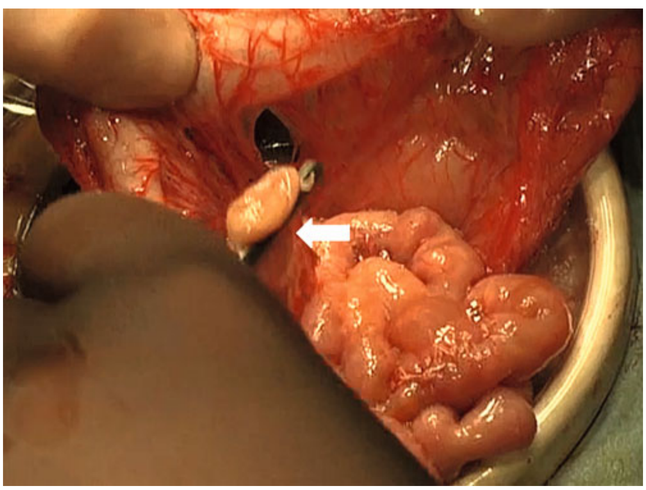

Fig. 45.9 Arrangement of the distal end of the Roux-en-Y loop. The distal end of the Roux-en-Y loop (*white arrow*) toward the hepatic hilum (retrocolic route)

identify reversed infundibular hepatic duct dilatation by dissecting hepatic hilum. It should be excised the hepatic duct in the first branch of the right or left hepatic duct (Fig. 45.7b).

The distal Roux-en-Y loop of jejunum is widely anastomosed via retrocolic route in an end-to-end fashion to the hepatic duct bifurcation at the hilum of the liver using a single layer of fine, interrupted, absorbable sutures (5/0 or 6/0) to avoid the development of a blind pouch (Fig. 45.10, anastomotic region of Roux-en-Y loop side) (Fig. 45.11a: posterior wall anastomosis) (Fig. 45.11b: anterior wall anastomosis).

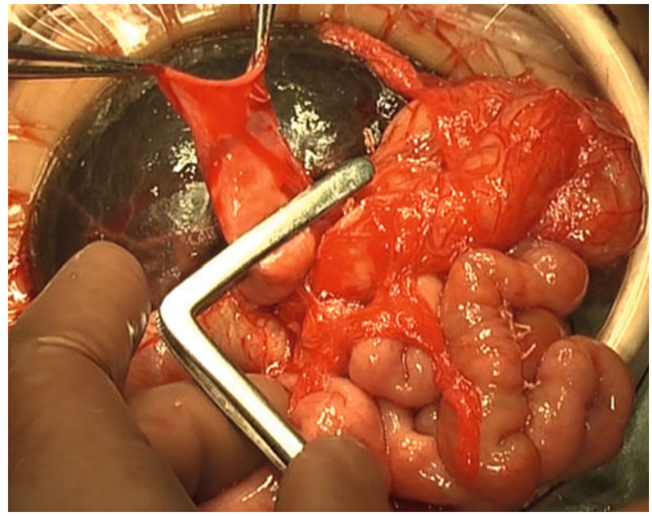

Fig. 45.10 The distal end of the Roux-en-Y loop via retrocolic route

45.2.8 Closure of the Abdomen

Mesenteric defects in the transverse mesocolon and small bowel mesentery are closed with 5-0 absorbable sutures. After the operative field is washed with warm saline, the abdomen is closed by three layers with insertion of anti-adhesive sheet. A drain should be placed in Morison's pouch and not in direct contact with the anastomosis (Fig. 45.12).

45.3 Postoperative Management

Postoperative management after pediatric general surgery is principally applied. Nasogastric tube is placed till bowel activity is recovered. After identifying first flatus and defecation, oral intake is started. If there is no problem, the drain is removed in the seventh to tenth postoperative day. Prognosis is relatively good. Cholangitis, pancreatitis, and hepatolithiasis must take into consideration noninvasive examination such as echography in the postoperative follow-up.

Anastomotic leakage is likely to resolve with local drainage, intravenous antibiotics, and nasogastric decompression, but it may be followed by anastomotic stricture. Postoperatively, biochemical liver function tests should return to normal.

Cholangitis may signify an anastomotic stricture, a hepatolithiasis, and a Roux-en-Y loop obstruction. Imaging methods including percutaneous transhepatic cholangiography may be able to clear stones and dilate strictures, but surgery is usually required to revise anastomotic stricture of hepaticojejunostomy [3].

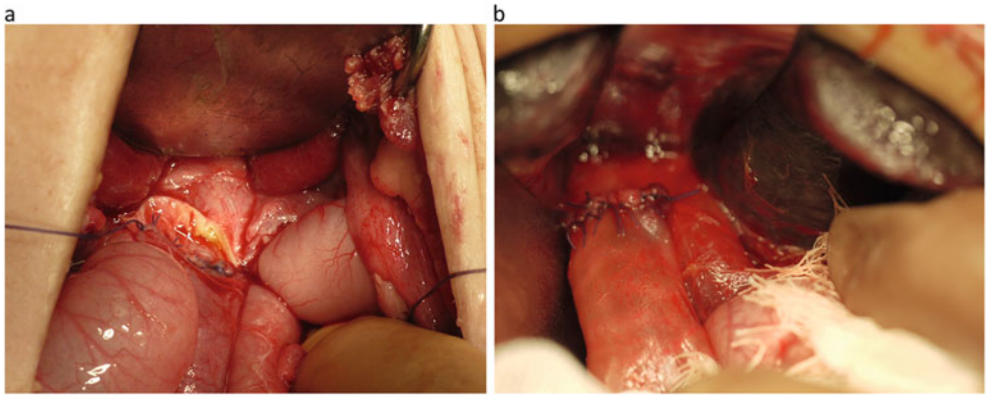

Fig. 45.11 Wide hilar hepaticojejunostomy. (**a**) Posterior wall anastomosis, (**b**) anterior wall anastomosis

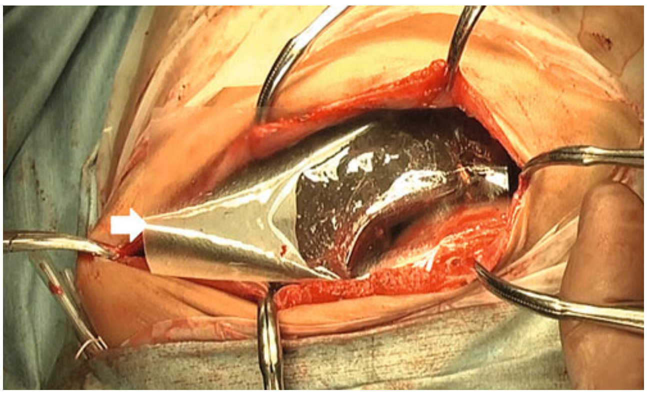

Fig. 45.12 Closure of the abdomen. Closure of the abdomen by three layers with inserting anti-adhesive sheet (*arrow*) just beneath the operative wound

Pancreatitis may develop many years later in patients with a dilated or complex common channel containing protein plugs. This complication is usually preventable by appropriate primary surgery. ERCP is a useful investigation in such patients, and endoscopic sphincterotomy may be curative.

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Splenectomy

46

Tomohiro Ishii and Takeo Yonekura

Abstract

Splenectomy is indicated for several hematologic disorders, splenic cyst, abscess, and trauma. In elective splenectomy, preoperative vaccinations are recommended for preventing serious infectious complications after the splenectomy. An elective splenectomy except the patients associated with splenomegaly is usually an uncomplicated operation with minimal bleeding. Recently, laparoscopic procedures have become a more widely applied modality particularly for an elective splenectomy. Surgical procedures of splenectomy require a precise knowledge of anatomy. Mobilization of the spleen is conducted by dissecting the ligamentous attachments to the abdominal wall and the diaphragm, which is followed by the dissection between the stomach and the spleen. After these dissections, splenic hilar vessels are ligated and splenectomy is completed. Care must be taken not to injure the tail of the pancreas since it lies close to the splenic hilum. The accessory spleen should be sought and removed in the case of hematological diagnoses to prevent the possible recurrence of symptoms. In case of splenic trauma where hemostasis is the uppermost and urgent issue, splenic hilar dissection and clamping should be undertaken initially to achieve temporary hemostasis. Partial splenectomy can be indicated for selected conditions such as localized splenic contusion without hemodynamic instability, splenic cyst, and splenic abscess.

Keywords

Open splenectomy • Partial splenectomy • Splenic trauma

46.1 Indication

Splenectomy itself is commonly indicated in children with medically uncontrollable hematologic disorders, such as idiopathic thrombocytopenic purpura, hereditary spherocytosis, thalassemia major, and sickle cell disease. It is also performed for splenic tumor, cyst, abscess, and trauma; however, partial rather than total splenectomy may be indicated. Laparoscopic procedures have recently become a more common modality. Open splenectomy is still preferred for the patients with splenomegaly due to technical difficulties; however, the number of reports describing the safety and feasibility of the laparoscopic splenectomy for splenomegaly patients is increasing [1].

46.2 Anatomy

Ligamentous attachments of the spleen to adjacent organs include the phrenosplenic ligament to the diaphragm, splenocolic ligament to the splenic flexure of the colon, splenorenal ligament to the left kidney, and the gastrosplenic ligament to the stomach. The first three ligaments maintain

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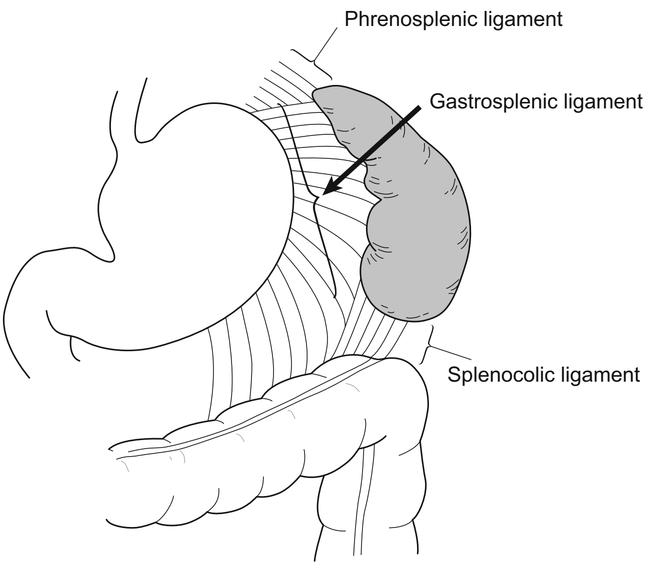

Fig. 46.1 Ligamentous attachments of the spleen

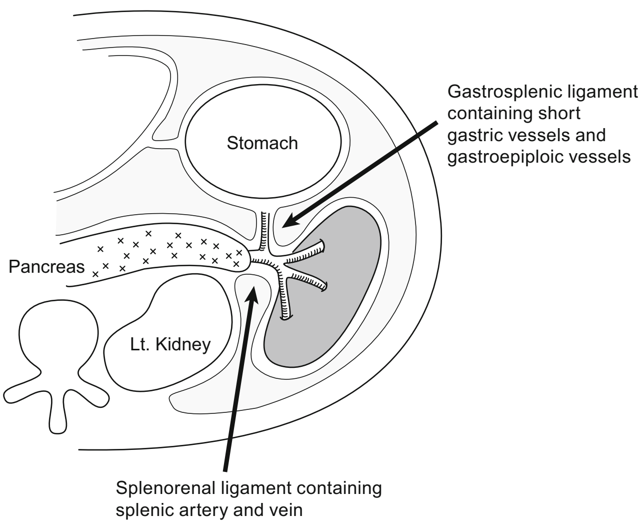

Fig. 46.2 Splenorenal and gastrosplenic ligaments and their vascular contents

the attachment of the spleen to the retroperitoneal surface and to the diaphragm, while the gastrosplenic ligament lies between the spleen and the stomach. The splenorenal ligament contains the splenic artery and veins, and the gastrosplenic ligament contains short gastric and left gastroepiploic vessels (Figs. 46.1 and 46.2).

46.3 Preoperative Immunization

Vaccinations for *Streptococcus pneumoniae*, *Haemophilus influenzae*, and *Neisseria meningitidis* are mandatory in elective splenectomy at least 2 weeks before the surgery to decrease the risk of overwhelming post-splenectomy infection (OPSI) [2].

46.4 Operations

46.4.1 Preparation of the Patient

The patient is placed in the supine, semi-decubitus, or decubitus position. Immobilization of the patient is important for utilizing the intraoperative position change especially when in the semi- and full decubitus position. In decubitus position, placement of a roll under the lower chest may be helpful for better exposure. A nasogastric or orogastric tube should be inserted for gastric decompression.

46.4.2 Incision and Exploration

A transverse skin incision from the midline to mid-axillary line is made. A left subcostal incision may provide better exposure for older patients with a narrow costal margin. A midline incision should be utilized for splenic trauma cases, since other intraperitoneal visceral injuries may be coincided (Fig. 46.3). After the laparotomy, the accessory spleen should be sought, most often found around the splenic hilum. The tail

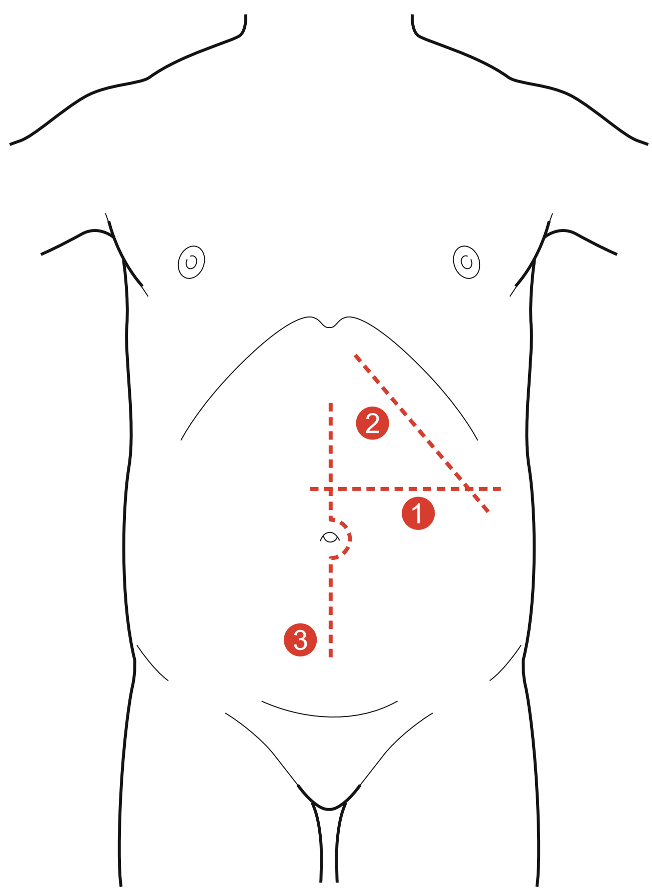

Fig. 46.3 Skin incision. (*1*) Transverse incision from the midline to mid-axillary line. (*2*) Left subcostal. (*3*) Midline

of the pancreas, the splenocolic ligament, the greater omentum, and the presacral area should also be inspected because leaving the accessory spleen can cause recurrence of the symptoms of some hematologic diseases [3]. The gallbladder should also be palpated to check for gallstones particularly in patients with hemolytic disease. Cholecystectomy is recommended when the gallstone is identified.

46.4.3 Mobilization of the Spleen

Splenophrenic and splenocolic ligaments are dissected by using electrocautery with gentle grasping and retracting of the spleen to caudal and cranial direction. A rough retracting maneuver may cause the unexpected bleeding from the splenic surface, therefore should be avoided. This is particularly emphasized in splenomegaly cases. The splenorenal ligament, which is the lateral attachment to the abdominal wall, is incised with the help of medial retraction or even delivery of the spleen out of the abdominal cavity. The incision should be made near the abdominal wall to prevent from entering the splenic surface itself incorrectly. The tail of the pancreas near the splenic hilum and vessels running into/from the spleen will be visualized by this dorsal mobilization (Fig. 46.4). Placing sponges or gauzes in the posterolateral fossa helps to control hemostasis from the dissected surface and keep the spleen upward position.

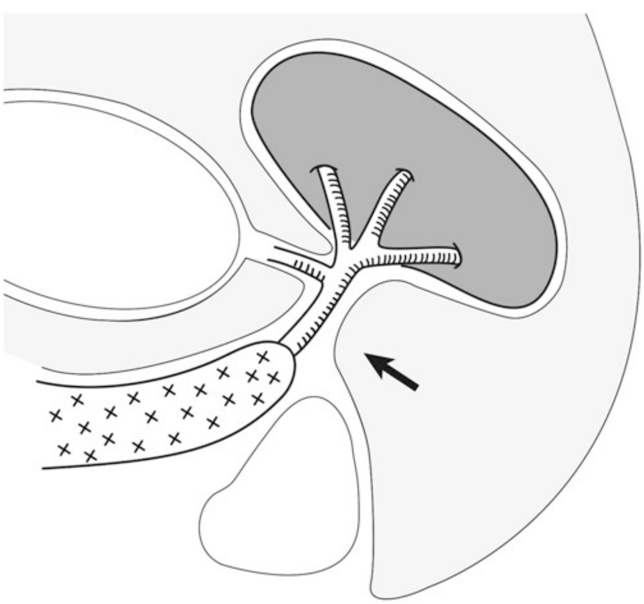

Fig. 46.4 Dissection of the splenorenal ligament (dorsal dissection)

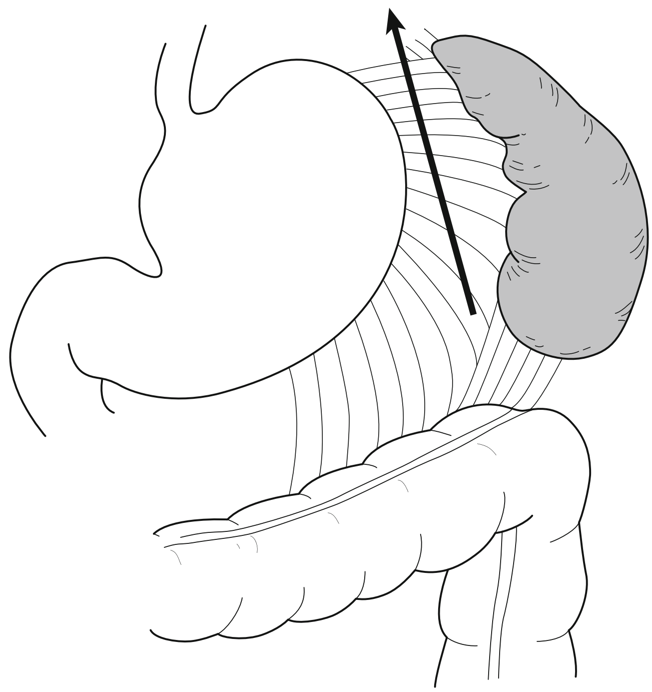

Fig. 46.5 Dissection of gastrosplenic ligament

46.4.4 Dissection of the Gastrosplenic Ligament

The gastrosplenic ligament which contains the short gastric vessels and the left gastroepiploic vessels is ligated and divided, or dissected by an energy device (e.g., vessel sealing system or ultrasonically activated device) (Fig. 46.5). Medial traction of the greater curvature of the stomach facilitates the exposure of the ligament. Any possible gastric wall injury during this dissection should be oversewn. The anterior dissection is completed by the release of this ligament.

46.4.5 Ligation of the Splenic Artery and Vein

Now splenic pedicle is isolated and ready to be divided (Fig. 46.6). Before clamping of the hilar vessels, a gentle squeeze may be applied to the spleen so that some of the blood in the spleen returns to the circulation. The artery and vein are then tied and divided. Care should be taken not to injure the tail of the pancreas, as it sometimes lies very close to the splenic hilum. In such circumstances, the splenic hilum is dissected and the branches of the splenic artery and vein are individually ligated away from the pancreatic tail. The stapler device can also be used to divide the pedicle as a whole. Again, the injury of the tail of the pancreas should be avoided during the stapling.

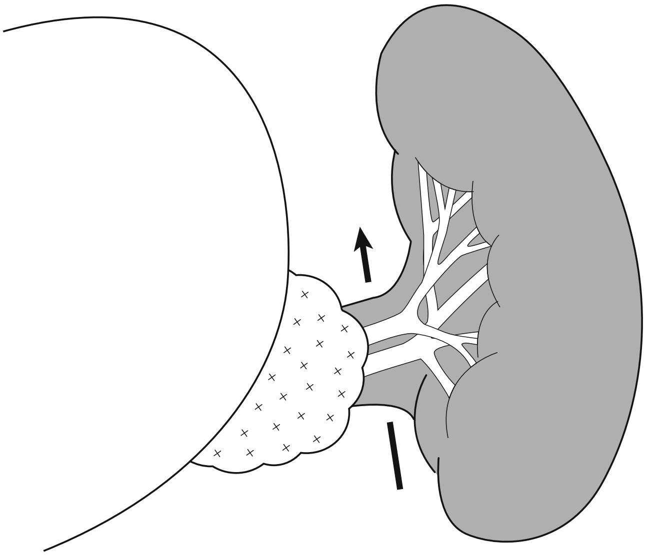

Fig. 46.6 Division of splenic hilum

46.4.6 Re-exploration of the Abdominal Cavity

The splenic fossa and adjacent area are irrigated with warm saline and inspected for hemostasis. The accessory spleen is inspected again. A drainage tube is not routinely placed unless there is suspicion of a pancreatic injury. Wound is closed in the surgeon's preferring manner.

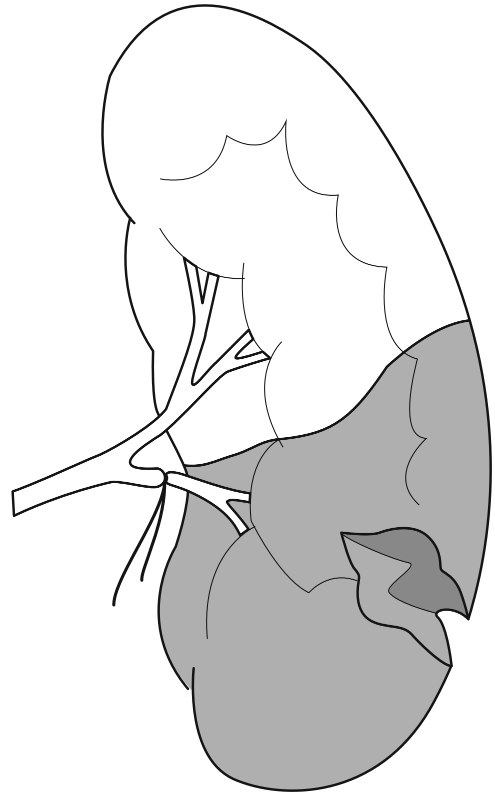

Fig. 46.7 Partial splenectomy for splenic trauma, ligation of lobar/segmental vessel corresponding to the injury area

46.5 Splenectomy for Trauma

46.5.1 Indication

Hemodynamically unstable cases even with initial fluid resuscitation should undergo an immediate operation [4]. The patients who do not respond to the nonoperative management also require surgical intervention.

46.5.2 Total Splenectomy vs Partial Splenectomy

Total splenectomy is indicated for patients with unstable circulation intraoperatively, coagulopathy, or multiple organ injury. Partial splenectomy or splenic repair is otherwise considered for the preservation of the immunological function of the spleen.

46.5.3 Total Splenectomy

In contrast to the elective splenectomy, total splenectomy for trauma needs rapid hemostasis. After entering the abdominal cavity, anteromedial traction of the spleen by the surgeon's non-dominant hand is applied. Wrapping the damaged spleen with gauze may help to control the bleeding. The posterolateral attachment is dissected sharply or bluntly, so that the spleen is mobilized out of the abdominal cavity. This dissection is continued underneath the pancreas. After temporal hemostasis is achieved by occluding the splenic hilar vessels by the surgeon's fingers, the extent of the injury is assessed. Application of temporal hilar occlusion with a vascular clamp may also be helpful. If total splenectomy is indicated, hilar vessels are ligated and divided from the posterior aspect of the hilum. Care should be taken to avoid the injury of the pancreatic tail. Hilar division is followed by the dissection of the gastrosplenic ligament. Accessory spleen should be in situ for possible preservation of the immunological function.

46.5.4 Partial Splenectomy and Splenic Repair

Partial splenectomy for trauma is indicated for deep splenic injury without the involvement of the hilar vessels. After the adequate mobilization, the extent and localization of the injury are assessed. Lobar or segmental vessels corresponding to the injury area will be tied and divided, followed by the splenic parenchymal resection along to the vascular demarcating line (Fig. 46.7). Bleeding from the cut

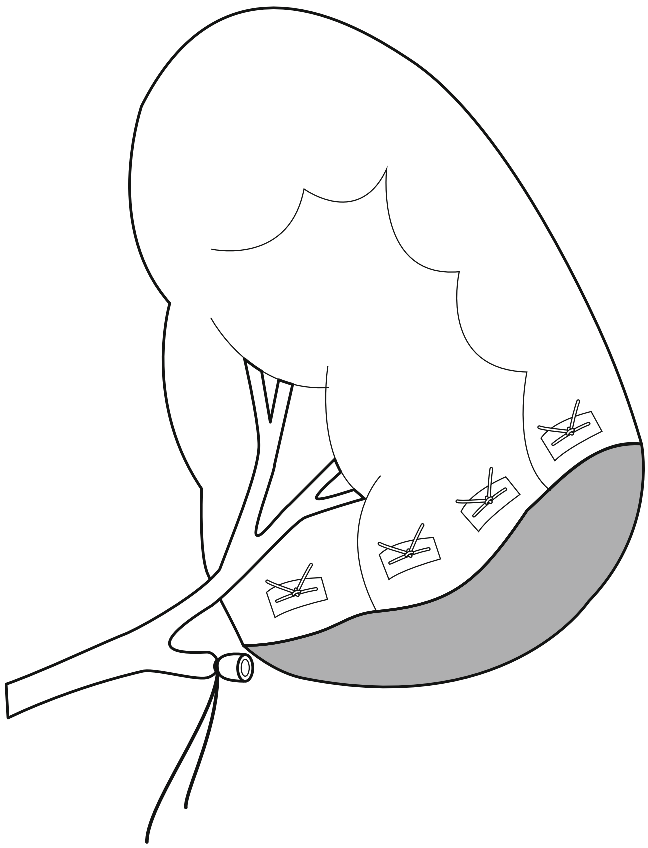

Fig. 46.8 Hemostasis from the cut surface with vertical mattress sutures over pledgets

surface is controlled by suture ligations and vertical mattress sutures over pledgets (Fig. 46.8). Superficial injury can be repaired by the direct suture of the parenchyma. Topical application of the hemostatic sheet may also be helpful.

46.6 Postoperative Complications

Postoperative complications after splenectomy include intraperitoneal hemorrhage, pancreatitis, infection, pleural effusion, venous thrombosis, and splenosis. Postoperative hemorrhage is rare and avoidable by ensuring the hemostasis before abdominal closure. Postoperative temporary elevation of serum amylase could occur due to the intraoperative manipulation of the pancreas; however, continuing elevation of serum amylase as well as abdominal pain and paralytic ileus raises the suspicion of pancreatitis or pancreatic injury. Acute infectious complications include intra-abdominal abscess, wound infection, and pulmonary infection related to atelectasis. If the pleural effusion, particularly on the left side develops, intra-abdominal or left subphrenic infectious complication should be suspected. Late infectious complications, mostly the OPSI, are prone to occur in pediatric patients. Preoperative vaccination is recommended to minimize the risk of OPSI, but long-term postoperative antibiotic prophylaxis is still controversial. Portal vein thrombosis has been documented to be rare but may be more common complication than it clinically detected. Splenosis can occur in trauma cases or in case of intraoperative splenic injury. Some hematologic disorder could recur due to the splenosis.

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47 Portal Vein Hypoplasia and Patent Ductus Venosus

Yukihiro Inomata and Shintaro Hayashida

Abstract

Patent ductus venosus and congenital portosystemic shunt with or without hypoplasia of portal vein can be diagnosed by US study before or after birth. Congenital hypoplasia of portal vein includes the type with hypoplastic intrahepatic portal system (type II) and the type with complete agenesis (type I). Differentiation of the types is important for the indication of the following treatment. Direct imaging of the portal vein via mesenteric venous branches through small laparotomy or percutaneous transhepatic puncture should be done. If the interventional radiology is not successful for the closure of the shunt or ductus venosus, surgical intervention should be considered.

The patent ductus venosus runs along the groove between the caudate lobe and left lateral segment. The duct near the left hepatic vein can be encircled and ligated. After surgical closure of such congenital portosytemic shunts, portal vein thrombosis and portal vein congestion should be expected as complications. If there are serious complications, release of the closure should be done.

Keywords

Ductus venosus • Portal vein hypoplasia • Congenital portosystemic shunt

47.1 Preoperative Management

Patent ductus venosus is a kind of congenital portosystemic shunt associated with or without portal vein hypoplasia. Congenital hypoplasia of portal vein includes the type with hypoplastic intrahepatic portal system (type II) and the type with complete agenesis (type I).

This anomaly can be diagnosed with clinical findings like encephalopathy or hepatic steatosis. However, in these days, with the advancement of the ultrasonographic (US) diagnostic tools, such kind of congenital shunt can be revealed prenatally or accidentally found in the screening of US study. Dynamic enhanced computed tomography (CT) can illustrate the location and width of the shunt vessel. The differentiation of the types is important for the indication of the following treatment. For this purpose, direct imaging is done, with retrograde insertion of the catheter through the vaca, if possible. If this procedure is successful, portography, US examination, and manometric study with balloon occlusion of the shunt vessel can show the status of the intrahepatic portal system (Fig. 47.1). Direct and normograde portography with small laparotomy and insertion of the catheter is also useful for the accurate diagnosis. If the intrahepatic portal system cannot be visualized, liver biopsy is another way for the definite diagnosis of portal agenesis. In case of portal agenesis, ligation of the patent shunt vessel is not possible, and liver transplantation can be indicated.

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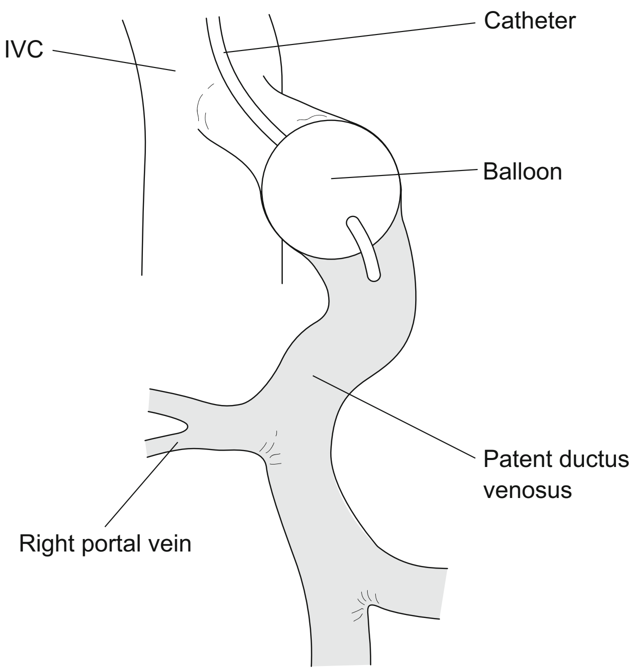

Fig. 47.1 Balloon occlusion of the shunt vessel

If there is a patent but hypoplastic intrahepatic portal system (type II), occlusion of the shunt vessel should be considered for the treatment. Such treatment can be done just following the above diagnostic procedure. If the diameter of the shunt vessel is less than 5 mm, occlusion with interventional radiology (IVR) can be possible. If IVR is not possible or failed, surgical closure of the shunt vessel is indicated. In aged children or adolescence, there is a possibility of the association of hepatic tumor, portopulmonary hypertension, or hepatopulmonary syndrome as the result of abnormal portosystemic shunt. Possibility of such complications also should be examined preoperatively.

In the case with large patent ductus venosus, surgical closure with monitor of portal vein pressure or intraoperative US is safer than IVR, because the trial of the closure can be reversed with the monitoring.

47.2 In the Practical Scenes

Laparotomy with upper midline incision or transverse incision can be applied (Fig. 47.2). Intraportal catheter is inserted via inferior mesenteric vein or remnant of the umbilical vein in the round ligament after probing and dilating. This catheter can be used for pressure study or portography. If this must be kept after the operation, the catheter is fixed with rubber band or elastic suture material, preparing for the removal.

Then the ductus venosus is dissected for ligation. For this procedure, spleen is compressed gently to the caudal side, and the fixing ligaments of the left lateral segment of the liver are

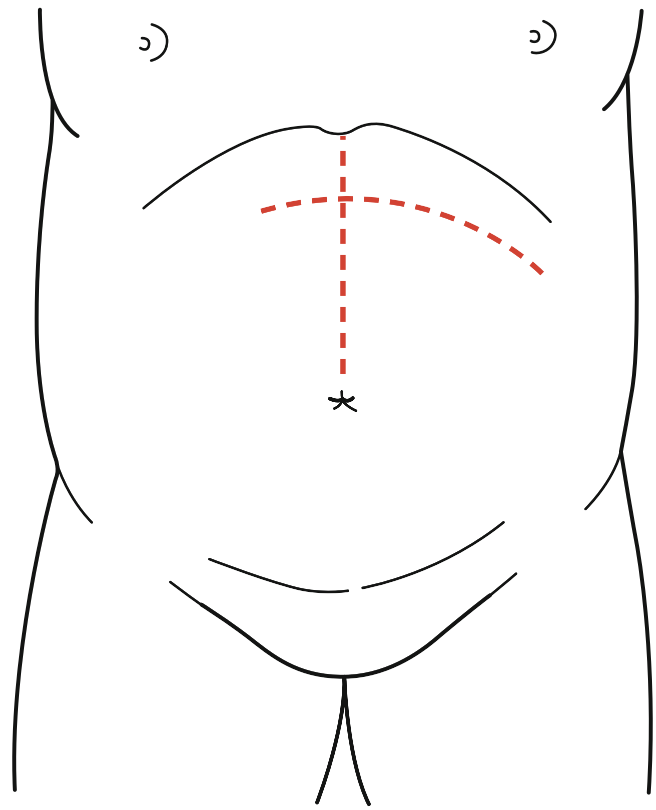

Fig. 47.2 Skin incision. Upper midline incision or left subcostal incision or transverse incision is applied

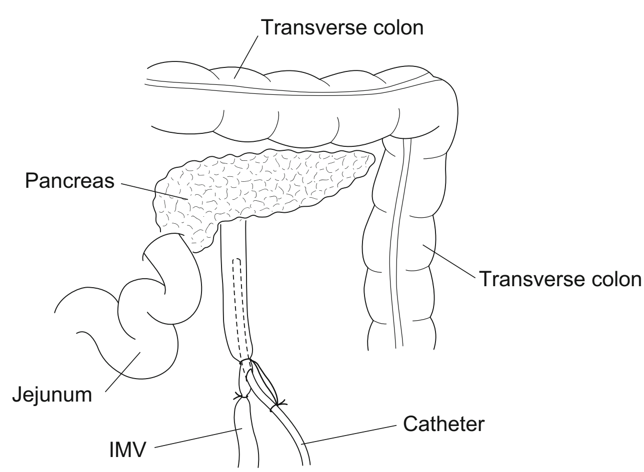

Fig. 47.3 Catheter insertion from inferior mesenteric vein for measurement of portal vein pressure

transected. If the wound is relatively small, sometimes this procedure is difficult due to the deepness of the field. Insertion of the sponge under the left coronary and triangular ligament and pulling of the lobe can facilitate easier cutting of the ligament (Fig. 47.3). After the transection of the ligament, the left lateral segment is reflected to the right side and fixed with malleable for visualization of the ductus venosus (Fig. 47.4).

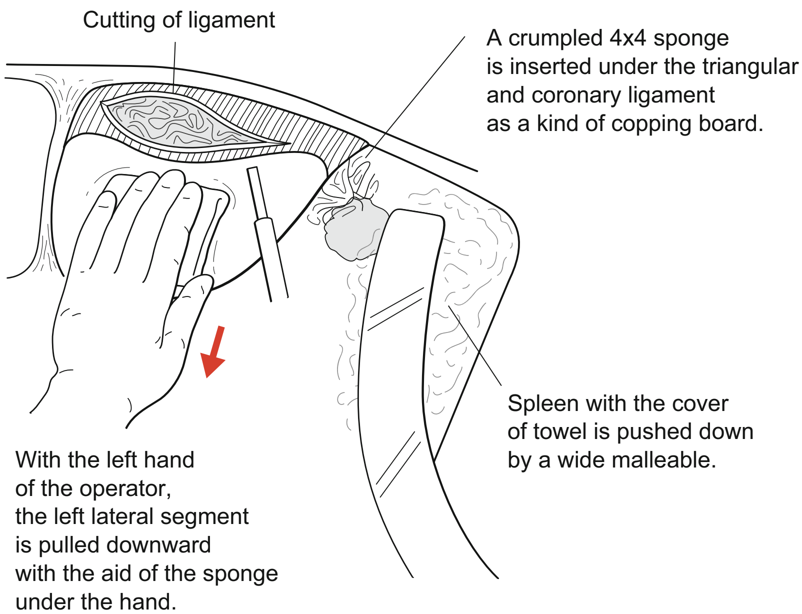

Fig. 47.4 Transection of left triangular and coronary ligament. Spleen with the cover of towel is pushed down by a wide malleable. A crumpled 4 × 4 sponge is inserted under the triangular and coronary ligament as a kind of copping board. With the left hand of the operator, the left lateral segment is pulled downward with the aid of the sponge under the hand. This procedure makes the ligament easier to be cut. Then the ligament is cut by electrocautery

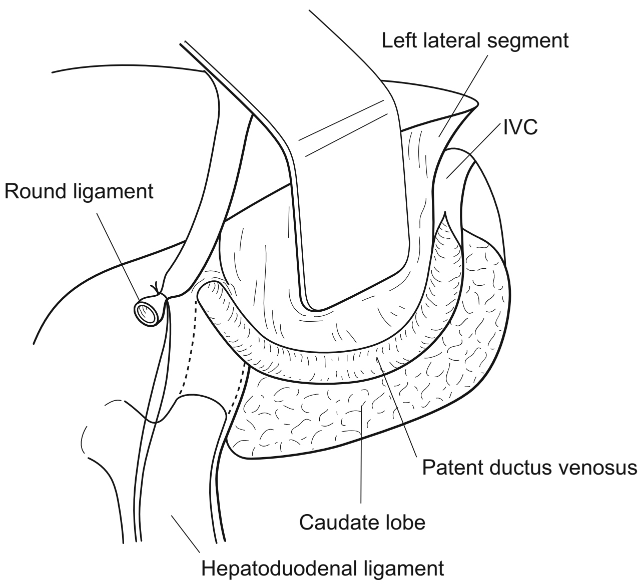

Fig. 47.5 The patent ductus venosus is dissected between the caudate lobe and left lateral segment

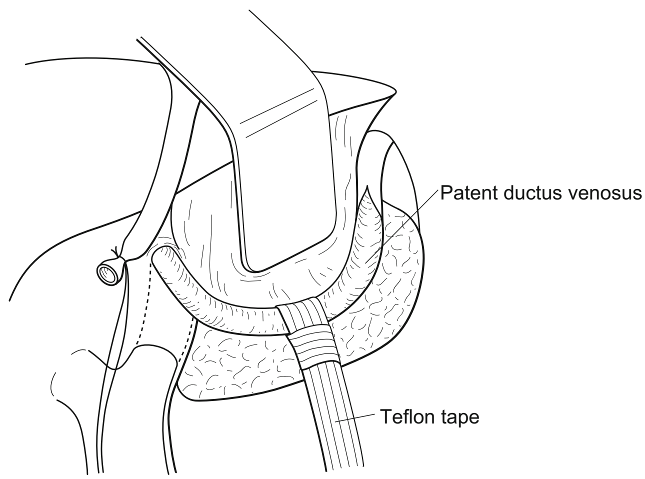

Fig. 47.6 Ligation of ductus venosus. The dissected duct is encircled with Teflon tape, and this tape is squeezed to close the shunt

The ductus venosus runs under the peritoneum along the hepatic side of the lesser omentum. The lesser omentum is opened to expose the top end of the caudate lobe. At the top end of the caudate lobe, left wall of the vena cava can be exposed with left wall of the left hepatic vein (Fig. 47.5). Encircling of the ductus venosus is necessary for the ligation. The proximal side (near the left portal vein) is difficult because that part is partly surrounded by the hepatic parenchyma. The distal portion, near the left hepatic vein, is easier because the surrounding connective tissue is looser. The duct is double ligated with thick (2-0 or more) sutures. If the wall is fragile, it might be torn with ligation. In that case, the duct is closed with Teflon tape sutured with 2-0 Prolene (Fig. 47.6) [1]. Monitoring of the portal pressure after trial of the closure is essential. The pressure should be less than 25 cm H_2O.

47.3 Postoperative Management

The liver function should be checked using US and biochemistry. There is a possibility of portal vein thrombosis. There are also possibilities of ascites, congestion, and paralysis of the intestine. If the portal pressure that was measured intraoperatively was relatively high (around 20 cm H_2O), the portal catheter should be kept for 2 weeks. In that case, possibility of the thrombosis with the catheter should be also cared. If the symptoms of ascites or bowel congestion persist, release of the closure should be considered. If the closure is successful, hepatic steatosis can be reversed around 1 month.

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Part VI

Urology

Pyeloplasty

48

Hiroshi Asanuma and Mototsugu Oya

Abstract

The widespread use of ultrasonography during pregnancy has resulted in a higher detection rate for antenatal hydronephrosis. Ureteropelvic junction obstruction is the most common pathological cause of neonatal hydronephrosis. Surgical indications for this hydronephrosis comprise a decrease of split renal function (>5 %) on renography or increased dilatation on ultrasonography in subsequent studies, or existence symptoms such as breakthrough urinary tract infection or the abdominal pain during follow-up.

The Anderson-Hynes dismembered method has been adopted most widely now. It is available in any cases with ureteropelvic junction obstruction due to intrinsic or extrinsic stenosis or high insertion. It is key point for the success of pyeloplasty to anastomose the apex of caudal angle of the renal pelvis and the crotch of the spatulated ureter with five sutures as knock stitch and come the funnel shape with the double pigtail stent finally.

Remove the stent 2–3 months postoperatively under cystoscopy. Evaluate renal pelvic dilatation and split renal function 6 months postoperatively. Success pyeloplasty should be defined as no symptom, reduced pelvic dilatation, and stable or improved split renal function compared to preoperative condition.

Keywords

Hydronephrosis • Pyeloplasty • Ureteropelvic junction

48.1 Etiology and Surgical Indication

The congenital hydronephrosis (ureteropelvic junction obstruction: UPJO) is defined as impaired urine flow from the renal pelvis into the proximal ureter with subsequent dilatation of the collecting system and the potential of renal deterioration. The widespread use of ultrasonography during pregnancy has resulted in a higher detection rate for antenatal renal pelvic dilatation. UPJO is the most common pathological cause of neonatal pelvic dilatation [1].

Symptomatic hydronephrosis causing urinary tract infection (UTI), flank pain, impaired renal function (split renal function <45 %), or the giant hydronephrosis is generally a surgical indication. However, asymptomatic hydronephrosis rarely requires immediate surgical intervention in young childhood even though severe dilatation, since renal function, is generally maintained, and it has higher possibility of spontaneous resolution. In these cases, conservative treatment is initially adopted.

It can be very difficult to distinguish obstructed and non-obstructed renal pelvic dilatation. Currently, the most popular definition is that an obstruction represents any restriction to urinary outflow that, if left untreated, will cause progressive renal deterioration [2]. Grade 1 or

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2 hydronephrosis, as defined by the Society for Fetal Urology [3], rarely has clinical problem and does not require surgical treatment in most cases. On the other hand, surgical correction is needed in approximately 10 % or 60 % of children with grade 3 or 4 asymptomatic hydronephrosis, respectively [2]. Therefore, after diagnosis as severe hydronephrosis, they have prophylactic antibiotics to prevent UTI and serial evaluation using ultrasonography and renography every 3 or 4 months (because it is rare that it causes decreased renal function before increased dilatation, follow-up using ultrasonography mainly is available in grade 3 hydronephrosis) [2].

Surgical indications for asymptomatic hydronephrosis comprise a decrease of split renal function (>5 %) on renography or increased dilatation on ultrasonography in subsequent studies, or existence of symptoms such as breakthrough UTI or the abdominal pain during follow-up [2].

Several surgical techniques for UPJO have been reported, which are classified for the dismembered procedure or the non-dismembered one. The Anderson-Hynes dismembered method has been adopted most widely now [1]. It is available in any case with UPJO due to intrinsic or extrinsic stenosis or high insertion. And surgical result is good because stenotic segment is completely resected, and recurrent stenosis is quite rare postoperatively.

On the other hand, Foley Y-V plasty method, which represents the non-dismembered procedure, is adopted in patients who has high insertion without severe pelvic dilatation or in whom PUJ continuity and its blood supply should be preserved because of history of ureteroneocystostomy.

These methods are also held with laparoscopic or retroperitoneoscopic techniques, or robot-assisted technique recently, with the similar success rates as standard open procedures [1].

48.2 Preoperative Management

Evaluate urinalysis and urine culture. If positive urine culture, administer antibiotics preoperatively. The patient should be performed voiding cystourethrography to evaluate vesicoureteral reflux and lower urinary tract abnormalities.

If the patient does not have typical hydronephrosis without megaureter, evaluate ureteral abnormalities such as mid-ureteral stricture or ureteral polyp using retrograde ureterography just before operation. Retrograde ureterography also shows definitive location of UPJ, and it is helpful to decide adequate skin incision.

48.3 Surgical Techniques

Insert a urethral catheter after induction of general anesthesia, and put the patient as straight flank position. In infants and young children, place a rolled towel under the contralateral waist on a flat table. Older children are better positioned by placing the table in the flexed position with the kidney rest raised. The position is stabilized by strips of tape from each side of the table across the child at the breast and hip. The flank abdominal area is prepared and draped.

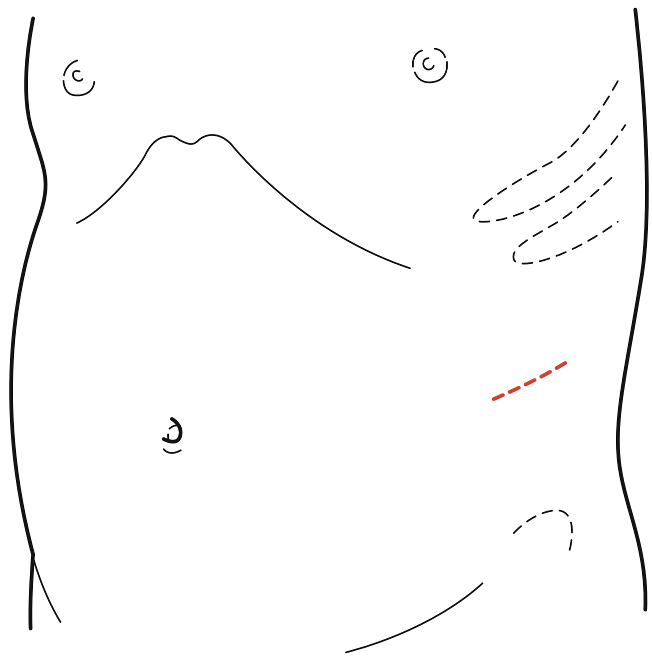

Fig. 48.1 Skin incision for pyeloplasty

Make a 4 cm incision following the skin lines over the UPJ location (Fig. 48.1). Incise the fascia of external oblique muscle, and split the three muscle layers (external oblique, internal oblique, and transversus abdominis muscle). Dissect flank pad tissue, and incise the lateral fascia vertically as far posteriorly as possible to avoid inadvertently entering the peritoneum.

Open the Gerota's fascia vertically. Once the renal parenchyma is seen, carefully expose the upper ureter first. Place vessel loop around the ureter, and expose the ureter cranially and caudally. Take care not to interfere with the segmental blood supply that enters the ureter medially. After place a wound ring retractor, and look for crossing lower-pole vessels. They usually can be moved out of the UPJ if they are present. With a hugely dilated pelvis, decompression of the pelvis with a 23-G butterfly needle may be required to expose the entire pelvis.

48.3.1 Dismembered Pyeloplasty (Anderson-Hynes Method)

After exposure of the UPJ, map out the diamond-shaped incision with a marking pen. Place stay sutures at the angles of the diamond in the pelvis and at the medial side in the

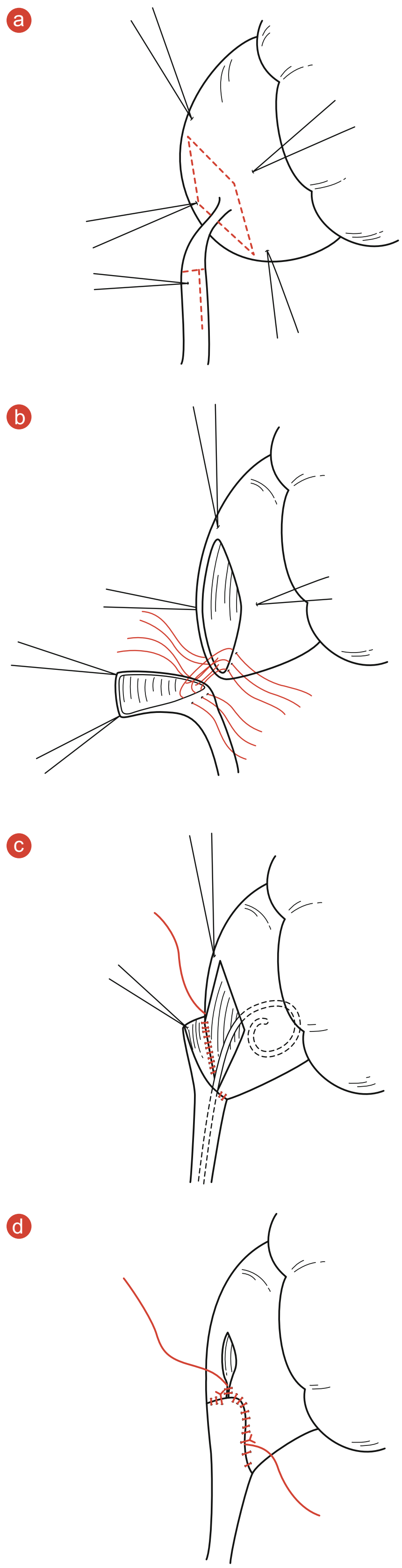

Fig. 48.2 Anderson-Hynes pyeloplasty

ureter (Fig. 48.2a). Cut from inside one stay suture to inside the next in the pelvis, and divide the ureter transversely. Remove the specimen containing the excised pelvis and obstructed UPJ. Spatulate the ureter on less-vascularized lateral surface for enough length beyond a narrow segment.

Insert a 5 Fr feeding tube into the ureter to prevent catching the far wall in a suture. Using loupes, place one 6-0 absorbable suture from the apex of caudal angle of the renal pelvis into and the crotch of the spatulated ureter. Place a second suture 1.5 mm away from the first, and place a third suture at the contralateral side symmetrically from the first. Similarly, place fourth and fifth sutures next to the second and third, respectively. Total five sutures are placed as knock stitch, and tie these sutures in number order (Fig. 48.2b).

Place and tie sixth suture next to the fourth, and continue this suture to the tip of the ureter on the far side as a running stitch. Remove the feeding tube, and insert a 4.7 Fr double pigtail stent with adequate length at this point (Fig. 48.2c). Do the same for seventh suture on the near side. After irrigating the pelvis and calyces free of clots, tie the two sutures together, cut one, and continue with the other to close the pelvic defect (Fig. 48.2d).

If it is difficult to insert a double pigtail stent, place 5 Fr tube into the renal pelvis as pyelostomy and 5 Fr ureteral stent across the anastomosis.

In children with crossing vessel, anastomosis is undergone opposite of crossing vessel. Finally, it is key point that this anastomosis becomes the funnel shape to maintain good urine passage.

Insert a drain and fasten it near, but not touching, the anastomosis or ureter below it by the long-suture technique. Close the wound in layers with absorbable sutures.

48.3.2 Non-dismembered Pyeloplasty (Foley Y-V Plasty)

Put a long Y-shaped marking and incise it between the lower pelvis and upper ureter (Fig. 48.3a). The ureteral incision should exceed a narrow segment enough. Insert a 4.7 Fr double pigtail stent with adequate length.

Anastomose the apex of the V-flap to the crotch of the spatulated ureter with five knock stitch using 6-0 absorbable sutures (Fig. 48.3b). Suture the remainder as a running stitch.

48.4 Postoperative Management

Remove the urethral catheter in 24–48 h, and the drain is removed on the day following removal of the urethral catheter if discharge is minimum. Remove the double pigtail stent 2–3 months postoperatively under cystoscopy [4].

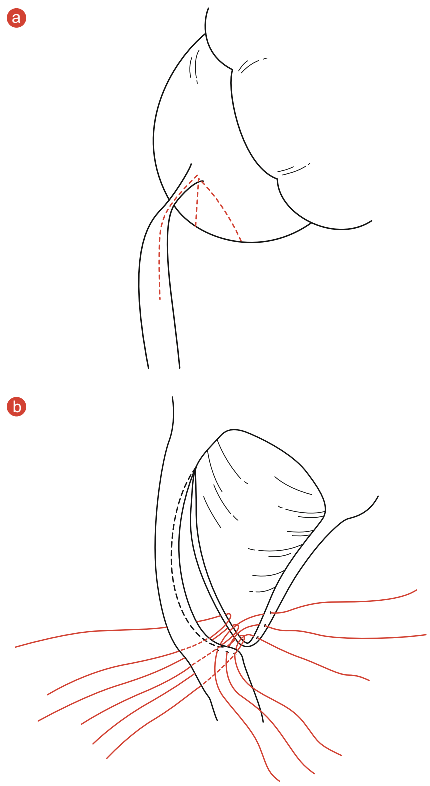

Fig. 48.3 Foley Y-V plasty

If pyelostomy and external ureteral stent has been placed, take the stent out 7 days when a nephrography shows good passage and no leakage at the anastomosis. Remove pyelostomy after a trial of its clamping [4].

Evaluate renal pelvic dilatation and split renal function 6 months postoperatively. Successful pyeloplasty should be defined as having no symptom, reduced pelvic dilatation, and stable or improved split renal function compared to preoperative condition.

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Vesicoureteral Reflux (VUR)

49

Yoshiaki Kinoshita

Abstract

As a preoperative definite diagnosis, the extent of reflux should be evaluated by voiding cystourethrography (VCUG) and international vesicoureteral reflux (VUR) grading system. The functional evaluation also should be done by ^{99m}Tc-DMSA scintigraphy. In addition, such other examinations as ultrasonography, intravenous pyelography (IVP), CT, and MRI should be performed for evaluation of associated anomalies.

As a first step of treatment, conservative therapy with prophylaxis antibiotics is initially introduced, and some cases can be managed. Some cases with breakthrough infection or findings of developing renal dysfunction should be treated by any kind of surgical intervention including endoscopic treatment and open surgery.

Keywords

Vesicoureteral reflux (VUR) • Cohen • Politano-Leadbetter • Lich-Gregoire • Deflux®

49.1 Endoscopic Treatment

As a minimally invasive surgery, endoscopic treatment using Deflux® (dextranomer/hyaluronic acid copolymer) is useful these days. Typical two methods (STING and HIT) are described.

Grades II to IV vesicoureteral reflux (VUR) (evaluated by VCUG) cases are considered to have good indication. Elder reported the success rates 79 %, 72 %, and 65 % for grades II, III, and IV, respectively [1]. Hunziker also reported the repeated trial is leading to 89 % of success rate even for the grade V case [2]. In this chapter, such typical two injection methods as subureteric transurethral injection (**STING**) and hydrodistention implantation technique (**HIT**) are described.

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49.1.1 STING (Subureteric Transurethral Injection) Method

(a) Ureterocystoscope was used and placed just in front of the ureteral orifice.
(b) Deflux metal needle® is introduced under the bladder mucosa 2–3 mm below the ureteric orifice at the 6 o'clock position (Fig. 49.1a, b). The needle is inserted 6–8 mm into the submucosa (Fig. 49.1c).
(c) Deflux® is injected until it forms the "volcanic" bulge with slit-like appearance of the orifice (Fig. 49.1d).
(d) After keeping the needle in position for about 30 s, it is pulled out.

49.1.2 HIT (Hydrodistention Implantation Technique) Method

(a) Ureterocystoscope was used and placed just in front of the ureteral orifice.

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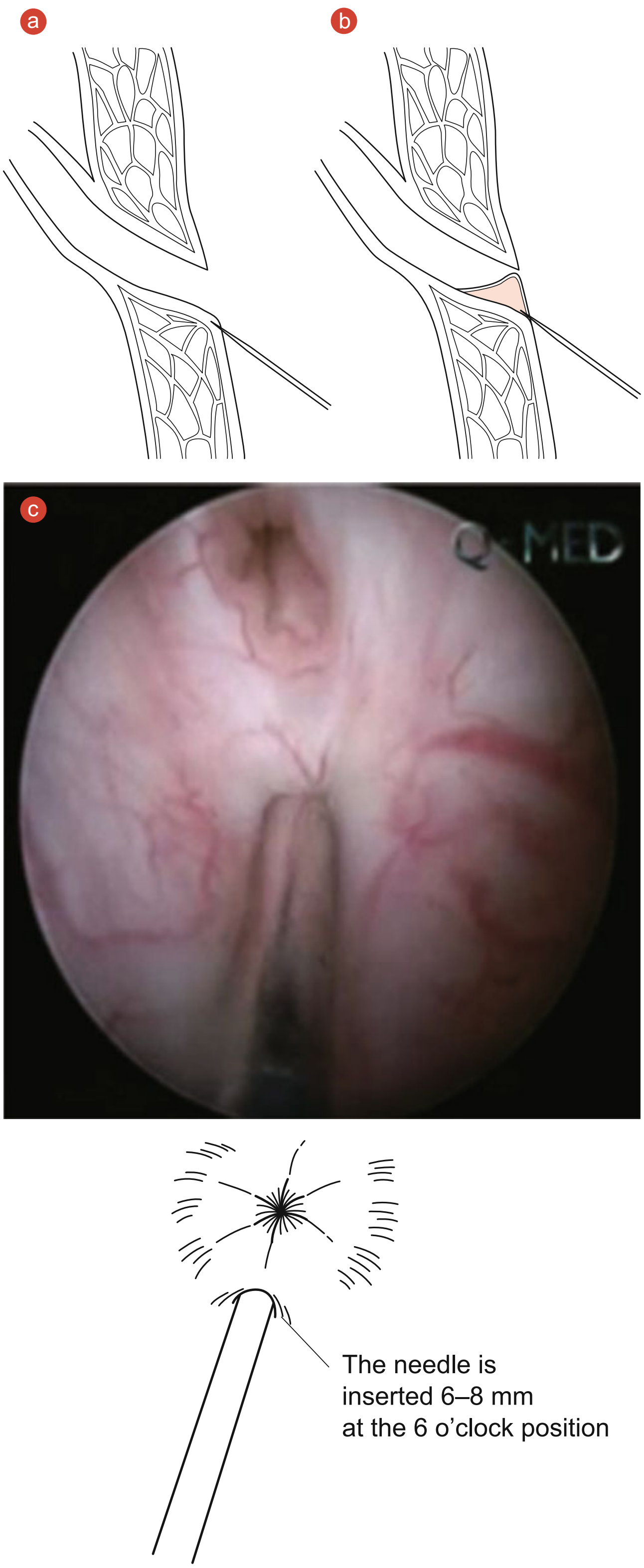

Fig. 49.1 (**a**) Deflux metal needle® is introduced under the bladder mucosa 2–3 mm below the ureteric orifice at the 6 o'clock position. (**b**) Deflux® is injected until the "volcanic" bulge formation has a slit-like appearance. (**c**) The needle is inserted 6–8 mm into the submucosa. (**d**) Deflux® is injected until the "volcanic" bulge formation has a slit-like appearance

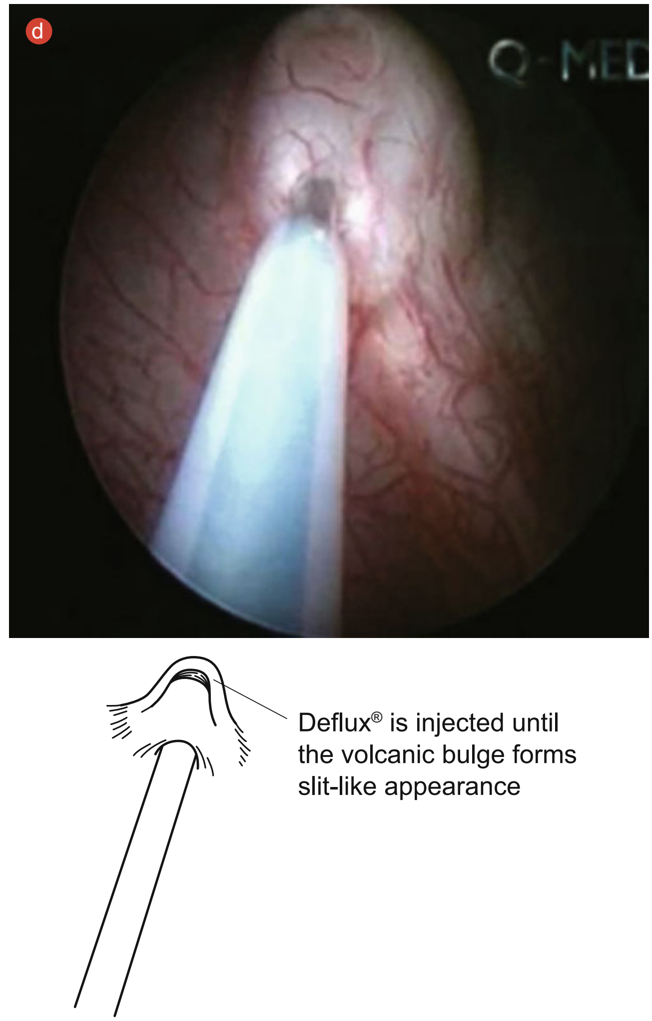

Fig. 49.1 (continued)

(b) The ureteral orifice is dilated by the water pressure, and Deflux metal needle® is inserted from the ureteral orifice into the proximal side of the ureter.
(c) Deflux® is injected at the 6 o'clock in the submucosal layer of the ureter until the mucosal protuberance formation (Fig. 49.2a, b).
(d) After keeping the needle for about 30 s, it is pulled out.

49.2 Open Surgery

As representative open surgery for VUR, Cohen method, Politano-Leadbetter method, and Lich-Gregoire method are described in this chapter.

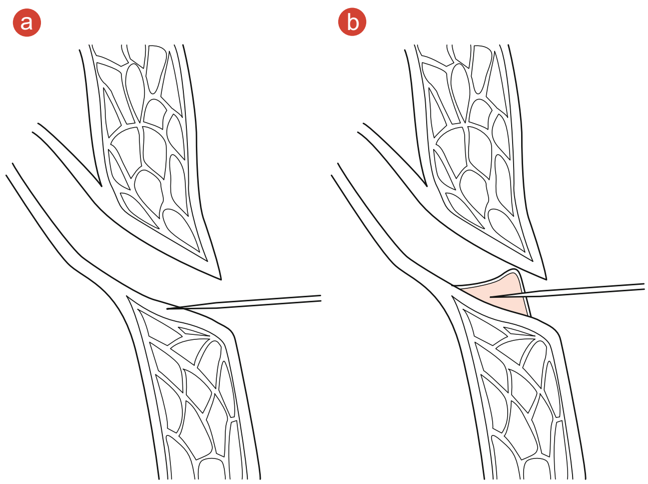

Fig. 49.2 (**a**) Deflux® is injected at the 6 o'clock position in the submucosal layer of the ureter until the mucosal protuberance formation. (**b**) Deflux® is injected until the "volcanic" bulge formation has a slit-like appearance

49.2.1 Cohen's Method

(a) About 5 cm skin incision is made above pubis along skin crease (Fig. 49.3a).
(b) Rectus abdominis muscle was divided for lateral side and the anterior wall of the bladder is incised.
(c) Ring retractor (Denis-Browne) is placed into the bladder to improve exposure.
(d) 4 Fr feeding catheter is inserted into the affected-side ureter and fixed by the stay suture around the orifice with 5-0 PDS.
(e) A circumference incision is made along the ureter, and the stented ureter is dissected free (about 4–6 cm) from bladder mucosa and trigonal muscle with scissors and needle-type electrocautery (Fig. 49.3b).
(f) The submucosal tunnel is made from the original ureteral orifice to just above the opposite ureteric orifice. Dissected ureter is pulled through the tunnel and new orifice

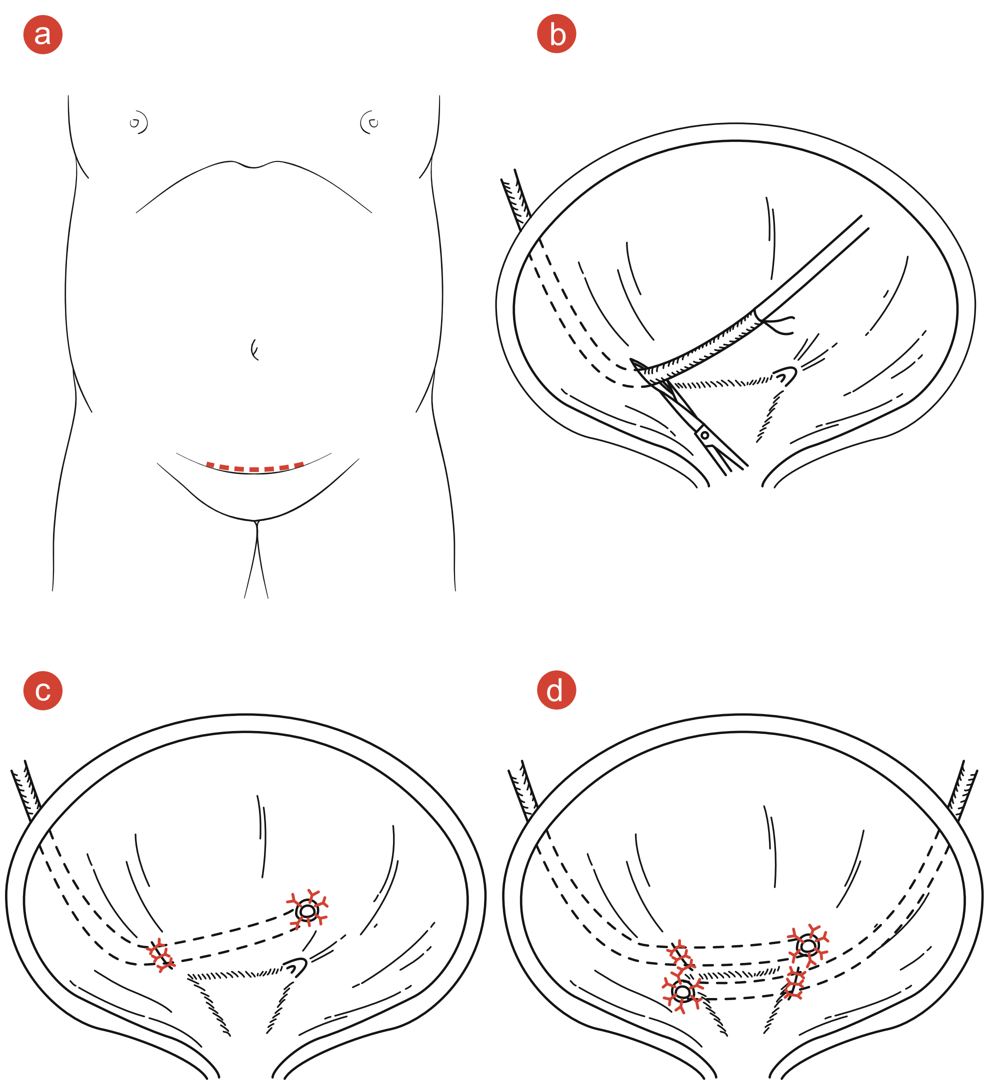

Fig. 49.3 (**a**) About 5 cm skin incision is made above pubis along skin crease. (**b**) A circumference incision is made along the ureter, and the stented ureter is dissected free (about 4~6 cm) from bladder mucosa and trigonal muscle with scissors and needle-type electrocautery. (**c**) Dissected ureter is pulled through the tunnel and new orifice is fixed with 5-0 or 6-0 PDS. (**d**) When reimplantation on both sides is made, the tunnel should be made parallel

is fixed with 5-0 or 6-0 PDS (Fig. 49.3c). Original orifice is closed.

(g) When reimplantation on both sides is made, the tunnel should be made parallel (Fig. 49.3d). The length of the tunnel is usually fivefold of the ureteral diameter.

(h) 4 Fr feeding catheter is inserted into the reimplanted ureter and injects saline for checking the patency of the orifice. In case, 6 Fr splint catheter is stented to prevent postoperative stenosis.

49.2.2 Politano-Leadbetter Method

(a) The same procedure until the approach into the bladder cavity.

(b) 4 Fr feeding catheter is inserted into the affected-side ureter and fixed by the stay suture around the orifice with 5-0 PDS.

(c) A circumference incision is made along the ureter, and the stented ureter is dissected free (about 4~6 cm) from bladder mucosa and trigonal muscle with scissors and needle-type electrocautery (Fig. 49.4a).

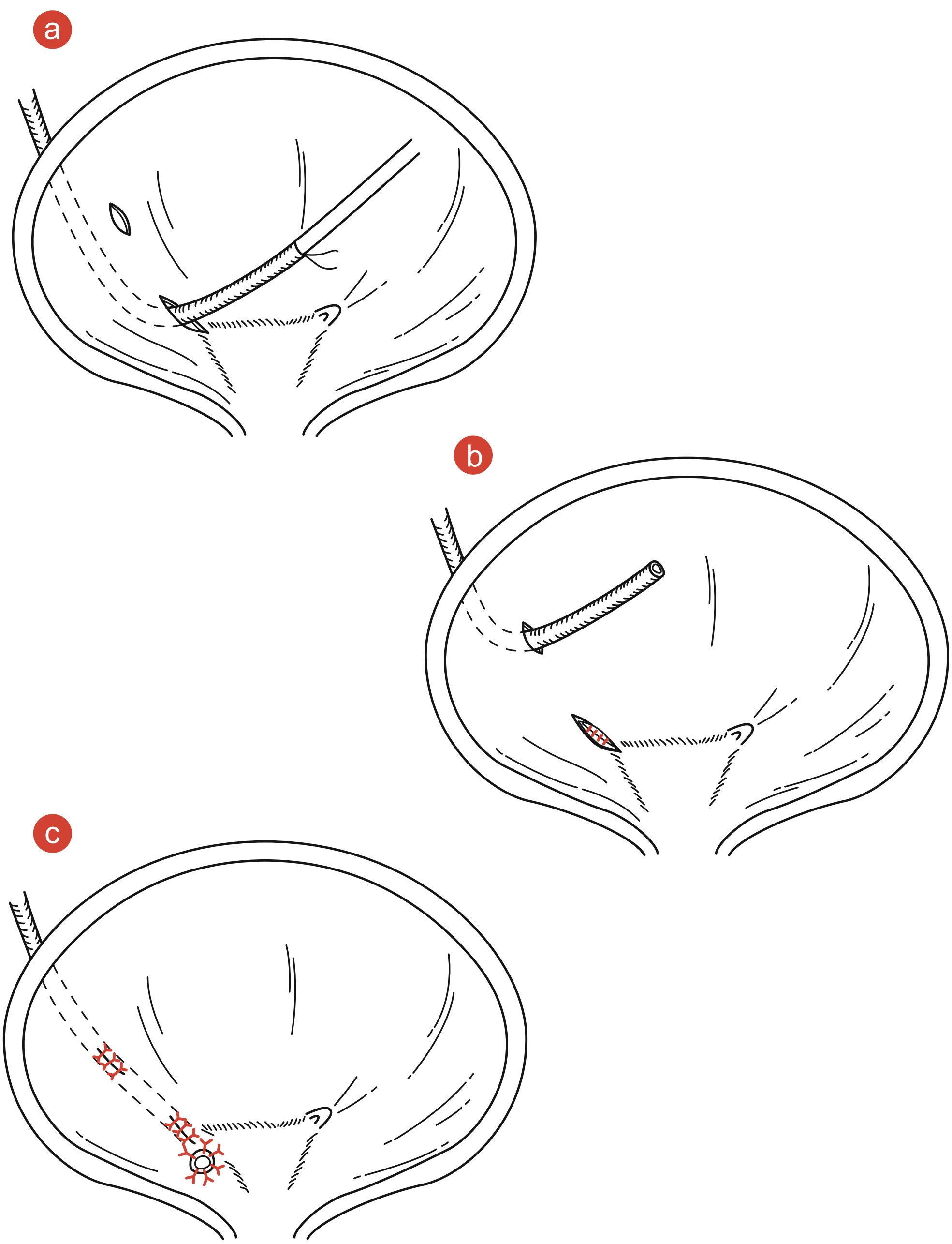

Fig. 49.4 (**a**) A circumference incision is made along the ureter, and the stented ureter is dissected free (about 4–6 cm) from bladder mucosa and trigonal muscle with scissors and needle-type electrocautery. (**b**) New hiatus is created at the proximal side of the original orifice, and submucosal tunnel is made from the original ureteral orifice to 2–3 cm proximal side. (**c**) Dissected ureter is pulled through from the new hiatus to the submucosal tunnel (Fig. 49.4b) and fixed around the original orifice with 5-0 or 6-0 PDS

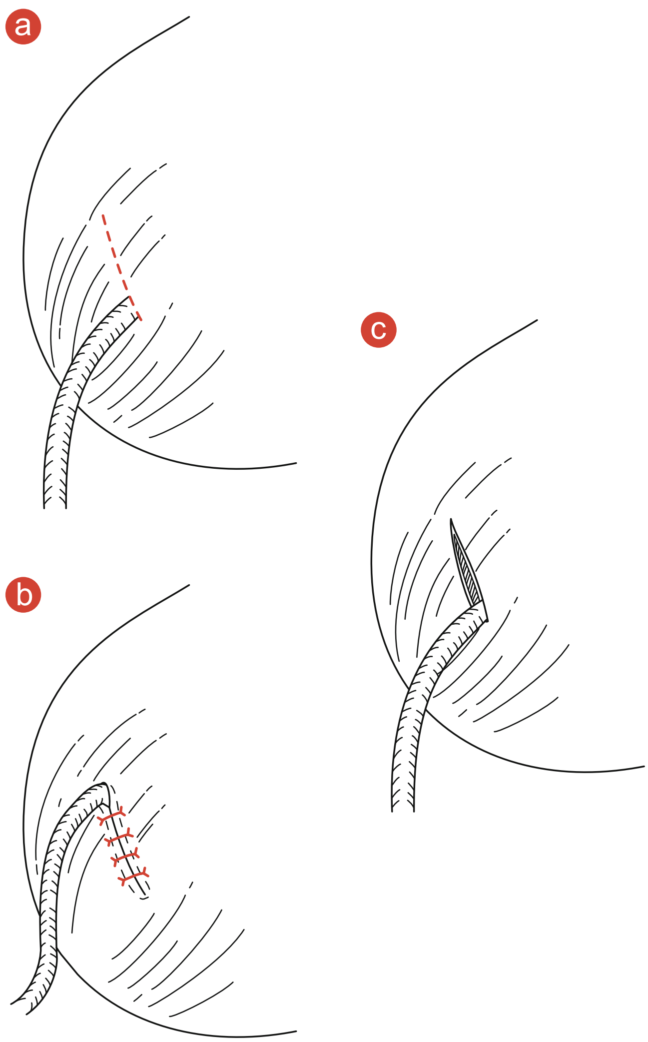

Fig. 49.5 (**a**, **b**) Vesical muscular layer is incised 2–3 cm from the junction to the proximal side. (**c**) Ureter is placed in a muscle layer tunnel from the original side to the proximal side. Muscle layer is closed with 5-0PDS

(d) New hiatus is created at the proximal side of the original orifice, and submucosal tunnel is made from the original ureteral orifice to 2–3 cm proximal side (Fig. 49.4b).

(e) Dissected ureter is pulled through from the new hiatus to the submucosal tunnel (Fig. 49.4b) and fixed around the original orifice with 5-0 or 6-0 PDS (Fig. 49.4c).

(f) 4 Fr feeding catheter is inserted into the reimplanted ureter and saline is injected to check the patency of the orifice. In case, 6 Fr splint catheter is stented to prevent postoperative stenosis.

49.2.3 Lich-Gregoire Method

(a) The same procedure until the exposure of anterior bladder wall.

(b) Ureterovesical junction was exposed by extra-vesical approach.

(c) Vesical muscular layer is incised 2–3 cm from the junction to the proximal side (Fig. 49.5a, b).

(d) Ureter is place in a muscle layer tunnel from the original side to the proximal side. Muscle layer is closed with 5-0PDS (Fig. 49.5c).

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Ureterocele

50

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Abstract

Ureterocele is classified into two types including orthotopic (simple) and ectopic (Acta Chir Scand. 1954;197(Suppl.):1). Orthotopic type's ureter forming the ureterocele ends in a normal or next to the normal site in the bladder. Ectopic type's ureterocele extends and opens into the bladder neck or posterior urethra. Urinary tract infection or urethral obstruction often occurs in some cases. Some cases of orthotopic type are asymptomatic. The location and the size of ureterocele, existence of VUR, and existence of duplex-system are evaluated by VCUG and IVP. In addition, renal function or associated anomalies should be evaluated by ^{99m}Tc-DMSA scintigraphy, CT, and MRI.

Orthotopic-type ureterocele with no symptom can be observed without treatment. However, the cases with UTI or the urinary tract obstruction should be treated by surgical intervention including endoscopic treatment and open surgery.

In this chapter, endoscopic treatment and open method for the cases of duplex-system ureterocele are described.

Keywords

Ureterocele • Endoscopic surgery • Duplex system

50.1 Endoscopic Surgery

1. Orthotopic (simple) ureterocele [1]
   Under observation of vesicoureteroscopy, small incision is made by the resected knife or sharp electrode at the distal side far away from the bladder wall (Fig. 50.1a).
2. Ectopic ureterocele [1]
   Under observation of vesicoureteroscopy, small incision is made by the resected knife at the distal side of the ureterocele. Longitudinal incision is added if the ureterocele is elongated into the urethra with enough notice of detrusor muscle (Fig. 50.1b).

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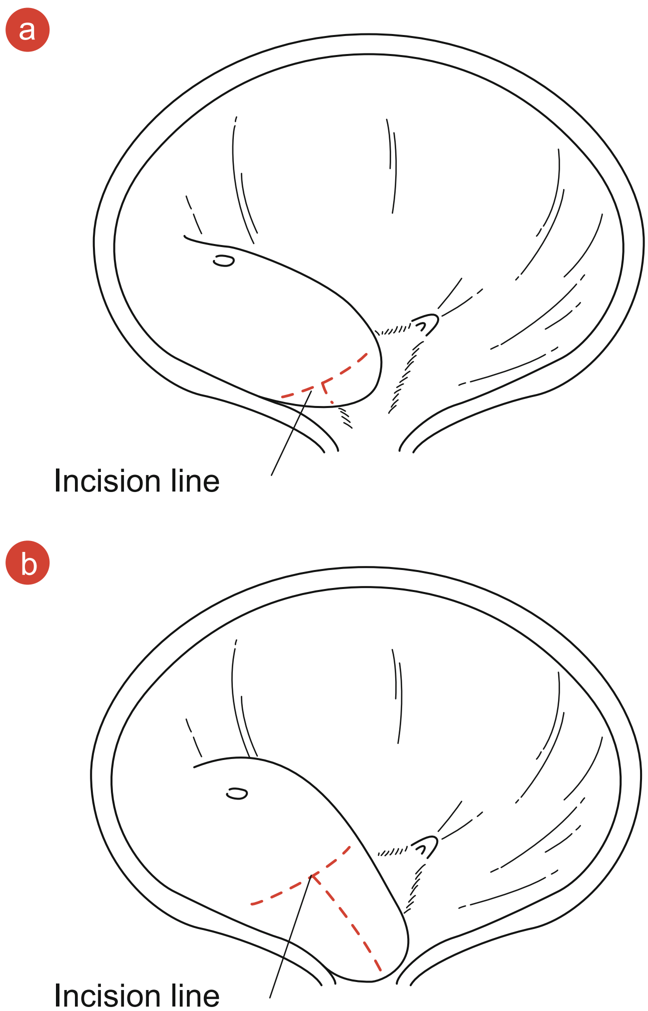

Fig. 50.1 (**a**) Small incision is made by the resected knife or sharp electrode at the distal side far away from the bladder wall. (**b**) Longitudinal incision is added if the ureterocele is elongated into the urethra with enough notice of detrusor muscle

50.2 Open Surgery (for the Cases of Duplex-System Ureterocele)

(a) The ureterocele, the orifice of the lower renal pole ureter often hidden behind its wall. Before incision of the ureterocele, 4 Fr feeding tube was stented and fixed if the orifice is visualized (Fig. 50.2a).
(b) The dome of the ureterocele is incised horizontally and dissected from the urothelium and the detrusor muscle (Fig. 50.2b).
(c) After the ureterocele is resected, the backing detrusor muscle is reconstructed by plication (Fig. 50.2c).
(d) Ureter is reimplanted by the Cohen's technique (Fig. 50.2d).

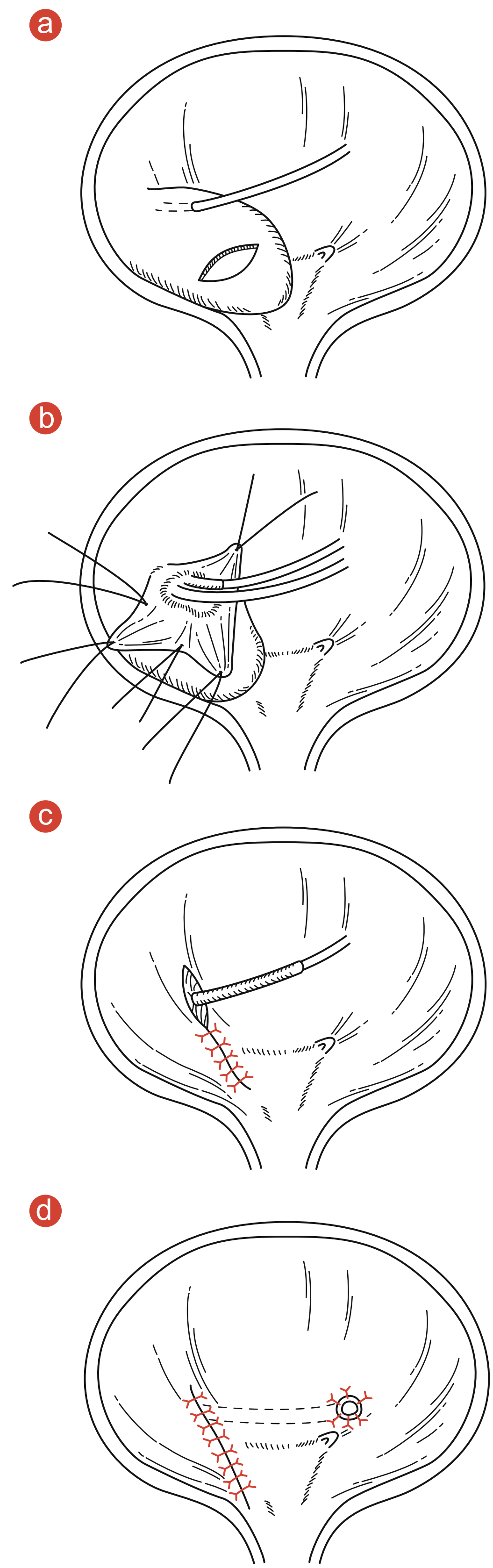

Fig. 50.2 (**a**) Before incision of the ureterocele, 4 Fr feeding tube was stented and fixed if the orifice is visualized. (**b**) The dome of the ureterocele is incised horizontally and dissected from the urothelium and the detrusor muscle. (**c**) After the ureterocele is resected, the backing detrusor muscle is reconstructed by plication. (**d**) Ureter is reimplanted by the Cohen's technique

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Suprapubic Cystostomy and Vesicocutaneostomy 51

Hiroshi Asanuma and Mototsugu Oya

Abstract

Suprapubic cystostomy and vesicocutaneostomy continue to be used frequently as temporary vesical diversion in pediatric patients who develop urethral obstruction (posterior urethral valves, cloacal anomalies, urethral trauma), recurrent urinary tract infection with severe vesicoureteral reflux, or neurogenic bladder associated with spina bifida not responsive to clean intermittent catheterization. Vesicocutaneostomy is more appropriate for long-term usage because of no catheter.

Suprapubic cystostomy is usually inserted into the bladder using Seldinger method in young children. Blocksom's method is easier and has been widely used in vesicocutaneostomy. It is important to evaluate bladder capacity and superior border of full bladder for adequate stoma marking and not to place the stoma in a position which is too large and too low to prevent bladder prolapse.

The decision to close a vesicocutaneostomy should be made only once the bladder function has been assessed and permanent therapy has been planned.

Keywords

Suprapubic cystostomy • Vesicocutaneostomy • Temporary urinary diversion • Bladder prolapse

51.1 Etiology and Surgical Indication

Suprapubic cystostomy and vesicocutaneostomy continue to be used frequently as temporary vesical diversion in pediatric patients who are in need of urinary tract rehabilitation and delayed reconstruction. Consider this procedure in children who develop urethral obstruction (posterior urethral valves, cloacal anomalies, urethral trauma), recurrent urinary tract infection with severe vesicoureteral reflux, or neurogenic bladder associated with spina bifida not responsive to clean intermittent catheterization [1].

Suprapubic cystostomy is easier and a less invasive procedure; however, it induces bladder atrophy and damage due to complete urine drainage and inevitable infection for long-term usage (Table 51.1, Fig. 51.1). On the other hand, vesicocutaneostomy can maintain the extensibility of the bladder and prevent a serious infection because of no catheter. Therefore, vesicocutaneostomy is more appropriate for long-term usage (more than several months).

51.2 Preoperative Management

Bladder anatomy and function should be evaluated using ultrasonography, voiding cystourethrography, urodynamic study, or cystoscopy if possible. Check bladder capacity and superior

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Table 51.1 Suprapubic cystostomy and vesicocutaneostomy

	Suprapubic cystostomy	Vesicocutaneostomy
Diversion status	Dry	Wet & diaper
	Catheter & urine bag	No catheter
Risk for UTI	High	Low
Bladder condition	Atrophy	Preserved bladder capacity
	Chronic inflammation	
At-home management	Catheter exchange (x1/M)	Finger bougie for prevention of stenosis
	Check for baloon	Diaper exchange

border of full bladder for adequate stoma marking of vesicocutaneostomy. Urine culture should be evaluated, and administer sensitive antibiotics preoperatively.

51.3 Surgical Techniques

51.3.1 Suprapubic Cystostomy

There are several catheter types such as pigtail catheter, Malecot catheter, or balloon catheter [2]. At first a pigtail catheter should be adopted from convenience of insertion, and it is common to replace in balloon catheter to avoid accidental extraction when the long-term usage is necessary.

The suprapubic area is prepared and draped, with the patient in the supine position. By using ultrasonography, confirm a full bladder, puncture position, and its depth and direction above the pubic symphysis in the midline (if urine volume is insufficient, inject a saline from urethral catheter) (Fig. 51.2). A 22-G needle is placed perpendicular to the skin and advanced until urine flows as a trial. Make a small incision on the puncture site, and dissect subcutaneous tissue bluntly. A 19-G needle is placed into the bladder and a guide wire is inserted for enough length. The fistula between skin and the bladder is dilated with the dilator. Finally, 6-Fr pigtail catheter is indwelled into the bladder through the guide wire. The catheter is secured to abdominal wall with suture material.

In elder children, the cystostomy kit with balloon catheter and peel-away metal sheath is convenient. 12-Fr or 14-Fr catheter with sheath is placed in the same manner after trial puncture, and the sheath is removed, leaving the cystostomy catheter in place.

51.3.2 Vesicocutaneostomy (Blocksom's Method)

There are two major techniques, Blocksom's method or Lapides's method. Blocksom's method is easier and has been widely used [1].

Put the patient in a supine position, and the lower abdominal area is prepared and draped. Insert a urethral catheter, and fill the bladder until it is quite full and palpable.

Make a 3-cm transverse incision 1–2-cm cranial in the midline between the umbilicus and pubic symphysis, over the dome of the bladder (too large or too low incision encourages bladder prolapse) (Fig. 51.3a, b). Incise the rectus fascia transversally after subcutaneous dissection, and split the rectus muscles bluntly (Fig. 51.3c).

Expose the bladder, and place a traction suture in the bladder dome wall to draw it inferiorly. Peel the peritoneum from the dome gently, mobilizing it until the obliterated umbilical arteries and urachus are identified. After ligation and transection of the urachus, pull the bladder into the wound so that the posterior wall is at skin level without tension (Fig. 51.3d). Approximate the anterior and posterior walls of the bladder to the rectus muscle and fascia with at least six 3-0 absorbable sutures, respectively (Fig. 51.3e, f).

Open the bladder by excising the urachus, not anterior wall, to avoid prolapse of the posterior wall of the bladder through the stoma. The vesicostomy should be calibrated to 24 Fr. If the fascial defect is too large, 3-0 absorbable sutures are used to narrow the opening. Approximate the full thickness of the bladder to the skin with 5-0 absorbable sutures to tubularize the stoma, with the stoma everting (Fig. 51.3g). Close the lateral skin defects around the outside of the bladder to achieve a 24-Fr lumen at the internal stoma. A stoma which is too wide in a child with normal thickness of the bladder wall will allow prolapse.

51.4 Postoperative Management for Vesicocutaneostomy

After edema of the stoma is improved, 24-Fr cystostomy is removed (Fig. 51.4). After that, make parents do bougie using the little finger to prevent stomal stenosis.

Dermatitis, when it occurs, is treated with antifungal and antibacterial agents, urinary acidification, and protective skin coatings.

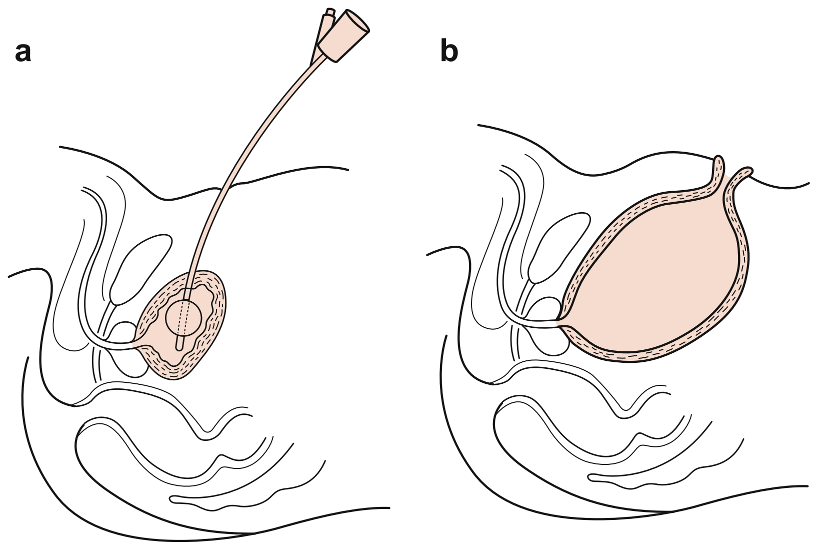

Fig. 51.1 Suprapubic cystostomy and vesicocutaneostomy. (**a**) Suprapubic cystostomy. (**b**) Vesicocutaneostomy

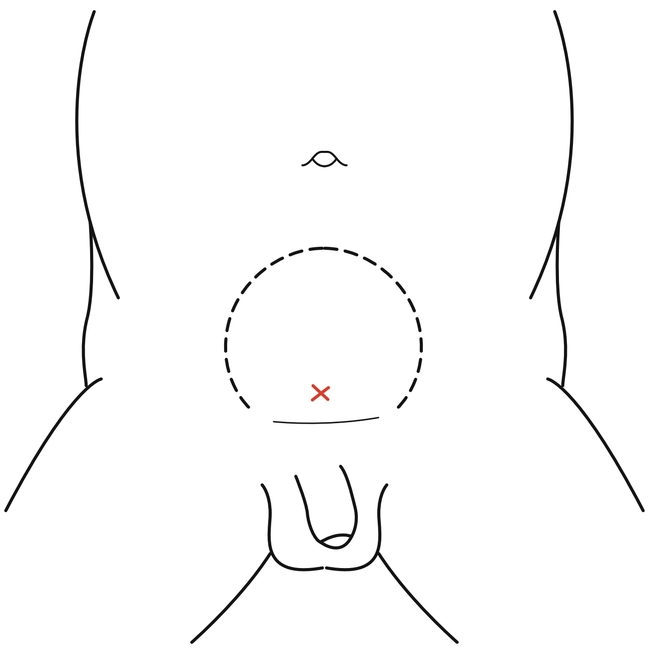

Fig. 51.2 Puncture site of suprapubic cystostomy

Prolapse of the posterior wall of the bladder is caused by placing the bladder incision too low and not fixing the dome (Fig. 51.5) [1]. Revision is necessary to make a new opening in the most cephalad part of the dome and narrow the fascial defect. Vesical epithelial eversion and squamous metaplasia are managed at the time that the vesicostomy is closed.

Stomal stenosis seldom is a problem, because an opening of 8 Fr is actually large enough, but obstruction may occur in some thickened bladders, evidenced by infection and the upper tract dilatation. Dermatitis also may narrow the lumen. Continuous bougie using the little finger could prevent stomal stenosis.

51.5 Closure of Vesicocutaneostomy

The decision to close a vesicocutaneostomy should be made only once the bladder function has been assessed and permanent therapy has been planned.

A balloon catheter is placed into the stoma, and incise an elliptical skin around the stoma. The subcutaneous and perivesical tissues are dissected circumferentially around the vesicostomy. The skin and protruding portion of the bladder are excised. Close the bladder in two layers, with running 3-0 absorbable suture for the bladder mucosa followed by interrupted 3-0 absorbable sutures for a second layer. Approximate the fascia and the skin with a drain indwelling.

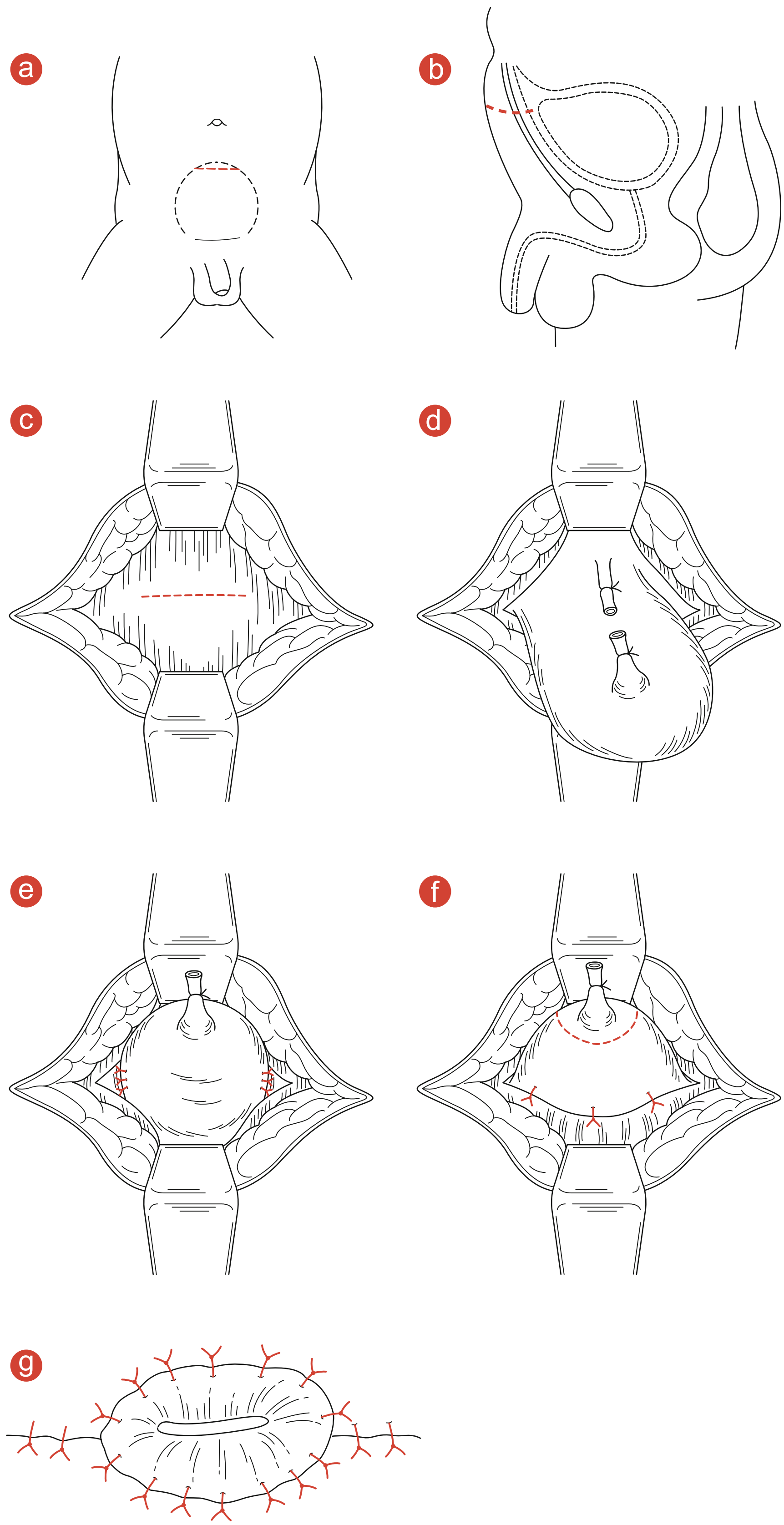

Fig. 51.3 Vesicocutaneostomy (Blocksom's method)

Fig. 51.4 Stoma of vesicocutaneostomy

Fig. 51.5 Bladder prolapse

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Bladder Augmentation

52

Yutaka Hayashi and Atsuyuki Yamataka

Abstract

The goal of bladder augmentation is to protect the upper urinary tract when less-invasive procedures are ineffective and to extend dry periods in children in whom incontinence is associated with low bladder compliance and capacity. There is no segment of the gastrointestinal tract (GIT) that is ideal for bladder augmentation, and stomach, ileum, and sigmoid colon have been used. Each segment has distinct advantages and disadvantages. Bladder auto-augmentation, which involves dissection of the seromuscular layers of the bladder, has been considered as an alternative to using segments of the GIT, to avoid disadvantages. There are two types of cystoplasty, namely, augmentation cystoplasty in which the bladder is enlarged and substitution cystoplasty in which the bladder is replaced. The method of choice depends on the state of the bladder. The main complications of bladder augmentation are infection, stone formation, metabolic complications, perforation, and cancer. Careful postoperative follow-up is crucial. It is particularly important to pay closer attention to patients, who are more than 10 years postoperative as they are at a relatively high risk for developing bladder cancer.

Keywords

Bladder augmentation • Neurogenic bladder • Vesicoureteral reflux • Clean intermittent catheterization

52.1 Introduction

Augmentation is indicated for bladders with small capacity and poor compliance, which are caused either by intrinsic disease of the detrusor muscle complex or from neurogenic overactivity that occurs secondarily to spinal cord disorders [1]. The goal of bladder augmentation is to protect the upper urinary tract when less-invasive procedures are ineffective and to extend dry periods in children in whom incontinence is a result of low bladder compliance or small capacity [2].

There are two types of cystoplasty, namely, augmentation cystoplasty in which the bladder is enlarged (clam procedure) and substitution cystoplasty in which the bladder is replaced (cap-patch procedure) [3].

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52.2 Preparation for Surgery

52.2.1 Indications for Bladder Augmentation

Indications for bladder augmentation at our institutions are (1) bladder capacity less than -2SD of standard capacity for normal children of matched age and sex, calculated according to the formula 30 + (patient age × 30) mL, (2) low bladder compliance (less than 10 mL/cmH_2O), (3) urinary incontinence unresponsive to conservative therapy for at least 6 months, and/or (4) presence of urinary tract infection (UTI) due to vesicoureteral reflux (VUR). Of these indications the most important are VUR and urinary incontinence [4].

Indications for ureteral reimplantation (URI) at our institutions are VUR of grade III or greater in at least one ureter or ureterovesical junction obstruction (UVJO). If lower grade VUR is present in the contralateral ureter and the ureteral orifice on that side is abnormally shaped on cystoscopy, bilateral URI is performed. Ureters are reimplanted into the native bladder or colon cap based on the condition of the bladder mucosa [5].

Our preference is to actively perform URI if VUR is present, to prevent future renal dysfunction. However, several authors have reported that when reflux is present at the time of bladder augmentation for neurogenic bladder, it is secondary to high bladder pressure that usually resolves after bladder augmentation without URI. Therefore, the indications for URI remain controversial.

52.2.2 Preoperative Investigations

The following preoperative investigations are recommended:

I. *Voiding cystourethrography*: To assess bladder capacity, bladder shape, and presence of VUR.
II. *Urodynamic studies*: To assess bladder compliance, detrusor leak point pressure, bladder overactivity, and sensation.
III. *Ultrasonography*, *magnetic resonance imaging*, *and intravenous pyelography*: To exclude UVJO.
IV. *Functional and biochemical analysis*: Renal function can be assessed by measuring serum electrolytes, creatinine, blood urea nitrogen, pH, β2-microglobulin, and N-acetyl-β-D-glucosaminidase, and renal scarring can be assessed with ^{99m}Tc-dimercapto-succinic acid scintigraphy.
V. *Urine culture*: To exclude UTI and confirm the type of antibiotic therapy to be used preoperatively if UTI is present.
VI. *Barium enema*: Evaluation of bowel shape.

52.2.3 Preparation for Surgery

Children are admitted to hospital 2 days prior to surgery and are commenced on a clear fluid diet. Bowel preparation is performed using Niflec® or Magcorol P®. An enema is performed on the day before surgery. We do not recommend preoperative administration of parenteral antibiotics because it could be implicated in increasing the frequency of methicillin-resistant *Staphylococcus aureus* enteritis [3].

52.2.4 Choice of Bowel Segment for Bladder Augmentation

Stomach, ileum, and sigmoid colon have been used for bladder augmentation. There is no segment of the GIT that is ideal for bladder augmentation, and each segment has distinct advantages and disadvantages. In selecting a segment, the following factors should be considered: (1) acceptable electrolyte reabsorption and loss, (2) accessibility of the segment, (3) simplicity of the procedure, (4) need for an antireflux mechanism, (5) risk for carcinogenesis, and (6) special requirements and age of the patient. Selection of a particular bowel segment for bladder augmentation can also depend on the preference of the surgeon, as there are no objective data that favor any one segment over another [1].

Sigmoid colon has the main advantage of being immediately behind the bladder with less risk for adhesion formation postoperatively. In addition, URI is possible with sigmoid colon. However, the risk for carcinogenesis is higher with sigmoid colon than with ileum.

Stomach has the advantages of little mucus formation and few metabolic consequences; however, acidosis may be induced. Acid secretion may also cause hematuria so most surgeons have abandoned the use of stomach for bladder augmentation.

Augmentation using ileum with cecum via the ileocecal arteries allows the formation of a mobilizable reservoir with a high capacity. However, removing a segment of ileocecum from the intestinal tract of children with neurogenic bladders who rely on constipation for rectal continence may result in loose stools and fecal incontinence, as well as secondary vitamin deficiency [1]. Ileum also has the advantage of low risk for carcinogenesis. Therefore, many urologic surgeons prefer ileum. However, to maintain bladder capacity, a long segment is required because it is narrow. In addition, URI is technically difficult [3].

52.3 Operations

52.3.1 Position and Incision

The child is placed in the supine position. The abdomen is accessed through a lower midline incision from the pubis to the umbilicus or a Pfannenstiel incision (Fig. 52.1). A lower midline incision can be extended easily if access to the entire abdomen is required. A Pfannenstiel incision allows less exposure but is superior cosmetically. The urachus is ligated and divided.

52.3.2 Accessing the Bladder

The peritoneum is incised to expose the dome of the bladder with its peritoneal covering. Using a traction suture at the urachus, a plane cleavage along the lateral bladder margin down to the ureters and superior vesical pedicle on each side is performed.

52.3.3 Incision of the Bladder

There are two types of cystoplasty, namely, augmentation cystoplasty in which the bladder is enlarged and substitution cystoplasty in which the bladder is replaced. Following maximal bladder exposure, incision of the bladder wall is performed in either a circumferential or midline fashion.

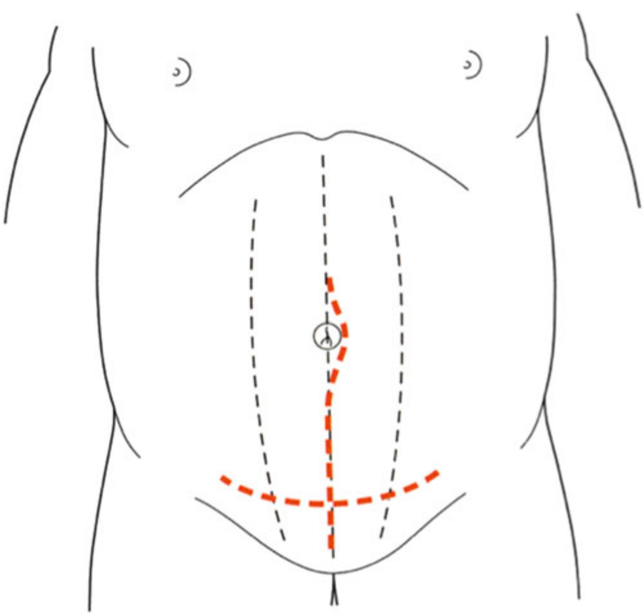

Fig. 52.1 Incision used for bladder augmentation surgery. Either a lower midline incision or a Pfannenstiel incision is used for bladder augmentation surgery

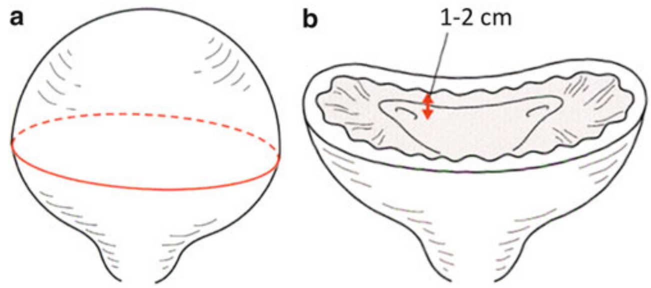

Fig. 52.2 Substitution cystoplasty. (**a**) Diagram of a circumferential bladder incision. (**b**) The bladder is exposed from a point 1–2 cm from the ureteric orifice

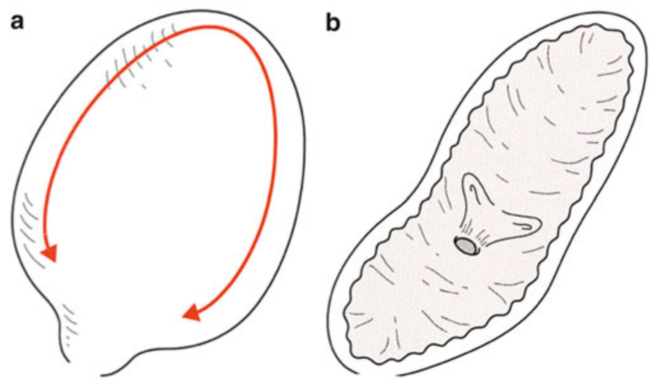

Fig. 52.3 Augmentation cystoplasty. (**a**) Diagram of a midline bladder incision. (**b**) The bladder is opened 1 cm from the bladder neck on each side

If the surgeon prefers a circumferential incision, the bladder is exposed from a point 1–2 cm from the ureteric orifice (Fig. 52.2a, b). In the case of a midline bladder incision, the bladder is opened 1 cm from the bladder neck on each side of the bladder (Fig. 52.3a, b). A safe incision is achieved by starting on the bladder dome and opening the bladder using diathermy down one side at time. Use of ureteric catheters is an option at the time of incision. The suitable procedure will depend on the state of the bladder. In our institutions, if the bladder is highly atrophic or fibrotic, substitution cystoplasty is selected. Moreover, because the peritoneum is required for extra-peritonealization of the bladder, this should be preserved.

52.3.4 Preparing the Bowel Segment

A convenient segment of the terminal ileum is isolated 15 cm proximal to the ileocecal valve. If the surgeon performs augmentation cystoplasty, the ileum should be equal in length to the measured maximal circumference of the bisected bladder. If the surgeon performs substitution

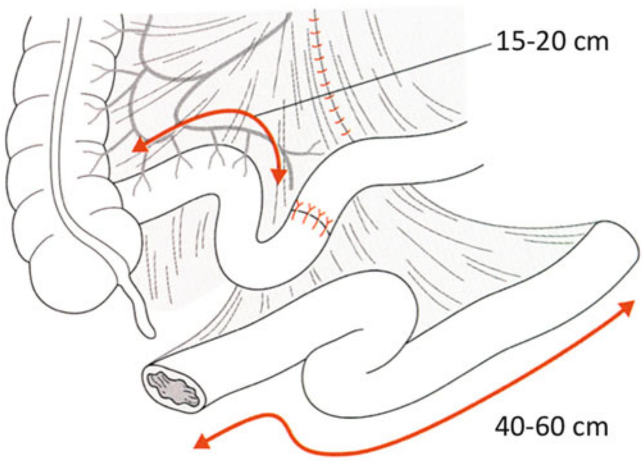

Fig. 52.4 Dissection of the ileum. A 40–60 cm length of the ileum is dissected

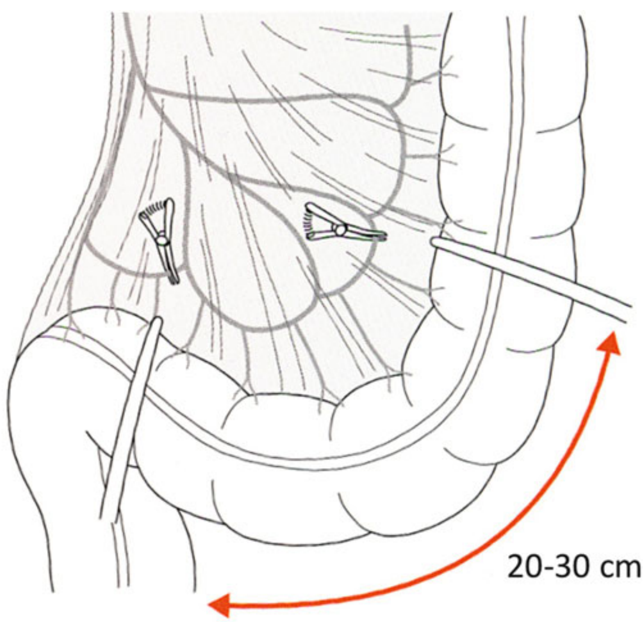

Fig. 52.5 Dissection of the sigmoid colon. A 20–30 cm long segment is dissected

cystoplasty, a 40–60 cm length of the terminal ileum should be dissected (Fig. 52.4). If the surgeon uses the sigmoid colon, a 20–30 cm segment should be dissected (Fig. 52.5). During these procedures, surgeons should take care not to damage the vascular pedicle. Two-layer anastomosis using GIA staplers or hand-sewn sutures is then performed.

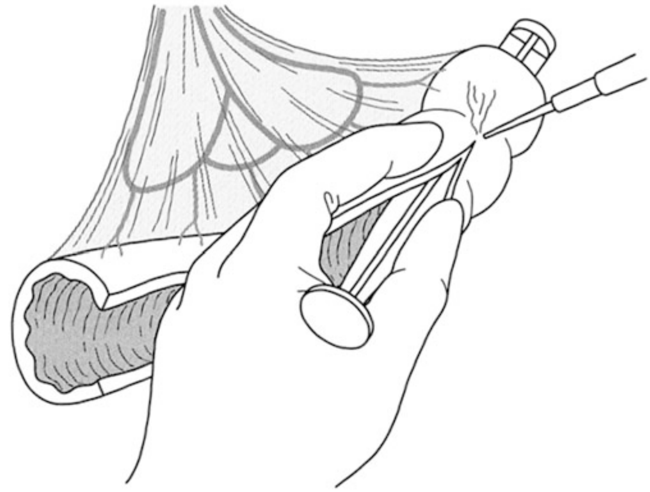

Fig. 52.6 Detubularization. The antimesenteric side is incised longitudinally

52.3.5 Detubularization

A detubularized bowel segment provides greater capacity at lower pressure and requires a shorter bowel segment than intact segments (Fig. 52.6). The surgeon should irrigate the bowel segment with an iodine solution (1:100 dilution) before detubularization. The antimesenteric border is incised longitudinally.

52.3.6 Augmentation Cystoplasty

The ileal patch is inserted into the bisected bladder and sewn in place. To prevent overlap of the ileal edge and bladder edges caused by the tendency of the bladder wall to contract during the procedure, the suture line is halved and thereafter quartered with stay sutures. An ileal patch is anastomosed to the posterior and anterior bladder wall using 3-0 absorbable continuous sutures to secure the stay suture (Fig. 52.7).

52.3.7 Substitution Cystoplasty

The surgeon first creates a U-shape colon cap using 3-0 absorbable continuous sutures (Fig. 52.8a). The native bladder and colon cap are anastomosed using 2-0 absorbable interrupted sutures (Fig. 52.8b). At that time, the surgeon

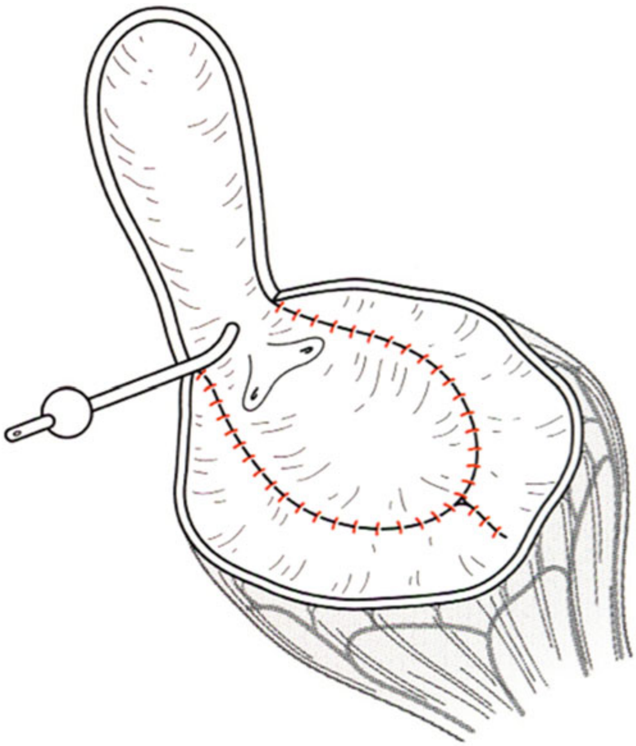

Fig. 52.7 Augmentation cystoplasty. An ileal patch is anastomosed to the bladder wall using absorbable sutures

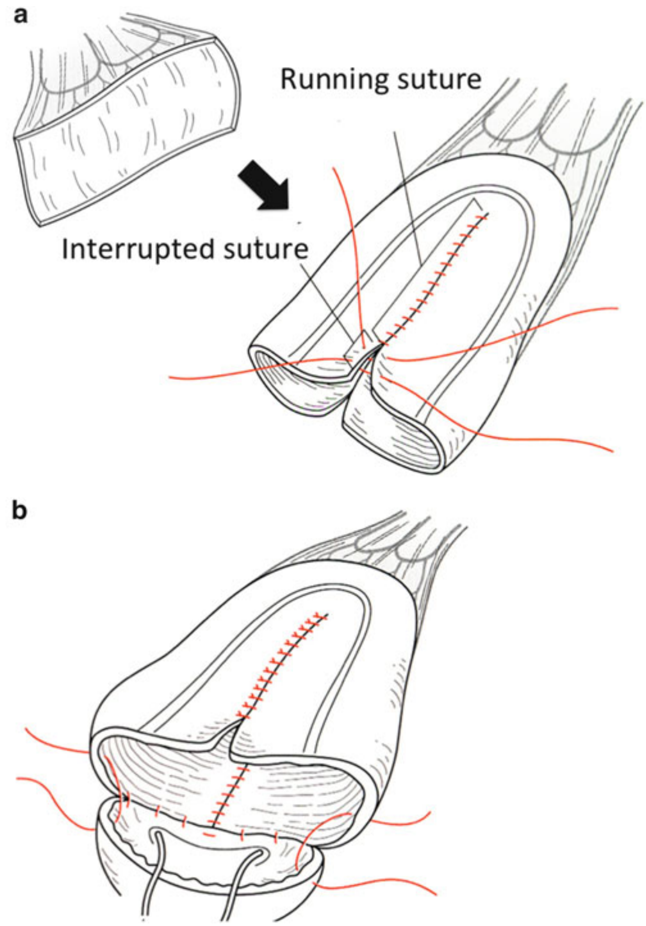

Fig. 52.8 Substitution cystoplasty. (**a**) A U-shape colon cap is created using absorbable sutures. (**b**) Diagram of anastomosis of the colon cap and native bladder

must be careful that there are no anastomoses to the ureters. The surgeon should place a catheter into the urinary tract, if necessary.

52.3.8 Reimplantation of the Ureter into the Colon Cap

When anterior reimplantation is used, the colon cap is first anastomosed to the native bladder using single-layer interrupted polyglyconate sutures, and the ureter(s) are reimplanted into the taenia coli in the anterior wall of the colon cap using Leadbetter's ureterosigmoidostomy technique (Fig. 52.9a–d). When posterior reimplantation is used, the ureters are first reimplanted into the posterior wall of the colon cap using Goodwin's ureterosigmoidostomy technique, and the colon cap is anastomosed to the native bladder after reimplantation. A 6 Fr or 7.5 Fr ureteric catheter is inserted into each reimplanted ureter as a stent [6].

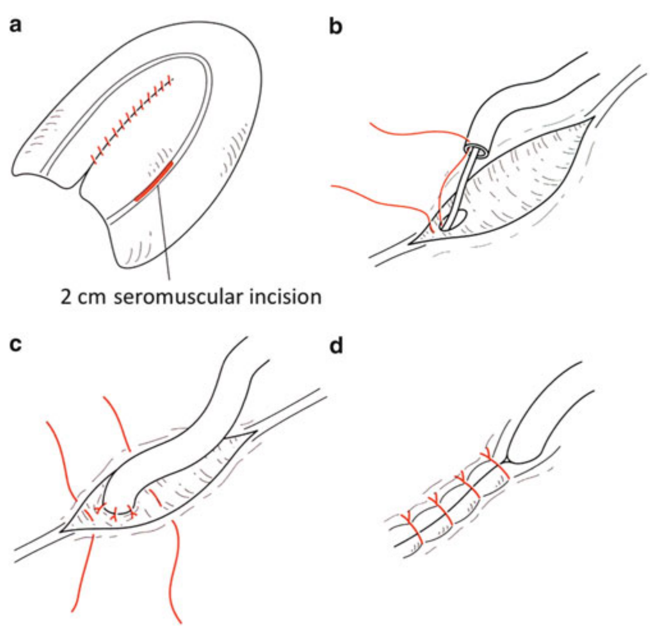

Fig. 52.9 Reimplantation of the ureter into the colon cap. (**a**) A 2 cm seromuscular incision is made. (**b**) A hole is created and anastomosis is performed. (**c**) Repairing the serosa. (**d**) Completion of reimplantation

52.3.9 Readaptation of the Peritoneum

The bladder is extended using normal saline and the peritoneum is sutured to the area with no tension.

52.4 Postoperative Management

Surgeons should pay attention to possible obstruction of the urinary catheter caused by mucus and coagulated blood. At our institutions, daily bladder irrigation is commenced 2–5 days postoperatively. Cystourethrography is performed 7 days postoperatively, and the urethral catheter is removed if there is no leakage from the anastomosis. The patients undergo daily bladder irrigation. Cystoscopy is performed annually including biopsies.

52.5 Complications

The main complications of bladder augmentation surgery are infection, stone formation, metabolic complications, perforation, and cancer. It is important to distinguish between the presence of bacteria, which is nearly always found in a child with an augmented bladder performing clean intermittent catheterization, and clinically significant UTI. Mucus formation is a well-known risk factor for stone formation post-bladder augmentation surgery. Bladder irrigation with normal saline has been shown to reduce the risk for stone formation. Reservoir perforation is a rare but life-threatening complication. It is difficult to detect and should be suspected in the case of abdominal or shoulder pain. Most cases of perforation require surgical intervention. It is now well established that an augmented bladder is at a relatively high risk for carcinogenesis. However, the majority of patients who developed cancer did so more than 10 years after surgery. This implies the need for adequate patient education and close follow-up using ultrasonography and cystoscopy well before 10 years has elapsed since surgery [2, 5].

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Posterior Sagittal Anorecto-Urethro-Vaginoplasty 53

Yutaka Hayashi, Akihiko Tsuchida, and Atsuyuki Yamataka

Abstract

A cloaca is a congenital malformation that occurs in females, in which the rectum and urogenital tract develop as a single perineal orifice. The vagina, urethra, and rectum are fused together inside the pelvis, creating a single common channel that emerges where the urethra normally opens. Incidence of cloacal anomalies is about 1 in every 20,000 live births. There are two major groups of patients with cloaca: one that comprises patients who are born with a common channel shorter than 3 cm and another that comprises patients with a longer common channel. For surgical correction, these two groups require technically different procedures. Patients with a common channel shorter than 3 cm require posterior sagittal anorecto-urethro-vaginoplasty or total urogenital mobilization, whereas patients with a common channel that is longer than 3 cm require vaginoplasty using a segment of bowel.

Keywords

Cloaca • Posterior sagittal anorecto-urethro-vaginoplasty • Total urogenital mobilization

53.1 Introduction

A cloaca is a congenital anomaly or malformation of the anorectum in females, in which the rectum and urogenital tract develop as a single perineal orifice [1]. The vagina, urethra, and rectum are fused together inside the pelvis, creating a single common channel that emerges where the urethra normally opens. Incidence of cloacal anomalies is about 1 in 20,000 live births [2]. Surgical reconstruction is performed aiming to achieve urinary control, bowel control, menstrual function, sexual function, and obstetric potential and represents a significant technical challenge [3]. In patients with cloacal malformation, the length of the common channel varies from 1 to 10 cm, which has important technical and prognostic implications. Patients with a common channel that is shorter than 3 cm usually have a well-developed sacrum and well-functioning sphincters and represent more than 62 % of all patients with cloaca [4]. Patients with a common channel that is longer than 3 cm usually have a more complex defect, including poor sphincter function and an underdeveloped sacrum [2]. These patients have a high incidence of associated anomalies and complex anatomy [4].

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53.2 Diagnosis and Management During the Neonatal Period

A cloaca is diagnosed clinically by careful separation of the labia to identify a single perineal orifice, which is pathognomonic for cloaca. Patients also often have small external genitalia. Patients with persistent cloaca have a 90 % chance of having an associated genitourinary abnormality. The main associated urologic anomalies include hydronephrosis, hydroureter, and vesicoureteral reflux. Associated genital anomalies include deformity of the uterus in 88.5 %, double vagina in 49.4 %, and vaginal stenosis in 84.5 % of patients, according to a report of the Japan Society of Anorectal Malformation Study Group in 2010 (unpublished data). Thus, a thorough investigation of the genitourinary system is mandatory for patients with cloaca [2].

All patients with cloaca require a colostomy, to prevent fecal contamination during surgical intervention [2]. A colostomy is performed by constructing a stoma in the transverse colon.

In more than 30 % of patients with cloaca, the vagina is distended abnormally and full of mucus (hydrocolpos) [2]. These patients have a palpable lower abdominal mass, and drainage of the hydrocolpos is required [5].

53.3 Preoperative Assessment and Timing of Surgery

Timing of surgery: when the patient reaches 8–10 kg in weight
Evaluation of pelvic floor muscles: magnetic resonance imaging and electric muscle stimulation (EMS)
Evaluation of intestinal and urogenital anatomy: cloacagram, voiding cystourethrography, barium enema, and vaginography

53.4 Operations

53.4.1 Cloaca with a Common Channel Shorter Than 3 cm

53.4.1.1 Posterior Sagittal Anorecto-Urethro-Vaginoplasty (PSARUVP)

For surgery, the patient is placed in the jack-knife position. Because it is necessary to change the position of the patient several times during surgery, the entire lower limbs of the patient require preoperative preparation. A long midsagittal incision is made from the middle part of the sacrum to the anal sphincter and extending down to the single perineal opening (Fig. 53.1). All musculature is divided in the midline. The low cloacal malformation is usually associated with a well-developed sacrum, a normal appearing perineum, and well-developed muscles and nerves.

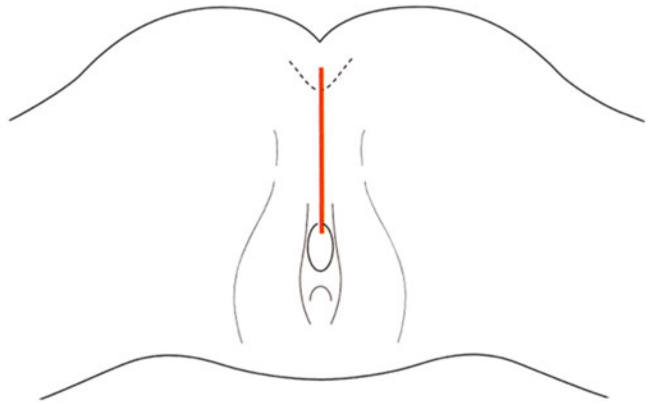

Fig. 53.1 Position of the skin incision. The patient is placed in the jack-knife position. A midsagittal incision is made from the middle of the sacrum to the perineal opening (shown in *red*)

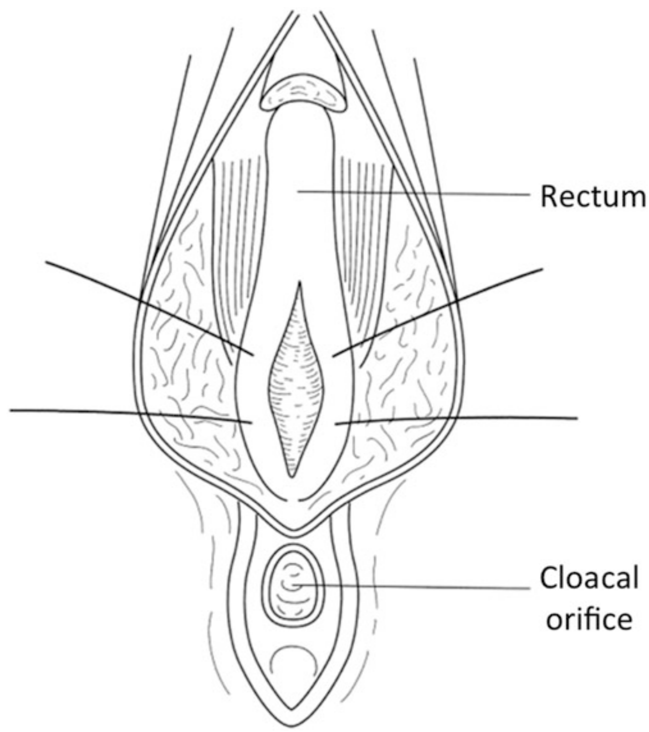

Fig. 53.2 Dissection of the cloaca. The rectum is opened to confirm the junction of the rectum, vagina, and urethra

After the coccyx is removed at the sacrococcygeal joint, the entire sphincter is divided in the midline using fine-needle cautery. When all musculature is divided, the rectum is exposed.

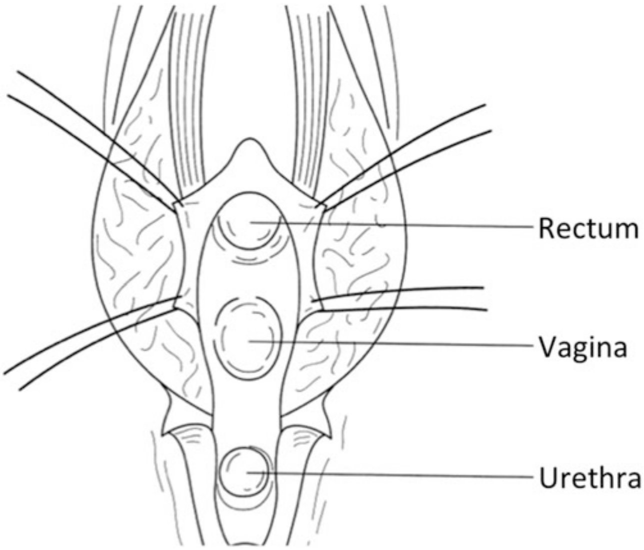

Fig. 53.3 Dissection of the rectum and vagina. Dissection is performed between the rectum and vagina

The rectum is opened in the midline and stay sutures are placed along the edges of the posterior rectal wall (Fig. 53.2). The incision is extended distally through the posterior wall of the common channel. The entire common channel is exposed, which enables direct measurement and confirmation of the length of the common channel (Fig. 53.3).

The rectum and vagina are separated. Multiple 6-0 stay sutures are placed at the edge of the rectal fistula orifice for the application of uniform traction on the rectum to facilitate dissection. In cloaca, the rectum and vagina share a common wall which is often very thin. Dissection is performed by cauterization using a very fine needle together with suction, to enhance accurate cauterization of microvasculature. Dissection is continued to the point where the rectum and vagina separate and each have full-thickness walls. Dissection between the vagina and urethra is performed similarly (Fig. 53.4). The rectum is positioned in front of the levator muscle and within the limits of the perineal muscle complex and the external sphincter. Anoplasty is performed with 5-0 absorbable sutures. The wound is closed, apposing corresponding structures in the midline. Finally, the vagina and urethra are sutured to the skin of the labia.

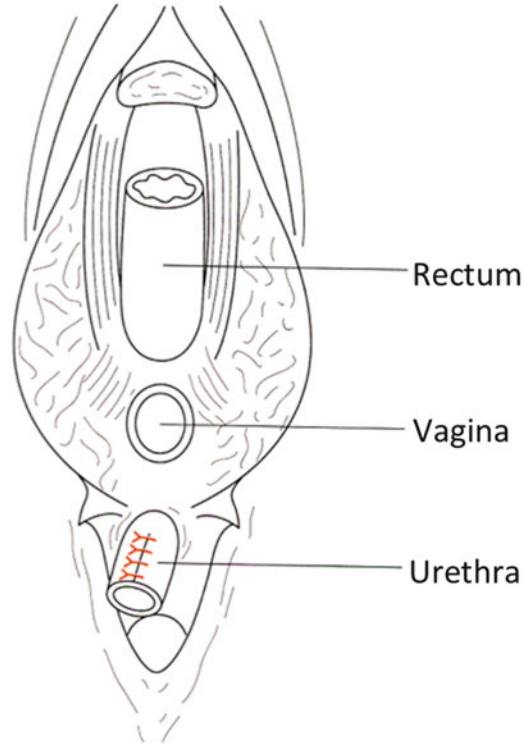

Fig. 53.4 Creation of the urethral orifice, vaginal orifice, and anal orifice. Each orifice is created after the urethra, vagina, and rectum are dissected

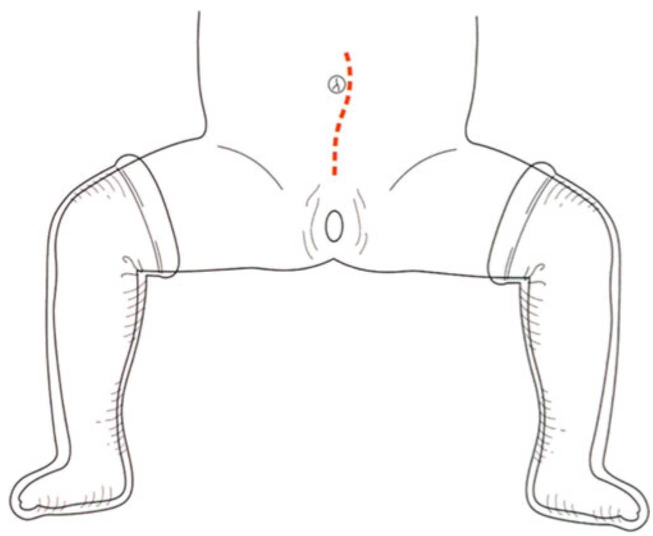

Fig. 53.5 Position and skin incision. The patient is positioned in the lithotomy position. A midline laparotomy is performed (shown in *red*)

53.4.1.2 Total Urogenital Mobilization (TUM)

TUM involves mobilization of both the vagina and urethra as a unit, without separation. TUM has two major advantages. One is preservation of a good blood supply to both the urethra and vagina. The other is to enable the location of the urethra to be identified easily to facilitate intermittent catheterization should it be necessary. This technique also ensures smooth urethral catheterization [2].

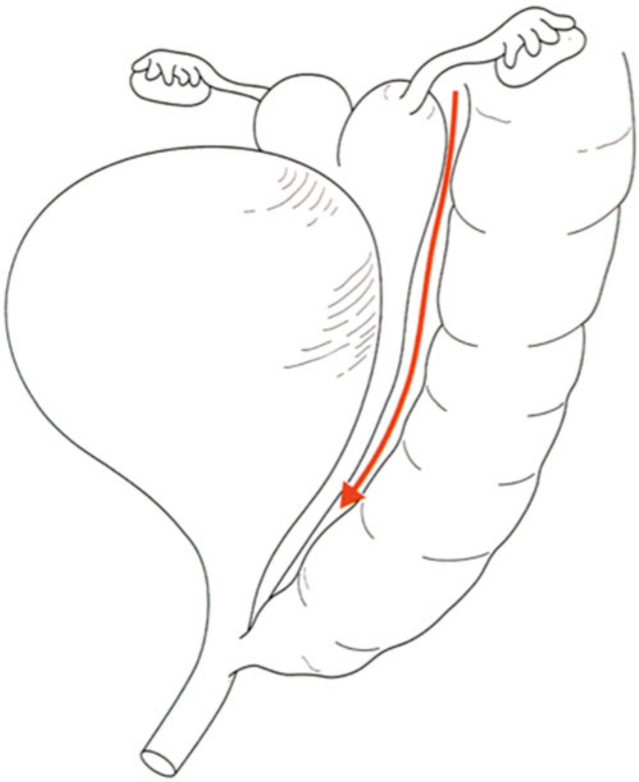

Fig. 53.6 Dissection of the rectum and common channel. Injury to the pelvic plexus during dissection of the rectum and the common channel must be avoided (*red arrow*)

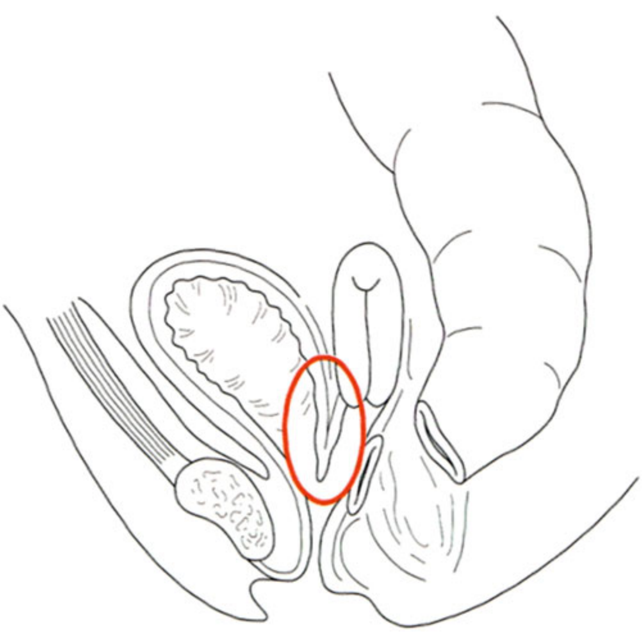

Fig. 53.7 Dissection of the vagina and urethra. Injury to the urethra during dissection of the vagina and urethra must be avoided (Note: the vagina and urethra share a common wall (*oval*))

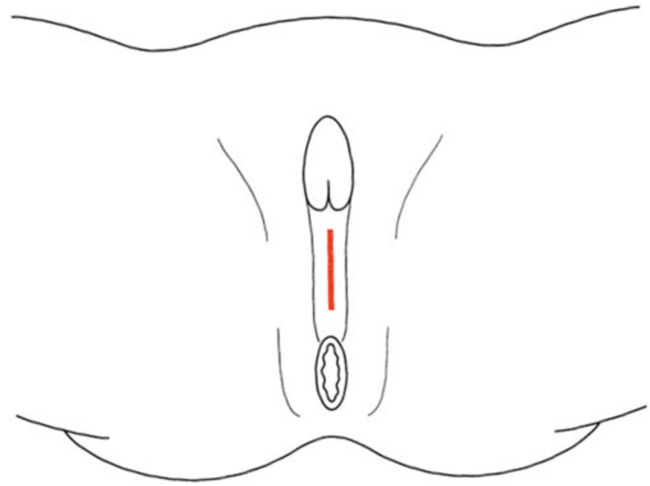

Fig. 53.8 Incision of the skin for creating the vaginal orifice and anal orifice. The skin is incised on the dorsal side of the cloacal orifice (*red line*) to enable subsequent rectal and vaginal pull-throughs

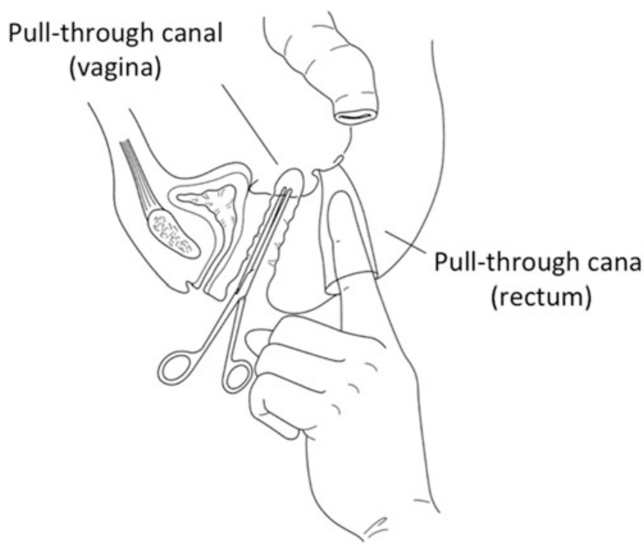

Fig. 53.9 Creation of the pull-through canal. The pull-through canal is created after the skin incisions are made. When planning the position of the pull-through canal, the center of the external anal sphincter must be identified using electric muscle stimulation, because the pull-through must pass through the center of the perineal muscle complex

53.4.2 Modified Georgeson's Procedure for Cloaca with a Common Channel Longer Than 3 cm

A very long common channel cannot be repaired by PSARUVP or TUM, and the channel should be left in situ for later intermittent catheterization. When the common channel is longer than 5 cm, it should be used to repair the urethra. In addition, replacement of the vagina with a segment of bowel is required.

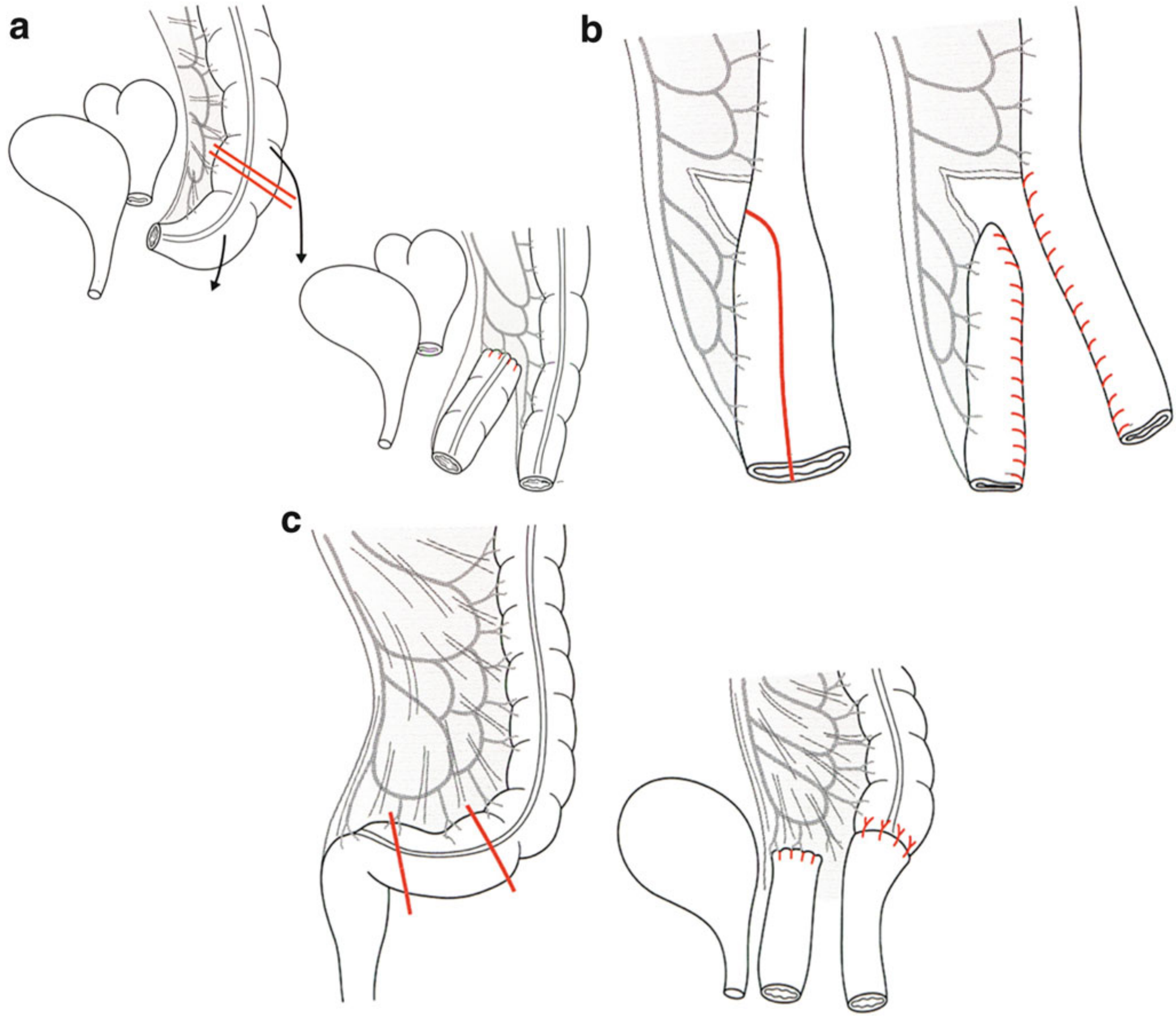

Fig. 53.10 Vaginoplasty using segments of bowel. (**a**) Vaginoplasty using rectum. (**b**) Vaginoplasty using megarectum. (**c**) Vaginoplasty using sigmoid colon

The patient is positioned in the lithotomy position. Preoperative preparation should extend from the nipples to the toes. A midline laparotomy is performed (Fig. 53.5). The colorectum is dissected downward caudally as far as possible, and the colorectal vessels divided (Fig. 53.6). After rectal dissection, the length of the vagina must be confirmed. If the vagina is short, some form of vaginoplasty is required. The vagina should be separated from the common channel carefully with preservation of its blood supply from the uterine vessels. Care is required when dissecting between the vagina and urethra because they share a common wall (Fig. 53.7). The skin is incised dorsal to the cloacal orifice to allow for rectal and vaginal pull-through (Fig. 53.8). At this time, the center of the external anal sphincter should be identified using EMS to ensure the rectum is pulled through the center of the perineal muscle complex (Fig. 53.9). When the rectum and vagina are positioned in the perineum, there must be no torsion or tension on any structures including vasculature.

If the vagina is absent, or very small and located very high, it can be replaced completely with either rectum (Fig. 53.10a, b), sigmoid colon (Fig. 53.10c), or small bowel [2, 4].

53.5 Complications

Complications include persistent urogenital sinus, vaginal atresia or stenosis, rectal prolapse, and urethral stenosis [3]. Vaginal dilatation using bougies is necessary to prevent vaginal atresia and stenosis.

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Hypospadias

54

Yutaka Hayashi and Atsuyuki Yamataka

Abstract

Hypospadias is a common congenital malformation in boys classically defined as a combination of (1) abnormal ventral opening of the urethral meatus, (2) abnormal ventral curvature of the penis (chordee), and (3) underdeveloped foreskin that does not wrap completely around the penis, often absent ventrally. The need for surgical reconstruction is obvious in patients with severe hypospadias and chordee to allow comfortable urination in a standing position and maximize reproductive/sexual function. There is no single universally accepted technique for hypospadias repair. The choice of urethroplasty technique may depend on the degree of chordee. Common complications are bleeding, infection, urinary retention, urethrocutaneous fistula, meatal stenosis, and diverticulum formation. To prevent complications, meticulous surgical technique is mandatory.

Keywords

Hypospadias • Snodgrass procedure • Sliding urethral plate • Soft tissue interposition

54.1 Introduction

Hypospadias is a common congenital malformation in boys, associated with abnormal positioning of the urethral meatus on the ventral side of the penis [1]. The term is derived from the Greek words *hypo* meaning "under" and *spadon* meaning "opening" [1]. Approximately 1 in 300 live male births are affected, and recent studies have suggested that the incidence of hypospadias may be on the rise with a three- to fivefold increase in severe hypospadias over the past two decades [2].

Hypospadias arises as a consequence of arrested development of the male urethra during gestational weeks 8–16. Severity depends on the timing of arrest, with the meatus positioned ventrally on the shaft of the penis or in the scrotum in less severe cases and in the perineum in more severe cases. Hypospadias is an autosomal dominant disorder with reported concordance in dizygotic twins of 9 % and 27 % in monozygotic twins, reflecting its hereditary nature. The risk of hypospadias in a boy with an older brother with hypospadias has been reported to be approximately 12–14 %, and the risk of hypospadias in the son of a father with hypospadias has been reported to be approximately 7–9 %. If there are two first-degree relatives with hypospadias, the risk of the next sibling having hypospadias is as high as 26 %. About 10 % of patients have a relative with hypospadias; however, most cases would appear to be sporadic [1].

There are several gestational factors that are associated with hypospadias, with the most important being low birth weight adjusted for gestational age. Severity appears to be

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correlated with low birth weight because restriction of growth and development occurs early as reflected by small head circumference and short body length. Maternal risk factors are preeclampsia, diabetes mellitus, epilepsy, and influenza during the first trimester. Hypospadias may also be associated with chromosomal abnormalities and occurs in several syndromes, probably because birth weight is lower in the majority of these patients. Estrogenic environmental hormones have received attention as a cause of hypospadias during the past few decades [1].

Hypospadias is classically defined as a combination of the following: (1) abnormal ventral opening of the urethral meatus, (2) abnormal ventral curvature of the penis (chordee), and (3) undeveloped foreskin that does not wrap completely around the penis usually absent ventrally. Hypospadias is usually easily identified during routine baby health checks, but in some instances of mild hypospadias, such as the variant with megameatus and intact prepuce and normal foreskin, hypospadias may not be recognized until the foreskin can be retracted [2].

54.2 Classification of Hypospadias

The most common classification system involves the position of the meatus. Glanular, coronal, and subcoronal positions constitute the majority of cases (approximately 70 %), but hypospadias can be more severe, with the urethral meatus located in the scrotum or perineum (Fig. 54.1) [2].

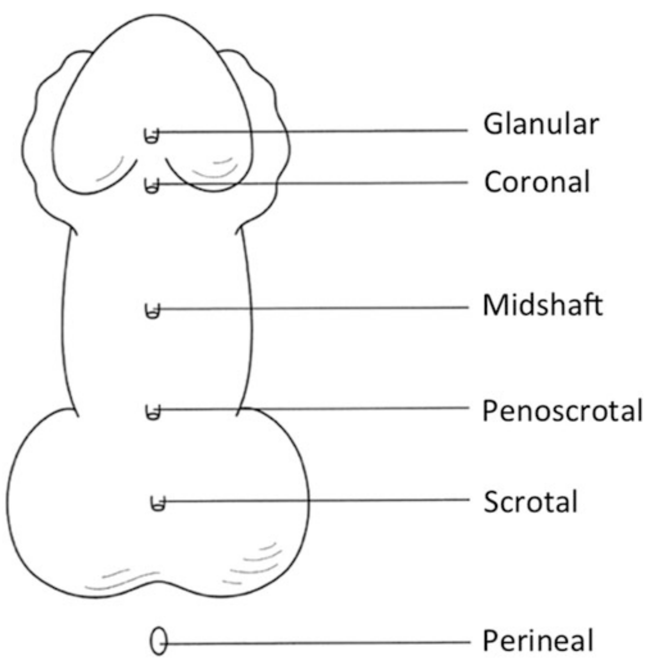

Fig. 54.1 Classification of hypospadias

54.3 Associated Conditions

Associated anomalies include cryptorchidism (8–9 %) and inguinal hernia/hydrocele (9–16 %). The incidence of associated genital anomalies increases in patients with more proximal hypospadias. An intersex condition should be considered in patients with concomitant hypospadias and cryptorchidism. Patients with severe hypospadias may also have a significantly enlarged prostatic utricle, which may serve as a nidus for urinary tract infections and cause voiding difficulties [2].

54.4 Preoperative Investigations and Preparation

54.4.1 Preoperative Investigations

Routine imaging of the urinary tract

Ultrasonography
Intravenous urography

Assessment of the lower urinary tract in cases of severe hypospadias

Endoscopy
Voiding cystourethrography

54.4.2 Hormone Therapy

There is considerable disagreement regarding the use of hormone therapy prior to surgical repair to enlarge the penis [2]. Preoperative testosterone has been shown to increase penis size as well as improve skin viability. However, there is a risk for precocious puberty with its use.

54.4.3 Timing of Surgery

A report by the American Academy of Pediatrics suggested that the best time for surgery for hypospadias repair is between 6 and 12 months of age [1]. This recommendation was made based on a number of factors, including the psychological aspect of hypospadias surgery and advances in pediatric anesthesia. Postoperative management in infants today is also easier than it was in the past because of new products that make neourethral catheterization and wound care safer [2].

54.5 Operations

The primary goal of hypospadias repair is to enable a patient to urinate comfortably while standing and ensure sexual/reproductive activity is effective. The need for surgical reconstruction is obvious in patients with severe hypospadias and chordee. There is no single universally applicable technique for hypospadias repair. Choice of technique begins with physical examination to assess the location of the meatus, the size of the penis, presence of chordee, and quality of the ventral skin over the native urethra.

Hypospadias is repairable in most patients if well-vascularized tissues are present. Hemostasis must be performed with meticulous precision, but cauterization must be judicious to avoid ischemic tissue necrosis which can lead to the breakdown of repaired tissue, infection, and urethrocutaneous fistula formation. Cautious use of vasoconstrictive agents around the corona of the glans can also reduce the amount of intraoperative bleeding.

Choice of urethroplasty depends on the degree of chordee. Curvature is evaluated by an artificial erection test. If curvature is severe (greater than 90°) and the penis is short, division of the urethral plate, excision of ventral fibrous chordee tissue, and placement of a corporal patch after a relaxing transverse incision of the tunica albuginea should be performed.

54.5.1 Preoperative and Intraoperative Artificial Erection

Saline (5–10 mL) is injected directly into both of the corpora cavernosa using a 27-gauge butterfly needle (Fig. 54.2). Alternatively, the needle may be passed through the glans into the tip of a corpus to minimize hematoma beneath Buck's fascia.

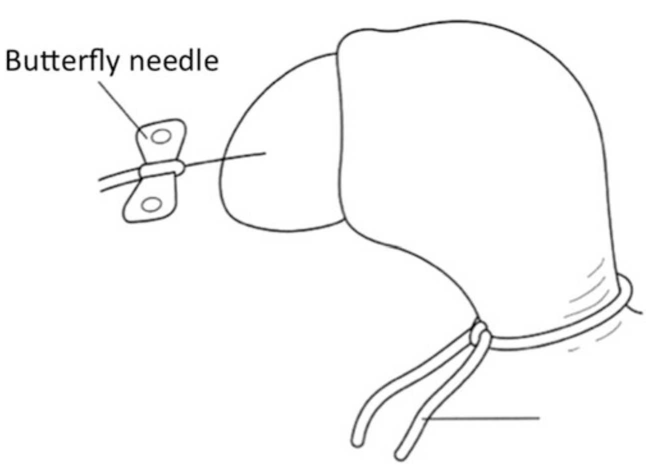

Fig. 54.2 Artificial erection. Saline is injected directly into both corpora cavernosa using a 27-gauge butterfly needle

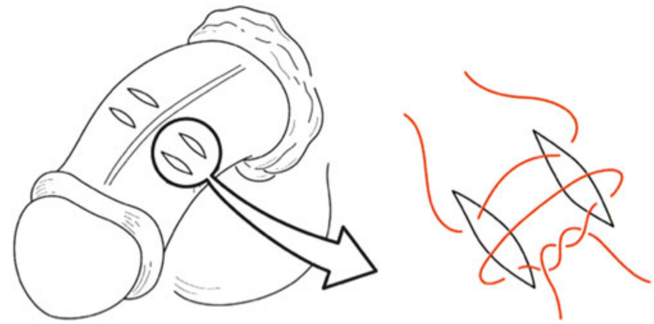

Fig. 54.3 Dorsal corporal plication. Two parallel incisions are made at the point of maximum curvature; the outer edges of the incisions are approximated

54.5.2 Correction of Chordee

54.5.2.1 Dorsal Corporeal Plication

Two parallel incisions are made dorsolaterally at the point of maximum curvature over the tunica albuginea of each corpus, and the outer edges of the incisions are approximated using 4-0 absorbable sutures (Fig. 54.3).

When penile curvature is pronounced and the penis is short, dorsal plication may not be appropriate because there is potential for shortening of the penis. Ventral transverse incision of the tunica albuginea and patch grafting may be more suitable [3].

54.5.2.2 Sliding Urethral Plate Repair

An artificial erection is first induced to confirm the severity of chordee and determine the length the U-flap that is required.

The U-flap is created by making a ventral incision along the penis that is extended distally to the meatus. Creating the U-flap involves making an incision ventrally along the penis, which extends distally to the meatus and dissection to create a long, wide, and U-shaped flap that preserves the ventral penile skin, including the entire urethral plate as far as the coronal sulcus (Fig. 54.4a). To maintain a healthy blood supply to the U-flap, particularly in the distal region, the distance between the incisions made for the arms of the U at the coronal sulcus should be wide and preferably at the 3 o'clock and 9 o'clock position with respect to the coronal sulcus, because the subcutaneous blood supply to the U-flap comes only from the coronal sulcus. The urethra is divided just proximal to the meatus during U-flap dissection (Fig. 54.4b), and the cut end of the urethra is then dissected proximally for 5–10 mm to expose the tunica albuginea behind the original meatus, which is usually located at the point of maximal curvature of the chordee (Fig. 54.4c). After excision of the fibrotic chordee, an artificial erection is again induced. If moderate to severe penile curvature is still present, the tunica albuginea is incised semi-circumferentially on the ventral side of the penile shaft to correct the corporeal

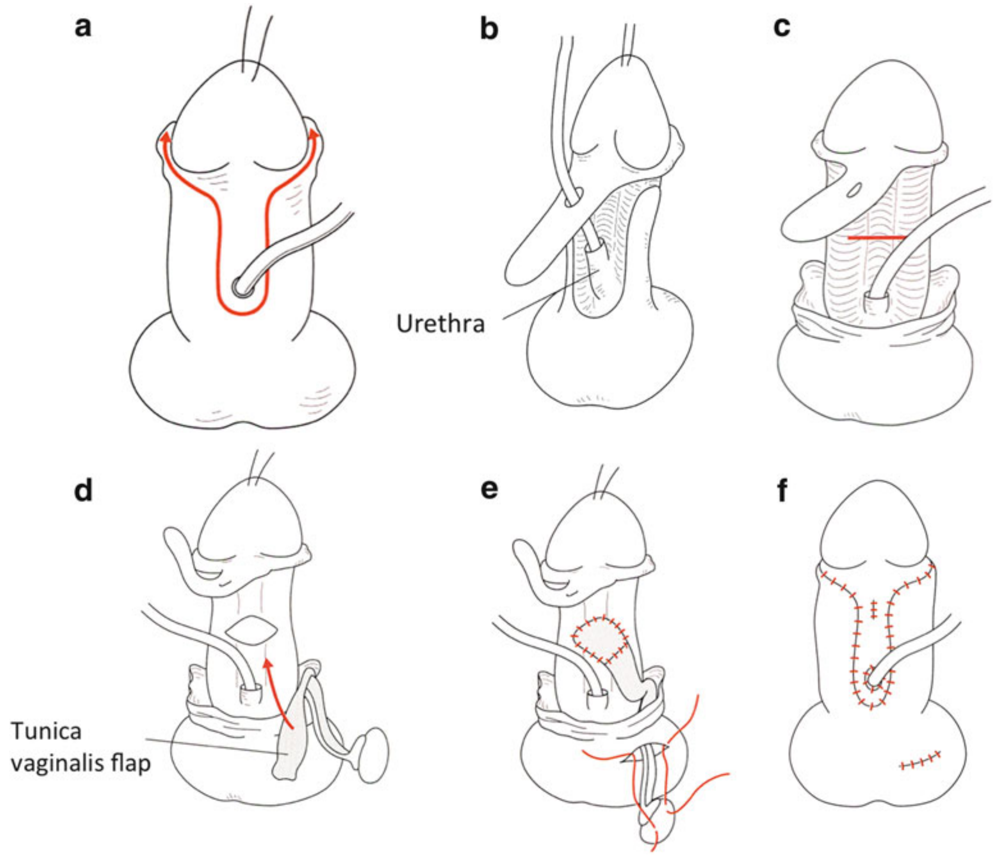

Fig. 54.4 Sliding urethral plate technique. (**a**) Creation of the U-flap. (**b**) Division of the native urethra. (**c**) Exposure of the tunica albuginea. (**d**) Creation of a tunica vaginalis flap. (**e**) Anastomosis of the diamond-shaped incision in the tunica albuginea and the pedicle of the tunica vaginalis flap. (**f**) Skin closure

disproportion, resulting in straightening and adequate lengthening of the penis. The resultant diamond-shaped opening in the tunica albuginea is covered with a pedicled tunica vaginalis flap that has been detached from the left testis and spermatic cord (Fig. 54.4d, e). The U-flap is returned to the ventral penile shaft and sutured in place (Fig. 54.4f). A buttonhole is made distally in the U-flap and anastomosed to the cut end of the urethra to create a neomeatus. Urethroplasty is performed 6–18 months later.

54.5.3 Urethroplasty

54.5.3.1 Meatal Advancement and Glanuloplasty (MAGPI)

For glanular and some coronal hypospadias without significant chordee, MAGPI is a simple procedure for hypospadias repair.

An incision line is drawn 5 mm behind the meatus (Fig. 54.5a), and an incision is made around the glanular groove. The dorsal meatus opens up in a diamond shape (Fig. 54.5b). This is closed transversally with two to three sutures (Fig. 54.5c). The ventral lip of the urethra is fixed with a holding stitch and brought forward (Fig. 54.5d). Any chordee present is then repaired before glanuloplasty. After ventrolateral de-epithelialization of the glans tissue proximal to the urethral meatus, glanuloplasty is performed in two layers (Fig. 54.5e, f) while gently retracting the lower lip of the urethral meatus upward (Fig. 54.5g).

54.5.3.2 Tubularized Incised Plate Urethroplasty (Snodgrass Procedure)

The urethral tubularization technique is not considered suitable for penises with a flat urethral plate, owing to the possibility of excessive tension of the neourethral suture line. The Snodgrass procedure is an improved version of the Thiersch-Duplay technique, which saves a narrow urethral plate for tubularization. The Snodgrass technique includes the vertical distal urethral plate incision technique to relax urethral plate tension.

A 10-mm-wide segment of the urethral plate distal to the urethral meatus is marked, and incisions are made along the lateral borders of the urethral plate (Fig. 54.6a). The distal end of this incision must be carefully planned to avoid ending up with a circumferentially sutured urethral meatus,

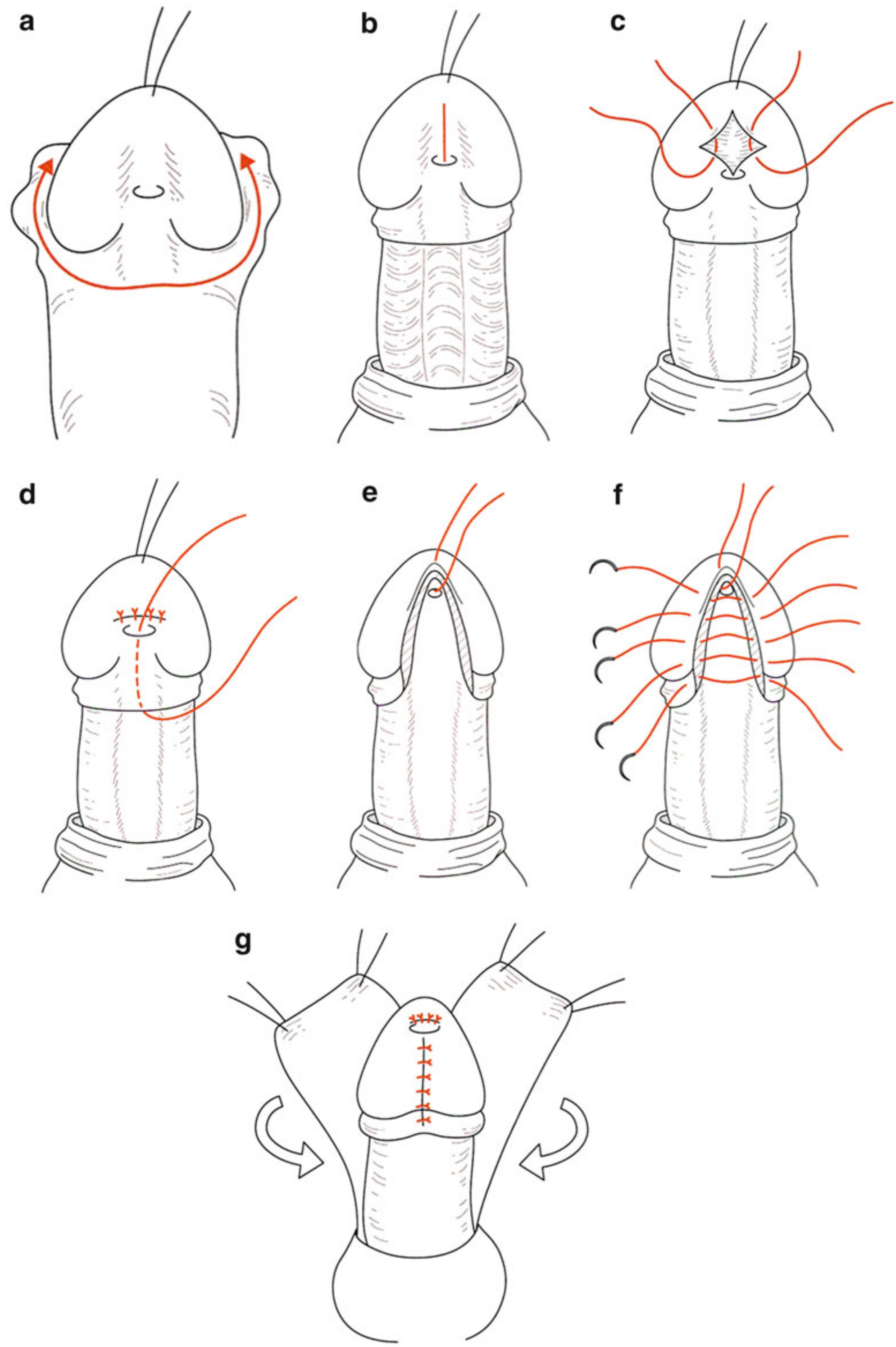

Fig. 54.5 MAGPI technique. (**a**) The incision line. (**b**) A diamond-shaped incision is created around the dorsal meatus. (**c**) Closure of the diamond-shaped incision. (**d**) The distal end of the urethral meatus is fixed with a stay suture and brought distal toward the glans. (**e**) Ventrolateral de-epithelialization of the glans. (**f**) Glanuloplasty. (**g**) Skin closure

which may contract and result in stenosis. An incision is made subcoronally and is completed ventrally proximal to the urethral meatus.

The foreskin is carefully peeled down to the base. The skin can be quite thin and adherent to the urethra, and dissection with sharp iris scissors using carefully placed skin hooks for countertraction provides optimal visualization of the surgical dissection planes to avoid buttonholing into a native urethra.

After repairing any chordee, glanular wings are created as appropriate, lateral to the urethral plate, so that subsequent glanuloplasty can be performed without tension. The urethral plate is gently wrapped around an 8-Fr catheter to check for any areas of tension. While providing symmetrical traction and countertraction, a deep midline vertical incision is made with a knife in the urethral plate margins around the tube. The urethral plate is tubularized around the catheter, using 6-0 or 7-0 absorbable interrupted sutures (Fig. 54.6b).

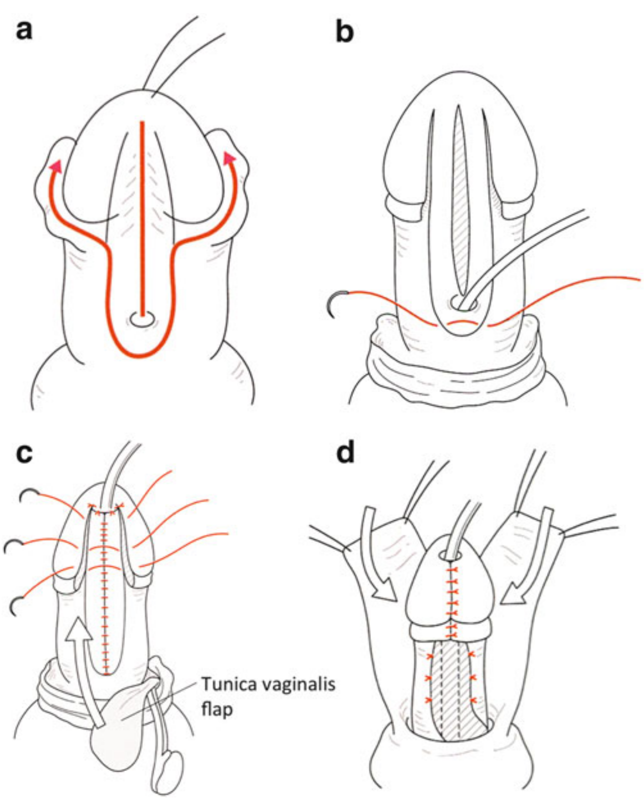

Fig. 54.6 Snodgrass procedure. (**a**) Skin incision. (**b**) Urethroplasty using absorbable sutures. (**c**) Interposed soft tissue layer. (**d**) The skin coverage is performed

The newly reconstructed meatus has a wide caliber lacking a circumferential suture line. In our institution, either the mobilized dorsal dartos or tunica vaginalis is used for second-layer coverage (Fig. 54.6c). Finally, skin coverage is performed (Fig. 54.6d).

54.5.3.3 Mathieu Procedure

Two parallel incisions are made on either side of the urethral plate up to the tip of the glans and down to the corpora cavernosa (Fig. 54.7a). The incision line delimits the perimeatal-based skin flap that is folded over and sutured to the edges of the urethral plate (Fig. 54.7b). The lateral wings of the glans are carefully dissected from the corpora cavernosa and approximated to produce a conical shaped glans (Fig. 54.7c).

54.5.4 Soft Tissue Interposition

Techniques for interposing vascularized tissue between the neourethra and the skin have been reported for preventing the formation of postoperative urethrocutaneous fistula. Pedicled soft tissue interposition has been performed using the inner dartos, ventral dartos, pedicled external spermatic fascia, pericordal adipose, scrotal adipose, or a combination of these [4, 5].

54.6 Postoperative Management

54.6.1 Urinary Catheterization

A newly reconstructed urethra with a long suture line is likely to heal better if a urinary catheter is inserted to allow urine to flow freely and protect the suture line. While it is

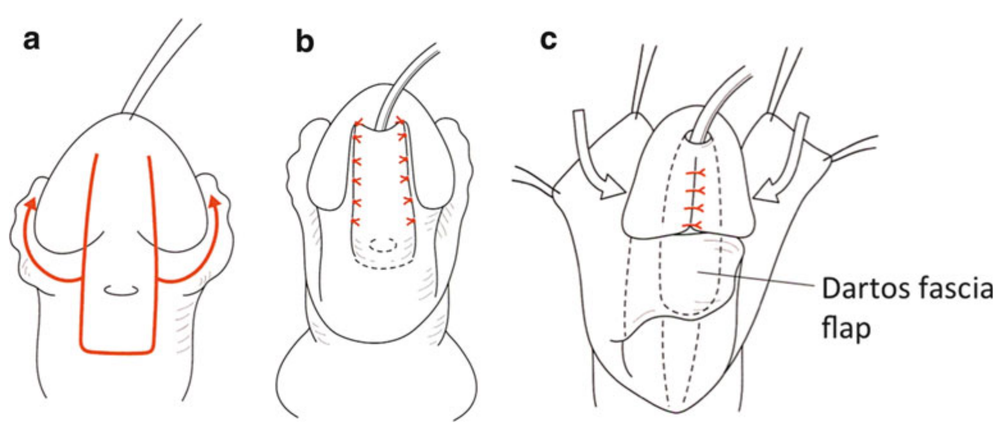

Fig. 54.7 Mathieu procedure. (**a**) Skin incision. (**b**) Urethroplasty. (**c**) Glanuloplasty

routine for many surgeons to leave an indwelling urinary catheter postoperatively for 7–10 days, recent studies have not proven the benefit of urinary catheterization.

54.6.2 Dressing

Careful and secure application of a dressing to the penis can prevent postoperative complications, such as hematoma and edema, and may additionally reduce parental anxiety. At our institutes, the penile dressing is removed 7 days postoperatively.

54.6.3 Complications

Early and common complications are bleeding, infection, and urinary retention, which can be adequately treated in the postoperative period. Later complications are urethrocutaneous fistula, meatal stenosis, diverticulum of the reconstructed distal urethra, residual curvature, and cosmetic problems.

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Posterior Urethral Valve

55

Yoshiaki Kinoshita

Abstract

Posterior urethra valve are well known to the serious cause of end-stage renal disease in the early childhood. The posterior urethral obstruction represents a mechanical obstruction in the urethral conduit leading to sequential secondary pathological changes including marked bilateral ureteric dilatation due to secondary VUR. Posterior urethral valve is classified into three types by Young et al. (J Urol 3:289, 1919).

As an ideal treatment of this disease, endoscopic treatment is usually considered.

In this chapter, endoscopic valve resection is described.

Keywords

Posterior urethral valve (PUV) • Young • Ablation

55.1 Endoscopic Valve Ablation or Resection

(a) The patient is placed in a lithotomy position.
(b) Tight and straight traction of penis is necessary for this procedure. Therefore, stay suture for dorsal glance by 5-0 PDS is often performed.
(c) 7.5–9.5 Fr endoscopy is inserted into the urethra.
(d) Ablation or resection of valve:
For each type of valve shapes (Figs. 55.1a, 55.1b, 55.1c) [1], the ablation or resection should be performed.
Using "Bugbee electrode apparatus" or "cutting knife" transendoscopy ablations at the 5 o'clock and 7 o'clock positions is performed for type I or type II (Figs. 55.2a, 55.2b).
12 o'clock ablation should be added for type II or type III cases (Fig. 55.3).
(e) Resection reaches to the depth of mucosal propria. Take enough notice not to injure urethral wall or detrusor muscle.

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Fig. 55.1a Type I

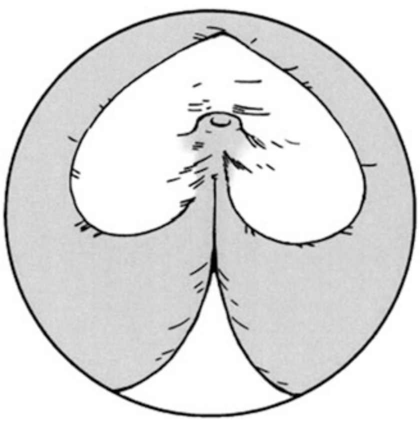

Fig. 55.1b Type II

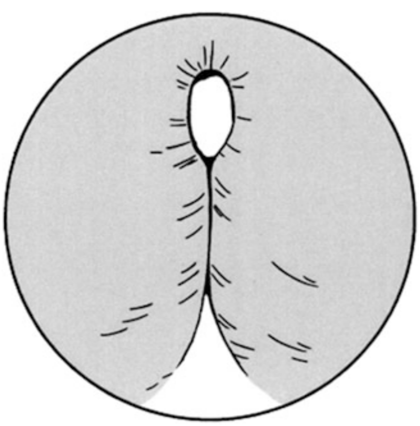

Fig. 55.1c Type III

Fig. 55.2a Resection or ablation at the 5 o'clock

Fig. 55.2b Resection or ablation at the 7 o'clock

Fig. 55.3 12 o'clock ablation should be added for type II or type III

Reference

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Phimosis

56

Takeshi Shono

Abstract

Most of newborn boys shows the true phimosis, and tight physiological adhesions between the foreskin and glans gradually disappear, and then the foreskin can be turned over at the age of 3–4 years (Kayaba et al. J Urol. 1996;156:1813–5). In some countries circumcision is sometimes carried out on newborns for the religious or traditional reasons; however, circumcision is not usually carried out on young infant in Japan. Many doctors agree that the complete exposure of the glans is not necessary in infant boys in Japan. The indications for the surgical treatment in phimosis are balanitis xerotica obliterans, recurrent foreskin balanitis, urinary infection risk due to the balloon-like swelling of the foreskin (ballooning), incarcerated phimosis, and the redundant foreskin in puberty, although conservative treatment with steroid ointment has reduced the surgical treatment for phimosis (Sumitomo et al. Jpn J Pediatr. 2011;64:1158–63). Either dorsal incision or circumcision has been performed as fundamental procedures for pediatric phimosis. However, recently triple incision is widely performed as a simple and convenient method (Wahlin Scand J Urol.1992;26:107–10). In this method the foreskin is preserved as much as possible depending on the idea that the glans is not always to be exposed in young children. Except for urgent stenosis in incarcerated cases, dorsal incision procedure is not performed, because the foreskin shows ugly sag "dog ear" after surgery. The triple incision procedure, the circumcision, and dorsal incision are described here.

Keywords

Phimosis • Triple incision • Circumcision • Dorsal incision

56.1 Preoperative Management

The regular preoperative examination for the general anesthesia is performed, such as chest X-ray and blood test. Food intake is inhibited in the morning although water intake is allowed up to 2 h before surgery. Postoperative complications such as foreskin edema, bleeding, and restenosis of the preputial opening are explained before surgery.

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56.2 Anesthesia and Positions

The patient is under general anesthesia by mask combined with caudal epidural anesthesia and placed in supine position with the legs slightly apart. The lower abdomen and the perineum and scrotum are disinfected with povidone-iodine or other disinfectants applied on the skin, and then a small sterile sheet is laid under the scrotum.

56.3 Operations

56.3.1 Triple Incision

The prepuce is gently opened until the stenotic ring is exposed by Pean forceps. Adhesions between the inner preputial layer and glans are dissected. Three longitudinal incisions are made on the foreskin across the stenotic ring to the inner preputial layer equally in the three directions, at 12:00, 4:00, and 8:00 o'clock (Fig. 56.1a). Foreskin is slowly inverted and the additional incisions are made for the remaining stenosis. The incision lines on the foreskin spreads in a rhomboid shape and the stenotic ring of the foreskin is released (Fig. 56.1a). During foreskin incision, injury of blood vessels that run just below the foreskin is avoided as much as possible; the bipolar diathermy is appropriately used for the pinpoint hemostasis. Then, the rhomboid-shaped incisional surface is closed transversely with interrupted 5-0 or 6-0 absorbable sutures (Fig. 56.1c). Foreskin suturing is sometimes performed in the oblique direction as to eliminate the swelling ends of the sutures (dog ear). Gentle dissections are added if the adhesion remains between the glans and inner layers of the foreskin.

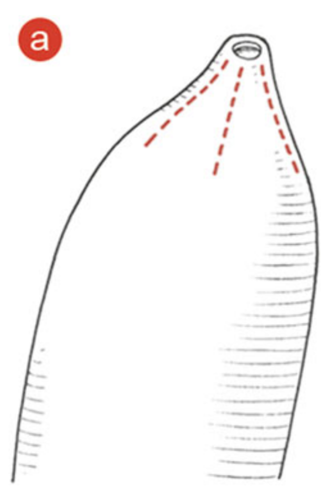


Fig. 56.1a Three longitudinal incisions are made on the foreskin across the stenotic ring to the inner preputial layer equally in the three directions, at 12:00, 4:00, and 8:00 o'clock positions

Fig. 56.1b Incision surface of the foreskin spreads in a rhomboid shape and the stenotic ring is released

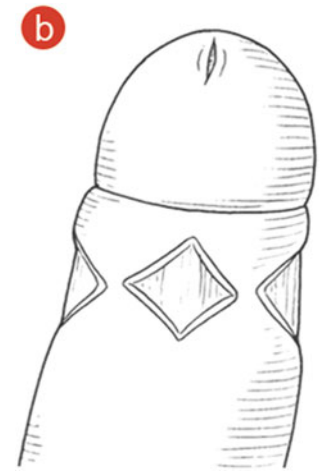
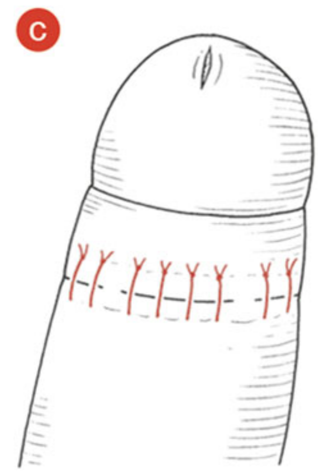


Fig. 56.1c The rhomboid-shaped incisional surface is closed transversely with interrupted 5-0 or 6-0 absorbable sutures



56.3.2 Circumcision

The prepuce is gently opened until the stenotic ring is exposed by Pean forceps. Adhesions between the inner preputial layer and glans are dissected. A dorsal incision is made using a fine small scissors to release the preputial stenotic ring and foreskin can be turned over (Fig. 56.2a). After fully inverting the foreskin, circumferential incision line is made on the foreskin with a surgical mark pen to adequately resect the stenotic ring of the foreskin (Fig. 56.2b). On the ventral site of the penile shaft, incision line is bended proximally as to avoid the foreskin frenulum (Fig. 56.2c). The foreskin is incised along the line with fine small scissors, and the edges of the incision are grasped by Pean forceps. Then foreskin is incised furthermore circumferentially and is separated from the subcutaneous tissue (Fig. 56.2d). Then the stenotic ring is resected with redundant foreskin. The bipolar diathermy is appropriately used for the pinpoint hemostasis. The wound is closed transversely with interrupted 5-0 or 6-0 absorbable sutures

Fig. 56.2a A dorsal incision is made using fine small scissors to release the preputial stenotic ring and the foreskin can be inverted

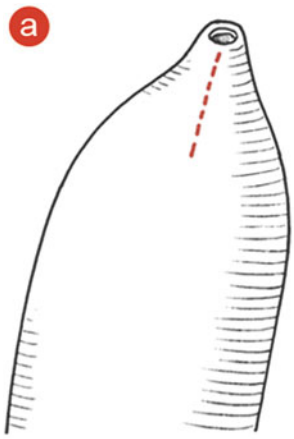


Fig. 56.2b The circumferential incision line is made on the foreskin with a surgical mark pen to adequately resect the stenotic ring of the foreskin

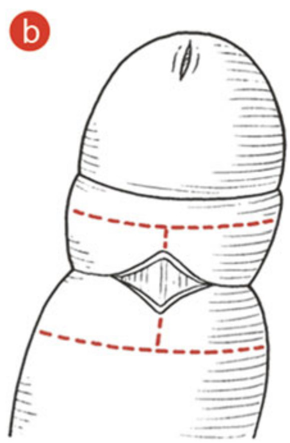
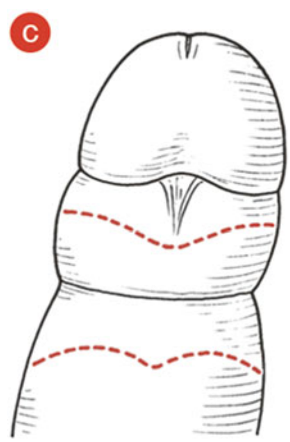


Fig. 56.2c On the ventral site of the penile shaft, incision line is bended proximally as to avoid the foreskin frenulum



(Fig. 56.2e). Excess resection of the foreskin is avoided because the glans can be exposed about only half in the natural state in children.

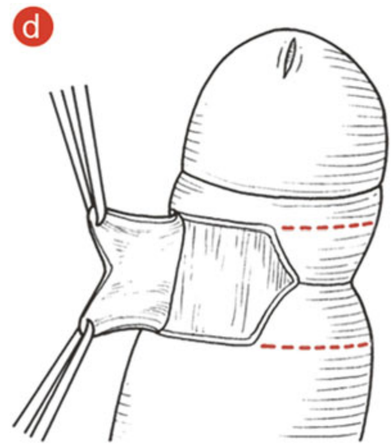


Fig. 56.2d The edges of the foreskin incision are grasped by Pean forceps. The circumferential incision is added and the foreskin is separated from the subcutaneous tissue

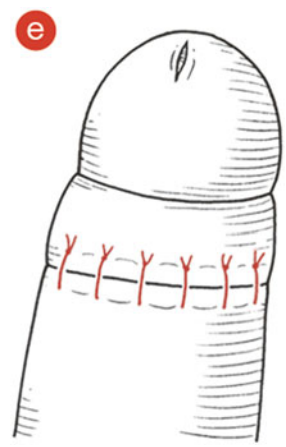


Fig. 56.2e The wound is closed transversely with interrupted 5-0 or 6-0 absorbable sutures

56.3.3 Dorsal Incision

The prepuce is gently opened until the stenotic ring is exposed by Pean forceps. Adhesions between the inner preputial layer and glans are dissected. A dorsal incision is made using a fine small scissors to release the stenotic preputial ring and foreskin can be turned over (Fig. 56.3a). After adequate release of the stenotic ring, the wound is closed transversely with 5-0 or 6-0 interrupted absorbable sutures (Fig. 56.3b).

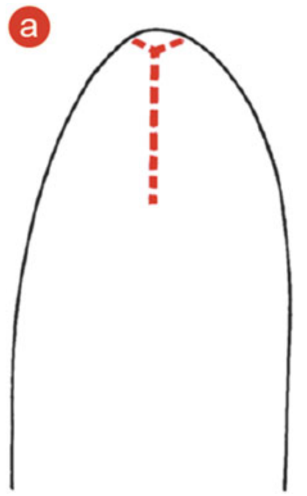


Fig. 56.3a A dorsal incision is made using fine small scissors to release the preputial stenotic ring and foreskin can be inverted

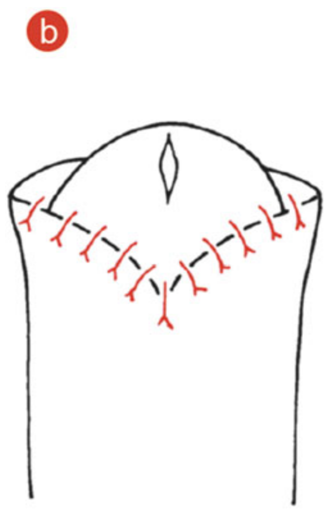


Fig. 56.3b After adequate release of the stenotic ring, the wound is closed with 5-0 or 6-0 interrupted absorbable sutures

56.4 Postoperative Management

The patient is allowed to take a shower the next day after surgery, and gentle traction of the foreskin once daily to prevent preputial adhesion is advised. The application of the antibiotic-containing ointment use twice daily for 1 week is useful to prevent the wound infection and re-adhesion between the glans and prepuce. Antibiotic is given only once during surgery.

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Cryptorchidism and Retractile Testis

57

Takeshi Shono

Abstract

Cryptorchidism is one of the most common diseases seen in daily practice for the pediatric surgeons; incidence of congenital undescended testis is approximately 1–1.5 %. Orchiopexy is the most recommended treatment for cryptorchidism to prevent secondary degeneration of the testis and increasing risk of malignancy. Although orchiopexy tends to be seemed the operation for the beginner surgeons, a skilled technique is required to dissect the frail vas deferens and testicular blood vessels in the procedure for the fertility improvement. Because spontaneous descent can be expected until a corrected age of 3–6 months, orchiopexy is performed after 6 months of age depending on the surgeon's experience; fertility improvement and the preventive effect of testicular tumor are expected by early surgery (Thorup et al. J Pediatr Surg. 2010;45:2074–86). We describe the open surgery for groin undescended testis and the laparoscopic surgery for abdominal testis in this chapter. Orchiopexy is not required for a typical case of retractile testis that shows reflex ascent in response to the thigh skin stimulation and soon descends down in the scrotum; the indications for orchiopexy in retractile testis are (1) small testis compared to contralateral one, (2) indistinguishable testis from cryptorchidism, (3) testis which is always in the groin with atrophic scrotum, and (4) testis combined with inguinal hernia.

Keywords

Cryptorchidism • Orchiopexy • Laparoscopy • Fertility • Retractile testis

57.1 Orchiopexy

57.1.1 Standard Open Surgery

57.1.1.1 Preoperative Management

In the patients with abnormal external genitalia or bilateral nonpalpable testes, both a chromosome examination and a human chorionic gonadotropin (hCG) stimulation test should be performed to determine the presence of testicular tissue in addition to the regular preoperative examination for the general anesthesia. On the day of surgery, food intake is inhibited in the morning although water intake is allowed up to 2 h before surgery.

57.1.1.2 Anesthesia and Position of Patient

The patient is under general anesthesia by a mask combined with caudal epidural anesthesia and is placed in the supine position with lightly opened lower legs. After induction of anesthesia, urinary catheterization is done, but the catheter is not detained during surgery. The skin of the lower abdomen,

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the perineum and the whole scrotum are disinfected with povidone-iodine or other disinfectants, applied on the skin, and then a small sterile sheet is laid under the scrotum.

57.1.1.3 Transinguinal Orchiopexy

Approach to the Inguinal Canal

Surgeons start the operation wearing a magnifying glass (2–2.5 times). A transverse skin incision 2 cm in length is made over the inguinal canal along the lower abdominal skin wrinkle lines (Fig. 57.1). Subcutaneous fatty tissue is dissected with square-ended retractors and diathermy; the superficial fascia (Camper's and Scarpa's fascia) is incised with the electric knife. After exposure of the external oblique aponeurosis, a small incision is made on it with a knife, and both edges of incision surface are gripped with mosquito forceps, and then the back surface of the external oblique aponeurosis is dissected with close scissors parallel to its fibers (Fig. 57.2). The inguinal canal is opened with a scalpel incision in the external oblique muscle aponeurosis parallel to its fibers; the incision is extended from the internal inguinal ring toward the external inguinal ring. As the ilioinguinal nerve runs parallel to the external oblique muscle aponeurosis, careful dissection is required not to damage the ilioinguinal nerve during the opening of the inguinal canal.

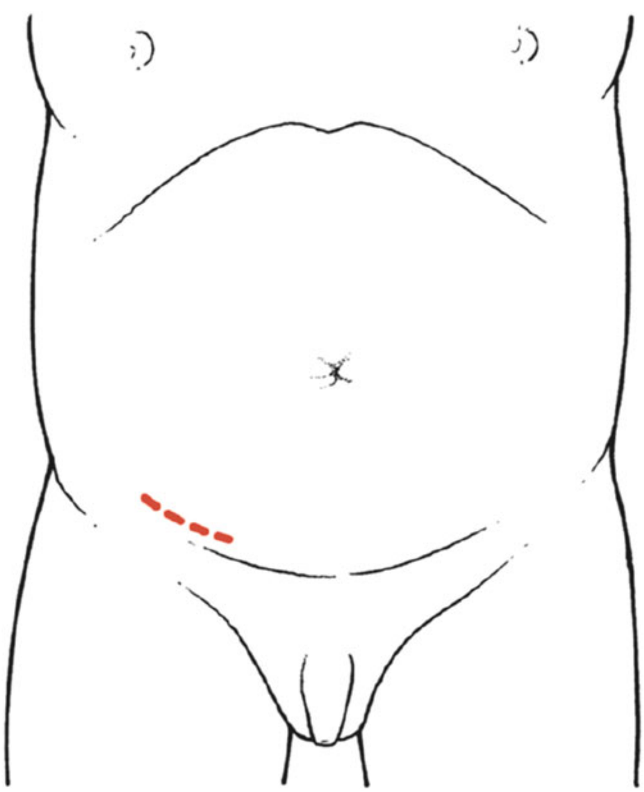

Fig. 57.1 A transverse incision is made in a length of 2.0–2.5 cm along the lower abdominal skin wrinkle line above the internal inguinal ring

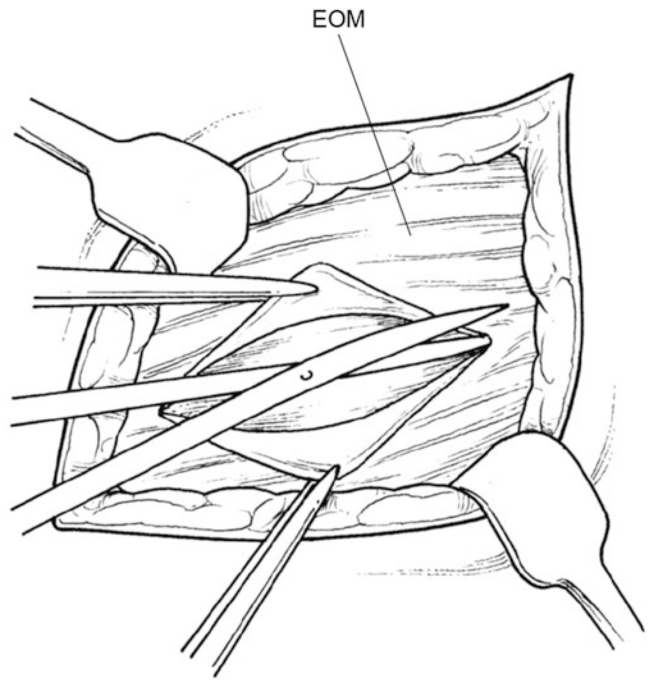

Fig. 57.2 After grasping both edges of the incision surface with a mosquito forceps, the back of the external oblique muscle aponeurosis is dissected and incised with Metzenbaum scissors in its fiber line. *EOM* external oblique muscle aponeurosis

Although undescended testis often locates in the inguinal canal or outside of the external inguinal ring, some testes locate in the superficial inguinal pouch beyond the external inguinal ring, and then careful attention should be paid during the dissection and incision of the subcutaneous tissues and external oblique aponeurosis.

Management of Processus Vaginalis (or Hernia Sac)

Patent processus vaginalis or obvious hernia sac is commonly found in the operation of the undescended testis. The management of processus vaginalis (or hernia sac) is an important procedure to get the enough length of spermatic cord. After exposing the inguinal canal, the spermatic cord is dissected and lifted up with soft tape, and then further dissection of the cord is performed toward the internal inguinal ring. At the point of 2–3 cm caudal of the internal inguinal ring, hernia sac which is closely adherent to the front surface of the spermatic cord can be identified and opened. The edge of the opened hernia sac is grasped in a triangular shape with the mosquito forceps, then the vas deferens and testicular vessels are carefully separated from the hernia sac with closed Metzenbaum scissors or Pean forceps, and then the hernia sac is divided like in the manner of inguinal hernia surgery (Fig. 57.3). After dividing the hernia sac, the central stump of the hernia sac is closed by high ligation (transfixing suture) with a 3-0 absorption thread at the internal inguinal ring. Ligature is hanged for

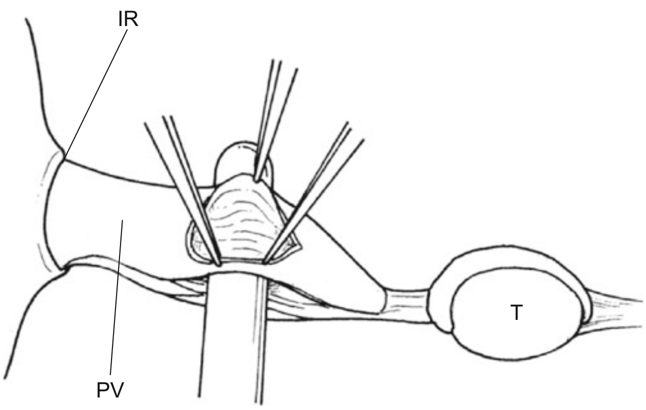

Fig. 57.3 The processus vaginalis is opened and the edge of the open face is grasped in a triangle form with a mosquito forceps; then, the spermatic duct and testicular vessels are separated from the processus vaginalis with closed Metzenbaum scissors. After separating spermatic duct and vessels, the processus vaginalis is divided. *PV* processus vaginalis, *IR* internal inguinal ring, *T* testis

the next further dissection of the spermatic cord toward retroperitoneal cavity. During above procedures, patent processus vaginalis (not obvious hernia sac) should not be opened, because an unexpected tear of the thin processus vaginalis may widely extend and its closure is difficult.

Testicular Isolation and Extension of the Spermatic Cord

Palpable undescended testis is often located in the inguinal canal or at the external inguinal ring, and it can be exposed and pulled out of wound by dissection and slightly pulling of the spermatic cord toward the distal site. Then the distal site of gubernacular attachment is carefully divided with scissors or diathermy, taking care not to damage a spermatic duct which sometimes extends caudally beyond the testis (long loop vas). After dividing the gubernaculum, the testis can be lifted up and the tunica vaginalis is opened, and the color, size of the testis, and the presence of the junctional abnormalities between the testis and epididymis are all checked. Sometimes severe hypoplastic unilateral testis is excised because of the negative effect on the contralateral descended testis. When the spermatic cord is not long enough for the testis to reach the scrotal bottom, the lengthening of the spermatic cord is done likely as (1) the spermatic cord is dissected over the internal inguinal ring and external spermatic fascia is divided, (2) a ligature thread of the processus vaginalis is lifted up anteriorly for the further dissection of the processus vaginalis at the internal inguinal ring, and (3) cross incision of the internal oblique muscle is made above the internal inguinal ring about 2 cm in length and further dissection of the testicular vessels is advanced in the retroperitoneal cavity (Fig. 57.4). Furthermore, the dividing of epigastric vessels can extend the spermatic cord 0.5–1.0 cm more. During the procedures for extension of the spermatic cord, excessive dissection around the spermatic cord should not be done to avoid the damage to the collateral vessels between a spermatic duct and the testicular vessels.

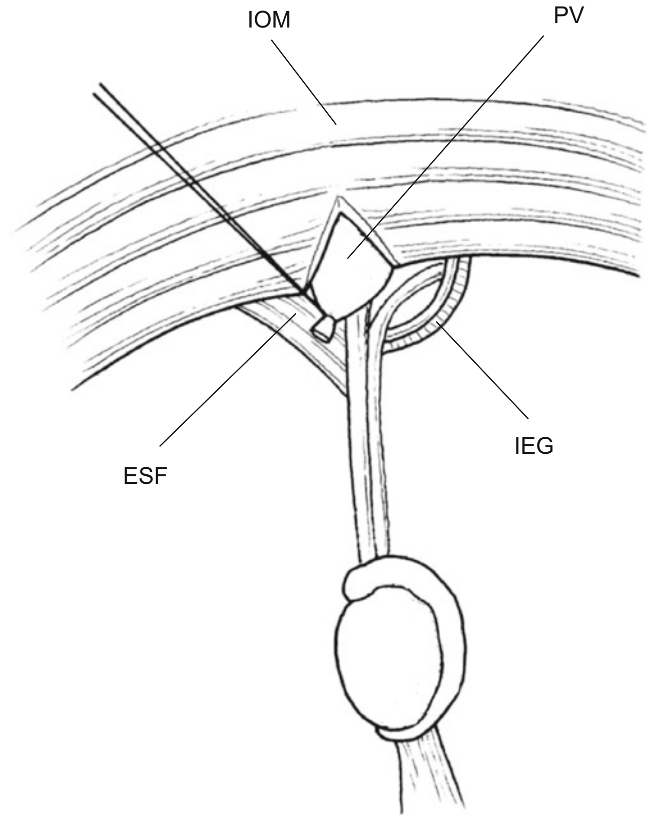

Fig. 57.4 Internal oblique muscle is cross incised 2 cm in length at the cranial point of the internal inguinal ring, and then the testicular vessels can be dissected toward the retroperitoneal cavity. *IOM* internal oblique muscle, *IEG* inferior epigastric vessels, *PV* stump of processus vaginalis, *FSE* external spermatic fascia

Fixation of the Testis in the Scrotum

After adequate length of spermatic cord obtained to allow testis to reach the scrotum, surgeon's index finger or a forceps grasping a small bended gauze is introduced through the inguinal incision down to the scrotum to make a new route for testicular descent. While surgeon's index finger pushes scrotal skin from the inside to stabilize it, a horizontal scrotal skin incision is made in length of 1 cm along a skin wrinkle (Fig. 57.5). A fine Pean forceps is used to make a subcutaneous dartos pouch, just deep to the dartos muscle toward the inferior bottom of the scrotum. If bleeding is seen, it should be stopped by diathermy. Next, a Kelly forceps is introduced through the scrotal wound and is forced up to the inguinal wound pressing the tip of the index finger (Fig. 57.6). A Kelly forceps grasps the stump of the gubernaculum or the tunica vaginalis near the testis and gently pulls the testis down into the scrotum through the new subcutaneous route from the inguinal incision to the

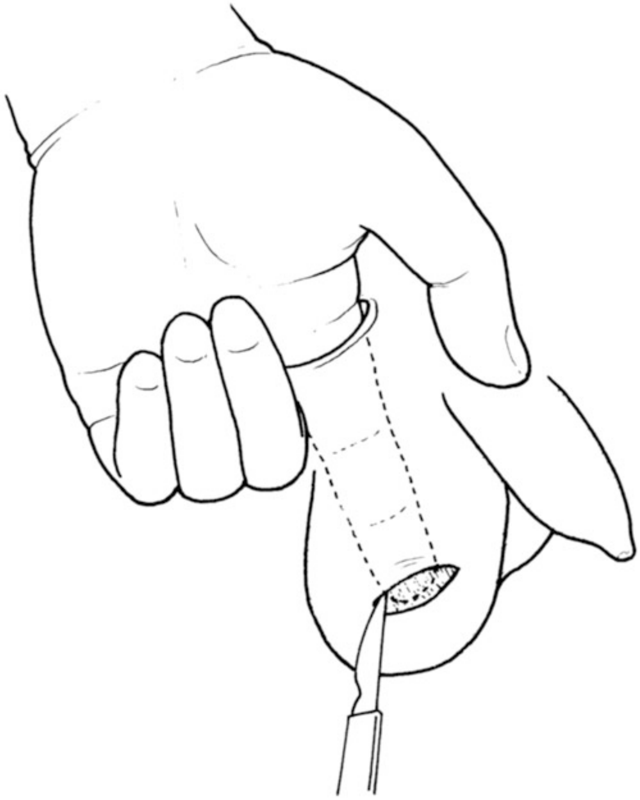

Fig. 57.5 Index finger is inserted into the scrotum through an inguinal wound dissecting the subcutaneous tissue, and then scrotal skin is pushed from the inside by the finger and the scrotal skin is incised in length of 1 cm along a skin wrinkle

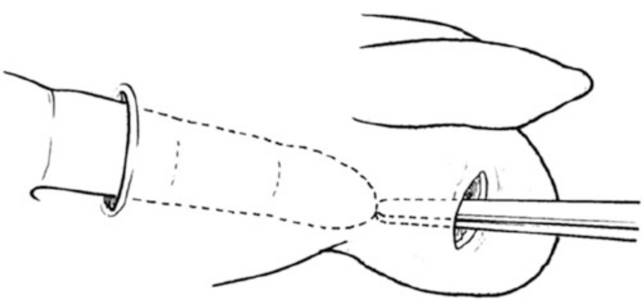

Fig. 57.6 A Kelly forceps is inserted from the scrotal wound reversely to the inguinal wound under the guide of the index finger

scrotum, making sure that cord structures are not twisted. After closing of base of subdartos pouch with one or two interrupted absorbable sutures, the testis is accommodated in the subdartos pouch and then is fixed to the scrotal septum with one stitch of 4-0 absorbable suture which passes through the tunica vaginalis but not the body of the testis (Fig. 57.7). When the length of the spermatic cord is not enough for a testis to reach the bottom of the scrotum, the

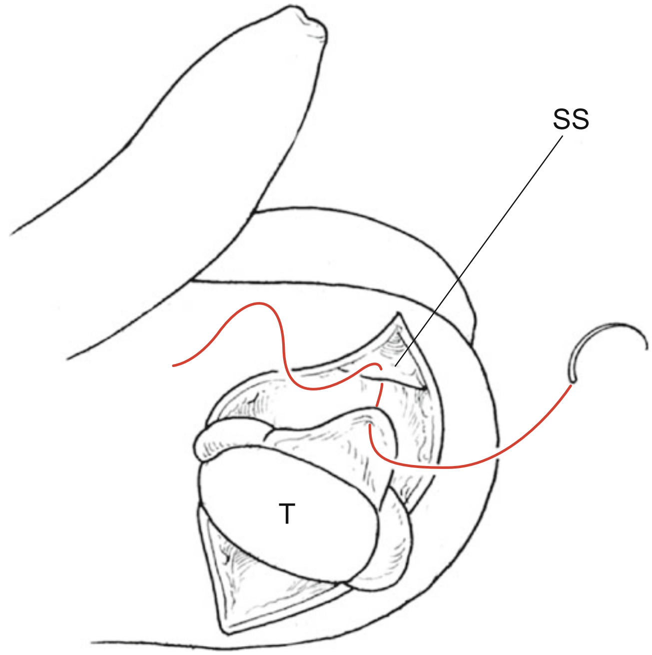

Fig. 57.7 After holding a testis in the subdartos pouch, the testis is fixed to the scrotal septum by one stitch of 4-0 absorption suture through the tunica vaginalis near the testis. *SS* scrotal septum, *T* testis

testis can be fixed at the middle part of the scrotum. Scrotal skin is closed with a 5-0 absorbable subcutaneous suture, and wound is completely dressed with waterproofing film. The inguinal wound is closed in layers, external oblique aponeurosis is closed with 3-0 absorbable sutures, and then the skin is closed with 5-0 absorbable sutures and dressed with waterproofing film.

Postoperative Management

Patients can start water intake and a meal 3 h after surgery, and they are discharged from the hospital the next day and return to normal activity without active sport. Prophylactic antibiotic is given only once during operation; patients can take a shower bath at home and are advised to visit the hospital for checkup 1 week later. Postoperative complications are small risk of testicular atrophy and retraction of testis. The patient and his family are explained that long-term follow-up is necessary, because the possibility of infertility and malignancy will remain in the future even if appropriate treatment is done.

57.2 Scrotal Approach to a Severe Retractile Testis and a Gliding Testis

Transscrotal orchiopexy is performed for a severe retractile testis or a gliding testis. At first testis is fixed between the left thumb and an index finger, and then a small horizontal

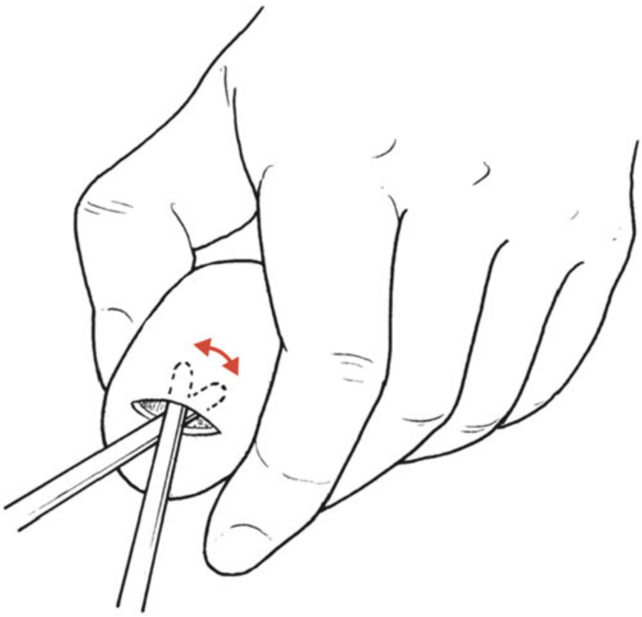

Fig. 57.8 After adding horizontal incision of 1 cm along a scrotal wrinkle, a fine forceps is placed in the subcutaneous tissue to make subdartos pouch toward the bottom of the scrotum

incision is made along the scrotal wrinkle on the skin of the middle scrotum. A fine forceps is placed in the subcutaneous tissue to make subdartos pouch toward the bottom of the scrotum (Fig. 57.8), and then the testis is pushed out of the wound. The spermatic cord is separated from the surrounding tissues creating the testicular mobilization. Then, small square retractors are applied to dissect the cranial tissue above the testis and identify the external inguinal ring. The spermatic cord is dissected and separated from the adipose tissue, cremasteric fibers, external spermatic fascia, and processus vaginalis by blunt and sharp dissection to gain the enough length for tension-free placement of the testis within the scrotum. In infant cases the inguinal canal can be easily opened with retractors, and if the processus vaginalis is identified, it can be grasped with a forceps and separated from spermatic cord and then is ligated at the internal inguinal ring (Fig. 57.9). After ligation of the processus vaginalis, the testis is lifted up and the tunica vaginalis is opened. The color of the testis, size, and epididymal attachment are all checked macroscopically. The manner of the testicular fixation in the scrotum is similar to a standard inguinal approach orchiopexy, a testis accommodated in the subdartos pouch and anchored to the scrotal septum with a 4-0 absorbable suture.

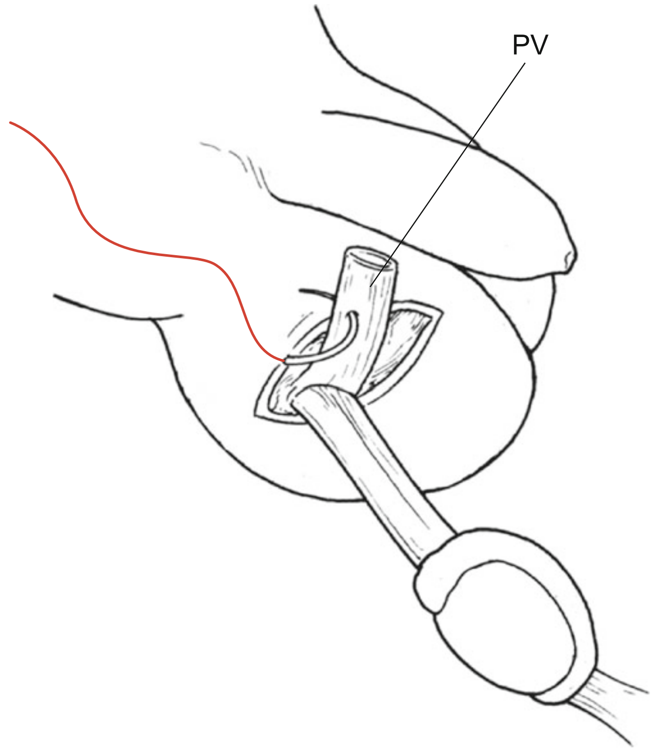

Fig. 57.9 The processus vaginalis is separated from the spermatic cord and ligated with transfixing sutures at the internal inguinal ring. *PV* processus vaginalis

57.3 Staged Orchiopexy for Inadequate Length of the Spermatic Cord

When the length of spermatic cord is absolutely short, staged orchiopexy without division of the testicular vessels or Fowler-Stephens (FS) orchiopexy is selected. Short spermatic cord is most likely to be a problem with testes in the groin or abdominal cavity, where either the spermatic duct or testicular vessels may be too short for the testis to reach to the scrotum. After dissection of the spermatic cord and a testis, the testis cannot be brought into the scrotum; a staged orchiopexy is preferable to FS orchiopexy, because many collateral vessels which should be preserving in FS orchiopexy might be divided. In staged orchiopexy a testis is fixed near the scrotum as much as possible in the first operation, and then 6–12 months later, it is fixed into the scrotum in the second stage, although severe adhesion around the testis makes it hard to isolate the testis in the second stage. In the FS method, testicular vessels are ligated and divided at the point of 2 cm cranial to the testis, and the testis is fixed in the scrotum expecting the blood flow from the spermatic duct's vessels. The FS method must be decided before the processing of the testis dissection.

57.4 Laparoscopic Surgeries for Nonpalpable Testis

Laparoscopic orchiopexy is performed for the nonpalpable testis; however, when a testis can be palpated under general anesthesia on the operating table orchiopexy is performed through a standard open inguinal approach. Laparoscopic surgery is performed in cases that testis cannot be palpated under the general anesthesia. The disrupted spermatic duct and vessels identified by laparoscopy indicate the abdominal vanishing testis, and the operation is finished (Fig. 57.10). The spermatic duct and testicular vessels entering the inguinal canal indicate a groin testis or inguinal/scrotal vanishing testis; therefore inguinal incision is added to perform the orchiopexy or nubbin excision. When the abdominal testis shows enough length of testicular vessels to reach the scrotum, single-staged laparoscopic orchiopexy is performed. If a testis can be moved to the contralateral internal inguinal ring before dissection, it can be pulled down into the scrotum in one-staged operation [2]. Fowler-Stephens operation is selected in the cases with immobilized testis due to short testicular vessels (Fig. 57.11). In the FS method testicular vessels are divided and blood supply will be expected from spermatic duct blood vessels; therefore, the FS method should be avoided in cases with disruption of the spermatic duct or joint abnormalities between the testis and epididymis [3]. In the single-staged FS procedure, division of the testicular vessels and orchiopexy are performed simultaneously, whereas in the two-staged FS method, division of the testicular vessels is performed in the first operation, and 6 months later orchiopexy is performed after the development of the spermatic duct blood vessels in the second operation. The results of the single-staged FS orchiopexy are inferior to that of the two-staged FS method in a lot of reports [4]; here, the two-staged FS method is described.

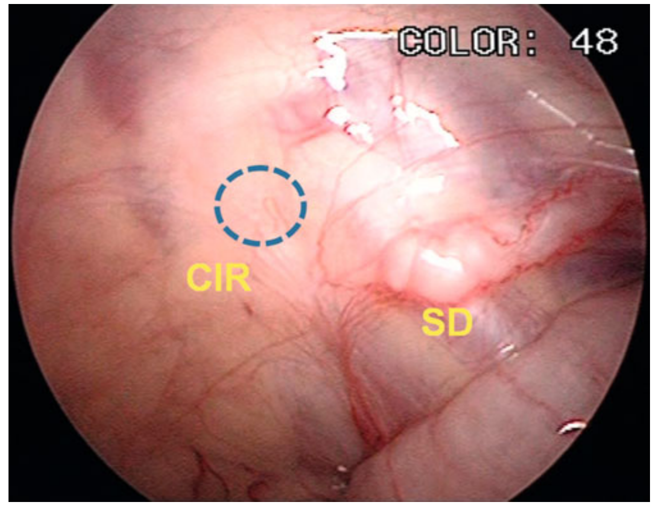

Fig. 57.10 Abdominal vanishing testis. A spermatic duct and the very small testicular vessels are disrupted in the abdominal cavity. *SD* disrupted spermatic duct, *CIR* closed internal inguinal ring

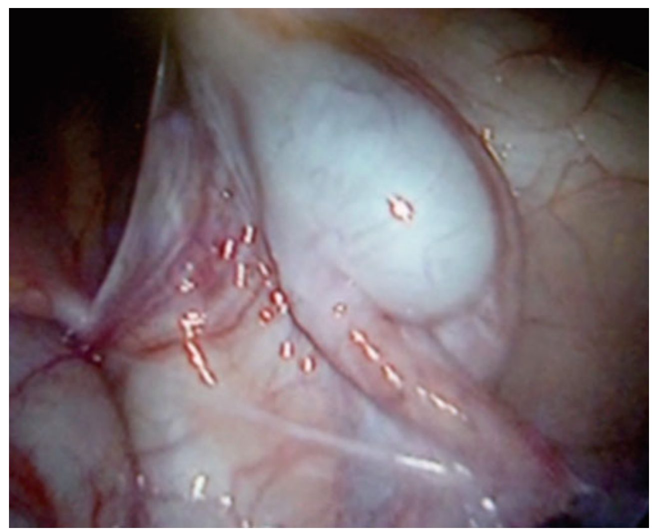

Fig. 57.11 Abdominal testis. The testis is located above the internal inguinal ring with poor mobility; the two-staged FS method is selected as an appropriate procedure

57.4.1 Laparoscopic Two-Staged Fowler-Stephens (FS) Orchiopexy

57.4.1.1 Preoperative Management

The preoperative examinations are the same as an open operation, but the patients are given laxative on the previous night, and an enema is performed early in the morning on the operative day. When patients do not finish urination before entering the operation room, urinary catheterization is done after anesthesia, but the catheter must not be placed during operation.

57.4.1.2 Anesthesia and the Position

Patients are placed in supine position with slightly opened lower limbs under endotracheal general anesthesia.

57.4.1.3 The First-Stage Operation

Laparoscopy for the first stage is initiated with an open technique for placing a 5-mm cannula transumbilically. Following the pneumoperitoneum established by insufflation of carbon dioxide (6 mmHg; 1 L/min flow), a 5-mm 30-degree telescope is inserted through the umbilical port, and additional 5-mm and 3-mm ports are placed on the contralateral abdominal wall of the affected side and middle point of the lower abdominal wall under the view of the telescope (Fig. 57.12). Then the patient was placed in a slight Trendelenburg position. After opening the retroperitoneal membrane, testicular vessels are ligated with 2-0 or 3-0 absorbable sutures and divided at the point of 2 cm cranial from the testis. The first operation is finished without closing the retroperitoneal membrane.

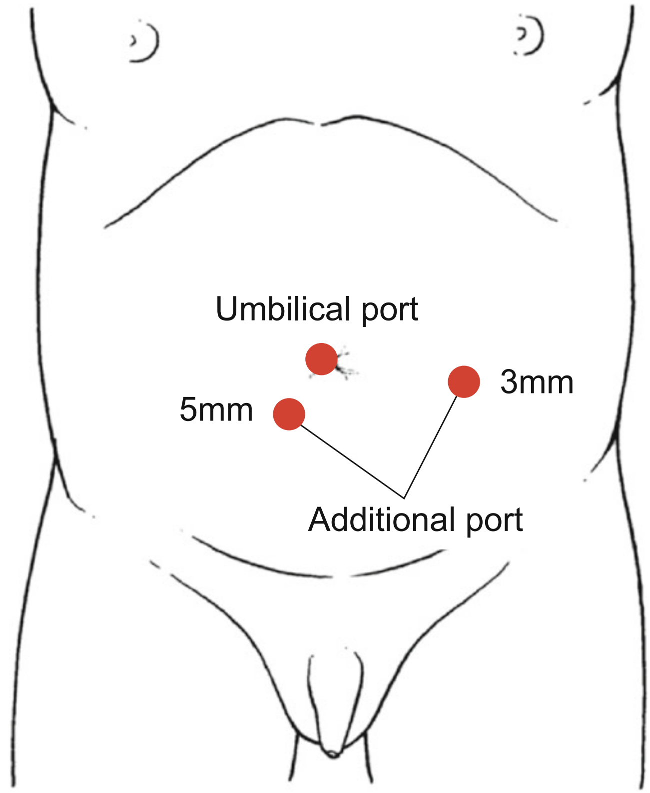

Fig. 57.12 A 5-mm 30-degree telescope is inserted through the umbilical port; additional 5-mm and 3-mm ports are placed on the contralateral abdominal wall of the affected side and middle point of the lower abdominal wall under the view of the telescope

57.4.1.4 The Second-Stage Operation

The second operation is performed at 6 months later. The ports are inserted through the same scar made at the first operation. The gubernacular attachments are grasped and transected taking care not to injure the "long loop vas" which sometimes extends to caudal side beyond the testis. The retroperitoneal membrane is incised at 10 mm apart from the spermatic duct and vessels making peritoneum belts using the ultrasonic wave device. The spermatic duct and vessels are isolated with neighboring peritoneum belts toward the bottom of the bladder (Fig. 57.13). After dissection of the testis and spermatic duct, the scrotal skin is incised 1 cm along a skin wrinkle to make a subcutaneous subdartos pouch. A Kelly forceps is inserted from the scrotal wound to the inguinal canal subcutaneously and pushed into the abdominal cavity between the epigastric vessels and median umbilical ligament making a new straight route for a testis descent (Fig. 57.14). The proximal stump of the gubernaculum or the tunica vaginalis near the testis is grasped with Kelly forceps, and then a testis is pulled down into the scrotum without twisting the spermatic duct and fixed in the subdartos pouch. If the internal inguinal ring is open, it is closed by the LPEC method [5]. The skin wound is closed by interrupted subcutaneous sutures with a 5-0 absorption thread and covered by waterproofing film.

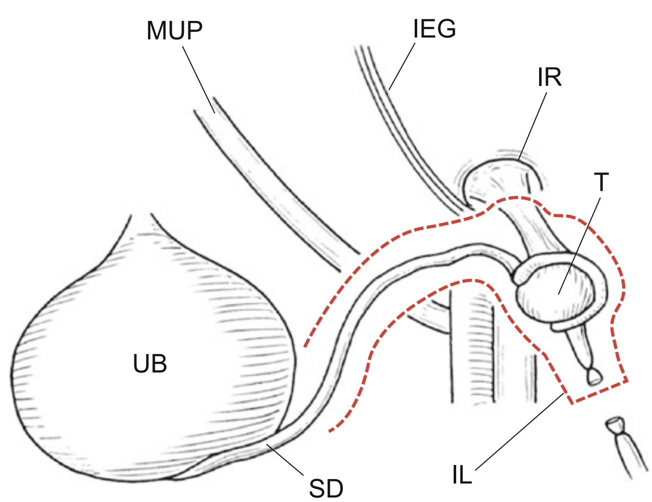

Fig. 57.13 The retroperitoneal membrane is incised at 10 mm apart from the spermatic duct and vessels making peritoneum belts using the ultrasonic wave device. The spermatic duct and vessels are isolated with neighboring peritoneum belts toward the bottom of the bladder. *UB* urinary bladder, *MUP* median umbilical ligament, *IEG* inferior epigastric vessels, *IR* internal inguinal ring, *SD* spermatic duct, *IL* incision line, *T* testis

57.4.1.5 Postoperative Management

The postoperative management is fundamentally the same as the opening method, and patients start water and meal intake at 3 h after surgery and they are discharged on the next day. When an operative time is long, patients take only fluid on the operation day. It is the same as the opening procedure of orchiopexy that long-term follow-up is necessary; surgeons must explain to a family that vasectomy for the sterilization is a contraindicated operation in the future.

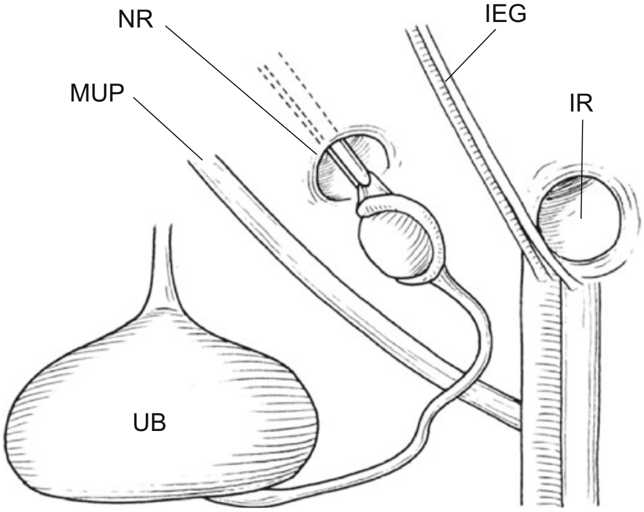

Fig. 57.14 A Kelly forceps is inserted from the scrotal wound to the inguinal canal subcutaneously and pushed into the abdominal cavity between the epigastric vessels and median umbilical ligament making a new straight route for a testis descent. *UB* urinary bladder, *MUP* median umbilical ligament, *IEG* inferior epigastric vessels, *IR* internal inguinal ring, *NR* new route for a testis descent

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Testicular Torsion

58

Hiroshi Asanuma and Mototsugu Oya

Abstract

Testicular torsion occurs most often in the neonatal period and around puberty. Perinatal testicular torsion mostly occurs extravaginally in the prenatal period. On the other hand, pubertal torsion usually occurs intravaginally and requires prompt surgical treatment. The degree of cord twisting and the time between onset of symptoms and detorsion are most important factors to decide early salvage rate of the testis.

In order to revive blood supply until operation, consider manual detorsion by rotation from within outward in pubertal boys with intravaginal torsion.

If the color of the testis recovers after untwisting it, orchiopexy is performed in the dartos pouch with at least three places of fixation using nonabsorbable sutures. In all cases, contralateral orchiopexy should be done to prevent future torsion.

Patients would need a long-term follow-up mainly for fertility and hormonal issues.

Keywords

Testicular torsion • Orchiopexy • Neonate • Puberty • Fertility

58.1 Etiology and Surgical Indication

Testicular torsion occurs when the spermatic cord twists upon itself, leading to vascular damage and a possible testicular loss from prolonged ischemia. The left testis is affected more frequently [1]. It is ten times more common in patients with undescended testes [1]. It is likely to occur more frequently during sleep or at the time of getting up and in winter season [1].

Testicular torsion occurs most often in neonatal period and around puberty. Perinatal testicular torsion mostly occurs extravaginally, and approximately 70 % of perinatal torsions occur in utero (Fig. 58.1) [2]. Extravaginal torsion occurs when the tunica vaginalis is not securely attached to the scrotum, allowing the tunica vaginalis with the testis to rotate as a unit. On the other hand, pubertal torsion usually occurs intravaginally. Several anatomic factors contribute to intravaginal torsion. The tunica vaginalis normally covers the anterior surface of the testis and extends varying distances over the epididymis and the spermatic cord. In the bell clapper deformity, the tunica vaginalis inserts at an abnormally high location on the spermatic cord, causing the testis to be suspended freely with vaginalis cavity, and facilitates rotation of the testis about the spermatic cord.

In the newborn, the patient with antenatal torsion may present with a large, firm, painless scrotal mass. On the other hand, postnatal torsion causes systemic symptoms such as appetite loss or vomiting, with acute onset of scrotal swelling. The neonate with prenatal torsion should undergo elective orchiectomy with contralateral orchiopexy once risk of anesthesia has been evaluated. Torsion that presents acutely after birth requires emergent surgical exploration like pubertal torsion as described below.

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In puberty, it is important to differentiate testicular torsion from other etiologies with acute scrotal pain and swelling such as torsion of the appendix or acute epididymitis (Table 58.1). The duration or strength of symptoms is shorter or more severe in testicular torsion compared to torsion of the appendix testis and acute epididymitis. An abnormal position of the testis is more frequent in testicular torsion than others. Loss of the cremaster reflex is a simple finding with high sensitivity for testicular torsion [1]. Doppler ultrasonography is really useful to evaluate acute scrotum; however, it is operator dependent and is not easy to perform in prepubertal patients. It may also show a misleading arterial flow in the early phases of torsion or in partial or intermittent torsion. Direct visualization of the spermatic cord twist using high-resolution ultrasonography is reported to have better sensitivity and specificity [1].

If testicular torsion cannot be ruled out with certainty, urgent surgical exploration is needed.

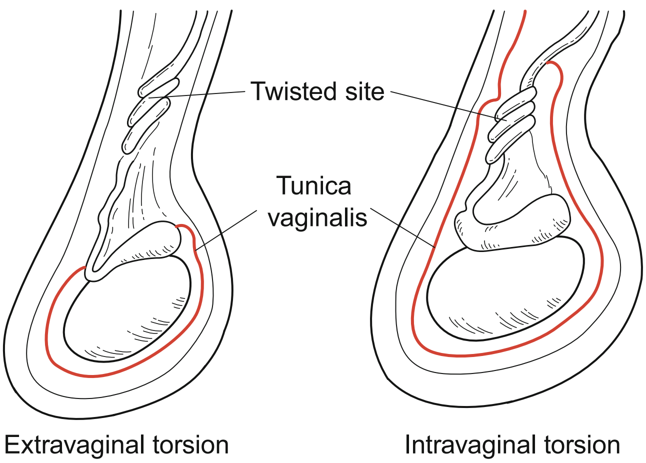


Fig. 58.1 Schema of extravaginal and intravaginal torsion

58.2 Preoperative Management

In order to revive blood supply even a little until operation, consider manual detorsion by rotation from within outward in pubertal boys with intravaginal torsion. This maneuver is not suitable for neonates with extravaginal torsion. When detorsion is successfully done, immediate relief of symptoms and normal findings at physical examination are recognized. Doppler ultrasonography may be used for guidance. However, bilateral orchiopexy is still required even after pain relief after manual detorsion because of possible residual torsion.

There is still controversy on whether to perform detorsion and preserve the ipsilateral testis or to perform an orchiectomy, in order to preserve contralateral function and fertility more than 24 h of symptom onset.

58.3 Operations

The boy is placed in supine position, and prepare the entire genital area. In general, provide general anesthesia (spinal anesthesia is available in adolescents).

Grasp the scrotum with the thumb and index fingers of the left hand or hand of the assistant, and press the testis forward. Make a short transverse incision through the scrotum, and extend it down to the tunica vaginalis. Single vertical midline incision is an alternative for bilateral orchiopexy. In neonate with suspicious of testicular tumor, inguinal incision is available (Fig. 58.2a).

Open the tunica vaginalis, and extrude the testis (Fig. 58.3). Untwist spermatic cord if torsion persists, and wrap the testis in warm saline gauze. Check the color of the testis after untwisting it. When torsion of the appendix testis is confirmed, resect it (Fig. 58.4).

Table 58.1 Differential diagnosis in acute scrotum

		Testicular torsion	Torsion of appendix	Acute epididymitis
Symptoms	Onset	Sudden	Sudden	Slow
		During sleep, early morning	During exercise	
	Peritoneal irritation sign	Positive	None	None
	Voiding symptom	None	None	Sometimes positive
Physical findings	Inspection	Elevated and horizontal	Blue dot sign	
	Palpation	Whole swelling	Localized induration	Localized swelling
	Cremaster reflux	Disappeared	Positive	Positive
Laboratory or examination findings	Pyuria	None	None	Sometimes positive
	Inflammatory reaction	Sometimes positive	None	Positive
	Ultrasonography	Decreased blood flow of testis	Normal blood flow of testis	Increased blood flow of epididymis
		Whirlpool sign		

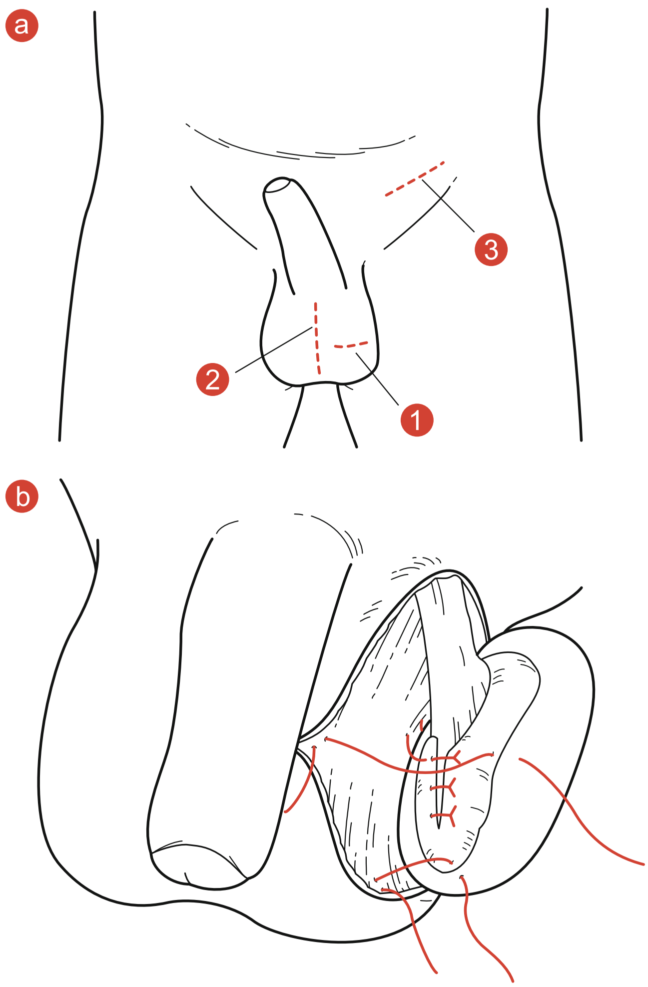


Fig. 58.2 Skin incision and orchiopexy for testicular torsion. (**a**) Skin incision: (*1*) transverse incision, (*2*) vertical midline incision, (*3*) inguinal incision. (**b**) Orchiopexy

If the testis is judged to be viable, trim excess tunica vaginalis, and approximate the cut edges of tunica vaginalis behind the testis. Dissect between the scrotal skin and dartos fascia to create the dartos pouch. Resect the appendix testis and put the testis into the dartos pouch. Approximate the testis at least three positions using 3-0 nonabsorbable sutures (Fig. 58.2b).

If the testis remains dark, make a short incision in the tunica albuginea. If active bleeding is not seen, it is judged to be nonviable. Divide the cord structure, and ligate them with 2-0 absorbable sutures. Orchiectomy is done.

In all cases, contralateral orchiopexy should be done in the same manner to prevent future torsion.

Close the scrotal skin with a 4-0 absorbable suture, and place a dry dressing covered by a scrotal supporter.

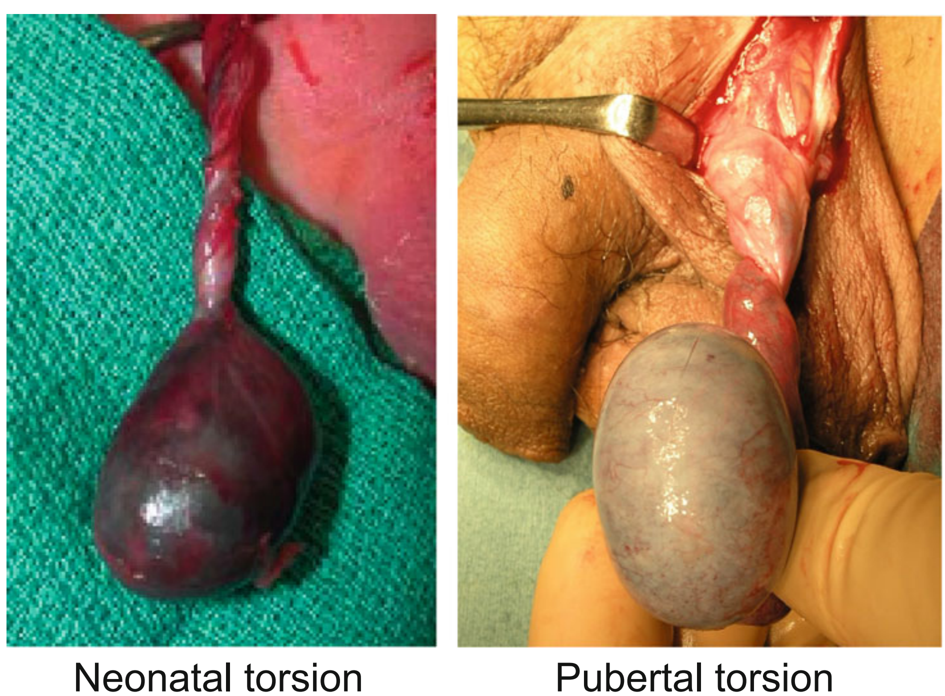
58.4 Postoperative Management

Postoperative complication such as hematoma or retorsion is rare.

The degree of cord twisting and the time between onset of symptoms and detorsion are most important factors to decide early salvage rate of the testis. Severe testicular atrophy occurred after torsion for as little as 4 h when the twist was >360° [1]. In cases of incomplete torsion (180–360°), with symptom duration up to 12 h, no atrophy was observed. However, an absent or severely atrophied testis was found in all cases of twist >360° and symptom duration >24 h.

Patients would need a follow-up mainly for fertility and hormonal issues. Although long-term outcome in terms of fertility is not conclusive, subfertility is found in more than one-third of patients after torsion [3]. Early orchiopexy with

Fig. 58.3 Operative findings in neonatal and pubertal torsion



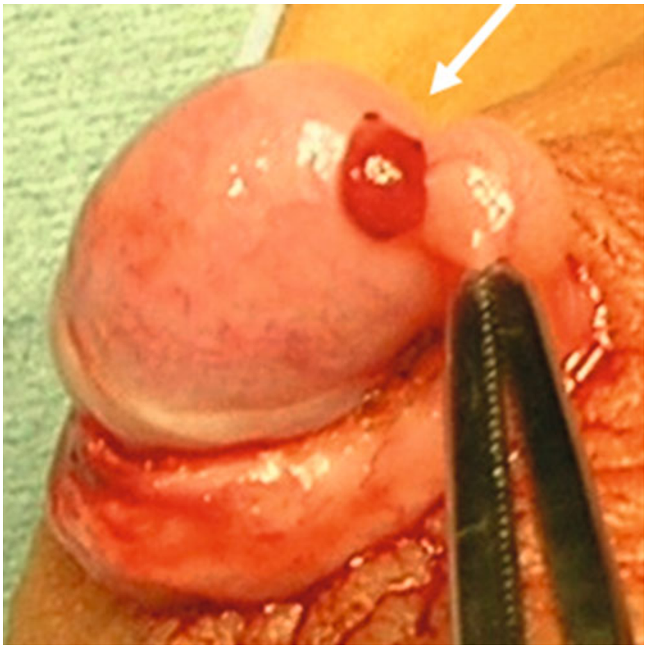


Fig. 58.4 Operative finding in torsion of the appendix testis

detorsion is found to preserve fertility [4]. Endocrine testicular function remains in the normal range after testicular torsion [5].

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Part VII

Tumors

59 Lymphatic Malformations

Tsugumichi Koshinaga

Abstract

Lymphatic malformations, classified as one of vascular malformations, are not neoplastic lesions. A particular care must be paid to minimize damage to the surrounding structures and functions. Preoperative diagnostic imaging should be used to determine whether total resection of the mass is feasible. Multiple surgeries may be frequently required to achieve complete resection of the lesion. Cautions must be taken for preserving the nerves and blood vessels especially when displaced by the huge mass. Try best to excise the mass completely; however, sacrifice of important neurovascular structures must be avoided. Partial excision would be suggested; if the dissection proves difficult involving the vital structures, unroofing should be performed by partially excising the walls of the mass to open up the remaining larger lymphatic vesicles. A closed suction drainage would be necessary even if complete excision of the mass appeared grossly evident.

Keywords

Lymphatic malformations • Lymphangioma

59.1 Preoperative Management

According to the International Society for the Study of Vascular Anomalies (ISSVA) 1996, lymphangioma is now regarded as a lymphatic malformation [1]. Lymphatic malformations are categorized as either microcystic or macrocystic, and these types frequently occur together. They are commonly found in sites including the neck, face, axillae and chest wall, mediastinum, retroperitoneum, and buttocks (Fig. 59.1). Ultrasonography, magnetic resonance imaging (MRI), and other diagnostic imaging techniques are useful for diagnosis, and it is important to assess the extent of the lesions. Particular attention must be paid regarding whether lesions in the neck or axillae have extended to the mediastinum. On MRI, lymphatic malformations appear hypointense on T1-weighted imaging and hyperintense on T2-weighted imaging due to the accumulation of lymph inside (Fig. 59.2). The microcystic type may appear to be a solid tumor. Multiple surgeries may be frequently required to achieve complete resection of the lesion, but repeated surgery may be more difficult and increase morbidity [2]. Sclerotherapy may facilitate resection. Preoperative diagnostic imaging should be used to determine whether total resection of the mass is feasible. If total resection seems unfeasible, the surgical resection line must be determined preoperatively. Recurrence rates after macroscopic total resection reportedly range from 17 % to 40 % [3].

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Fig. 59.1 Left cervical lymphatic malformation

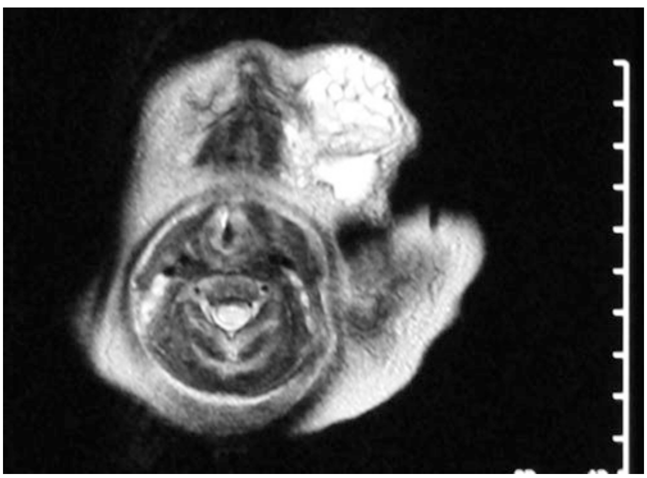

Fig. 59.2 MRI (T2-weighted imaging) of a left cervical lymphatic malformation

59.2 Operations

Bearing in mind that lymphatic malformation (lymphangioma) is not a neoplastic lesion, particular care must be paid to minimize damage to the surrounding structures and functions [4].

The details of surgery will vary depending on the site of the lesion, and we here describe how to perform surgery for a lesion in the neck.

59.2.1 Body Position

Place a cushion behind the patient's shoulder, and immobilize the patient with the face directed away from the affected side to extend the neck on the affected side.

59.2.2 Skin Incision

Make a transverse incision along a neck fold across the center of the mass (Fig. 59.3). When excising excess skin, be sure to remain sufficient skin not to remove too wide an area. As the skin and the layers of subcutaneous tissue may be lengthened and widened resulting thin by the mass, a relatively small skin incision may be appropriate. Rupture of the cystic part of the mass will make the operation more difficult, by the discharge of lymph from inside and concomitant collapse and contraction.

59.2.3 Dissection

When reaching the surface of the mass, extend to expose it over a wide area by dividing the platysma bilaterally (Fig. 59.4). Next, dissect to expose the surface of the mass from the subcutaneous tissue. If the proper layer is dissected, this procedure is comparatively easy, but dissection would be difficult if infection has been present or sclerotherapy has been yet performed. Starting from the superior margin of the wound (mandibular side), one will reach the surface of the mass from the skin with surrounding tissue, visualizing some small nerves and vascular structures (Fig. 59.5). Cautions must be taken for preserving these nerves and blood vessels especially when displaced by the huge mass. One should avoid injury to nerves and vessels running hiding in the mass when dissecting the fibrous tissues in the surface of the mass. The small lymph vessels must be ligated before starting dissection to prevent postoperative lymphorrhea. A bipolar coagulator is a useful tool to prevent not only hemostasis but postoperative lymphorrhea.

59.2.4 Excision of the Mass

Once the entire surface of the mass is exposed, the mass may be moved out from the wound (Fig. 59.6). Try best to excise the mass completely not to leave the part of the mass remaining; however, sacrifice of important neurovascular structures must be avoided. Partial excision would be suggested; if the dissection proves difficult involving the vital structures, unroofing should be performed by partially excising the walls of the mass to open up the remaining larger lymphatic vesicles.

59.2.5 Drainage and Wound Closure

Insertion of a drain would be necessary even if complete excision of the mass appeared grossly evident (Fig. 59.7). A closed suction drainage with negative pressure, rather than

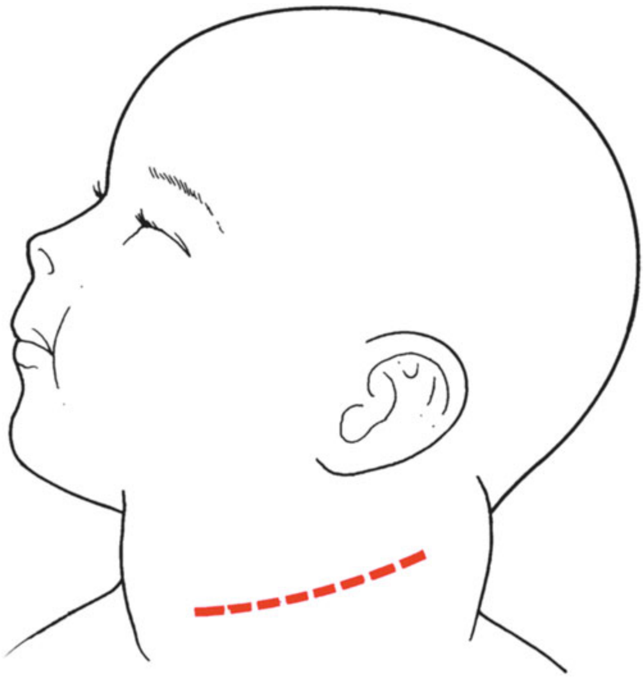

Fig. 59.3 Skin incision. Make a transverse incision along a neck fold across the center of the mass

Fig. 59.4 Dissection (*1*). When reaching the surface of the mass, extend to expose it over a wide area by dividing the platysma bilaterally

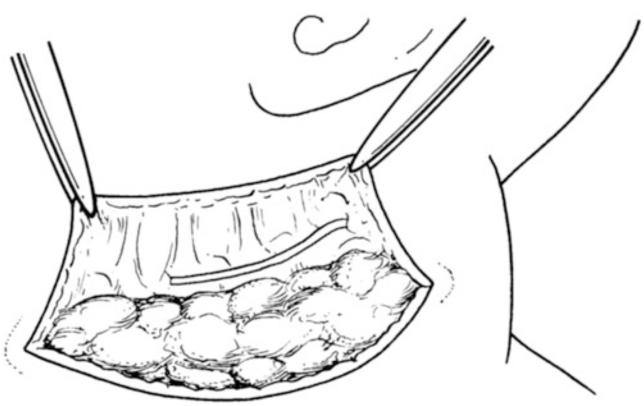

Fig. 59.5 Dissection (*2*). Reach the surface of the mass from the skin with surrounding tissue, visualizing some small nerves and vascular structures

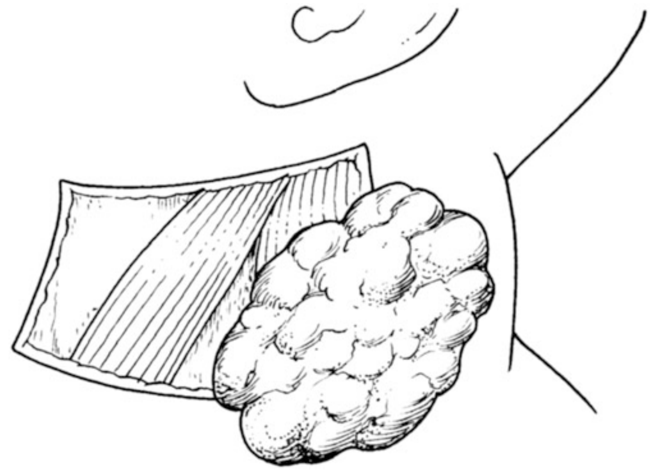

Fig. 59.6 Excision of the mass. Excise the mass when the entire surface is fully exposed

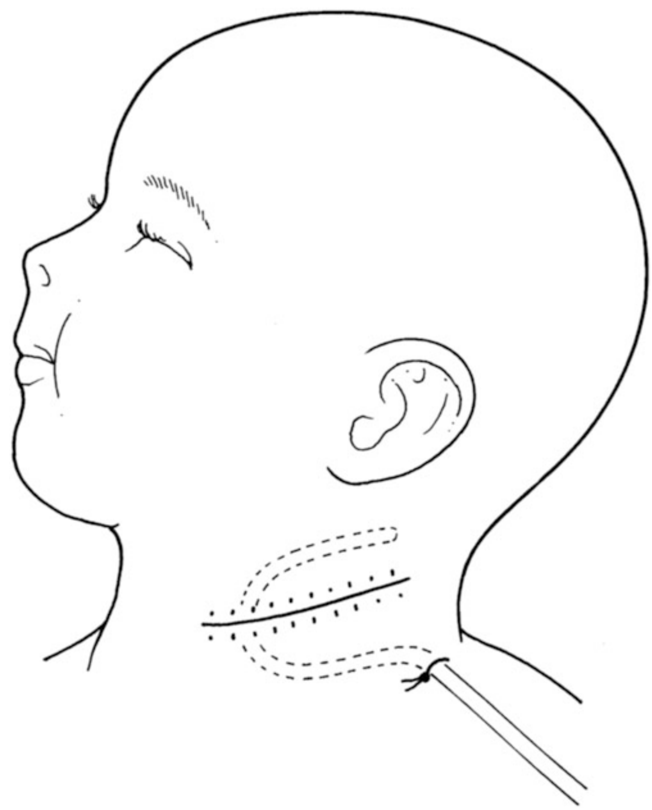

Fig. 59.7 Drainage and wound closure. Insertion of a closed suction drain would be necessary

an open drainage, is preferable to aspirate lymph and exudate from the possible residual lymphatic tissues. Absorbable suture threads should be used for wound closure to proximate the adjacent tissues to minimize the dead space left by the excision of the mass. The platysma and skin are then closed by subcuticular suture. Measure the volume of postoperative drainage every day to check that it is decreasing daily. In most cases, the drain can be removed after about 5 days. If the mass persists, however, decide when to remove the drain on the basis of the amount of fluid being drained.

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60 Neuroblastoma

Tatsuro Tajiri

Abstract

Neuroblastoma is unique in its biological heterogeneity. As a result, it is crucial that the therapies selected for its treatment are appropriate according to the patient's classification based on several risk factors, including the patient's age, staging, and the grade of the tumor's biological malignancy. Surgery is one of the key options in the multidisciplinary therapies, with surgeries for neuroblastoma classified into three categories: radical primary resection, open biopsy, and radical second-look operations. It is necessary to select the appropriate surgery on an individual basis. Recently, the Japan Neuroblastoma Study Group (JNBSG) has been performing clinical studies using a classification system that includes three risk groups (low, intermediate, and high) based on the risk classifications of the Children's Oncology Group (COG). The surgical guidelines combine the low and intermediate groups to create two groups of patients: the low- and intermediate-risk group and the high-risk group.

Keywords

Neuroblastoma • International Neuroblastoma Risk Group (INRG) • Image-defined risk factors (IDRFs) • Japan Neuroblastoma Study Group (JNBSG)

60.1 Preoperative Management

60.1.1 Low- and Intermediate-Risk Neuroblastoma

As a clinical staging system for neuroblastoma, the International Neuroblastoma Staging System (INSS), which is a postsurgical staging system, has been used in Japan for decades. Recently, a pretreatment staging system based on clinical criteria and pretreatment images has been developed into the new International Neuroblastoma Risk Group (INRG) staging system (Table 60.1) [1]. In this system, the image-defined risk factors (IDRFs) are used to evaluate the surgical risk for each patient and to determine the appropriate surgical procedures, such as whether to perform either resection or biopsy as a primary procedure. Pretreatment images (contrast CT or MRI) are analyzed to identify the presence or absence of IDRFs. It is recommended that radiological specialists analyze the images.

Images of each primary tumor are investigated for the existence of IDRFs. The tumors with at least one positive IDRF are defined as IDRF positive. Vessel factors are the most important risk factors in this system, with arteries that are "encased" in a tumor being defined as IDRF positive. The IDRF evaluation criteria for "contact" and "encasement" are illustrated in Figs. 60.1 and 60.2 [2].

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Table 60.1 The INRGSS (an international neuroblastoma risk group classification system)

Stage	
L1	Locoregional tumor not involving the vital structures as defined by the list of image-defined risk factors
L2	Locoregional tumor with the presence of one or more image-defined risk factors
M	Distant metastasis disease (except Stage Ms)
Ms	Metastatic disease confined to skin and/or bone marrow

60.1.2 Guideline for Radical Primary Resection (for Localized Neuroblastoma)

In IDRF-negative cases, the localized tumor should be resected completely in the primary surgery, regardless of the origin, with the preservation of the adjacent organs. Lymph nodes involved in the tumor should be resected en bloc. However, in cases where the damage of the surrounding organs or major vessels is inevitable in the complete resection of the primary tumor, only an open biopsy should be performed, even if the patient has been evaluated as IDRF negative.

60.1.3 Guideline for Open Tumor Biopsy

A tumor biopsy should be performed safely and properly to obtain a sample of sufficient size for both the pathological diagnosis and the biological analysis of the tumor. A tissue sample of at least 1 cm^2 in area is required for a precise diagnosis; thus, a needle biopsy is not recommended under this guideline.

It is recommended that the biopsy specimen be taken from the primary tumor. However, lymph nodes with obvious metastases are another option. In the cases where gross heterogenic regions are observed in one tumor, samples should be obtained from each region. Tumor tissue may be necrotic in the center; thus, the sample tissue should be resected sharply (avoiding compression), immediately under the tumor capsule.

Laparoscopic or thoracoscopic approaches might be considered for tumor biopsy since they are less invasive than an open biopsy. At present, there is insufficient evidence to support the recommendation of laparoscopic or thoracoscopic procedure for neuroblastoma biopsy.

60.1.4 High-Risk Neuroblastoma

For high-risk neuroblastoma, a tumor biopsy should be performed first, and a radical tumor resection should be performed after chemotherapy as a second-look operation. According to the JNBSG's clinical study protocols for high-risk neuroblastomas, a radical operation should be performed as a delayed local therapy after the administration

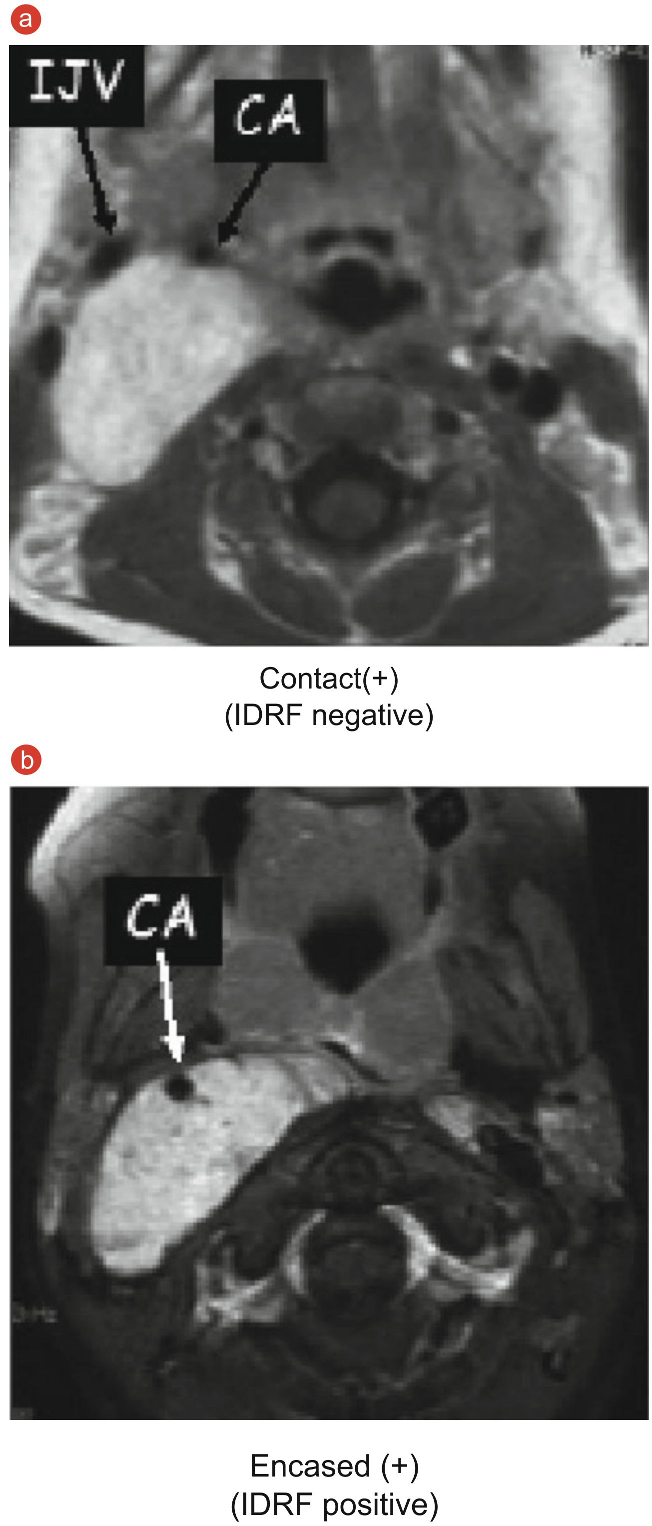

Fig. 60.1 IDRF evaluation images (MRI). (**a**) Contact (+) (IDRF negative), (**b**) Encased (+) (IDRF positive). *IJV* internal jugular vein, *CA* carotid artery

of high-dose chemotherapy. The patient is supposed to have a neutrophil count of more than 500/m^3, and it is necessary to ensure that the conditions of the patient's major organs

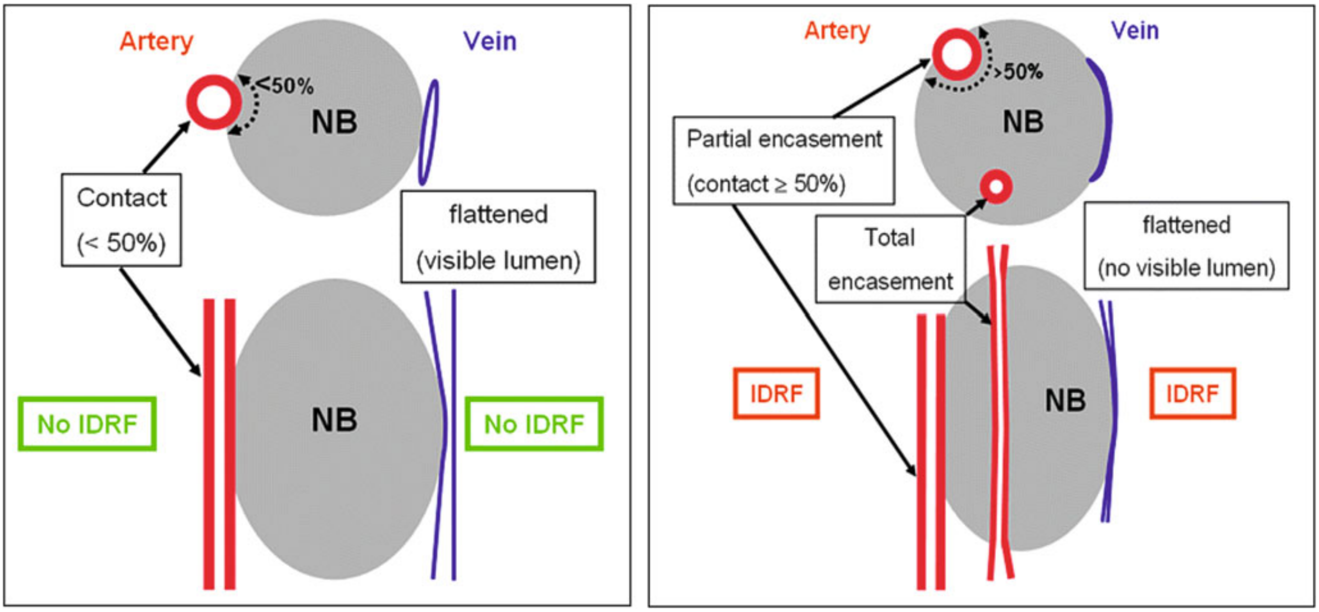

Fig. 60.2 A schematic illustration of the IDRF evaluation. Regarding the arteries, in cases where a vessel is completely surrounded by the tumor (total encasement), or more than half of the circumference of the vessel is surrounded by the tumor (contact ≧ 50 %), the vessel is considered to be "encased," and the patient is considered to be IDRF positive. Vessel "contact" is defined by the surrounding of less than half of the artery circumference by the tumor; such cases are considered to be IDRF negative. In the case of veins, "encased" means the complete compression of the vessel with no visible lumen. "Contact" means that the lumen is visible and that case is IDRF negative

(the heart, lung, liver, and kidneys) will tolerate general anesthesia. It is important to discuss the possible necessity of blood transfusions with anesthesiologists before surgery in order to maintain the patient in an appropriate condition for the surgery. Furthermore, we recommend preparing not only red cell concentrates but also platelet concentrates and fresh frozen plasma for transfusion during the surgery. The impairment of bone marrow function in patients who have undergone intensive chemotherapy must be taken into consideration. As a consequence, the patient's recovery from a massive hemorrhage during surgery would be delayed in comparison to other surgical patients.

60.2 Points for Radical Surgery: Resection of the Primary Tumor

Organs surrounding the tumor must be preserved during the resection of the primary tumor regardless of its region. If possible, the lymph nodes involved in the tumor should be resected en bloc.

60.2.1 Tumors of Adrenal Gland or Retroperitoneal Origin

When the active invasion of the tumor into the kidney or the liver is observed during the surgery, the organs are partially resected together with the tumor. Renal function should be preserved to the extent that is possible. When the renal vessels are involved in the tumor and are difficult to detach from the tumor, the tumor capsule should be incised and the tumor should be resected to the extent that is possible. The renal blood flow should be preserved, and a nephrectomy should be avoided. When spasms of the renal vessels occur during surgery, the vessels should be wrapped in a piece of gauze soaked in Xylocaine, and the procedure should be continued with the maximum effort made to preserve the renal function. When the total resection of the tumor is impossible, even with renal resection, priority should be given to the preservation of renal function, while the tumor is resected to the extent that is possible. In the case that some of the major arteries from the abdominal aorta (such as the celiac or superior mesenteric artery) are involved in the tumor and are difficult to detach, the vessels should be preserved and the tumor should be resected to the extent that is possible, with an incision into the capsule. When a direct invasion into the spleen or splenic vessels is observed, a splenectomy should be considered together with the tumor resection for patients older than 5 years of age. In younger patients, the tumor should be resected to the extent that is possible while avoiding damage to the spleen.

60.2.2 Mediastinal Tumors

In cases where the tumor shows a dumbbell form, the nerve root should be resected at the level of the intervertebral foramen, avoiding the complication of the nervous systems. In principle, the resections of the vertebral arch or of tumors of retroperitoneal origin are not performed. However, in cases where the symptoms of spinal cord compression appear and it is possible to perform surgery within 72 h of the onset of symptoms, the resection of the tumor in the vertebral canal is allowed. In the case of an active invasion, the diaphragm should be resected. Otherwise, the diaphragm should be preserved to the extent that is possible.

60.2.3 Cervical Tumors

In the resection of tumors, damage to the major vessels such as the cervical artery or subclavian vein, and major nerves should be avoided. Tracheoplasty should be avoided during the tumor resection. Partial resection of the thyroid gland is performed in cases where active tumor invasion is found.

60.2.4 Presacral Tumors

Attention must be paid to preserving the nerve roots. Damage to the major vessels such as the intra- and extra-iliac arteries should be avoided in the resection of the tumor.

60.3 Radical Tumor Resection for Left Adrenal Neuroblastomas

An incision is made on the left upper abdomen (Fig. 60.3), with a Kent retractor helping to secure the operation field (Fig. 60.4).

Incising the peritoneum lateral to the descending colon and left colonic flexure, the tumor above the left kidney is exposed by mobilizing the descending colon to the right (Fig. 60.5). At this point, attention must be paid to avoid damage to the mesenteric vessels of the colon. If the colonic mesentery is damaged, it should be repaired before the abdomen is closed. In cases where it is difficult to identify the tumor border to the posterior side of the pancreas and to the splenic vein, the splenorenal ligament and splenodiaphragmatic ligament are dissected to expose the tumor, after which the organs may be mobilized to the right to remarkably improve the operation field. If it is possible to release the tumor adhesion from the kidney or renal vessels, the kidney should be reserved and the tumor should be dissected between the tumor capsule and the retroperitoneum by electrocoagulation (if it is difficult to achieve a complete tumor resection without damage to the kidney, a nephrectomy should be performed only in cases where it is possible to achieve the complete resection of the tumor).

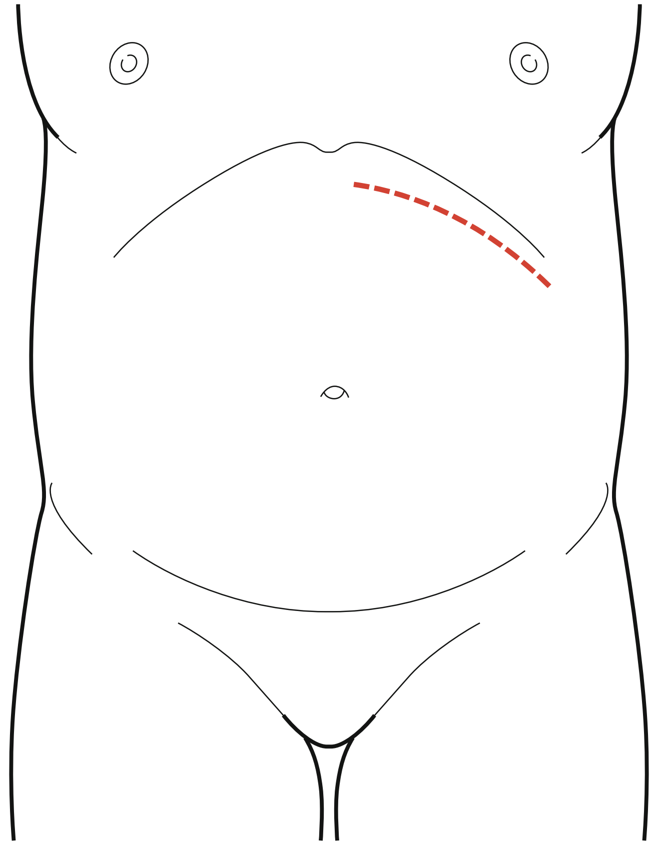

Fig. 60.3 Skin incision

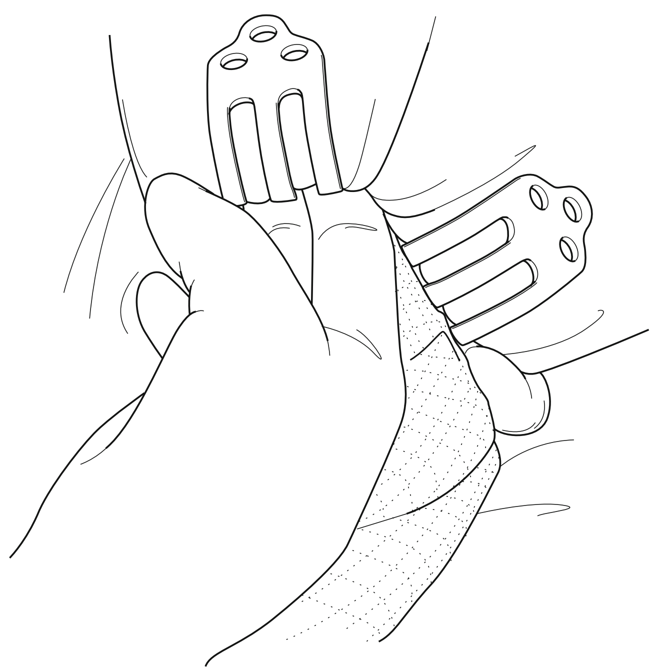

Fig. 60.4 The approach to the operation field: the operation field is secured using retractors

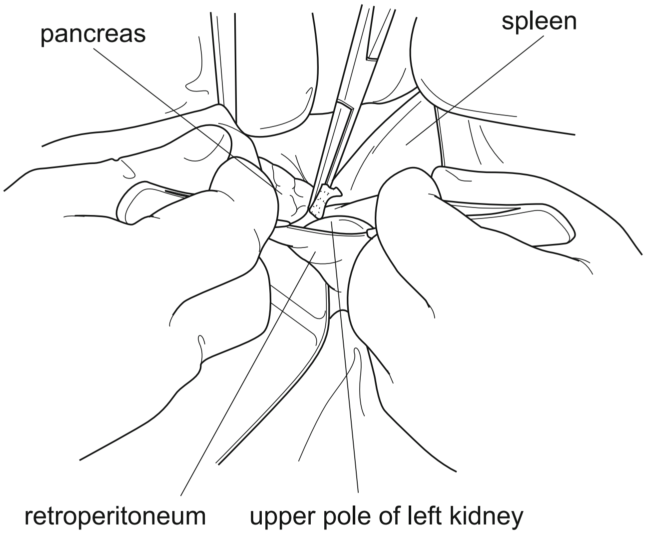

Fig. 60.5 The exposure of the tumor: an incision is made on the retroperitoneum, and the descending colon and the peritoneum are detached from the tumor

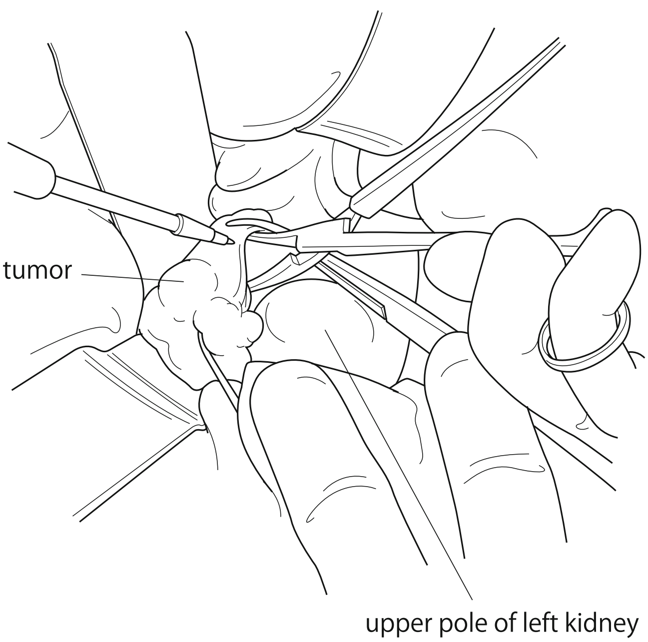

Fig. 60.6 Dissection around the tumor: the tumor is detached from the surrounding tissues

For the resection, the tumor is approached from the top, bottom, and behind, mobilizing to the anterior and interior sides of the body (Fig. 60.6).

There are feeding blood vessels from the abdominal aorta, inferior diaphragmatic artery, renal artery, inferior vena cava, renal vein, and inferior diaphragmatic vein to the interior side of the tumor. They should be ligated and repeatedly dissected. In cases where the tumor edge is close to the renal hiatus, the dissection must be performed quite gently. It is also effective to spray a chemical such as

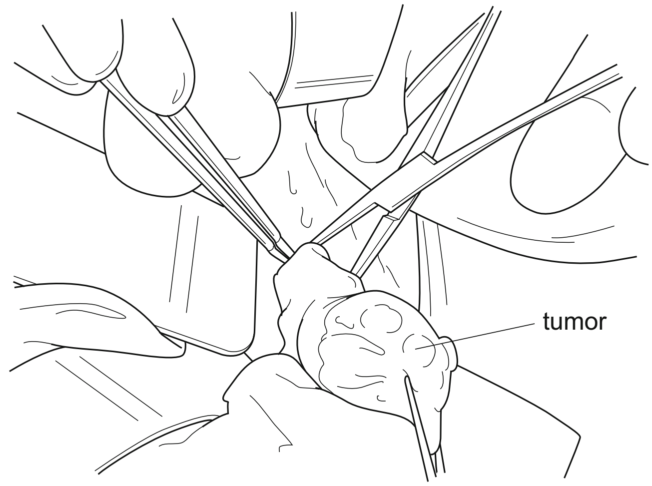

Fig. 60.7 Tumor removal: the tumor is removed together with the surrounding fatty tissue

papaverine to prevent the vessel spasm (surgeons should be especially careful in cases of right adrenal neuroblastoma, where the tumor is attached to the inferior vena cava, as the distance between the feeding vessels and the inferior vena cava is short). After all of the vessels are ligated and divided, the tumor should be removed with the surrounding fatty tissue (Fig. 60.7).

Systematic lymph node dissection is not ordinarily required; however, the lymph nodes surrounding the tumor should be dissected en bloc. Any obvious metastatic lymph nodes or lymph nodes of larger than 2 cm in size should also be dissected. When lymph node metastases are recognized in the pretreatment images, they should be dissected for sampling during the surgery. Chylous ascites sometimes occurs after surgery. Thus, care must be taken during the dissection of lymph nodes. The placement of metal clips which do not influence MRI examination at the top and the bottom of sampling site would be useful for the subsequent radiation therapy.

Drains must be placed in preparation for postoperative hemorrhage and chylous ascites after dissection of lymph nodes around the abdominal aorta.

As a precaution, an adhesion barrier film (Seprafilm®) should be placed under the surgical scar to prevent of adhesive ileus after surgery. The abdominal wall is then closed in layers with absorbable sutures.

60.4 Points of Postoperative Management

60.4.1 Infection Control

Neuroblastoma patients are expected to be at a high risk of general infection because of their low neutrophil count. The proper choice of antibiotics, based on the preoperative monitoring of bacterial cultures, is necessary, and the route of administration and the duration of antibiotic therapy should be carefully planned. When any symptoms of infection arise, gamma globulin should be administered without hesitation. For infection control while the bone marrow function is impaired, the infection control tactics must be planned in discussions between pediatric surgeons and pediatric oncologists.

60.4.2 Hemostasis and Coagulation

A decrease in the patient's platelet transfused pre- and perioperative transfusion time is an indicator of a hemorrhage. Hemorrhages occur at the operation site; however, there is also a risk of intestinal, brain, and tracheal hemorrhage. It is necessary to monitor the patient's hemostasis and coagulation and to perform platelet and fresh frozen plasma transfusions as appropriate.

60.4.3 Management of Ascites

Massive ascites may occur after surgery. Proper liquid infusion and blood transfusion are necessary to maintain the renal blood flow in patients with renal malfunction or reduced renal capacity. The retrograde contamination of the drainage tube can easily occur in these patients due to their impaired immune function.

60.4.4 Scar Management

When long-term chemotherapy and high-dose chemotherapy influence the patient's nutritional status, wound healing will often be retarded, and close observation of the surgical scar is necessary. Careful scar management is required because the patient will be in an immunocompromised state, with a high risk of wound infection.

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Wilms' Tumor

61

Hiroshi Matsufuji

Abstract

Although chemotherapy has improved the outcomes of Wilms' tumor treatment, surgical resection of the tumor and surgical staging play the most important roles on the management of disease. When preoperative evaluation shows the possibility of complete resection of the tumor, biopsy of the tumor may not be needed. Regional or aggressive lymph node dissection is not required, lymph node sampling for surgical staging plays important roles for the subsequent treatment plan.

If evaluations using such as enhanced CT scan or MRI fail to show the bilateral lesions in the kidneys, surgical exploration of the contra-side may not be mandatory. In the case with bilateral Wilms' tumor, chemotherapy and nephron-sparing surgery should be considered.

Tumor rupture or spillage during operation migrates the tumor staging, adversely.

Keywords

Wilms' tumor • Surgical staging • Nephrectomy • IVC • Bilateral nephroblastoma

61.1 Resection of Right Kidney Wilms' Tumor (Right Nephrectomy)

61.1.1 Abdominal Incision

1. A right generous transverse upper abdominal incision across the left rectus muscle is placed. The operative wound should be large enough to mobilize and deliver the tumor without rupture. The rectus sheath is incised and both rectus muscles are completely divided using electrocautery. The peritoneum is incised and entered. The encountered falciform ligament is ligated and divided. When incision is extended laterally by dividing the lateral abdominal muscles, it should be cared to avoid injury of the surface of the tumor, the liver, or the intestine under direct vision (Fig. 61.1).
2. The whole abdominal cavity is inspected and palpated to detect the tumor rupture, bilateral tumor, peritoneal seeding, lymph node swelling, or liver metastasis. Contralateral exploration may be unnecessary if preoperative evaluation using CT scan or MRI fails to show contralateral lesions. When unexpected contralateral lesion is detected, tumors of both sides are biopsied without further resection. The chemotherapy and nephron-sparing surgery should be considered.

61.1.2 Dissection of the Mesentery

The mesentery of the right colon is dissected from the anterior surface of the tumor and the Gerota's fascia. The white line is incised and the mesentery of the right colon is

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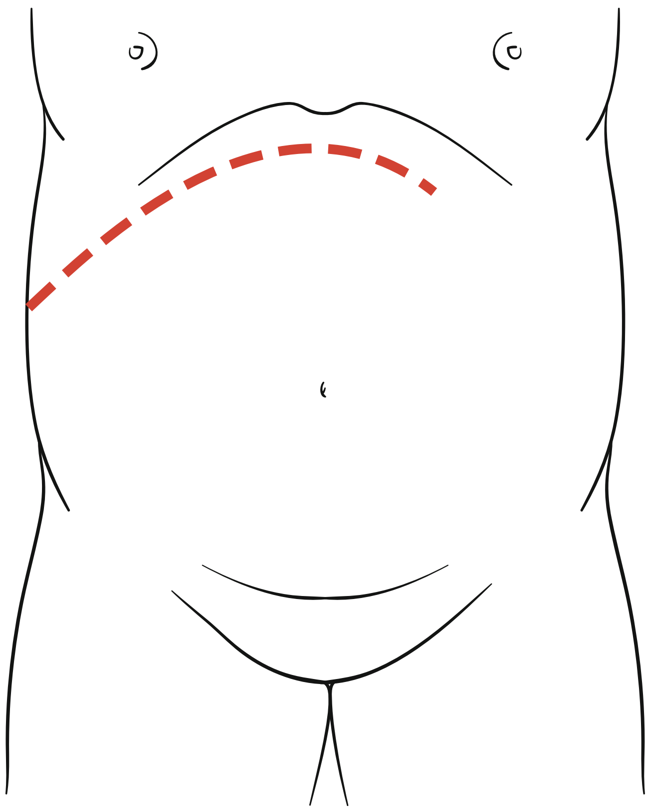

Fig. 61.1 Skin incision

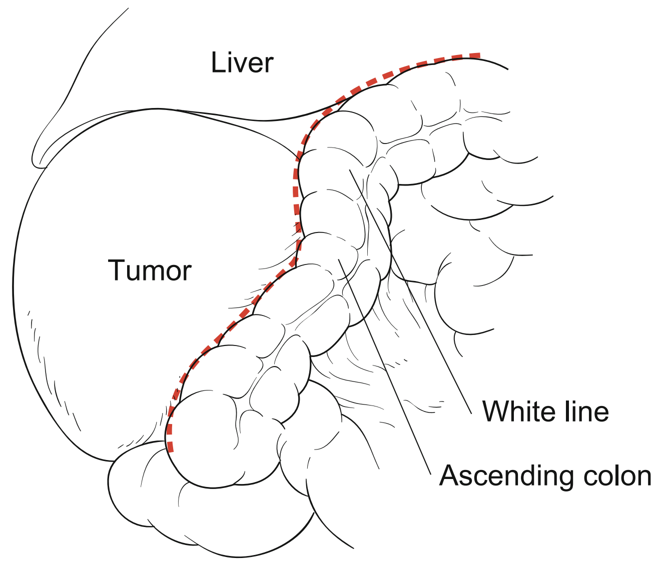

Fig. 61.2 Dissection of the ascending colon mesentery

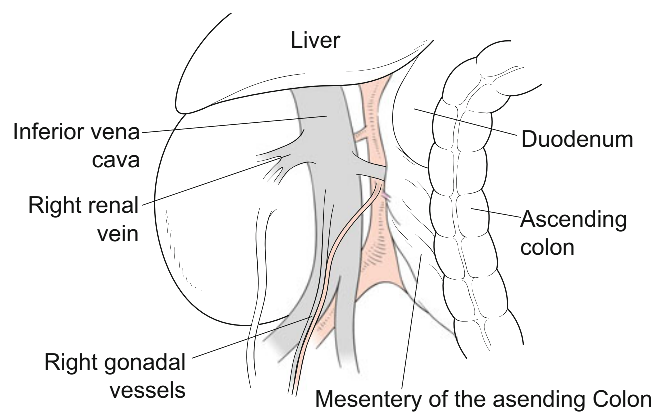

Fig. 61.3 Dissection of inferior vena cava

dissected between the fusion fascia and the Gerota's fascia. Kocher maneuver is added to mobilize the duodenum. The inferior vena cava (IVC) and abdominal aorta are exposed proximally to the renal vessels and distally to the bifurcation. The right ureter is ligated and divided well apart from the kidney and the gonadal vessels are also divided (Fig. 61.2).

61.1.3 Dissection of IVC, Renal Vein, and Renal Artery

1. When the IVC and the abdominal aorta are identified, the resection of the right kidney tumor is started. If the tumor is large distorting the adjacent structures, lateral mobilization of the kidney with the help of lateral extension of the incision is an useful maneuver to create a wider space in the medial side of the hilum of the right kidney (Fig. 61.3).
2. Dissection of the IVC is started from caudal portion which is free of the tumor and is extended proximally. Gentle traction of the IVC using vascular sling may be useful. In the case with large tumor, the IVC and the branches of the renal vein are stretched by the tumor, and these branches are carefully mobilized and divided between ligatures. When the renal vein and the IVC are exposed, those are palpated carefully to detect intravenous extension of the tumor.
3. The right renal vein is dissected gently free of surrounding tissues and pulled caudally using vascular sling to detect the right renal artery which locates cranially and dorsally to the renal vein. If the adrenal gland is preserved, the inferior adrenal vein and artery which branch off the renal vessels are ligated and divided. The right renal artery is ligated doubly using suture and ligation and divided as well as the renal vein. If it is difficult to divide the right renal artery securely between the ligatures, proximal ligature can be placed at the level of the left margin of the IVC (Fig. 61.4).

61.1.4 Dissection of the Kidney

1. When the renal vessels are divided, the right kidney is dissected from the surrounding tissues. The kidney within Gerota's fascia is lifted and the posterior dissection is

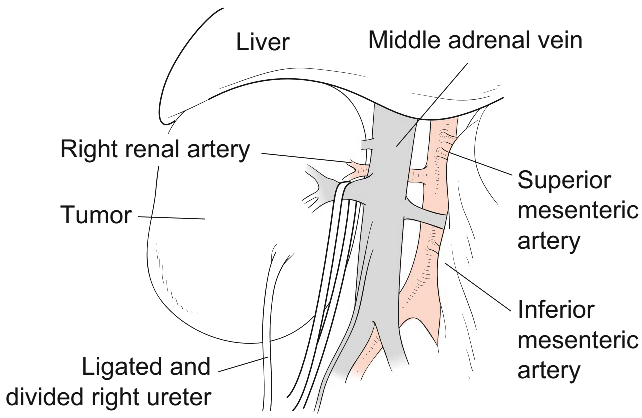

Fig. 61.4 Right renal vein and right artery

Table 61.1 NWTS staging

Stage	
Stage I	Tumor is limited to the kidney and can be completely removed by surgery
Stage II	Tumor has spread to the areas surrounding the kidney and can be completely removed by surgery
Stage III	Tumor has spread to the areas surrounding the kidney, including blood vessels, lymph nodes, or other nearby organs, and cannot be completely removed by surgery
Stage IV	Tumor has spread beyond the area of the kidney into organs such as the lungs, liver, bone, and brain
Stage V	Tumors are in both kidneys. Each kidney is staged separately

completed under direct vision. If the tumor is located upper pole of the kidney, the adrenal gland is removed with the kidney. The cephalic aspect of the tumor may be attached to the undersurface of the liver. These are separated sharply and bluntly to avoid breaching the liver surface. The superior and middle adrenal vessels are carefully ligated and divided. When the kidney is removed, enlarged lymph nodes on the large vessels are taken off separately for staging the tumor (Table 61.1). The renal bed is inspected and the hemostasis is confirmed.

2. After irrigation of the whole abdominal cavity with warm saline water, the wound is closed in layers. It is preferred to leave a drain on the tumor bed.

61.2 Resection of Left Kidney Wilms' Tumor (Left Nephrectomy)

61.2.1 Abdominal Incision and Dissection of the Mesentery

Through a left transverse upper abdominal incision across the right rectus muscle, the abdominal cavity is entered. The mesentery of left side colon is dissected carefully from the anterior surface of the tumor. The ureter and gonadal vessels are ligated and transected.

61.2.2 Dissection of Abdominal Aorta, Renal Vein, and Renal Artery

Dissection begins caudally, sweeping adventitial tissue and lymph nodes, laterally off the abdominal aorta; if necessary, encountered lumber arteries may be divided between ligatures. The left renal vein and its branches are gently exposed. The renal vein is mobilized and elevated with a vascular sling to expose the renal artery which locates dorsal to the cephalic border of the renal vein. The inferior adrenal vessels are divided. The renal artery and vein are divided between the ligatures (Fig. 61.5).

61.2.3 Dissection of the Kidney

The posterior aspect of the kidney is mobilized by blunt and sharp dissection. The superior dissection is hazardous on the left side, and damage to the spleen and tail of the pancreas must be avoided. Some small veins of the pancreas are carefully ligated and divided. The adrenal gland is removed if the tumor is in the upper pole of the kidney. The spleen is mobilized by separating the ligaments, and the pancreas and spleen are lifted out of the abdominal cavity. In this circumstance, the adrenal vessels should be carefully controlled with ligatures. The kidney within Gerota's fascia is delivered from the abdomen and the posterior dissection is completed. The renal bed is inspected following removal of the kidney to confirm hemostasis. Lymph nodes on the great vessels are removed separately for tumor staging.

61.3 Operations for the Right Side Wilms' Tumor with Inferior Vena Cava Extension

1. When the tumor extends into the inferior vena cava (IVC) through the renal vein, it may be removed with the kidney. Preoperative chemotherapy may affect the adhesion of the intra-caval tumor to its wall.
2. The IVC is palpated to identify the caval extension of the tumor. The IVC distal and proximal to the intra-caval extension and both renal veins are encircled with vascular slings to control the blood flow during cavotomy.
3. The liver is mobilized to expose to the suprahepatic or hepatic IVC. The falciform ligament is divided up to the diaphragm. The right and left triangular ligament is separated as well. When the tumor extends above the infra-hepatic IVC, the suprahepatic or hepatic IVC is

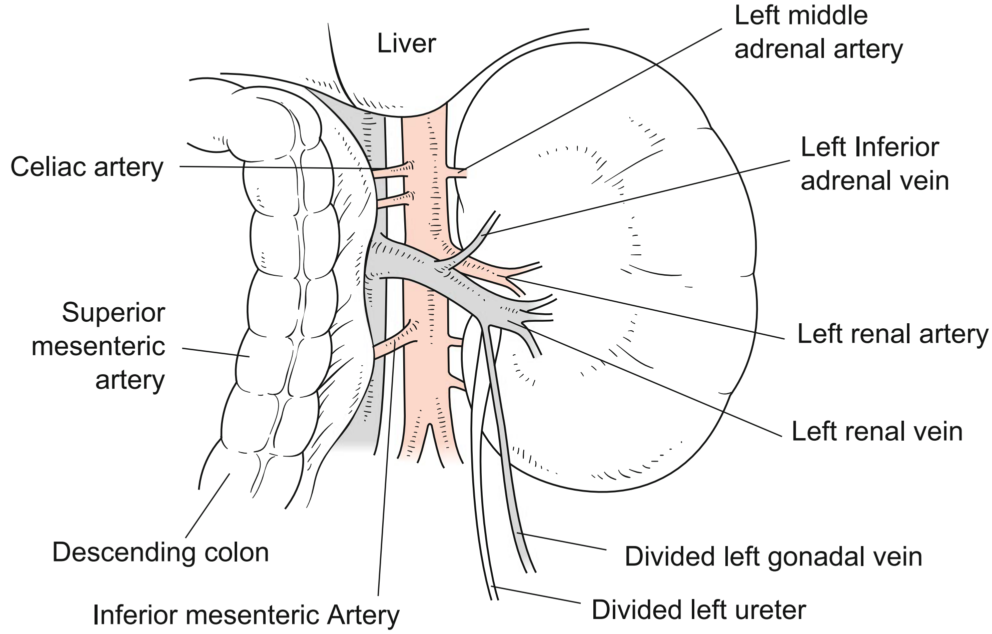

Fig. 61.5 Left nephrectomy

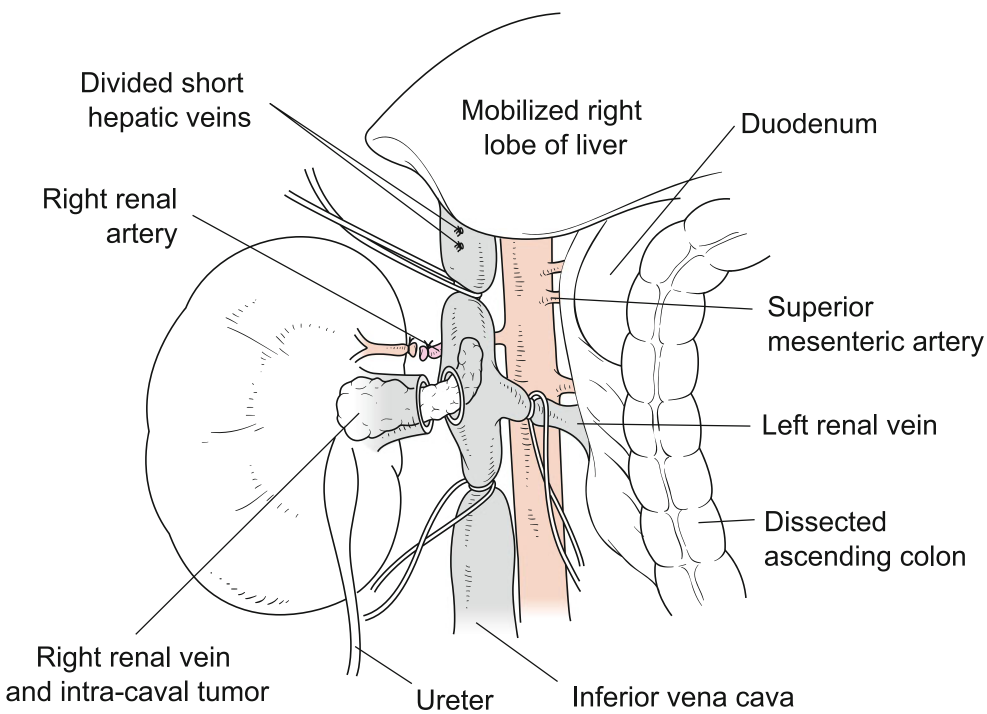

Fig. 61.6 Operation for Wilms' tumor with intra-caval extension

encircled by a vascular sling. The liver is retracted caudally to expose the suprahepatic IVC and anterior aspect is freed of connective tissues. The liver is rotated to the left sides of the patient, and the suprahepatic IVC is dissected circumferentially using blunt instruments and encircled by a vascular sling. Some short hepatic veins are ligated and divided. The IVC proximal to the tumor extension is encircled by a vascular sling. The lumber veins may be ligated and divided carefully (Fig. 61.6).

4. The vascular slings are tightened to control the blood flow during cavotomy. The renal vein is incised circumferentially and the intra-caval tumor is removed en bloc with the kidney. If the intra-caval tumor adhered to the wall, the incision is extended to the IVC and the tumor is dissected sharply. The IVC is closed using Proline continuous sutures. Those vascular slings are unfastened and hemostasis is confirmed.

Hepatoblastoma

62

Ken Hoshino

Abstract

Of the solid tumors treated by pediatric surgeons, the prognosis in cases of hepatoblastoma depends largely on whether or not complete tumor resection has been achieved by appropriated surgery. Therefore, in the design of treatment strategies for pediatric malignant solid tumors, hepatoblastoma is a representative type of tumor that requires precise operative procedure.

Basic hepatectomy refers to "systematic hepatectomy." Historically, surgery for pediatric liver tumors has focused on "tumor resection." Such surgery is somewhat similar to the so-called "enucleation" and is not systematic hepatectomy, which is based on the vascular supply.

Keywords

Hepatoblastoma • Systematic hepatectomy • PRETEXT • Transection plane • Liver transplantation • Lobectomy

62.1 Liver Anatomy

Systematic hepatectomy begins with an understanding of the liver "anatomy."

The liver can be roughly divided into eight segments, segments S1 through S8. S1 usually refers to the caudate lobe. S2 through S4 are called the "left lobe," and S5 through S8 are called the "right lobe." The falciform ligament of the liver runs from the round ligament of the liver, joining the abdominal wall to the liver. The ligament does not represent the border between the right and left lobes of the liver, but serves as the border between the left lateral segment and left medial segment of the liver, as described later in more detail. The border between the right and left lobes is the line joining the gallbladder to the inferior vena cava (Cantlie line) or the line along the middle hepatic vein. The left lobe can be divided into the left lateral segment (S2 + S3) and the medial segment (S4), while the right lobe can be divided into the anterior segment (S5 + S8) and the posterior segment (S6 + S7). The portal vein sends branches with corresponding numbers (P1 through P8) to these segments, suggesting that these segments are arranged along the areas supplied by individual portal venous branches (Figs. 62.1 and 62.2).

62.2 Determination of Areas to Be Resected for Complete Tumor Excision

Localization of the tumor in a given case is a very important step, which directly affects the strategy for the treatment of hepatoblastoma. This step involves classification according

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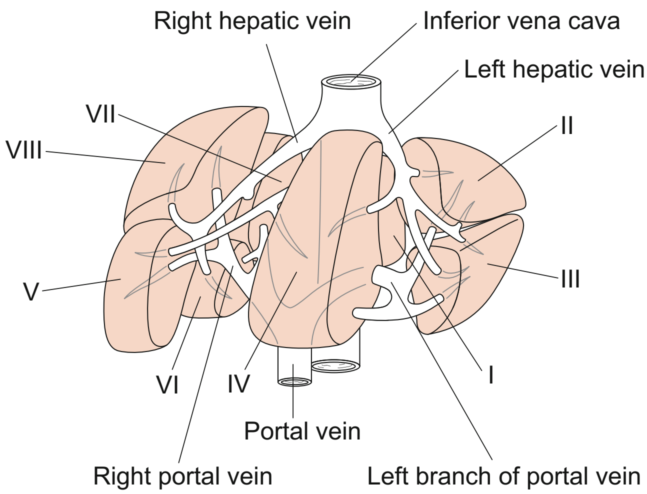

Fig. 62.1 Liver segment (segments I–VIII) and portal vein/hepatic vein

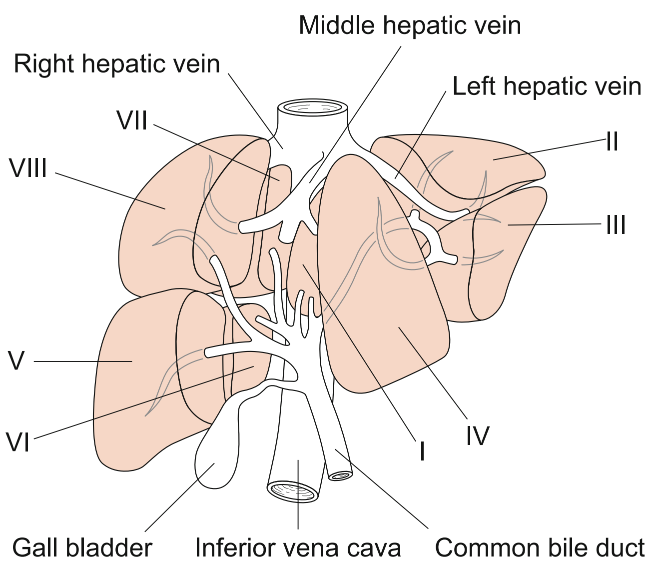

Fig. 62.2 Liver segment (I–VIII) and bile duct/hepatic vein

to PRETEXT, details of which are given in Fig. 62.3. This classification is based on which of the four segments of the liver (left lateral, left medial, right anterior, and right posterior segments) contains the tumor and how many serial tumor-free segments can be found. Resection of the left lateral segment or the posterior segment is selected for PRETEXT I cases, while resection of the left lobe or right lobe is selected for PRETEXT II cases. For PRETEXT III cases, resection of all the three segments of the right lobe, three segments of the left lobe, or two central segments is selected. CT imaging (3D-CT) is used for the tumor localization. The tumor-affected segments are identified by checking the relationships of the tumor with the portal or hepatic vein. Fortunately, hepatoblastoma responds well to chemotherapy, and the sizes of tumors that are excessively large at the first visit can be reduced by chemotherapy. Reliable localization by diagnostic imaging is often easy for hepatoblastoma. However, we occasionally encounter cases of hepatoblastoma where tumor resection is not simple (e.g., where the tumor is in contact with the inferior vena cava, or the tumor partially invades the hepatic vein which needs to be left unresected). Such cases are labeled as having "unresectable tumor." Figure 62.4 illustrates a case in which resection of more than three segments of the left lobe was needed, with only the right inferior hepatic vein serving as the drainage vein.

The last checkpoint in deciding the operative procedure is the status of the residual liver. In children, the liver itself is often normal except for the tumor-affected area. So, the operative procedure is decided on the basis of the extent of the expected residual liver volume after surgery. When dealing with children, the author thinks that, unlike in adult cases, it may be unnecessary to become too nervous about performing three-segment resection. However, in cases where intense bile stasis is seen in the entire liver (e.g., due to tumor invasion of the bile duct; Fig. 62.5), dysfunction of the residual liver may also occur. Therefore, evaluation of the extent of residual liver, ICG measurement, etc., are also important steps.

62.3 Practice with Standard Operative Procedure for Hepatectomy (Left Lobectomy)

In this section, I shall describe left lobectomy (resection of segments S2–S4 of the liver), which is a typical hepatectomy procedure most closely involving the basic manipulations of liver surgery among all the procedures of hepatectomy available at present.

In this procedure, the left liver and left caudate lobe are resected en bloc. The operation consists of three steps: (1) vascular manipulation of the left part of the liver at the hepatic hilus, (2) mobilization of the left part of the liver and the caudate lobe, and (3) transection of the hepatic parenchyma and dissection of the left hepatic vein.

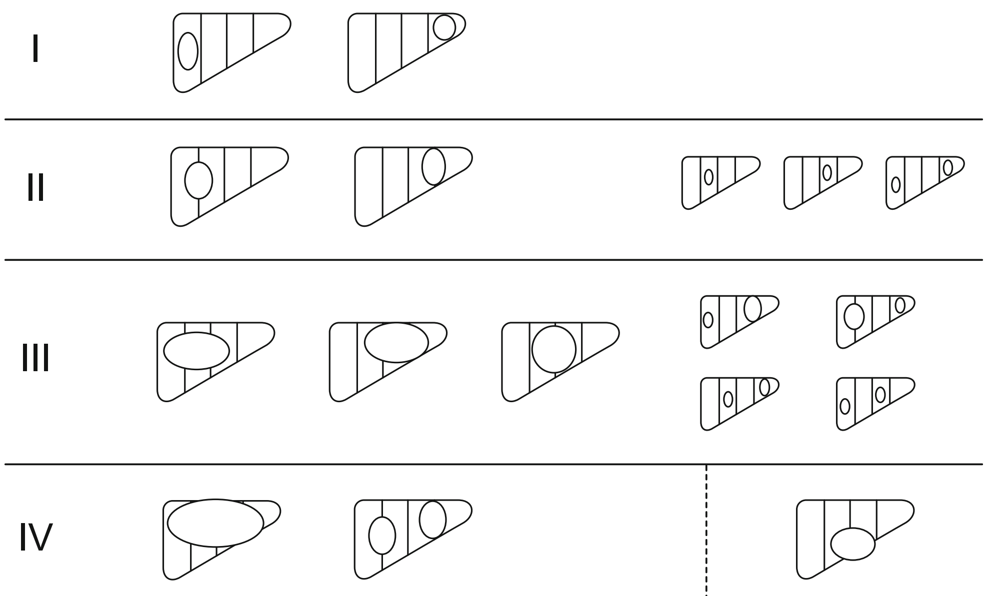

Fig. 62.3 PRETEXT (pretreatment extent of tumor) system

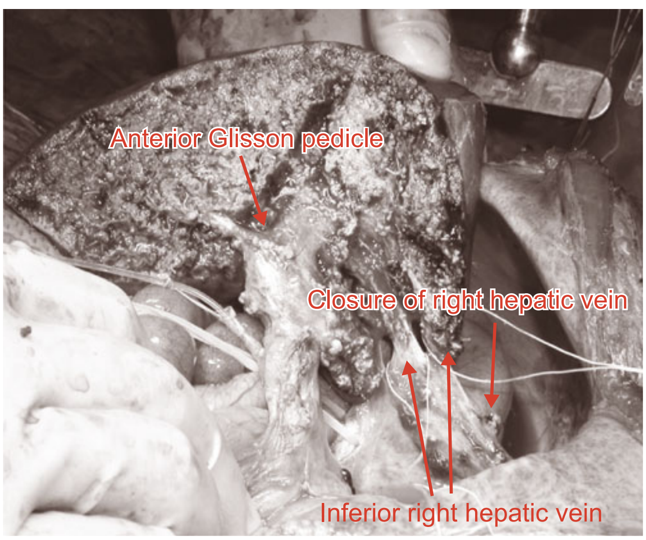

Fig. 62.4 Over-trisegmentectomy (inferior right hepatic vein preserving)

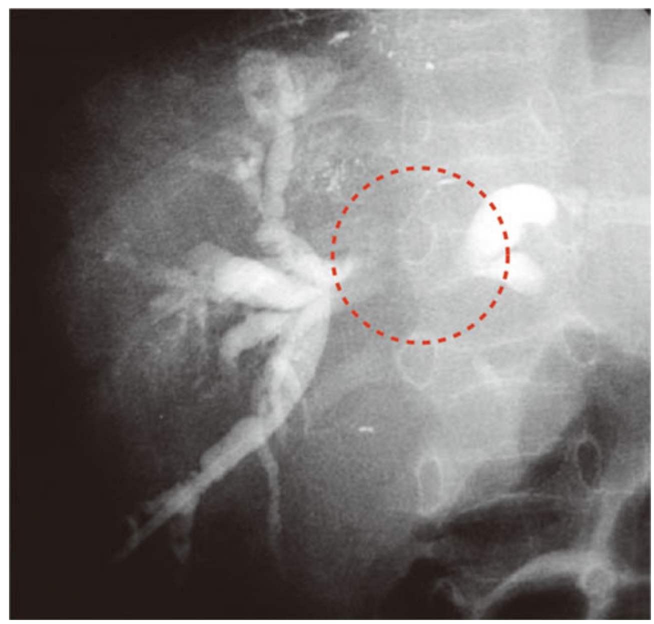

Fig. 62.5 Bile duct stenosis due to tumor invasion

62.4 Manipulation at the Hepatic Hilus (Fig. 62.6)

First, the cholecystectomy is performed. Then, the left branch of the hepatic artery is identified and a tape is applied to it. Before ligation, the middle hepatic artery and right hepatic artery must be checked. This is followed by manipulation of the portal vein. The dorsal side of the left hepatic artery is exposed longitudinally on the left side of the common hepatic duct, to expose the portal vein. The portal vein is freed in the direction toward the hepatic hilus, and the right and left bifurcation point is identified. Multiple branches of the caudate lobe are found immediately behind the bifurcation of portal vein or slightly to the left of it. Under direct vision, these branches are ligated and dissected carefully. Then, the left branch of the portal vein is double-ligated and dissected. The left hepatic duct is found cranial to the left branch of the portal vein and is ligated and dissected at a point several mm from the right and left branches. The arrangement of the bile duct is also often complicated in this area. If not seen clearly, the manipulation of the left hepatic duct may be carried out after transection of the liver.

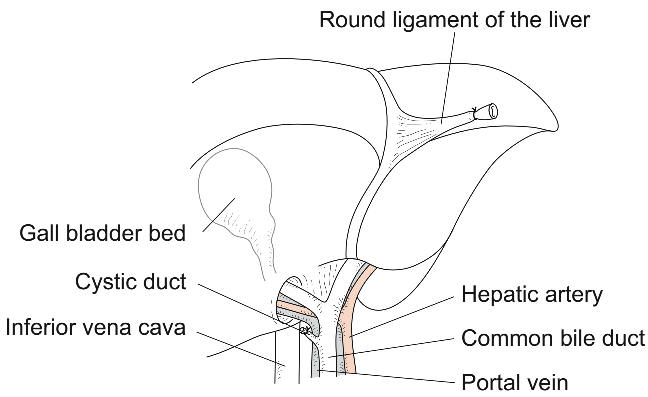

Fig. 62.6 Anatomy of hepatic hilus

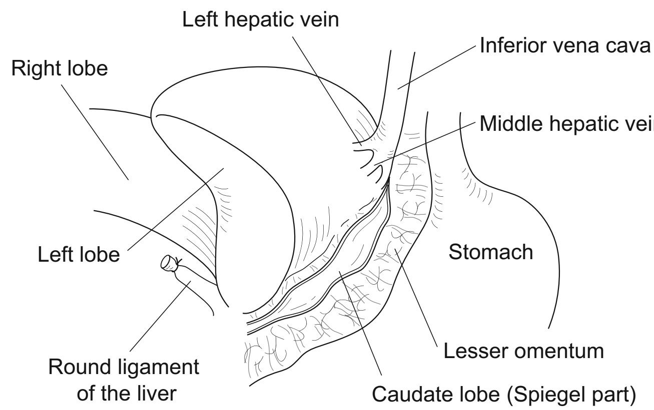

Fig. 62.7 Liver mobilization

Because there is also a variation in which the right anterior branch arises from the left hepatic duct, it is safe to insert a small-diameter tube from the cystic duct to the common bile duct and to identify the origin of the left hepatic duct by cholangiography.

62.5 Liver Mobilization (Fig. 62.7)

At the suprahepatic IVC (the upper part of the liver facing the inferior vena cava), the hepatic vein entry point is freed and identified. The minor omentum is incised and the caudate lobe is exposed (this part is called "Spiegel part"). The caudate lobe is freed from the inferior vena cava as if stripping off the Spiegel part. While carefully ligating and dissecting the short hepatic vein from caudal side of OVC to the cranial side, up to the root of the left hepatic vein and the right edge of the inferior vena cava is exposed.

62.6 Liver Transection

To perform left lobectomy, the hepatic parenchyma requires transection along the middle hepatic vein, while leaving the middle hepatic vein preserved. That is, transection plane cuts through the following three lines, e.g., the liver surface ischemic line (demarcation line), the left edge of the middle hepatic vein, and a vertically line passing through the center of the vena cava. To ensure precise transection, it is necessary to perform ultrasound monitoring of the middle hepatic vein and to bear its status in mind during the operation. An essential point is to detect a thicker venous branch entering the middle hepatic vein at the early stage of transection and

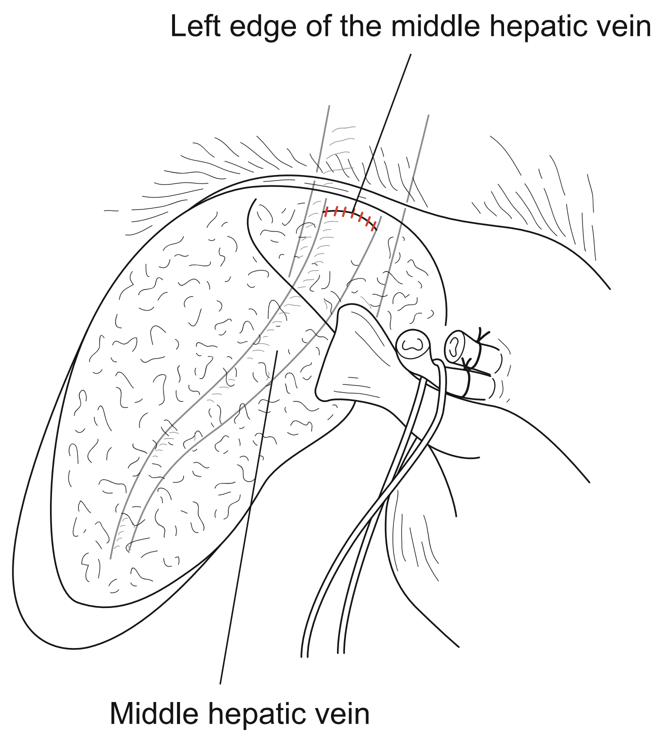

Fig. 62.8 Transection plane (left hepatectomy)

to identify the main trunk of the middle hepatic vein quickly using such a branch as a guide; that is, how to access the middle hepatic vein precisely is an essential point. After left lobectomy, the middle hepatic vein is exposed on the surface of the transected liver (Fig. 62.8). Figure 62.9 shows the transected plane after posterior segment resection. In this case, the right hepatic vein is exposed on the transected plane. Figure 62.10 illustrates the skin incision line (a) and the liver transection line (b) for standard hepatectomy.

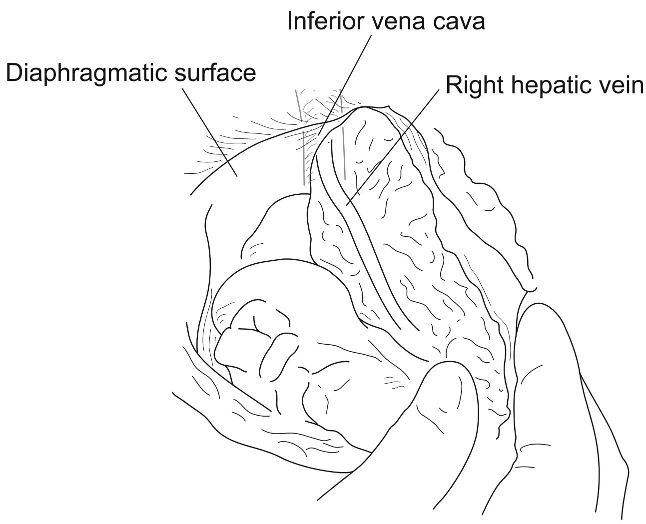

Fig. 62.9 Transection plane (posterior segmentectomy)

62.7 Skills in Hepatectomy: How to Reduce Blood Loss

Bleeding during hepatectomy, which involves transection of a solid organ, is always associated with the risk of massive blood loss. Skills for the prevention of bleeding or minimization of blood loss are important.

The hepatic vein is not always arranged along the segment border, and transection at the segment border does not always allow reduction of bleeding. Among other things, bleeding from the hepatic veins can often not be easily controlled. If the hepatic parenchyma is cut carelessly without the full concentration of the operator (surgeon) during this manipulation, unexpected bleeding from the hepatic vein branches may occur. It needs to be borne in mind that the hepatic vein branches will be exposed after manipulation of the Glissonean sheath code.

Several techniques needed for hepatectomy are described below.

62.8 Glissonean Sheath Code Transection at the Hepatic Hilus

The operative procedure for hepatectomy can be roughly divided into manipulation of vessels of the Glissonean system, manipulation of the hepatic veins, and transection of the hepatic parenchyma. If manipulation of the blood vessels distributed in the areas to be resected is done in an integral manner in the unit of Glissonean sheath at the hepatic hilus, systematized hepatic resection will become possible [1]. Within the liver, we can see the hepatic artery, the portal vein, and the bile duct surrounded by connective tissue called "Glissonean sheath." These vessels/ducts show diverse forms of branching outside the liver, but they always show segmental branching in the liver parenchyma, without distribution to any other segment of the periphery. At the hepatic hilus, they enter the liver parenchyma, assuming the form of three major Glissonean sheaths. Glissonean sheath code transection is a safe and easy way of vascular manipulation.

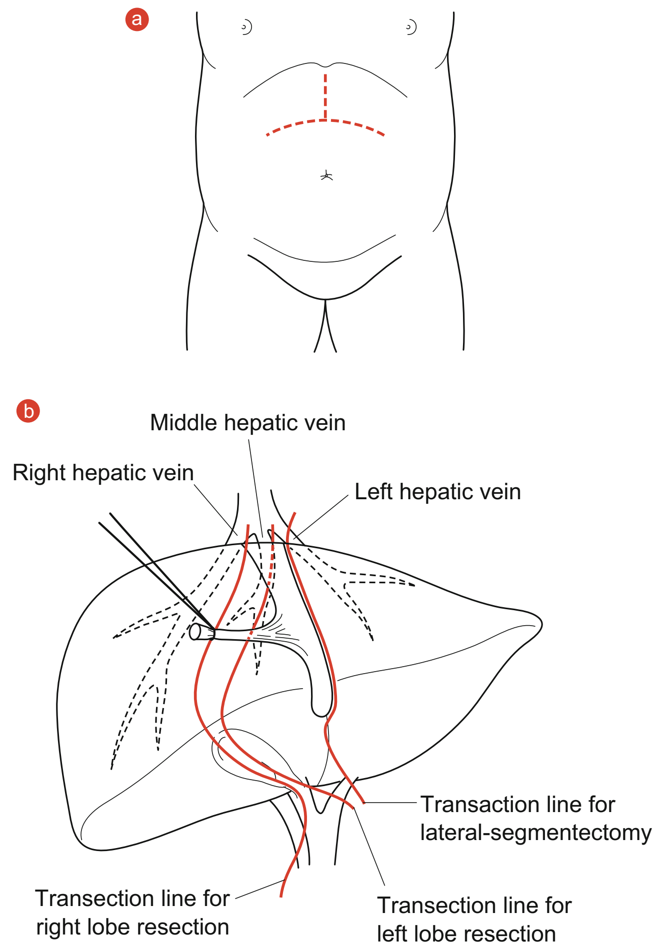

Fig. 62.10 (**a**) Skin incision line, (**b**) liver transection lines

62.9 Hepatic Blood Flow Obstruction

Obstruction of the blood flow to the liver is a major element for reducing the blood loss during hepatectomy. Pringle's maneuver at the hepatic hilus has been most extensively used for blood flow obstruction of the Glissonean system [2]. Cycles of obstruction and release are repeated depending on the liver function status in a given case and bearing in mind the necessity to avoid post-reperfusion injury. A cycle often consists of blood flow obstruction for 10–15 min and reperfusion for 5 min.

62.10 Hanging Maneuver

Since it was first reported by Belghiti et al. [3], the hanging maneuver has been rated as useful for controlling bleeding during liver transection and is used widely. After manipulation of a few short hepatic veins on the caudal side, the anterior plane of the inferior vena cava is freed between the right hepatic and middle hepatic vein at the upper part of the liver. Then, a Teflon tape is passed and raised to transect the liver approximately at points anterior and posterior to the Cantlie line. If the resection surface is held upward, the wall of the hepatic vein branch receiving blood flowing back can be compressed, and the blood flow can be reduced, to enable easy bleeding point identification and hemostasis. Furthermore, since the plane of transection is slightly high relative to the venous pressure, back flow of blood from the inferior vena cava can also be reduced.

62.11 Principles of Liver Transection (Emphasis on Control of Bleeding)

During liver transection, countertraction to a minimum necessary extent is needed for separation of the liver parenchyma. For this purpose, a needle stitch with a thread for traction is usually applied to both sides on the liver cut surface. This is intended to simplify transection and is also aimed at reducing venous bleeding by placing the liver parenchyma higher than the right atrium and inferior vena cava.

In cases where bleeding has started to occur and is difficult to control by simple hemostatic manipulation, it is important to return the plane of transection to the original position. Hemostasis can be achieved by this manipulation in most cases. Bleeding from the hepatic veins tends to pose difficulties if the surgeon attempts to stop it at the point of bleeding directly. However, if manipulation is carried out at a point slightly away from the bleeding point to create a space for compression and to apply sustained compression for a while, hemostasis is often achieved soon and effectively.

Following recent advances in liver transplant technologies, patients with hepatoblastoma have also begun to be treated by liver transplantation [4, 5]. Active debates have been held to determine whether liver transplantation should be preferred over liver resection, which requires a high level of surgical skill, in cases with unresectable tumor [6], or if liver transplantation is to be performed in cases of advanced hepatoblastoma, or whether liver transplant should be selected right away (primary liver transplant) or performed in the event of post-hepatectomy tumor recurrence in the residual tumor (rescue transplant) [7]. In any event, it is a favorable development that the scope of surgical treatments has expanded.

For us pediatric surgeons, it is most important to understand the basic concepts of hepatectomy sufficiently and to apply typical systematized hepatic resection. Although operative procedures requiring high skills, such as atypical hepatectomy and liver transplantation, are also available as advanced-level alternatives, surgeons having a basic skill for systematized hepatic resection precisely can often complete perfect resection by standard systematized resection even for tumors that initially appear difficult to resect.

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Sacrococcygeal Teratoma

63

Akihiro Yoneda

Abstract

Sacrococcygeal teratoma (SCT) is the most common germ cell tumor in neonates. Because of the recent progress in prenatal diagnosis, the number of prenatally diagnosed patients with SCT is increasing. These patients frequently have a huge tumor, which results in high-output heart failure, consumption coagulopathy, and respiratory distress. Thus, these patients are sometimes forced to undergo high-risk surgery. Older patients with SCT have an increased chance of malignancy, which must be treated not only by surgery but also with chemotherapy. The author herein describes the operative procedures for SCT and the pre- and postsurgical management of SCT patients.

Keywords

Sacrococcygeal teratoma • Management • Neonate • Surgery • Recurrence

63.1 Preoperative Management

63.1.1 Special Consideration Based on Age

63.1.1.1 Neonates

As most of the neonatal patients with huge sacrococcygeal teratoma are treated while in a severe general condition, careful preoperative care is necessary [1]. Expected cesarean section is usually selected because of the high risk for tumor rupture during vaginal delivery. The neonatal patient often requires an emergent operation soon after delivery under poor general conditions such as high-output heart failure and consumption coagulopathy. Thus, close communication is necessary between the pediatric surgeons and doctors in other departments, such as obstetrics, neonatology, and anesthesiology. Although the patients should, when possible, undergo surgery after stabilization, it is quite hard to decide the optimal timing of surgery. It is important to prepare for the emergent operation at the optimal timing. The patients with pancytopenia or DIC should be preoperatively treated with RBC, FFP, or platelet transfusion. The monitoring of arterial blood pressure and central venous pressure are necessary. Proper venous access for rapid transfusion should be secured at the upper extremities. The patient often requires catecholamine for cardiac failure.

63.1.1.2 Infants

Operations in infantile cases are usually performed with the patient in a stable condition. The older the patients are, the higher the possibility of malignancy. Thus, measurement of the serum AFP level and the assessment of distant metastases are necessary. The patients with an unresectable tumor or metastasis should undergo a biopsy followed by neoadjuvant chemotherapy.

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63.1.2 Preoperative Examination

63.1.2.1 Radiological Examination

For all patients: chest and abdominal X-ray, ultrasonography, enhanced CT scan Mandatory: MRI, barium enema, VCG, intravenous urography For prenatally diagnosed cases: prenatal ultrasonography and prenatal MRI For patients with malignant tumors: enhanced CT scan for the liver, lung, and distant lymph nodes metastasis.

Cardiac ultrasonography is necessary for checking for heart failure in cases of huge sacrococcygeal teratoma.

63.1.2.2 Neurological Assessment

Urinary and bowel function, motor disturbance of the lower extremities.

63.1.2.3 Blood Analysis

RBC, WBC, platelet count, hemostatic function, AFP (the normal AFP level is usually higher in neonates or younger infants).

63.2 Operations

63.2.1 Initial Laparotomy

If ligation of the feeding arteries and drainage veins is required before tumor resection in the patients with cardiac failure due to a huge tumor, an initial laparotomy should be indicated. An initial laparotomy is also indicated in the patients with a large retroperitoneal tumor corresponding to Altman type III or IV.

With the patients in a supine position, an infraumbilical transverse incision is made (Fig. 63.1a). The aortic bifurcation is exposed and the feeding arteries for the tumor are identified. The median sacral artery is the most likely candidate artery, but branches from the iliac arteries can sometimes be feeders (Fig. 63.2). As the patients are often in a high-risk condition due to coagulopathy and high-output cardiac failure, it is important that the dissection should be meticulously carried out to avoid massive bleeding. The

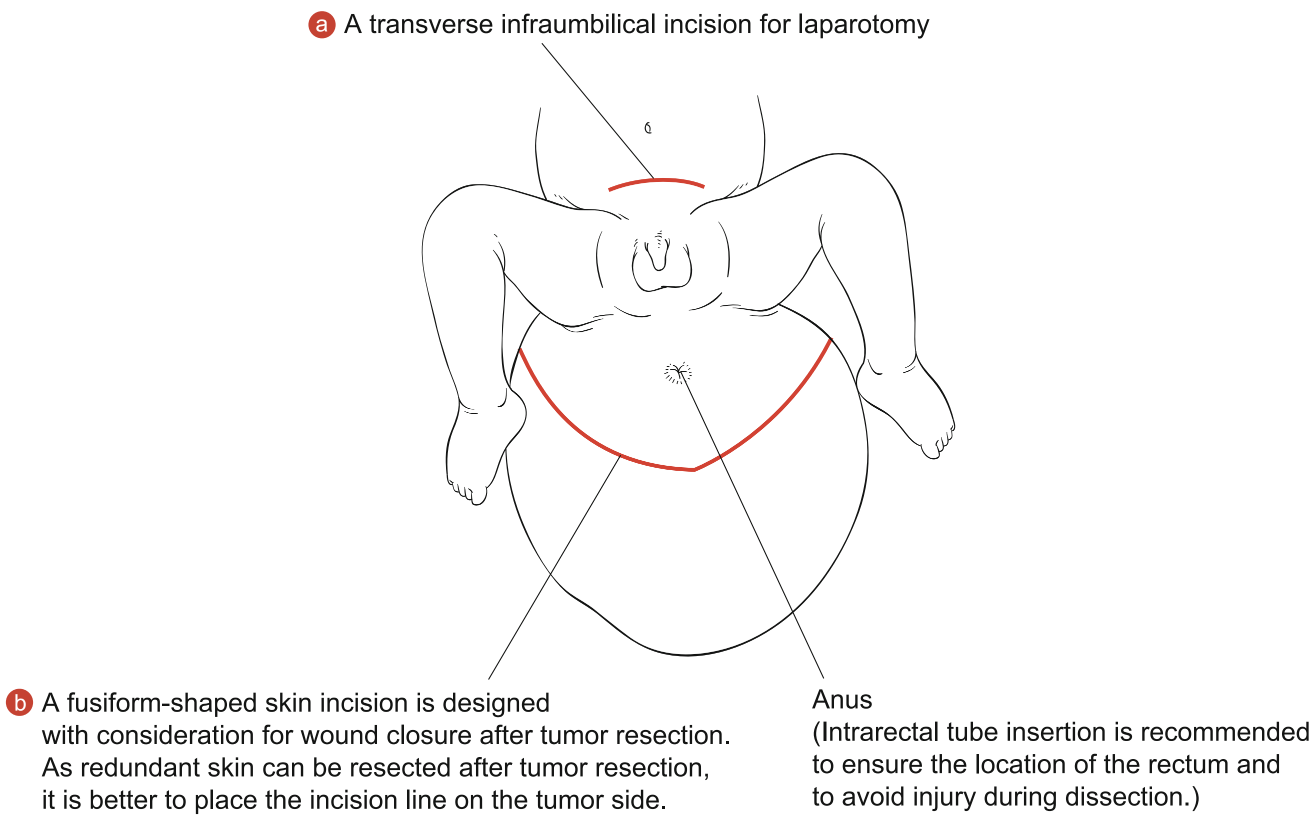

Fig. 63.1 Skin incision

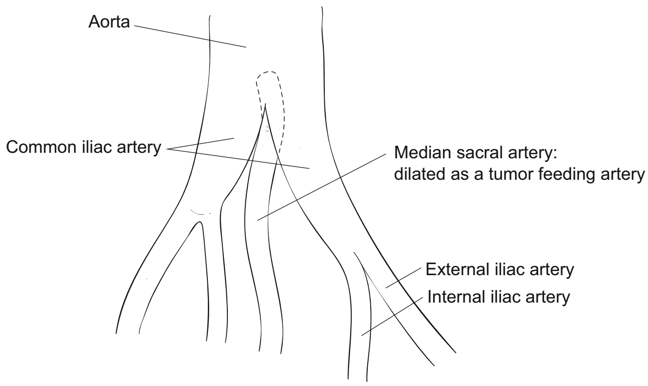

Fig. 63.2 The ligation of a tumor-feeding artery and a tumor drainage vein

Fig. 63.3 The supine position in a neonatal patient with a huge SCT. The lower abdomen and both lower extremities are totally sterilized

patient's general condition should become more stable once the ligation of the feeding arteries and drainage veins is completed.

Moreover, tumor dissection from the abdominal cavity must be performed in patients with Altman type III or IV tumors. During these dissections, injury of the ureter, pelvic plexus, spermatic cord, and ovary should be avoided to the extent that is possible.

Laparoscopic surgery may be indicated for the patients that are in a stable condition.

After the intra-abdominal procedures are completed, the abdominal cavity is temporarily closed.

63.2.2 Tumor Dissection

The patient's position is decided by the location and type of the tumor. The jackknife position is generally suitable for Altman type I or II tumors. In the prenatally diagnosed cases, the author prefers the supine position, because it is easier to open the abdomen or to undergo intraoperative resuscitation without a position change.

The lower abdomen and both lower extremities are totally sterilized (Fig. 63.3). Urethral catheterization and intrarectal tube insertion are recommended to ensure the location of the urethra and the rectum and to avoid injury during dissection.

A fusiform-shaped skin incision is designed with consideration for wound closure after tumor resection. As redundant skin can be resected after tumor resection, it is better to place the incision line on the tumor side. The incision line should be kept at a distance of at least 2 cm from the anus, even in neonatal patients, to avoid wound contamination after resection (Fig. 63.1b).

For small-sized tumors, a midline incision from the coccygeal bone to the perineum, with the patient in a jackknife position, is superior for cosmetic reasons (Fig. 63.4a). In this case, a similar approach to posterior sagittal anorectoplasty can be performed. For large-sized tumors, a transverse incision line is advantageous because it allows better visualization during the tumor dissection under the jackknife position (Fig. 63.4b). In this case, a chevron incision is suitable. The apex of the incision is placed at the coccygeal bone.

In cases where a cystic component accounts for a large part of the tumor volume, the tumor should only be dissected through a perineal approach. The adequate aspiration of intracystic fluid makes dissection easier.

63.2.3 Tumor Resection

In teratomas, it is generally easy to dissect the tumor along the lines of the tumor capsule. Thus it is essential to identify the tumor capsule at the start of the operation. Maximum attention should be paid to rectum and the related muscles during the dissection. In many cases it will be stretched and thinned down by a huge tumor. It is recommended that a tube be placed in the rectum to ensure its location. If the rectum is accidentally injured, the decision to perform colostomy should be made quickly in order to avoid prolonged surgery, especially in high-risk neonatal cases. Other important structures, such as the gluteal muscles, the ischiatic nerve, and the urethra, should be carefully reserved. Sometimes energy devices, such as the LigaSure, the Powerstar, and the LCC, are useful to shorten the duration of the operation.

After tumor dissection, the tumor is finally connected to the body by the coccygeal bone. It is essential to resect the coccygeal bone in order to avoid tumor recurrence, especially in neonatal cases. Prior to the resection, the tumor-feeding arteries and the drainage veins should be carefully ligated and dissected, if the initial abdominal approach has not been used. After the proper dissection of the vessels, the coccygeal bone can easily be dissected by electrocautery (Fig. 63.5).

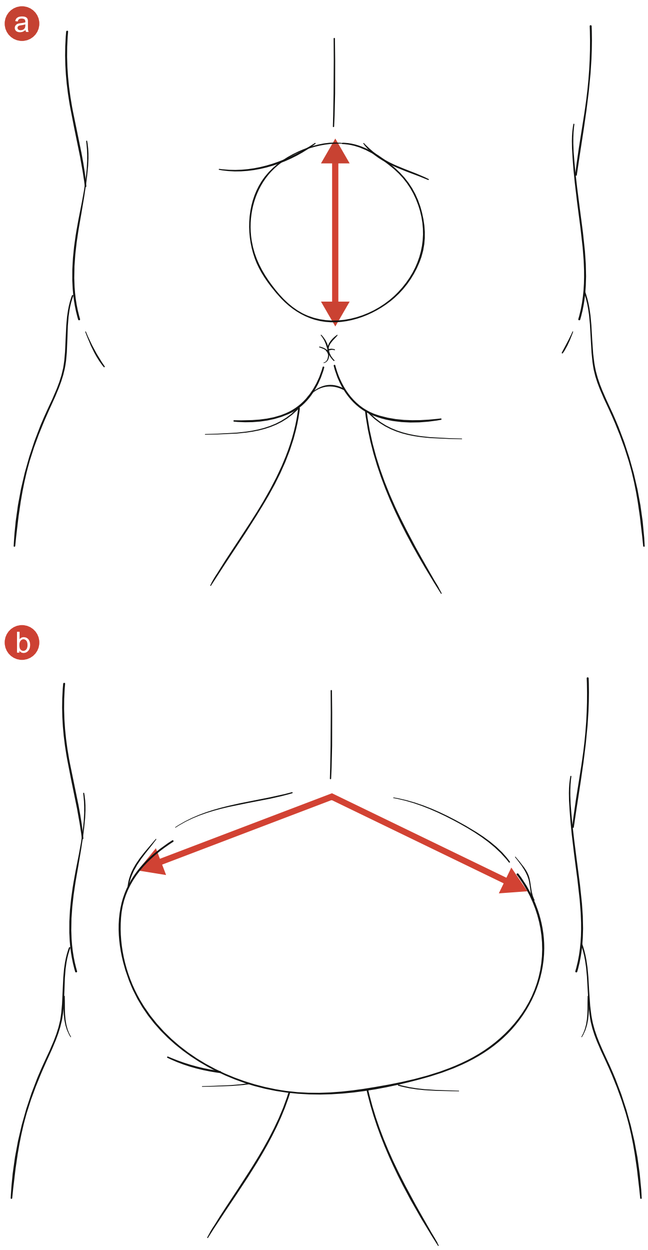

Fig. 63.4 The jackknife position. **a** For small-sized tumors, a midline incision from the coccygeal bone to the perineum under the jackknife position is superior for cosmetic reasons. **b** For large-sized tumors, a transverse incision line is advantageous because it allows better visualization during the tumor dissection under the jackknife position

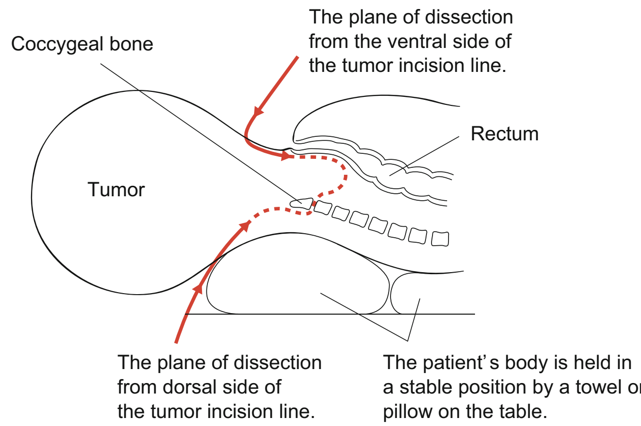

Fig. 63.5 Tumor dissection (sagittal view)

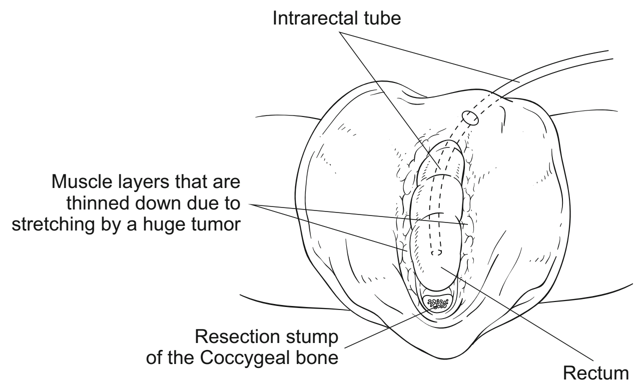

Fig. 63.6 Tumor stump

Meticulous hemostasis should then be achieved by electrocautery or by the ligation of small vessels. A tissue sealing sheet is sometimes effective for treating uncontrollable bleeding from the tumor bed. It is recommended that the muscles that surround the rectum and anus be reconstructed properly; however, it is sometimes difficult to locate muscle layers that are thinned down due to stretching by a huge tumor. A nerve stimulator is sometimes helpful to identify the muscle layers (Fig. 63.6).

The subcutaneous layers are closed by absorbable sutures. If a large dead space has to be left after the resection of a huge tumor, then a closed surgical drain should be placed to allow continuous low-pressure drainage. Special attention is necessary to avoid contamination by soiling when dressing the wound (Fig. 63.7).

After finishing the wound closure for the sacrococcygeal lesion, the wound in abdomen is then closed in the usual manner.

63.3 Postoperative Management

In neonatal cases, the patient should undergo intensive postoperative care, such as catecholamine for heart failure, transfusion for massive hemorrhaging, and artificial respiration for respiratory assistance under close supervision. Frequent ultrasonography examinations are necessary to detect brain hemorrhage and monitor the circulatory status.

As dysuria is frequently observed after the resection, special attention should be paid to urination after the decannulation of the urinary catheter. Total parenteral nutrition is sometimes useful to protect the wound from soiling.

Fig. 63.7 Wound closure

A neurological assessment is necessary after the patient's general condition improves to check for lower limb movement, urinary function, and anorectal function.

The late recurrence of sacrococcygeal teratoma has been reported in from 2 to 35 % of neonatal benign cases [2]. A malignant component is observed in most of the recurrent tumors at the age of approximately 1 year. In most cases the recurrence is not a result of either an immature histology or incomplete resection. Thus, the patient should be carefully examined for malignant teratoma over a follow-up period of at 2–3 years after the resection of mature or immature teratoma. Aside from radiological evaluation, the measurement of the serum level of AFP is useful for the follow-up. Malignant teratoma is sensitive to chemotherapy, thus most patients can be successfully treated if the recurrence is detected early.

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Part VIII

Abdominal Organ Transplantation

64 Donor Operation in Living Donor Liver Transplantation

Yukihiro Inomata and Shintaro Hayashida

Abstract

First step for donor surgery in living donor liver transplantation (LDLT) is the precise evaluation of the anatomy of vessels (portal vein, hepatic artery, and hepatic veins) and the estimation of the liver volume by three-dimensional CT (3D-CT) with the aid of simulation software. Anatomy of the bile duct is evaluated by preoperative DIC-CT or MRCP and intraoperative cholangiography.

Laparotomy of donor surgery tends to be smaller than before. There are four kinds of segmental graft of the donor liver. For pediatric recipients, left lateral segment is most common. In small babies, reduced left lateral segment or monosegment (S2 or S3) can be used. Dissection of the vessels at the hepatic hilum is followed by the parenchymal transection.

Cavitron ultrasonic aspirator (CUSA) and coagulation tool are used for parenchymal transection. Intraoperative US study is adequately used for the real-time confirmation of the vascular anatomy. The bile duct is transected sharply without burning for hemostasis. To maintain the blood supply, connective tissue around the bile duct is minimally dissected. Vascular connection to the graft liver should be kept to the very end of the harvesting. The graft liver is perfused with cold preservation solution via the portal vein.

As for the complications of donor surgery, biliary leakage and visceral adhesion are most common. Rare but serious ones like deep vein thrombosis or portal vein thrombosis should be paid attention.

Keywords

Living donor • Liver transplantation • Hepatectomy

64.1 Preoperative Management

Evaluation of the donor liver with imaging study is essential for living donor liver transplantation (LDLT). In these days, three-dimensional (3D) computed tomography (CT) is commonly used. This study allows the evaluation of the anatomy of vessels (portal vein, hepatic artery, and hepatic veins) and the estimation of the liver volume. CT with drip infusion cholangiography is also possible to evaluate the biliary system. This anatomy is usually done with the intraoperative cholangiography, but preoperative CT cholangiography can reveal the 3D configuration of the biliary system and may be

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Fig. 64.1 Instruments for parenchymal transection. *Upper*: Coagulation tip for soft coagulation apparatus (VIO®). Irrigation tip is attached on the tip of the coagulator to avoid the burning deposit. *Lower*: CUSA (Cavitron ultrasonic aspirator) by the operator and the coagulation tip held by the assistant are used for minimal bleeding in the parenchymal transection

easier in understanding. Magnetic resonance cholangiography (MRC), although it is less clear than CT, can also show the branching of bile ducts without the risk of hypersensitivity of the contrast dye.

Various kinds of simulation software are available for the estimation of the volume of the liver based on the data of CT. This technology has made the accurate estimation of the volume of the targeted area, like an area perfusing by or draining with a specified vessel. With this technique, volume of the graft liver as well as the remnant liver can be estimated. Preparation of ultrasonography is also necessary for the safe resection in the donor surgery to know where we are on the way of the parenchymal transection.

As the tool of the transection, Cavitron ultrasonic aspirator (CUSA) is commonly used, but this procedure might be modified according to the favorite in each institution. We usually use the soft coagulation system (VIO system®) as an energy device, adding the drip infusion system of saline for prevention of burning (Fig. 64.1). Two systems of the suction at the operation field should be prepared.

Storage of the autologous blood in advance for the transfusion in the operation is now rarely done because of the relatively small amount of blood loss.

64.2 In the Practical Scenes

Graft lobes for LDLT are shown in the figure (Fig. 64.2).

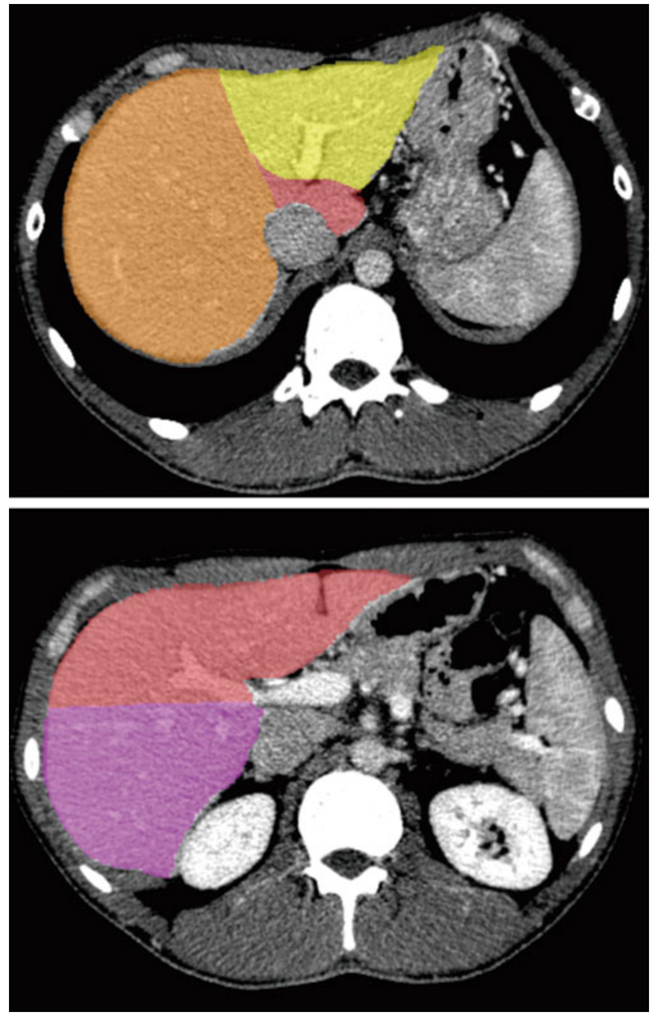


Fig. 64.2 Segments of the liver used for living donor liver transplantation. *Upper*: *yellow*, whole left lobe; *orange*, right lobe without middle hepatic vein; *yellow* + *red*, left lobe with caudate lobe. In the case of LDLT for infants and small children, a part of left lobe, called left lateral segment, is used. *Lower*: *purple*, posterior segment of right lobe

64.2.1 Laparotomy

The so-called Benz incision has been usually used, but midline incision without transverse extension is also available for the left side lobes. In the case of right lobectomy, turned-L incision, which includes long transverse incision to the right side, is commonly used (Fig. 64.3).

The wound retractor is used for effective visualization of the field. We use Kent® retractor (Fig. 64.4).

Followings are the descriptions of the important points for each lobe resection.

64.2.2 Left Lateral Segmentectomy

The order of the regular procedures in this lobectomy is cutting of the fixing ligaments of the liver, transection of

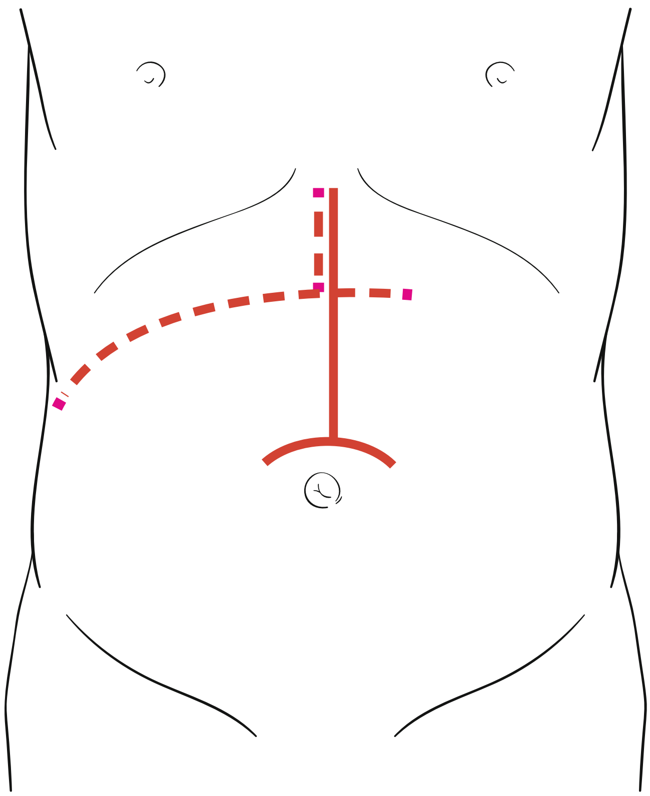
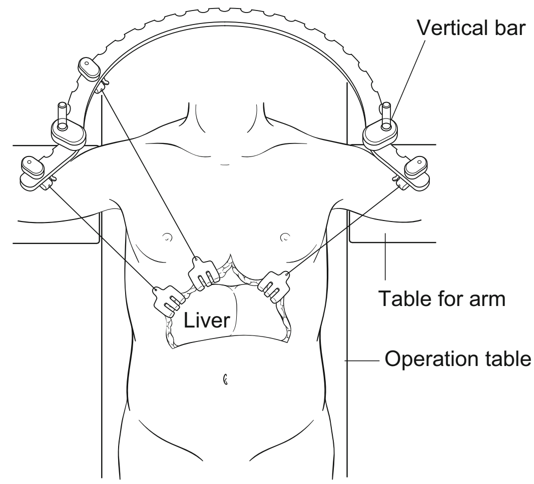


Fig. 64.3 Skin incision. *Solid line*: for left lobectomy. In the case of skinny donor or for left lateral segmentectomy, transverse part is not necessary. *Dotted line*: for right lobectomy. Inverted L-figure incision can be used



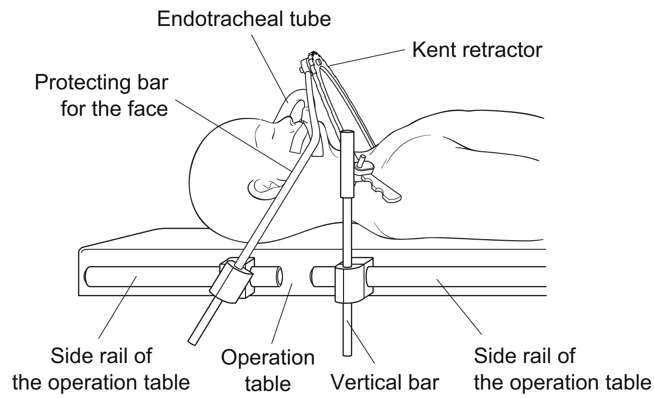


Fig. 64.4 Wound retractor. A Kent retractor is used. A pair of the vertical bars is fixed to the operation table at the level of a little cranial side to the shoulder of the donor. The transverse bar is fixed as low as possible, but the position of the endotracheal tube should be paid attention

the Arantius duct, transection of the lesser omentum, identification and isolation of the left and middle hepatic artery, identification of the left hepatic duct, intrahepatic cholangiography and judgment of the transection site of the bile duct, start of the parenchymal transection, transection of the bile duct, encircling of the left portal branch, completion of the parenchymal transection, dissection and cleaning of each vessel, heparinization, transection of the hepatic artery and of the portal vein, transection of the hepatic vein, removal of the graft liver, closure of the vascular stumps, and closure of the bile duct stump.

64.2.2.1 Dissection Around the Liver

After laparotomy, the left lobe is mobilized first with transection of left triangular ligament. Thick sponge is put on the spleen for protection, and the spleen is pushed downward by malleable. The 4 × 4 is pushed under the left triangular and coronary ligament. The operator holds and pulls down the left lateral segment downward, and the ligaments are cut with electrocautery on the sponge pushed in. After resection of the coronary and triangular ligament, the left lateral segment is reflected right side, and the insertion of the Arantius duct is isolated and transected. The lesser omentum is cut along the Arantius duct to the left side of the hepatoduodenal ligament. If there is an aberrant vessels running from the lesser curvature of the stomach to the liver, this should be kept uninjured. Branches of the portal vein to the caudate segment are ligated and transected. For identification of these portal branches, the caudate lobe is pushed to backward with malleable.

64.2.2.2 Dissection at the Porta Hepatis

To expose the anatomy of the vessels at the hepatic port, a mass of sponge is inserted to the right lateral side of the liver. The assistant or a piece of the retractor holds the anterior margin of the liver to expose the hilum. In case of left lateral segmentectomy, the gallbladder can be kept unresected. To find the hepatic artery, the peritoneum is opened and the adipose tissue is dissected at the midportion between the hepatic hilum and duodenum. If a wall of the artery is found, dissection is proceeded with the guide of the preoperative imaging study. Typical position of each vessel is shown in Fig. 64.5. The artery is fine and fragile and

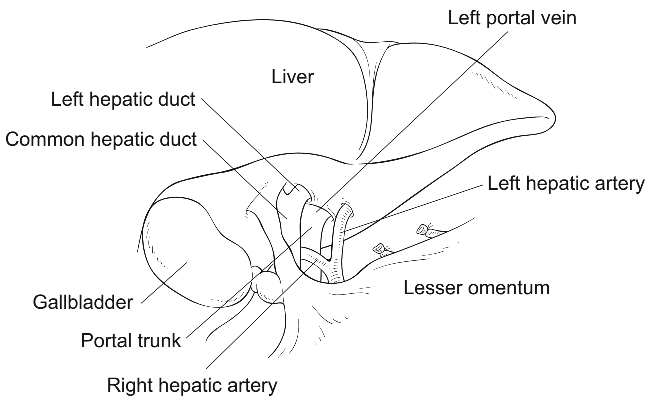


Fig. 64.5 Location of vessels at the hepatic hilum

vulnerable to physical injury like strong holding, compression with rubber band, or heat burn by the electrocautery and should be treated very gently during the dissection. For prevention of burn, we use the flushing of water by the assistant just after burn of the surrounding tissue by electrocautery. The bile duct locates on the wall of the left portal trunk.

64.2.2.3 Bile Duct Transection

For the accurate selection of the suitable transection point of the bile duct, intraoperative cholangiography (IC) is done. If the gallbladder is kept unresected, puncture of the choledochus with 24G intravenous catheter is used for infusion of contrast dye. There are two ways for IC: one with one-shot irradiation with marking of a small clip on the duct and the other fluoroscopy with C-arm. The timing of IC depends on the favorite of each institution, and we do it on the way of parenchymal transection after the transection reaches to the hepatic hilum. The suitable site of the bile duct is identified with IC, and the bile duct is transected very sharply with scissors. At first, small incision at the duct is made, and fine probe is inserted into the bile duct for evaluation of the branching in all the direction, and then the transection is then completed (Fig. 64.6). There is an arterial bleeding from the wall of the bile duct. This should be controlled with suturing with the 6-0 absorbable stitches and not with coagulation with cautery.

64.2.2.4 Parenchymal Transection

Transection line is marked with electrocautery on the surface of the liver just right side to the falciform ligament. A pair of stay sutures with 3-0 Prolene is placed at the starting point of transection at the anterior margin of the liver, and these are used for pulling and holding. The operator used the CUSA and the assistant used the energy devices for coagulation like VIO.

After transection of the bile duct, the transection groove is made a little open, and this makes the transection procedure easier after that. The portal vein is encircled easily and

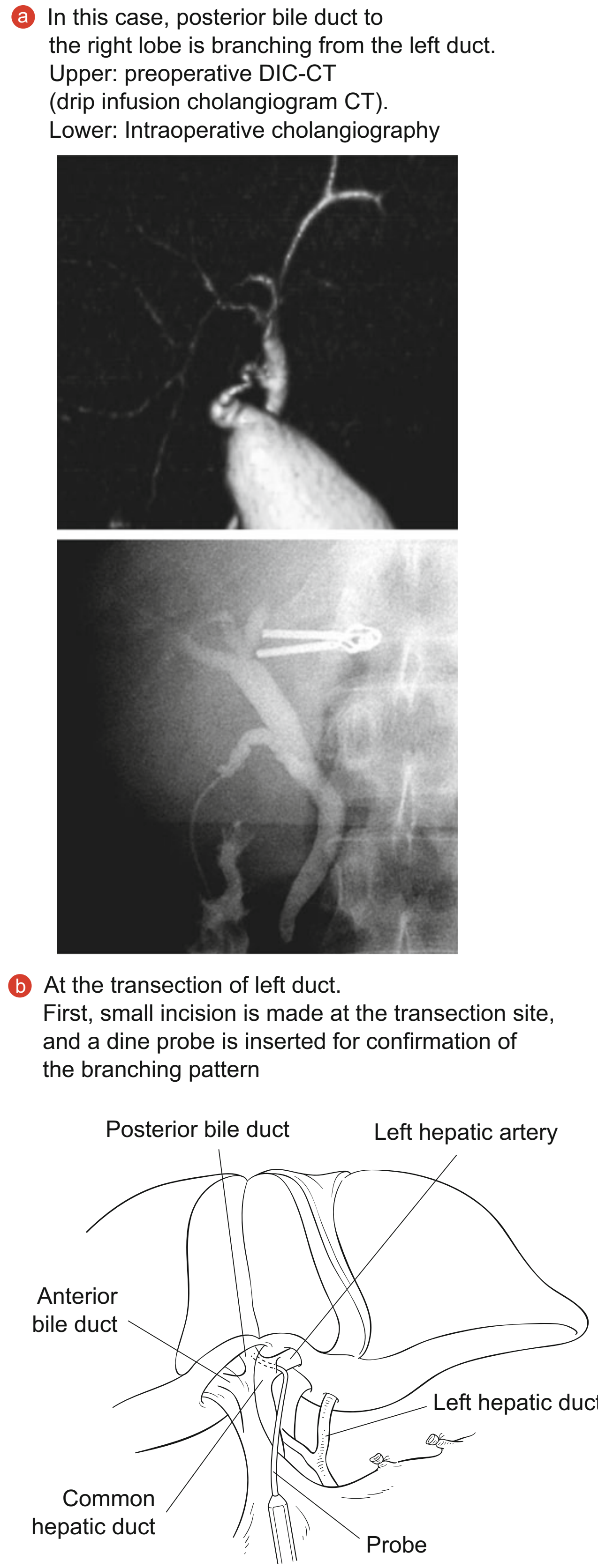


Fig. 64.6 Recognition of the anatomy of the bile duct for transection at the suitable site. (**a**) In this case, the posterior bile duct to the right lobe is branching from the left duct. *Upper*: preoperative DIC-CT (drip infusion cholangiography CT). *Lower*: intraoperative cholangiography. (**b**) At the transection of left duct. First, small incision is made at the transection site, and a dine probe is inserted for confirmation of the branching pattern

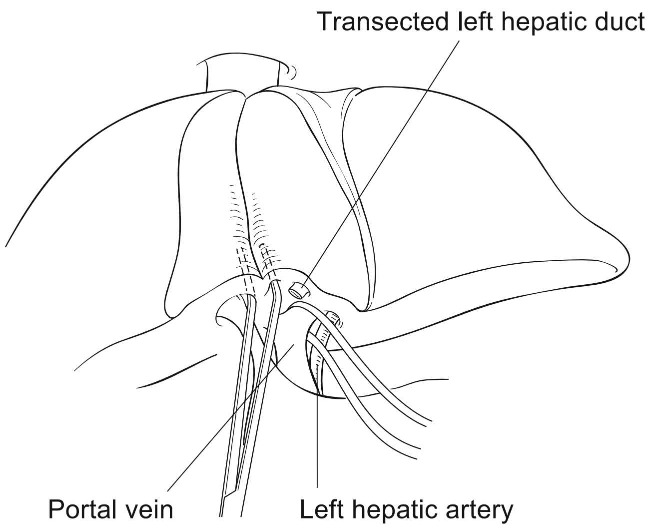


Fig. 64.7 Parenchymal transection after bile duct transection. Angled DeBakey forceps is inserted under the liver and pulled forward so that the transection line is pulled up and clearly indicated for direction

safely after transection of the bile duct. A tip of the curved DeBakey forceps is inserted at the upper margin of the left portal trunk into the groove between the caudate and the lateral segment, and it is pulled up to reveal the transection line. The hilar plate is first transected with the aid of this procedure, and then the left lateral segment is separated from the caudate lobe (Fig. 64.7). After reaching to the left hepatic vein (LHV), residual parenchyma on the backside of the LHV is finally cleaned off using CUSA with reflection of the left lateral segment to the right side.

Before harvesting of the graft, final dissection and cleaning of the hepatic artery and portal vein is done at the hepatic hilum. There are sometimes multiple hepatic veins perfusing the lateral segment. The wall of the artery at the transection point is completely cleaned with dissection of the surrounding nerve tissue. With this complete cleaning, the artery can be prepared as long as possible.

64.2.2.5 Vascular Transection and Taking Out of the Liver Graft

The operator asks to the anesthesiologist the heparinization. We usually use one-shot intravenous injection of 1000 units of heparin. After waiting 2 min, the graft is harvested. The order of the transection of the vessels is as follows: (1) artery, (2) portal vein, and (3) hepatic vein. The artery is doubly ligated with 4-0 silk sutures only on the proximal side and then sharply transected. If there are multiple arteries, the finer vessel is first transected and the backflow from the other arterial supply is observed. This information can be used for selection of the hepatic artery that should be reconstructed in the recipient side. The portal vein is catheterized for perfusate. This perfusion is done in situ or ex situ. In case of in situ perfusion, left portal trunk is partially cut after clamping and the catheter is inserted via this hole and then the vein is completely cut (Fig. 64.8). I prefer the tube for blood transfusion. After clamping and transection of LHV, the perfusion through the portal vein is started in situ. The volume of the perfusate is three times of the possible volume of the graft. After the perfusion, the graft is taken out and moved to the basin with cold preserving solution.

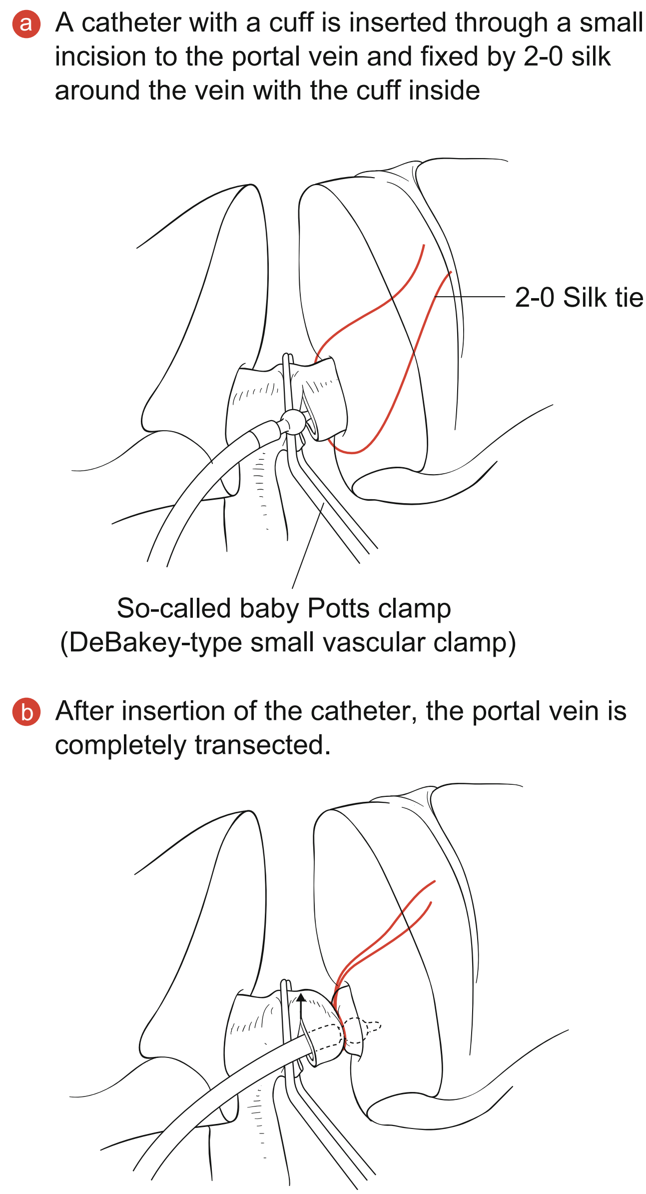


Fig. 64.8 Transection of the portal vein, with insertion of perfusion catheter in situ in the donor. The perfusion from the portal vein can be done also ex situ after harvest of the graft liver. (**a**) A catheter with a cuff is inserted through a small incision to the portal vein and fixed by 2-0 silk around the vein with the cuff inside. (**b**) After insertion of the catheter, the portal vein is completely transected

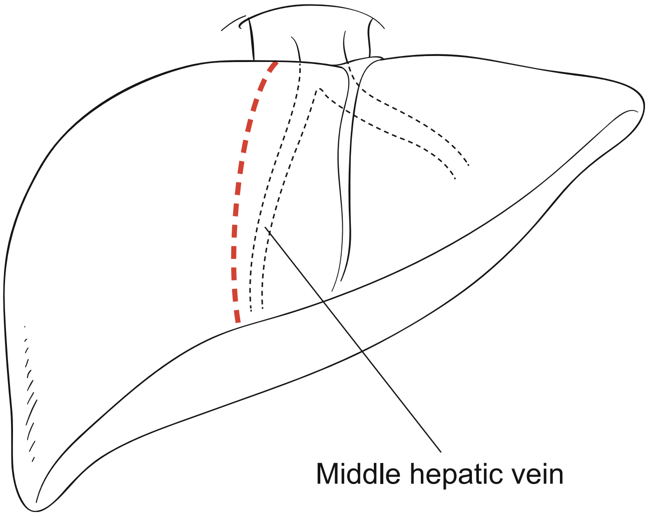


Fig. 64.9 Transection line of the parenchyma in the case of left lobectomy (left lobe with middle hepatic vein) (*1*). With US guide, location of the middle hepatic vein (MHV) is traced. The transection line (*dotted line*) is drawn by an electrocautery, 1 cm right to the MHV. At the anterior margin of the liver, the line of MHV and the transection line are reaching to the same point, which is usually at the notch at the gallbladder bed

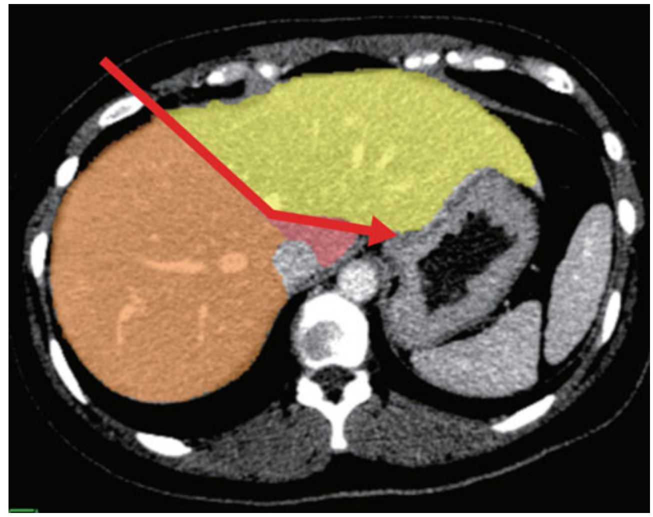


Fig. 64.10 The transection line of the parenchyma in the case of left lobectomy (*2*). The groove made by the transection is turning to the left after traversing the MHV

Stump of LHV is closed with running suture of 5-0 Prolene, and that of portal vein is closed with 6-0 Prolene. The stump of the bile duct is closed with 6-0 absorbable sutures. If there is a necessity in the recipient side, ovarian vein (in case of female donor) or inferior mesenteric vein is harvested as the vascular graft.

64.3 Left Lobectomy Without Caudate Lobe Resection

Cholecystectomy is done and a tube (usually 5 Fr) is inserted through the cystic duct for IC. Intraoperative ultrasonography (US) is used for detection of the line of middle hepatic vein (MHV). The transection line is about 1 cm right to the line of MHV (Fig. 64.9). Transection of bile duct, encircling of portal vein, and transection of the parenchyma is similar to that of left lateral segmentectomy. During the course of the parenchymal transection, the distal part of the MHV is ligated and transected. The cutting line of the parenchyma is arranged to scoop up the left lobe with MHV. This means that the cutting line will be more coronal (Fig. 64.10). The veins draining from anterior segment of the right lobe is transected along the MHV.

64.4 Left Lobectomy with Caudate Lobe Resection

In this procedure, the so-called hanging maneuver is applied. A hanging tape (we use a 6-mm Penrose drainage tube) should be passed through the space between the inferior vena cava (IVC) and the liver. This comes between the stumps of MHV and right hepatic vein (RHV) at the cranial side. For this purpose, special forceps to dissect the anterior surface of the inferior vena cava is used (Fig. 64.11). On the ventro-left surface of the IVC, there is a space that has no running of the short hepatic vein. This space is used for the pass of the tape.

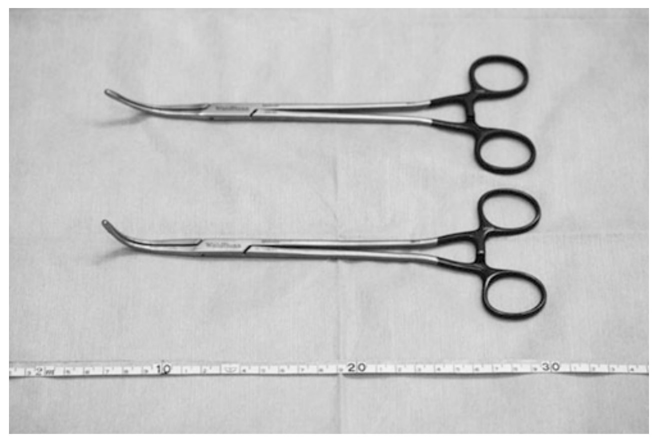


Fig. 64.11 Dissector used for passing of a tape in the hanging maneuver. A right angle and a blunt angle dissector are used for dissection through the avascular space between the IVC and the liver. This kind of dissector is specially made for this purpose, and the tip of them is very blunt and smooth

The transection line of the parenchyma in this type of lobectomy is very straight along the Cantlie line. After encircling of the left portal trunk, the tape for hanging is relocated to the upper side of the portal trunk. Hanging of this tape makes the parenchymal transection easier and more accurate (Fig. 64.12). After completion of the parenchymal transection, dissection between the IVC and the liver is

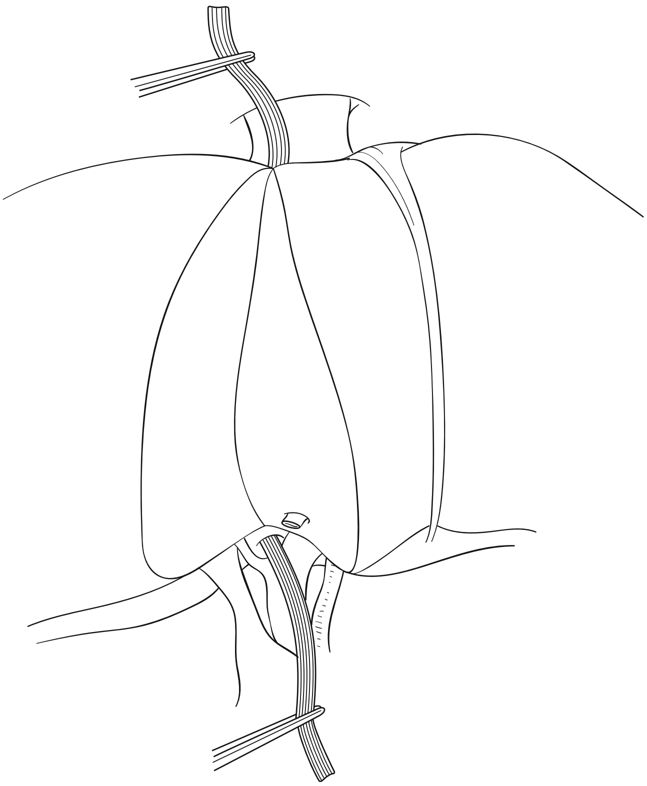


Fig. 64.12 Transection of the left lobe with caudate lobe. A 6-mm Penrose drain is passed between the right and the middle hepatic vein at the cranial side, to the space between the left and right portal trunk at the caudal side. Hanging of this drain tube can show the direction of the transection and make the operation field shallow

done. If there are short hepatic veins with the diameter 5 mm or thicker, they should be kept for possible reconstruction in recipient operation.

64.5 Right Lobectomy

Hanging maneuver is also applied. First, the right triangular ligament and coronal ligament are transected. Right adrenal gland is sometimes firmly attached to the liver, and this should be separated sharply using the electrocautery. If there is bleeding of from veins or the gland, hemostasis using the 6-0 stitches is done. Small short hepatic veins are ligated and transected, but if the diameter is 5 mm or larger, they should be kept for the possible reconstruction in the recipient side. There is an IVC ligament just on the right side of the RHV. There is sometimes small vessel included in the ligament, so the ligament is clamped and then transected. The stump of the ligament is closed with running suture. The space left side of the RHV is gently dissected and 6-mm Penrose drainage tube for hanging is passed through this space. If there are hepatic vein(s) that should be kept, this hanging tube should be passed also left to the vein(s).

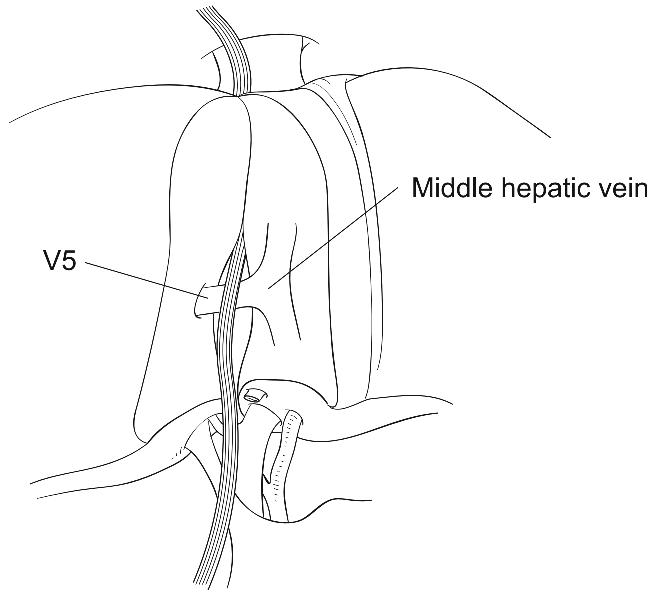


Fig. 64.13 Right lobectomy with the aid of hanging maneuver. There are several veins draining from the anterior sector of the right lobe to the MHV. If these are preserved for the possible reconstruction in the recipient operation, the hanging tape is relocated to keep these veins

After this procedure, cholecystectomy, dissection of the hepatic hilum, and IC follow. Unlike to the left lobectomy, right portal trunk is encircled before the transection of the parenchyma. The right hepatic artery usually passes under the common hepatic duct. Before the parenchymal transection, the hepatic artery and the portal branch to the right lobe are both temporarily clamped with appropriate vascular clamps, and the discoloration on the surface of the liver is confirmed as the possible graft, and the demarcation line is marked with electrocautery.

64.5.1 Parenchymal Transection

The demarcation line usually winds its way. So, in the parenchymal transection, the real line is drawn 1 cm right to the running line of the MHV. Usually, this line fits with the demarcation line showed with the vascular clamping. In case of this type of right lobectomy without MHV, drainage veins from the anterior sector of the right lobe should be considered for preservation or abandon for reconstruction in the recipient operation. Volume estimation of the draining area for each responsible vein should be measured using the simulation software before the surgery. If the estimation is not available, the diameter larger than 5 mm can be used as the indicator for preservation. If the vein is preserved, relocation of the hanging tape should be done in the transection (Fig. 64.13).

In situ cannulation to the right portal vein is usually difficult because it is too short. Ex situ cannulation and perfusion is done.

64.6 Closure of the Abdomen

In any type of lobectomy, any tube for biliary drainage or abdominal cavity is not placed. A sheet for the prophylaxis of adhesion is applied. The abdomen is closed layer by layer, and skin stapler is used.

64.7 Postoperative Management

1. Epidural tube is used for the postoperative analgesia and removed a few days later after confirmation of the coagulation function. Earlier getting out of bed is highly recommended.
2. Routine procedure for the prophylaxis of deep vein thrombosis is applied.
3. Considering the possibility of the thrombosis, Doppler US study should be done routinely for the hepatic vein and the portal vein.
4. If there is a persistent fever or abdominal pain, biliary leakage should be suspected. If US study reveals the fluid retention, it should be drained with drainage tube placement.
5. In cases with left-sided lobectomy, gastric torsion might be caused by the adhesion of the stomach to the cutting plane of the liver. Early detection and the stretching of the stomach by the endoscope is sometimes effective.

Recipient Operation in Living Donor Liver Transplantation

65

Koichi Mizuta, Taizen Urahashi, Yoshiyuki Ihara, and Yukihiro Sanada

Abstract

A bilateral subcostal incision is made in infant. In biliary atresia, adhesion of bowels to the liver should be carefully dissected, because intestinal perforation at the time of transplantation becomes a fatal postoperative complication. The graft liver is put into the peritoneal cavity, and hepatic vein anastomosis is then performed with 5-0 Asflex running suture clamping totally the suprahepatic and infrahepatic IVC. Portal vein anastomosis is the most difficult part of the implantation in a pediatric recipient with biliary atresia. It is important to adjust the alignment of the donor and recipient portal vein and not to tighten the suture for prevention of anastomotic stenosis. When graft portal flow is insufficient, ligation of the coronary vein and dissection of retroperitoneal portal vein collateral vessels should be done to increase the portal blood flow. The hepatic artery anastomosis is performed using the microvascular technique. About 10–12 stitches of 9-0 Nylon are required to a single artery reconstruction. Biliary reconstruction is performed by hepatico-jejunostomy using external biliary drainage. The anastomosis is accomplished with a 6-0 PDS running suture in the posterior layer and an interrupted 6-0 PDS in the anterior layer. Doppler ultrasonography is repeatedly performed to determine the most suitable position of the graft liver. Then, the graft is fixed by stitching it to the proper anterior abdominal wall. The abdominal wall is closed with 1-0 or 2-0 Vicryl. After washing the subcutaneous with saline, the subcutaneous layer is sutured with 4-0 Vicryl, and the skin is closed with buried suture.

Keywords

Living donor liver transplantation • Biliary atresia • Hepatic vein • Portal vein • Hepatic artery

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65.1 Preoperative Management

1. It is important to perform liver transplantation in the proper timing according to the individual patient, which is different by adaptation disease of liver transplantation. In patients with biliary atresia, portal vein stenosis or hepatofugal portal flow in ultrasonography is a sign or indication of liver transplantation regardless of their bilirubin values.

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2. Liver transplant recipients with end-stage liver disease are in malnutrition and compromised state. The recipient should be administered sufficient enteral nutrition from the preoperative period to improve the nutritional status (e.g., 120~140 kcal/kg/day in infant).
3. When liver transplantation candidates with end-stage liver cirrhosis such as biliary atresia have high fever, early treatment should be started taking into bacterial cholangitis, bacterial liver abscess, spontaneous bacterial peritonitis, and bacterial translocation.

65.2 Operations

65.2.1 Laparotomy: Liver Removal

A bilateral subcostal incision is made in infant (Fig. 65.1a). For older children, an upward midline extension is occasionally required (Mercedes Benz mark incision) (Fig. 65.1b). For the recipient of biliary atresia, the previous surgical wound should be used as much as possible. In order to prevent intestinal damage during laparotomy, to approach into the peritoneal cavity must always directly above the liver.

In cases where portal hypertension is present, round ligament of the liver around and the abdominal vein have become a rich collateral circulation. Because it is difficult to stop bleeding from thrombocytopenia and abnormal coagulation, hemostasis should be definitely performed using ligation and vessel sealing system (LigaSure™ Small Jaw). Adhesions of the liver surface, falciform ligament, coronary ligament of the liver, and hepatic triangular ligament mobilized the liver while dissecting using an electrocautery and LigaSure™.

The liver is mobilized while carefully dividing falciform ligament, coronary ligament of the liver, and hepatic triangular ligament using an electrocautery and LigaSure™.

In the right liver underside, the hepatorenal ligament is divided, and then infrahepatic inferior vena cava (IVC) is confirmed. The adrenal gland is carefully dissected from the right side of the IVC by sharp dissection or an electrocautery. Dissection of the hepatogastric ligament is carried out with care to branches of the left gastric vein (coronary vein) and accessory left gastric artery.

In biliary atresia, the colon, Roux-en-Y jejunal limb, stomach, and duodenum are adherent to liver underside. Adhesion of bowels to the liver should be carefully dissected, because intestinal perforation at the time of transplantation becomes a fatal postoperative complication. Especially, adhesions of strong parts of bowels are removed from the liver while dissecting the liver capsule adhesion connecting to the bowels in cut mode. During dissection of

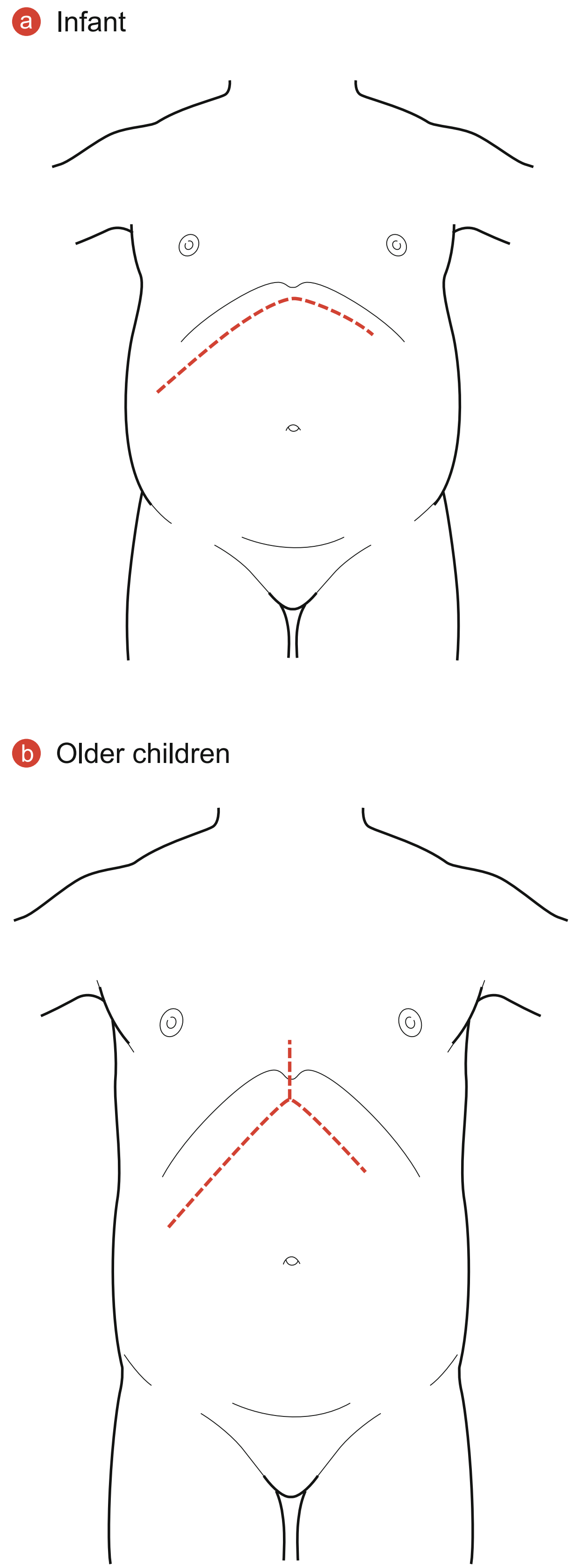

Fig. 65.1 Skin incisions in infant and older children

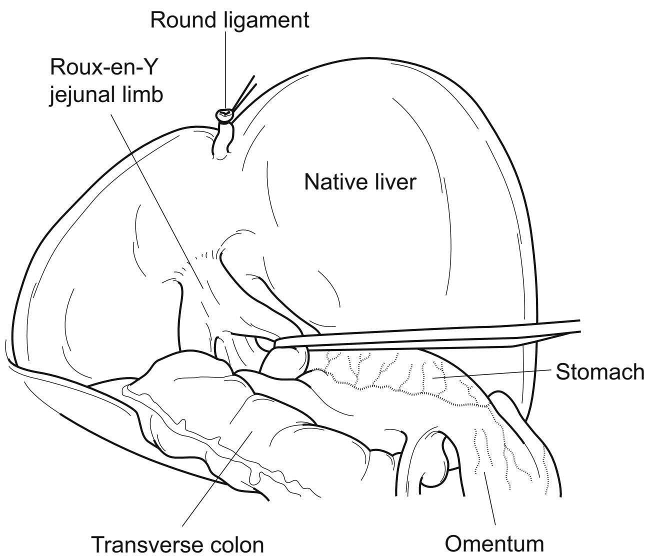

Fig. 65.2 Portenterostomy in biliary atresia

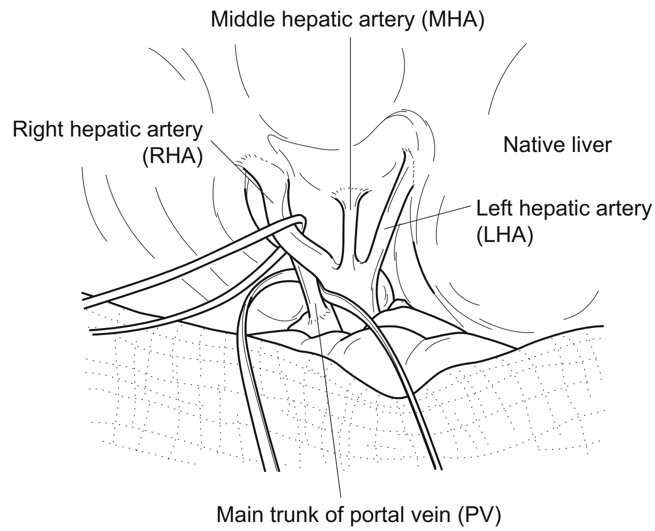

Fig. 65.3 Hepatic hilum in biliary atresia

the intestinal tract, cooling with saline should be performed to avoid heat injury of the intestinal tract caused by electrocautery. When the identification of the Roux-en-Y jejunal limb and duodenum is difficult, insertion of ED tube preoperatively will help the identification of the duodenum. After the Roux-en-Y jejunal limb is identified, it then dissected toward the liver hilum, and divide it near the liver hilum as much as possible with a stapler (Fig. 65.2).

The branches of hepatic artery are identified and dissected. Taping of the hepatic artery at the time of dissection, to become a cause of arterial spasm, should be minimized. All branches of hepatic artery are divided as much as possible at the distal side. Ligation of the artery should not be done because it may crush the artery or lead to intimal dissection. The portal vein is then identified and dissected up to the right and left branches (Fig. 65.3). Some caudate branches of the portal vein are divided from the portal vein. The portal vein of proximal side is dissected down to the level of the pancreas while dividing the left gastric vein. In the liver cirrhosis patients with collateral circulation, at this time, the portal vein is dissected at distal left portal vein and right portal vein (unhepatic phase). Large lymph nodes around the proximal portal vein should be resected because they may interfere with the portal blood flow after transplantation.

Short hepatic vein of 2 mm or more in size is transfixed or sutured to avoid slippage of the ligature. The right IVC ligament is encircled and continuously sutured after division. Right hepatic vein (RHV) is then encircled and divided at more distal side. Dissection on the left side of the liver and the back of the caudate lobe is made easier by dividing the RHV. After ligation of left IVC ligament and ductus venosus, the common trunk of the middle hepatic vein (MHV) and left hepatic vein (LHV) is encircled. Then total hepatectomy is performed by dividing the trunk at the level of the parenchyma.

65.2.2 Hepatic Vein Reconstruction

After total hepatectomy, hemostasis of abdominal cavity is performed. In infant recipient, the hepatic vein is formed into one large orifice using RHV, MHV, and LHV while dividing their septum (Fig. 65.4a, b). The suprahepatic and infrahepatic IVC can be clamped totally to prepare anastomosis in a patient with biliary atresia whose IVC was occluded by enlarged caudate lobe. Recipient hepatic vein diameter should be larger than the graft hepatic vein. If the recipient hepatic vein size is too large, the left side of it is sutured (Fig. 65.4b). In the pediatric recipients with IVC of 20 mm more in size, the common trunk of the MHV and LHV is sutured, and then a transverse incision from the RHV is put on the IVC to make a new orifice to reconstruct (Fig. 65.4c).

The graft liver is put into the peritoneal cavity and hepatic vein anastomosis is then performed on the 3-point stay with 5-0 Asflex (monofilament polyvinylidene fluoride sutures) running suture. After posterior wall anastomosis, the perfusion of cold Ringer's solution is stared from the portal vein

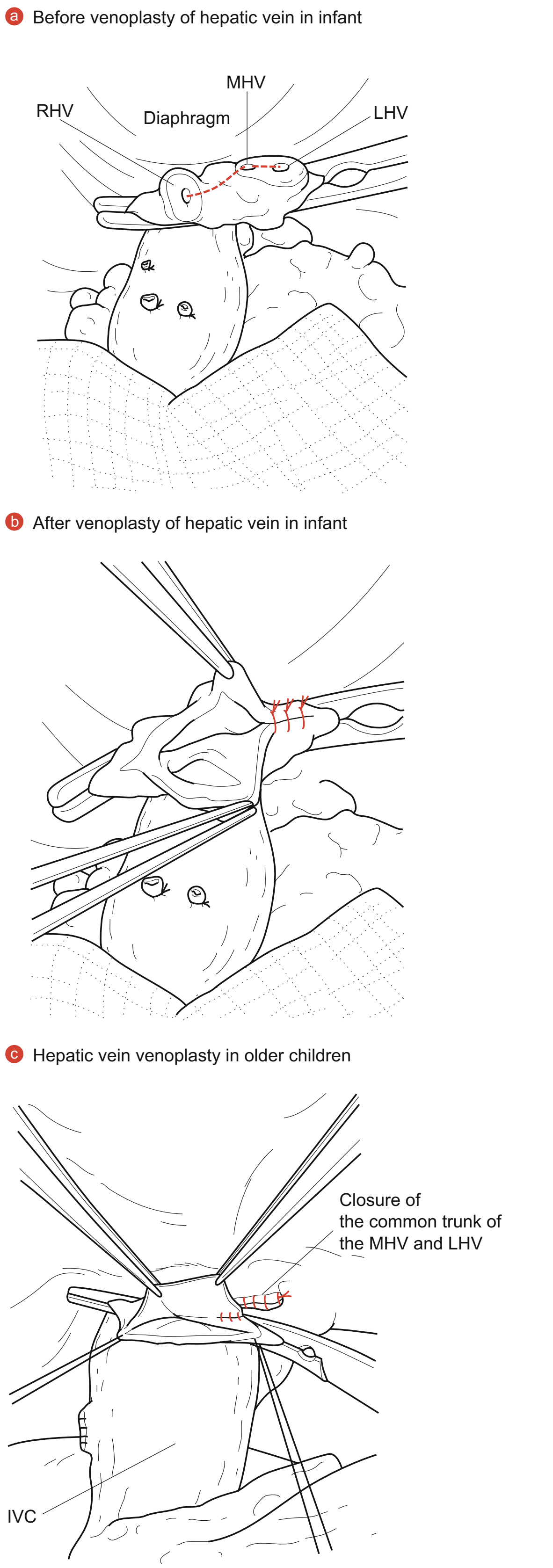

Fig. 65.4 Recipient hepatic vein venoplasty. (**a**) Before venoplasty of hepatic vein in infant. (**b**) After venoplasty of hepatic vein in infant. (**c**) Hepatic vein venoplasty in older children

to wash out the UW solution. After anastomosis of the anterior wall with running suture, the graft is perfused with backflow from the IVC by releasing vascular clamp of IVC.

65.2.3 Portal Vein Reconstruction

When the main portal vein of the recipient is not stenotic and has sufficient portal flow, the bifurcation of the right PV and left PV in infants and the main trunk of the portal vein in elder children are used for anastomosis, respectively. At the time of anastomosis, the graft liver is placed in a natural position and the alignment of the donor and recipient portal vein are noted not to twist. Portal vein anastomosis is performed on the two-point support with 6-0 absorbable surgical sutures (PDSII) with running suture (Fig. 65.5a). It is important not to tighten the suture for prevention of anastomotic stenosis.

Portal vein anastomosis is the most difficult part of the implantation in a pediatric recipient with biliary atresia. Graft interposition is chosen to portal vein anastomosis in the recipient whose portal vein is smaller and less than 4 mm or whose portal flow is insufficient. The confluence of the superior mesenteric vein and splenic vein is encircled (Fig. 65.5a) and then interposed with the donor's ovarian vein, inferior mesenteric vein, middle colic vein, and saphenous vein (Fig. 65.5c). In small recipient with biliary atresia (body weight <8 kg), hepatofugal portal blood flow is sometimes observed due to atretic portal vein and portal vein collateral system such as by large coronary vein or retroperitoneal portal vein collateral. Ligation of the coronary vein and dissection of retroperitoneal portal vein collateral vessels should be done to increase the portal blood flow.

65.2.4 Hepatic Artery Reconstruction

The hepatic artery anastomosis is performed using the microvascular technique. The graft liver is put into left abdominal cavity and preparation of anastomosis is done. About 10–12 stitches of 9-0 Nylon are required to a single artery reconstruction. If there are two hepatic arteries in graft liver, we usually reconstruct both of them.

65.2.5 Biliary Reconstruction

Biliary reconstruction is performed by hepaticojejunostomy in pediatric recipient. In a patient with biliary atresia, a healthy portion of the Roux-en-Y jejunal limb which was made at the previous surgery can be used for anastomosis. When making a new Roux-en-Y jejunum limb in a patient with inherited metabolic disorders, the jejunum limb should

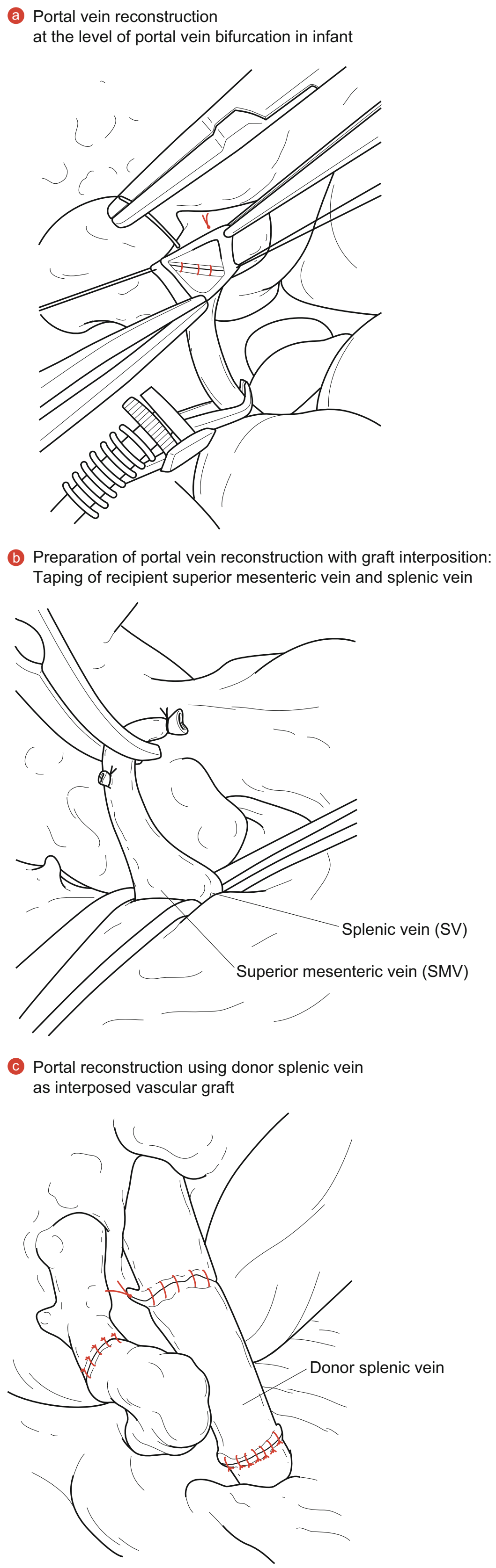

Fig. 65.5 Portal vein reconstructions. (**a**) Portal vein reconstruction at the level of portal vein bifurcation in infant. (**b**) Preparation of portal vein reconstruction with graft interposition: taping of recipient superior mesenteric vein and splenic vein. (**c**) Portal reconstruction using donor splenic vein as interposed vascular graft

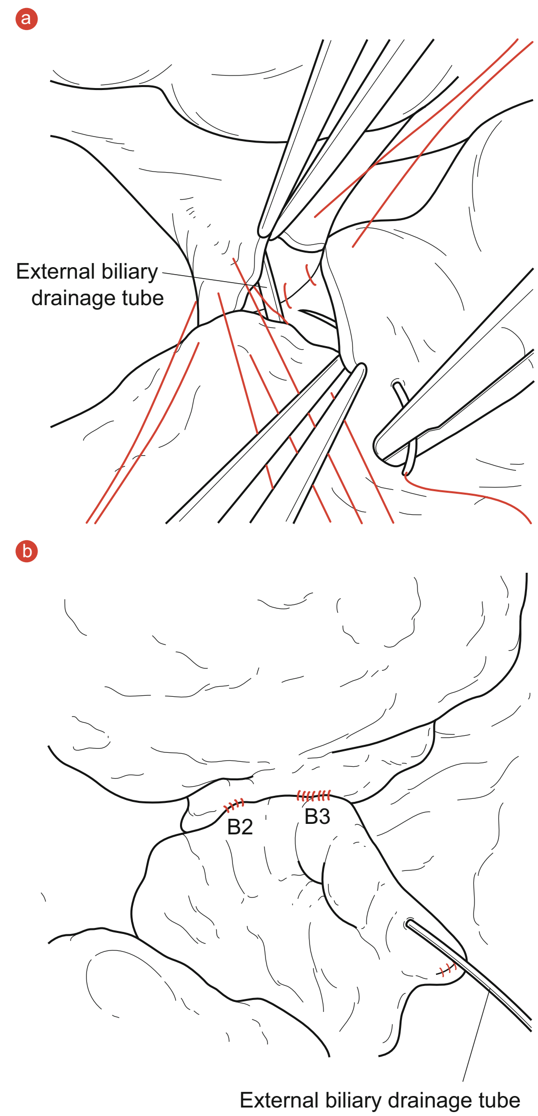

Fig. 65.6 Biliary reconstructions with hepaticojejunostomy using external biliary drainage

be created short (20–25 cm) so as to enable easy insertion of double-balloon endoscopy for treatment of postoperative biliary complications. Hemostasis of the graft bile duct before anastomosis is temporarily carried out by using a small vascular clip. The diameter of the graft bile duct is measured and an opening of the smaller size is made on the jejunum. Then, 4Fr catheter is inserted from the jejunum opening as external biliary drainage and is pulled out to blind end side. The anastomosis is accomplished with a 6-0 PDSII running suture in the posterior layer and an interrupted 6-0 PDSII in the anterior layer (Fig. 65.6a). If there are two bile ducts, which are separated more than 5 mm in the graft, two anastomoses to the jejunum are made, respectively (Fig. 65.6b).

65.2.6 Abdominal Closure

After taking liver tissue from transplanted liver (zero biopsy), the abdominal cavity is washed with warm saline of sufficient amount. Then, hemostasis is done carefully. In particular vascular and biliary anastomosis, liver resection surface, and around IVC should be observed cautiously. Before wound closure, careful inspection is made for bowel perforation and serosal injury. All suspicious areas are sutured with 5-0 Vicryl. Doppler ultrasonography is repeatedly performed to determine the most suitable position of the graft liver. Then the graft is fixed by stitching it to the proper anterior abdominal wall (Fig. 65.7). A closed system abdominal drain is inserted toward right subphrenic cavity. In the case of the older children, additional closed system abdominal drain is inserted toward Douglas' pouch or left subphrenic cavity. The abdominal wall is closed with 1-0 or 2-0 Vicryl. After washing the subcutaneous with saline, the subcutaneous layer is sutured with 4-0 Vicryl and skin is closed with buried suture. If the graft blood flow becomes insufficient at abdominal wall closure in the low-weight infants such as neonate, the abdominal wall is released and changed to skin closure.

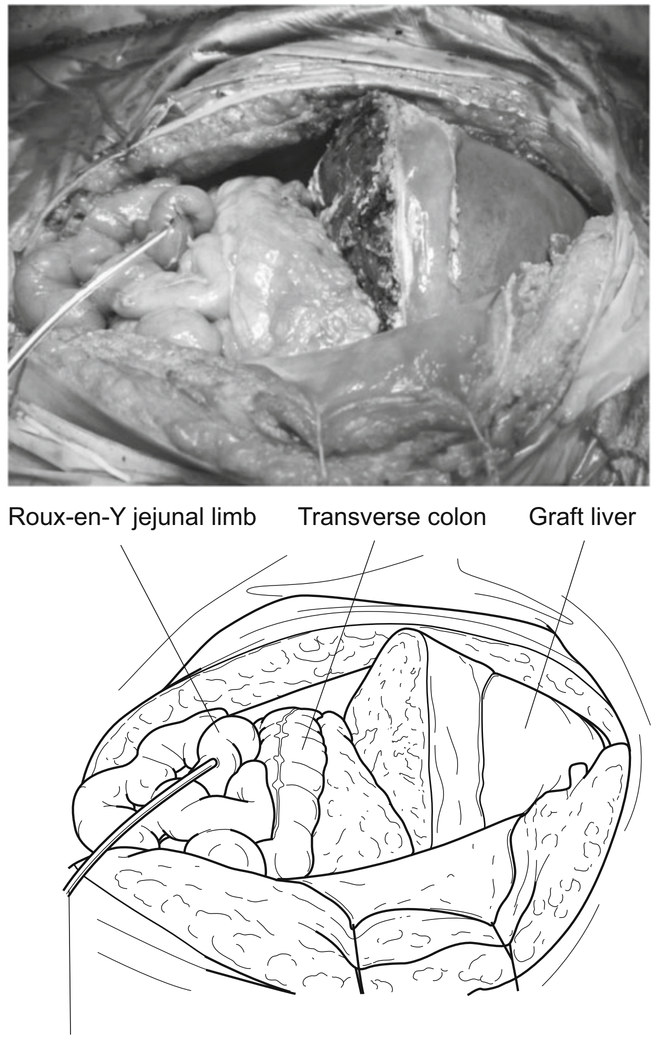

Fig. 65.7 Figure at abdominal closure in infant case

65.3 Postoperative Managements

1. For cardiorespiratory management in ICU, strict monitoring water balance is need for avoiding severe dehydration and excessive fluid overload. It is better to manage with a little overhydration side for maintaining renal function and preservation of graft function.
2. Bleeding tendency immediately after surgery should be treated with fresh frozen plasma transfusion to prevent the collapse of coagulation and fibrinolysis.
3. Enteral nutrition from ED tube that was inserted during surgery is started in early postoperative period. Enteral nutrition is effective to prevent bacterial translocation and activate liver regeneration and biliary excretion.
4. During postoperative 5 days, tacrolimus blood concentration is checked twice a day and adjusts to optimal range. When unknown etiology massive ascites appear, liver biopsy should be done to confirm acute rejection.
5. Vascular complications such as hepatic artery thrombosis, portal vein stenosis, and hepatic vein stenosis are early diagnosed by frequent Doppler ultrasonography. First choice of the treatment for them is interventional radiology.