Practical Gastrointestinal Endoscopy

The Fundamentals

Peter B. Cotton
MD FRCP, FRCS
Director, Digestive Disease Center
Medical University of South Carolina
Charleston, South Carolina USA

Christopher B. Williams
MA, BM, BCh, FRCP
Endoscopy Unit
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FIFTH EDITION

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Contents

Preface to the fifth edition

Our earlier book, *Practical Gastrointestinal Endoscopy*, 4th edition (1996), was popular with a broad spectrum of endoscopists, from beginners to the most experienced. The field has become even more complex since that time, and it is increasingly difficult to cater to all needs in a single book. As a result, we have made several important conceptual changes. This book now focuses on the fundamentals of standard endoscopy practice, i.e. the core information which should be learned during the first year or so of training, and which remains the basis on which all of our endoscopic skills continue to build.

We have removed from the original text of *Practical Gastrointestinal Endoscopy* all of the advanced techniques (like ERCP), and also the content aimed mainly at managers and teachers. We then updated the remaining core sections, and complemented the text with two CD-Roms, concerning upper endoscopy, and colonoscopy, which should greatly enhance the educational experience. At the same time we are developing other resources concerning advanced endoscopy techniques, which we hope will be useful to senior trainees and practitioners. They will be published also by Blackwell Publishing, on-line and in print. By these means we intend to provide comprehensive resources for endoscopists at all levels of practice. We believe these plans are consistent with the changing learning and publishing environments, and hope that they meet our goal of enhancing the availability of high-quality endoscopic services to all patients who need them.

Peter B. Cotton
Christopher B. Williams
2003

Preface to the first edition

The human gut is long and tortuous. Diagnosis and localisation of its afflictions relied for many decades on barium radiology, which provides indirect data in black and white. Man is by nature inquisitive and direct inspection in colour is instinctively preferable and probably more accurate. Rigid open-ended instruments allow direct visual examination (and biopsy sampling) of only the proximal 40 cm and distal 25 cm of the gut. Semiflexible lens gastroscopes were introduced in the 1930s and 1940s and used by a few experts; examinations were uncomfortable and incomplete, and biopsy facilities were poor.

The situation has changed dramatically since the late 1960s with the introduction of fully flexible and manoeuvrable endoscopes. Upper gastrointestinal (GI) endoscopy is now a routine procedure which has superseded the barium meal as the primary diagnostic tool. Duodenoscopy allows direct cannulation of the papilla of Vater for cholangiography and pancreatography (ERCP). The whole colon can be examined, and methods are available for small intestinal endoscopy. Tissue specimens can be removed from all of these areas under direct vision, using biopsy forceps, cytology brushes and snare loops.

A further revolution occurred in the late 1970s with the arrival of endoscopic therapy. Transendoscopic snare removal has revolutionized the management of polyps, and flexible endoscopes now allow removal of foreign bodies, sphincterotomy for gallstones, insertion of stents, dilation of strictures, and direct attack on bleeding lesions and tumours.

GI endoscopy is a skill which requires motivation, determination and dexterity. Patients may suffer if examinations are not performed correctly, and endoscopic techniques themselves may fall into disrepute if results are suboptimal or unnecessary complications occur. The speed of development and the consequent clinical demand for endoscopy initially outstripped the evolution of training facilities. Many of the present 'experts' (including the authors) were self-taught, but instruction and experience of endoscopy should now be an integral part of GI training programmes.

This volume attempts to provide a basic framework for this process, and includes some 'tricks of the trade' which we find helpful.

Peter B. Cotton
Christopher B. Williams
1980

Acknowledgements

Peter Cotton gratefully acknowledges advice and help from several professional colleagues, especially Rob Hawes, Mike Wallace, Mark Delegge, Willie Webb, and Phyllis Malpas, and continuing expert secretarial assistance from Rita Oden, and the support of other staff of the Digestive Disease Center, Charleston, South Carolina.

Christopher Williams particularly acknowledges the support of Dr Christina Williams, and also that of his colleagues at St Mark's Hospital, London, especially Dr Brian Saunders. His colonoscopy CD-Rom carries its own credits, but owes much to the technical wizardry of Stephen Beston.

Note on the fifth edition

We have, on the advice of our publishers, adopted American spelling for this edition.

Apologies

For convenience, we continue to refer to doctors as 'he', and nurses as 'she', recognizing that these attributions are increasingly incorrect.

Information on the Accompanying CD-ROMs

CD 1: UPPER GASTROINTESTINAL ENDOSCOPY

Starting the program

On most computers, the CD-ROM will start automatically. If it does not, double-click the file Upper-Gastro.exe to launch.

Software and hardware requirements

The CD-ROM will not install any files on your PC, but does require Windows Media Player 9 to play the video content.

If this is not already installed on your system, you may install it from the CD. If you have Windows XP, double-click on MPSetupXP.exe. If you have Windows 98 SE, Me, or 2000, double-click on MPSetup.exe. You may also download installers from the Microsoft Windows Media Player Web site:

http://www.microsoft.com/windows/windowsmedia/9series/player.aspx

For optimum performance, the minimum recommended computer specification is a Pentium III or equivalent (performance problems noted with Dell Optiplex GX240), 128MB of RAM, a monitor and video card capable of displaying 32-bit color at 800 × 600, and audio playback capability.

Technical notes

Should this program encounter any problems and quit unexpectedly, the Windows taskbar may be hidden from view. To restore the taskbar, re-launch the CD-ROM and choose the Quit option.

CD 2: COLONOSCOPY

Starting the program

On most computers, the CD-ROM will start automatically. If it does not, double-click the file Colonoscopy.exe to launch.

The CD-ROM will not install any files on your PC, but does require Windows Media Player 6.4 or better to play the video

content. If this is not installed on your system, you will need to install it. If you have Windows 95 or NT4 double-click on "mpfull.exe" and if you have Windows 98, 2000 or XP double-click "wmp7.exe". You may also download installers from the Microsoft Windows Media Player Web site:

http://www.microsoft.com/windows/windowsmedia/9series/player.aspx

The minimum computer specification is a Pentium PII (Pentium PIII recommended), with 64Mb RAM (128Mb recommended), an 8x CD-ROM drive and a monitor capable of displaying 16-bit colour (thousands) at 800 × 600.

The Endoscopy Unit and Staff

1

Most endoscopists, and especially beginners, focus on the individual procedures and have little appreciation of the extensive infrastructure that is now necessary for efficient and safe activity. Aging experts can remember practicing with one instrument, a makeshift room and, maybe, a passing nurse. Now many of us work in large units with multiple procedure rooms full of complex electronic equipment, with space dedicated to preparation, recovery and reporting, in collaboration with teams of specially trained nurses and support staff. Endoscopy has become a sophisticated industry. More and more units resemble operating room suites—but with a human touch. Endoscopists are also learning (often painfully) some of the imperatives of surgical practice, such as efficient scheduling, disinfection and safe sedation/anesthesia. Setting up and running an endoscopy unit is a complex topic with an expanding literature, of particular interest to directors and nurse managers.

Endoscopy is a team activity, requiring the collaborative talents of many people of different backgrounds and training. It is difficult to overstate the importance of an appropriate environment and professional support staff, in order to maintain patient comfort and safety, and to optimize clinical outcomes. Procedures are performed by many different types of doctor, including gastroenterologists, surgeons, internists (general physicians), some family practitioners and radiologists. Nowadays some procedures are performed by specially trained nurses. There are also many different types of supporting staff.

STAFF

Specially trained endoscopy nurses are essential.

They have many important functions, including to:

- prepare patients for their procedures, physically and mentally;
- set up all of the necessary equipment;
- assist the endoscopist during procedures;
- monitor patients' safety, sedation and recovery;
- clean, disinfect and process equipment;
- maintain quality control.

Technicians and nursing aides may contribute to these functions. Large units need a variety of other staff, to handle reception, transport, reporting and equipment management.

FACILITIES

The modern endoscopy unit has areas designed for many different functions. Like a hotel or airport (or Victorian household), the endoscopy unit should have a smart public face ('upstairs'), and a more functional back hall ('downstairs'). From the patient's perspective, endoscopy consists of areas devoted to reception, preparation, procedure, recovery and discharge. Supporting these activities are a series of other functions, which include scheduling, cleaning, preparation, maintenance and storage of equipment, reporting and archiving, and staff management.

Procedure rooms

These have certain key requirements. In general they should:
- not be cluttered or intimidating, because most patients are not sedated when they enter. The room should resemble a modern kitchen rather than an operating room.
- be large enough to allow a patient stretcher trolley to be rotated on its axis, and to accommodate all of the equipment and staff (and any emergency team), but also compact enough for efficient function.
- be laid out with the specific functions in mind, keeping nursing and doctor spheres of activity separate (Fig. 1.1), and minimizing exposed trailing electrical cables and pipes.

Each room should have:
- piped oxygen and suction (two lines);
- lighting that is focused for nursing activities, but not dazzling to the patient or endoscopist;

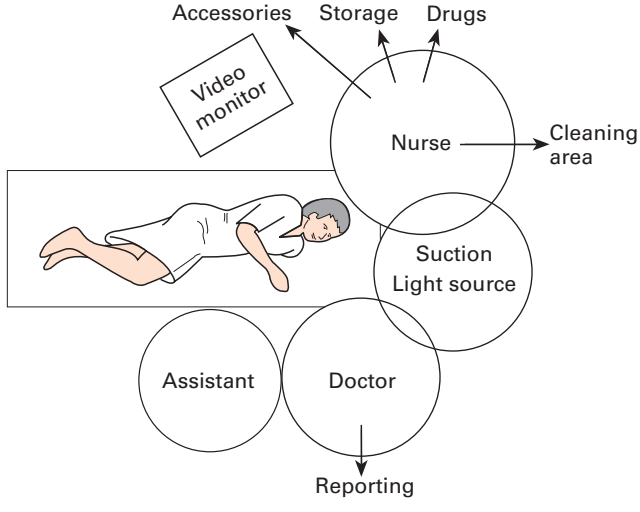

Fig. 1.1 Functional planning—spheres of activity.

• video monitors (for the endoscopy image and monitoring outputs) placed conveniently for the endoscopist and assistants;
• adequate counter space for accessories, and a large sink for dirty equipment;
• storage space for the equipment required on a daily basis;
• systems of communication with the charge nurse desk, and emergency call;
• disposal systems for hazardous materials.

Peri-procedure areas

The peri-procedure areas that patients encounter include:
• reception, and waiting for patients and accompanying persons.
• preparation (safety checking, consent, undressing, intravenous (IV) access).
• recovery. This should be separate from the preparation area—so that patients coming in are not mixed with those going out (for obvious reasons)—but adjacent for efficient nursing management.
• postprocedure interview and discharge. A private area must be available for sensitive consultations.

Staff areas

The endoscopy unit also has many support areas that patients do not see, including:
• a central focus workstation—this is needed in a unit of more than three endoscopy rooms; like the bridge of a ship, it is where the nurse captain of the day controls and steers the whole operation;
• endoscope storage, cleaning and disinfection;
• storage of all other equipment, including an emergency cart;
• medication storage;
• reporting;
• management office;
• staff belongings and refreshments.

MANAGEMENT AND BEHAVIOR

Such a complex organization requires efficient management and leadership. This works best as a collaborative exercise between the medical director of endoscopy, and the chief nurse or endoscopy nurse manager. They must be skilled in handling people (doctors, staff and patients), complex equipment and significant financial resources. They must develop and maintain good working relationships with many departments within the hospital (such as radiology, pathology, sterile processing, anesthesia, bioengineering), as well as numerous manufacturers

and vendors. They need to be fully cognizant of all of the many local and national regulations which now impact on endoscopy practice.

The wise endoscopist will embrace the team approach, and realize that maintaining an atmosphere of collegiality and mutual respect is essential for efficiency, job satisfaction and staff retention, and for optimal patient outcomes. Sadly, patients sometimes tend to be packaged as mere commodities during the endoscopy process. Treating our customers (and those who accompany them) with respect and courtesy is fundamental. Always assume that patients are listening, even if apparently sedated, so never chatter about irrelevances in their presence. Never eat or drink in patient areas. Background music is appreciated by many patients and staff.

DOCUMENTATION

Information for patients (such as explanatory brochures and maps) is discussed in Chapter 3 (see 'Patient preparation').

The agreed policies of the unit (including regulations dictated by the hospital and national organizations) are enshrined in an Endoscopy Unit Procedure Manual (Fig. 1.2). This must be easily available, constantly updated, and frequently consulted.

Day-to-day documentation includes details of staff and room usage, disinfection processes, instrument and accessory use and problems, as well as the procedure reports.

Procedure reports

Usually, two reports are generated for each procedure—one by the nurses, and one by the endoscopist.

Nurse's report

The nurse's report usually takes the form of a preprinted 'flow sheet', with places to record all of the preprocedure safety checks, vital signs, use of sedation/analgesia and other medications, monitoring of vital signs and patient responses, equipment and accessory usage, and image documentation. It concludes with a copy of the discharge instructions given to the patient.

Fig. 1.2 Endoscopy unit practices are collected in a procedure manual.

Endoscopist's report

The endoscopist's report includes the patient's demographics, reasons for the procedure (indications), specific medical risks and precautions, sedation/analgesia, findings, diagnostic specimens, treatments, conclusions, follow-up plans and any unplanned events (complications). Endoscopists use many re-

porting methods—handwritten notes, preprinted forms, free dictation and computer databases.

Eventually all of this documentation (nursing, administrative and endoscopic) will be incorporated in a comprehensive electronic management system. Such a system will substantially reduce the paperwork burden, and increase both efficiency and quality.

EDUCATIONAL RESOURCES

Endoscopy units should offer educational resources for all of its users, including patients, staff and doctors. Clinical staff need a selection of relevant books, atlases, key reprints and journals, and publications of professional societies. Increasingly, many of these materials are available on-line, so that easy internet access should be available. Many organizations produce useful educational videotapes and CD-ROMs and DVDs are increasingly available. In the future some of these tools will be linked directly with endoscopy reporting systems.

Computer simulators are becoming valuable training (and credentialing) tools. Teaching units will need to embrace that technology also.

Patients are also increasingly interested and well served with educational materials. Details are given in Chapter 8.

FURTHER READING

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2 Equipment

A BRIEF HISTORY

Some older gastroenterologists can remember when endoscopy consisted of rigid metal sigmoidoscopes and esophagoscopes (wielded by thoracic surgeons), and so-called 'semiflexible' gastroscopes. These were metal tubes with a somewhat flexible tip, providing limited views (and no tissue sampling), at considerable discomfort. They were used by only a few enthusiasts in the 1930s through the 1960s. Better gastric visualization was achieved with intragastric cameras, devised by the Japanese because of their focus on gastric cancer. The (British) description of image transmission around bends using fiber-optic bundles led quickly to the development of truly flexible gastroscopes in the USA and then Japan. These entered clinical practice in the mid-1960s. Their popularity was further stimulated by improved visualization, increased tip control, and by the development of a biopsy capability. The latter went some way to providing scientific legitimacy to a technique that was initially shunned by the academic world. Instruments were developed specifically for total upper endoscopy ('pan-endoscopy'), for colonoscopy, and then for duodenoscopy and enteroscopy. More details about the early days of colonoscopy are given in Chapter 6.

Subsequent refinement and the proliferation of therapeutic applications moved endoscopy into the mainstream of gastroenterology, and fueled its enormous expansion worldwide. It is ironic that many academic units in the USA, which initially derided endoscopy, are now largely supported by its financial fruits.

Another important technical breakthrough occurred in the 1980s, with the introduction of video-chip technology. Videoscopes allow the digital image to be displayed conveniently for the endoscopist (no longer poring over the eyepiece), and for the staff and trainees. Also, the image can be stored, processed, analyzed and transmitted anywhere.

Other revolutions are in process now. The transmitting wholly swallowed endoscopy capsule has arrived, and endoscopists are further encroaching on traditional surgical territory with the development of sewing devices. The marriage between endoscopy and computing will produce many more magical new tools. Computer simulation will dramatically change teaching and credentialing.

ENDOSCOPES

Although endoscopes now come in numerous varieties, sizes and applications, they have many common features. They have a control head with valves (buttons) for air insufflation and suction, a flexible shaft carrying the light guide and one or more service channels, and a maneuverable bending section at the tip. An umbilical 'connecting tube' joins the endoscope with the light source and processor, and supplies air and suction (Fig. 2.1). The image is transmitted via a fiber-optic bundle, or electronically from a charge-coupled device (CCD) chip.

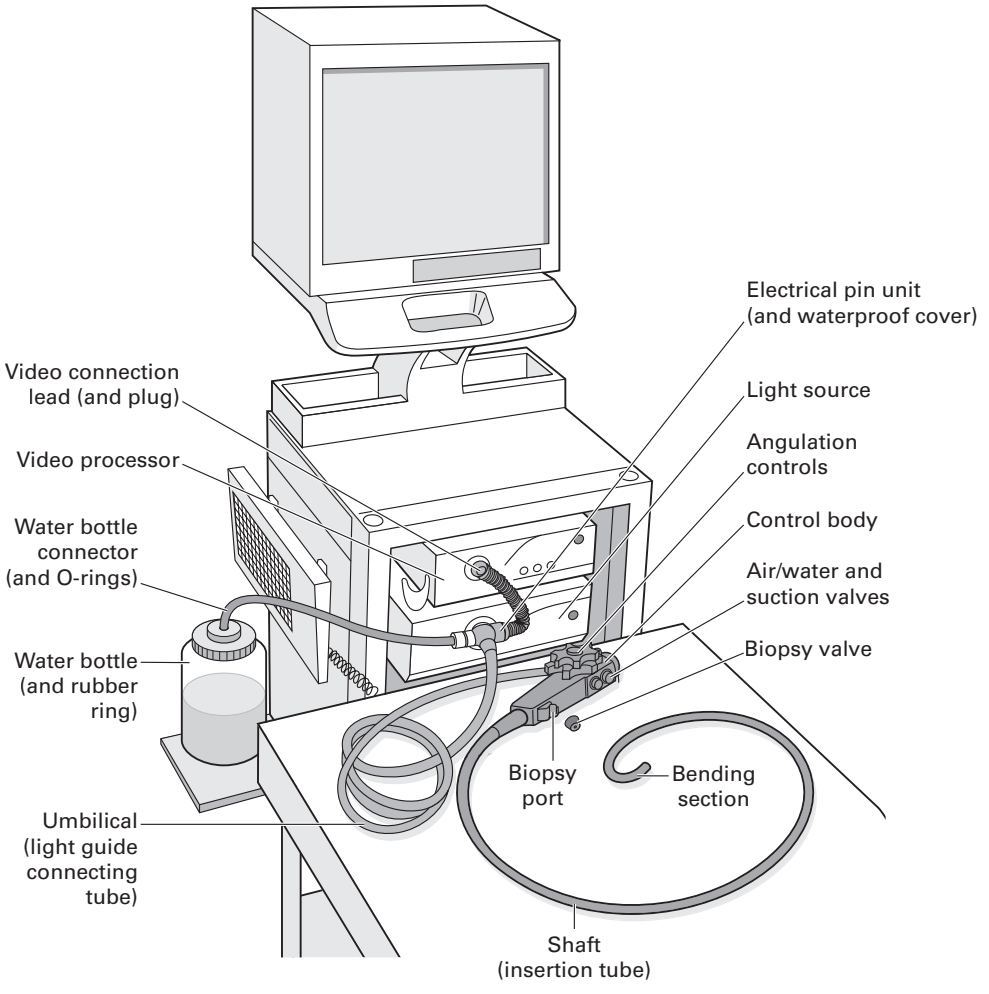

Fig. 2.1 Endoscope system.

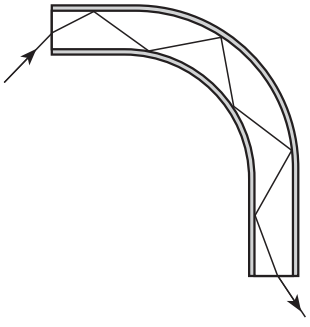

Fig. 2.2 Total internal reflection of light down a glass fiber.

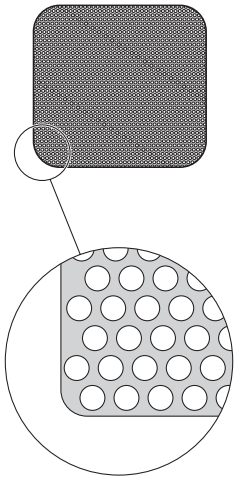

Fig. 2.3 Fiber bundle showing the 'packing fraction' or dead space between fibers.

Fiberscopes

Fiberscopes use optical viewing bundles that contain thousands of fine glass fibers. Light impacting the face of each fiber is transmitted by repeated internal reflections (Fig. 2.2). Faithful transmission of an image depends upon the spatial orientation of the individual fibers being the same at both ends of the bundle (a 'coherent' bundle). Each individual glass fiber is coated with glass of a lower optical density to prevent leakage of light from within the fiber, since the coating does not transmit light. This coating (Fig. 2.2) and the space between the fibers causes a dark 'packing fraction', which is responsible for the fine mesh frequently apparent in the fiber-optic image (Fig. 2.3). For this reason, the image quality of a fiber-optic bundle, though excellent, can never equal that of a rigid lens system.

Video-endoscopes

These are mechanically similar to fiberscopes, but the image is captured with a CCD chip, transmitted electronically, and displayed on a video monitor. Viewing through a monitor has several advantages. The endoscopist does not have to keep his neck bent down to the eyepiece (which can result in 'endoscopist's neck'), and peripheral vision is maintained to appreciate other activities in the room. Other people in the room (including the patient) can watch the video display, and the assistants are more involved in the procedure. Keeping the endoscopist's face away from the biopsy/suction port also reduces the risk of splash contamination.

Individual photo cells (pixels) in the CCD chips can respond only to degrees of light and dark. Color appreciation is arranged by two methods. So-called 'color CCDs' have their pixels arranged under a series of color filter stripes (Fig. 2.4). By contrast,

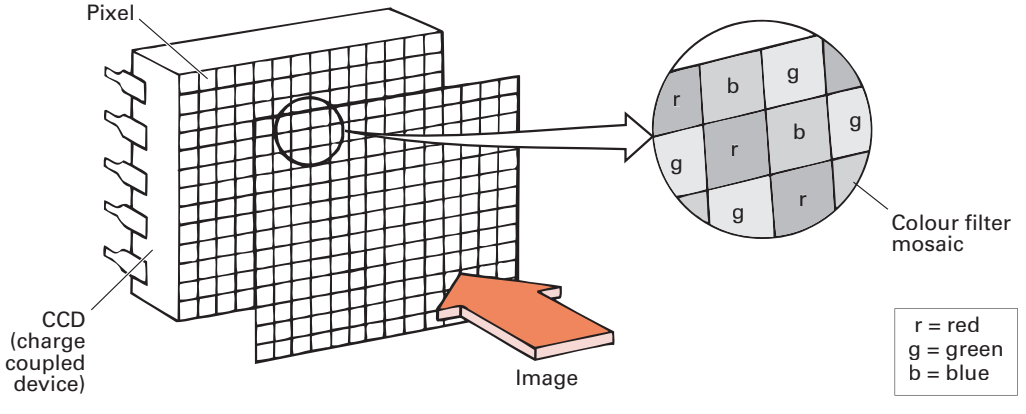

Fig. 2.4 Static red, green and blue filters in the 'color' chip.

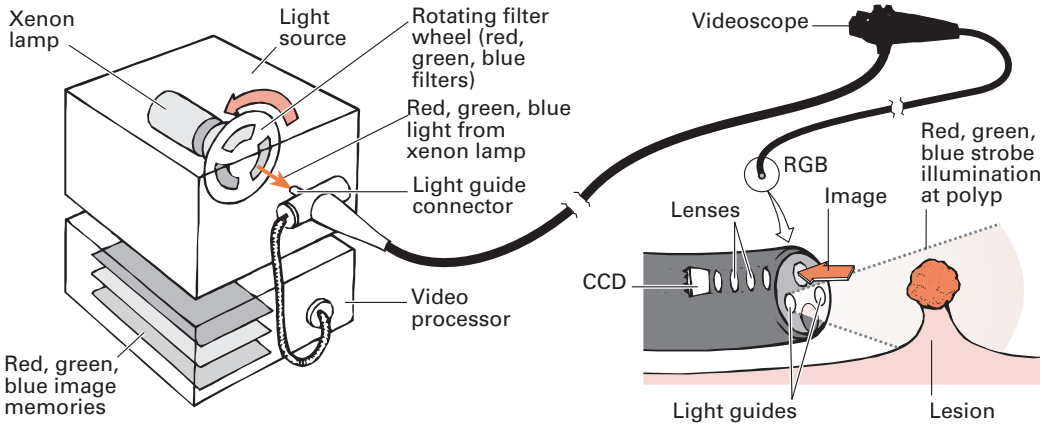

Fig. 2.5 Sequential color illumination.

'black and white CCDs' (or, more correctly, sequential system CCDs) use a rotating color filter wheel to illuminate all of the pixels with primary color strobe-effect lighting (Fig. 2.5). This type of chip can be made smaller, or can give higher resolution, but the system is more expensive because of the additional mechanics and image-processing technology.

Illumination is provided from an external high-intensity source through one or more light-carrying fiber bundles.

Tip control

The distal bending section (10 cm or so) tip of the endoscope is fully deflectable, usually in both planes, up to 180°. Control depends upon pull wires attached at the tip just beneath its outer protective sheath, and passing back through the length of the instrument shaft to the two angulation control wheels (for up/down and right/left movement) on the control head (Fig. 2.6). The wheels incorporate a friction breaking system, so that the tip can be fixed temporarily in any desired position. The instrument shaft is torque stable, so that rotating movements applied to the head are transmitted to the tip—when the shaft is relatively straight. Mechanical angulation controls may soon be replaced by electronic devices.

Instrument channels and valves

The internal anatomy of endoscopes is complex (Fig. 2.7). The shaft incorporates an 'instrumentation' channel extending from the entry 'biopsy port' to the tip of the instrument. Channel sizes vary from about 1 to 5 mm (but usually about 3 mm) depending upon the purpose for which the endoscope was designed (from neonatal examinations to major therapeutic procedures). In

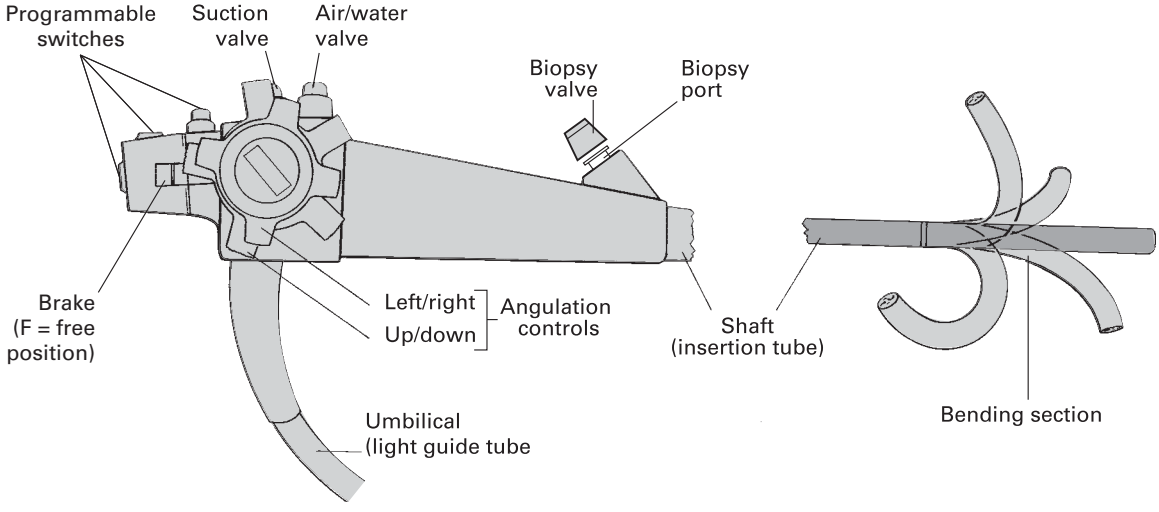

Fig. 2.6 Basic design—control head and bending section.

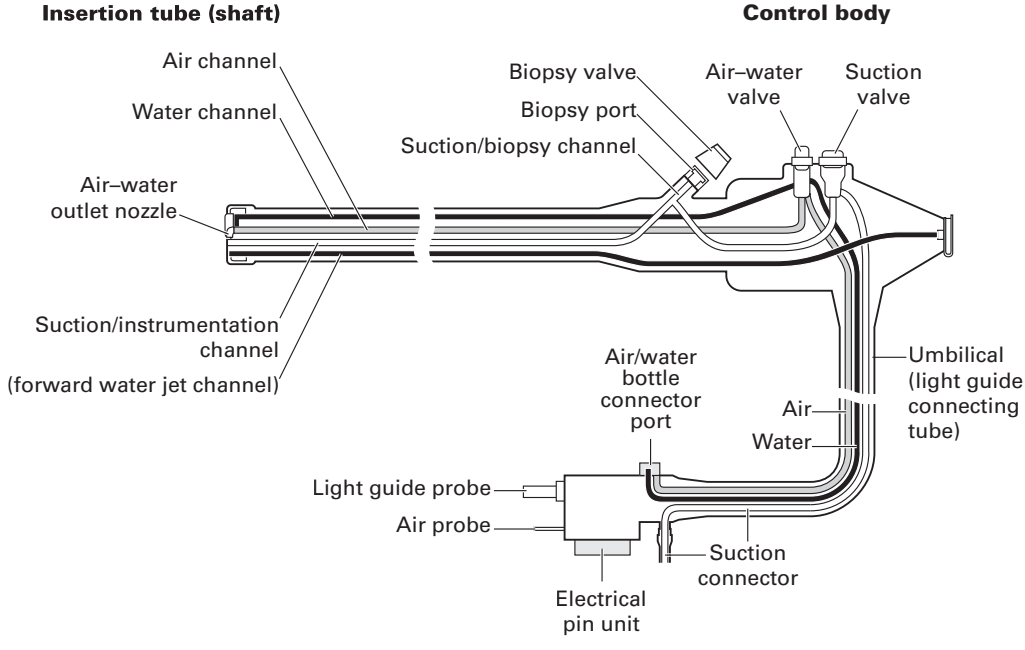

Fig. 2.7 The internal anatomy of a typical endoscope.

some instruments, especially those with lateral-viewing optics, the tip of the channel incorporates a deflectable elevator or bridge (Fig. 2.8), which permits directional control of forceps and other accessories independent of the instrument tip; this elevator is controlled by a further thumb lever. The operating channel is used also for aspirating secretions; an external suction pump is

connected to the 'umbilical' of the instrument near to the light source, and suction is diverted into the instrument channel by pressing the suction valve. Another small channel allows passage of air to distend the organ being examined; the air is supplied from a pump in the light source and is controlled by another valve. The air system also pressurizes the water bottle, so that a jet of water can be squirted across the distal lens to clean it.

Different instruments

The endoscopy unit must have a selection of endoscopes for specific applications. They may differ in length, size, stiffness, channel size and number, sophistication and distal lens orientation. Most endoscopies are performed with instruments providing *direct forward vision*, via a wide-angle lens (up to 130°) (Fig. 2.9). However, there are circumstances in which it is preferable to view *laterally*—particularly for ERCP (Fig. 2.8). Oblique and even movable-lens instruments have been developed, but are no longer popular.

The overall diameter of an endoscope is a compromise between engineering ideals and patient tolerance. The shaft must contain and protect many bundles, wires and tubes, all of which are stronger and more efficient when larger (Fig. 2.7). A colonoscope can reasonably approach 15 mm in diameter, but this size is acceptable in the upper gut only for specialized therapeutic instruments.

Routine upper endoscopy is mostly performed with instruments of 8–11 mm diameter. Smaller endoscopes are available; they are better tolerated by all patients and have specific application in children. Some can be passed through the nose rather than the mouth. However, smaller instruments inevitably involve some compromise in durability, image quality, maneuverability, biopsy size, and therapeutic potential.

Several companies now produce a full range of endoscopes at comparable prices. However, light sources and processors produced by different companies are not interchangeable, so that most endoscopy units concentrate for convenience on equipment from a single manufacturer. Endoscopes are delicate, and some breakages are inevitable. Careful maintenance and close communication, repair and back-up arrangements with an efficient company are necessary to maintain an endoscopy service. The quality of the support is often a crucial factor affecting the choice of manufacturer.

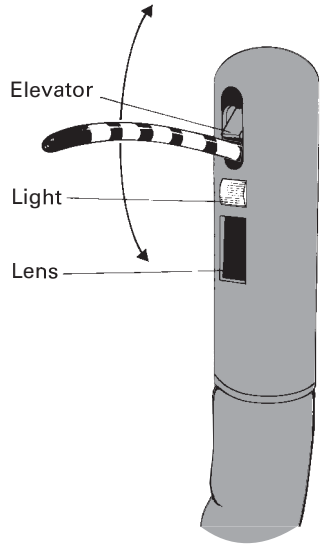

Fig. 2.8 A side-viewer with a deflectable elevator.

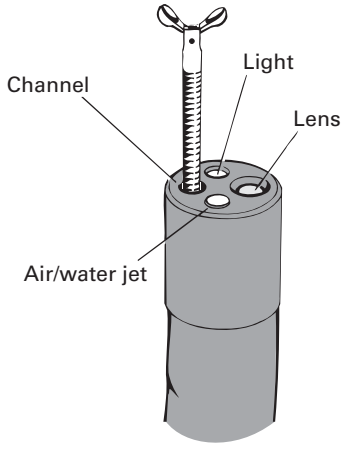

Fig. 2.9 The tip of a forward-viewing endoscope.

ENDOSCOPIC ACCESSORIES

Many devices can be passed through the endoscope channel for diagnostic and therapeutic purposes.

Biopsy forceps consist of a pair of sharpened cups (Fig. 2.10), a spiral metal cable, a pull wire, and a control handle (Fig. 2.11).

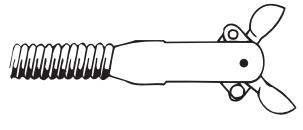

Fig. 2.10 Biopsy cups open.