Introduction:

Laparoscopic surgery has the potential to decrease postoperative pain and shorten recovery. Although a laparoscopic surgery generally takes longer than its equivalent open surgery, this is not always the case, especially in experienced hands. The disadvantage of longer surgery time can be offset by shorter in-hospital recovery, which allows the hospital to perform more operations overall. Often, a hospital that does laparoscopic surgery well will have a good reputation in the community, attracting more patients for that reason as well.

Becoming facile at laparoscopic surgery takes time and commitment, both on the part of the surgeon and the hospital. New equipment must be purchased, learned about, and maintained. New procedures will be billed differently. The equipment is more complex and prone to breakage and malfunction, especially if mishandled. The surgeon is well advised to seek a mentor and perform laparoscopic surgery under supervision as much as possible before starting to practice it alone.

There are a number of complications particular to laparoscopic surgery, including complications of pneumoperitoneum, injury to adjacent structures during trocar placement, and injury to intra-abdominal structures during surgery. Vascular injury during trocar placement, in particular, can be fatal. Some complications arise when a familiar operation is done in a new way; one example is the increase in biliary tract injuries that occurred after laparoscopic cholecystectomy was widely adopted in the United States.

Some critics will argue that laparoscopy has no role in resource-limited settings like ours. With scarce resources, they would say, the focus should be on procedures that are likely to help the most people. Certainly we agree that safe access to lifesaving and disability-preventing procedures should be primary in importance. However, in settings where these "basics" are done well and are accessible to all, we feel that the advantages of laparoscopy should not be withheld from patients.

It is possible to do laparoscopic surgery well in a resource-limited setting, but it must be done differently than in a resource-rich country. Specifically, the use of disposable instruments should be minimized. Reusable stainless steel laparoscopic trocars and energy devices are available from India and China, where laparoscopy is being done perhaps more commonly. Conversely, singleuse trocars and instruments from industrialized countries will be harder to source and adapt for our setting, and will malfunction if re-used beyond their intended lifespan.

The cannulas that allow laparoscopic access without letting pneumoperitoneum escape are variably called ports or trocars; these two words are essentially interchangeable. In this chapter we will explain trocar positioning and trocar placement. Other chapters will discuss pneumoperitoneum options and alternatives, scopes and cameras, and use of energy devices. We will further discuss some specific procedures in other chapters.

Trocar positioning:

The main goal of trocar positioning is to allow access of the camera and working trocars to the surgical site. The best way to accomplish this is to think in terms of a 4-sided "diamond," with the surgical site at one corner, the camera's trocar at another, and two working trocars at the other two corners. Sometimes the two working trocars will be at opposite ends of the square with the camera looking between them. At other times, the two working trocars will be next to each other with the camera opposite.





Consider the figure above, demonstrating one possible trocar configuration for laparoscopic appendectomy. The appendix (Red "X") is at one corner of the "diamond." In general, visualization is best when the camera is far from the surgical site, through the blue trocar, on the opposite side of the "diamond." However, this configuration forces the camera operator to reach in between the surgeon's two hands, which can be awkward.

If the scope is placed through the purple trocar, visualization may be more difficult because the scope is closer to the appendix. But the surgeon and camera operator will be more comfortable, as their arms will not need to overlap.



Surgeon (Red) operating through the two trocars on opposite sides of the "diamond" while the camera operator (Blue) must hold the camera (through the Blue trocar) in between the surgeon's arms, an awkward position that is difficult to hold for a long time. Visualization may be better, because the camera is farther away from the pathology (Red "X".)



Surgeon (Red) operating through two adjacent corners of the "diamond" while the camera operator (Blue) uses the Purple trocar on the opposite corner of the diamond. The camera operator is more comfortable and can hold this position for





longer. The disadvantage is that the camera is closer to the pathology (Red "X") so the view may not be as useful.

We demonstrate other examples of the "diamond" principle in trocar placement below:



The "diamond" trocar setup for laparoscopic esophageal surgery. The camera is in the Red umbilical trocar. The Purple and Blue trocars are the working trocars. The patient will be placed in lithotomy position and the surgeon will stand between the patient's legs. The camera operator will stand on one side holding the camera between the surgeon's arms. Other trocars on the right and left flank can be placed for additional assistance and liver retraction.



The "diamond" setup for laparoscopic trans-abdominal right inguinal hernia repair. The camera will go through the Purple trocar and the camera operator will stand on the patient's right.

The Red and Blue trocars will be the working trocars for the surgeon, who stands on the patient's left. Both arms are tucked. For bilateral inguinal hernia repair, the Blue trocar is placed directly opposite the purple one; the surgeon and camera operator switch sides midway through the operation.



The "diamond" setup for laparoscopic cholecystectomy. The camera is in the umbilical trocar, the Blue and Purple trocars are the working trocars, and both surgeon and camera operator stand on the patient's left side. We prefer to place the trocar as cranially as possible, and the Purple trocar as laterally as possible, to avoid crowding the "diamond." Another trocar will be placed on the patient's right flank- this will retract the dome of the gallbladder as cranially as possible, expanding the "diamond" even further.

When the Hasson open technique is used (described further below) the umbilical trocar will be an 11mm one. 10mm scopes are easier to maintain and less fragile, so many surgeons in resourcelimited settings are often forced to use these. If the other trocars are 5mm, then a 10mm scope can be placed in the umbilical trocar only, which will also affect the conduct of the operation. In the configurations above, consider how the surgery would be limited if the camera could only go in the Red trocar.

If, on the other hand, the surgeon has a 5mm scope available, it can be placed in any trocar, or even changed from one trocar to the other as the operation proceeds. Of course, other 11mm trocars can be placed besides the umbilical one. For



example, it is common to place a 11mm trocars at the epigastric site during laparoscopic cholecystectomy.

Trocar Placement:

There are many ways to introduce laparoscopic trocars. We present one simple and reliable method, consisting of open placement of the first trocar through the Hasson technique, and percutaneous placement of subsequent trocars under direct laparoscopic visualization.

Open Trocar Placement

In a patient with no previous abdominal surgeries, we prefer to use the supraumbilical position. This approach allows an inconspicuous scar, in an area where access is easy because the preperitoneal layer is thin.

1. Make a transverse incision just above the umbilicus. If there is any chance that the operation will convert to an open one, make the incision vertical. Otherwise, a transverse incision heals with a better cosmetic result. If the patient is not obese the incision is 2.5cm in length. If the patient is obese, it can be 4cm long.



The transverse supraumbilical incision is made just above the umbilicus, and curves slightly downward on either side for improved cosmesis.

2. Carry the dissection through the subcutaneous tissue, using small retractors to help dissection. Clear the anterior rectus sheath at the midline.



Using a combination of diathermy and blunt dissection with the retractors, the anterior rectus sheath is cleared.

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3. Incise the anterior rectus sheath transversely. Continue dissection until you reach the preperitoneal fat but do not continue through the peritoneum. This maneuver allows you to have the smallest possible hole in the fascia to minimize gas leakage during the surgery.



The fascia is divided until the preperitoneal fat is seen. With excellent retraction and some practice, it is possible to consistently divide the fascia only, without dividing the preperitoneal fat or the peritoneum.

4. Using the small finger, bluntly perforate the peritoneum and enter the abdominal cavity. Probe the intraperitoneal space, making note of any adhesions or masses. If your finger meets resistance, you have not completely divided the fascia. Expose and divide further with diathermy.



Once the fascia has been divided, the preperitoneal space and peritoneum are entered bluntly with the small finger. Probe the adjacent space to make sure there are no adhesions or structures that can be injured when the cannula is placed.



After blunt fingertip entry, the intra-abdominal contents can be seen in the base of the wound.



5. Place retention sutures through both edges of the fascia on either side of the incision. With proper retraction, you can grasp the fascial edges with forceps and place the suture in them easily. Each will be about ¼ of the way from the edge of the fascial incision; once the trocar is in place, pulling on them will tighten the fascial incision and minimize gas leakage.



With proper retraction, the fascia edge can be grasped with a forceps and a suture passed, taking care not to injure intraabdominal contents. With a slightly longer incision, this technique can be used even on obese patients.



Retention sutures after placement.

6. Grasp the fascia with forceps and insert the trocar into the peritoneum using a blunt

obturator. Do not pull on the retention sutures during this stage, this will make insertion more difficult. If only a sharp obturator is available, be very careful and withdraw the obturator after you feel the trocar pass through the fascia.



Insert the trocar tip through the fascia, grasping the edge of the fascia with a forceps. The sutures are kept loose until the tip of the trocar is within the peritoneum.



A blunt obturator tip inside a Hasson trocar. This tip can be gently passed into the abdominal cavity without concern for injury.





A sharp obturator tip inside a Hasson trocar. These are made to be passed under direct visualization, through tissue, with the laparoscope already inside the abdomen. Be very careful when using this obturator for an open approach. Withdraw the obturator as soon as the tip of the trocar is past the fascia.

7. Secure the trocar in place by attaching the retention sutures tightly to the trocar.



Once the trocar is inserted fully, it is secured with the retention sutures



One technique for decreasing air leak is applying a penetrating towel clamp to one or both sides of the skin incision adjacent to the trocar.

8. Upon completion of the surgery, withdraw the trocar. Pull up on the two retention sutures while spreading them, to expose the incision. Place a third suture through the fascia between the two previous ones, lifting each side individually to see the needle and make sure there is no bowel injury.



The two retention sutures, still attached to hemostats, can be spread and pulled laterally to show the fascial edges. If this is



properly done, you do not need a retractor. A third suture is then placed in between the retention sutures. Be sure to see the tip of the needle while placing this suture to avoid entrapment or injury of peritoneal contents.



Before cutting the sutures, pull them upwards while injecting local anesthetic into the fascia around the closure site.

Percutaneous Trocar Placement Under Visualization

1. Once you have pneumoperitoneum, insert the scope and visualize the area where you plan to place a trocar from the inside. Inject the peritoneum with local anesthetic under visualization. Avoid the epigastric vessels, which run parallel and about 5 cm lateral to the linea alba on each side.



The surgeon injects local anesthetic into the skin, fascia and peritoneum under direct visualization with the laparoscope.

2. Make a skin incision about 2mm longer than the diameter of the trocar.



Make an incision in the area where the trocar is planned, after visualizing that area with the laparoscope.

3. Grip the head of the trocar between your thumb and middle, ring, and small fingers, extending your index finger along the shaft of the trocar.



The proper way to hold a trocar while inserting it percutaneously. The palm grip maintains firm control, but the index finger resting on the skin of the abdominal wall stops the trocar if it plunges in suddenly.





Improper way to hold a trocar while inserting it: grip is excellent, but there is no way to slow a sudden plunge into the abdominal cavity.

4. Insert the tip of the trocar and place your finger on the skin adjacent to the entry point. Push in a controlled manner, twisting slightly, while using your index finger to prevent the trocar from "plunging" into the abdomen. Watch the tip of the trocar continuously with the scope. If there is excessive resistance, do not push harder. The most common cause of resistance will be a skin incision that is not big enough. Be aware that devastating complications can occur if the trocar "plunges" in suddenly, including bowel or vascular injury. Perforation of the aorta or an iliac artery with a 5mm or 11mm trocar can lead to rapid blood loss and even death.



Proper technique, with the fingertip resting on the skin.



As the surgeon begins to apply pressure to the trocar, the peritoneum begins to bulge inwards at the location that it will eventually break through (Black arrow.)



The camera operator must keep the tip of the trocar in view at all times. Here, the sharp tip of the trocar is about to break completely through the fascia and peritoneum. As the tip becomes more apparent, the surgeon applies less pressure to maintain control and prevent the trocar from "plunging" into the abdomen out of control.

- 5. Upon completing the surgery, withdraw all percutaneously placed trocars while watching from the inside with the scope. If there is any bleeding from the abdominal wall it must be controlled, as described below in "Pitfalls."
- 6. The site of any trocar 10mm or larger must be closed at the end of the surgery. The





exception is an epigastric location, as there is no tissue that is likely to herniate in this area. A percutaneous closure device such as the Carter-Thomason device allows you to do this under laparoscopic guidance. Otherwise, expand the skin incision a little, dissect down to the fascia, and close it with a simple interrupted absorbable suture.

Pitfalls

- Poor trocar placement can make an easy surgery difficult and a difficult surgery impossible. Try to make the "diamond" as wide as possible and try to make the trocar sites as far as possible away from the surgical site.
- Some trocar positions will place the surgeon in an awkward position: rotating the patient towards the surgeon will help with this problem.



With the patient completely flat, the surgeon must take an awkward angle to approach the intra-abdominal pathology. Note that this condition will not change by merely raising or lowering the table.



With the patient rotated, the surgeon's posture is much more relaxed. This will lead to less pain and more endurance for the surgeon, and a safer surgery overall.

- Epigastric vessel injury. This may be noted immediately, or after removal of the trocar. If it occurs, do not withdraw the trocar. Replace it if necessary and then pass a Foley catheter through it. Inflate the balloon, slide the trocar out of the abdominal wall along the catheter, and then pull upwards on the balloon, applying pressure to the bleeding site. This will stop the bleeding and give you time to plan definitive hemostasis. You can then ligate the vessels on either side of the balloon without deflating it. To ligate the vessels, either intracorporeal sutures use or а percutaneous trocar site closer, such as a Carter-Thomason device.
- Bowel or vascular injury during trocar placement: we favor initial open trocar placement (as explained here) to make this complication less likely, even though other options exist. Special care must be taken during percutaneous placement of trocars- be sure you are aware of where the tip of the cannula is at all times, and that you are in full control of it at all times during placement. Be especially careful in the right and left lower quadrants, as the external iliac arteries are very nearby. A trocar headed in the wrong direction can perforate these vessels without entering the peritoneal cavity (i.e. before

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you see the tip,) so be aware of what direction it seems to be going as you place it.

• Trocar site hernia: any trocar that is 10cm or larger is prone to forming an incisional hernia and must be closed. Be meticulous about closing an open supraumbilical trocar well, as described in this chapter. For obese patients, we use nonabsorbable sutures at the Hasson cannula site. Other 10mm trocars that were placed percutaneously must be closed, except those anterior and superior to the liver where hernia is less likely. A percutaneous closure device is available for this purpose; if this is not available, widen the skin incision and close the fascia from outside with a figure of 8 suture.

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