Minimal Access Neonatal Surgery

15

Gordon Alexander MacKinlay

Abstract

Minimal access techniques—Laparoscopy, thoracoscopy and retroperitoneoscopy—have gradually been adopted in many centres undertaking paediatric surgery. In some units the approach has become commonplace but in others the skills required are developing more slowly or the necessary equipment is unavailable. Hopefully this will change as more and more paediatric surgeons learn to appreciate the benefits that endoscopic surgery provides to the young patients in their care.

Keywords

Minimally invasive surgery • Newborn surgery • Outcomes

In the twenty-first century it is unacceptable to perform any surgical procedure on a child by the open route if it can be safely and easily be carried out through minimally invasive surgery.

Minimal access techniques—laparoscopy, thoracoscopy, and retroperitoneoscopy—have gradually been adopted in many centres undertaking paediatric surgery. In some units the approach has become commonplace but in others the skills required are developing more slowly or the necessary equipment is unavailable. Hopefully this will change as more and more paediatric surgeons learn to appreciate the benefits that endoscopic surgery provides to the young patients in their care.

Endoscopic surgery involves minimal access wounds in the abdominal or thoracic wall and leads to reduced handling, drying and retraction of viscera. This results in less post-operative ileus and therefore earlier feeding is possible. There is less adhesion formation which is not only beneficial should further surgery be required but also prevents long-term complications. As the degree of the surgical insult is reduced there appears to be less immunosuppression and this may also lead to faster recovery. There are fewer respiratory complications and fewer wound infections. For the surgeon there is improved visualisation in 'difficult' areas of the abdomen such as the pelvis or the oesophageal hiatus. As far as the parents and child are concerned the minimal scarring is

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P.D. Losty et al. (eds.), *Rickham's Neonatal Surgery*, https://doi.org/10.1007/978-1-4471-4721-3_15

the most obvious benefit. It has been said that 'each scar on a child is a scar on the soul of the parents' [1].

The application of minimal access techniques to the neonate requiring surgery is dependent on the experience of the individual surgeon and an advanced degree of expertise and confidence in minimal access techniques on older children. Many neonatal surgical conditions are amenable to minimal access techniques. These are encompassed in this chapter although individual disease entities are covered in greater detail throughout this book.

15.1 Physiological Considerations in Neonates Undergoing Minimal Access Surgery

It is important for both the surgeon and the anaesthetist to be aware of the likely physiological effects of endoscopic surgery on the neonate.

The metabolic response to surgery differs in neonates to that seen in older children and adults [2]. There is a small increase in oxygen consumption and resting energy expenditure immediately after surgery with a return to normal levels by 12–24 h. The increase in resting energy expenditure is significantly greater in infants undergoing a major operation than in those subjected to a minor procedure. The limited increase in energy expenditure may be due to diversion of energy from growth to tissue repair. There are limited data available on older children, but they appear to have a different pattern of postoperative resting energy expenditure. There is a fall in the early postoperative period, similar to data collected in adults, but no late hypermetabolism. Protein metabolism mirrors energy expenditure and contributes to the overall changes observed. Various factors affect the magnitude of the response. It seems that in children intraoperative thermoregulation and metabolism are significant drivers of many of the postoperative changes. Minimally invasive surgery may maintain preoperative metabolic processes by altering the postoperative processes on a physiological level or by maintaining thermoregulation in children.

The carbon dioxide gas used in insufflation of the body cavity, thorax or abdomen will have a more significant effect in small infants. In thoracoscopy the impaired respiratory capacity imposed by lung collapse has significant implications for oxygenation and CO_2 excretion [3]. Further, the absorption of CO_2 insufflated into the chest, coupled with the impaired ventilation, can lead to a marked increase in arterial CO_2 concentration. The ability to increase CO_2 excretion, in the face of the increased load created by its absorption, is crucial to safe thoracoscopy in children.

The CO_2 is absorbed and excreted via the lungs. There is an increase in end-tidal CO_2 as a result of absorption from the pleura or peritoneum. In thoracoscopy there is the additional factor of ipsilateral lung collapse further increasing the $EtCO_2$ [4]. Single lung ventilation has a significant effect on $EtCO_2$.

There are also haemodynamic changes due to right to left shunting, a phenomenon that is very important in the early stages of thoracoscopy for oesophageal atresia during which the anaesthetist may find it easiest to control the situation by a period of hand 'bagging' the infant.

The insufflation of cold CO_2 into the thorax does not appear to cool the infant. In our study [4] we found that thoracoscopy was associated with an increase in core temperature in the intraoperative period. This may be due to maintained thermoregulation due to the absence of an open surgical wound. This finding is in keeping with the increase in core temperature noted in children undergoing laparoscopy [5] and during thoracoscopy in another study [6]. Thoracoscopy may, therefore, alter intraoperative core-temperature regulation.

15.2 Thoracic Procedures

15.2.1 Diaphragmatic Hernia

It is recommended that thoracoscopic repair of congenital diaphragmatic hernia should only be carried out by surgeons with specific training and experience in laparoscopic and thoracoscopic surgery in neonates and children [7].

The first laparoscopic repair of a posterolateral Bochdalek diaphragmatic hernia was by van der Zee and Bax in 1995 [8]. The first reported congenital diaphragmatic hernia surgically corrected by a thoracoscopic approach was by Becmeur et al. [9] in 2001 although these were in older infants of 8 and 19 months.

The baby should be in a stable cardiovascular and respiratory condition and under general anaesthesia. Endo-tracheal intubation is sufficient without single lung intubation and the patient is placed in a lateral decubitus position on the operating table. The surgeon stands at the head of the table with the assistant to his left and the scrub nurse on the opposite side of the table.

The telescope port (usually 5 mm) is placed below the tip of the scapula and two working ports (3 mm) are placed, one in the anterior axillary line in the 4th intercostal space and the other half way between the telescope port and the spine in the 4th or 5th space.

The first port is inserted after injecting 0.25% Marcaine and adrenaline and is inserted using an open technique, gently opening the space first with an artery forceps and then the port is introduced with a blunt trocar. CO_2 is insufflated at a flow rate of 0.5 L/min at a pressure of 6 mmHg to begin with (it may be increased to 8 mmHg later if necessary and with the agreement of the anaesthetist. A 30° telescope is introduced and gradually the bowel will reduce through the defect sufficiently to allow the two working ports to be introduced under direct vision. Reduction is best achieved using blunt atraumatic instruments such as 3 mm Johan forceps that are fenestrated and handle bowel safely.

The bowel is gradually reduced through the defect. Pushing the stomach down carries the spleen safely into the abdomen without potential trauma from handling the spleen directly.

Once the abdominal contents are reduced the defect is best repaired with non-absorbable sutures. Care should especially be taken at careful repair of the lateral corner of the defect as recurrence can occur here. If necessary a suture passed from outside the chest wall at this point and tied subcutaneously will secure this area safely. It may be necessary to use a patch such as a GORE-TEX® soft tissue patch. This needs to be cut to size externally, rolled and passed through a port. It can then be sutured into position with non-absorbable sutures tied intra-corporeally.

A chest drain is not necessary allowing the hypoplastic lung to expand slowly.

15.2.2 Oesophageal Atresia

Tovar [10] observed—'Only a handful of cases of this particularly rare condition are treated every year in most large centers and it is obviously difficult to acquire the necessary skills for this particular operation in small babies with tiny thoracic spaces. How to achieve this goal when not so many consultants operate upon more than one or two cases per year?'

Thoracoscopic repair of oesophageal atresia was first successfully achieved by Lobe and Rothenberg at the International Pediatric Endosurgery Group (IPEG) meeting in Berlin in 1999 [11]. This was in a 2-month-old infant with isolated oesophageal atresia. In 2000 Rothenberg [12] reported the first thoracoscopic division of a tracheoesophageal fistula and repair of oesophageal atresia in an infant. The first in the UK was in Edinburgh in 2001 [13].

The baby is anaesthetised with endotracheal intubation and placed semi-prone on the operating table (Fig. 15.1). Some use a bronchial blocker to achieve single lung ventilation but this

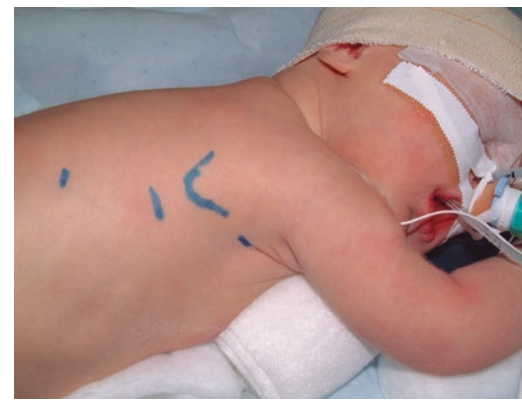

Fig. 15.1 Semi-prone position on table

adds to the anaesthetic time and has little advantage over endotracheal intubation. When the first port is inserted, CO_2 is insufflated at a flow rate of 0.5 L per minute to a pressure of 6 mmHg. Initially there is usually a period of desaturation and a rise in pCO_2, requiring ventilation to be adjusted accordingly. Within a few minutes however the baby stabilises and the other two ports can be inserted.

The first port (5 mm) is inserted below the tip of the scapula. As CO_2 is insufflated the lung gradually collapses. A short 4.5 mm 30° telescope is used. Two further ports are inserted, both 3.5 mm, one up in the axilla and the other more posteriorly in a line with the other two (Fig. 15.2). It is important that valved ports are used with good seals round the instruments to maintain the tension pneumothorax. The pressure on the insufflator may read 6 mmHg but with a leaky seal the lung will not collapse.

The assistant stands (or sits) to the right of the surgeon to hold the camera and the table height is adjusted to give a comfortable ergonomic position for the surgeon (Fig. 15.2).

With the lung collapsed a good view of the posterior mediastinum is obtained. The distal pouch is seen to distend and collapse with respiration. The azygos vein may be divided if necessary using a 3 mm monopolar hook diathermy. Lifting the vein gently with the hook, it empties, and is easily divided. Dissection commences around the distal pouch to free it circumferentially. A right-angled forceps such as a 3 mm Mixter forceps facilitates this. The fistula is then transfixed and ligated, close to its junction with the trachea, with a 5/0 non-absorbable suture such as braided polyester. The fistula is then divided.

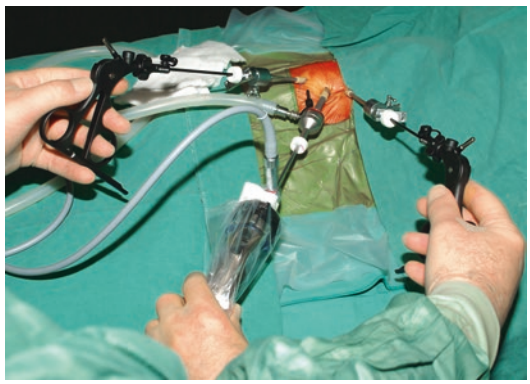

Fig. 15.2 Comfortable ergonomic position of instruments

The upper pouch is then identified; asking the anaesthetist to gently jiggle the Replogle tube will help in its location. Little dissection of the upper pouch is usually necessary unless there is a long gap. With pressure on the Replogle tube an opening in the distal end of the upper pouch is made with scissors. Cutting across three-quarters of the diameter in the first instance creates a flap (later excised) that can be used for traction to facilitate initial suture placement. Care must be taken to ensure that the mucosa is opened. The anastomosis is achieved with interrupted 5/0 braided polyglycolic acid sutures. Some prefer monofilament sutures but the braided suture ensures secure knot tying without slipping. If there is any tension, by using the tumbled square knot technique, the ends can be approximated safely. In cases of tension it is also helpful to paralyse and ventilate the infant for a few days to prevent disruption of the anastomosis [14]. Once the first few sutures are placed, a fine (5 Fr) silastic nasogastric tube is passed by the anaesthetist and advanced into the stomach with surgical guidance. This tube facilitates suture placement (ensure that sutures include the mucosa) and can be used to commence nasogastric feeds within 24 h.

Once the anastomosis is complete then a small chest drain may be passed through the lowest port site, if desired, and the lung is seen to expand as the other ports are removed. The port sites are closed with absorbable sutures to deeper layers and tissue glue to skin. An excellent cosmetic result is achieved without the potential sequelae of a thoracotomy incision. A contrast swallow at 5 days may be performed, prior to commencing oral feeds.

15.2.3 Aortopexy

If tracheomalacia is present and related to the oesophageal atresia it is usually due to an intrinsic

localized anomaly of the trachea at the site of the distal fistula. Aortopexy is appropriate in such cases and may be performed thoracoscopically [15].

The patient is placed supine on the operating table with a pad of Gamgee under the left side of the chest to elevate it 15–20°. The surgeon stands to the left of the operating table with the assistant seated to his left. The monitor is at the opposite side of the table. A 5 mm cannula is inserted in the mid axillary line by an open technique after infiltrating the skin and subcutaneous tissue with 0.25% Marcaine with adrenaline. CO_2 is insufflated at a pressure of 5 mmHg and a flow rate of 0.5 L/min. A 30° telescope is introduced and then two 3.5 mm ports are inserted above and below the first. The anterior mediastinum is visualized and the thymus swept away to the right from the aortic root, taking care of the phrenic nerve. The ascending aorta is identified and if required the pericardial reflection over the aorta can be opened. A hollow needle is passed through the sternum to check the appropriate position for the sutures and a tiny skin incision is made alongside it. A 3/0 prolene suture on a round-bodied needle is inserted through this incision and through the sternum, which is soft at this age, and then carefully a superficial bite of the aortic wall is taken with the needle ensuring that it does not enter the lumen! The suture is then cut so that the needle can be passed through the chest wall for extraction leaving sufficient length of suture intra-thoracically to be passed back out through the previously positioned hollow needle. This suture is then held externally in an artery forceps whilst two or three other sutures are positioned in a similar manner, above and below the first.

Under bronchoscopic control the 3–4 sutures are then pulled upwards and tied subcutaneously as the tracheal lumen is observed to open up. The lung is then allowed to re-expand, the port holes are closed and no drain is required.

15.2.4 Lung Resection

Thoracoscopic resection of lung lesions in the neonatal period is seldom necessary as many conditions can be left until the child is older. It requires advanced paediatric endoscopic skills, as the working space is limited. Congenital lung cysts, congenital cystic adenomatoid malformations, pulmonary sequestrations and congenital lobar emphysema can all be treated thoracoscopically. There is no difference in measurable outcomes between early and delayed resection of congenital lung lesions [16]. It is appropriate to use a management strategy of observation, with delayed resection, for asymptomatic patients [17].

Congenital lobar emphysema can often be treated conservatively [18]. Congenital cystic adenomatoid malformation (CCAM) is often diagnosed antenatally. Whilst some surgeons perform lobectomy for CCAM in the neonatal period, most will wait until the infant is older but it is wise to undertake surgery before infection arises as this can make lobectomy more difficult [19]. In my practice we choose to perform a thoracoscopic lobectomy before the infant's first winter.

Pulmonary sequestration may be intra or extra-lobar and surgery can be postponed until the infant is a few months of age.

Congenital lung cysts usually present beyond the neonatal period and elective surgery can be planned appropriately.

Thoracoscopy for all these conditions is feasible and best performed in a lateral decubitus position. Anaesthesia is best administered via a right or left mainstem intubation of the contralateral side or by introducing a bronchial blocker (a Fogarty catheter is usually used). The baby is supported on a bean bag with a cotton wool roll under the chest to allow the rib spaces to open up and taped to the table which can then be tilted toward or away from the surgeon as necessary to allow gravity to displace the collapsed lung appropriately during the procedure. The surgeon and assistant stand on the same side of the operating table with the baby facing them. The monitor is positioned on the opposite side of the table.

Each port site in turn is infiltrated with 0.25% Marcaine with adrenaline prior to incision. The first port is inserted by an open technique, a 5 mm incision is made in the mid axillary line in the 5th

or 6th space and blunt dissection is used to find a way through the intercostal muscles into the pleural cavity. A 5 mm cannula is then inserted using a blunt trocar and then a short 4.5 or 5 mm 30° telescope is introduced. If desired a smaller port and 'scope may be used but a larger telescope gives a better view. Once it is confirmed that the port is intra-pleural, CO_2 is insufflated at a pressure of 5 mmHg at a low flow rate (0.5 L/min). The port at this level should be looking directly into the oblique fissure. Appropriate positioning of two further 3 mm ports is under direct vision. These are usually in the anterior axillary line above and below the level of the optic port. For a lobectomy a pulsed bipolar sealing device is desirable for dividing the branches of the pulmonary artery to the affected lobe. This may be a 3 mm or 5 mm instrument depending on the manufacturer. If a 3 mm instrument is not available then a 5 mm port will be required, or ligation and division of the vessels may be performed but this is more time consuming. Dissection is performed from anterior to posterior [20].

For a lower lobectomy first the inferior pulmonary ligament is mobilized and the inferior pulmonary vein is identified but not mobilized at this point. In the case of a sequestration a systemic vessel (sometimes more than one) is usually identified coming directly from the aorta below the diaphragm (or sometimes above). This vessel is ligated (or clipped) and divided first in sequestration. After division of all the vessels the bronchus to the lobe is divided and oversewn with non-absorbable sutures. A stapling device is too large for neonates or small infants.

The lobe is then extracted through the lowest port site and a chest drain inserted and connected to an underwater seal.

15.2.5 Cyst Excision

Bronchogenic or other cysts are dissected out as appropriate and by keeping close to the cyst wall during mobilization most can be excised safely and relatively easily.

Foregut duplication cysts such as oesophageal duplication are best approached with the baby semi-prone as for oesophageal atresia repair. The pleura overlying the cyst is incised and the duplication is carefully mobilized from the oesophageal wall. The oesophageal mucosa is exposed but should be left intact and the defect in the oesophageal muscle is then repaired.

15.2.6 Chylothorax

Thoracoscopic ligation of the thoracic duct may be performed in cases of chylothorax. The magnification obtained in thoracoscopy can make the identification of a chyle leak easier. The approach is similar to that for oesophageal atresia repair and the port sites described for that (above) allow excellent visualization of the posterior mediastinum. The duct may either be ligated or clipped.

15.2.7 Mediastinal Masses

Mediastinal masses are uncommon in the neonate and usually arise from the sympathetic chain as a neuroblastoma, ganglioneuroblastoma or ganglioneuroma. Rarely is it necessary to undertake surgery for these in the newborn and it is important to evaluate the case in conjunction with the oncological multi-disciplinary team. Thoracoscopic excision and extraction of the tumour in a bag is required.

15.3 Abdominal Procedures

Neonatal laparoscopic surgical procedures have become widely accepted over recent years. Laparoscopy is well tolerated in the neonate and many congenital abdominal conditions can be approached in this way with the benefits of minimal access surgery.

For the majority of laparoscopic procedures the primary (optic) port is best placed at the umbilicus. This not only gives access to all quadrants of the abdomen but is also the most cosmetic. I always use the inferior umbilical fold for the umbilical

port site. The incision should, if possible, be within the fold, which can be everted to achieve optimal placement. Some surgeons choose the upper fold for example in the approach for pyloric stenosis but this is illogical as it places the optic closer to the operative field and thus achieves a more restricted view. In the neonate, in particular, the lower fold is best as often the umbilical vein is still patent and can bleed whereas the arteries in the inferior fold are rapidly occluded.

Others choose the centre of the umbilicus for their incision as the most direct approach but this distorts the appearance of the normal umbilicus. An incision within the inferior umbilical fold can be widened if necessary to allow exteriorization of bowel for extra-corporeal surgery. Simply stretching the skin incision with an artery forceps will extend the incision along Langer's lines, which are circumferential at the umbilicus. Extending it with a scalpel may cross the lines and create a cosmetically inferior scar.

15.3.1 Pyloromyotomy

Pyloromyotomy can easily be performed laparoscopically and this is the preferred approach. A double-blind multicenter randomized controlled trial of open versus laparoscopic pyloromyotomy was halted at the recommendation of the data monitoring and ethics committee because of significant treatment benefit in the laparoscopic group [21]. My own unit chose not to participate in that trial as we already considered laparoscopy was the best approach and this study proved it.

The baby is placed either at the foot of a shortened operating table or, if preferred, across the table. The surgeon stands at the baby's feet and the assistant to the left. The monitor is best placed across the table if a flat screen is available otherwise at the head of the table.

A 5 mm port is inserted in the inferior umbilical fold under direct vision having infiltrated the skin and subcutaneous tissue with 0.25% Marcaine with adrenaline. Only a very short length of port should be inside the abdomen so it is best sheathed with a short length of catheter to limit its excursion into the abdomen. The catheter may be sutured to the skin and fascia to prevent dislodgement. The instruments are introduced directly into the abdomen through 3 mm access wounds, one in the right hypochondrium, the other just to the left of the midline in the epigastrium (Fig. 15.3). A 3 mm fenestrated forceps of the Johan type is passed through the right hypochondrial site and used to grasp the duodenum gently, just beyond the pylorus. A laparoscopic retractable pyloromyotomy knife or a suitably narrow blade such as an ophthalmic 69 Beaver, on a handle, is carefully introduced through the epigastric site and an incision is made along the length of the pylorus from the pyloro-duodenal junction onto the antrum of the stomach. It is important that this incision is down into the muscle of the pylorus. The blade is removed and replaced with a 3 mm laparoscopic spreader that is introduced into the split in the pyloric tumour (Fig. 15.4). As the

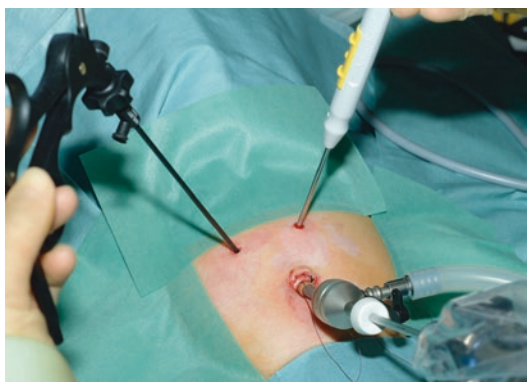

Fig. 15.3 Instrument sites in pyloromyotomy

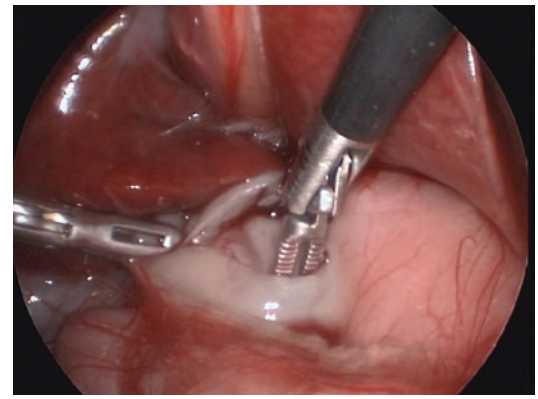

Fig. 15.4 Spreading the pyloromyotomy

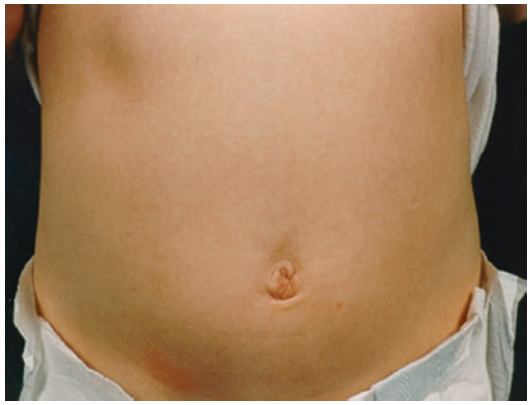

Fig. 15.5 Barely perceptible wounds post pyloromyotomy

spreader is opened to its full extent the muscle is widely separated to show the intact mucosa bulging. Changing the graspers to either side of the split allows further separation and moving the instruments in opposite directions parallel to the pylorus confirms that an adequate length pyloromyotomy has been achieved.

The instruments are carefully removed, taking care not to draw the flimsy omentum out behind them. The wounds are closed with a deep 4/0 polyglycolic acid suture and tissue glue to skin (Fig. 15.5). The operation takes only a few minutes. Feeding can commence as soon as the baby returns to the ward as the gastric paresis that occurs in some open techniques is seldom seen.

15.3.2 Fundoplication

Occasionally pre-term infants with severe gastro-oesophageal reflux may have difficulty weaning from ventilation or suffer recurrent severe respiratory symptoms due to aspiration until an anti-reflux operation is performed. Laparoscopic fundoplication is well tolerated [22] and significantly improves the outcome. The baby is placed on the operating table in a position similar to that for pyloromyotomy.

A 5 mm port is inserted by the open technique through a 5 mm incision in the inferior umbilical fold having infiltrated the skin and subcutaneous tissue with 0.25% Marcaine with adrenaline. Pneumoperitoneum is established with CO_2 at a pressure of 8–10 mmHg at a flow rate of 0.5–1 L/min depending on the size of the baby. Two further 'working' ports each 3.5 mm are inserted, one in the right, the other in the left hypochondrium. The exact position is dependent on the size of the baby. If the baby is too small for a Nathanson liver retractor an instrument is passed through a 3 mm stab wound in the right side of the abdomen just below the edge of the liver and the left lobe of the liver is elevated by this instrument which if ratcheted can be fixed to the peritoneum in the left flank. A further 3 mm stab incision in the left flank is used for an instrument to retract the gastric fundus (Fig. 15.6). The short gastric vessels rarely need to be divided in these cases. The oesophagus is gently mobilized at the hiatus with minimal dissection and a window developed behind the oesophagus where the two limbs of the right crus of the diaphragm will be visualized. Care is taken to leave the posterior vagus attached to the oesophagus. The two limbs of the right crus are approximated with one suture of braided polyester to narrow the hiatus, taking care to leave room for normal swallowing. A wide bore nasogastric tube in situ at this stage can prevent too tight a closure. It is removed at the end of the procedure or replaced with an appropriate sized tube for post-operative feeding if required. The fundus is then grasped by an instrument passed from right to left behind the oesophagus and gently drawn

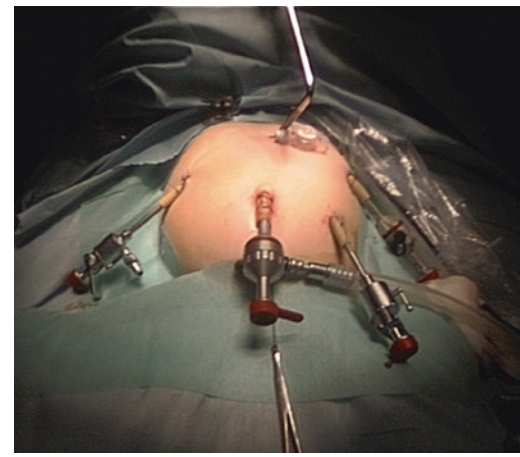

Fig. 15.6 Port sites for laparoscopic fundoplication (note gastrostomy button)

through to allow a loose wrap of fundus around the intra-abdominal portion of the oesophagus. This is approximated using three sutures of 3/0 braided polyester. The first suture brings the two parts of fundus together. The second suture, above the first, approximates the two sides and is also attached to the diaphragm at the hiatus. The third suture approximates the two sides also taking a bite of the anterior wall of the oesophagus. The latter two sutures help to prevent wrap migration into the thorax.

The ports are removed and closed with absorbable sutures to fascia and tissue glue to skin.

15.3.3 Gastrostomy

If a gastrostomy is required in the neonatal period it is safest to place it under laparoscopic guidance. In a small baby a telescope port is placed at the umbilicus and a further 3 mm 'stab' wound made in the right hypochondrium through which an atraumatic grasper is passed. The site of the proposed gastrostomy is chosen and the stomach held close to the abdominal wall as a 2/0 polyglycolic acid suture on a curved, round bodied needle is passed though the abdominal wall picking up the anterior gastric wall and back out through the abdominal wall a few mm away from the entry site. A further suture about 1 cm from the first is passed in similar fashion such that traction on the two 'U' sutures will bring the stomach up to the anterior abdominal wall. Suitable reduction in insufflation pressure facilitates this manoeuvre.

Using a Seldinger technique a cannula is passed percutaneously into the stomach between the two sutures followed by a guide wire. Graduated dilators are then passed though the abdominal wall into the stomach dilating up to 14Fr for a 12Fr button gastrostomy tube (of measured length) that is finally passed over the guide wire, into the stomach. Using one of the smaller size dilators to stiffen and guide the tube into the stomach facilitates this. The two sutures are then tied over the wings of the button device to retain it in place (Fig. 15.6). These sutures are removed in 7 days.

15.3.4 Duodenal Atresia

Laparoscopic repair of duodenal atresia has developed since 2001. The baby is placed at the end of the operating table as described for pyloric stenosis. The surgeon stands at the foot of the table with the assistant to the left. The first (5 mm) port is inserted in the inferior umbilical fold and once pneumoperitoneum is established two further 3.5 mm ports are placed, one in the right lower quadrant, the other in the left hypochondrium. An instrument for a liver retractor may be introduced through a stab wound in the epigastric region or the liver may be hitched up with a percutaneous suture through the falciform ligament. Alternatively the apical stitch in the anastomosis can be brought out through the abdominal wall to stabilize the enterostomies for the anastomosis [23, 24]. The duodenum is Kocherised, the proximal dilated and collapsed distal segments are identified and a diamond shaped anastomosis is made after incising the proximal bowel transversely and the distal bowel longitudinally. This is achieved with interrupted polyglycolic acid sutures. Others have used nitinol u-clips with good results [25].

Laparoscopic repair of duodenal atresia remains one of the most demanding paediatric laparoscopic surgical procedures [26].

15.3.5 Malrotation

Laparoscopic correction of malrotation in the neonate was first described in 1998 [27]. At first many considered it should only be considered for cases without volvulus but it is feasible even with volvulus and signs of ischaemia [28].

The baby is placed supine at the end of the table as for pyloromyotomy.

A 5 mm port is inserted in the inferior umbilical fold and the abdomen insufflated with CO_2 at a pressure of 8–10 mmHg with a flow rate of 0.5 L/min. A 5 mm 30° telescope is inserted and the bowel inspected. In the case of volvulus there may be evidence of chylous fluid in the peritoneal cavity. The bowel is collapsed and shows a dusky appearance with only the stomach and duodenum

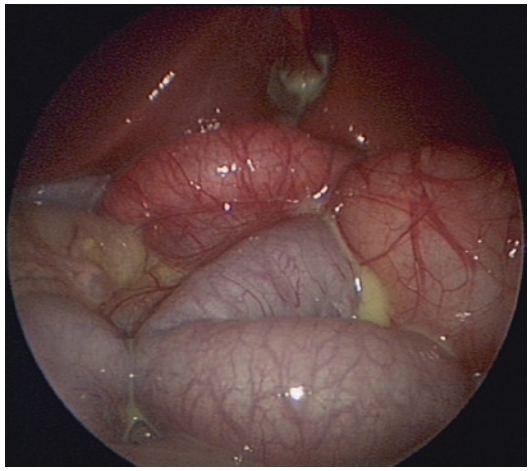

Fig. 15.7 Ischaemic bowel and chylous fluid in volvulus neonatorum

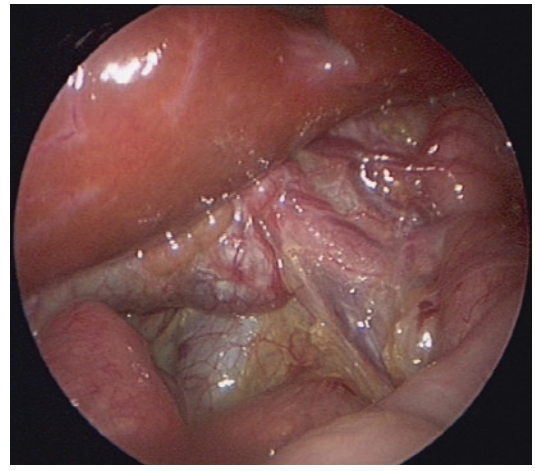

Fig. 15.8 Wide separation of root of mesentery, having corrected the volvulus

appearing pink (Fig. 15.7). Two 3.5 mm ports are placed on either side of the abdomen slightly below the level of the umbilicus and using two atraumatic bowel graspers such as fenestrated Johan forceps the bowel is gently inspected. As the bowel always rotates in a clockwise direction (north and south of the equator unlike water emptying down a plug hole) the bowel is gently rotated en masse in an anticlockwise direction. As the bowel is derotated the colour improves and returns to normal. Once this has been achieved Ladd's bands are visualised and divided with a 3 mm monopolar hook diathermy. The root of the mesentery is widely separated by carefully dividing the peritoneum with the hook diathermy. Once wide separation has been achieved the operative procedure is complete (Fig. 15.8). The ports are removed and the wounds closed (Fig. 15.9). Feeding can recommence within 24 h.

15.3.6 Small Bowel Atresias and Duplications

Small bowel atresias can be dealt with using a laparoscopically assisted approach, identifying the atresia laparoscopically and exteriorizing the loop of bowel via the umbilical port site and performing the resection, tapering (if necessary) and anastomosis externally [29, 30].

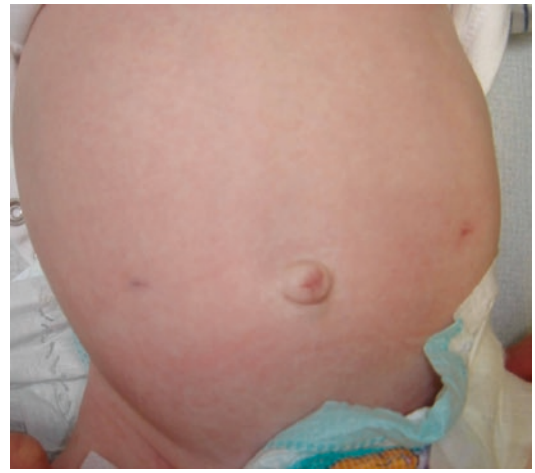

Fig. 15.9 Post operative wounds following correction of volvulus neonatorum

Duplication cysts can also be treated using this technique, aspirating the fluid from the cyst before exteriorizing the affected loop of bowel.

15.3.7 Hirschsprung Disease

In the early 1990s Georgeson [31] described the laparoscopic approach to endo-rectal pull-through for Hirschsprung disease. This can be performed in the neonatal period or delayed for a

period during which the bowel is decompressed by regular irrigations every 6–8 h.

The advantage of the laparoscopic approach is the ability to obtain biopsies to determine the exact level of the disease. Others prefer a purely transanal approach [32] but occasionally one may encounter a total colonic Hirschsprung's or a higher than expected transition zone so the laparoscopic biopsy technique is safer.

For the laparoscopic endo-rectal pull through the baby is placed in a supine position across the end of the operating table with the right side towards the foot of the table. The surgeon stands at the head of the baby and the assistant is best seated at the end of the table to hold the camera. The first port (5 mm) is inserted either in the inferior umbilical fold or as suggested by Georgeson it may be placed in the right hypochondrium to provide a wider view of the abdomen. Either way it is placed using an open technique having first infiltrated the skin and subcutaneous tissue with 0.25% Marcaine with adrenaline.

The abdomen is insufflated with CO_2 at a flow rate of 0.5 L/min to a pressure of 8 mmHg. Two further 3.5 mm ports are inserted, one to the right side of the abdomen at umbilical level and the other a little higher on the left.

The baby is placed in a Trendelenburg position and prepped front and back from the lower chest downwards including the legs that are encased in sterile stockinette or similar. The baby's bottom should be close to the edge of the table to facilitate the rectal dissection. Some padding is used to support the legs comfortably at the edge of the table.

First seromuscular biopsies are taken using a fine grasper and curved laparoscopic Metzenbaum scissors. These are sent for frozen section to confirm the level of disease prior to commencing dissection. With an atraumatic instrument lifting the colon towards the anterior abdominal wall, a window is developed in the mesocolon using a 3 mm hook diathermy. This is continued, staying close to the bowel wall, down to the peritoneal reflection and circumferential dissection at this level for a further 1–2 cm is performed. Staying close to the bowel wall prevents damage to the nervi erigentes and the vas in the male. The bowel is thus mobilized from the transition zone down to below the peritoneal reflection.

The ports are left in position and the CO_2 insufflation discontinued allowing the abdomen to deflate. The surgeon and assistant move to the opposite side of the table. The baby's feet are elevated using the stockinette, which can be fixed to the drapes over the baby's torso giving access to the anus. The rectal mucosa is accessed by placing 6–8 traction sutures through the perianal skin and the muco-cutaneous junction to radially retract the anal margin. Alternatively a retractor ring and hooks provides excellent exposure. Care must be taken not to overstretch the anal sphincters at this stage and during the dissection.

The mucosa is marked with cautery 5–10 mm above the dentate line circumferentially and then using a fine cautery needle the mucosa is incised at this level attaching multiple 5/0 silk sutures to the edge of the mucosa to provide traction. It is imperative that only the mucosa is dissected free from the underlying internal sphincter. Once a good submucosal plane is developed the dissection becomes easier and is continued until the rectal sleeve prolapses down. The advantage of the previous laparoscopic dissection is that there is little bleeding at this stage. Once the sleeve has prolapsed easily it is incised circumferentially and the mobilized bowel is pulled through it until the highest (ganglionic) biopsy site is seen. It is preferable to pull down a further 5–10 cm to ensure that the affected disease is fully resected. The muscle cuff is split posteriorly and pushed back into the pelvis. The affected bowel is sent to pathology for confirmation of the level of disease and the pulled through bowel is anastomosed carefully to the distal mucosal cuff using multiple 5/0 absorbable sutures to ensure that there is no leak.

On completion of the anastomosis the retraction sutures/ hooks are removed and the anus retracts. The surgeon, after a change of gloves, moves back to the other side of the table to check with the 'scope that there is no twist on the bowel. The ports are removed and the sites closed. Feeds can recommence the following morning.

15.3.8 High Ano-Rectal Malformations

Georgeson described a similar approach to high ano-rectal malformations [33]. In the neonatal period these cases are usually treated with a colostomy initially and the rectal pull through procedure is usually performed when the baby is a few weeks of age. It can be successfully treated with a primary single stage procedure within a day or two of birth [34].

The aim is to correct the high anorectal anomaly without the mid sagittal division of the muscles in the widely accepted approach described by Peña. The dissection is similar to the dissection for Hirshsprung's disease beginning at the peritoneal reflection continuing deeply close to the rectal wall until it tapers into the fistula distally. When the rectourinary or high rectovaginal fistula is reached the bowel is divided and the fistula usually sutured or clipped.

The legs are then elevated and the perineal dissection commenced after defining the perineal anal site using a muscle stimulator. A vertical 1 cm incision is made and the initial dissection is commenced with an artery forceps followed by a Veress needle with a radially expanding sheath, which is advanced in the midline with laparoscopic guidance from above entering the pelvis in the midline immediately posterior to the urethra in the male. The magnified view of the pelvic floor afforded by the laparoscope enables accurate placement in the 'v' of the puborectalis sling. The sheath is left in situ and the needle removed prior to gently dilating the tract in a gradual manner to 5 mm and then 10 or 12 mm. The rectum is then grasped from below and drawn down through the tract to be anastomosed to the skin at the neo-anus. A recent study has compared the anorectal angle and continence using this technique with that in the posterior sagittal approach [35]. This confirmed that a similar anorectal angle is achieved in both operations and that the laparoscopic approach has less detrimental functional impact.

15.3.9 Necrotising Enterocolitis

Laparoscopy in the initial evaluation of NEC is invaluable and can help to avoid potentially un-necessary surgery in an already extremely unwell infant [36]. In tiny preterm infants it is best to insert a 3.5 mm port at the umbilicus by the open technique and then the abdomen is insufflated with CO_2 at a flow rate of 0.2 L/min to a pressure of 5 mmHg. A 3 mm 30° telescope is used. In some cases free intestinal content may appear at the umbilicus whilst performing open access for the first port in which case there is obvious perforation and little visibility on inserting the telescope may indicate the need for laparotomy. On the other hand if there is no sign of free fluid on gentle inspection at laparoscopy then conservative management can be continued and the morbidity of a laparotomy in an extremely sick premature infant is avoided. Pneumatosis may be clearly visible (Fig. 15.10). This correlates with the preoperative radiological appearance (Fig. 15.11).

If necessary the laparoscopy can be performed in the neonatal unit. After an appropriate period of conservative management contrast studies of the bowel are advised prior to re-introducing feeds. If an isolated stricture is identified then further laparoscopy allows the area to be mobilized and exteriorized at the umbilical port site for resection and anastomosis. Even a tiny premature infant with severe necrotizing entero-

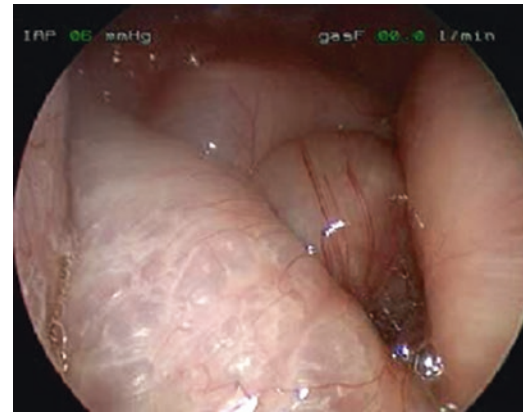

Fig. 15.10 Visualisation of pneumatosis intestinalis in NEC

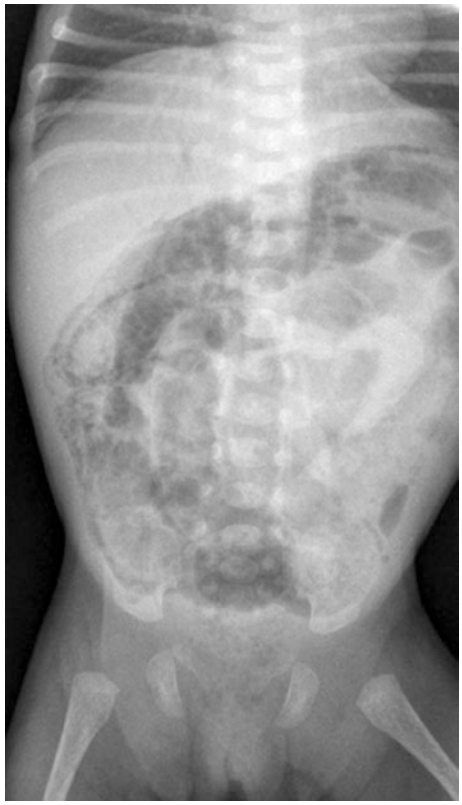

Fig. 15.11 Pre-operative x-ray showing pneumatosis

colitis can grow up with an abdomen with imperceptible scars.

15.3.10 Biliary Tract

The laparoscopic Kasai procedure was first described in 2002 [37] and subsequently a few cases were published but the results seemed not as good as the conventional open repair. At a meeting of the International Pediatric Endosurgery Group in 2007 it was concluded that the results were inferior and the procedure was not recommended [38]. A prospective study was stopped after inclusion of 12 laparoscopically operated infants due to a lower survival with the native liver after laparoscopic versus conventional Kasai operation [39].

In Japan and elsewhere in the East where the condition is more common they aim to make the laparoscopic dissection of the porta hepatis as close as possible to Kasai's original description and the longer term results are awaited [40, 41].

Certainly the laparoscopic approach for correctable biliary atresia is well suited to the laparoscopic approach as is choledochal cyst excision. Whilst I have successfully performed a number of these resections laparoscopically we cannot compete with the large numbers in the Far East [42].

For choledochal cyst excision a 5 mm port is placed in the inferior umbilical fold by an open technique. CO_2 pneumoperitoneum is established at 10 mmHg with a flow rate of 1 L/min. Two further 3.5 mm working ports are positioned in the left and right upper quadrants. A Nathanson Liver retractor is inserted in the epigastrium to give good exposure of the gallbladder, choledochal cyst and porta hepatis (Fig. 15.12). An intraoperative cholangiogram is performed via a flexible needle passed through the abdominal wall into the gallbladder.

It is sometimes helpful to mobilise the gallbladder from its bed early in the dissection and it can be used to provide traction during dissection of the cyst. Dissection is largely performed using a 3 mm monopolar diathermy hook. The cyst is dissected carefully keeping close to the

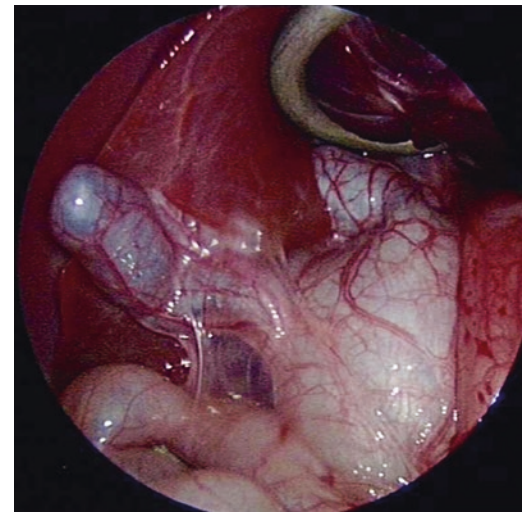

Fig. 15.12 Laparoscopic view of gall bladder and dilated cystic duct leading into choledochal cyst

cyst wall and separating it from the pancreas, duodenum, portal vein and hepatic artery. Occasionally I find that the communication with the duodenum is barely perceptible but if identified it is closed with an absorbable suture. Once the cyst is freed right up to the common hepatic duct it is left in situ whilst a Roux-en-Y jejunal loop is constructed. The jejunum is traced down from the duodeno-jejunal junction and the chosen loop exteriorized at the umbilical port site for the Roux-en Y construction prior to returning it taking it retro-colically up to the porta. The cyst content is aspirated percutaneously and the common hepatic duct transected. The cyst can be extracted via the umbilical port site (Fig. 15.13). An end to side hepato-jejunostomy is performed using interrupted 5/0 absorbable sutures. A suction drain is positioned below the anastomosis and the ports removed and the wounds closed.

If preferred it is simpler and quicker to perform a hepato-duodenostomy and Liem [42] claims that the incidence of ascending cholangitis is not significantly greater than hepato-jejunostomy. (I have used this technique in one case with an operative time of around 2 h, less than half the time taken for hepato-jejunostomy).

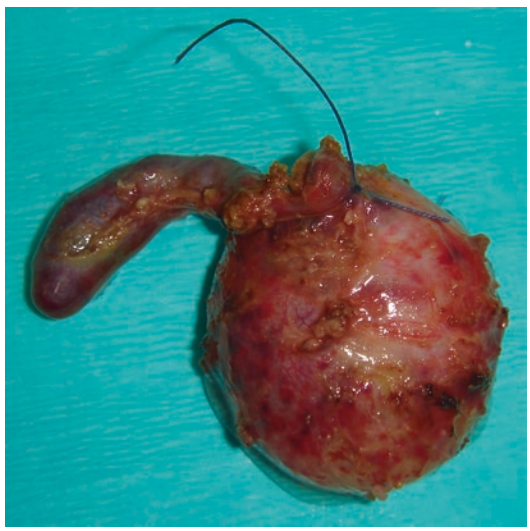

Fig. 15.13 Excised choledochal cyst with gallbladder attached

15.3.11 Pancreas

For hyperinsulinism in the neonatal period, refractory to medical management, the laparoscopic approach to the pancreas is easier than open surgery in view of the great magnification of the anatomy, which is beautifully displayed. Laparoscopic pancreatectomy for persistent hyperinsulinemic hypoglycemia of infancy was first described in 2001 [43]. The approach is with a 5 mm port at the inferior umbilical fold and two further 3.5 mm ports in the right and left upper quadrants. Exposure is facilitated with two stay sutures through the abdominal wall picking up the antrum and body of the stomach [44]. Dissection is performed using a monopolar 3 mm diathermy hook carefully dissecting the pancreas from surrounding structures. If a focal nodule is identified this can be excised otherwise, as in open surgery, dissection is continued up to the common bile duct and the pancreas transected at this level and suture ligated.

15.3.12 Ovarian Cyst

Laparoscopy is excellent in establishing the diagnosis in a neonatal intra-abdominal cyst distinguishing ovarian cysts from duplication and other intra-abdominal cysts. Percutaneous aspiration under ultrasound guidance is potentially dangerous [45].

A 5 mm port is placed in the inferior umbilical fold by open technique after infiltrating with 0.25% Marcaine with adrenaline. The abdomen is insufflated to 8 mmHg at a flow rate of 0.5 L/min. A 30° telescope is introduced and the cyst is visualized. The cyst may be punctured under direct vision inside the abdomen and then the deflated cyst can be exteriorized via the umbilical port site and treated as appropriate depending on how necrotic it is. Occasionally on inspection a cyst may be auto-amputated with no attachment and the ovary may be absent on one side confirming the diagnosis [46].

15.3.13 Intersex

Laparoscopy can be useful as part of the multidisciplinary work up of a neonate with ambiguous genitalia. Laparoscopic biopsies of gonads may be taken if required.

15.4 Tumour Surgery

15.4.1 Renal Tumours

Laparoscopic nephrectomy may be performed in the neonate for conditions such as mesoblastic nephroma in which case the tumour is mobilized laparoscopically and extracted via a Pfannenstiel incision in a bag.

15.4.2 Hepatic Tumours

As part of the diagnostic work up of a newborn with a hepatic lesion it is safe to perform trucut biopsy under laparoscopic guidance. As bleeding may be quite significant this is safer than percutaneous ultrasound guided biopsy. It is very important to position an additional 5 mm port prior to the biopsy to enable the introduction of an endopledget. This is held close to the biopsy site as the needle is withdrawn to be able to apply local pressure and control any potential haemorrhage.

15.4.3 Sacrococcygeal Teratoma

In cases of large sacrococcygeal teratoma in a haemodynamically unstable infant it is helpful to use a laparoscopic approach to interrupt the median sacral artery. It is also helpful in dissection of the intrapelvic component [47].

15.5 Inguinal Hernia

Whether or not inguinal herniae in children should be routinely performed laparoscopically is a matter for debate. The numbers of cases are large and the majority, in most centres, are performed by open surgery.

In the neonate and premature baby however the hernia sac is easily torn during open surgery and it can become a frustrating and tedious operation particularly for surgeons in training. The laparoscopic approach, providing that the surgeon has acquired the necessary skills, may be simpler and also may reduce the likelihood of injury to the vas in males, as the magnification is so great. It also enables the evaluation of the contralateral side.

The baby is placed supine on the operating table and the bladder emptied by a Credé manoeuvre a 5 mm port, or smaller, is inserted in the inferior umbilical fold. The abdomen is insufflated with CO_2 to a pressure of 8 mmHg at a flow rate of 0.5 L/min. A 30° telescope is used. Two further 3.5 mm ports are inserted at a slightly lower level in either flank. If desired the instruments can be passed through tiny stab wounds, avoiding the use of ports and affording greater cosmetic benefit. Putting the baby in a Trendelenberg position gives good exposure of the internal inguinal rings as the bowel is displaced by gravity. A 3/0 absorbable suture on a round-bodied needle is inserted through the abdominal wall and grasped with a laparoscopic needle holder. The internal inguinal ring can be closed with a purse string suture or an N or Z type closure is achieved [48]. Some prefer to incise at least part of the peritoneum at the internal ring prior to the suturing in the hope of reducing recurrence.

Others use a laparoscopic assisted extraperitoneal technique [49] in which a special 'herniotomy hook needle' (similar to an aneurysm needle) is used. The hook is prepared with a monofilament absorbable suture and passed through a 2 mm stab incision made over the internal inguinal ring and the hook is passed retroperitoneally from lateral to medial lifting the peritoneum forward from the vas and vessels and once beyond them is brought into the peritoneal cavity where a grasper holds the suture as the needle is withdrawn to a subcutaneous position prior to advancing it round the

remainder of the circumference of the internal ring back to the suture. This is threaded through the needle, which is withdrawn, thus completely encircling the hernial sac. It is then ligated externally closing the internal ring and burying the knot subcutaneously. The recurrence rate with this method is said to be minimal.

Conclusion

Many senior paediatric surgeons argue that evidence is lacking for changing from open surgery to minimal access surgery. It is true that there have been very few randomised controlled trials to support the approach. Small incisions for laparoscopic ports are just a different approach to the abdomen. I doubt that when surgeons determined that they could open the abdomen via a midline, paramedian, subcostal, Pfannenstiel incision etc. that randomised trials were demanded. The time has come to accept the laparoscopic approach that has been proving its success in paediatric surgery over more than two decades. Although we as paediatric surgeons pride ourselves in making small neat wounds which are closed with subcuticular sutures or even skin glue the scars grow with them and underlying them is a potential for adhesive problems which are not as common with endoscopic surgery. Children deserve to grow up without scar even if they require major surgery. I am sure that the next generation of surgeons will be surprised to learn that surgeons used to open up body cavities through big incisions. Our adult surgical colleagues have adopted the endoscopic approach in many areas. We are fortunate that paediatric surgery covers an age range rather than an organ system and these techniques are applicable for most of the surgery that we perform. The neonate especially can benefit with less long-term morbidity.

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