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Laparoscopy in Low Resource Settings

An Educational Resource

Laparoscopy in low resource settings

Richard Davis, David Jeffcoach, Mark Snell

This resource assumes a basic knowledge of laparoscopy including proper diagnosis and use of CO2/air insufflation, abdominal access, port placement, port site closure, and management of medical complications.

Introduction:

The authors of this essay have practiced for years in austere settings, attempting to use a minimally invasive approach to surgery wherever it is safe and feasible. We have learned some lessons that we hope to pass on here.

Minimally invasive surgery is most often practiced in high-resource settings. We feel it is quite feasible to use this approach in a low-resource setting. However, technology that is well suited to one setting often will not translate easily to another. It is helpful to keep some general principles in mind:

- High tech equipment (digital) will be easier to use when it functions properly, but will be expensive to acquire and difficult to troubleshoot, repair, and maintain.
- Low tech equipment (analog, mechanical) will be slightly more difficult to use and will require more expertise to operate and to prevent complications. But it will be less expensive to acquire and easier to troubleshoot, repair, and maintain.
- It will be very tempting to accept donated high-tech equipment, but beware of dependence on this pathway, and of difficulties in repairing this equipment when it breaks down. Some have called this the "Junk for Jesus" phenomenon.

We will divide this essay into three sections: **Acquisition**, **Use (Including Alternatives,)** and **Maintenance**.

Acquisition

There are three basic strategies for acquiring any equipment in a hospital in an austere environment: Donation, Purchase, and Lease. Each approach has its unique set of advantages and pitfalls.

Donation of equipment is very common in hospitals in austere settings. This equipment may have come from an individual donor, who either had it delivered or brought it themselves. Or it may have come from a charitable organization which wanted to help improve the quality of care in your country.

Visiting clinicians will be an important source of donated equipment. They may offer to bring it to you, and leave it when they depart, or they may bring it for their own use and to take when they depart. (The latter scenario often applies when a surgical team comes to do specialized surgeries.)

Your country may impose restrictions on medical equipment that is entering the country. This may include tariffs based on the estimated value of the equipment, or restrictions on importing expired equipment or medications. Likely you will be the one advising visiting clinicians on these restrictions. It can be difficult to calculate them in advance, or to navigate the bureaucracy of your country. Here are some strategies for dealing with this issue:

- Discuss with a colleague who has brought in donated equipment before, possibly at another hospital. Mission Hospitals may have extensive experience in this field.
- Have the clinician carry a paper receipt for every item they are bringing, declaring its value. This can be as simple as getting a letter from the donating party (often a hospital getting rid of old equipment.) Use a value that would seem reasonable to a Customs agent, even if the item is worthless to the donating party.
- Instruct the carrier to be prepared to pay a percentage of this value. Avoid arguing with the Customs agent or making patronizing comments such as "I'm trying to help your country!" Just consider it part of the cost of bringing in equipment. Agree in advance whether the donor or the recipient will pay the tariff.
- Write a letter for a carrier, on Hospital letterhead, detailing the equipment and what it is being used for.
- Beware of bringing expired medicines. We have had a whole suitcase containing usable, nonexpired medical equipment, confiscated because there was also some expired medicine inside the suitcase. The policy towards importing expired medicines will vary between countries.

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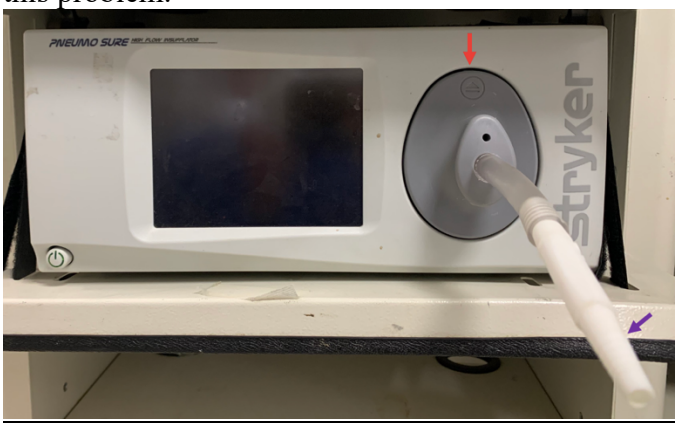
Donated equipment may cause more problems than it is worth, so at least be aware that it can be a mixed blessing. It may be equipment you do not actually need. For example, its technology may or may not be applicable in your country. It may use a different voltage or be incompatible with your other equipment.

Another common problem arises when a donated piece of equipment, intended for use in a resource-rich setting, is too fragile to last long in your setting. One example is sensitivity to electrical surges. As another example, we have used a donated expensive laparoscopic insufflator which was very sensitive to water moisture in the compressed gas. One attempt to use this insufflator resulted in its permanent failure.

Yet another problem arises when the machine breaks down. There may be no qualified technician or spare parts in the country. Repair may cost more than the machine is worth. The original donor will most likely be unwilling to foot the bill for these repairs. Irreparable donated used equipment is unfortunately quite common in developing countries.[1] We discuss this issue a bit more below, although unfortunately there is no good solution to this problem.



Donated laparoscopic insufflator. When it works, this device is extraordinarily easy to use. Notice that the disposable tubing system with proprietary attachment to the device (Red Arrow) has been modified with a connector (Purple Arrow) that allows it to be reused. If the proprietary attachment is lost, or if the complex electronics stop working, the machine is likely irreparable in our setting.

Purchase of equipment requires quite a bit of research and planning, but can be a better value given the hidden costs of "free" equipment as described above. Try and find a company that has the product you like, sufficient quality, and methods to import if applicable. This company should also offer excellent tech support. Ask other surgeons, particularly nationals of your country, if they have any experience with sourcing equipment. It is very helpful to try and keep all laparoscopic equipment coming from the same company. This will allow you to use the equipment together, expand inventory, and replace parts, avoiding problems that come when trying to get different brands to work together on one laparoscopic system.

The issue of compatibility between equipment is crucial. Potential mismatch can exist between the camera and processor, between the light source, cable and scope, and between the processor and the monitor. For example, processor to monitor connection will be VGA, HDMI, or S-Video. The camera to processor connection will be proprietary to the manufacturer and may not be interchangeable between model years, or even between different countries of origin for the same model year.

On a related note, video monitors are regulated as medical devices in high-income countries. This restriction may not apply in your country and you may be free to use a computer monitor or flat-screen television, as described further below.

Material for purchase can be sourced from your own country, India or China, or a country in the Global North. Each has its own set of issues:

Material from India or China can easily be found on eBay or the internet. India in particular is a good source of refurbished equipment. The prices may be less than those offered by dealers in your own country, but keep in mind that in-country companies' prices include the tariff, which you will have to pay if you import equipment yourself. This cost can be extremely difficult to calculate in advance. Likely there will be delays and "red tape" due to bureaucracy. Most likely, if a piece of equipment purchased in China or India fails or is defective, it will be almost impossible to have the manufacturer pay for repair or replacement.

Material purchased in your own country has several advantages: the company which sold it may be more likely to stand behind the product, and at least you have a person to contact. If the item is particularly expensive, consider purchasing a maintenance contract. If you have a biomedical department, get their approval before purchasing the item. We have had difficulties getting in-country

company representatives to take responsibility for their products, however, so accountability is by no means guaranteed.

Material imported from industrialized countries is the most expensive. There will potentially also be "fragility" and cross-compatibility issues, as described in the previous section. Consider also how you are going to bring it into the country: if importing it with an international shipping company, you will be subject to tariffs. Likely these will be high, based on the cost of the item. If someone is carrying equipment for you, and it is clearly brand new, they will be asked to show a receipt. If you are raising money for this purchase, factor in the tariff on importing it. As stated above, it may be difficult to calculate this amount in advance.

Getting purchased equipment into the country can sometimes be accomplished with less fees and tariffs through a smaller shipper. One example of this is Salihiya.com. We have successfully used this company. Communication was poor, but the cost was much lower than it would have been with a major carrier. We would recommend against using this technique to import very expensive items, but we know people who have done so successfully.

Lease of equipment is increasing in some countries as they become more industrialized. The subtype of lease known as "Operating Lease" may be a viable option in any type of hospital if the volume is high enough. It can primarily be found at hospitals that cater to high paying private patients.

One form of Operating Lease works as follows: companies that make most of their revenue selling disposable items will sign a contract with you to place equipment at your hospital that is compatible with these disposable items. You do not pay for the equipment, only for the disposable items. One example is Reagent Placement, in which laboratory companies provide analyzer equipment, and take responsibility for maintaining it, in exchange for a contract where the hospital purchases all the reagents for the analyses. This agreement is based on the number laboratory tests the hospital typically performs, meaning how often the hospital is likely to purchase the reagents. It is conceivable that this approach could be applied to laparoscopic equipment if the volume of surgeries was high enough.

The main pitfall of such an agreement is that the equipment is not yours, so you are dependent on the company for repairs. At one author's hospital, we currently have a non-functioning electrosurgical unit, acquired under an Operating Lease, that has been waiting to be repaired for more than a month (while we continue to purchase cautery pencils and grounding pads from the supplier!)

Use of Equipment, Including Alternatives

Cameras and receivers must be compatible with each other, unfortunately there is no standard connection that allows one company's camera to connect to anther's receiver. And even as digital technology becomes less expensive, laparoscopic cameras and receivers continue to demand high cost. These costs are likely elevated due to concerns such as litigation and government regulation of medical devices. An unfortunate side effect is decreased availability of such equipment in low-income countries.[2]

In countries where such concerns are less pressing, innovative solutions have been deployed. One such solution is the use of a mobile phone as a laparoscopic camera for both diagnostic and therapeutic laparoscopy.[3,4]. The use of a cellphone as a laparoscope connecting to an external monitor (through Wi-Fi or wire) with a simulator is described in the ALL-SAFE ectopic pregnancy module. However, we cannot recommend this approach for actual patient application at this time.

Dedicated laparoscopic cameras are made to be waterproof and can be sterilized by submersion in chemicals such as glutaraldehyde (Cidex). But they will be likely to last longer if they are used with a sterile cover (re-usable fabric or disposable plastic) and then simply wiped clean after use.

Monitors must provide a clear view of what's on the camera. As mentioned above, if they are not subject to official regulation, standard flat screen computer or television monitors can work well. It is important when obtaining this equipment to be sure that the monitor's input matches the output of your camera receiver.

The position of the monitor will make a great deal of difference to the surgical team's

comfort. Mounting the monitor on the wall and then adjusting everything else in the room is an acceptable alternative to an expensive mobile system. This strategy also minimizes potential damage to your monitor system.

Surgeon performing direct laryngoscopy with an operating telescope connected to a flat screen television (Purple Arrow) which was purchased locally at a supermarket. The patient has been rotated to allow the surgeon to comfortably see the monitor. Note the donated monitor (Red Arrow) that displays an inferior image and is not being used.

Scopes are the most fragile part of a laparoscopic system. They can be sterilized in steam, but repeated exposure to high temperatures and moisture can make the optics become foggy. Chemical submersion is the best sterilization technique for scopes.

Avoidance of fogging during surgery is best accomplished by keeping the scope warm. Store it in a cut IV bag of warm fluid when it's outside the body. Sterile alcohol "spirit" on a cotton swab can be an acceptable defogging solution.

Scopes can be repaired, occasionally in-country. If you do need to send it out of country for repairs, provide a letter to the one carrying it in both directions as it is subject to confiscation on either trip. This issue is discussed further in the section **"Maintenance"** below.

Insufflation systems can be very troublesome when they do not function perfectly. As with scopes, there is no viable low-tech alternative to the insufflation system itself, since precise regulation of the intra-abdominal pressure is crucial to the success of the operation and the safety of the patient.

If you are using donated, recycled, or secondhand equipment it is likely that you will have a higher amount of air leakage, which will cause higher turnover of CO2 tanks if you are using these. Minimize leakage by developing a meticulous technique of surgical access; make each port hole exactly the size you need it to be and no bigger. Once you have accomplished this, most of your air leak will come from reused "single use" ports, when the seals begin to age.

Alternatives to CO2 insufflation include gasless laparoscopy and air insufflation. Gasless laparoscopy uses sterile hooks in the abdominal wall, attached to the ceiling or to a frame above the operating table, to suspend the abdominal wall without any insufflation. Our experience with this technology is that it is cumbersome and often does not allow for adequate visualization.

Air insufflation is an alternative that is easy to implement and safe. It does not lead to hypercarbia as CO2 does. Rather than a tank of compressed gas, an air compressor is connected to the insufflation system. Usually the air compressor is placed outside the operating room due to the noise. As mentioned above, moisture within the compressor's line may cause problems for some high-end electronic insufflation systems. Air will take longer than CO2 to reabsorb, and the patient may have longer lasting symptoms of pneumoperitoneum such as abdominal or shoulder pain as a result. It is important to avoid procedures that might allow air to enter the chest cavity; air that fails to reabsorb quickly here may require drainage with a thoracostomy tube.

Ports come in two types: disposable (plastic) and reusable (stainless steel.) Each has its own benefits and disadvantages.

Disposable port benefits:

- Have a complex (disposable) internal valve and seal system which allow them to accommodate instruments of different diameters
- Can sometimes be resterilized if cleaned properly
- Sharp plastic nonbladed trocars are safer than sharpened stainless steel trocars.

Disposable port pitfalls:

- Often break after several cycles of reuse, especially at attachment of CO2 insufflation port to body.

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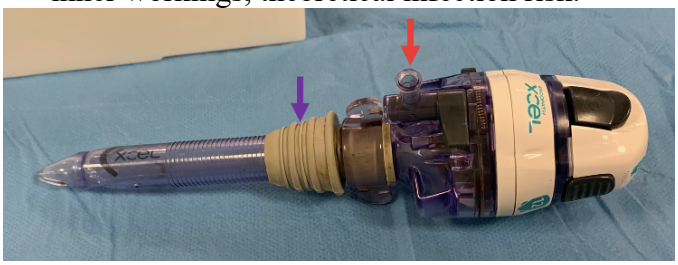
- Internal valve and seal system leaks after several cycles of reuse and sterilization.
- Difficult to source, expensive
- More difficult to remove debris and blood from inner workings, theoretical infection risk.



Disposable port being reused. Weakest point is where the air insufflation system connects (red arrow,) this will fatigue and break after several uses. Notice the Hasson sleeve (purple arrow,) taken from a different disposable port with a slightly different size. During laparoscopy, air leaks around this sleeve.

Reusable benefits:

- Strong, stands up to repeated reuse and sterilization
- Easier to clean and sterilize
- Loss of air through an old seal is easily treated by replacing the silicone seal.

Reusable pitfalls:

- Often only accepts one size of instrument due to simpler seal system; a "sizer" is sometimes required to pass a 5mm instrument through an 11mm port.
- Small but expensive items, subject to loss or theft
- Some stainless steel trocars have a razor-sharp obturator, with a higher potential for patient injury if not carefully placed.

Disassembled view of 5mm stainless steel laparoscopic cannula. The whole assembly including the inner (purple arrow) and outer (red arrow) seals can be sterilized in steam or chemical systems. These seals can be purchased separately and replaced when they become worn. The trocar tip, not seen in this photo, is blunt.

Specimen bags can be made from sterile gloves. Alternatively, organs that are not distended or grossly infected can be grasped directly, moved into the camera port under direct visualization, and passed out one of the abdominal incisions after removal of the port.

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Demonstration of the technique for making an endoscopic bag from a sterile glove. The assistant grasps the fingers and the cuff and pulls them apart. The surgeon then ties a knot around the glove just below the fingers. The fingers are then cut off and the bag is inserted into the abdominal cavity for specimen retrieval.

Clips can be obtained in either disposable appliers that are intended for single use, or in re-usable appliers that the clips are loaded into. An alternative is to use a "Roeders" slip knot[5] and knot pusher, or to become facile with intracorporeal knot tying. A "cardboard box" laparoscopic trainer such as the one described in the ALLSAFE modules allows the surgeon to acquire this skill outside of the operating room.

If your supply of clips is limited, try to reserve them for situations where they are truly needed. For example, it is very difficult to control hemorrhage from a small, avulsed vessel stump with an intracorporeal knot.

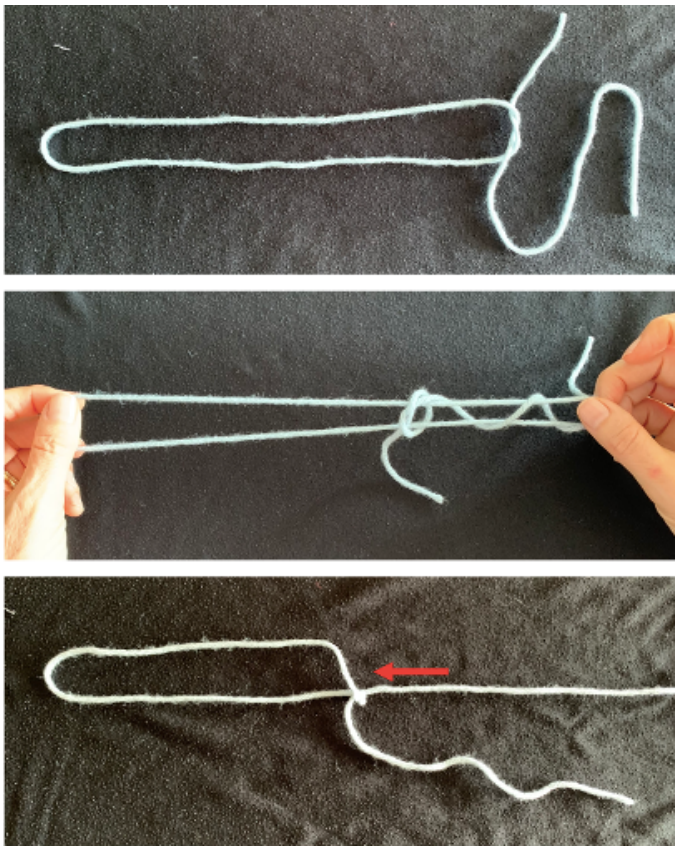

Figure: Roeder's knot demonstrated.
Top: a loop is made consisting of a simple knot. The end opposite the knot can be passed around a structure inside the abdominal cavity, such as the undivided appendiceal stump, before the simple knot is tied.
Middle: An assistant holds one or both ends of the loop, including the previously tied simple knot. One end of the suture is passed around the loop three times and then tied in another simple knot, as shown.
Bottom: The suture is pulled into a knot, which slides along one of the limbs of the suture in the direction shown. To avoid tension on the other end of the loop, the knot can be pushed with a knot pusher until it is tight in position. Alternatively, the short end of the suture can be grasped with a laparoscopic needle driver, which is passed through the same port and used to tighten the knot.

An Extraperitoneal space maker for totally extraperitoneal hernia repair is not absolutely necessary. It is possible to enter the extraperitoneal space and dissect it laparoscopically; this can be accomplished with an optical access trocar (OPTIVIEW by Ethicon, SURGIVIEW by US Surgical, or VISIPORT by Covidien.) Alternatively, obtain intra-abdominal access and then place another port, while watching laparoscopically, above the pubic symphysis through all layers of the abdominal wall except the peritoneum. The peritoneum can then be bluntly dissected. Connecting the insufflator to this port helps the

dissection proceed until a scope can be inserted in this space.

Maintenance

There are three options for maintenance and repairs of equipment: In-hospital, in-country, and out of the country.

In-hospital maintenance is likely to be the method you use the most. If your country's universities offer degrees in Biomedical Engineering, understand that someone with this degree may not have much hands-on experience in actually repairing equipment; make sure they have plenty of support. If such a person is not available, identify an intelligent, self motivated and independent individual and invest in this person. Advance your engineer's knowledge and career by connecting them with other biomedical engineers or product representatives, (even if these are in other countries) and enrolling them in courses on repair of specific instruments, either in-country or in other countries by remote link.

An individual who has been well trained to repair biomedical equipment is a rarity, and other hospitals may want to "poach" this person. Make sure that they are treated well and paid well; a discussion with the Human Resources about their specialized skill may be appropriate. This is especially important if your Biomedical Engineer has been hired into a newly created position; the HR department may not be aware of how important they are to your operations.

Maintain open lines of communication and be realistic about what can be repaired in your setting. Be aware that in certain cultures, saying "I can't" to an order from a superior might be seen as disrespectful. Make sure that your biomedical engineer understands that some equipment, especially donated equipment, may be irreparable, and that it is acceptable to say so.

In-country repairs become more possible as a country becomes more economically advanced and biomedical equipment companies establish a presence in that country. Thoroughly investigate which companies have representatives in your country. Try to purchase equipment from those companies. This will facilitate repair and availability of spare parts. Representatives may not have good customer service and repairs may take a long time. Even so, an in-country contact and slow repairs may be better than the alternative, sending the piece of equipment back to its country of origin and dealing with transportation, customs, and the other hassles that come with that approach.

Cultivate relationships with surgeons at other hospitals and try to find out which companies have good customer service and a track record of timely repair, so that you can purchase equipment from those companies. Be willing to provide this information to other surgeons as well. Make small orders at first and "test" a company's customer service.

Out of country repairs may be necessary for some specialized, reusable equipment. In our experience, equipment that is most amenable to this approach is typically small, expensive and complex. Examples include:

- Flexible endoscopes: steering mechanisms break, seals leak, or electronics fail
- Rigid endoscopes: lenses crack, seals leak
- Laparoscopic cameras: lenses crack, electronics fail

We have avoided sending larger equipment such as laparoscopic insufflators or camera receivers. The expense and difficulty of sending bulky heavy equipment like this overseas is seldom worth the trouble.

You may be able to get repairs done at a reduced rate in an industrialized country, especially if you are involved in humanitarian work. There is no harm in asking.

Equipment that is leaving your country for repairs will pass through the hands of Customs agents on two separate occasions. Make sure that you provide the carriers with official documentation for both journeys. We have had scopes confiscated on arrival in the United States- the Customs officials suspected that it was headed for an unregulated clinic. This misunderstanding could have been avoided (and was eventually resolved) with a letter stating that the scope was coming into the country for repairs only.

On the equipment's return to your country, avoid paying a tariff a second time by making sure the equipment is accompanied by a letter on hospital

letterhead. This should state that the equipment is property of the hospital, that it was already imported legitimately, and that it is currently returning for repairs, rather than entering the country for the first time.

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