World Laparoscopy Hospital INDIA UAE USA

Laparoscopic Equipment and Instruments

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INSUFFLATION SYSTEM

Laproflattor

The electronic carbon dioxide (CO_2) laproflattor is a general-purpose insufflation unit for use in laparoscopic examinations and operations **(Fig. 1)**.

Controlled pressure insufflation of the peritoneal cavity is used to achieve the necessary work space for laparoscopic surgery by distending the anterolateral abdominal wall and depressing the hollow organs and soft tissues. CO_2 is the preferred gas because it does not support combustion. It is very soluble which reduces the risk of gas embolism, and is cheap. Automatic insufflators allow the surgeon to preset the insufflating pressure, and the device supplies gas until the required intra-abdominal pressure (IAP) is reached. The insufflator activates and delivers gas automatically when the IAP falls because of gas escape or leakage from the ports. The required values for pressure and flow can be obtained using jog keys and digital displays. Insufflation pressure can be continuously varied from 0 to 30 mm Hg; total gas flow rate and volumes can be set to any value in the range 0–45 L/min.

Patient safety is ensured by optical and acoustic alarms as well as several mutually independent safety circuits. The detail function and quadromanometric indicators of insufflator is important to understand safety point of view. The important indicators of insufflators are preset pressure, actual pressure, flow rate, and total gas used.

Fig. 1: Insufflator.

Quadromanometric Indicators

Quadromanometric indicators are the four important readings of insufflator. The insufflator is used to monitor:

1. Preset insufflation pressure
2. Actual pressure
3. Gas flow rate
4. Volume of gas consumed

Preset Insufflation Pressure

This is the pressure adjusted by surgeon before starting insufflation. This is the command given by surgeon to insufflator to keep IAP at this level.

The preset pressure ideally should be 12–15 mm Hg. In any circumstance, it should not be more than 18 mm Hg in laparoscopic surgery. However, in extraperitoneal surgery preset pressure can be more than 18 mm Hg. The good quality microprocessor-controlled insufflator always keeps IAP at preset pressure. Whenever IAP decreases due to leak of gas outside, insufflator eject some gas inside to maintain the pressure equal to preset pressure and if IAP increases due to external pressure, insufflator sucks some gas from abdominal cavity to again maintain the pressure to preset pressure.

When surgeon or gynecologist wants to perform diagnostic laparoscopy under local anesthesia, the preset pressure should be set to 8 mm Hg. In some special situation of axilloscopy or arthroscopy, we need to have pressure >19 mm Hg.

Actual Pressure

This is the actual IAP sensed by insufflator. When Veress needle is attached, there is some error in actual pressure reading because of resistance of flow of gas through small caliber of Veress needle. Since continuous flow of insufflating gas through Veress needle usually gives extra 4–8 mm Hg of measured pressure by insufflator, the true IAP can actually be determined by switching the flow from insufflator off for a moment. Many microprocessor-controlled good quality insufflator delivers pulsatile flow of gas when Veress needle is connected, in which the low reading of actual pressure measures the true IAP.

If there is any major gas leak, actual pressure will be less and insufflator will try to maintain the pressure by ejecting gas through its full capacity.

Actual pressure if >20–25 mm Hg has following disadvantage over hemodynamic status of patient:

- Decrease venous return due to vena caval compression leading to:
  - Increased chance of deep vein thrombosis (DVT) of calf
  - Hidden cardiac ischemia can precipitate due to decrease cardiac output
- Decrease tidal volume due to diaphragmatic excursion
- Increase risk of air embolism due to venous intravasation
- Increased risk of surgical emphysema
- Decreased renal perfusion.

Flow Rate

This reflects the rate of flow of CO_2 though the tubing of insufflator. When Veress needle is attached, the flow rate should be adjusted for 1 L/min. Experiment was performed over animal in which direct intravenous (IV) CO_2 was administered and it was found that risk of air embolism is less if rate is within 1 L/min. At the time of access using Veress needle technique, sometime Veress needle may be inadvertently enter inside a vessel but if the flow rate is 1 L/min there is less chance of serious complication. When initial pneumoperitoneum is achieved and cannula is inside abdominal cavity, the insufflators flow rate may be set at maximum, to compensate loss of CO_2 due to use of suction irrigation instrument. This should be remembered that if insufflator is set to its maximum flow rate then also it will allow flow only if the actual pressure is less than preset pressure otherwise it will not pump any gas. Some surgeon keeps initial flow rate with Veress needle to 1 L/min and as soon as they confirm that gas is going satisfactorily inside the abdominal cavity (percussion examination and seeing obliteration of liver dullness) then they increases flow rate. No matter how much flow rate you set for Veress needle, the eye of normal caliber Veress needle can give way CO_2 flow at maximum 2.5 L/min. When the flow of CO_2 is >7 L/min inside the abdominal cavity through cannula, there is always a risk of hypothermia to patient. To avoid hypothermia in all modern microprocessor-controlled laproflattor, there is electronic heating system which maintains the temperature of CO_2.

Total Gas Used

This is the fourth indicator of insufflator. Normal size human abdominal cavity needs 1.5 L CO_2 to achieve intra-abdominal actual pressure of 12 mm Hg. In some big size abdominal cavity and in multipara patients, sometime we need 3 L of CO_2 (rarely 5–6 L) to get desired pressure of 12 mm Hg. Whenever there is less or more amount of gas is used to inflate a normal abdominal cavity, surgeon should suspect some errors in pneumoperitoneum technique. These errors may be leak or may be preperitoneal space creation or extravasations of gas. The detail principles and techniques of safe access are discussed in Chapter 6: Abdominal Access Techniques.

SUCTION/IRRIGATION SYSTEM

It is used for flushing the abdominal cavity and cleaning during endoscopic operative intrusions **(Fig. 2)**.

It has been designed for use with the 26173 AR suction/instillation tube. Its electrically driven pressure/suction pump is protected against entry of bodily secretions. The suction irrigation machine is used frequently at the time of laparoscopy to make the field of vision clear. Most of the surgeons use normal saline or Ringer's lactate for irrigation purposes. Sometime heparinized saline is used to dissolve blood clot to facilitate proper suction in case of excessive intra-abdominal bleeding.

Irrigation and Suction Tubes

A suction-irrigation probe can be a versatile instrument. Laparoscopic suction and irrigation tube is one of the very important instruments which surgeon should practice frequently **(Fig. 3)**. Vision is one of the limitations of laparoscopic surgery. The blood is the darkest color inside abdominal cavity and excess of blood inside absorbs most of the light. Whenever there is bleeding, one should first try to suck it out. Controlled suction and irrigation enhance the observation and improve operative technique. Suction and

Fig. 2: Laparoscopic suction irrigation machine.

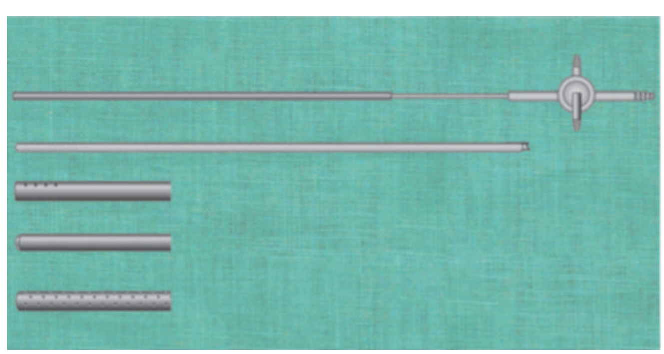


Fig. 3: Laparoscopic irrigation and suction tubes.

irrigation tube also can be used for blunt dissection. At the time of using suction and irrigation, the tip of the suction irrigation cannula should be dipped inside blood, otherwise the gas will be sucked and surgeon will lose his vision due to loss of pneumoperitoneum. 10-mm suction tube should be used if there is >1,500 mL of hemoperitoneum or if there is blood clots inside the abdominal cavity. Sometime small spilled stones can also be sucked with the help of laparoscopic irrigation suction tube at the time of laparoscopic cholecystectomy. It is very useful instrument for doing peritoneal toilet in case of appendicular or duodenal perforation.

ENERGY SOURCE SYSTEM

Electrosurgery is the use of radiofrequency alternating current to cut and coagulate tissues. It has proven a major advance in surgery by minimizing blood lose, reducing operative time, and providing a clear and clean surgical field without the need to tie off all blood vessels.

In laparoscopy, cutting and the establishment of hemostasis forms the core of laparoscopic surgery. For a laparoscopic hernia repair, both monopolar and bipolar modes are required.

Coagulating and Dissecting Electrodes

Spatula and hook are the main electrodes used for monopolar cutting and coagulation **(Fig. 4)**.

Spatula is either "W" shaped or blunt. Hooks are also of various shapes, e.g., "L" shaped, "J" shaped or "U" shaped **(Fig. 5)**.

Hooks are simple instrument whose distal tip can vary slightly. They must be insulated along the entire length because they are used with the monopolar current. The hook with ceramic cone protecting the distal end is available which protects efficiently against current diffusion **(Fig. 6)**.

Some ball-shaped, barrel-shaped or straight coagulation electrodes are also available to achieve proper hemostasis. These blunt electrodes are particularly useful when there is generalized oozing of blood and surgeon cannot see specific bleeder point, e.g., bleeding from the gallbladder bed at the time of laparoscopic cholecystectomy. These blunt electrosurgical instruments are also used for fulguration at the time of ablation of endometriosis.

Bipolar Forceps

Bipolar forceps are one of the very important electrosurgical instruments in minimal access surgery **(Fig. 7)**.

It is safer than monopolar instruments because electron travels only through the tissue held between the jaw and patient's body is not a part of circuit. Both the jaws of bipolar are insulated and the patient return plate is not necessary to be attached **(Fig. 8)**.

The detailed principle of electrosurgery is discussed later in laparoscopic dissection techniques.

Fig. 4: Spatula.

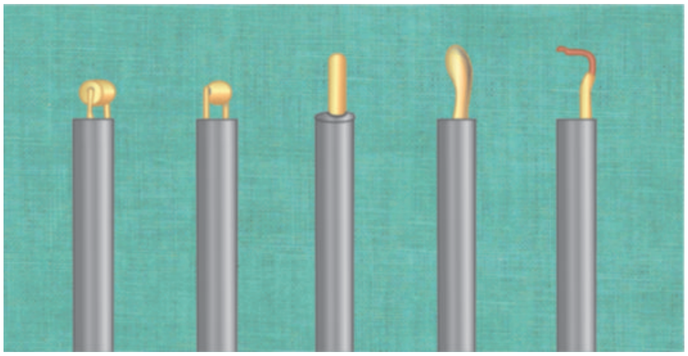


Fig. 5: Various types of hooks.

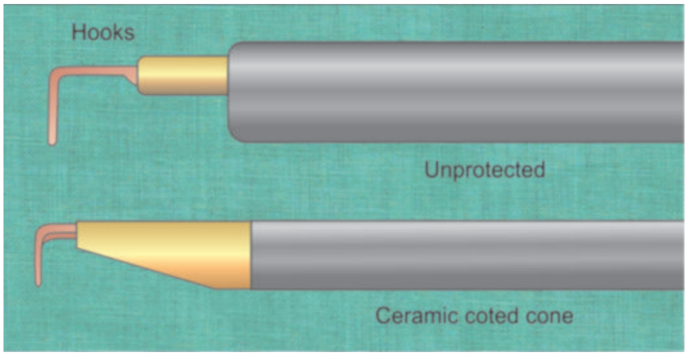


Fig. 6: Ceramic coating of hook.

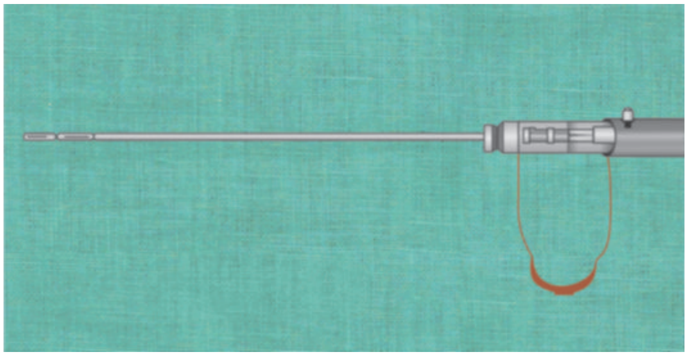


Fig. 7: Bipolar forceps.

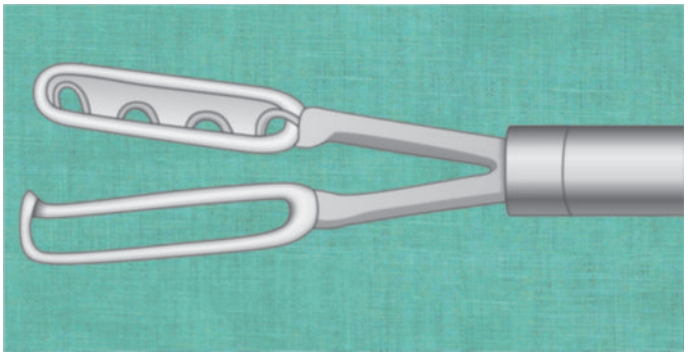


Fig. 8: Jaw of bipolar forceps.

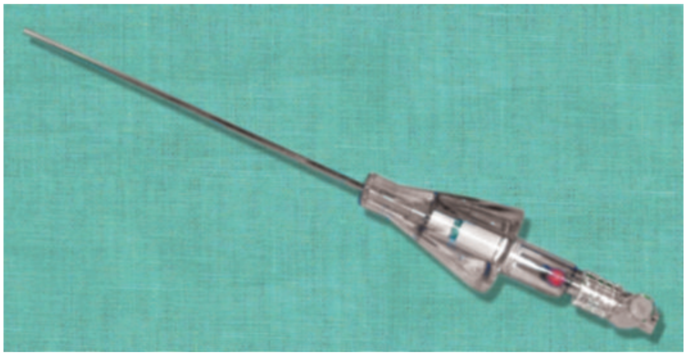


Fig. 9: Veress needle.

LAPAROSCOPIC WORKING INSTRUMENT

Disposable or Reusable Instrument

Several factors should be considered at the time of choosing laparoscopic instrument, including cost, availability, and reliability. Reusable instruments are expensive initially but in long run they are cost-effective. The cost of disposable instruments is less compared to reusable but patient cost is increased. In developing countries, disposable instruments are very rarely used because labor cost is low compare to the cost of disposable instrument. In Europe and the United States of America, surgeons often choose to use disposable instrument in order to save high labor cost. The main advantage of disposable instrument is high performance due to its sharpness and reduced chance of disease transmission due to certified high-end factory sterilization. However, once discarded, environment concerns are raised about disposal and biodegradability of disposable instruments. Ideally, disposable instrument should not be used repeatedly because handling, sorting, storing, and sterilization make these instruments questionable. The disposable instruments are not sterilized properly by dipping in glutaraldehyde because they are not dismountable. Insulation of disposable instrument also can be torn easily which can lead to electrosurgical injuries.

Insufflation Cannulas

Veress Needle

Veress needle was invented by a chest physician for aspiration of pleural effusion keeping in mind that its spring mechanism and blunt tip will prevent the injury of lung tissue **(Fig. 9)**.

Veress needle consists of an outer cannula with a beveled needle point for cutting through tissues. Inside the cannula is an inner stylet, which is loaded with a spring that "springs forward" in response to the sudden decrease in pressure encountered upon crossing the abdominal wall and entering the peritoneal cavity. The lateral hole on this stylet enables CO_2 gas to be delivered intra-abdominally.

Veress needle is used for creating initial pneumoperitoneum so that the trocar can enter safely and the distance of abdominal wall from the abdominal viscera should increase. Veress needle technique is the most widely practiced way of access. Before using Veress needle every time, it should be checked for its potency and spring action. Veress needle is available in three length 80 mm, 100 mm, and 120 mm. In obese patient 120 mm and in very thin patient with scaphoid abdomen 80 mm Veress needle should be used. Veress needle should be held like a dart at the time of insertion.

Hasson Cannula

In an effort to decrease the incidence of injuries associated with the blind access of the peritoneal cavity with the Veress needle and the initial trocar, Hassan proposed a blunt (open) minilaparotomy access. He develops a reusable device of similar design to a standard cannula but attached an olive-shaped cone (sleeve) **(Fig. 10)**.

This cone would slide up and down the shaft of the cannula and would form an airtight seal at the fascial opening. In addition, the sharp trocar was replaced by a blunt obturator. This cannula is held in place by the use of stay sutures passed through the fascial edges and attached to the body of the cannula **(Fig. 11)**.

The reason the olive sleeve is designed to slide up and down the shaft of the cannula is to allow for variations in abdominal wall thickness. The tension provided by the fascial sutures when attached to the device serves to create a seal to prevent gas leakage. To adjust the length of the cannula within the abdominal wall, the fascial sutures require detachment from the device, adjustment of the olive sleeve and reattachment of the sutures.

Several disposable open-access devices have been released. They are similar to the reusable system originally described by Hasson except that the stay sutures are attached directly to the olive, allowing manipulation of the cannula depth without detaching the stay sutures. The basic method of peritoneal access, however, has remained the same.

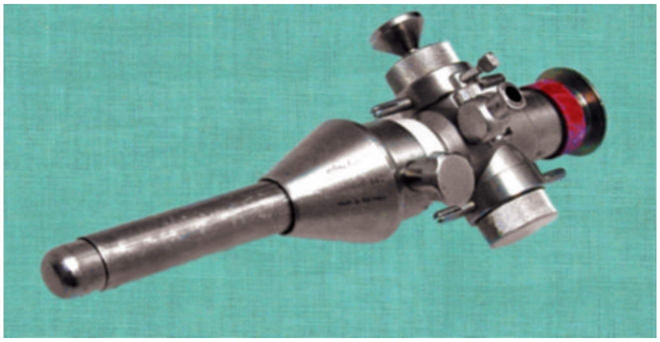


Fig. 10: Hasson trocar and cannula.

PORT ACCESS INSTRUMENT

Trocar and Cannula

The word “trocar” is usually used to refer to the entire assembly but actual trocar is a stylet which is introduced through the cannula. The trocars are available with different types of tips. The cutting tips of these trocars are either in the shape of a three-edged pyramid or a flat two-edged blade.

Conical-tipped trocars are supposed to be less traumatic to the tissue. The tip can be penetrated through the parietal wall without cutting and decreased risk of herniation or hemorrhage is reported.

Cannulas are in general made from plastic or metal. Plastic devices whether they are transparent or opaque, need to be designed in such a way as to minimize the reflection of light from the telescope. Reusable and disposable trocars are constructed by a combination of metal and plastic. The tip of disposable trocar has a two-edged blade. These are very effective at penetrating the abdominal wall by cutting the tissue as they pass through. Most of the disposable plastic trocars have spring-loaded mechanism that withdraws the sharp tip immediately after it passes through the abdominal wall to reduce the incidence of injury of viscera. Trocar and cannula are of different sizes and diameter depending upon the instrument for which it is used. The diameter of cannula ranges from 3 to 30 mm; the most common size is 5 mm and 10 mm. The metal trocar has different types of tips, i.e., pyramidal tip, eccentric tip, conical tip or blunt tip depending on the surgeon’s experience **(Fig. 12)**.

All the cannulas have valve mechanism at the top **(Figs. 13A and B)**.

Valves of cannula provide internal air seals, which allow instruments to move in and out within cannula without the loss of pneumoperitoneum. These valves can be oblique, transverse, or in piston configuration.

These valves can be manually or automatically retractable during instrument passage. Trumpet type valves are also present which provide excellent seals, but they are not as practical as some of the other systems. They require both hands during instrument insertion, which may explain why they are less often used in advanced laparoscopic cases.

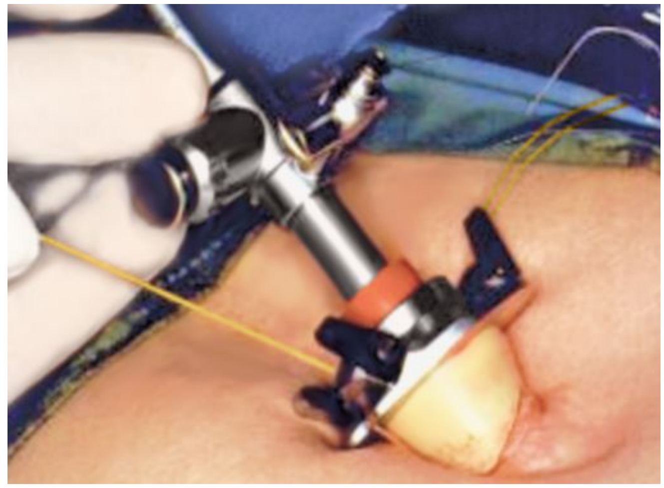


Fig. 11: Hasson cannula in proper position.

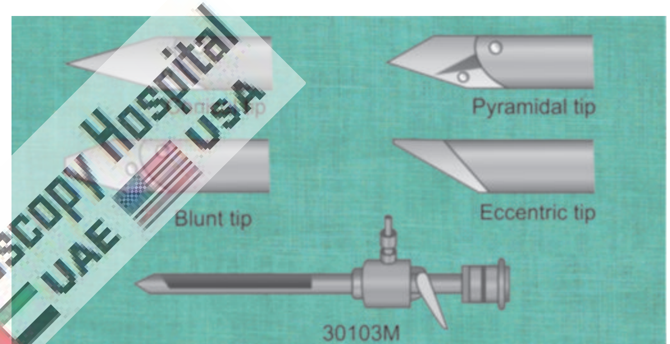


Fig. 12: Tip of the trocar.

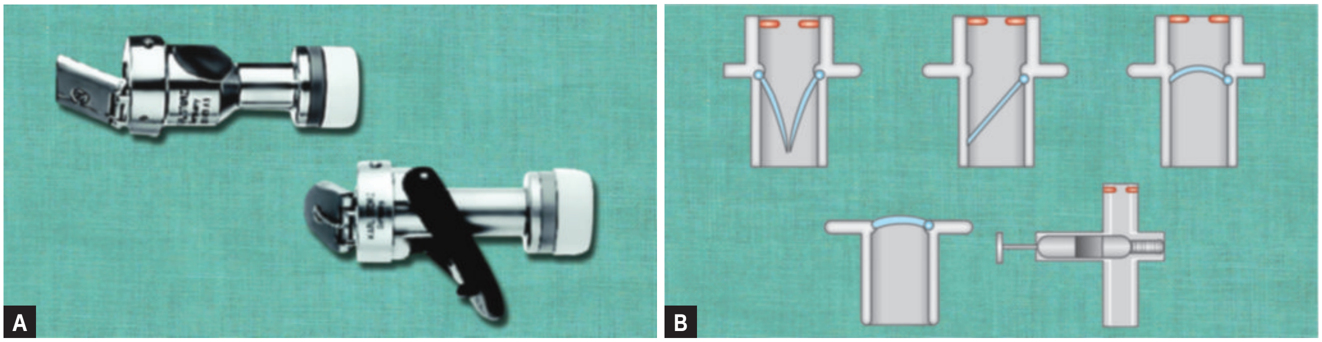
The flexible valves limit the leakage of CO_2 during work whatever the diameter of the instrument used.

It should be remembered that sharp trocars although looking dangerous are actually better than blunt one because they need less force to introduce inside the abdominal cavity and chances of inadvertent forceful entry of full length of trocar are less. There is always a difference in the marked exterior diameter of the cannula and the interior usable diameter. The end of the cannula is either straight or oblique. An oblique tip is felt to facilitate the easy passage of the trocar through the abdominal wall.

Trocar and cannula should be held in proper way in hand so that head of the trocar should rest on the thenar eminence, the middle finger should rest over the gas inlet and index finger is pointed toward the sharp end of the trocar.

Visiport

The Visiport is a kind of optical trocars which is a disposable and expendable visual entry tool which includes a cannula and hollow trocar with cutting blade at tip **(Fig. 14)**. It is applied after insufflation of CO_2 in the abdomen. This technique of inserting Visiport is palmed via surgeon’s hand and maintained perpendicular to distend patient’s CO_2 to abdomen. When accurate anatomical status of trocar tip



Figs. 13A and B: (A) Different valve mechanism of cannula; (B) Different valve mechanism of cannula (internal view).

Fig. 14: Visiport.

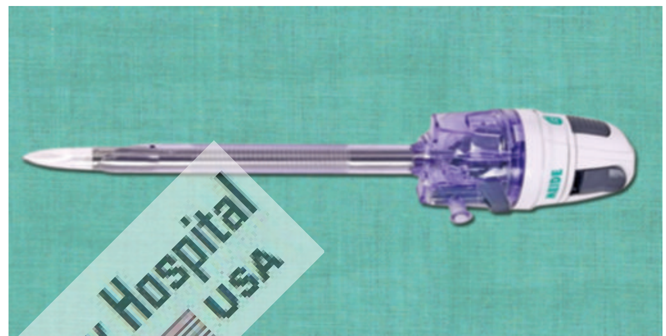


Fig. 15: Bladeless optical trocar.

is checked by visualization of layers of abdominal wall on monitor, downward axial pressure is used and activated to trigger cutting blade. Downward pressure causes trocar to advance optical bladed tip and its situation is checked again and again seeing on the monitor. These sequences are repeated till the peritoneal cavity is arrived. This is not fired till the accurate anatomical status of trocar tip is known. However, none of the laparoscopic entry methods have distinct superiority over other. On the other words, Visiport technique is also associated with abundant complication. Visiport optical trocar technique is faster for initial trocar placement than Hasson technique. However, it is associated with complications compared to open Hasson technique. Therefore, there is benefit with respect to speed for initial trocar placement and harm based on complications of sharp cutting blade in Visiport trocar system.

Bladeless Optical Trocar

There are many single-use bladeless optical trocar systems available which provide a versatile, operationally flexible, and unique mode of entry into the abdominal cavity for any laparoscopic procedure **(Fig. 15)**. The distinctively engineered visual tip greatly reduces wound defect size as well as insertion force into the abdominal cavity. Injuries due to blind entry and a sharp blade are virtually eliminated with the use of bladeless optical tip trocar system. The optical tip provides direct visualization of the various tissue layers when accompanied by a laparoscope during insertion. Because the bladeless tip separates and dissects without cutting, trauma to the abdominal wall and vessels are minimized.

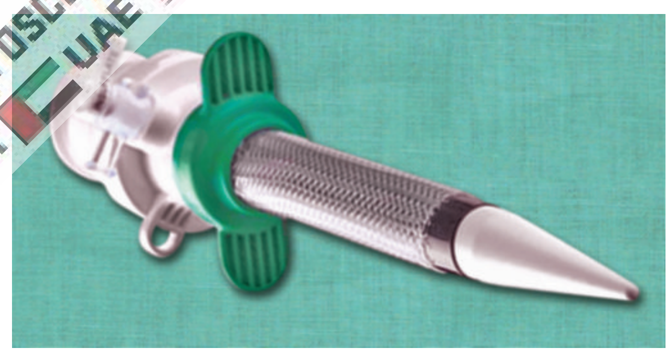


Fig. 16: Step radially expanding trocar.

Step Trocar

Step radially expanding technology allows the VersaStep bladeless trocars to yield smaller fascial defects for an equivalent cannula size compared to conventional bladed trocars. The VersaStep bladeless trocars use Step radial dilation technology. The VersaStep system can be found in a 70 mm, 110 mm or 150 mm working length and can be 5 mm, 11 mm, 12 mm or 15 mm in diameter. The trocars are designed to keep fascial issues from being a threat. It can keep gas completely airtight within the abdominal cavity and can help allow instruments from 4.5 mm, 12 mm or 15 mm to be exchanged as needed. In this technology initially less diameter trocar is introduced which is stretchable. Over this stretchable cannula again desired diameter of trocar is pushed to radially dilate the abdominal port wound. This results in less chance of hernia. This trocar system is strictly disposable and cannot be used second time as outer sheath breaks after single use **(Fig. 16)**.

LAPAROSCOPIC HAND INSTRUMENTS

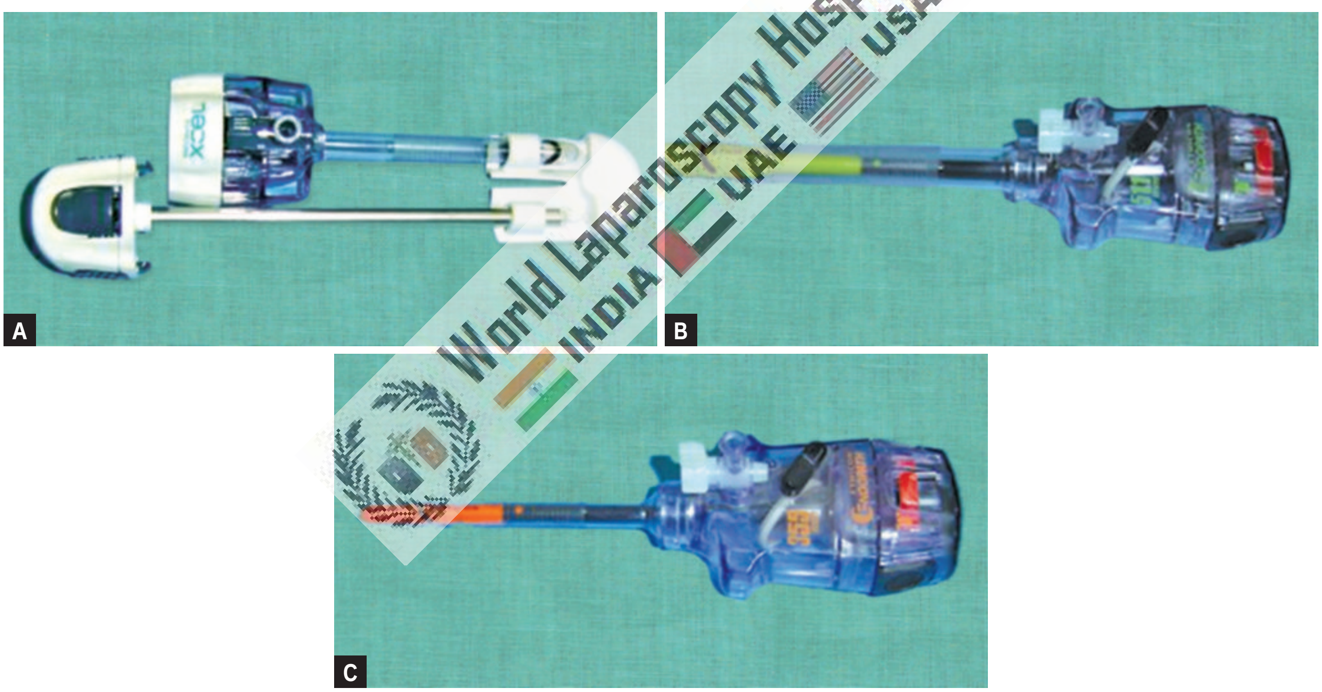
Laparoscopic hand instruments vary in diameter from 1.8 to 12 mm but majority of instruments are designed to pass through 5–10 mm of cannula. The hand instruments used in laparoscopic surgery are of different length (varies company-to-company and length of laparoscopic instrument varies from 18 to 45 cm) but they are ergonomically convenient to work if they have same length of approximately 36 cm in adult and 28 cm in pediatric practice. Shorter instruments 18–25 cm are adapted for cervical and pediatric surgery. Certain procedures for adult can also be performed with shorter instruments where the space is constricted. 45-cm instruments are used in obese or very tall patients. For better ergonomics, half of the instruments should be inside the abdomen and half outside. If half of the instrument is in and half out, it behaves like class 1 lever and it stabilizes the port nicely so the surgery will be convenient.

Most of the laparoscopic procedures require a mixture of sharp and blunt dissection techniques, often using the same instrument in a number of different ways. Many laparoscopic instruments are available in both reusable and disposable version **(Figs. 17A to C)**.

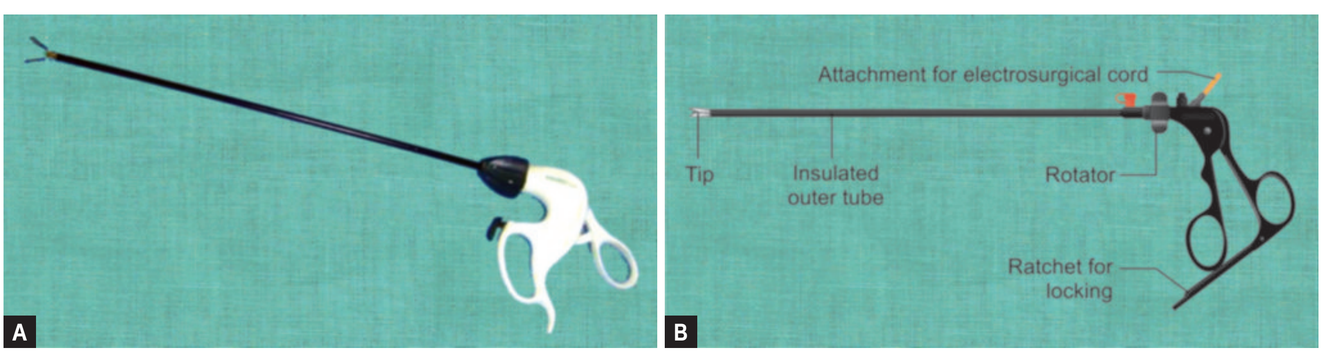
Most reusable instruments are partially dismountable so that it can be cleaned and washed properly. Some manufacturers have produced modular system where part of the instrument can be changed to suit the surgeon's favorite attachment like handle or working tip.

Most laparoscopic instruments such as graspers and scissors have basic opening and closing function **(Figs. 18A and B)**. Many instrument manufacturers during past few years are able to rotate at 360° angle which increases the degree of freedom of these instruments **(Fig. 19)**.

Certain types of instrument offer angulations at their tip in addition to usual 4° of freedom. These instruments are



Figs. 17A to C: (A) Disposable trocar and cannula; (B and C) Disposable trocar and cannula (another view).



Figs. 18A and B: (A) Disposable grasper; (B) Reusable graspers.

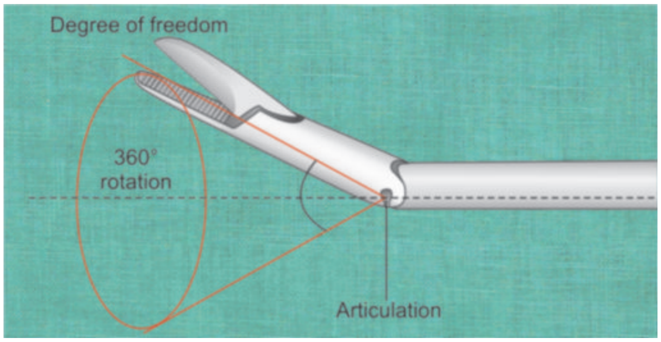


Fig. 19: Articulation of hand instrument.

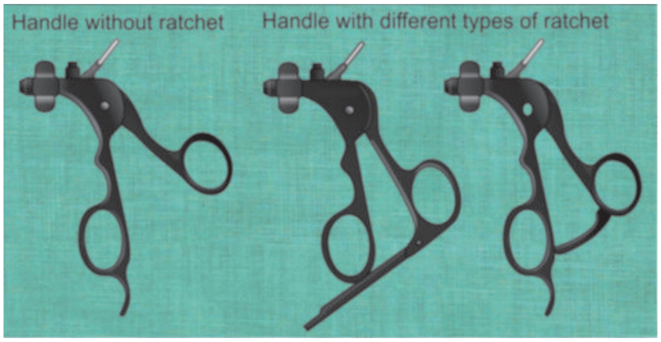


Fig. 20: Different types of handle of hand instrument.

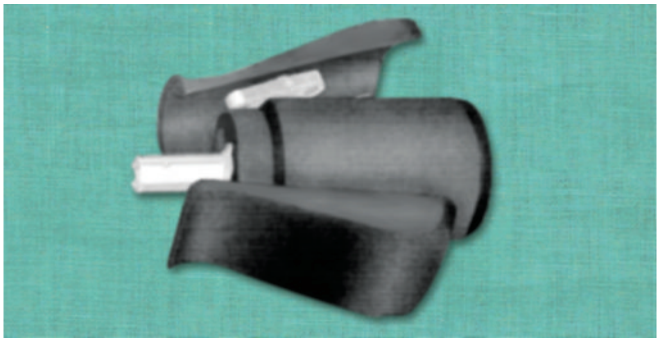


Fig. 21: Cuschieri ball handle.

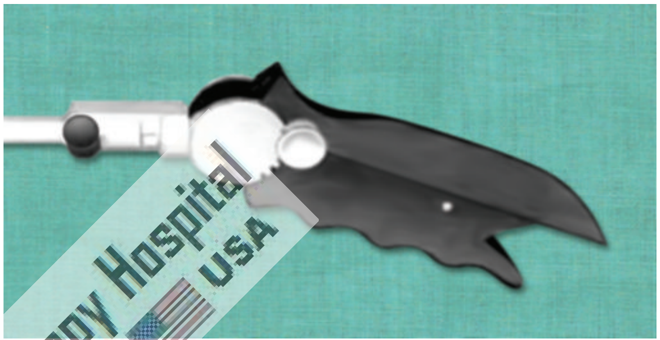


Fig. 22: Cuschieri pencil handle.

used to avoid obstacles and for the lateral grasping when the instrument is placed outside of the visual field. This feature is available for both reusable as well as disposable instrument. The complex mechanism of such instrument makes their sterilization very difficult.

A variety of instruments, especially retractors have been developed with multiple articulations along the shaft. When these are fixed with the tightened cable, the instrument assumes a rigid shape which could not have been introduced through the cannula.

Most of the hand instruments haves three detachable parts:
1. Handle
2. Insulated outer tube
3. Insert which makes the tip of the instrument.

Different Handles of Hand Instrument

Certain instrument handles are designed to allow locking of the jaw **(Fig. 20)**.

This can be very useful when the tissue needs to be grasped firmly for long period of time preventing the surgeon's hand from getting fatigue. The locking mechanism is usually incorporated into the handle so that surgeon can easily lock or release the jaws. These systems usually have a ratchet so that the jaws can be closed in different position and to different pressure. Most of the laparoscopic instrument handles have attachments for unipolar electrosurgical lead and many have rotator mechanism to rotate the tip of the instrument.

Some multifunctional laparoscopic handles have attachment for suction and irrigation and sometime hand switch for cutting and coagulation switch of electrosurgery. Cuschieri ball handle, invented by Professor Sir Alfred Cuschieri, lies comfortably in surgeon's palm **(Fig. 21)**.

This design reduces the fatigue of surgeon and eases rotation of the instrument by allowing rotation within the palm rather than using wrist rotation. Squeezing the front of the handle between the thumb and the first finger increases the jaw closing force; squeezing the rear of the handle between the thenar eminence of the thumb and last finger opens the jaws.

Cuschieri pencil handle also has great ergonomic value especially when used with needle holder **(Fig. 22)**.

This multifunctional laparoscopic handle allows the angle between the handle and the instrument to be altered to suit the surgeon's wrist angle. The conveniently placed lever of this pencil handle when pressed can change the angle. Just like ball handle, pressure at the front increases the jaw closing force while pressure at the rear opens the jaw **(Fig. 23)**.

OUTER SHEATH OF HAND INSTRUMENT

The insulation covering of outer sheath of hand instrument should be of good quality in hand instrument to prevent accidental electric burn to bowel or other viscera **(Fig. 24)**.

Insulation covering may be of silicon or plastic. At the time of cleaning the hand instrument, utmost care should

Fig. 23: Multifunctional laparoscopic handle.

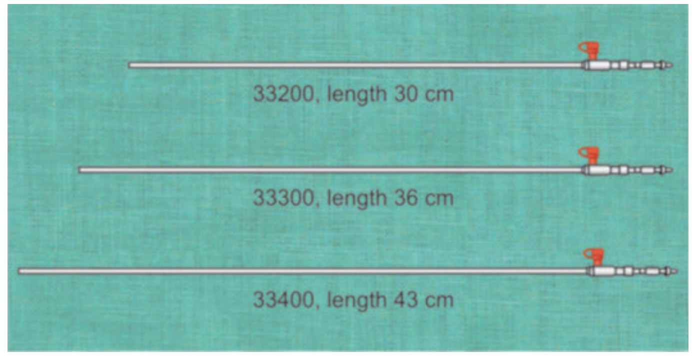


Fig. 24: Outer sheath of hand instrument.

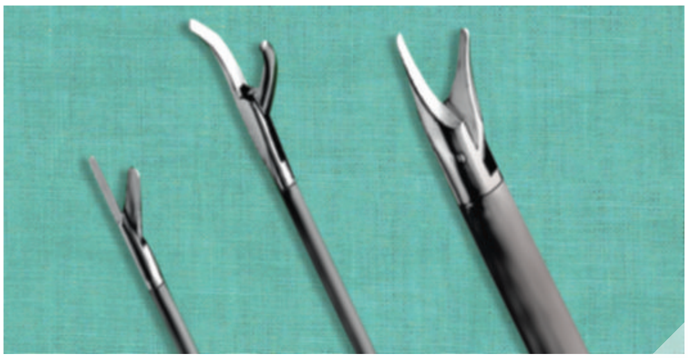


Fig. 25: Insert of hand instrument.

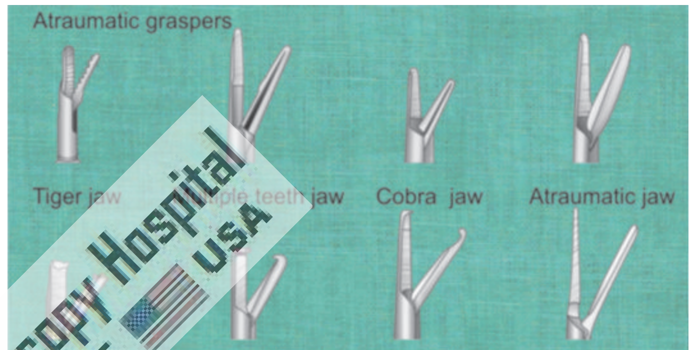


Fig. 26: Different jaw of graspers.

Fig. 27: Double-action jaw graspers.

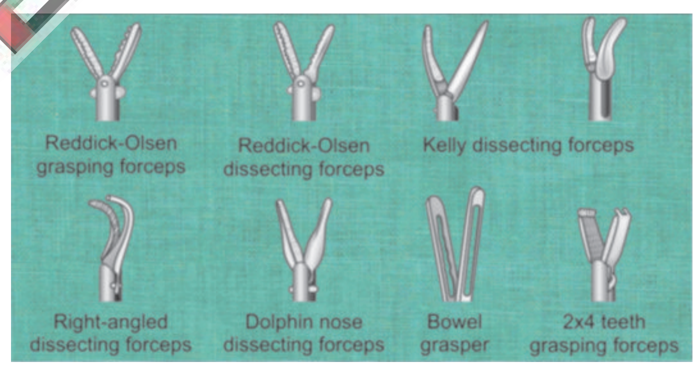


Fig. 28: Serrated jaw graspers.

be taken so that insulation should not be scratched with any sharp contact. A pin hole breach in insulation is not easily seen by naked eye but may be dangerous at the time of electrosurgery.

Insert of Hand Instrument

Insert of hand instrument varies only at tip **(Fig. 25)**.

It may be graspers scissors, or forceps. This grasper may have single-action jaw or double-action jaw. Single-action jaw opens less than double-action jaw but close with greater force. Thus, most of the needle holders are single-action jaw. The necessary wider opening in double-action jaw is present in grasper and dissecting forceps. Single-action graspers and dissectors are used where more force is required **(Fig. 26)**.

Single-action Jaw Graspers

These graspers are good when you do not have control over depth and surgeon wants to work in single plane in controlled manner particularly during adhesiolysis.

Double-action Jaw Graspers

These are shown in **Figures 27 and 28**.

INSTRUMENTS FOR SHARP DISSECTION

- Scissors
- Electrosurgery hook
- High-frequency (HF) electrosurgery spatula (Berci)
- HF electrosurgery knife
- Knife.

Scissors

Jean-Claude Margueron of Emar in 14th century BC invented scissors. Scissors are one of the oldest surgical instruments used by surgeons. Scissors are used to perform many tasks in open surgical procedure but its use in minimal access surgery is restricted. In minimal access surgery, scissors require greater skill because in inexperienced hand it may cause unnecessary bleeding and damage to important structures.

Mechanism of Cutting

The scissors have three parts:

1. Blade
2. Fulcrum
3. Handle

The cutting force of the scissors works on the law of lever. The force applied on the blade can be calculated by length of the handle and force applied on the grip of handle. A pair of scissors is an example of first-class levers connected together at the joint known as fulcrum.

There are three types of lever. Scissors works on the principle of class 1 lever **(Fig. 29)**. In class 1 lever, the pivot (fulcrum) is between the effort and the load. The more length of the handle or the fulcrum of the scissors, the less force of cutting will be required. The laparoscopic scissors do not apply the exact law of lever because of the cylinder action of the long shaft, but the design of handle helps in the amplification of force by lever action.

Scissors function by the combination of:

- Gripping
- Squeezing
- Tearing

When the blades of scissors close, its sharp edges grind against each other and any tissue which comes between the blades of scissors will get cut. The scissors-tissue interaction can be described in five stages:

Engagement

In the process of engagement, the two blades of the scissors engage a piece of tissue to cut. The amount of tissue engaged should not be more than the space between the jaw of blades otherwise the chance of slipping of tissue is more. After engagement, the force applied on the handle of the scissors initiates cutting.

Elastic Deformation

This stage starts just after the engagement of tissue between the blades of the scissors. In this process, the tissues between the two blades of scissors start deforming. This stage is called elastic deformation, because if the force on the handle of scissors is removed then the tissue deformity will return to its normal state.

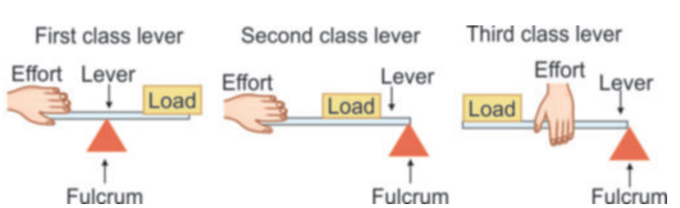


Fig. 29: Types of lever.

Plastic Deformation

Further force on the handle of scissors will cause the tissue between the blades to go into a plastic deformed state, which is irreversible. After undergoing this state of tissue deformation, even if further process of cutting is stopped the impression on the tissue remains.

Fracture

Further increased force on the fulcrum of scissors will result in the fracture of intercellular plane of the tissue. This stage of cutting is peculiar to scissors because unlike the scalpel, the site of tissue fracture is intercellular.

Separation

After the fracture, the tissue separates along line of the blade of scissors, and then this whole process of cutting will continue on the engaged tissue.

Histology of the Tissue After Cutting

Histological examination of the tissue after cutting with scissors shows that there is separation of tissue through intracellular plane. Microscopic examination shows serrated cut margin along the line of tissue separation.

TYPES OF LAPAROSCOPIC SCISSORS

There are different kinds of laparoscopic scissors based on the shape and indications for using them. All these are available in reusable and disposable type **(Fig. 30)**.

Straight Scissors

The blade of this scissors is straight and it is widely used as an instrument for mechanical dissection in laparoscopic surgery.

Straight scissors can give controlled depth of cutting because it has only one moving jaw **(Fig. 31)**. At the time of cutting, the fixed jaw should be down and moving jaw should be up.

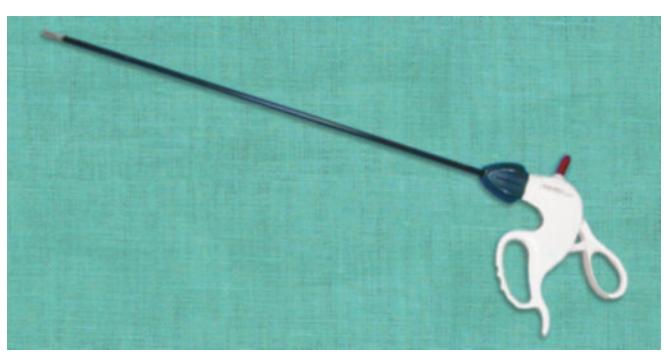


Fig. 30: Disposable scissors.

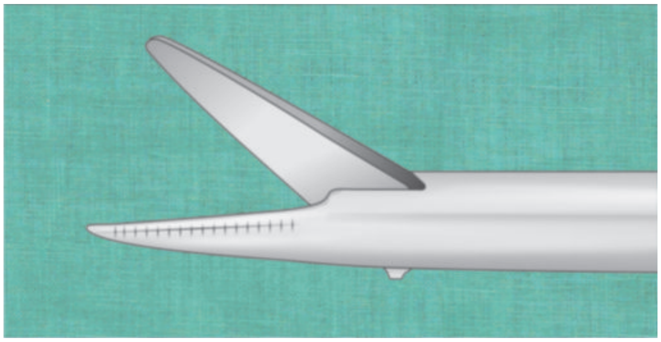


Fig. 31: Straight scissor.

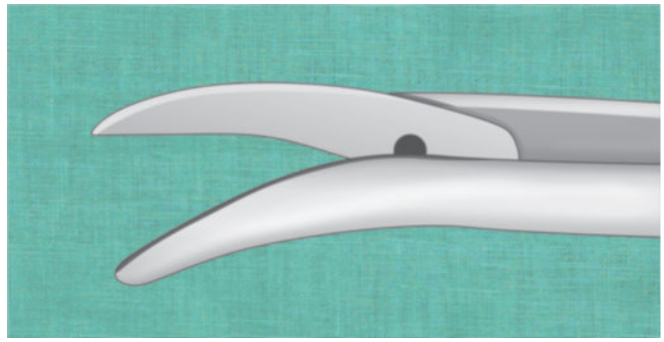


Fig. 32: Curved scissor.

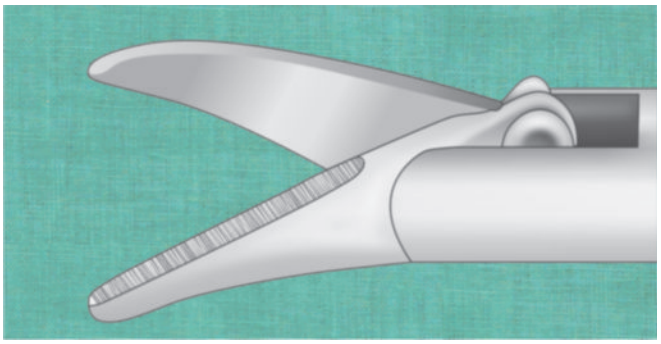


Fig. 33: Serrated scissor.

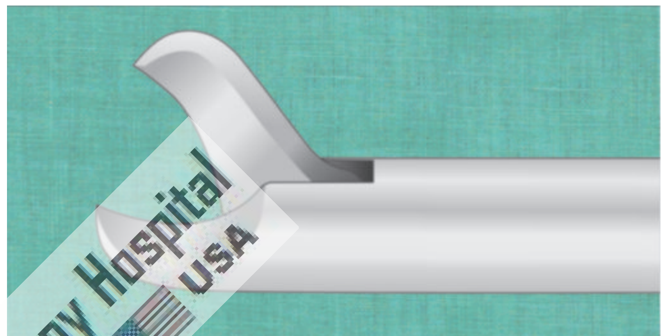


Fig. 34: Hook scissor.

Curved Scissors

The blade of this scissors is slightly curved and this is the most widely used scissors in laparoscopic surgery **(Fig. 32)**.

These scissors are mounted on a curved handle which is either fixed or retractable. The types with a fixed curvature proximal to the scissor blades require introduction through flexible valveless ports. The surgeon prefers this scissor because the curvature of the blade of the scissors abolishes the angle of laparoscopic instruments manipulation and better view through telescope is achieved.

Serrated Scissors

The main advantage of this scissors is that the serrated edges prevent the tissue to slip out of the blades. It is a useful instrument in cutting a slippery tissue or ligature. Serrated scissors may be straight or curved **(Fig. 33)**.

Hook Scissors

The sharp edge of both blades is in the shape of a flattened C. The blades can be partially closed, trapping tissue in the hollow of the blades without dividing it and allowing it to be slightly retracted. This allows the surgeon to double check before he closes the blades completely.

The main advantage of this scissors is that it encircles the structure before cutting: tissue is held between its jaws and there is no chance of slipping. The hook scissors are especially useful for cutting secured duct or artery in laparoscopic surgery. The cutting of nerve bundle in neurectomy becomes very easy with the help of this scissors. Hook scissors are also helpful in partial cutting of cystic duct for intraoperative cholangiography. All the other scissors cut from proximal to distal whereas the hook scissors cut distal to proximal **(Fig. 34)**.

Micro-tip Scissors

These very fine scissors are either straight or angled, and are used to partially transect the cystic duct. The main advantage of this scissor is to cut the ducts partially for facilitating cannulation. It may be used for cutting the cystic duct for performing intraoperative cholangiogram. Exploration of small ducts such as common bile duct (CBD) is very helpful with microscissors due to its fine small blades. Fine microscissors are also available in its curved form **(Fig. 35)**.

The use of scissors endoscopically requires little modification of open techniques.

The basic instrument is a miniaturized, long handled version of conventional scissors and can be single or double action. There are some special types of scissors used in endoscopic surgery.

Insulated Scissors

These allow the use of electrocautery through the scissors. However, when using nondisposable instruments, electrocoagulation using the open blades leads to blunting of the edges. Electrocoagulation using the scissors is thus limited, and when carried out is applied only with the blades

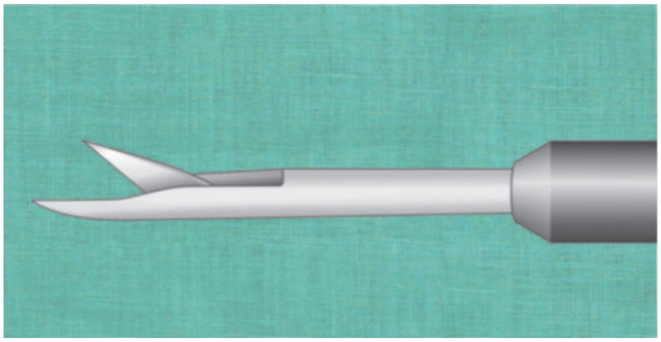


Fig. 35: Micro-tip scissor.

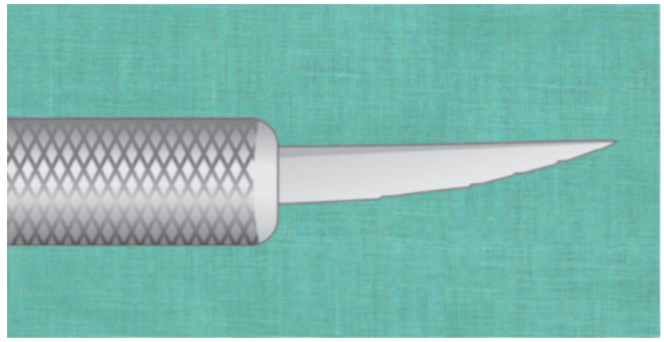


Fig. 36: Endoknife.

closed. Scissor dissection is usually carried out with a grasper in the other hand. If this instrument is insulated, then any vessels encountered can be easily coagulated by the grasper. A further disadvantage associated with electrocoagulation with the scissors results from the long noninsulated segment required to accommodate the blades and hinge mechanism. For safe practice, this requires to be kept in view, and this limits the magnification available to the surgeon.

Scissors have the following advantages:

- Inexpensive
- Safe in safe hand
- Operator determined precise action
- Closed blades can work for blunt dissection and electrocautery
- Piercing tissue with closed blades and then opening helps in obtaining a good plane of dissection.

Scissors have the following disadvantages:

- Nonhemostatic
- Accidental chances of cutting small ducts and vessels
- If overlooked, due to its pointed end, there is chance of injury to viscera
- If used for electric coagulation, its blades get blunt easily.

ENDOKNIFE (SCALPEL)

The knife is not used frequently in endoscopic surgery due to the problems associated with the safety of a blade, which cannot be closed or deactivated. However, it does have some important uses.

In our practice, a disposable blade (Beaver) is mounted on a metal rod, which has a socket at the distal end into which it can be screwed **(Fig. 36)**.

The most common use of the knife is for opening the hepatic duct or CBD during exploration for stones. A small, clean cut, linear stab wound is created in the anterior wall. Great care is required during incision and removal of the knife. However, a sharp curved scissors is better and safer than the endoknife for the choledochotomy.

Biopsy Forceps

Punch, cutting and dissecting biopsy forceps are used to take biopsies at the time of laparoscopic surgery **(Fig. 37)**.

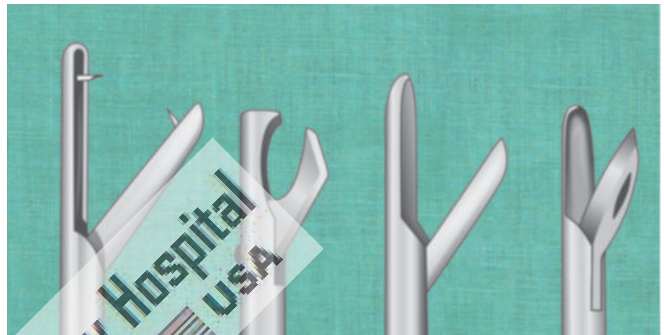


Fig. 37: Biopsy forceps.

The toothed punch biopsy forceps have special teeth which prevent accidental drop of tissue inside the abdominal cavity.

Aspiration Needle

These long needles are used in laparoscopy to aspirate fluid from distended ovarian cysts, gallbladder, or any localized pocket of pus in liver **(Fig. 38)**.

It may be used for drilling of polycystic ovary. Aspiration needle should be inserted inside the abdominal cavity with extreme precaution because if the pathway of entry or exit is ignored it can cause perforation of viscera.

Fan Retractor

These retractors are used to retract liver, stomach, spleen or bowel whenever they interfere in vision or they come in way of other working instrument **(Fig. 39)**.

There are many newer varieties of retractors available which are less traumatic. Cuschieri liver retractor is one of them which is very useful in fundoplication **(Fig. 40)**.

This liver retractor has a distal end which can be rotated by moving handle. Retractor is introduced in abdominal cavity when it is straight. Once it is inside the abdomen, the distal end can take various shapes just like serpent. This retractor can also be used for simple, atraumatic manipulation of bowel.

Nathanson Liver Retractor

Nathanson liver retractor is used to fully support and retracts the liver during laparoscopic upper gastrointestinal (GI)

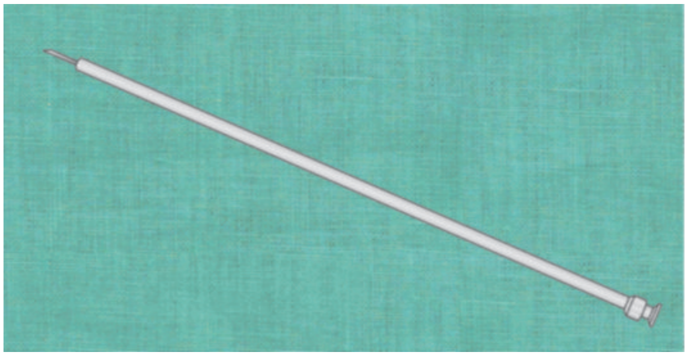


Fig. 38: Aspiration needle.

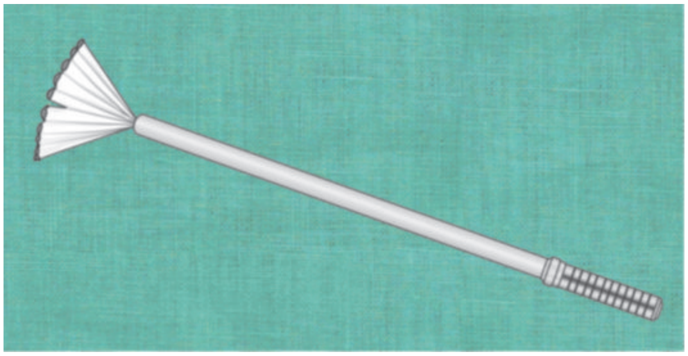


Fig. 39: Fan retractor.

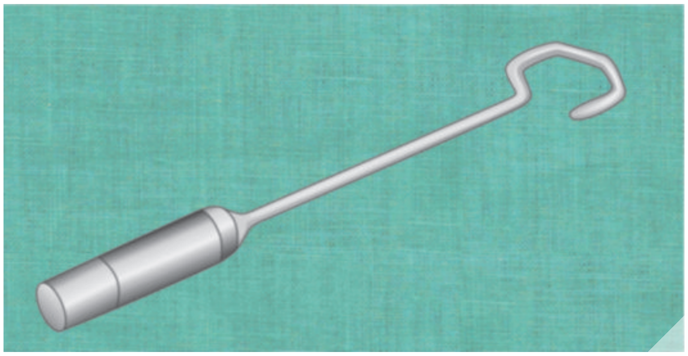


Fig. 40: Cuschieri liver retractor.

Fig. 41: Nathanson liver retractor.

surgery, enabling a better view of the operating field. Complex laparoscopic upper GI procedures necessitate the use of the Nathanson retractor for retraction of the left lobe of liver. This retractor is usually inserted in the epigastric region by blunt force, first introducing 5-mm epigastric port, following removal of a 5-mm port. This liver retractor is self-supported by clamping to the operating table **(Fig. 41)**.

NEEDLE HOLDERS

Needle holders should grasp the needle rock solid hard to prevent rotation **(Figs. 42 and 43)**.

Hence, until now, reusable needle holders are not available.

Needle holders have different types of jaws **(Fig. 44)**.

Flat grasping surface makes it possible to turn needle in all direction as in conventional surgery. Dome-shaped indentation at the tip automatically orients the needle in a particular direction although this function is not always useful, it can sometime make it easier to grasp the needle. Laparoscopic knotting and suturing should be learnt on a good quality endotrainer. The art and science of laparoscopic suturing and knotting is explained later in tissue approximation technique. Surgeons should slowly learn these techniques. They will develop their confidence once capable of suturing inside abdominal cavity and as a result conversion rate will also decrease.

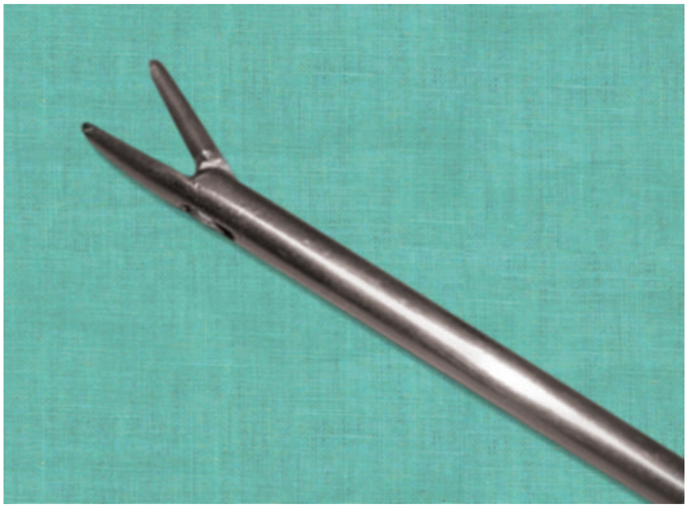


Fig. 42: Jaw of needle holder.

Many automatic laparoscopic suturing devices are invented for intracorporeal suturing but none of them are substitutes of manual laparoscopic suturing because these devices can work only under appropriate tissue plane suitable for their application **(Figs. 45A to C)**.

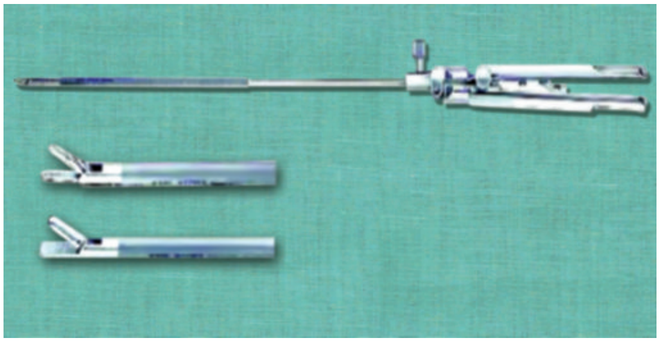


Fig. 43: Laparoscopic straight handle needle holder.

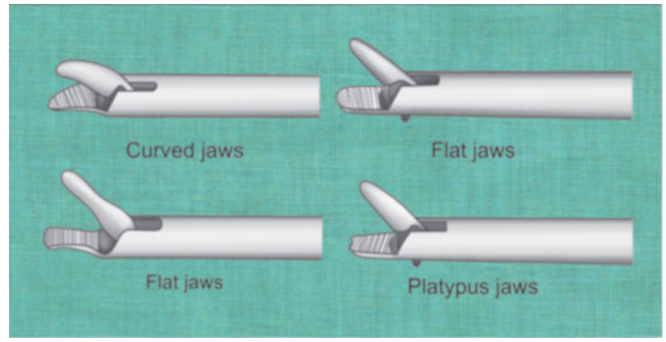
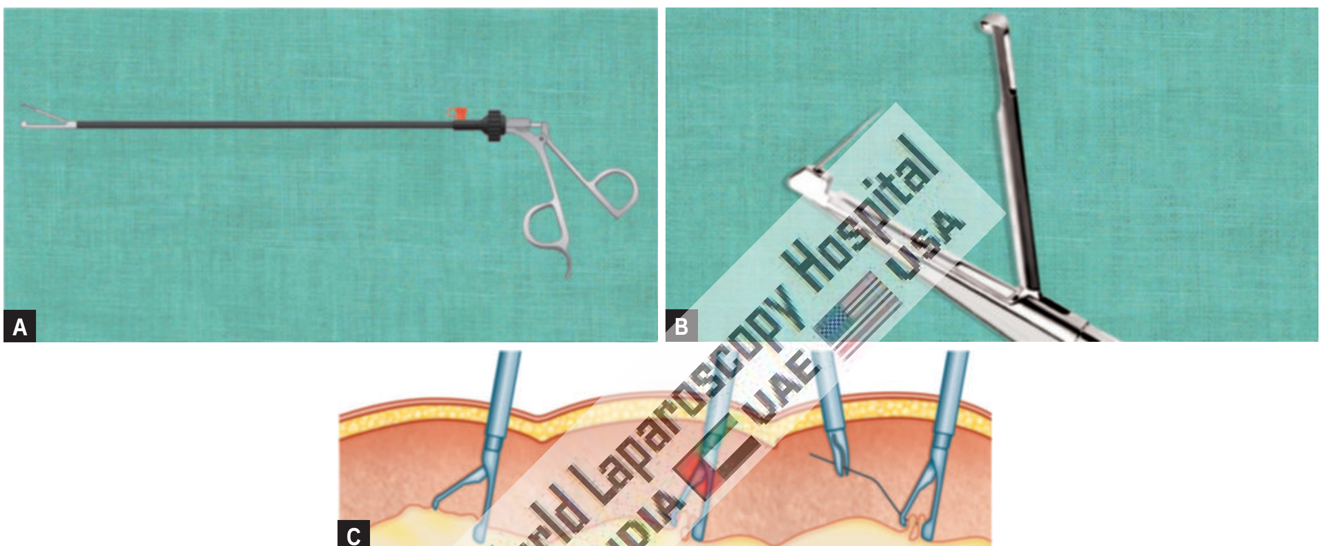


Fig. 44: Different types of jaws of needle holder.



Figs. 45A to C: (A) Laparoscopic autosuturing instrument; (B) Autosuturing device; (C) Autosuturing device (mechanism).

ROBOTIZED LAPAROSCOPIC NEEDLE HOLDERS

JAIMY Advance, the first motorized laparoscopic 5 mm needle holder, is first of its kind robotized needle holder. This easy to use, reusable and unique but expensive robotic needle facilitates advanced laparoscopic suturing. It is developed to fit all hand sizes and simple one-handed operation. With bidirectional flexion and unlimited rotation of its end-effector, this needle holder can access difficult to reach areas in the abdominal cavity. It overcomes the ergonomic restrictions of conventional laparoscopy without increasing incision size, hence making complex procedures easier. Reusable, space saving and easy to use, motorized needle holder takes minimally invasive surgery a step further. Although it must be practiced using by the surgeon and if surgeon is good in laparoscopic suturing by conventional needle holder, this device is not required **(Fig. 46)**.

KNOT PUSHER

Although pretied loops are available in the market but surgeon should learn how to tie these extracorporeal knots.

Pretied loop can be used for any free structure like appendix but for continuous structure like cystic duct, surgeon has to perform extracorporeal knotting intraoperatively **(Fig. 47)**.

For extracorporeal knotting, knot pushers are used. These knot pushers are of either closed jaw or of open jaw type **(Fig. 48)**.

LAPAROSCOPIC CLIP APPLICATOR

Disposable preloaded clip applicators are available in 5 mm and 10 mm diameter **(Figs. 49 and 50)**.

These are expensive, but nice to use because the loading time of clip can be minimized. Disposable clip applier comes with 20 preloaded clips **(Fig. 51)**.

In case of emergency, when bleeding has to be stopped immediately one after another, clip can be applied rapidly with the help of these clip applicators.

Titanium is most widely used metal in minimal access surgery for tissue approximation. It rarely reacts with human body and this is why it is popular. It is easy to apply and can be left inside abdominal cavity. After few weeks, it is covered

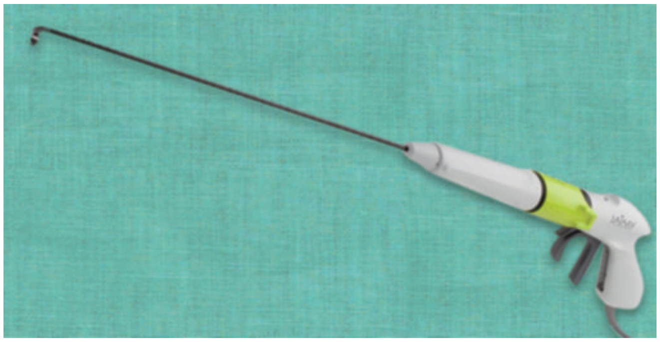


Fig. 46: Robotized laparoscopic needle holder.

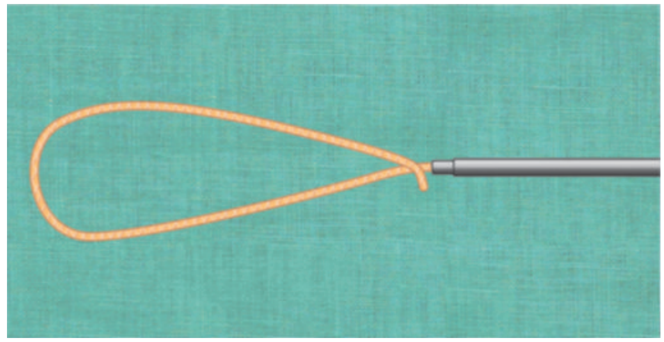


Fig. 47: Pretied loop.

Fig. 48: Laparoscopic knot pusher.

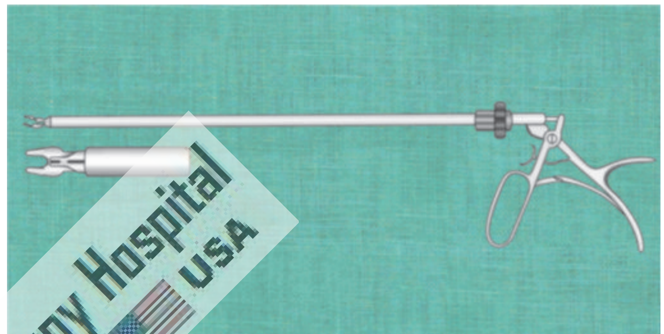


Fig. 49: Laparoscopic clip applicator.

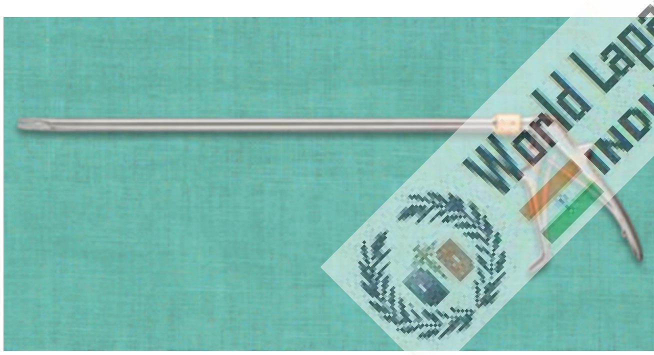


Fig. 50: Laparoscopic reusable clip applicator.

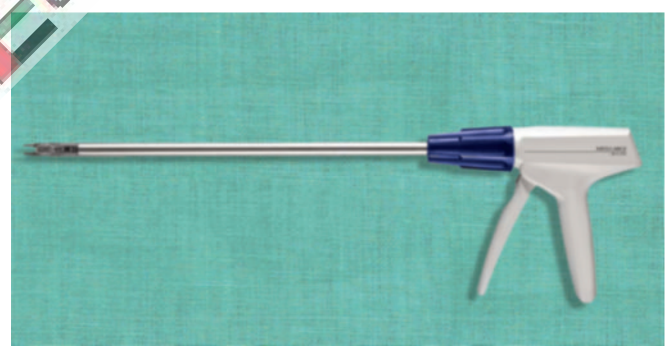


Fig. 51: Laparoscopic disposable clip applicator.

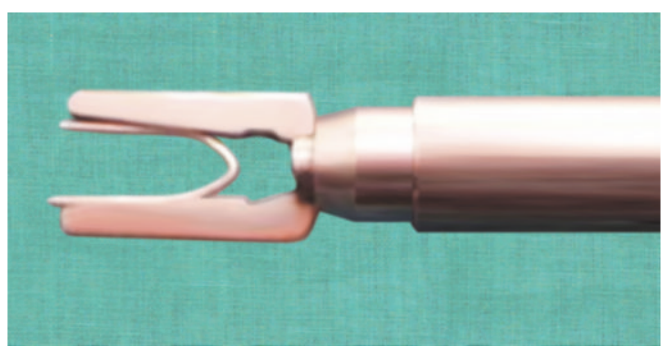


Fig. 52: Clip loaded over laparoscopic clip applicator.

by fibrous tissue. Titanium clip is used by 99% of surgeons for clipping cystic duct and cystic artery at the time of laparoscopic cholecystectomy. Recently, silicon clips have been launched. Absorbable clips (Absolok, Ethicon) are preferred to clip cystic ducts nowadays. It adds to safety by working at the tip and it does not have chance to form cystic duct clip stone. The absorbable soft clips can also be used in running stitches at the beginning and at the termination of knotting.

Medium large size clip is of 9 mm and used most frequently for cystic duct and cystic artery **(Fig. 52)**.

The medium size clip is 7 mm in length and can be used to clip cystic artery or thin cystic duct. The large size clip is 11 mm in length and it is used to control thick wide cystic ducts or large mesenteric vessels. The jaw of clip applicator should be at right angle to the structure and before clipping surgeon should take care that both the jaws are seen. If one of the jaws is hidden, there is always a possibility that some tissue will get entrapped between the jaw of clip and clip will be loose. At the time of securing any duct or artery with titanium clip, three clips are generally applied. Two clips are left toward the structure which is secured and one clip is toward the tissue which surgeon wants to remove to prevent spillage of fluid **(Fig. 53)**.

The distance between first and second clip should be 3 mm and distance between second and third clip should be 6 mm so that after cutting in between second and third clip there will be 3 mm stump both the sides. The clip should not be applied very near to each other, because clips are held in position by dumbbell formation and if they are very near to each other, they will nullify the dumbbell formation of each other and both the clips will be loose.

Cystic Duct Clip Stone

Recently, many cases have been reported of cystic duct clip stone and this is the reason why in many institutions clipping of cystic duct is replaced by extracorporeal knotting.

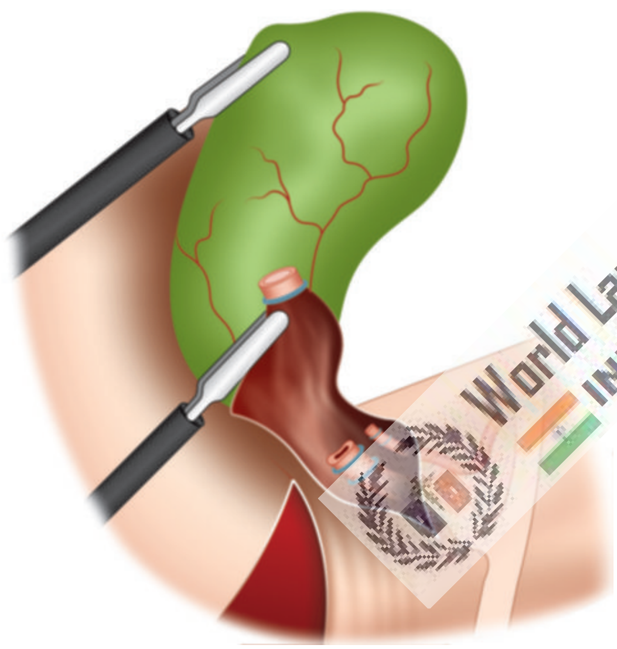


Fig. 53: Clip on cystic duct and artery.

If titanium clip is applied on the cystic duct, sometime it may crush one of the walls of cystic duct and it may get internalized inside the lumen of cystic duct. Inside the lumen of cystic duct, it acts as a nidus for the deposition of bile pigment and the formation of stone. The cross-section of these stones, the clip inside is seen glistening such as pupil of a cat and so it is also known as "cat eye stone". These stones can slip inside the CBD and may cause CBD obstruction.

Although the reported case of CBD obstruction is very less, the surgeon should try to ligate cystic duct to avoid this complication.

Falope Ring Applicator

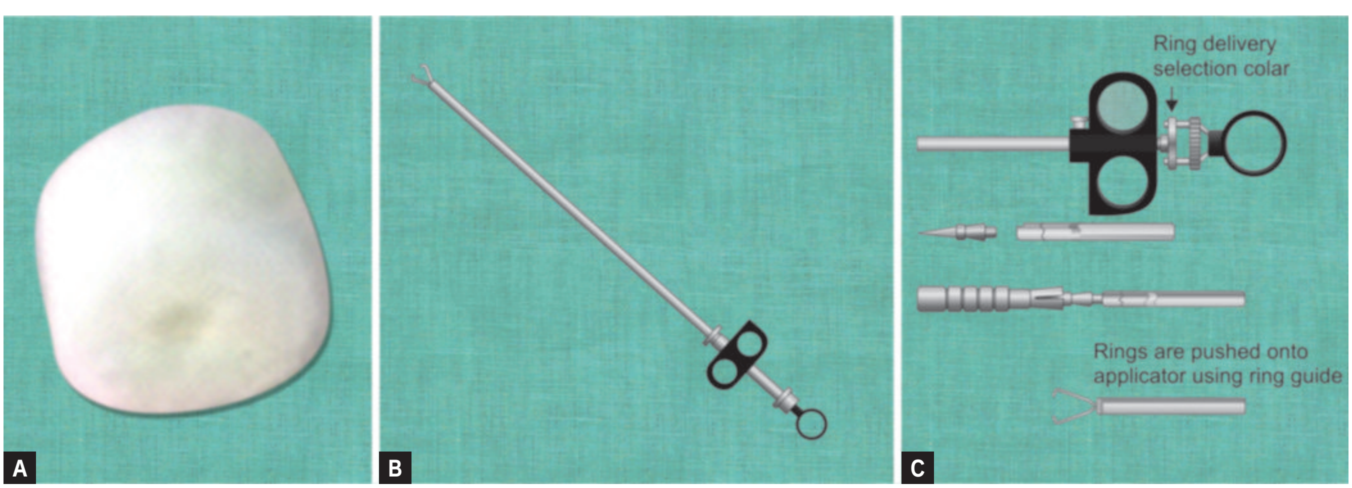
Falope Ring applicator is used for application of silastic ring to perform tube ligation. These may be fitted with one or two silastic rings **(Figs. 54A to C)**.

Myoma Fixation Screw

When performing a laparoscopic myomectomy, it is difficult to stabilize a smooth, hard fibroid. This is used to fix the subserous or intramural myoma at the time of laparoscopic myomectomy. Myoma screw can also be used to fix and retract big size uterus at the time of laparoscopic hysterectomy **(Fig. 55)**.

Uterine Manipulator

Uterine manipulator is one of the very essential instruments for mobilization of the uterus, identification of the vaginal fornices and sealing of the vagina during hysterectomy **(Fig. 56)**. There are different types of uterine manipulator. Their most obvious function is to suitably mobilize the uterus. By anteverting or retroverting the uterus, gynecologists get a good exposure of both the anterior wall and vesicouterine fold, the posterior wall and uterosacral ligaments. Lateral movements allow the exposure of the infundibulopelvic ligaments, utero-ovarian ligaments, and the anterior and posterior leaves of the broad ligament. These movements are



Figs. 54A to C: (A) Falope ring; (B) Falope ring applicator; (C) Handle of Falope ring applicator (mechanism).

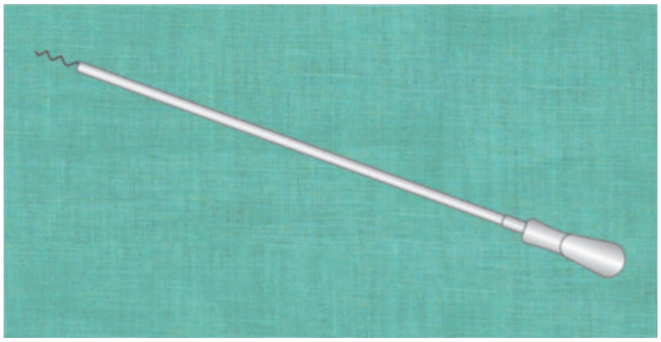


Fig. 55: Myoma screw.

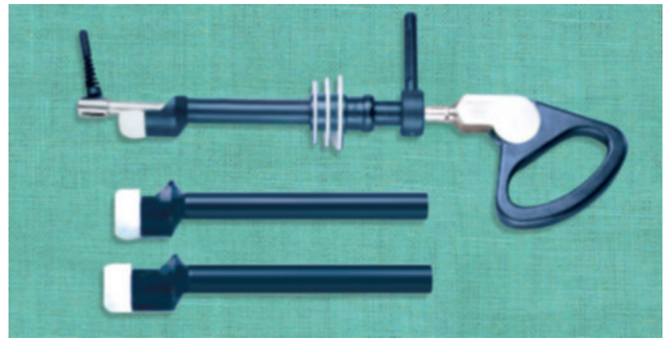
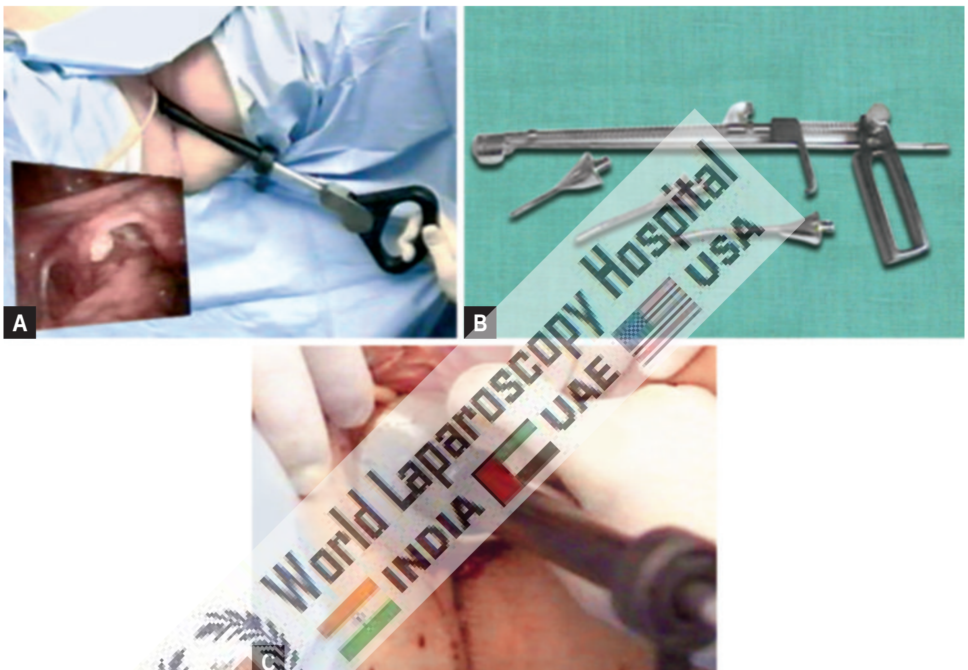


Fig. 56: Clermont-Ferrand uterine manipulator.



Figs. 57A to C: (A) Lateral traction over uterus by uterine manipulator; (B) Different attachments of uterine manipulator; (C) Sealing of vagina with cuff of uterine manipulator for total laparoscopic hysterectomy (TLH).

important in cases of large uterus. The elevation movement is important in cases of rectovaginal endometriosis in which the uterus needs to be moved upward into the abdomen, providing the best exposure of the uterosacral ligaments and the cul-de-sac. The ideal uterine manipulator should be inexpensive, convenient and quick to use, safe especially by avoiding the need for dilatation and a tenaculum, and have the ability to inject solutions into the uterine cavity and most importantly offer the optimal range of motion of the uterus while avoiding the need for an assistant.

Uterine manipulator is used in most of the advanced gynecological procedures. Most uterine manipulators are essentially rigid instruments that are attached or fixed to the uterus, protrude from the vagina, and require the use of a tenaculum to grasp the cervix, which occasionally may bleed.

The Clermont-Ferrand uterine manipulator provides a good 140° movement of the uterus in the anterior and posterior directions **(Figs. 57A to C)**. In addition, it has the ability to flex the uterus on itself. Its graduated snap-in mechanism, which has five different positions, gives stability to the uterus at various angles, and the snap-in release button allows unrestricted movement. The manipulator rod, when pushed forward, helps to delineate the vaginal fornices with the help of an anatomical blade attached anteriorly. It has a series of silicon seal to maintain the pneumoperitoneum after the colpotomy incision. It is a reusable instrument. Though versatile, this instrument has its drawbacks; it requires cervical dilatation up to Hegar number 9 before its insertion in the cervix, so may not be useful in cases of cervical stenosis. It is pretty complex to assemble and requires a fair amount of training to use this device properly. Clermont-Ferrand uterine manipulator seems to be a good choice for operative laparoscopies involving hysterectomy, endometriosis in the posterior cul-de-sac, and sling surgeries **(Fig. 56)**.

The RUMI manipulator with the Koh colpotomizer from CooperSurgical is a versatile uterine manipulator. Not only does it have extremely good uterine manipulation in the anterior, posterior, and lateral planes, it also helps with the very easy delineation of the vaginal fornices. The Koh-cup distances the ureter form the uterine vessels and facilitates its easy coagulation. This device helps to complete laparoscopic dissection of the cervix and vagina much more easily, resulting in greater efficacy and less blood loss while eliminating the difficulties pertaining to vaginal access. This enhanced uterine mobility also speeds uterovesical peritoneal dissection and inferior displacement of the bladder. Furthermore, the RUMI manipulator allows for significant lateral uterine displacement, improving visualization and ease of dissection of the uterine vasculature and broad ligament. Only drawback of this uterine manipulator is that it is partially disposable **(Fig. 58)**.

The Mangeshikar uterine manipulator is a reusable, completely detachable, low-cost uterine manipulator **(Fig. 59)**. Though specifically designed for total laparoscopic hysterectomy, it can be used in almost all gynecological laparoscopic surgeries. By appropriately mobilizing the handle, the uterus along with the adnexa can be manipulated from side to side and can be rotated along its long axis, thus enabling anteversion and retroversion as well as dextro- and levorotation. Sliding in the vaginal delineator helps identify the vaginal fornices and choosing the right-sized delineator drum helps maintain the pneumoperitoneum.

Thus, the Mangeshikar uterine manipulator offers advantages in its ability to perform a completely laparoscopic hysterectomy and other gynecological surgery by maintaining the loss of pneumoperitoneum. The significant uterine mobility that this system provides facilitates dissection of the ascending uterine arteries in a manner that reduces the risks of ureteric injury. Mangeshikar uterine manipulator is fully autoclavable and reusable system.

Tissue Morcellator

The morcellator is used to grasp the tissue to be removed and cuts it into small bits, which are forced into the hollow part of the instrument **(Fig. 60)**.

It can be designed to remove a myoma or an ovary. It can be introduced through a 10-mm port or through the colpotomy wound **(Fig. 61)**.

Tissue Morcellator and Its Complications

The Food and Drug Administration (FDA) currently estimates that a hidden uterine sarcoma may be present in approximately 1 in 225 to 1 in 580 women undergoing surgery for uterine fibroids based on recent publications. The FDA also estimates that a leiomyosarcoma may be present in approximately 1 in 495 to 1 in 1,100 women undergoing surgery for uterine fibroids based on recent studies. Prior to 2014, the clinical community estimated uterine sarcomas to be present much less frequently, in as few as 1 in 10,000

Fig. 58: RUMI uterine manipulator.

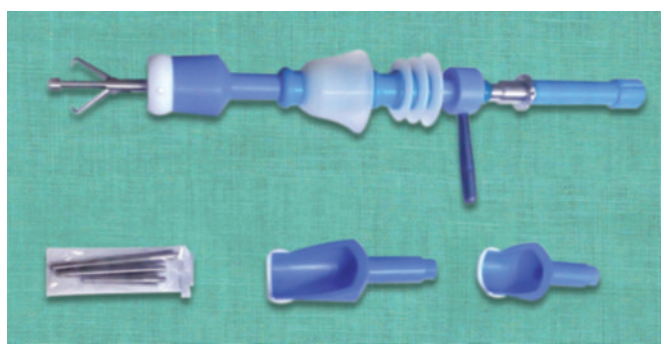


Fig. 59: Mangeshikar uterine manipulator.

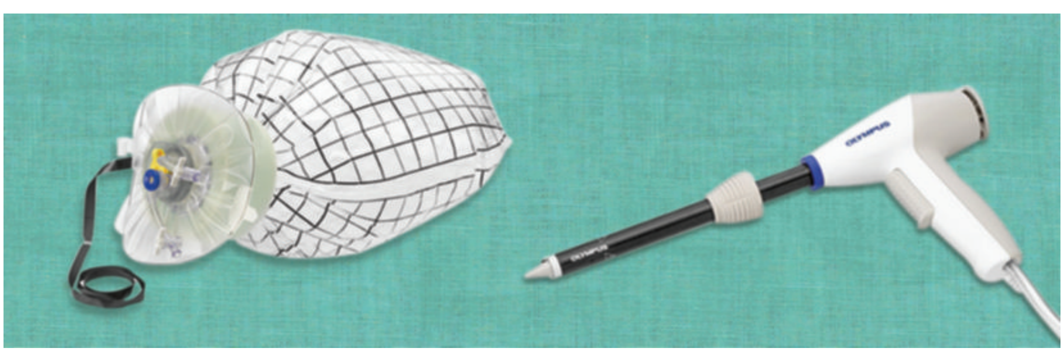


Fig. 60: Tissue morcellator.

women undergoing surgery for uterine fibroids. Several studies show that using a laparoscopic power morcellator during gynecological laparoscopic surgery in women with hidden uterine sarcomas is associated with lowering their chances of long-term survival without cancer. While these studies have limitations, women who have had fibroid surgery with a laparoscopic power morcellator later found to have a hidden uterine sarcoma, have lower disease-free survival, when compared to women who were treated with manual morcellation or without morcellation.

Uterine sarcomas and uterine fibroids may have similar signs and symptoms. At this time, there is no reliable method for predicting or testing whether a woman with fibroids may have a uterine sarcoma. The FDA recommends gynecologist share this information with patients and warns against using laparoscopic power morcellators in gynecologic surgeries to treat patients with suspected or confirmed cancer, and in women over age 50 having a myomectomy or hysterectomy for uterine fibroids.

Fig. 61: Morcellation of myoma in myomectomy.

Morcellator Use with Tissue Containment System

The FDA recommends that gynecologist use tissue containment systems when using laparoscopic power morcellators, and that they ensure the laparoscopic power morcellator and tissue containment system are compatible. Legally marketed laparoscopic power morcellation containment systems are intended to isolate and contain tissue that is considered benign. Based on testing and clinical data, use of a containment system confines morcellated tissue within the containment system.

Due to this increased risk, we continue to recommend use of laparoscopic power morcellation only in appropriate women undergoing myomectomy or hysterectomy. In addition, it is good that when morcellation is appropriate, only contained morcellation be performed. MorSafe is an innovative single-use disposable device intended to be used as a receptacle for benign tissue mass during gynecological procedures such as laparoscopic myomectomy or laparoscopic hysterectomy. MorSafe is to be used in conjunction with the morcellator to safely contain and remove the shredded benign tissue mass. The device has unique features to allow for quick deployment, insufflation, morcellation, and spill-proof withdrawal of the bag **(Fig. 62)**.

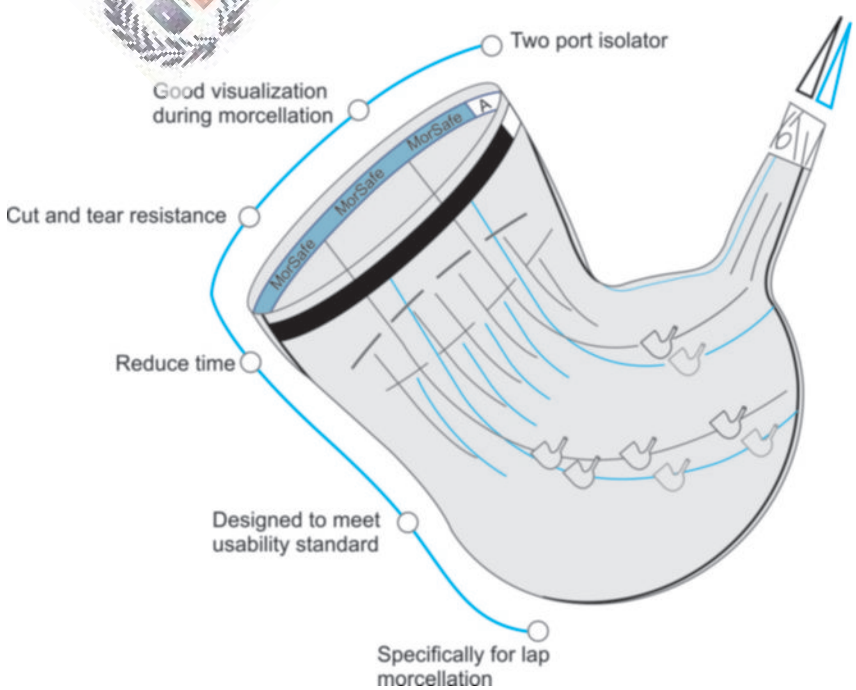
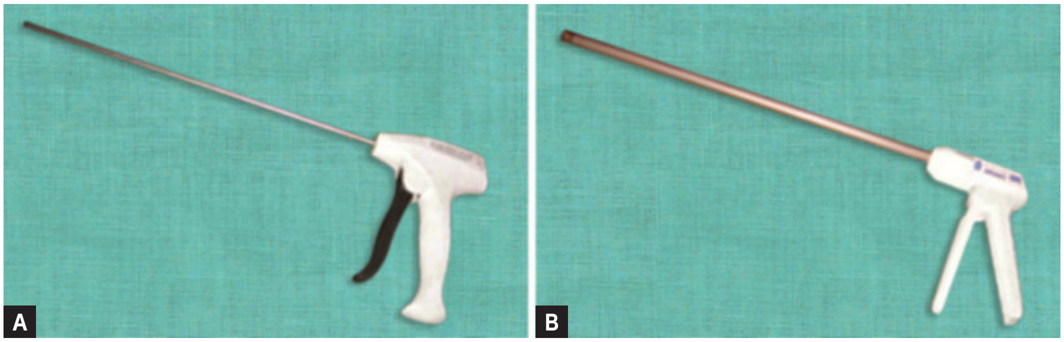


Fig. 62: MorSafe tissue containment system.



Figs. 63A and B: Endoanchor and tacker.

TABLE 1: Different types of implant for fixing mesh.

Feature	*ESS endoanchor*	*Protack*	*Tacker*
Number of implants	20	30	20
Geometry of implant	Anchor	Helical Fastener	Helical Fastener
Implant material	Nitinol	Titanium	Titanium
Implant length	5.9 mm	3.8 mm	3.6 mm
Implant width	6.7 mm	4 mm	3.4 mm
Port size required	5 mm	5 mm	5 mm
Shaft length	360 mm	356 mm	356 mm
Trigger fire orientation	Release to deploy	Depress to deploy	Depress to deploy

Fig. 64: Jaw of stapler.

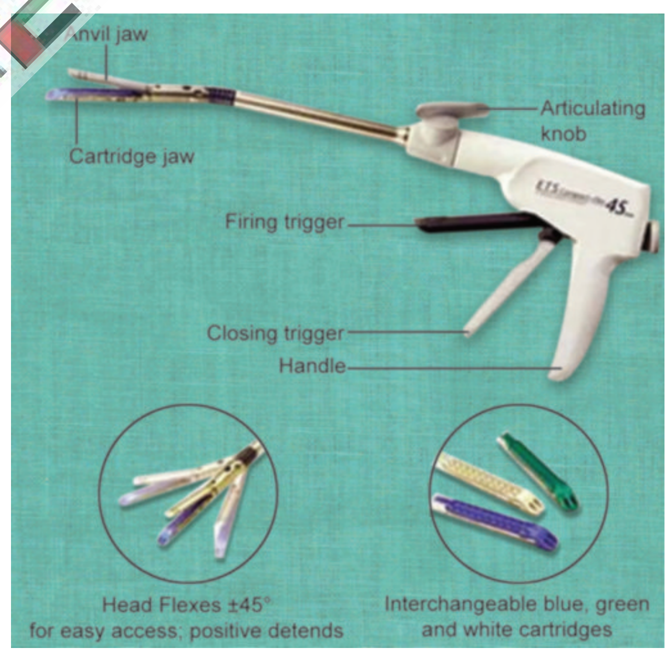


Fig. 65: Endopath ETS Compact-FLEX45 articulating endoscopic linear cutters.

MorSafe, with its unique two-port design, offers the surgeon superior visibility during the surgery compared to a single-port approach. Designed to fit and take the shape of the abdomen, it has been constructed utilizing a special tear-resistant material to prevent leakage. It also contains a special ring in the bag opening to allow the surgeon ultimate control of the bag opening and easy access to the interior of the bag during surgery.

Hernia Stapler, Endoanchor and Tacker

For fixing mesh in hernia surgery, many preloaded devices are available **(Figs. 63A and B)**.

Currently, three popular brands of implants to fix the mesh are available. These are tacker, protack or anchor. The comparative chart of these implants is shown in **Table 1**.

There are many varieties of laparoscopic stapler **(Fig. 64)**.

The LONG45A Endocutter manufactured by Ethicon has a shaft that is 10 cm and it allows easier access during laparoscopic weight loss surgery, such as gastric bypass, where longer instruments are needed for morbidly obese patients. The ETS 45 and ETS-FLEX45 endoscopic linear cutters provide a 45-mm staple and cut line **(Fig. 65)**.

The 34-cm shaft length makes the device suitable for many minimally invasive surgical procedures. The cutters are intended for transaction, resection, and/or creation of anastomosis in minimally access surgical procedures.

Laparoscopic surgical instruments are extremely variable and increasing number of instruments is being designed for specific application. Instruments are getting complex with greater functionality and freedom of movement. Such instruments reflect the trend toward the automation of procedure. In the future, such developments ultimately will lead to full robotization.

Laparoscopic Linear Stapler

Laparoscopic linear stapler is very useful device for tissue approximation. Staples are made available in various sizes and heights so that the surgeon can choose the one that provides appropriate homeostasis/tissue apposition without significant ischemia or tissue destruction. Dimensions of commonly available staple cartridges that are used to accommodate different tissue thicknesses for appropriate tissue management are shown in **Figure 66**.

If the closed staple height is too high, then it may inadequately oppose the tissues and result in leakage, bleeding, and/or dehiscence. Conversely, if the staple height selected is too low, then ischemia, serosal shearing, or "cheese wiring" may result, potentially leading to leakage or frank necrosis. There are at least three staple heights for most linear staplers. Most modern laparoscopic staplers bend each staple into a B-shape staple form, which helps to secure the tissue in place. However, malformed staples can occur because staple leg bending depends on several tissue/stapler characteristics including tissue thickness, tissue viscosity, staple height, and other staple properties (thickness, bending characteristics, type of metal, etc.). Staples are designed to form consistently, and staples that are not forming as intended should be investigated.

Color	Rows	Tissue type	Open staple height	Closed staple height
Gray	6	Mesentery	2.0 mm	0.75 mm
White	6	Vascular	2.5 mm	1.0 mm
Blue	6	Standard	3.5 mm	1.5 mm
Gold	6	Standard/thick	3.8 mm	1.8 mm
Green	6	Thick	4.1 mm	2.0 mm

Fig. 66: Color of staple cartridge used for different tissue thicknesses.

Echelon Flex Endopath Staplers

The Echelon flex endopath staplers designed to deliver reliable performance across a wide range of tissue types and thicknesses on a one-handed, easy to use platform. Enhanced system-wide compression aids in proper staple formation, which is necessary to achieve a leak resistant and hemostatic staple line. Compression before firing gently exudes fluid from targeted tissue before firing **(Figs. 67 and 68)**.

Tri-Staple

Endo GIA□ articulating endoscopic linear stapler with Tri-Staple□ is Covidien product and it is designed to work in harmony with the natural properties of tissue to optimize performance before, during, and after stapling **(Figs. 69 and 70)**. With its stepped cartridge face, Tri-Staple□ technology delivers optimum tissue compression, optimizing interaction between the tissue and staple. It has the following advantages:

- Generates less stress on tissue during compression and clamping
- Allows greater perfusion into the staple line
- Provides superior performance in variable thicknesses.

Tri-Staple□ technology improves staple line strength, leak resistance, and hemostasis when compared to the universal reloads. No single stapler can address the wide range of tissue management issues surgeons face on a daily basis. The current review focused on bariatric, thoracic, and colorectal studies. It was shown that different types

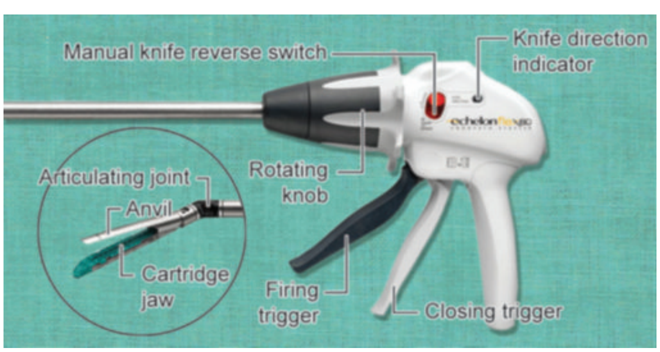


Fig. 67: Endopath articulating endoscopic linear cutter.

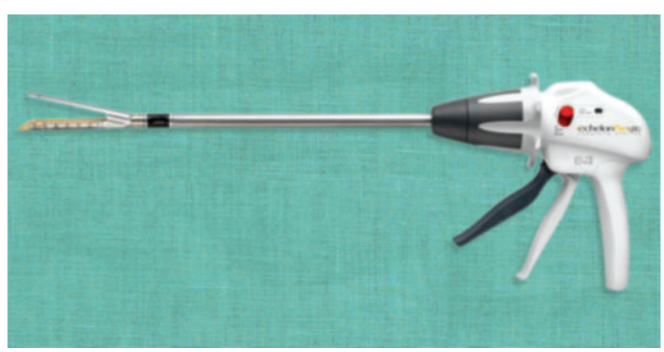


Fig. 68: Endopath articulating endoscopic linear stapler.

Fig. 69: Covidien Endo GIA articulating endoscopic linear stapler cartridge.

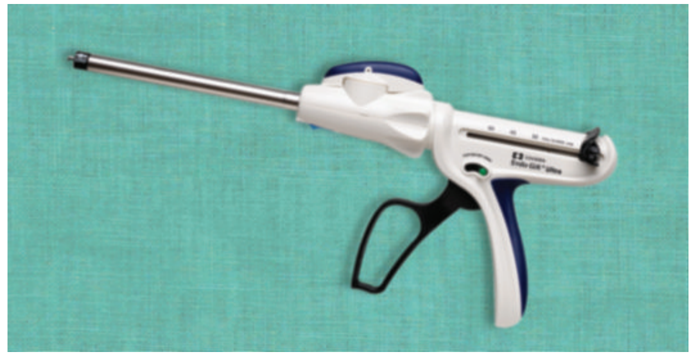


Fig. 70: Covidien Endo GIA articulating endoscopic linear stapler gun.

of tissues have different thicknesses and biomechanical properties that may require the use of staples of different heights or the use of a different types of stapler (linear vs. curved vs. circular) to construct a stable anastomosis. Each tissue type has its own challenges, and the pathology of the tissue must also be taken into account.

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