2 Instrumentation and Equipment

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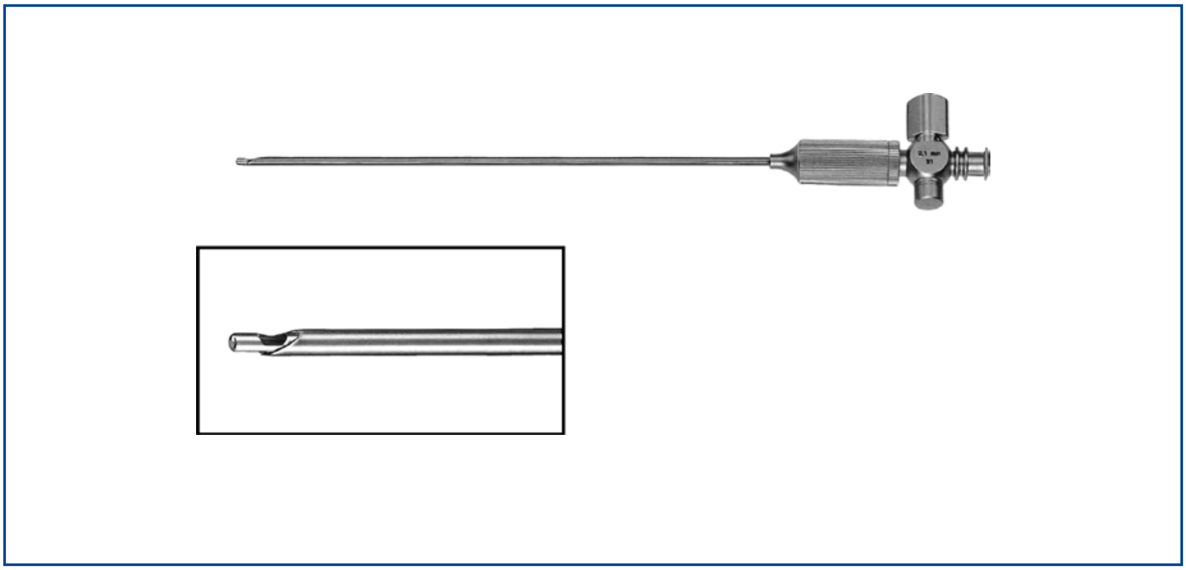
2.1 Port and Trocar

A port is a tubular sleeve-like device through which operative access is obtained in endoscopic surgery. A trocar is a spike-like device (conical- or pyramidal-tipped) that is placed inside the port sleeve with its tip exposed toward the end of the port. The port and trocar are inserted as a set through the abdominal or chest wall, and the trocar is removed after the port is in place. The port has a valve mechanism to allow instruments to be passed through it without the loss of insufflated gases. (Courtesy of Richard Wolf, Knittlingen, Germany)

2.2 Veress Needle

A Veress needle is used for creating the initial pneumoperitoneum so that the subsequent trocars and ports can enter safely. It consists of an inner cannula that is spring-loaded and retracts within the sharp outer needle while passing through the anterior wall, and then springs forward when it is in the open cavity. The inner cannula is sealed at the distal end, but has a hole on the side of the tip *(inset)* for the gas to flow through. The Veress needle should be checked for its patency and spring action prior to use. (Courtesy of Richard Wolf, Knittlingen, Germany)



2.3 Blunt Grasping Forceps

Blunt graspers are the principle means of manipulating tissue and providing exposure to the operation site. It is compulsory that each endoscopic surgery set has at least two pairs of graspers. Blunt graspers have opposing jaws with fine, parallel grooves. They may have a single-action *(inset above)* or double-action *(inset below)* jaw mechanism. The handle may be a scissor grip, spring loaded or ratcheted (see Figure). The handles and bodies of the graspers should be insulated, but should have the possibility for use with electrosurgery. (Courtesy of Richard Wolf, Knittlingen, Germany)

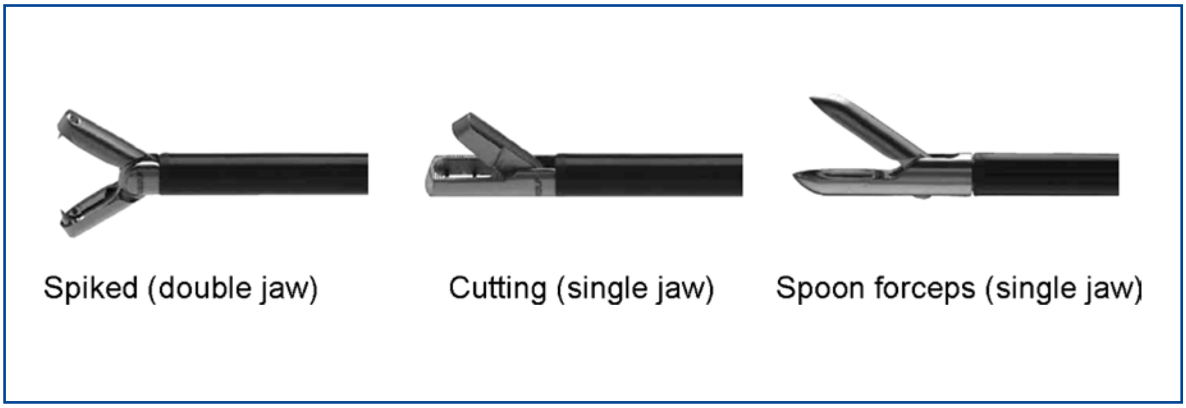
2.4 Dissectors and Tissue Extractors

Various types of endoscopic scissors are available for sharp dissection. However, the hook scissor *(inset)* is a special scissor used in endoscopic surgery in that its unique blade shape helps to withdraw the tissue into the grasp prior to completing the cut. This is advantageous when a relatively large amount of tissue has to be cut. (Courtesy of Richard Wolf, Knittlingen, Germany)

Tissue extractors are single-action jaw forceps with ratchet teeth that permit a greater force to be applied to extract tissues.

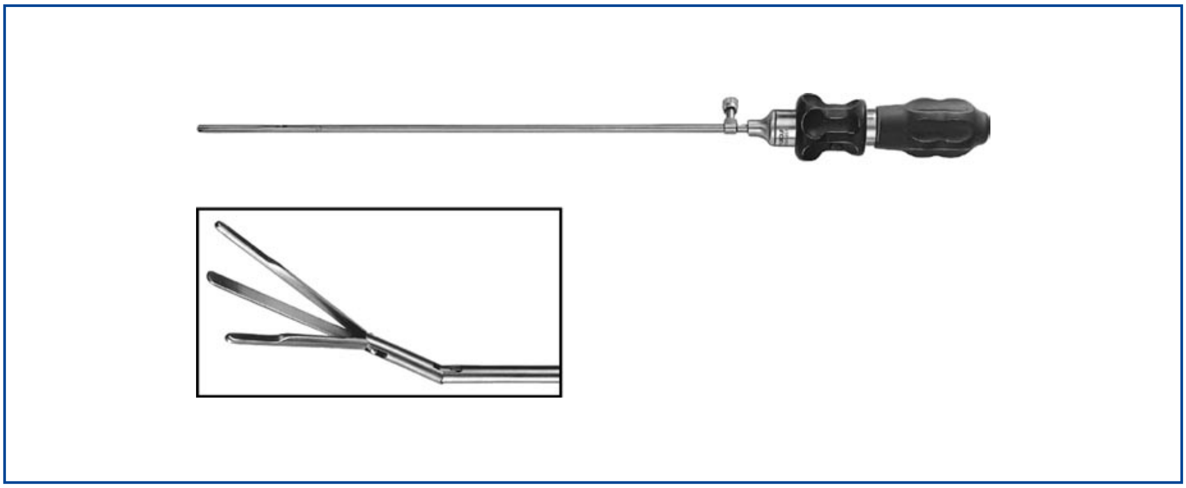
2.5 Biopsy Forceps

Biopsy forceps facilitate the removal of small tissue specimens for pathological studies. Spoon forceps have been specially developed for this purpose as they provide an alternative to dissecting a portion of the tissue and retrieving it with ordinary graspers, which may crush the tissue in the process of retrieving. On the other hand, spike biopsy forceps have special pins that prevent accidental drop of tissue inside the abdominal cavity. (Courtesy of Richard Wolf, Knittlingen, Germany)



2.6 Endoscopic Retractor Instruments

Endoscopic retractors are used for manually maneuvering tissue that would otherwise obstruct the view of the operative site. They may be straight or curved. The retractor instrument is sized for insertion through the endoscopic ports and comprises a pair of arms that are opened with a scissors motion *(inset)*. Care must be taken to ensure that tissue out of sight is not injured when endoscopic retractors are used. (Courtesy of Richard Wolf, Knittlingen, Germany)

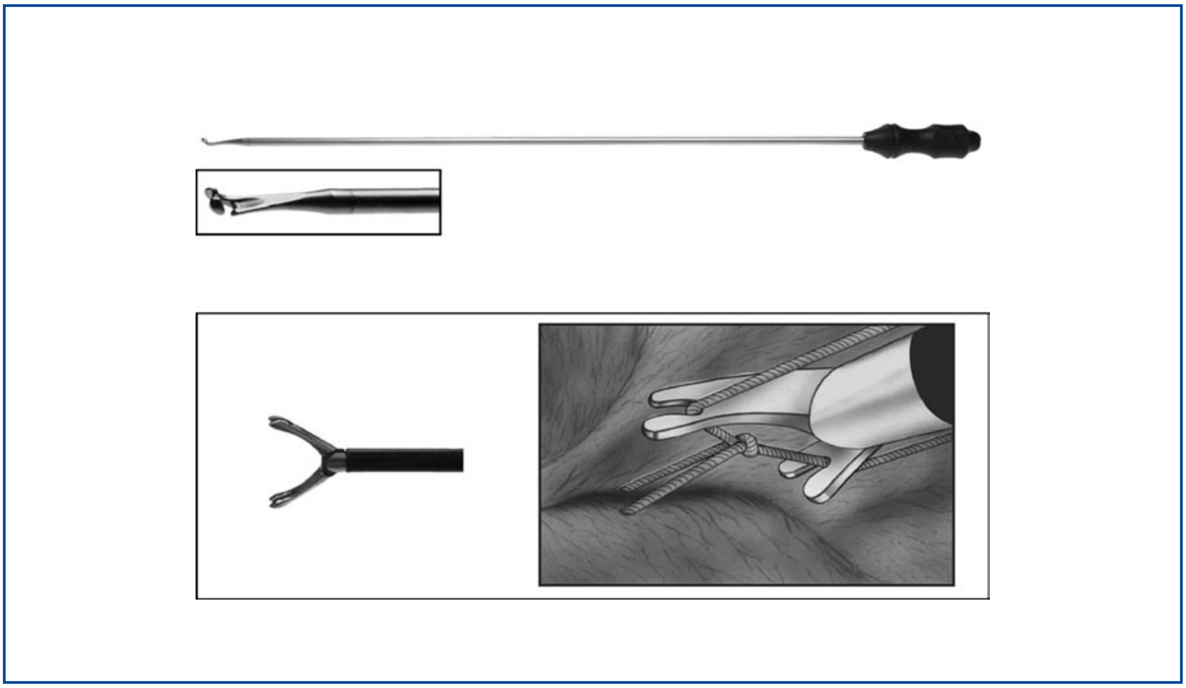


2.7 Needle Holders

Various types of handle grips are offered to maximize the ergonomics of suturing and knot tying. However, most surgeons prefer the axial handle as this ergonomic design reduces hand fatigue and provides optimal as well as efficient needle control. A variety of tip styles (straight to curved) have been developed over the years, leading to an improvement in the design of needle holders. However, the curved tip is used at most centers to tie knots. (Courtesy of Richard Wolf, Knittlingen, Germany)

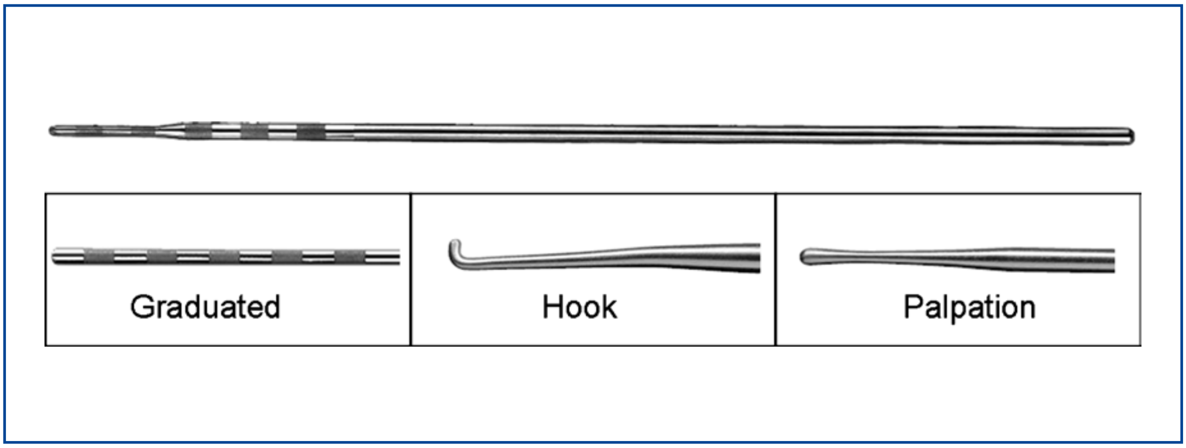
2.8 Knot Pushers

A surgical knot-pusher device allows a prepared knot to be pushed down through the length of the suture. The device includes a handle and an elongated body extending from it *(above)*. The elongated body has a curved tip that is tapered and has a groove along the length of the tip *(inset)*. Modular knot pushers *(below)* have grooves in both the prongs and function on the same principle as the rod type. (Courtesy of Richard Wolf, Knittlingen, Germany)



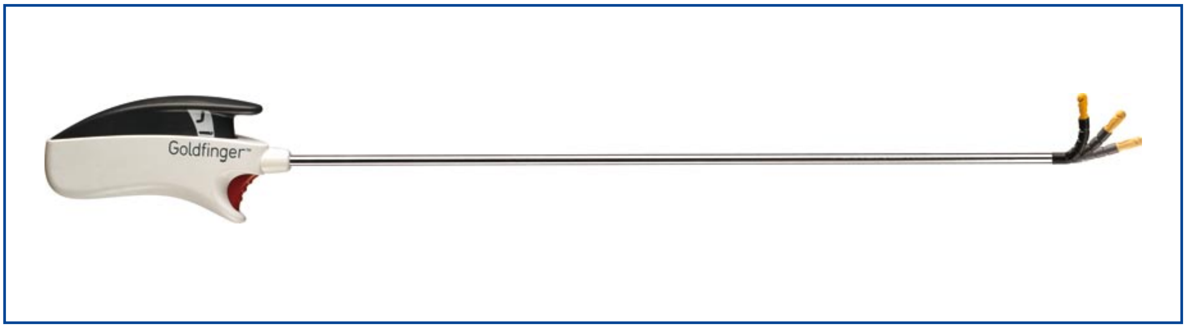
2.9 Probes

Probes are blunt instruments that are utilized to manipulate tissues. Depending on the type of manipulation required, the following types can be used: (1) graduated, (2) hook, and (3) palpation. Hooked probes are generally used for lifting structures that also need to be palpated. (Courtesy of Richard Wolf, Knittlingen, Germany)



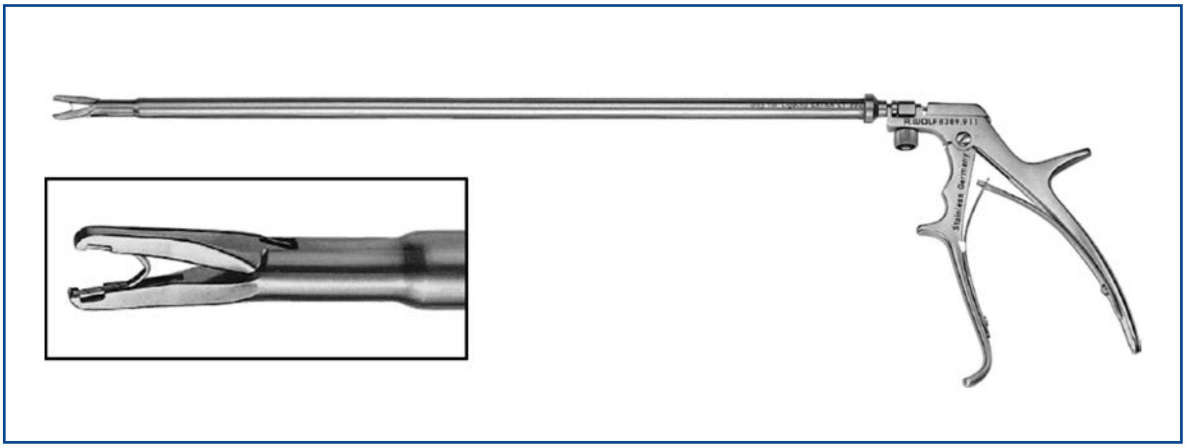
2.10 Goldfinger® Dissector

The Goldfinger® dissector (Johnson & Johnson Medical Products, Ethicon Endo-Surgery, Cincinnati, OH, USA) is a tool developed for bariatric surgery that aids in the placement of the gastric band. The tip of the Goldfinger dissector can flex 90° in the vertical axis, which is similar to the movement obtained by flexing a finger. The tool is passed behind the esophagus and is pushed back up through the opening made in the gastophrenic ligament, where the thread loop of the gastric band is secured to it. (Courtesy of Johnson & Johnson Medical Products, Ethicon Endo-Surgery, Vienna, Austria)



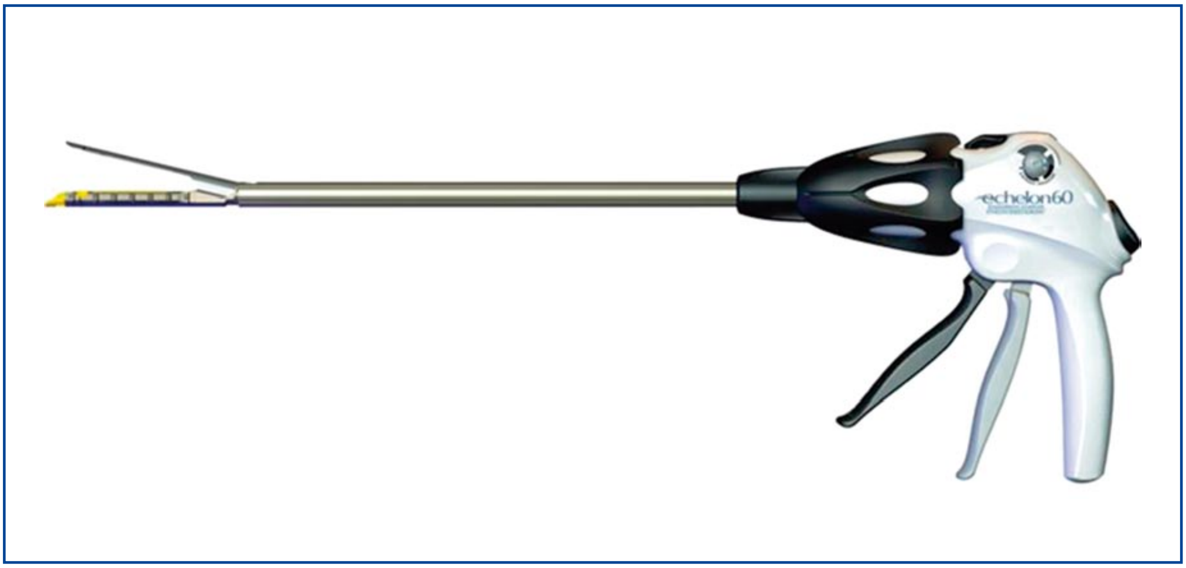
2.11 Endoscopic Clip Applicators

Titanium is the most widely used metal in minimal-access surgery for tissue approximation. An endoscopic clip applicator is a device that allows application of clips within body cavities. Titanium clips are held in position by a dumbbell formation of the tissue they are applied on. If the clips are applied very close to each other, the dumbbell formation will be nullified and the clips will fall loose. (Courtesy of Richard Wolf, Knittlingen, Germany)



2.12 Endoscopic Linear Stapler

An endoscopic linear stapler device is able to eliminate most of the need for suturing within the surgical cavity. It comprises a single-use loading unit with titanium staples for resection, transection and anastomosis. Care should be taken in port selection, as endoscopic staplers are only available in the 10-mm size. (Courtesy of Johnson & Johnson Medical Products, Ethicon Endo-Surgery, Vienna, Austria)

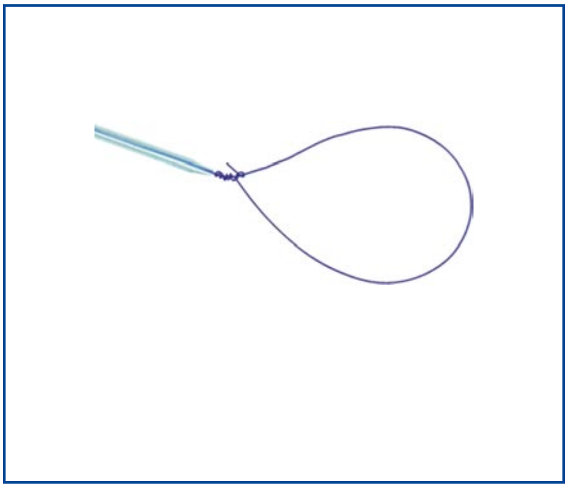


2.13 Circular Intraluminal Anastomosis Stapler

The end-to-end anastomosis stapler enables a circular intraluminal anastomosis of the bowel by placing a double-staggered row of titanium staples. The instrument is activated by squeezing the handles firmly. Immediately after staple formation, a knife blade in the instrument resects the excess tissue. (Courtesy of Johnson & Johnson Medical Products, Ethicon Endo-Surgery, Vienna, Austria)

2.14 Specimen Retrieval Bags

Specimen retrieval bags are designed to enable the safe retrieval and extraction of tissues from the body without spillage or contamination. The bags are made of polyurethane to eliminate porosity and provide the necessary strength. Two support arms help to facilitate bag opening and tissue capture. The bag and support arms are attached to a shaft and introducer to facilitate their use in laparoscopic procedures. Each bag is a sterile, single-patient-use, disposable product. (Courtesy of Covidien Austria, Brunn am Gebirge, Austria)



2.15 Endoscopic Loop Suture

Endoscopic sutures are available as pretied loops. In order to apply the suture, the loop and its applicator are placed through an appropriate cannula and inserted into the cavity. The tissue to be ligated is grasped through the loop and then pulled to allow the loop to slide over it. The external end of the applicator is then broken free and pulled to tighten the loop. The pretied Roeder knot slips forward along the suture and will stay relatively in the area where it is applied. (Courtesy of Johnson & Johnson Medical Products, Ethicon Endo-Surgery, Vienna, Austria)

2.16 Automated Laparoscope Assistance

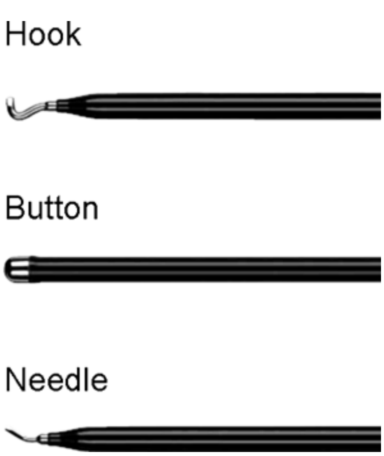
Automatic laparoscope manipulators are systems that render an additional hand for movement or positioning of the scopes during a procedure. Such systems help in autonomous coordination of the hand and eye, directly by the surgeon. The systems are generally composed of a base unit, a mobile and mechanically adjustable arm, and a shaft holder. Recently developed units (Lapman™, Richard Wolf, Knittlingen, Germany) are delivered with an autoclavable "hand control remote" that can be held in position in the palm of the surgeon's hand under the sterile gloves. (Courtesy of Richard Wolf, Knittlingen, Germany)

2.17 Electrosurgery Devices

2.17.1 Coagulation and Dissection

Coagulation by desiccation is performed when the instrument comes into contact with the tissue, to slowly heat and evaporate water from the tissue. This process continues until the tissue becomes desiccated to the point that it no longer conducts electric currents and an eschar is produced.

Electrosurgery equipments have controls for setting waveforms. The waveforms represented are *cut* and *coagulate*. The electrosurgery solid-state generators start with 50 cycles of current and transform them to frequencies of more than 50,000 cycles, which is above the level of neuromuscular stimulation, to achieve the desired result in the tissue. (Courtesy of Richard Wolf, Knittlingen, Germany)



2.17.2 Monopolar Coagulation

In monopolar electrosurgery, current passes through the body from the active electrode (instrument) to the grounding electrode pad, which is attached to the patient's body. Monopolar electrosurgery is widely used and enables the surgeon to both, *cut* and *coagulate*. Along with the power level used, the efficacy of coagulation or cutting is also determined by the shape of the electrode. The hooked-shaped electrode is one of the most useful devices, since cutting may be achieved either by pulling or alternatively using the heel of the hook. (Courtesy of Richard Wolf, Knittlingen, Germany)

2.17.3 Bipolar Coagulation

In bipolar electrosurgery, the functions of both the active electrode and return electrode are performed at the site of surgery. Only the tissue grasped is included in the electrical circuit. Because the return function is performed by one tine of the forceps, no patient return electrode is needed. This eliminates most of the safety concerns associated with monopolar electrosurgery. Bipolar electrosurgery is generally employed for captive hemostasis; however, sharp hemostatic dissection is possible with the newer configurations available. (Courtesy of Erbe Elektromedizin, Tübingen, Germany)

2.17.4 Harmonic Technology/Instruments

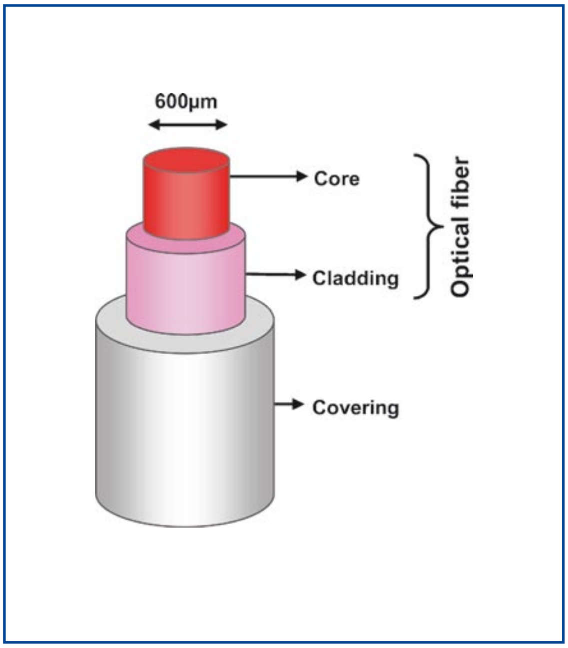
The Ultracision® harmonic scalpel (Johnson & Johnson Medical Products, Ethicon Endo-Surgery, Cincinnati, OH, USA) uses ultrasound technology for precise cutting and controlled coagulation. The main benefits of this instrument are:

1. Greater precision near vital structures.
2. Fewer instrument exchanges.
3. Minimum charring and desiccation.
4. Reduced need for ligatures.
5. Coagulation/cutting at lower temperatures.
6. Less lateral thermal damage.
7. Heat development in the tissue rather than the instrument.
8. No electrical circuit through the patient.

(Courtesy of Johnson & Johnson Medical Products, Ethicon Endo-Surgery, Vienna, Austria)

2.17.5 LigaSure™ Sealing Device

The LigaSure™ (Valleylab, Boulder, CO, USA) sealing device uses an optimized combination of pressure and energy to create seals by melting the collagen and elastin in the vessel walls and reforming it into a permanent, plastic-like seal. It fuses vessels up to and including 7 mm in diameter and tissue bundles without dissection or isolation. Furthermore, when the instrument determines that the seal is complete, a tone sounds and output to the handpiece is automatically discontinued. Lateral thermal spread is minimal (1–2 mm) and the unique energy output results in no sticking or charring. (Courtesy of Covidien Austria, Brunn am Gebirge, Austria)



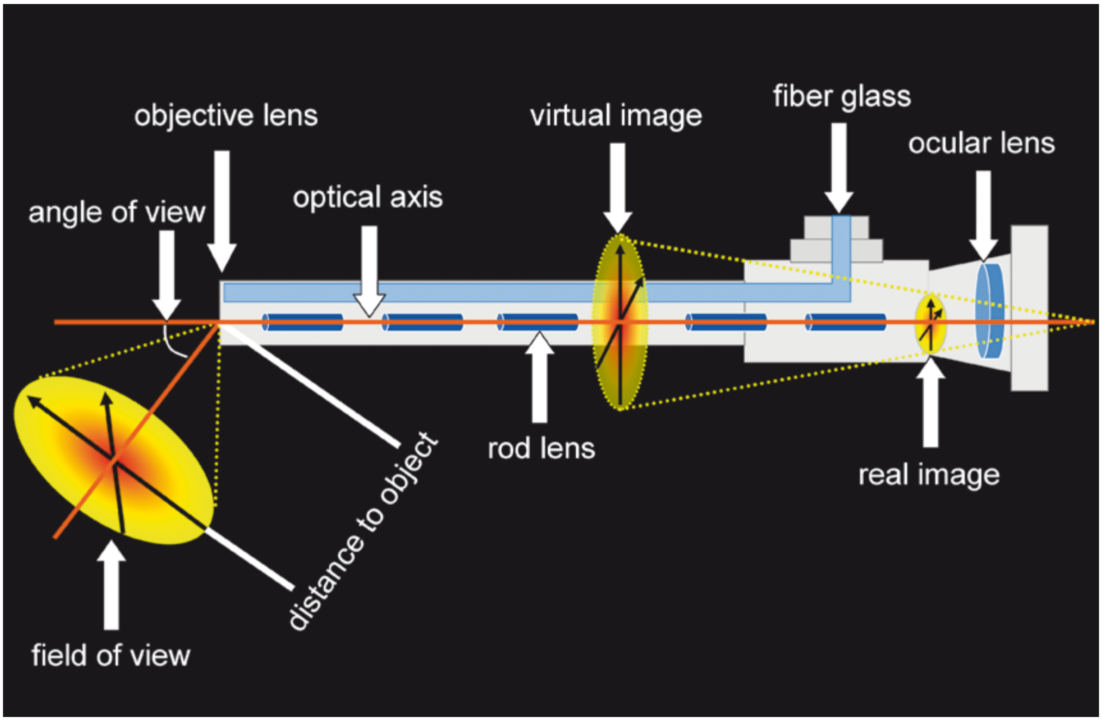
2.18 Laser Fiber Optics

The most frequently used lasers in operative procedures are argon, potassium-titanyl-phosphate (KTP) and neodymium-doped yttrium-aluminum-garnet (Nd:YAG). Laser energy is delivered to the tissues through optical fibers – fiber optics. The optical fiber consists of a 600-µm pure silica core surrounded by a low-refractive-index silica cladding. In order to prevent breakage, a covering of silicone rubber and nylon is applied. The 600-µm fiber optics offer the best combination of coagulation and cutting, which is combined with the appropriate amount of stiffness and flexibility. For laser application in endoscopic surgery, various laser fiber-optic delivery device options (operating scopes/reducing valve ports) are available.

2.18.1 Scopes and Video Camera Systems

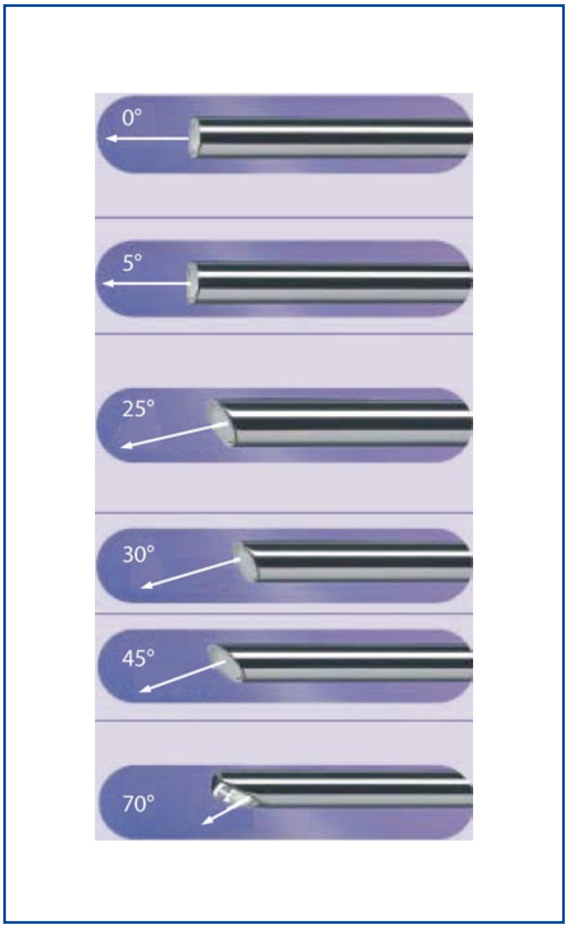
2.18.1.1 Anatomy of a Rigid Scope

Central to the instrumentation is the scope. Its backbone is the rod lens system designed by Hopkins. The shaft of scopes houses both light fibers and viewing optics. The viewing optics consist of three distinct parts: the objective lens, rod lenses, and ocular lens.



2.18.1.2 Field of View

The field of view (also field of vision) is the angular extent of the observable area that is seen at any given moment. The field of view in scopes for endoscopic surgery can vary from 60° to 82° depending up on the type of instrument. Wider angles of view provide a greater depth of field in the image with better utilization of illumination. A smaller field of view allows the scope to be farther from the tissue, for the same to be observed.



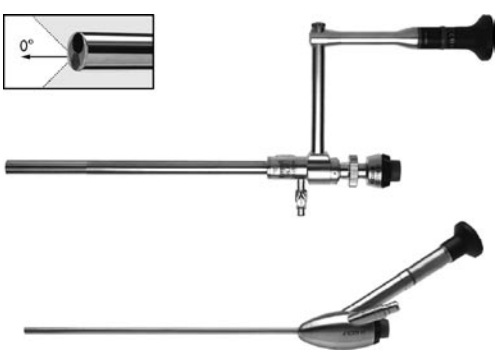
2.18.1.3 Angle of View

The angle of view in scopes can vary with respect to the central axis of the scope. Scopes that offer an axis view are designated as 0° and provide a straight view of the structure in question. Scopes are also available with a 5°, 25°, 30°, 45°, and even 70° angle of view, allowing utilization of the scopes much as a periscope. The off-axis scopes enable one to observe down into the gutters and up the anterior abdominal wall as well as sideways. Off-axis scopes are difficult to work with; however, they provide an excellent means of obtaining close inspection of tissues at difficult angles and positions.

2.18.1.4 Scope Size and Screen Image

The decrease in the size of scopes was an important factor in the advancement of minimally invasive surgery in the pediatric age group. Although scopes are available in sizes from 1.9 mm to 12 mm in diameter, the majority of the procedures are performed using 5- or 10-mm scopes.

When compared to the reduced view obtained in the previous generation of scopes *(left)*, modern 5-mm, full-screen scopes provide a bright, distortion-free, full-screen image *(right)*. In addition, the image size in modern 5-mm scope is equivalent to that obtained by the previous-generation 10-mm scope. (Courtesy of Richard Wolf, Knittlingen, Germany)



2.18.1.5 Operating Scopes

Beside the optical component and the lens system, operating scopes posses an additional work channel that allows the introduction of instruments (between 3.5–5.0 mm in diameter and 220 mm in length) through the scope. These scopes have a 0° angle of view and 85° field of view. Operating scopes have been used frequently in gynecology for tubal ligations; however their use in pediatric surgery has risen with the increasing trend in single-port laparoscopic applications. (Courtesy of Richard Wolf, Knittlingen, Germany)

2.18.1.6 Charge Coupled Device (CCD) Video Cameras

Scope cameras are available in either single-chip or three-chip versions (one chip offers 300,000 pixels/cm^2). In single-chip CCD cameras, all the three primary colors (red, blue and green) are sensed by a single chip. In three-chip CCD cameras, there are three chips for separate capture and processing of the primary colors.

Single-chip CCD cameras produce images of 450 lines/inch resolution and are ideal for outpatient surgery. On the other hand, three-chip CCD cameras have high fidelity with unprecedented color reproduction to produce images of 750 lines/inch resolution that can be viewed optimally on flat-panel screens and are best suited for endoscopic surgery. (Courtesy of Richard Wolf, Knittlingen, Germany)

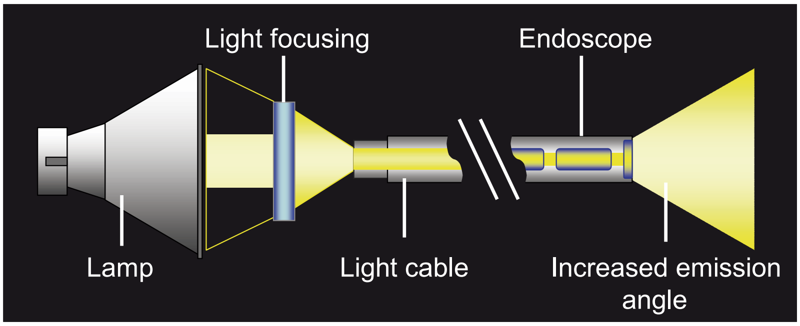
2.19 Light Sources

2.19.1 Light-Source Generators and Transmission Pathways

There are two commonly utilized light sources: halogen and xenon. A schematic overview of light transmission is outlined in the diagram (*next page*).

Halogen bulbs (250 W) provide a highly efficient white light source with excellent color rendering. Electrodes in halogen gas lamps are made of tungsten and reach color temperatures up to 5000–5600 K.

Xenon bulbs (300 W) consist of a spherical or ellipsoidal envelope made of quartz glass. The color temperature of a xenon lamp is 6000–6400 K. Xenon bulbs last longer than halogen, but are significantly more expensive. (Courtesy of Richard Wolf, Knittlingen, Germany)



2.19.2 Fiber-Optic Cables for Light Transmission

A fiber-optic cable is used to transmit light from the light source to the scope. Fiber-optic bundles are very flexible and are made of small, 5-μm-diameter fibers. Since individual fibers are subject to breakage, fractured optical cable fibers reduce the capacity to transmit light. To prevent cable breakage, the cable should be handled with care, and inserted and removed from its socket without angling at the flexible as well as the rigid junction. Cables should never be bent at acute angles. Fiber-optic cables should be discarded when less than 75% of the fibers transmit light. (Courtesy of Richard Wolf, Knittlingen, Germany)

2.19.3 The Concept of White Balancing

White balancing should be performed before inserting the camera inside the abdominal cavity. This is necessary before commencing surgery to diminish the added impurities of color that may be introduced due to a variety of reasons such as: (1) voltage difference, (2) staining of the tip by cleaners, and (3) scratches and wear of the eyepiece.

White balancing is achieved by keeping a white object in front of the scope and activating the appropriate button on the video system or camera. The camera senses the white object as its reference to adjust all of the primary colors (red, blue and green). (Courtesy of Richard Wolf, Knittlingen, Germany)

2.20 Insufflation, Irrigation and Aspiration Devices

2.20.1 Insufflation Devices

Modern insufflators automatically monitor and regulate the internal pressure of the abdominal cavity. Insufflators have four clearly visible gauges: (1) a carbon dioxide (CO_2) flow rate indicator (maximum 10 l/min), (2) a CO_2 cylindrical pressure indicator, (3) a total volume of gas delivered indicator, and (4) an intra-abdominal pressure indicator. A filter is placed between the insufflators and sterile tubing attached to ports. The required values for pressure and flow can be set precisely using digital displays. (Courtesy of Richard Wolf, Knittlingen, Germany)

2.20.2 Concepts in Irrigation and Aspiration

Vision is one of the limitations of endoscopic surgery. Blood has the darkest color inside the abdominal cavity and excess of blood therein absorbs most of the light. So, whenever there is bleeding during endoscopic procedures, blood should first be aspirated before irrigating to prevent reduction of vision. Aspiration of fluids and washing of tissues to enable better visualization is accomplished with an irrigation/aspiration system. The instrument that is used to gently spray the irrigation solution is also employed to aspirate the irrigant. Suction/irrigation instruments can also be used for blunt dissection. (Courtesy of Richard Wolf, Knittlingen, Germany)

2.20.3 Instruments for Irrigation and Aspiration

Irrigation/aspiration instruments for endoscopic procedures are available in a variety of handle- and tip-form combinations. Furthermore, some hand instruments, especially those designed for electrosurgical dissection, have channels within for aspiration of smoke from the surgical site.

At the time of using suction, it is important to visualize the tip of the irrigation/suction instrument and ensure that it is dipped inside blood or other fluid to be evacuated. If not completely immersed, a loss of insufflated gas will occur. (Courtesy of Richard Wolf, Knittlingen, Germany)

2.21 Video and Data Storage Equipment

2.21.1 Digital Video Recorders

Modern endoscopic surgery towers are generally equipped with digital video disc (DVD) recorders (DVRs), which enable recording of a procedure in digital quality. The procedures are recorded on commercially available DVDs, which can later be viewed on normal DVD players or edited on personal computers.

DVRs have evolved into devices that are feature rich and provide services that exceed the simple recording of video images that was previously achieved using video cassette recorders (VCRs). DVR systems provide a multitude of advanced functions, including video searches by event and time.

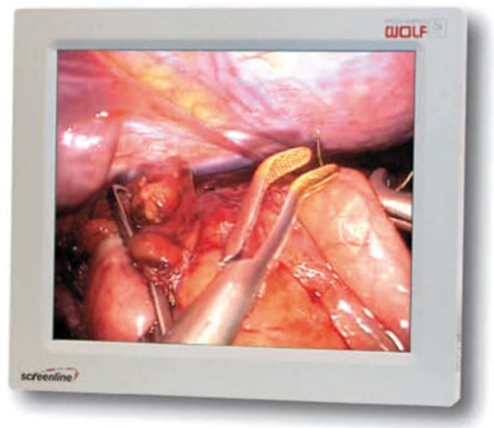
2.21.2 Digital Video Printers

A variety of printers from small print format to large A5 print format are available. These printers offer high-resolution prints, quick, 20-s print time, and high-quality, curl-free prints at 400 dpi resolution. Most modern printers come with a four-frame memory. The new compact design of printers allows for easy integration with other video equipment. Small, compact printers are ideal for the office setting, but large-print format printers are preferable in the operating room.

2.21.3 Digital Video Managers

These are computer-based systems that display intuitive patient information screens that allow for quick and easy input of vital data. The data is stored on hard drives and can be viewed as images or videos, and may be stored or deleted. The editing screen enables viewing and editing procedures.

Current systems allow storage of up to 50 patient archives for multiple procedures. These systems are compatible with personal computers and hospital network software. (Courtesy of Richard Wolf, Knittlingen, Germany)



2.21.4 Flat-Panel Screens

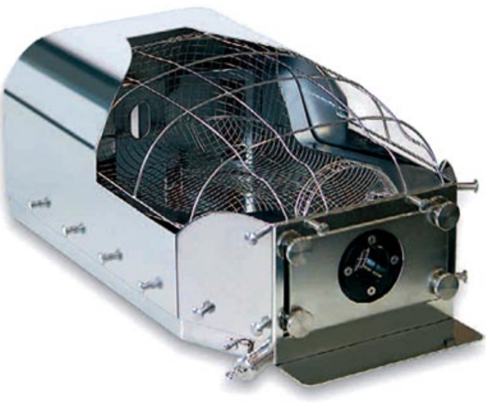
The industry offers a variety of high-quality LCD monitors with ultrasharp detail and perfect color rendition. The 14-inch medical and non-medical-grade monitors including stand-alone and built-in audio speaker are ideal for office endoscopy; however, 19-, 21-, and 23-inch medical-grade monitors are presently an integral component of video carts and are ideal for endoscopic surgery visualizations. Due to their light weight, flat-panel monitors can be held by swivel arms on video carts. (Courtesy of Richard Wolf, Knittlingen, Germany)

2.21.5 Endoscopic Surgery Towers

Endoscopic surgery towers are mobile carts that house the equipment. Their mobility enables the placement of equipment according to the procedure and position of the team. Standard towers consist of:

1. Monitors.
2. Video processing equipment.
3. Light-source generator.
4. Gas (CO_2) insufflator.
5. Aspiration/suction device.
6. Documentation equipment.
7. Stand for CO_2 cylinder.

(Courtesy of Richard Wolf, Knittlingen, Germany)



2.22 Trainers for Endoscopic Surgery

2.22.1 Pelvitrainers

A realistic surgical training requires an anatomical model that allows the easy integration of animal organs. The regular repetition of procedures demands quick preparation of the training setup with optimal fixation of the organs within the pelvitrainers.

Modern trainers such as the Tübingen MIC Trainer™ (Richard Wolf, Knittlingen, Germany) have realistic anatomical shape that simulates the frontal abdominal wall of an insufflated patient, and covers that deliver a reality effect for the introduction of the trocars and ports. (Courtesy of Richard Wolf, Knittlingen, Germany)

2.22.2 Virtual Reality Simulators

The LapSim® System (Surgical Science Sweden, Göteburg, Sweden) is a digital training aid that replaces the vulnerable patient with expendable pixels. By recreating digitally the procedures and environment of endoscopic surgery, LapSim® provides an effective training tool for endoscopic surgeons. Augmenting surgical training with simulation offers great promise because maneuvers can be practiced over and over until they are mastered. (Courtesy of Surgical Science Sweden, Göteborg, Sweden)

NOTE

Tyco Healthcare is now Covidien (Covidien, Mansfield, MA, USA) with endoscopic surgery product brands- Autosuture (division of United States Surgical -USS), Valleylab and Syneture.

Recommended Literature

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2. Mercy CM, Cooke DT, Chandra V, Shafi BM, Tavakkolizadeh A, Varghese TK (2007) The road to innovation: emerging technologies in surgery. Bull Am Coll Surg 92:19–33
3. Eriksen JR, Grantcharov T (2005) Objective assessment of laparoscopic skills using a virtual reality stimulator. Surg Endosc 19:1216–1219