8 Prevention and Treatment of Surgical Complications in Patients with Retroperitoneal Tumor

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According to our recent studies, the rate of combined multiple organ resection was 25.2% among 523 cases of retroperitoneal tumor (RPT) surgeries. The most common combined abdominal and pelvic organ resections include kidney resection (n = 73, 13.96%), partial resection of small bowel (n = 51, 9.75%), adrenalectomy (n = 25, 4.78%), partial ureteral resection n = 22, 4.21%), resection of pancreatic body and tail (n = 20, 3.82%), adnexal resection (n = 15, 2.87%), splenectomy (n = 13, 2.49%), partial duodenal resection (n = 10, 1.91%), cystectomy (n = 10, 1.91%), distal gastrectomy (n = 7, 1.34%), and hysterectomy (n = 5, 0.96%). Major blood vessel excision and reconstruction are common during RPT surgery. Therefore, the complication rate of RPT surgery is relatively high. The proper treatment of intraoperative and postoperative complications is essential to RPT therapy.

1 Massive Bleeding

The most common and severe complications of RPTs are macrovascular damage and massive bleeding. Due to a large size and deep location, RPT frequently compresses and squeezes blood vessels. Furthermore, because of the limited size of incision, the compressed blood vessels are not well exposed during the tumor separation. As a result, blood vessels are easily damaged, thus causing bleeding.

1.1 Systemic Treatment of Bleeding

Bleeding is the most serious complication of RPT surgery, which may be attributed to the following factors: (a) accidental injury resulting in rupture of major retroperitoneal vessels, such as abdominal aorta, inferior vena cava, iliac vessels, mesenteric vessels, and vessels supplying blood to retroperitoneal organs, (b) rupture or bleeding of large thick tumor-supplied blood vessels surrounding the tumor during the separation, (c) isolation of RPT through presacral space leading to presacral vessel rupture and bleeding, and (d) coagulation dysfunction causing persistent errhysis from tumor bed following excision.

If massive bleeding (such as more than 3000 ml) occurs during RPT surgery, patients may experience hemorrhagic shock, characterized by dramatic drop in blood pressure and increase in heart rate, due to hypovolemia. Under such condition, patients should be closely monitored for vital signs by anesthesiologists, for whom invasive arterial pressure monitoring is the preferred choice. Meanwhile, rapid supplementation of

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plasma, RBCs, plasma substitute, and other anti-shock strategies should be applied. Surgeons must keep calm and not blindly clip bleeding points with forceps in order to avoid accidental injury to important major blood vessels or retroperitoneal organs if unexplained bleeding occurs. Furthermore, the rupture of major retroperitoneal blood vessels may become wider and wider due to the forceps, thus causing heavier and heavier or even life-threatening bleeding. At this point, surgeons should immediately stop bleeding with fingers, gauze, or gauze pad while quickly ascertaining the causes of bleeding. If bleeding occurs to major blood vessels, the rupture zone is generally small and should be pressed by the first assistant gently. The repair should not be performed until the tumor has been separated from the ruptured blood vessel, making it extremely difficult to repair the vessel without free ends. Conversely, the repair will cause the rupture zone to become wider and eventually fail. As a result, the ruptured blood vessel has to be sacrificed, leading to the removal of tissues that lose blood supply. Until the tumor is successfully separated from blood vessel to a certain extent, the ruptured blood vessel cannot be controlled and sutured with noninvasive techniques under direct vision.

Postoperative bleeding is the most common complication following the surgery of RPTs, and if not treated promptly, it can result in serious consequences. The causes of postoperative bleeding include (a) bleeding of RPT surgical wound. Although a thorough hemostasis is performed before the end of surgery, patients with large surgical wounds may experience severe bleeding postoperatively due to coagulation dysfunction, especially within 24 h after surgery; (b) individual small vessel bleeds due to failure of ligature; and (c) since the intraoperative angiorrhaphy is not performed precisely, anticoagulant therapy that is conducted to prevent postoperative thrombosis may cause bleeding at the repair site. Patients with RPTs usually receive large doses of conventional hemostatic substance after surgery. Dynamic changes in hemoglobin level as well as the nature and amount of peritoneal drainage should be closely observed. If the abdominal drainage is dark bloody with an increase in quantity, coupled with continuous decline in hemoglobin level, abdominal bleeding may be highly suspected. If no improvement has been observed following volume expansion with appropriate blood transfusion, exploratory surgery should be considered to stop bleeding. In most cases, no significant vascular hemorrhage is seen in the secondary exploratory surgery; however, numerous blood clots can be identified locally, which consume large amounts of coagulation factors. Thus, blood clots are removed intraoperatively, and the bleeding area is fully burnt with argon knife or electric knife. After flushing with a large volume of normal saline, the drainage is repositioned, and then a sufficient number of platelets or fresh blood are infused, supplemented with hemostatic drugs. The above approaches can be used effectively to stop bleeding. If vascular ligature falls off and active bleeding persists locally, the bleeding points should be carefully sutured. If the vascular repair site bleeds, the vessel rupture should be completely closed with Prolene (polypropylene) suture. The bleeding from vessels supplying blood to tumors around RPTs may be controlled with clamps and by suture or ligation.

1.2 Topical Treatment of Bleeding

Major retroperitoneal arteries have thick walls. The outer membrane closely attached to the tumor should be separated for complete resection of RPTs, so the artery is usually intact during the separation. However, local vascular wall may be damaged due to a long-term compression of artery. Sometimes, even the separation of outer membrane can break the fragile blood vessels, leading to heavy bleeding. This phenomenon is frequently seen in RPTs located in the lower abdomen and pelvis. For example, the iliac arteries, including the common iliac artery and external iliac artery, may be squeezed into a bow-like shape. These arteries are partially wrapped and occasionally even wholly enclosed by the tumor. If arterial bleeding occurs, surgeons should try to fully separate the arteries, dissociate, and block the proximal and distal ends of the compressed arteries in principle to avoid heavy bleeding. In

case of severe damage, the suture and repair can cause a tear in the arterial wall, so vascular transplantation is required following resection of such vessel segment. The separation may accidentally damage the inferior vena cava; however, the repair is not difficult thanks to its wide diameter, thick wall, and easy dissociation, which can be conducted after clamping with noninvasive vascular forceps, and the suture rarely results in stenosis of the blood vessels. Once it is broken and bleeds during the separation, renal vein is mostly repaired under direct vision, and if it is difficult to repair, the renal vein may be alternatively pressed by surgeons' fingers. The repair cannot be resumed until the tumor is removed. Once the superior mesenteric vein is broken and bleeds, surgeons must keep calm and not blindly clamp the blood vessel with forceps. In such case, part of the mesentery can be clamped with noninvasive vascular forceps. The repair should be appropriately conducted only after the resection or dissociation of the tumor has been completed. Improper suture can often cause stenosis of blood vessels and subsequently lead to postoperative thrombosis.

1.3 Prevention and Treatment of Wound Bleeding and Coagulation Dysfunction

Since the surgery of RPTs usually generates larger wounds, the hemostasis for the wounds is vital to the safety of the operation. Wound bleeding is more common than major vascular bleeding, which may exceed 5000 ~ 10,000 ml in volume. Causes of bleeding include (a) the presence of rich collateral circulation between the tumor and abdomen or internal organs, and especially collateral circulation opened in tumors with active metabolism, leads to exposure of wound vascular network; (b) the surgery that requires a long time causes consumption of large amounts of coagulation factors, while lots of coagulation substances are transfused into bodies, coupled with hemodilution after infusion of large volume of liquid, jointly resulting in postoperative coagulation disorders. Emphasis should be laid on comprehensive treatment of oozing wound. The important factors associated with the coagulation dysfunction include the operation time of more than 4 h, intraoperative blood loss of more than 3000 ml, infusion of liquid volume of more than 5000 ml, and transfusion of blood reserve of more than 3000 ml. Preoperative malnutrition, liver dysfunction, or history of chronic liver impairment can adversely affect the synthesis of coagulation substances in the liver, making patients more susceptible to coagulopathy. Most of patients with RPTs need vitamin K supplements intraoperatively and procoagulant drugs intraoperatively. If there is a significant bleeding tendency, with more wound bleeding and fewer blood clots, one to two vials of fibrinogens should be intravenously infused to rapidly and effectively improve coagulation function. If it is difficult to correct coagulation abnormalities, the surgery should be completed as soon as possible. Spray coagulation with argon knife achieves good effects on minor wound oozing, which can be used together with various hemostatic sponge and gauze. For severe and extensive wound bleeding during RPT surgery, complete hemostasis is often infeasible. Never attempt to stop bleeding for a long time intraoperatively. The longer the operation time, the worse the coagulation function and the heavier the bleeding. When the speed of blood transfusion cannot keep up with that of bleeding, serious circulatory failure may occur. In this case, the wound should be packed with gauze to quickly terminate the surgery. Abdominal bandage compression strategy may be a preferred option for alleviating the crisis. Hemostasis with packs (tamponade) can gain time for saving patients' lives while creating conditions for the improvement of coagulation.

Key points of hemostasis with packs (tamponade) include clearing uncoagulated blood in surgical field and then quickly packing the wound with gauze. Intrauterine packing with gauze is a commonly used method, namely, placing one end of continuous strip of gauze into the deepest wound and the other end outside the abdominal wall for convenience of removal. The blood vessels may be directly compressed by multiple large gauze pads. The number of gauze used for

packing depends on the expected compression volume, usually 3 ~ 5 strips for a small volume and more than 8 ~ 10 strips for a large volume. All gauzes should be dry and packed promptly to reduce and prevent failure caused by blood soaking.

Gauze removal: the gauze is generally removed 3–5 days after the surgery. If the general condition of the patient is improved with basically normal blood clotting function and occlusion of small bleeding vessel, the gauze may be removed at 3 days after operation. If the gauze is removed at more than 5 days after surgery, secondary abdominal infection may occur. The timing to remove the gauze is determined by the intraoperative bleeding and postoperative improvement of general condition. If minor bleeding occurs intraoperatively, intrauterine gauze for packing should be placed in an orderly manner to ensure good accessibility and hemostasis effect, which can be removed under inhalation or intravenous anesthesia. If a secondary surgery is expected to stop bleeding, the patient should be under general anesthesia and gauze removed under direct vision with the incision opening.

1.4 Injury and Bleeding of Presacral Venous Plexus

The risk of resection of pelvic RPTs is very high due to the large tumor volume and difficulty in surgical field exposure. If RPT adheres to or invades presacral tissue, bleeding of presacral venous plexus will frequently occur in the separation process of tumors. Presacral venous plexus is an "H"-shaped blood pool that is comprised of inferior vena cava system, transverse sacral venous system, and sacral vertebral venous system, which lacks venous valve and allows blood to flow bidirectionally. During the resection of pelvic RPTs, torrential bleeding may occur if presacral fascia is injured or the presacral venous plexus is torn, which may be life threatening. The bleeding of presacral space is often difficult to be controlled by suturing due to lack of soft tissue. If possible, the bleeding vessels should be clearly identified before ligation or suture, or otherwise the blind ligament or suture may lead to heavier bleeding. Clinically, we always firstly stop bleeding with gauze packing oppression, using a small piece of gauze shaped like a peanut; secondly, we apply large curved forceps to rapidly block bleeding by accurate oppression. Under direct vision, the smaller the oppression range, the better the hemostatic effect. Bleeding points are then clamped with titanium clips or absorbable clip or stapled with thumbtacks plus hemostatic sponge. Alternatively, the bone surface is directly sutured with a small triangular needle and thin thread. Keep in mind that bleeding points are difficult to be controlled with circular needles, which may even cause heavier bleeding. If the hemostasis for presacral bleeding can't be achieved during the surgery of RPTs, surgeons should decisively stop bleeding by gauze packing to complete the surgery as soon as possible in order to prevent excessive blood loss, rather than repeatedly attempting to use other methods.

The author has reported one case of external iliac artery sigmoid resection and transplantation combined with sigmoid resection and anastomosis, whose arterial anastomotic site was close to colonic anastomotic site. On day 7 after the surgery, a large amount of blood in the stool was detected. After exploration, two anastomotic sites were confirmed to be channeled. Colostomy was conducted to repair the anastomotic sites of the blood vessels. If two anastomotic sites had been separated by omentum during the first surgery, this complication would have been avoided.

2 Injuries and Fistula of Digestive Organs

Any part of the digestive system that is pushed or compressed by RPTs may be damaged accidentally during tumor resection.

As a large RPT in the upper right abdomen can cause significant displacement of the duodenum, the wall of duodenum that may be damaged in the separation process should be carefully sutured. Retroperitoneal tumors located in the left upper abdomen sometimes can cause significant displacement of the body and tail of the pancreas or spleen. If spleen is broken during the surgery, it

can be repaired with clogging agent or suture after tumor resection; occasionally, subsequent splenectomy is necessary. If pancreatic injury occurs, the damaged area should be sutured carefully.

Risky factors attributed to the high incidence of digestive fistula after resection of RPTs include postoperative hypoproteinemia and other malnutrition; distal intestinal obstruction syndrome after surgery, coupled with high pressure in proximal intestine; intestinal rupture without being repaired during the separation of adhesion, or only intestinal serosa and muscle are damaged but high pressure in the intestine after surgery leading to rupture; multiple intestinal repair and anastomosis intraoperatively; and anastomosis and repair of gastrointestinal tracts that have not been subtly conducted by surgeons. Preventive procedures are as follows: (a) improve the postoperative nutritional status as possible; (b) strictly check if any intestinal injury is missed by chance; (c) if intestinal resection and anastomosis are performed, ensure good intestinal blood supply and tension-free anastomosis; (d) guarantee that distal intestine is smooth and the adhesion is fully loosened; and (e) if high-risk factors attributed to fistula still exist, establish intraoperative bypass through the stoma, or place a plurality of drainage catheter or double catheter if necessary. Once gastrointestinal fistula occurs after surgery, complete drainage should be conducted timely, and reoperation with supplementary cannulation or establishment of bypass through proximal intestinal stoma should be performed if necessary.

If the resection of RPT is incomplete and the distal obstruction is suspected, duodenal injury will increase the risk of fistula. Duodenal fistula with very high mortality is extremely difficult to treat once it occurs. Therefore, in terms of duodenal injury, gastrostomy for decompression, "T"-tube drainage of common bile duct, and placement of jejunal feeding tube should be considered on the basis of repair, in order to improve the healing rate of the fistula.

Pancreatic fistula is associated with pancreatic injury caused by RPTs. If pancreas is damaged or partial pancreas is resected intraoperatively, drainage catheter should be placed locally to maintain unobstructed drainage and to prevent abscess formation. If intractable pancreatic fistula is expected after surgery, silver clip marker is placed intraoperatively for future radiotherapy. For patients with minor pancreatic fistula, partial drainage is mostly effective, and for those with severe pancreatic fistula, double-catheter flushing can reduce the corrosive effects of pancreatic juice on the surrounding tissue, thus facilitating healing process. Patients who remain unhealed after receiving more than 6 weeks of drainage may be treated with a low dose of radiation. Patients who develop pancreatic pseudocyst may undergo ultrasonic intervention and subsequently receive electively internal drainage if ineffective.

Artery-intestinal fistula (fistula between arteries and the gastrointestinal tract) after RPT resection combined with intestinal and arterial resection and reconstruction is the most serious and dangerous complication in RPT surgery. It prevails in gastrointestinal anastomosis while overlapping vascular anastomosis. The interaction between vascular pulsation and inflammation of gastrointestinal anastomosis leads to intravascular gastrointestinal fistula. Clinically, patients present with sudden gastrointestinal bleeding. If postoperative gastrointestinal bleeding occurs in patients who undergo RPT surgery with gastrointestinal anastomotic site located close to suture points of blood vessels, intravascular gastrointestinal fistula rather than simple anastomotic bleeding or stress ulcer bleeding should be considered. Once intravascular gastrointestinal fistula is suspected, an emergency surgical exploration should be conducted firstly to stop bleeding. The purpose of preventive strategy is to maintain a certain distance between gastrointestinal anastomosis and vascular anastomosis as possible; if it is impossible, omentum or peritoneum should be used to keep them apart. If sigmoid colon and rectum anastomotic site overlaps iliac artery anastomotic site, colostomy is a much safer choice.

3 Cardiopulmonary Complications

Large RPTs often compress iliac vein or inferior vena cava. Removal of the tumor relieves the oppression; consequently a lot of water reflux

may lead to heart failure in patients who have already presented with lower extremity edema before operation. Common clinical presentation is refractory heart failure, characterized by temporary improvement after treatment with diuretics and recurrence in 3–4 h later. These patients should be closely monitored for central venous pressure in the first 3 days after surgery. In addition to limiting fluid intake, appropriate diuretics are administered. Major RPT surgery requires high oxygen consumption, thus causing relative myocardial hypoxia, and sometimes a decline in blood volume may result from blood loss. All these risk factors can contribute to heart failure, so this surgery is not suitable for elderly patients or those with cardiac dysfunction.

Pulmonary infection, atelectasis, and pulmonary embolism are common postoperative pulmonary complications in RPT surgery. Pulmonary infection is related to long operation time, major trauma, and trauma reaction-induced sodium retention, heart failure, pulmonary edema, reactive pleural effusion, and poor pulmonary reserve function caused by major abdominal surgery especially partial diaphragm resection. Those with pulmonary dysfunction and large RPTs are susceptible to pulmonary complications; thus, appropriate antibiotic prophylaxis should be performed preoperatively. Patients whose surgeries require a longer duration or frail elderly patients who have difficulties in excreting sputum are prone to developing postoperative atelectasis, and therapists may assist these patients with sputum expectoration or perform sputum suctioning with a bronchoscope if necessary.

The risk factors for postoperative pulmonary embolism include invasion or oppression of major veins caused by RPTs, intraoperative injury of veins, or pre-existing venous thrombosis and tumor thrombus. As pulmonary embolism caused by RPTs is often a fatal complication, emphasis should be laid on prevention, including preoperative prevention of hypovolemia, preventive placement of inferior vena cava filter, intraoperative prevention of damage or excessive mechanical compression of vein wall, and postoperatively preventive anticoagulation.

4 Damage and Complications of the Urinary System

Ureter can be pushed forward or moved to contralateral abdomen by RPT, thus presenting a bow-like shape. Ureteral catheters should be placed before surgery in such a way that they are easily identified during the surgery. It is not difficult to separate the tumor capsule from the ureter; however, special care should be taken to prevent injury to ureteral blood supply. Once it is injured intraoperatively, the ureter should be repaired after tumor resection. If a ureteral segment is resected, the broken free ends of the segment should be gathered together and anastomosed; if all else fails, the free proximal end of the ureter may be anastomosed to the contralateral ureter. If patients undergo repair and anastomosis, a double-pigtail "D"-shaped catheter should be placed in the ureter, with the upper end positioned in the pelvis and the lower end inserted into the bladder. The drainage must be placed at the site of repair as leakage of urine frequently occurs at the early stage after operation and gradually reduces until healed. Usually, the catheter used as a stent can be removed from the bladder with cystoscopy within 3–4 weeks. As large RPTs located in the pelvis can compress and squeeze the bladder, it is challenging to identify the ureter that has run into the triangular area. Surgeons should localize the ureter in the proximity and then trace back to the triangular area in the bladder and finally separate it from the tumors. If the tumor involves the triangular area in bladder and the bladder wall in the triangular area is injured intraoperatively, including partial resection of this portion, the anastomosis of bilateral ureters and apex urocyst can be performed. If it is hard to perform anastomosis, ureterosigmoidostomy and ileum fistulation or ostomy by which ureter directly runs in vitro may offer alternative options.

The surgery of retroperitoneal liposarcoma that is mostly derived from perirenal fat tissue is often accompanied by unilateral nephrectomy; in conjunction with a long-term intraoperative hypotension and large surgical trauma, patients

are susceptible to postoperative renal dysfunction. Patients should be closely observed for changes in renal function and any drugs that may be harmful to kidneys should be contraindicated.

Leiomyosarcoma located in inferior vena cava may involve the entire right and left renal veins. En bloc resection of the tumor together with inferior vena cava, as well as right and left renal veins, may be performed without reconstruction and transplantation of inferior vena cava; however, the urine in the bladder should be emptied after disruption of inferior vena cava and right kidney during surgery, and then the left renal vein is blocked, and 20 mg furosemide is administered intravenously. After half an hour's observation, the discharge of more than 100 ml of urine indicates that the left kidney loop can flow back via the established collateral vein and recover to normal function. Most patients can maintain normal renal function postoperatively.

5 Damage of Nerve Tissue

Primary RPTs can arise from nerve tissue. If the basal part of tumor is located at the intervertebral foramen, complete resection is likely to injure spinal nerves. The damage to unilateral single nerve root generally does not cause serious complications, but the involvement of multiple spinal nerves may result in corresponding symptoms of nerve injury. Sometimes, if the base of neurofibromas is located in the spinal canal, joint surgery should be performed in cooperation with neurosurgeons. During the surgery, surgeons firstly remove the outer layer of the spinal canal followed by partial tumor within the spinal canal.

Retroperitoneal tumors located in the lower abdomen and pelvis often compress sciatic nerve or femoral nerve. In some cases, femoral nerve can be completely wrapped by RPTs. If femoral nerve is resected together with the tumor, resulting in complete loss of function, patients will be unable to contract quadriceps muscle or to walk without the aid of crutches postoperatively. However, some patients do walk without the aid of crutches and require no further treatment during 1 or 2 years of follow-up. If symptoms are not improved, patients may undergo secondary surgery which transfers partial knee flexors into extensors in order to correct the extension function of the knee joint.

Some RPTs in the pelvic sidewall, which grow backward through the greater sciatic foramen, can compress the sciatic nerve. For this reason, the sciatic nerve is easily damaged during the removal of the tumor. Complete resection of sciatic nerve that is partially injured is rarely performed. Sciatic nerve injury may cause drop foot complication or intractable lower-limb pain and even inability to stand. If the RPT causes an extensive damage of peritoneum plexus, postoperative gastrointestinal paralysis and intestinal pseudo-obstruction can be observed when the injury is located in the upper abdomen, whereas voiding dysfunction, urinary incontinence, fecal incontinence, and other symptoms will be expected when the injury is located in the lower abdomen and pelvis.