Vascular Complications

12

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General Considerations

Vascular complications are one of the most common and urgent complications encountered during robotic urologic surgery. Although complication rates for robotic surgery compare favorably with their open and laparoscopic counterparts [1], complications can occur during any stage of surgery, including during initial access and port placement, intraoperatively, and postoperatively. Timely recognition and a calm, thoughtful response are critical to ensure minimal harm to the patient. Management may require blood transfusions, open conversation, angioembolization, or reexploration.

Avoidance of vascular complications requires appropriate patient selection, knowledge of the surgical anatomy, and proper surgical technique. Thorough preoperative planning and preparation can go a long way toward reducing the risk of vascular complications. All imaging studies should be reviewed prior to surgery to identify anatomic variations. Preoperative coagulation tests should be obtained on high-risk patients. When appropriate, anticoagulation/antiplatelet agents should be held prior to surgery.

At the time of a suspected vascular injury, the surgeon must quickly decide if it can be managed with a minimally invasive approach or if open conversion is necessary. In fact, vascular injuries are the most common cause of open conversion. Patient safety should be the only concern in this situation, not maintenance of a minimally invasive approach, as this is a life-threatening situation. Eighty-one percent of deaths during laparoscopic surgery were attributed to major vascular injuries [2]. An open tray should always be available in the room and ready to be opened without advanced notice. If open conversion is necessary, a large incision should be used. A midline location typically works well, depending on patient positioning and the procedure being performed. Obtain proximal and distal vascular control, and repair the injury.

In the event of a major intraoperative vascular injury, anesthesia should be notified immediately so that they may request blood products and begin hemodynamic resuscitation of the patient. Additional surgical, nursing, and anesthesia staff may be required. Vascular or trauma surgeons may be called into the room if needed.

This chapter discusses common intraoperative and postoperative vascular complications including thromboembolic complications. Procedure-specific vascular injuries are discussed in their respective chapters.

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Access-Related Complications

Seventy-five percent of major vascular injuries occur during initial access for laparoscopic cases [3, 4]. Initial access can be obtained with either a closed or open technique (Veress needle technique or Hasson technique, respectively). Veress needle access entails blind puncture of a hollow needle with a retractable blunt tip. Insufflation is through the needle. Hasson (open entry) technique entails obtaining access via sharp dissection through all layers [5, 6]. When choosing the location to obtain initial access and deciding between an open versus closed technique, keep in mind if the patient has had previous surgeries and the location of previous incisions. Choose a site a safe distance away from scars. Prior to attempting initial access, always ensure a working camera, insufflation, cautery, and laparoscopic suction. Precious time may be wasted setting up equipment after a suspected injury has occurred.

The AUA Handbook of Laparoscopic & Robotic Fundamentals concluded there was insufficient evidence to recommend one technique over another for obtaining access [7]. Although there is likely a greater incidence of vascular injury with the closed technique, the open Hasson technique does not eliminate the risk of vascular injury [8–10]. The most commonly injured vessels are the aorta, the inferior vena cava, the iliac vessels, and the epigastric vessels [11]. When the great vessels are likely to be near the site of access, the Hasson technique may be preferable [12]. The open approach may also be preferable for children, very thin patients, and patients with extensive adhesions. In some instances, access may be preferable through a retroperitoneal or extraperitoneal approach.

Ultimately, comfort and familiarity with different access approaches are critical when encountering difficulty in gaining access.

Veress Needle Injury

The reported incidence of vascular injury during Veress needle access is low [8, 13–16]. A meta-analysis reported a 0.23% risk of vascular injury with the Veress technique [15]. During needle passage, there is a risk of injury to superficial abdominal wall vessels or deeper abdominal, retroperitoneal, or pelvic vessels. Very thin and obese patients are at an increased risk for injury as the angle and distances of common surgical landmarks and vascular structures are different. During Veress needle insertion, the needle should be advanced without exerting too much force. Two distinct “pops” or “clicks” should be felt/heard as the needle is advanced through the fascia and the peritoneum. The angle of the needle during insertion should be adjusted based on patient body mass index (BMI) from 45° in nonobese patients to 90° in obese patients (Fig. 12.1) [17]. Decide in advance the number of attempts of Veress needle passage before switching to open access. The bifurcation of the great vessels is approximately at the level of the umbilicus, placing the right common iliac artery at risk when obtaining access from a periumbilical location.

After placement of a Veress needle, the needle should always be aspirated to assess for blood. This is done to recognize vascular injuries and prevent insufflation into vascular structures. Possible causes of injury include incorrect angle of insertion and/or too much axial force on the needle during insertion. If blood is withdrawn during aspiration, access should be obtained in a different location. Some surgeons prefer to leave the needle in place with the stopcock closed, without further manipulation of the needle, to help identify the location of the injury. Others prefer to remove the Veress needle if a vascular injury is suspected, before attempting access in a different location. Either approach is normally acceptable as most Veress needle vascular injuries are small and do not require repair. If a major vascular injury is suspected, however, the Veress needle should always be left in place to facilitate quick identification of the location of the injury.

Insufflation should not be performed through a Veress needle into a suspected vascular structure as this may cause a CO_2 embolism. CO_2 embolism presents as acute circulatory collapse with elevated central venous pressure (CVP), elevated right heart pressure, hypoxia, hypercarbia, and a stereotypical “mill wheel” heart

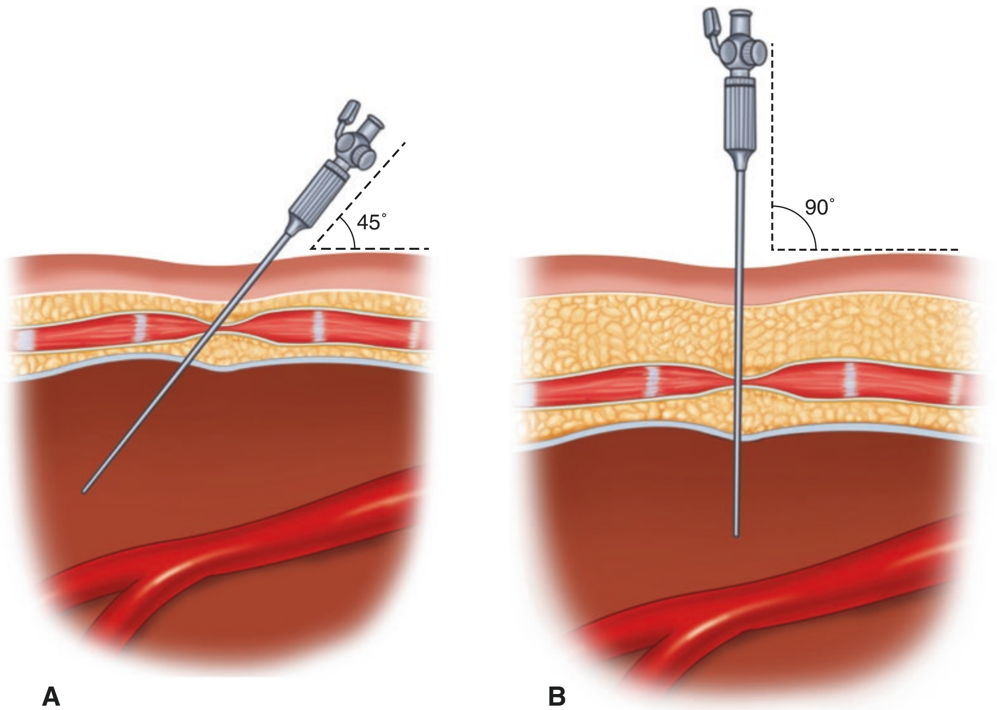

Fig. 12.1 Angle of Veress needle during placement in nonobese (**a**) and obese (**b**) patients

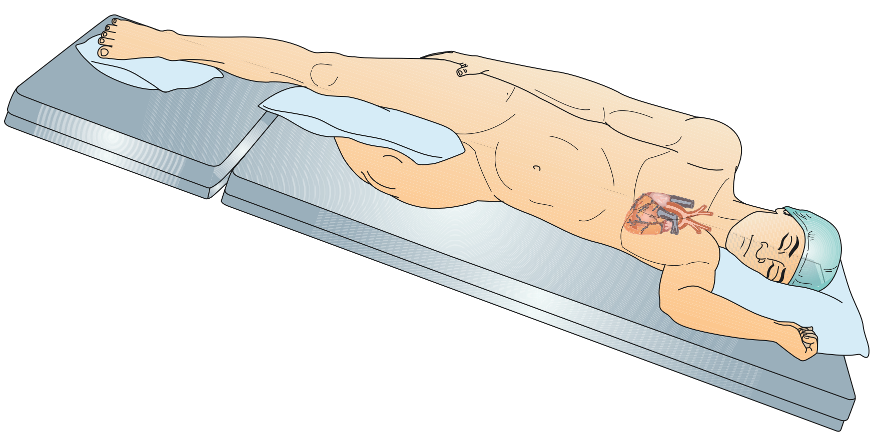

Fig. 12.2 Left lateral decubitus position with the head down

murmur. To treat, immediately stop insufflation, desufflate the abdomen, and place the patient in the left lateral decubitus position (right side up) with the head down (Trendelenburg position) (Fig. 12.2) [18]. This maneuver, the Durant maneuver, prevents an "air lock" in the pulmonary circulation. An attempt may then be made to aspirate the gas bubble with a central venous catheter from the right ventricle. The patient may ultimately require cardiopulmonary bypass.

Trocar Injury

Vascular injury during initial trocar placement has the potential to be much more devastating (Fig. 12.3). A meta-analysis showed a 0.03% incidence of vascular injury with the Hasson technique [19]. Although the likelihood of this injury is low, the mortality rate is higher than with a Veress needle injury. Unlike with smaller diameter Veress needle injuries, trocar injuries almost always require open conversion. Trocar injuries may occur during initial trocar placement, but they should never occur during secondary trocar placement as these are performed under direct vision. Ensure the skin incision is long enough to accommodate the trocar, and do not apply too much axial force during trocar insertion. For additional control, both hands may be used while advancing the trocar, to prevent sudden, deep progression of the tip of the trocar.

Optical trocars, in which the camera sits within the trocar's transparent obturator, allow for direct visualization of all layers as the trocar is inserted and are associated with few complications [20]. This can be used in either a desufflated abdomen, which has a higher complication rate [21, 22], or after initial insufflation with a Veress needle. Cutting trocars, which use a blade to penetrate the fascia, are associated with a higher risk of injury to abdominal wall vessels compared to blunt/dilating trocars.

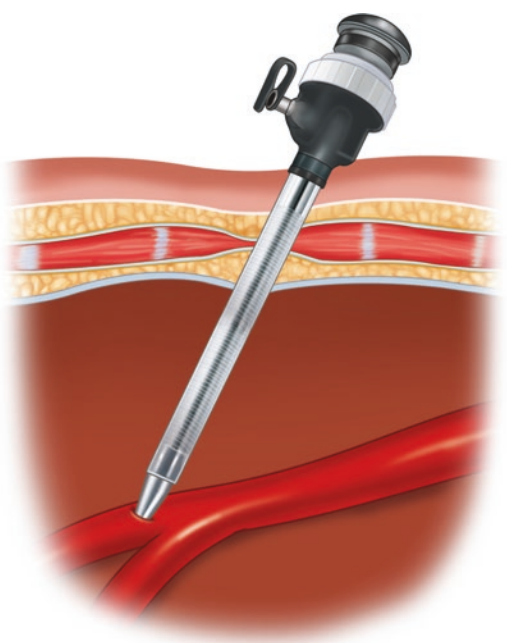

Fig. 12.3 Vascular injury during initial trocar placement

Injury is initially suspected by blood filling the trocar. If this is encountered, the trocar should be left in place to help tamponade the injury and facilitate rapid identification of its location, similar to suspected major Veress needle injuries. The trocar port should be closed and not connected to insufflation. If secondary trocars can be safely inserted, pressure may be held on the bleeding site with a gauze sponge or laparoscopic instrument, allowing for a more controlled assessment of the situation. Alternatively, if there is concern for a major injury, immediate laparotomy should be performed. If open conversion is necessary, the laparoscope may be directed toward the body wall, and the incision may be made directly over the laparoscope to facilitate a rapid, safe entry [23].

Of note, sometimes a major bleed may be more subtle, and a retroperitoneal or mesenteric hematoma may be the only sign of an injury. A small, non-expanding hematoma may be monitored intraoperatively. If it is expanding, the hematoma should be opened and repaired. Opening a hematoma is likely to cause bleeding, so this should be anticipated.

Bleeding alongside a trocar or along the inner anterior abdominal wall is suggestive of an injury to the epigastric vessels. These are the most commonly injured small vessels during Veress needle or trocar placement [11]. Injury most often occurs during insertion of secondary trocars through the rectus muscle [24]. To avoid this injury, trocars should be placed either in the midline or at least 6 cm lateral to midline. There may also be a delayed presentation with development of an abdominal wall hematoma or port site ecchymosis. Different techniques have been described for the management of epigastric bleeding encountered intraoperatively including direct cauterization, temporary tamponade with the trocar or a foley balloon placed through the trocar, or suture ligation either under direct vision or with a fascial closure device (Carter-Thomason CloseSure®

System, Inlet, Trumbull, CT); however, suture ligation is the preferred method. Cauterization may lead to re-bleeding. Foley placement through the port site will stretch the opening, disrupt muscle, and may further disrupt the vessel in the abdominal wall.

Intraoperative Vascular Injuries

Vascular injuries occurring after initial access may be a result of blunt, sharp, or thermal dissection or by suture ligation, clipping, or stapling. Vascular injuries during tissue dissection account for 25% of major vascular injuries [3, 4]. Proper surgical technique helps to prevent most vascular injuries. This includes meticulous dissection, working from superficial to deeper layers, to prevent "working in a hole." Injuries may be caused by unintentional instrument motions or may even occur outside the camera's field of view by the surgeon or the bedside assistant. The most feared injuries with the highest risk of mortality are to the great vessels and their major branches. Intuitively, vascular injuries are more common during those procedures that require dissection around major vascular structures.

Initial management often involves raising the pneumoperitoneum to 20–25 mmHg, ensuring adequate suction, and holding direct pressure, sometimes with the use of a mini-laparotomy pad. Bleeding from a venous source is often reduced solely by raising the pneumoperitoneum. The bleeding site should be compressed either with a robotic grasper, laparoscopic instrument, suction, or fourth arm [23, 25]. The surgeon must assess the magnitude of the injury and whether it is arterial or venous; low-volume oozing typically suggests venous bleeding, while large volume, pulsatile bleeding suggests arterial bleeding.

Management options include direct pressure, monopolar cautery, bipolar thermal sealing, clipping (e.g., titanium or locking clips), stapling, suture repair, and hemostatic agents. Simply applying direct pressure will often stop the bleeding from small venous tears. When needed, the surgeon should insert additional trocars, use a gel hand port, or convert to open surgery. If the patient is hemodynamically stable, then repair may be attempted robotically. Suction should be used judiciously in the event of a venous injury, as it decreases pneumoperitoneum and promotes bleeding.

In addition to an open tray, additional equipment should be available in the room in the event of a vascular injury. This includes laparoscopic and robotic needle drivers, Lapra-Ty and Weck clip appliers, Bulldog clamps, Satinsky clamps, hemostatic agents, gauze sponges, and a "rescue stitch." The rescue stitch typically consists of a large needle suture with a clip tied at the end for the rapid repair of a vascular injury [26]. Multifilament sutures are easier to handle and tie, although vascular surgeons typically recommend monofilament sutures. A large needle is easier to see in a blood-filled surgical field (e.g., 2-0 Vicryl, CT-1 needle, 10 cm, with a Hem-o-lok clip tied at the end).

If the patient is unstable or the bleeding is massive, then immediate open conversion should be performed [27]. The bleeding will be worse after opening the abdomen and losing pneumoperitoneum, so the bleeding site should be immediately compressed. To counteract this, a mini-laparotomy pad may be inserted and pressure applied against the source of bleeding with a laparoscopic instrument while obtaining open access. Alternatively, a laparoscope can be used to directly compress the source of bleeding.

Vascular load staplers and clips, such as titanium and locking clips (e.g., Hem-o-lok, Teleflex Medical, Research Triangle Park, NC), have been shown to safely control large vessels as securely as traditional suture ligature [28–30]. Vascular stapler malfunction has been reported in up to 1.7% of cases and can result in major blood loss. To avoid this, ensure there are no clips within the stapler jaws when firing. Conversely, clips can be placed over staple lines. As a general rule, clips should be used sparingly in areas where staplers may be fired (e.g., renal hilum). Align the vessel or intended tissue within the markings on the stapler cartridges prior to firing. The stapler should be applied several millimeters distal to the origin of the blood vessel to provide an adequate stump in case of malfunction. The same rule also applies to clip application. When controlling large vessels with clips, it is advisable to place three clips on the "stay" side of the vessel and one or two clips on the "specimen" side.

Hemostatic agents are often used to minimize blood loss by promoting local coagulation, as adjuncts to traditional hemostatic techniques. There are numerous agents on the market including "glues" or "sealants," gels, and sheets. These should not be relied upon to stop significant surgical bleeding alone. A detailed discussion of individual agents is beyond the scope of this chapter. Comparative trials are lacking, so the utility of many of these agents remains mostly speculative.

Unintentional injuries to the spleen and liver may be caused by overzealous retraction. This may be prevented by a careful division of attachments and gentle retraction or packing to keep these organs out of the operative field. Splenic injuries have been reported in up to 2.6% of retroperitoneal surgery [31]. Small lacerations and capsular tears to the liver or spleen may be treated by releasing traction and applying gentle pressure with or without hemostatic agents. Splenectomy may be necessary if other measures to obtain hemostasis fail. These patients should receive meningococcal, pneumococcal, and Haemophilus influenzae type b immunizations [32].

At the end of an operation, the operative field should be inspected at low insufflation pressure. If a significant volume of blood accumulates during this period of low pressure, an exhaustive search should be conducted to find and control the site of bleeding. Irrigation of the surgical site may demonstrate pooling of blood, which aids in identification. Because trocars may tamponade bleeding, all port sites should be inspected under direct vision at low pressure and while being removed to assess for bleeding [24]. Minor bleeding can be managed with cautery. More significant bleeding may require suture ligation either directly or with a fascial closure device (Carter-Thomason CloseSure® System, Inlet, Trumbull, CT).

Postoperative Bleeding

Patients can present with signs and symptoms of bleeding at any time after surgery. These include hypotension, tachycardia, anemia, dyspnea, altered mental status, lightheadedness, syncope, low urine output, high drain output, ecchymosis, abdominal pain, and abdominal distension. The quality and volume of surgical drain output can be indicators of hemorrhage, but the absence of blood in the drain does not exclude bleeding. Postoperative labs should be performed. It may take several studies before hemoglobin levels indicate anemia.

The diagnosis is often made based on clinical suspicion and characteristic signs and symptoms; however, additional imaging including CT can be utilized. Small hematomas may be managed conservatively [33]. Large hematomas pose the risk of severe pain and infection, with drainage of the hematoma an option [34]. Hemodynamically stable patients with suspected delayed bleeding can be managed with selective angioembolization. Hemodynamically unstable patients should be managed with surgical exploration. Reexploration by a robotic or laparoscopic approach may be attempted. If a surgical drain was placed, it can be used for insufflation. A large 10 mm suction cannula should be used to aspirate all blood clots [35].

Delayed bleeding presenting for several weeks after surgery may be due to an arteriovenous fistula or pseudoaneurysm [36]. These most commonly occur after partial nephrectomy with a reported incidence of 0.4% for pseudoaneurysm and 12% for arteriovenous fistula [37]. A venous fistula may also present as postoperative hematuria. These can be managed with angioembolization.

Thromboembolic Complications

Thromboembolic diseases include both deep vein thrombosis and pulmonary embolism. These are the most common preventable causes of hospital death [38]. Although the advent of minimally invasive surgery has decreased the incidence of thromboembolic events, many patients undergoing robotic urologic surgery are at an increased risk for these complications. Risk factors include hypercoagulability from cancer, pelvic surgery, prolonged immobilization, lithotomy position, pneumoperitoneum, and vascular injury [39].

There are several different modalities available to prevent these life-threatening complications, including early ambulation postoperatively. Mechanical devices, which act by reducing lower extremity venous stasis and releasing antithrombotic factors, include graduated compression stockings and intermittent pneumatic compression devices. Of note, in the event of an iliac vein injury, intermittent pneumatic compression devices should be deactivated as they increase bleeding and counteract the tamponade effect of pneumoperitoneum. Pharmacologic prophylaxis includes low-dose unfractionated heparin, subcutaneous low molecular weight heparin, oral warfarin, and newer anticoagulants.

The perioperative management of anticoagulation/antiplatelet agents must weigh the increased risks of significant bleeding against those of thromboembolic events. For certain elective procedures, the risk of thromboembolic complications is considerably higher than that of significant bleeding. In general, anticoagulants/antiplatelets should be resumed as early as possible after surgery [40]; however, there is limited evidence of the shortest interval after which the risk of significant bleeding is minimal. Mechanical prophylaxis should be used in all patients during the entire postoperative period, with an emphasis on early mobilization. The decision to give pharmacological prophylaxis must be taken on a case-by-case basis [41].

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