SECTION 1 Pre-procedure

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CHAPTER 1

The Endoscopy Unit, Colonoscope, and Accessories

Introduction

Colonoscopy is performed in the hospital, the ambulatory surgical center, or the physician office. Endoscopy units range in size from 1 to 10 or more procedure rooms, and in staffing from one or two to over 50 persons. Regardless of size, staffing, and location, the endoscopy unit must promote safe, efficient, cost-effective, highquality patient care. A pleasant, comfortable endoscopy facility promotes staff productivity and alleviates patient anxiety. The modern gastrointestinal endoscopy unit is constructed specifically for endoscopic procedures. Specific design concerns include: smooth patient flow; patient privacy; patient safety; spacious procedure rooms; adequate preparation and recovery space; and a pleasant, reassuring environment. The materials must be durable and sanitary, yet aesthetically attractive.

In broad terms, the facility is divided into the administrative area—which is used for patient intake, scheduling, billing, and record maintenance—and the clinical area—which contains the dressing rooms, the pre-procedure area, the procedure rooms, a clean equipment storage area, a cleaning and disinfection zone, and a recovery room. Amenities such as physician–patient consultation rooms, a procedure reporting area, and staff lounge and dressing rooms enhance the quality of the unit.

When building a facility, careful planning and close collaboration between the endoscopists and an architect who possesses expertise in endoscopy unit design is encouraged. The unit design should conform to the practice styles of the endoscopists and the procedure mix and demographics of the practice. Unit construction requires patience (it may take a year to design and construct a new unit), attention to detail, experience, foresight, and cost-sensitivity. As modern endoscopy units are increasingly digitized, specialized expertise in information technology, cabling, and connectivity is essential.

If the facility is built as an ambulatory surgical center or within a hospital, many of the specifics, such as the size of the rooms and

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Optimizing the work environment

- Proper ventilation
- Appropriate temperature
- Adjustable lighting
- Free of trip hazards
- Workspace fastidiously cleaned between cases and especially at the end of the day
- Free of distractions such as sounds from other rooms
- Adequate workspace for each member of the team

corridors, will be regulated. Office-based endoscopy in many states must now meet the criteria of one of the national accrediting organizations. In general, a circular flow of patients works well: the patient moves from the waiting and intake area to the preprocedure assessment/changing area, to the procedure room, to the recovery/dressing area, and then back to the intake area, where billing and/or new appointment scheduling is completed. The interdependent areas (e.g. procedure and recovery, procedure and scope washing) should be located close to each other. The number of procedure rooms should be projected from the procedure volume of the practice, and will drive the number of overall square feet and all other architectural decisions. The procedure rooms contain the complex, expensive equipment and are the most heavily staffed rooms in the unit. Therefore, the entire facility must be designed to keep the procedure rooms busy with active procedures, rather than also having to serve as recovery rooms.

The procedure rooms

In the USA, licensing laws generally mandate that the procedure room have a net area of at least 19 m². This excludes areas occupied by built-ins, such as cabinets or equipment towers, but not area occupied by movable equipment, such as an endoscopic equipment tower. The room must accommodate the equipment and the patient stretcher, and still allow free movement and clear sight lines for the physician, assistant, anesthesiologist and other participants. Because of the amount of equipment required for endoscopy, vertical arrangement of components on towers or carts or in built-in cabinets is generally desirable.

In a modern video-endoscopy room, the central architectural design point is the "physician tower," which holds the endoscopic light source and image processor. The endoscope is plugged into the processor, and the endoscopist stands immediately in front of the tower. The patient stretcher must be within easy reach of the endoscopist. The distance from the front of the tower to the edge of the patient stretcher should be between 66 and 81 cm, as determined by the length of the scope's universal cord (Fig 1.1). It



Fig 1.1 Basic clearances in the procedure room.



Fig 1.2 Position of monitors for the colonoscopist and assistant.

is most efficient for the assistant to stand on the opposite side of the stretcher from the endoscopist (Fig 1.2); this location promotes easy access to the patient (e.g. to give abdominal pressure and to monitor respirations), the endoscopist (e.g. to provide a snare for polypectomy), and the other equipment (e.g. the cautery device).

Once the positions of the tower and stretcher are established, then the other equipment is located. One video monitor is situated directly across from the endoscopist, establishing a comfortable, clear sight line. The monitor should be mounted at least 1.8 m above the floor. A second endoscopy video monitor is positioned behind the endoscopist for the assistant. The assistant should have clear visual access to the patient, the monitor, and the cardiopulmonary monitoring equipment.

An endoscopic reporting system is often integrated into the room design. This allows nurses and physicians to chart immediately, increasing both accuracy and efficiency. The equipment and electrical cabling must be laid out with forethought: it is unsafe and unkempt to have wires running across the floor. Often an overhead cabling conduit will keep the room tidy but a series of floating ceiling booms will also (expensively) solve the problem. The ancillary equipment should be carefully positioned and handy for the endoscopy assistant. Lighting must be purposeful: the patient's face and chest should be visible, allowing the assistant to monitor the patient's color and respiratory pattern, but the ambient lighting should be minimal, to encourage the team to focus on the endoscopic image. The room must be well ventilated with continuous air exchange and adequately soundproofed, and the temperature must be controlled by an independent thermostat.

The non-procedure areas

The waiting and recovery areas also merit careful planning. The total number of required seats in the waiting area depends on the

Ancillary equipment and built-ins

- Suction machine (unless wall suction is available)
- Water irrigation pump
- Location to place the scope before and after the case
- Counter space for gloves, lubricant, and other accessories
- Cabinetry for accessories, medications, and miscellaneous small equipment such as catheters and saline
- Counter space for the assistant to process specimens and perform charting
- Ancillary monitoring devices, such as machines for obtaining vital signs (blood pressure and pulse), and perhaps capnography
- At least one sink
- Oxygen and perhaps CO₂ tanks

projected case volume of the unit, as well as the procedure and recovery room turnover time. Each patient brings one or more companions; thus, for each patient, at least two seats are required in the waiting area. In general, at least six waiting spaces should be provided for every busy procedure room—two for the patient in recovery, two for the patient in the procedure, and two for the pre-procedure patient. The gastrointestinal endoscopy patient waiting area must be aesthetically pleasant, comfortable, and served by adequate, private bathroom facilities.

The patient changing and pre-procedure areas should be private, secure, and convenient to the procedure area. Depending on the workflow, this area may contain seating for a physician or staff member to perform the pre-procedure interview and obtain informed consent. In some units, the patient walks to the procedure room; in others, the patient lies on a stretcher in the preprocedure room and intravenous access is obtained in this area.

The recovery bed capacity is a notorious bottleneck in endoscopy units. If colonoscopy takes 45 minutes and recovery takes 45 minutes, one recovery bed will be required per procedure room. In general, this ratio is desirable. The recovery room must permit close patient monitoring and be adequately served by restroom facilities. In some units, patients recover in individual rooms, whereas in others, patients recover in separate "bays" within a larger recovery room.

The administrative area should accommodate all reception, scheduling, filing and record-keeping, and billing/insurance functions. The reception area should promote face-to-face interactions between patients and staff, but also accommodate private conversations regarding sensitive matters. Adequate, well-marked toilet facilities must be nearby. Many waiting rooms include artwork, wi-fi access, telephones, television monitors, water coolers, reading materials, or music. Computer- and telephone-equipped staff workstations should be available. Staff foot traffic should move unimpeded. Cabinets for patient record storage should be adequate, although the transition to electronic records may diminish this requirement. Depending on the characteristics of the practice, an on-site billing area may be included.

The colonoscope

The modern video colonoscope combines state-of-the-art electronic imaging technology and sophisticated mechanical engineering. Its fragile components—glass illumination fibers, angulation cables, and suction and air/water channels—are packed within a water-tight tube that is 130–168 cm in length but only 9–13 mm in diameter. The column must be strong enough to permit the endoscopist to push it through the 1.8-m-long colon, flexible enough to bend around the sharp turns, and elastic enough to return to a straight shape when the scope is pulled back. It must transmit the hand actions of the endoscopist from the proximal shaft down to



Fig 1.3 The design and parts of a typical video colonoscope.

the tip. The scope must be sturdy enough to withstand the repetitive and diverse stresses that occur during thousands of procedures and cleaning cycles, yet delicate enough to provide impeccable tip control and visualization.

The scope is divided into several sections (Fig 1.3). The long connector tube that runs from the scope head to the light source is called the "universal cord." The universal cord is plugged into the light source, which also has connections to the video processor, the suction, and the air/water supplies. The head of the instrument contains endoscopist-operated switches and valves that control many scope functions. The "insertion tube" is the long, straight tube that intubates the colon. At the distal end of the insertion tube is a 10-cm bending section, which is controlled by the angulation wires using two control wheels. The variable stiffness control, if present, is located at the junction where the control section meets the insertion tube. The distal scope tip contains the channel openings, the air-water nozzle that allows insufflation and lens cleaning, the objective lens, and the light guide lens. The charge-coupled device (CCD) is a small chip (camera) that is located just behind the objective lens and that electronically captures the images and transmits them through electrical wires to the video processor



Fig 1.5 Internal cutaway view of a colonoscope shaft.

(Fig 1.4). The control section contains: the angulation dials and locks for up/down and right/left tip deflection; the air–water and suction valves; and the remote switches that control photography, illumination light type (e.g. white light versus narrow band), and zoom.

Although the control section has the greatest visible complexity, the insertion tube is a marvel of modern engineering (Fig 1.5).

The insertion tube must carry: three hollow tubes (channels) for suction/biopsy, air and water (to wash the lens), and water (for the forward-directed jet); four angulation cables, positioned at 3, 6, 9 and 12 o'clock, which connect the right/left and up/down controls to the distal bending section of the instrument; the variable-stiffness cable; the fine electrical wires that carry the signals from the CCD to the image processor; the fiber-optic bundles-containing thousands of hairlike, 30-µm-wide, glass fibers-which transmit the light from the xenon lamp to the distal end of the instrument; the outer casings of metal that provide the scope with its mechanical properties; and the polymeric outer casing, which is smooth, durable, biocompatible, and watertight. The insertion tube must responsively transmit torque from the external shaft of the instrument, through the bends in the colon, to the instrument's tip. Mechanically, this is accomplished by oppositely spiraled flat metal bands that run the length of the instrument. These bands are arranged so that a twist of the scope in one direction will tighten one set of bands and maintain torque integrity, whereas a twist in the opposite direction will tighten the other spiral bands. The stiffness of the insertion tube is determined principally by the formulation of the outer polymeric layer and an outer wire mesh.

The distal 40 cm of the insertion tube is more flexible than the proximal portion. This allows the distal segment to snake around the convolutions of the colon without the proximal portion forming loops. Some instruments have a variable stiffness capability activated by a ring on the proximal end of the insertion tube. Rotation of the ring pulls a wire and adds rigidity to the insertion tube. The tip deflection capability of most colonoscopes is 180° up/down and 160° right/ left. The angle of view of most scopes is 140°, although one manufacturer has recently introduced a scope that has a 170° viewing angle. Most modern video colonoscopes contain "high-resolution" optics that can distinguish two lines or points that are located only fractions of a millimeter apart. The image resolution increases as the scope tip moves closer to the mucosal surface, until a critical distance is reached (<1 cm) when focus is no longer achieved and the image degrades. Modern instruments also offer "high-definition" image sensors, which can feed to densely pixilated monitors.

Preventing scope damage between cases

- After washing scopes, hang them vertically (for drainage) in a protected, ventilated, dedicated cabinet
- When transferring the scope from person-to-person or person-to-storage-location, hold the scope tip carefully so it cannot drop to the floor
- Leak-test scopes between cases
- Train dedicated individuals for scope cleaning and maintenance
- Quality control all reprocessing reagents
- Adhere strictly to established scope reprocessing methods
- Educate all clinical staff regarding proper scope handling
- Service scopes at appropriate intervals

Preventing scope damage during the case

- When passing an ancillary device through a working channel, use gentle thrusts and never force
- Whenever possible, do not pass ancillary devices through a channel when the scope tip is in a retroflexed position
- Avoid hyper-deflection of dial controls, which strains cables
- Avoid suctioning large seeds and debris
- If scope malfunction occurs, switch scopes and inform staff of the problem

Mucosal imaging can be further enhanced with magnification or with alteration of the light that is delivered to the mucosal surface. The electronic magnification feature on most commercially available scopes simply enlarges the image, sacrificing the outer portion of the image, without increasing resolution. True optical zoom technology increases resolution, but is not widely commercialized. The white light typically used for illumination can also be selectively filtered. In narrow band imaging (NBI), filters transmit wavelengths of light that are highly absorbed by hemoglobin, thus producing a brownish color to the surface with intensity related to mucosal blood flow. Some manufacturers use image-processing technology to "bring out" characteristics and contrasts in the image after it has been acquired.

Endoscopic accessories

The endoscopy unit must stock a variety of accessories, including snares, forceps, retrieval devices, clips, and injector needles. The unit must stock an adequate inventory and a variety of devices needed to solve the commonly encountered colonoscopic predicaments. Many accessories are available in disposable and reusable versions. The disposable variety increases the up-front cost, but saves labor (no reprocessing and reassembly required) and ensures case-to-case sterility. Reusable devices must be sturdy enough for repeated use and sterilization cycles. Reusable snares require disassembly for cleaning. Most accessories are available from a variety of manufacturers, with small differences in engineering and cost.

Polypectomy snares

The polypectomy snare consists of a thin wire loop attached by a long connector wire to the control handle. The wire is enclosed within a 7-French plastic sheath, which is passed through the working channel of the scope. The wire loop is opened and closed by the endoscopy assistant, using the control handle. The snare handle connects to an electrosurgical unit, and the connector wire conducts electrical current to the loop. Although bipolar snares have been developed (one wire positive and the other negative), most snares are monopolar, requiring a remote return electrode (grounding pad) to complete the electrical circuit.

The wire loop is typically fashioned from braided stainless steel wire, which combines favorable strength, configurational memory, and electrical conductance. Stiffer monofilament wires promote transection over coagulation. The loop configuration is usually oval or elliptical, although "D" and hexagonal shapes are available (Fig 1.6). Rotatable snares and combination injector/snares are available but are not essential. Some colonoscopists believe that tiny wire protrusions (barbs) on the wire snare loop facilitate flat polyp capture. The large loop snares are 5×3 cm, whereas the "mini-loop" is 3×1 cm. As most polyps are less than 1 cm in diameter, the smaller loop is adequate for most polypectomies.



Fig 1.6 Polypectomy snares. Snares differ in loop diameter, shape, and filament diameter. After it is embedded in the mucosa, the pointed tip can act as a fulcrum.

Polypectomy snares

- Stock small-loop and large-loop snares
- Maintain an appropriate-sized inventory of snares, so that the "right" snare is available at all times
- Disposable or multiple-use varieties are acceptable
- Multi-use snares require careful (time-consuming) reprocessing
- Specialty snares (e.g. barbed snares) are not necessary for almost all polypectomies
- Train endoscopic assistants and endoscopists regarding the differences among snares

Polyp retrieval devices

A resected polyp can usually be retrieved from the lumen by suctioning it through the working channel into a specimen trap, or by grasping it within the snare loop and pulling out the scope. Most metal grasper-type retrieval devices can only capture one or two fragments of a resected polyp. The synthetic fiber mesh baskets (such as the "Roth Net" or "Spider Net") function like a butterfly net, and can collect multiple pieces of tissue during one pass; they are useful for retrieving multiple fragments of a large polyp after a piecemeal resection in the proximal colon (Fig 1.7a,b).







Fig 1.8 Polyp retrieval trap. A compartmented trap permits capture of polyp from different areas of the colon. Even samples taken by biopsy forceps will be caught within the small grid that collects polyps.

Specimen traps

Several types of specimen traps are available (Figs 1.8 and 1.9). The single bucket type is best for obtaining a fluid/stool for microbiology; it is adequate for polyp entrapment, but can overflow, causing the polyp to travel into the main suction canister (Fig 1.10). The single chamber, filter type cannot overflow, but cannot collect fluid for microbiology (Fig 1.11). The four chamber type allows polyps from several locations to be caught within one device, but can cause confusion if the site of each polyp is not carefully recorded (Fig 1.8).



Fig 1.9 Using simple mesh to retrieve polyp specimens. A mesh pad can be inserted between the suction port on the scope and the suction tubing. This will function as a filter, trapping a resected specimen when it is suctioned through the system.

Fig 1.10 The canister-type traps can overflow. This can cause a polyp to be lost (c).

Biopsy forceps

Biopsy forceps are discussed in Chapter 8.

Injection needles

During colonoscopy, there are multiple indications for tissue injection, including elevation of sessile polyps, hemostasis, and tattooing. Injection is accomplished using disposable metal injection needles. These needles have a stiff outer sheath of 2.3–2.8 mm diameter, with a smaller inner channel for fluid passage. The tip of the needle is beveled and the needle size is 21–25 G. The needles are retractable, and must be passed through the working channel in the retracted position in order to avoid an expensive puncture injury to the scope. The needles can be locked in their extended position during introduction of the tip into target tissue. Fluid is pushed from a syringe connected to the sheath. In general, if the tiny needle punctures the full thickness of the colon wall, there is no untoward effect.

Spray catheters

When fluid is pushed through a spray catheter, it is dispersed through multiple fine apertures in the metal nozzle at the catheter's tip, producing a fine mist in a 360° arc. The technique is useful for chromoendoscopy, because it can cover the mucosal surface efficiently and relatively evenly. Spray catheters may be disposable or reusable.

Endoscopy clips

Clipping devices contain two stainless steel, detachable, tweezerlike prongs that are attached by a long delivery catheter to an external control handle. Clips can be used to close a polypectomy site, seal a perforation, mark a lesion (they are radiopaque, and are palpable by a surgeon), clamp a bleeding vessel, or anchor a decompression tube. Numerous clips can be placed on a lesion. Clips can be deployed with the colonoscope in the retroflexed position. Most clip applicators are for single use. Some are applied and fired without the ability to reposition the device, whereas others may be repeatedly opened and closed. Some devices are rotatable, which may help achieve a favorable orientation. The outer plastic sheath is the same diameter as a snare sheath. Once fired, the clip remains attached to the target tissue for 2–4 weeks, after which it sloughs.

Detachable loops

These plastic, non-conductive loops close like a noose around a polyp pedicle and strangulate the large blood vessels that course through the stalk. Their main use is for prevention of bleeding when removing a large pedunculated polyp, but they can also be applied to a bleeding pedicle after polypectomy. Once positioned, the loop is tightened, and then locked shut with a plastic collar controlled by an external handle. In practice, these ligatures have a limited role, partly because the loop has little tensile strength and can become enmeshed in the head of a polyp during attempts to encircle the stalk.



Fig 1.11 Simple filter-type specimen trap. Unlike the canister-type traps, this device cannot overflow with fluid, causing specimen to be lost. However, fluid/ stool cannot be captured for microbiological analysis.



Fig 1.12 Plastic transparent cap. This may be attached to the end of an endoscope and enhance observation behind folds as the instrument is withdrawn through the colon. (From *Colonoscopy: Principles and Practice*, 2nd edition.)

Thermal devices

Thermal devices are discussed in Chapter 9.

Transparent caps

Affixed to the tip of the colonoscope and extending several millimeters beyond the faceplate, these clear plastic cylinders are designed to enhance visualization of the valleys between the haustral folds (Fig 1.12). Several reports suggest that they may increase detection of small polyps, with no decrease in the maneuverability of the scope. A special cap may be used during endoscopic mucosal resection, in a method analogous to variceal banding. Here the mucosal target is suctioned into the cap, and then a snare seated in a small ridge at the tip of the device is closed around the tissue.

Overtubes

Overtubes slide over the scope after it has been straightened in the sigmoid and restrict loop formation and facilitate advancement of the instrument. Overtubes should not be used to straighten a loop, as it may damage the colon wall. Overtubes must be placed on the colonoscope before it is inserted into the colon, effectively shortening the instrument until they are deployed. Originally, overtubes were inserted under fluoroscopic control to ensure that the scope was straight, but "feel" may also be relied upon to deploy this device. With enhancements in scope engineering, overtubes are not commonly used today.

Summary

The modern endoscopy suite should promote safety, efficiency, hygiene, and comfort. Electronic procedure reporting represents an important advance. Careful attention to practice characteristics during the planning phase is essential. The scope is a platform for numerous diagnostic and therapeutic procedures. Improvements in optics and mechanical engineering have enhanced all clinical functions, and further improvements are forthcoming. Multiple accessories are available that support colonoscopic practice.

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