Complications of Port Placement

10

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General Considerations

Port placement is the first step in every minimally invasive surgery. Besides the general recommendations related to port placement in laparoscopic surgery, in the particular case of robotic surgery, certain guidelines for proper docking and operation of the system should be met during surgery. Certainly, a key component for achieving a safe and effective robotic surgery is the optimal port placement. Proper entry and avoiding external clash of the robot arms are fundamental for surgery success.

The first step in laparoscopic surgery is the creation of the pneumoperitoneum and initial trocar placement. These steps are very significant as most of the complications occur during this initial approach. It is well established that over 50% of the trocar-related injuries to the bowel and vasculature are during the initial entry [1]. In robotic surgery, 8-mm cannulas are used. It is important to point out that the inherent risk of inserting these ports does not differ from standard laparoscopy.

Although complications associated with port-site placement are uncommon, in experienced hands, the potential for associated morbidity is high. Surgeons performing robotic surgery must have the knowledge and necessary skill to prevent, recognize, and manage complications related to port-site placement.

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Risk Factors

Multiple factors are involved in complications related to port placement. There are factors related to the patient and the surgeon.

Patient-Related Risk Factors

Obesity

Obesity is a growing problem worldwide; in some cases, it constitutes a real public health problem. Due to the association of obesity with diseases such as renal cancer and prostate cancer, there is no doubt that in practice the need to treat a significant proportion of patients with high body mass index is observed [2].

A thick layer of adipose subcutaneous tissue limits the access, especially to the insertion of needle and primary trocar. Due to the thickness of the abdominal wall and the preperitoneal fat,

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accurate assessment of the location of the needle tip is difficult.

The open technique is an alternative as regards these patients; however, some researchers believe that a larger skin incision is necessary for Hasson trocar insertion in obese patients, leading to leakage of gas and disadvantages during surgery [3], this is particularly important when the Xi system is used, in which case all ports, including optics, are of 8 mm. Other studies suggest that the use of optical trocar is an excellent choice regarding these patients, with a low rate of intestinal or vascular injuries [4].

The difficulty in mobility of conventional laparoscopic instruments when surgery is performed on obese patients is one of the limitations that have been overcome with the use of robotic surgery because the surgeon does not need to overcome the resistance of a large abdominal wall before carrying out the necessary movements, instead s/he would find him/herself in an optimal ergonomic position on the console. The use of long cannula is highly recommended for these groups of patients to keep the remote center in proper position and to prevent the cannula from accidentally slipping out; in this case, there is the risk of losing the pneumoperitoneum and the robot docking.

Not only obesity is a disadvantage, very thin patients are also susceptible to injury due to the proximity between the skin and the intra-abdominal and retroperitoneal structures. In the case of robotic surgery, sometimes patients with very low body mass index are a challenge for a proper port placement as it is difficult to obtain the recommended distances between the ports and the space for the assistant.

Prior Abdominal Surgery

Prior abdominal surgery is associated with an increased risk of access-site complications [5]. According to some studies, the rates of adhesions are 0–15% in patients with previous laparoscopic surgery, 20–28% in those with previous laparotomy through a low transverse incision, and 50–60% in patients with previous midline laparotomy [6]. Adhesions may be right under the scar or may be further away.

Therefore, in patients with a history of abdominal surgery, the following options should be taken into account: the use of Palmer's point or the open approach preferably far from the site of previous incisions. Care should be taken that the selection of the entry site may not lead to a port misplacement that may cause difficulties in the docking and operation of the system during the surgery.

Once the abdomen is insufflated and the primary port is placed, the abdominal cavity should be inspected to determine whether adhesiolysis is needed prior to the placement of additional ports. The handling of these adhesions by using the robot will depend on the possibility to dock the robot prior to the adhesiolysis. If this is not possible, the adhesiolysis will be performed by conventional laparoscopy and subsequently the docking will be performed.

Other Abdominal Conditions

Pregnancy or large abdominal masses may cause problems when approaching the abdominal cavity as they may displace the abdominal viscera and reduce the space within the abdominal cavity [7].

In patients with portal hypertension or inferior vena cava obstruction, the presence of a collateral venous network on the abdominal wall increases the risk of bleeding during the placement of ports, and the increase of pressure within the portal system makes the patient more susceptible to bleeding at the level of the mesentery and the omentum [8].

Surgeons-Related Risk Factors

The experience of the surgeon is intimately related to the occurrence of complications in minimally invasive surgery, and robotic surgery is not an exception. The surgeon must know the guidelines, master the relevant aspects of the abdominal anatomy, select and use the instruments properly, identify high-risk patients, select the suitable technique according to each patient and procedure, and be familiar with the alternative strategies. In any case, the surgeon must have the ability to identify and manage the complications that may occur.

Previous studies in nonrobotic laparoscopic surgery have shown that the incidence of com-

plications in the first 100 cases was considerably superior to the subsequent cases (13.3% vs. 3.6%) [9].

Training in robotic surgery is gradual, and it is divided into four phases – introduction to da Vinci surgery, da Vinci technology training, initial case series plan, and continuing development. For the first proctored surgical procedures, the surgeon has already fulfilled case observations, in service training with a clinical representative, virtual simulation, and animal simulation lab. Therefore, s/he is completely acquainted with the system. This outstanding training model has become an example in the introduction of new technologies into surgical practice and contributes to reduce the incidence of complications.

Prevention

Obviously, the best method to manage port-site complications is prevention. So, the following considerations must be taken into account when performing the procedure.

Choosing the Initial Approach

There are three main options for the creation of the pneumoperitoneum – closed technique, open technique, and optical trocar.

The Veress needle is used in the closed technique. It is a blunt-tipped, spring-loaded inner stylet with sharp outer needle. The stylet retracts during passage through the abdominal layers to allow penetration. Once the peritoneum is entered, the lack of resistance allows the blunt stylet to protrude; theoretically, this should prevent perforation of intra-abdominal structures. As the blunt tip does not lock once in the peritoneal cavity, it can again retract exposing the needle if it comes into contact with an intra-abdominal structure.

It has been shown that the most effective way to confirm intraperitoneal placement of the Veress needle is initial gas pressure <10 mmHg. Other techniques such as the double-click test, aspiration test, and the saline drop test are not useful in confirming placement [10] (Fig. 10.1).

In the open technique, the abdominal cavity is approached passing through each of the layers until the peritoneal cavity is reached. No step is

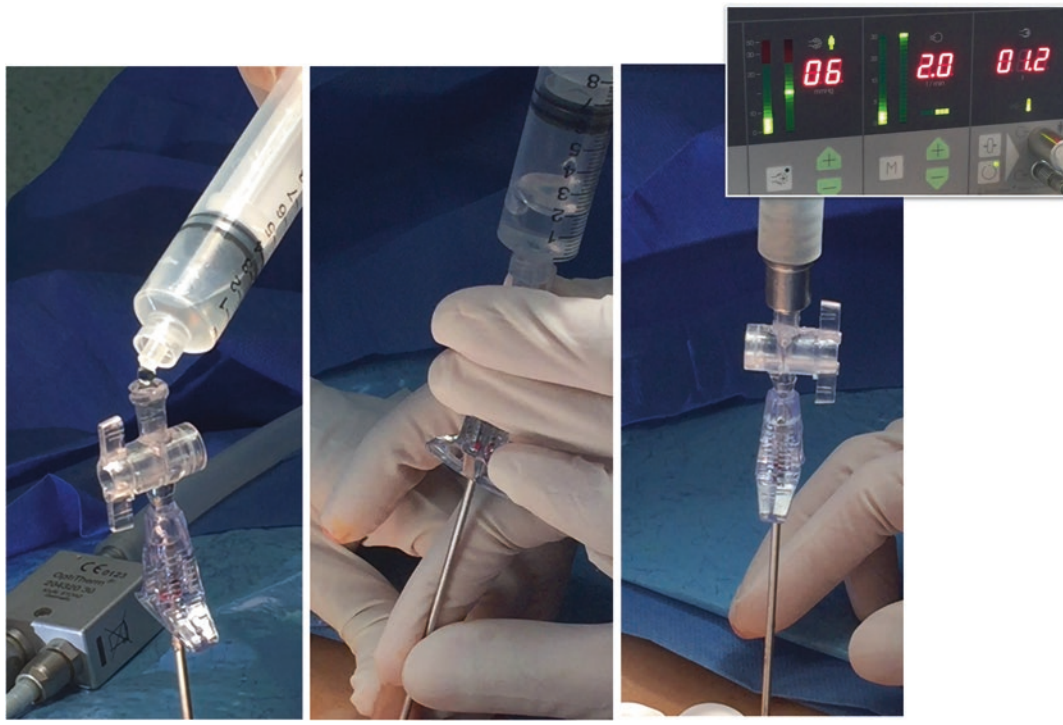

Fig. 10.1 Intraperitoneal Veress needle confirmation

completed blindly; therefore, theoretically it offers advantages such as certainty of establishing peritoneum, anatomic repair of the facial incision, elimination of the risk of gas embolus, and reduction in vascular and bowel injuries related to the initial access [11].

According to some studies, the open technique eliminates the risk of major vascular injury and reduces the rate of major visceral injuries. However, the study of a higher level evidence of Cochrane database concluded that no significant differences in the incidence of injury between both techniques were found [12].

The visual entry technique accesses the abdominal cavity with a specialized optical port that has a conical nonbladed transparent tip, allowing each layer of the abdominal wall to be seen with a 5 mm 0-degree laparoscope as it is being traversed (Fig. 10.2). A firm, constant alternating clockwise–anticlockwise motion is used. According to Thomas et al., despite each layer of the abdominal wall is displayed, the use of this device does not remove intra-abdominal injuries [13]. The combination of pneumoperitoneum with closed method followed by the optical trocar placement is an excellent choice.

Each surgeon should choose the method that s/he feels more comfortable with and s/he has more experience with, but should be familiar with alternative techniques.

Nasogastric Tube and Foley Catheter

The placement of a nasogastric tube to decompress the stomach reduces the likelihood of gastrointestinal injuries, in operations involving port placement in the lower abdomen is also recommended to empty the bladder using a Foley catheter; this also allows an early detection of injuries. The presence of air or hematuria in the urine collecting bag should be considered a suspected bladder injury [14].

Palmer's Point

Palmer's point is located in midclavicular line 3 cm below the rib in left upper quadrant. This is a point where in theory the probability of abdominal adhesions is considerably lower than the rest of the abdomen, which is the best option in the case of patients with a history of abdominal surgery [15] (Fig. 10.3).

If Palmer's point is used, it is especially necessary to empty the stomach using a nasogastric tube. This point should not be used in patients

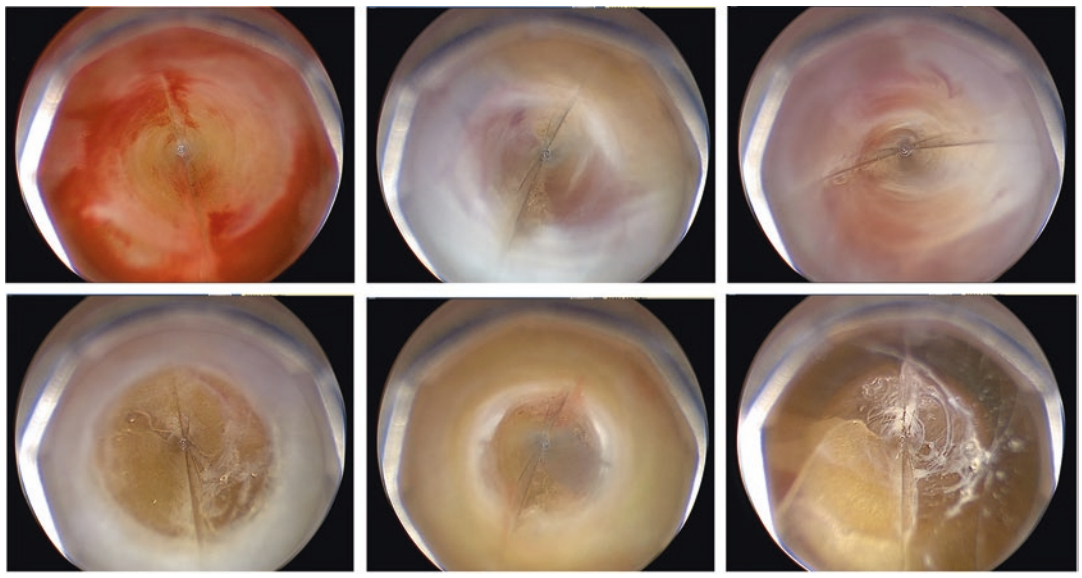

Fig. 10.2 Abdominal wall layers identified during optic trocar introduction

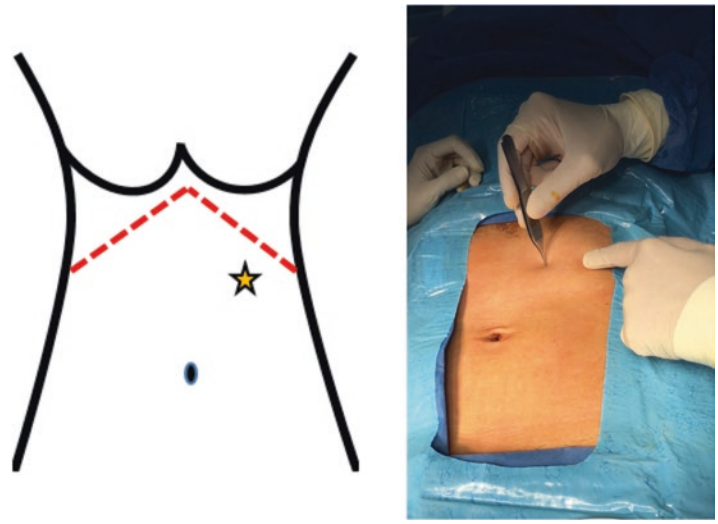

Fig. 10.3 Palmer's point ubication

with a history of splenectomy, gastric surgery, or in the presence of hepatosplenomegaly.

Primary Trocar Placement

If the open technique has been used, the trocar is already on the site, which is an advantage because a blind step was avoided.

If the pneumoperitoneum was created using the Veress needle, the entry of the primary trocar is carried out following these recommendations: Oblique direction, introduce with the valve open, as the escape of pneumoperitoneum through this, is a sign of intraperitoneal location. The pressure of the pneumoperitoneum can be temporarily increased for this first port placement; such temporary increase proves no hemodynamic impact on the patient [6]. Once the port is placed, the camera is introduced to confirm a proper location and to examine the abdominal cavity.

This first port placement by using an optical trocar is an option that requires experience, has shown to decrease the time required for the initial approach and the creation of pneumoperitoneum, yet this technique is not free of complications [16].

Secondary Trocar Placement

Injuries can occur during secondary trocar insertion. The number, size, and portion of these trocars are dictated by the procedure being done.

Fig. 10.4 Robotic trocar obturators

Transillumination technique helps avoid bleeding produced by vessel injury on the abdominal wall. In any case, ports should be introduced under direct vision with special care to identify and avoid epigastric arteries.

There are different robotic trocars obturators: sharp, bladeless, and blunt (Fig. 10.4). The use of noncutting trocars has shown advantages over the incidence of bleeding in the abdominal wall, postoperative pain, and patient satisfaction. However, trocars require much more application of force for insertion, which can potentially increase the rate of injury [17].

Other Considerations in Robotic Surgery

Remote center: Trocar location with the remote center in proper position is particularly important

to reduce postoperative pain and increase patient satisfaction. However, trocar location at the appropriate point should not become a limiting factor when carrying out the procedure or in specific situations that require going further or retract the trocar.

Tension in the abdominal wall: Once the robot arms are connected, it is important to release the tension on the abdominal wall to prevent injuries and reduce postoperative pain.

Avoid external conflict and clash with limbs: The movement of robot arms must be verified during the procedure, so that arms do not clash each other. Also, it is important to be certain that they will not clash with patient's limbs or with costal arches to avoid injuries.

Diagnosis and Treatment

The incidence of bowel and vascular injuries is quite low. However, a major vascular injury or an unrecognized bowel injury may carry a significant increase in morbidity and mortality. Complications and its prevention are summarized in Table 10.1.

Table 10.1 Prevention of complications in portals placing and management

Complication	Prevention	Management
Vascular lesion	–	–
Abdominal wall	Transillumination	Direct pressure rotating the tip of the trocar
	Visualization of the epigastric vessels	Insert Foley catheter
	Secondary trocar introduction under direct vision	Place U stitches with the suture passer
	Removal of trocars under direct vision to verify hemostasis	Extend the skin incision
		Use of monopolar, bipolar, or ultrasonic energy for hemostasis control
Intra-abdominal	Trocar introduction under direct vision	If serious vascular injury is suspected, conversion to an open procedure must be considered
	Proper technique	Direct compression of the bleeding site
	Open access	Increase insufflation pressure
		Repair with precise intima to intima apposition without tension
		If ligation of a vessel does not lead to ischemia, definitive repair may be postponed until the patient is stable
Visceral injuries	*Open access*	–
	Palmers point	
	Secondary trocar introduction under direct vision	
Solid organ	–	Apply pressure on the injury using an instrument or with sterile gauze
		Increase the pressure of the pneumoperitoneum
		Use of monopolar, bipolar, or ultrasonic energy
		Application of dry hemostatic agents
Small bowel	–	Primary closure
		Resection and anastomosis
Colon	–	Consider colostomy depending on the patient condition and procedure
Bladder	Use Foley catheter in lower abdominal surgery	Less than 5 mm – Foley catheter
		Major injuries – Primary closure and Foley catheter placement

Vascular Injuries

Vascular injuries during laparoscopic surgical procedures are probably underreported, and their incidence rate is estimated to be 0.05–0.26% [18].

Vascular injuries may involve retroperitoneal, intra-abdominal, or abdominal wall vessels. The most common vascular injury site is the abdominal wall, especially considering the epigastric vessel injuries.

The options for controlling bleeding from the abdominal wall include using the trocar that the bleeding is coming through for direct pressure rotating the tip against the bleeding site. Alternative strategies are as follows: a Foley catheter can also be inserted, inflated, and gentle traction applied to tamponade the site; also, U stitches can be placed under direct visualization using a suture passer (Fig. 10.5). In rare cases, it is necessary to enlarge the incision in the skin for adequately controlling the vessel and to achieve hemostasis.

Major vascular injury is a preventable, unacceptable, and potentially lethal complication; its incidence should be reduced as much as possible.

The most common sites of intra-abdominal vascular injury include iliac vein, greater omental vessels, inferior vena cava, aorta, pelvic and superior mesenteric veins, and lumbar veins [2].

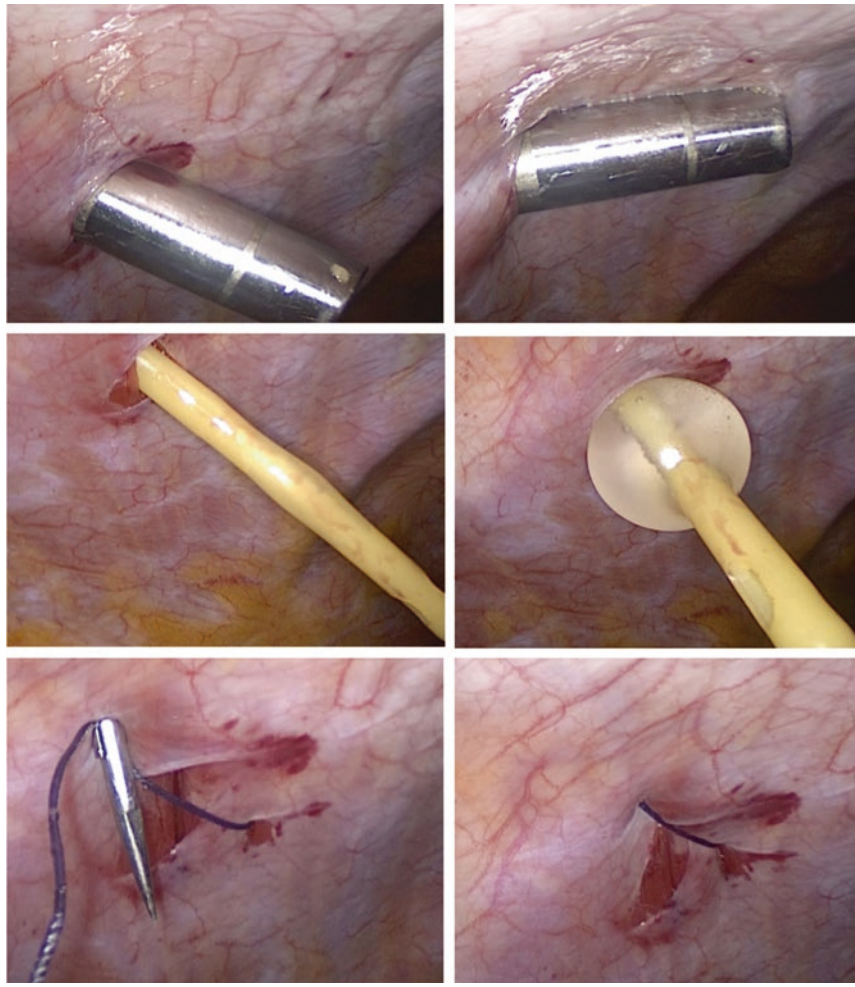

Fig. 10.5 Hemostatic maneuvers for abdominal wall bleeding control

Concerning intra-abdominal injuries, Suarez [19] has described basic principles of repair, as follows:

- Once a potentially serious vascular injury is suspected, immediate conversion to an open procedure must be considered.
- Direct compression of the bleeding site is the quickest and safest way to gain initial control of blood loss, especially with a venous injury.
- If the patient exhibits unstable vital signs, adequate volume replacement, while controlling the blood loss, must take place prior to attempting repair of the injury.
- If the bleeding site is difficult to see, early and wide exposure of the site and the surrounding structures must be obtained.
- The vessel wall must be repaired with precise intima to intima apposition without tension; venous injuries may be best handled by ligation rather than suture repair if the patient is unstable.
- If ligation of a vessel does not lead to ischemia, definitive repair may be postponed until the patient is stable.

If a retroperitoneal hematoma is found at the time of the examination of the abdominal cavity with the optical trocar, it may indicate that it should be explored and the injury should be repaired immediately according to the findings.

At the conclusion of the procedure, after trocar removal, all ports should be visualized to ensure that there is no bleeding that was tamponaded by the trocar itself. If this bleeding is present, it can be stopped by cautery, pressure, or any of the measures mentioned above.

Visceral Injuries

The incidence of bowel injury is between 0.04% and 0.5% [20], and 30–50% of the bowel injuries are not diagnosed intraoperatively, this leads to a mortality rate of up to 30% [6]. Adequate exploration of the abdominal cavity with the camera is essential to discard the presence of injuries following the initial approach.

Solid Organ Injuries

The management of liver or spleen injuries includes initially to apply pressure on the injury using an instrument or by introducing sterile gauze into the abdominal cavity. Increasing the pressure of the pneumoperitoneum may help control hemostasis. It is ideal to use bipolar forceps once the bleeding site is identified. The use of dry hemostatic agents (Surgicel and Gelfoam) or thrombin sealants should be considered if the bleeding does not stop. The use of suture to achieve hemostasis should be carefully assessed as it could lead to larger tears.

Gastrointestinal Tract Injuries

This injury must be repaired at the time of its detection. It should not be delayed until the end of the procedure because detecting it again could be very difficult. Once identified, the extent of the injury must be determined. Small bowel injuries may be controlled by primary closure using intracorporeal suturing and knot-tying techniques, which are hugely facilitated by the da Vinci system. Major injuries requiring bowel resection can be managed by stapling or manually using the robot.

Colon injuries pose a bigger problem. Depending on their severity, they can be treated by primary repair, in which case, drainage is always recommended. Major injuries will require a segmental resection. The decision to perform primary anastomosis or colostomy should be individualized taking into account the patient's condition and the primary procedure to be performed.

The great majority of the delayed diagnoses require laparotomy, bowel resection, washout, and drainage of the cavity.

Other Visceral Injuries

Bladder injuries may occur during procedures in lower abdomen. As discussed above, the use of a Foley catheter may reduce the risk of injury and allows early diagnosis by noting that the collection bag fills with air or the presence of hematuria.

Instilling dye into the bladder allows an accurate diagnosis of bladder injury. If the injury was caused by a Veress needle and is less than 5 mm, it can be managed with bladder decompression using a Foley catheter for 7–10 days. Major injuries will require closure with absorbable suture, for which the robot's excellent vision and handling are of great help. Likewise, the Foley catheter must remain during the postoperative period.

Final Consideration

Abdominal access and properly port placement without complications are key to the success of robotic surgery. When complications do occur, excellent training will allow them to be properly managed.

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