Colonoscopy and Flexible Sigmoidoscopy

Flexible colonoscopy started, improbably, in 1958 in Japan with Matsunaga's intracolonic use of the gastrocamera under fluoroscopic control, and subsequently Niwa's development of the 'sigmocamera'. Not surprisingly, these had application only in the hands of pioneer enthusiasts. Following the development of the fibreoptic bundle, similar determination by Provenzale and Revignas in Italy and Fox in the UK allowed imaging of the proximal colon after pulling it up using a swallowed guide string or pulley system. Overholt in the USA introduced the 'fiberoptic coloscope' in 1966, but its limited angulation and angle of view again restricted the technique to a few hardy spirits. The West was surprised by the production in 1969 by Japanese engineers (Olympus Optical and Machida) of remarkably effective colonic instruments combining the well-developed and torque-stable mechanics of a gastrocamera with superior fibreoptics. These were easy to handle and gave excellent views, although initial limitations of glass-fibre technology and fragile fibres restricted angulation to around 90° and angle of view to 70°. Very rapid developments in both Japan and the USA brought the four-way acutely angling instruments with near 'fish-eye' vision to which we are now accustomed, further enhanced by the introduction in the USA in 1983 of the video-endoscope (Welch-Allyn). Although small-scale colonoscopy production continues in Germany, Russia and China, the combined mechanical, optical and electronic know-how of Japanese manufacturers now dominates the market.

Description in Japanese abstracts of intragastric snare polypectomy in 1970 was followed by its performance in the colon in 1971 by Deyhle in Europe and Shinya in the USA. This set the seal on the emergence of colonoscopy as a powerful technique, set to leapfrog barium-contrast technology as the method of choice for intracolonic diagnosis and, with emerging scanning techniques, largely to replace 'diagnostic laparotomy'. Further refinements of handling technique and instrument technology over the years have substantially transformed colonoscopy from an aggressive and somewhat hazardous experience into a socially acceptable and sophisticated methodology. Its unavoidably intrusive nature and the varied mechanical constraints of the individual colon are limiting factors; overcoming these as far as possible is the current challenge to the flexible endoscopist.

**Indications, limitations and complications**

The exact place of colonoscopy in clinical practice is outside the scope of this book and depends on local circumstances and available endoscopic expertise. Clinical judgement or financial considerations may sometimes determine that flexible sigmoidoscopy alone (limited colonoscopy with limited bowel preparation) is sufficient for the particular clinical purpose. Thus flexible sigmoidoscopy is, on grounds of logistics, safety and patient acceptability, being considered for population screening, whereas total colonoscopy is more appropriate for those at increased risk for colorectal cancer or requiring symptomatic evaluation.

A double-contrast barium enema (DCBE) remains a safe way (one perforation per 25,000 examinations) of showing the configuration of the colon, the presence of diverticular disease and the absence of strictures or large lesions in patients with pain, altered bowel habit or constipation; it also shows extramural leaks or fistulae which are invisible to the endoscopist. However, the limitations of even a high-quality DCBE are well known, and include the ability to miss large lesions because of overlapping loops, to misinterpret between solid stool and neoplasms or between spasm and strictures, with particular inaccuracy for flat lesions such as angiodysplasias or minor inflammatory change and small (2–5 mm) polyps. Single-contrast barium enemas, in particular, have been dismissed as 'a good way to diagnose inoperable cancer', although perversely it is often on the barium-filled segments of a DCBE examination that filling defects are best demonstrated.
However, colonoscopy too has its limitations — failure of proper examination due to failed bowel preparation or an inability to reach the caecum being obvious ones. The lack of definite landmarks, unless the ileocaecal valve is reached and identified, means that gross errors in localization are possible during the insertion of the colonoscope in up to 30% of cases, even for expert endoscopists. Although it is justifiable to consider colonoscopy by an expert endoscopist as the gold standard, any colonoscopist needs to be aware of the potential for blind spots where it is possible to miss very large lesions, especially in the caecum, just around acute bends and in the rectal ampulla. The accuracy for small lesions is probably better than 90% but it is not 100%. The notion of routinely having a prior barium enema 'to show the shape of the colon' is irrelevant to the endoscopist, since short colons with short mesenteries can be difficult and painful to endoscope, whereas some very long colons prove to be painless and easy. Nonetheless, if a contrast examination has previously been performed, the presence of severe diverticular disease or a very redundant colon (a transverse colon which droops down to the pelvic brim in the erect film is particularly discriminant) increase the likelihood that the procedure will be demanding.

The complication rate of colonoscopy is higher (around one perforation per 1700 examinations in published series overall). All colonoscopy complication series to date include early experience with outdated instruments and are certainly too pessimistic. There has been no significant complication during diagnostic examinations in our experience, or that of others performing colonoscopies at St Mark's Hospital, during the past 20 000 examinations. However, this is the experience of a specialist hospital and, whilst showing the potential for the technique, is not representative of what may be happening in the hands of unskilled endoscopists needing to use heavy sedation to cover up for their ineptitude. Any endoscopist performing therapeutic procedures such as dilatations or polypectomies will inevitably experience complications, although these are remarkably infrequent. Fatalities have, however, been reported after oversedation or due to mismanaged colonoscopic perforation. The endoscopist should therefore be on guard that problems can occur and should work with the knowledge and co-operation of a backup surgical team.

Colonoscopy achieves more than contrast radiology, partly in greater accuracy and also through its biopsy and therapeutic capabilities. Because of its colour view and biopsy capability, colonoscopy is particularly relevant to patients with bleeding, anaemia, bowel frequency or diarrhoea and, because of pinpoint accuracy and therapy, to any patient at risk for cancer — in whom detection and removal of any adenomas is important for the patient's future. Colonoscopy is thus the method of choice for most clinical patients and for cancer surveillance examinations and follow-up. The proviso must be added that a few patients who are very difficult to colonoscopy for reasons of anatomy or postoperative adhesions may be best examined by combining limited left-sided colonoscopy (much more accurate than DCBE in the sigmoid colon) with a barium enema to demonstrate the proximal colon, which can be arranged at the same visit and with the same bowel preparation. Particularly if carbon dioxide (CO\(_2\)) insufflation is used during the endoscopy, the colon will be absolutely deflated within 10–15 min and the DCBE can follow immediately. Even after air insufflation, some radiologists report satisfactory DCBE although the proximal colon can be air-filled and difficult to coat adequately with barium. Colonoscopic biopsies with standard-sized forceps are no contraindication to performing a DCBE and prior hot-biopsy or pedunculated polypectomy should not be either; whereas larger biopsies or sessile polypectomy contraindicate the distension pressure required for DCBE.

Limited examination by flexible sigmoidoscopy or left-sided colonoscopy may, therefore, have a significant role in clinically selected patients with minor symptoms such as left iliac fossa pain or spotting on toilet paper. DCBE alone may be considered by some to be adequate in 'low-yield' patients with constipation or minor functional symptoms where the result is expected to be normal or to show minor diverticular disease. Endoscopy is particularly useful in the postoperative patient, either to
inspect in close-up (and biopsy if necessary) any deformity at the anastomosis or to avoid the difficulties of barium or air leakage that a stoma presents for the radiologist.

**Contraindications and infective hazards**

Against this clinical background, there are few patients in whom colonoscopy is contraindicated. Any patient who might otherwise come to diagnostic laparotomy because of colonic disease is fit for colonoscopy, and colonoscopy is often undertaken in very poor risk cases in the hope of avoiding surgery. For a 3-week period after myocardial infarction, it is unwise to perform colonoscopy due to the risk of dysrhythmias. There is no contraindication to colonoscopy (without fluoroscopy) during pregnancy, although, on common-sense grounds, it may be best avoided in those with a history of miscarriage. In any acute and severe inflammatory process, such as ulcerative, Crohn’s or ischaemic colitis, where abdominal tenderness suggests an increased risk of perforation, colonoscopy should only be undertaken with good reason and extreme care. If large and deep ulcers are seen, the bowel wall may be weakened and it may be wise to limit or abandon the examination. In the chronic stage of irradiation colitis, a year or more after exposure, the bowel can be perforated even without excessive force; if the diagnosis has been made, and insertion proves difficult, it may be wiser to withdraw.

*Colonoscopy is absolutely contraindicated* in acute diverticulitis which is due to local sepsis and threatened perforation. It should not be performed in any patient with marked abdominal tenderness, peritonism or peritonitis from whatever cause because of the high risk of causing perforation.

Possible septicaemia or infectivity are a consideration in certain patients. Passage of the colonoscope, and indeed any other agent including air or barium insufflation, causes transient release of bowel organisms into the bloodstream and peritoneal cavity. This constitutes a relative contraindication to endoscopy of patients with known ascites or on peritoneal dialysis. They, and patients with heart-valve replacements, and also marasmic infants or immunosuppressed or immunodepressed adults, should be protected by the prior administration of antibiotics (see p. 34). There is no contraindication to the examination of infected patients (e.g. patients with infectious diarrhoea or hepatitis) since all normal organisms and viruses will be inactivated by routine cleaning and disinfection procedures including a 4 min soak and channel perfusion with 2% glutaraldehyde. Mycobacterial spores, however, require a much longer period and, therefore, after the examination of suspected tuberculosis patients and before and after the examination of AIDS patients who are susceptible to, and possible carriers of, mycobacteria, a 60 min soak of the instrument in glutaraldehyde is recommended (see Chapter 3).

**Patient preparation**

Most patients can organize their bowel preparation at home, present themselves for examination and walk out shortly afterwards. Management routines depend on national, organizational and individual factors. In some countries (the USA, France, Italy, Germany) patients are prepared to administer their own cleansing enemas; in others this has to be done by the endoscopy nursing staff. Some nationalities (Dutch, German, Japanese) do not expect sedation whereas others (British, American) frequently insist on it. Management is influenced, amongst other things, by cost, the type of bowel preparation and sedation used, the age and state of the patient, the potential for major therapeutic procedures and the availability of adequate facilities and nursing staff for day-care and recovery. Experienced colonoscopists in private practice and large units are motivated to organize streamlined day-case routines, even for patients with large polyps. These variables result in an extraordinary spectrum of performance, from the many skilled colonoscopists who require patients for less than an hour in an office or day-care unit, to others with less experience and a traditional hospital background who feel
that hours, or even days, in hospital are essential.

Colonoscopy can be made quick and easy; this requires both a reasonably planned day-care facility and an endoscopist with the confidence and skill to work gently and fast. A few patients are better admitted before or after the procedure; the very old, sick and very constipated may need professional supervision during bowel preparation, and frail patients may merit overnight observation afterwards, especially if their domestic circumstances are not supportive or they live far away. We admit a few patients with large polyps, especially if the lesion is broad-stalked or sessile, or if the patient has a bleeding diathesis or is on anticoagulants or antiplatelet medications (aspirin, dipyridamole, etc.). However, even such patients, providing they live near good medical support services and are fully informed as to what to do in a crisis, can often be justifiably managed on an out-patient basis.

## Bowel preparation

Failures of bowel preparation occur mainly in older patients with diverticular disease and those with colons damaged by colitis. Constipated patients should be primed with senna at bedtime for several nights preceding the normal preparation regimen. Really stubborn constipation, as in cases of megacolon or cystic fibrosis, can be cleared by hourly doses of magnesium sulphate crystals (Epsom salts, 15–30 g) with large volumes of clear fluid, but since this and the subsequent colonoscopy are likely to be unpleasant for all concerned, the experience should be avoided if at all possible (unprepared barium enema is sometimes sufficient to show the pathological colon configuration).

## Limited preparation

For limited colonoscopy or flexible sigmoidoscopy in the 'normal' colon, limited preparation should be enough. The patient need not diet and simply has one or two disposable phosphate enemas (e.g. Fleet's Phospho-soda, Fletchers') 20–30 min beforehand. Examination is performed shortly afterwards so that there is no time for proximal bowel contents to descend. The colon is often perfectly prepared to the transverse or hepatic flexure, especially in young patients (except babies, in whom phosphate enemas are contraindicated). Note that patients with any tendency to faint or with functional bowel symptoms (pain, flatulence, etc.) are more likely to have severe vasovagal problems after phosphate enemas; make sure they are supervised or have a call button and that lavatory doors open from and to the outside in case the patient faints against the door. Diverticular disease or stricturing makes preparation more difficult and phosphate enemas are less likely to work for mechanical reasons; if a good view is important (as for apparent stricturing or possible malignancy) we normally recommend full bowel preparation even for a limited examination. If there is a serious possibility of obstruction, per oral preparation is dangerous, even potentially fatal, and in ileus or pseudo-obstruction normal preparation simply does not work; one or more large-volume enemas are administered in such circumstances (up to 1 litre or more can be held by most colons). A contact laxative such as oxyphenisatin (300 mg) or a dose of bisacodyl can be added to the enema to improve evacuation (see below).

For reasons of institutional convenience or patient compliance, it is sometimes found that a dose of oral laxative is a more convenient approach, for instance taken at home late at night to act in the morning before coming for an early flexible sigmoidoscopy appointment.

## Full preparation

The object of full preparation is to cleanse the whole colon, especially the proximal parts, which are characteristically coated with surface residue after limited regimens. However, patients and colons vary.
No single preparation regimen predictably suits every patient and it is often necessary to be prepared to adapt to individual needs. Constipated patients need extra preparation; those with severe colitis may be unfit to have anything other than a warm saline enema. A preparation which has previously proved unpalatable, made the patient vomit or failed is unlikely to be a success on another occasion. The doctor, nurse or secretary, should talk to the patient to find out about their normal bowel habit (loose or constipated, laxative requirements, results of previous purgatives, etc.) and to explain the need for special diets and purgation. Minutes spent in explanation and motivation may prevent a prolonged, unpleasant and inaccurate examination due to bad preparation. For most people without prior experience of it, anticipation of the indignity, possible pain and/or dreaded result of colonoscopy are much worse than the procedure itself usually turns out to be. Anything which will justifiably cheer them up, as well as motivate them for the period of dietary modification and bowel preparation, is extremely worthwhile.

**Diet**

Iron preparations should be stopped 3–4 days before colonoscopy, since organic iron tannates produce an inky black viscid stool which interferes with inspection and is difficult to clear. Constipating agents should also be stopped 1–2 days before, but most other medication can be continued as usual, allowing for modification of anticoagulant regimens and the avoidance of aspirin, non-steroidal anti-inflammatory drugs (NSAIDs) and similar platelet-inhibiting agents, if possible, in those of polyp-bearing age. The patient should have no indigestible or high-residue food (including muesli, fibrous vegetables, mushrooms, fruit, nuts, raisins, etc.) for 24 h before colonoscopy; staying for 24 h on clear fluids is even better if the patient is compliant. Fruit juices or beer may be easier to drink in large quantities than water, and white wine or spirits can also help morale — especially in the fasting phase. Red wine in any quantity can, with tannates, darken the bowel contents and is best avoided. Written instructions are well worthwhile; many patients, anxious to get a good result, find it easier to follow specific instructions and it helps avoid unnecessary telephone calls.

**Oral lavage regimens**

Oral lavage regimens have supplanted the traditional purge plus enema approach in most practices because they are more effective and cause no pain. On the other hand, some patients will not or cannot drink the 3–4-litre volumes of fluid required, experience uncomfortable distension, become nauseated or vomit, or simply dislike the taste of the chosen solution. Further work is needed to provide the ideal compromise — a powder which can be sent through the post and dissolved to produce an acceptable volume of a pleasant-tasting combination of non-absorbed solutes and electrolytes, and perhaps also containing a physiological gut activator and/or a prokinetic agent to speed transit.

**Balanced electrolyte solution.**

A balanced electrolyte solution, including the requisite amount of potassium chloride (KCl) and bicarbonate to avoid body losses, is physiologically correct, although unfortunately the taste of the additives (especially KCl and NaSO₄) is unpleasant. Normal (0.9%) saline is used by some centres, which has the advantage of being very cheap and easy to make up or post, but less physiological than balanced electrolyte solutions.

**Balanced electrolyte solution with polyethylene glycol solution (PEG).**

Polyethylene glycol solution, also simply called PEG or PEG/electrolyte mixture (GoLytely, Nulytely, Colyte, etc.), is widely used, primarily because it has formal (Food and Drug Administration) approval
allowing commercial flavouring and packaging and easy prescription by doctors. Although often known as PEG preparation, the PEG component of a PEG/electrolyte mixture contributes only a minority of osmolality (but the majority of the packaged weight and volume) — sodium salts unfortunately being, of physiological necessity, the important component. Even chilled, its taste is mildly unpleasant due to the addition of NaSO$_4$, bicarbonate and KCl to minimize body fluxes. Modification of the original formula (Nulytely), lowering the sodium content by omitting NaSO$_4$ and reducing KCl, only slightly improves the taste. Patient acceptance of electrolyte/PEG oral preparation can be enhanced, without impairing results from the endoscopist's point of view, by the simple expedient of administering the 3–4 litres necessary in two half doses ('split administration', with 2 litres drunk the evening before and 1–2 litres on the morning of the examination). There are conflicting reports about whether adding prokinetic agents or aperients contributes anything, and the consensus is that they do not.

Mannitol.

Mannitol (and similarly sorbitol or lactulose) is a sugar for which the body has no absorptive enzymes. In solution it presents an iso-osmotic fluid load at 5% (2–3 litres) or a hypertonic purge at 10% (1 litre) with a corresponding loss of electrolyte and body fluid during the resulting diarrhoea, although this is only of concern in the elderly and normally can be rapidly reversed by drinking. The solution tastes very sweet and can be nauseous to those without a sweet tooth, although this can be much reduced by chilling and adding lemon juice or other flavourings. Children, in particular, tend to vomit it back. Mannitol alone (1 litre drunk iced over 30 min, followed by 1 litre of tap water) is a very useful way of achieving rapid bowel preparation (2–3 h) for those requiring urgent colonoscopy.

There is a potential explosion hazard because colonic bacteria possess the necessary enzymes to metabolize mannitol and other carbohydrates to form explosive quantities of hydrogen. If they have been used in preparation any electrosurgical or laser procedure is hazardous unless CO$_2$ insufflation has been used, or alternatively all colonic gas is conscientiously several times exchanged by aspiration and re-insufflation of room air.

Picolax.

Picolax, a proprietary combination, produces both magnesium citrate (from magnesium oxide and citric acid) and bisacodyl (from bacterial action on sodium picosulphate), tastes acceptable and works well in most patients. Providing enough fluid is drunk, no enema is needed.

Sodium phosphate.

This, presented as a flavoured half-strength orally administered equivalent of the phosphate enema (Fleet's Phospho-soda), has received numerous good reports recently. It is considered to be as effective as PEG/electrolyte solution but significantly more acceptable to patients. This is principally because the volume which needs to be ingested is only 90 ml, followed by at least 1 litre of other clear fluids of choice (water, juices, lager, etc.).

Administration of oral lavage

Low-residue diet instructions will have been given. The patient should be advised to use, and preferably supplied with, petroleum jelly or barrier cream (colourless if possible to avoid lens contamination) to avoid perianal soreness. As mentioned above, large-volume PEG/electrolyte solutions are ideally split-administered in two doses, starting on the evening beforehand with the residue on the morning of the examination. If an afternoon examination is scheduled, and the patient does not have a long distance to
travel, both doses can be drunk on the day of examination; if in doubt, a purgative (such as senna, 4–6 tablets) can be also be taken at the previous bedtime. The PEG/electrolyte solution should be drunk steadily at a rate of around 1.5 litres/h (250 ml/10 min initially). Chilling mannitol solution makes it taste much less sweet; cooling PEG/electrolyte solution also improves palatability but may overcool the drinker too. Adding sugar-containing flavouring agents, such as fruit cordials, to PEG/electrolyte solution is discouraged on the basis that increased sodium absorption could occur. Sodium phosphate solution is easily downed with a 'chaser' of some more pleasant drink and then 1 litre or more of fluid to follow in the next hour or two.

The patient should be encouraged to carry on with normal activities during the drinking period, rather than sitting still, in order to encourage transit, but should stop drinking temporarily if nausea or uncomfortable distension occur. Bowel actions should start within about an hour, returns are often clear by 2–3 h and colonoscopy can sometimes be started 1–2 h later. The endoscopist may have to aspirate large quantities of fluid during the examination but the patient is spared the dietary changes, cramps and enemas of a purge regimen and the result is usually excellent.

**Purgation and enemas**

Sufficient contact laxative or purgative must be taken to produce fluid diarrhoea, which shows that unaltered small intestinal contents are emerging and the colonic residue has been cleared. A large dose is given to ensure this but, as the response is individual rather than dose-related, there is no danger. Nonetheless, any agent producing diarrhoea may also cause nausea or abdominal cramps in some patients. It takes only about 8 h for colonic water absorption to reform ileal effluent into solid stool so that, ideally, administration should be judged to cause the diarrhoea to stop only shortly before examination. However, since some people respond to laxatives in 1–2 h and colleagues take as much as 8–10 h, exact timing is difficult. If the patient is to get some sleep and then be able to travel without risk of accident, the best compromise is for the laxative to be taken at 3–5 p.m. on the previous afternoon. For a mid-afternoon colonoscopy, the purge can be taken early the same morning or, alternatively, at bedtime in the expectation that there will be no action until the gut reactivates in the morning.

**Purges.**

Castor oil (30–40 ml) acts on both the small and large intestine, but is disliked by most patients. Its after-taste and oily texture can be masked by mixing it with orange juice or an effervescent drink immediately before drinking, and following with a 'chaser' of orange juice. Senna preparations work equally well providing a large dose is given (140 mg of sennosides), preferably as syrup or granules. Osmotic purges such as magnesium salts (citrate tastes better than sulphate or hydroxide) can also be effective with repeated 1- or 2-hourly doses and high fluid intake until clear diarrhoea results.

**Enemas.**

Enemas, whether tap water, isotonic saline or purgative (bisacodyl or oxyphenisatin) are self- or nurse-administered 1–2 h before the examination until the returns are clear. Two or three enemas, each of 1–2 litres, may be needed. The fluid should reach the caecum; lavage or 'washouts' of the social variety, where small volumes of water are run in and out of the distal colon, are useless. Having got the fluid in it must also be got out, which entails the patient being able to sit relaxed on the lavatory for 15–20 min initially and then to revisit and evacuate at will afterwards. The returns are inspected and, if any solid matter remains, the enema is repeated. Patients with diverticular disease or painful spasm-obstructing enema inflow are given an intramuscular antispasmodic injection (hyoscine N-butylbromide 40 mg i.m.; Glucagon 0.5 mg i.m.).
Bowel preparation in special circumstances

Children

Paediatric patients accept pleasant-tasting oral preparations such as senna syrup or magnesium citrate very well. Drinking large volumes is less well accepted and mannitol may cause nausea or vomiting. The childhood colon normally evacuates easily except, paradoxically, in colitis patients who prove perversely difficult to prepare properly. Small babies may be almost completely prepared with oral fluids plus a saline enema (see p. 267). Phosphate enemas are contraindicated in babies because of the possibility of hyperphosphataemia.

Colitis patients

These patients require special care, during and after preparation. Relapses of inflammatory bowel disease are said occasionally to occur after over-vigorous bowel preparation, although they can also be provoked by simple distension during an unprepared barium enema, which perhaps suggests that the cause is mechanical rather than chemical. Magnesium citrate, senna preparations, mannitol, saline or balanced PEG/electrolyte solutions are all generally well tolerated, and the latter is favoured in patients with diarrhoea from active colitis. A simple tap-water or saline enema will clear the distal colon sufficiently for limited colonoscopy. Patients with severe colitis are unlikely to need colonoscopy at all, since plain abdominal X-ray or an unprepared barium enema will usually give enough information; for severely ill patients even a barium enema is risky and colonoscopy positively contraindicated due to the potential for perforation. When the indication for colonoscopy in a patient with colitis is to exclude cancer or to reach the terminal ileum to help in differential diagnosis, full and vigorous preparation is necessary. A patient fit enough for total colonoscopy is fit for full bowel preparation, which is essential because inflammatory change often makes the proximal colon difficult to prepare properly.

Constipated patients

Patients with constipation may, for obvious reasons, need extra bowel preparation. This is very difficult to achieve in patients with megacolon, Hirschsprung's disease, cystic fibrosis, etc., in whom colonoscopy should be avoided if at all possible. Constipated patients should continue any habitually-taken purgatives in addition to the colonoscopy preparation, and preferably in large doses for several days beforehand. The principle is to achieve regular soft bowel actions during the days before taking the main purge, if necessary using additional doses of paraffin emulsion, magnesium citrate/sulphate, etc. Larger than standard doses of senna or other purgatives are unlikely to produce any extra effect, but frequent doses of magnesium salts and large volumes of fluid are guaranteed to move mountains (see above), providing there is no obstruction.

Colostomy patients

The colons of colostomy patients are as difficult to prepare as those of normal subjects (and often more so). The preparation regimen should not be reduced just because the colon is shorter; if anything it should be increased, with a prior 'pump-priming' maximal dose of senna on the night before. Oral preparation with one of the lavage regimens described above is well tolerated, whereas enemas/colostomy washouts are tedious and difficult to perform satisfactorily, unless the patient is accustomed to this and used to performing it personally.

Stomas, pouches and ileorectal anastomoses

These present few problems. Ileostomies are self-emptying and normally need no preparation other than
perhaps a few hours of fasting and clear fluid intake. Kock or ileoanal pelvic pouches can be managed either by saline enema or by oral lavage. After ileorectal anastomosis, the small intestine can adapt and enlarge to an amazing degree within some months of surgery, so that if the object of the examination is to examine the small intestine, full oral preparation should be given. For a limited look, a saline or tap-water enema is usually enough.

Defunctioned bowel

A defunctioned bowel, for instance the distal loop of a 'double-barrelled' colostomy, always contains a considerable amount of viscid mucus and inspissated cell debris which will block the colonoscope. Conventional tap-water/saline rectal enemas or tube lavage through the colostomy are needed before examining a defunctioned bowel.

Active colonic bleeding

Blood is a good purgative and some patients requiring emergency colonoscopy need no specific preparation providing examination is started during the phase of active bright-red bleeding. Posturing the patient during insertion of the instrument will shift the blood and create an air interface through which the instrument can be passed; changing to the right lateral position clears the proximal sigmoid and descending colon, which is otherwise a blood-filled sump. Actively bleeding patients requiring preparation for more accurate total colonoscopy are best managed by nasogastric tube or oral electrolyte/mannitol lavage. This allows examination within an hour or two and ensures that blood is washed out distal to the bleeding point, rather than carried proximally with enemas. Blood can be refluxed to the terminal ileum from a left colon source, which makes localization difficult, unless it is being constantly washed downwards by a per oral high-volume preparation. Massively bleeding patients can be examined peroperatively with on-table colon lavage combining a caecostomy tube with a large-bore rectal suction tube (and bucket).

Medication

Sedation and analgesia

At the time that the colonoscopy booking is arranged, the patient should be given a preliminary verbal and written explanation both of bowel preparation and of the procedure. On arrival for colonoscopy, a few minutes of further explanation will reassure and calm most patients and allow the endoscopist to judge whether the particular individual is likely to require sedation, and if so how much. Most people tolerate some discomfort without resentment if they understand the reason for it. Few people expect to be semi-anaesthetized for a visit to the dentist, but on the other hand they understandably expect the intensity and duration of any pain to be within 'acceptable limits'— a threshold which is not always easy to predict before colonoscopy, because both individual anatomy and tolerance of the unpleasant quality of visceral pain vary so much. It is sensible to warn the patient that there can be some stomach ache or air distension during the procedure, but to ask him to complain at once rather than to suffer in silence, and also to ask for extra analgesia if wanted.

Using moderate or no sedation and employing the skills, changes of position and other 'tricks of the trade' described hereafter, the only pain experienced by the patient during a correctly performed colonoscopy in a 'normal' colon should be for the 20–30 s it takes to pass the sigmoid–descending colon junction and then to straighten the instrument back again; during the rest of the procedure there should be little more than a feeling of distension or apparent desire to pass flatus. It is worth pointing out that any pain that does occur is a useful warning to the endoscopist, is not dangerous and can usually be
terminated in a few seconds (by straightening out the loop which must have formed to cause it).

The use of sedation has advantages and disadvantages. Without it, the bowel is possibly more tonic, shorter and so easier to examine; more importantly, the patient can co-operate with any changes of position, needs no recovery period and can travel home unaided immediately. The colonoscopist is also forced to develop a good, and gentle, insertion technique. With sedation, the patient is more likely to find the examination tolerable or to have amnesia for it. The endoscopist can be more thorough and is also more likely to achieve total colonoscopy in a shorter time. However, with heavy sedation endoscopists can get away with ham-handed technique, which is a bad investment in the long term, more likely to result in complications and more expensive in instrument repair bills. It is often said that it is dangerous to sedate because the safety factor of pain is removed; this is not strictly true, providing that the endoscopist raises his own threshold of awareness as the patient's pain threshold is raised, responding to restlessness or changes of facial expression as a warning that the tissues are being overstretched. With the heavy sedation wrongly employed by some endoscopists (e.g. diazepam 10 mg i.v. or midazolam 5 mg i.v., combined with pethidine (meperidine) 50–100 mg i.v.), the drowsy patient cannot co-operate or complain effectively, so the subtleties of colonoscopic technique may be ignored and there is no 'negative feedback' when loops form. The end result is that colonoscopy becomes a 'heavy' procedure with a potential for complications due to air distension and excessive force, whereas the total colonoscopy rate may be disappointing because of loops formed but not removed. Equally, some endoscopists who never employ sedation admit to only 70–80% success in performing total colonoscopy, presumably because some examinations were intolerable.

Most endoscopists use a balanced approach to sedation which will be affected by many factors including personal experience and the patient's attitude. A relaxed patient with a short colon having a limited examination rarely needs sedation, but a tense sick patient with a tortuous colon or severe diverticular disease requiring total colonoscopy needs some protection. Exceptional patients have such a morbid fear of colonoscopy, or such a low pain threshold, that it is justified to resort to light general anaesthesia if colonoscopy is particularly indicated. General anaesthesia is hazardous when combined with an inexperienced colonoscopist, who is able to use brutal technique because the anaesthetized patient cannot protest.

**Nitrous oxide inhalation**

We and colleagues have recently described the use of a nitrous oxide/oxygen mixture as a useful 'half-way house' between no sedation and conventional intravenous sedation. The 50 : 50 nitrous oxide : oxygen mixture is self-administered by the patient, inhaling from a small cylinder fitted with a demand valve. Breathing the gas through a small sterile mouthpiece (Fig. 9.1) avoids the difficulties that can be experienced in getting a good fit with a face mask, and also the phobia that some patients feel for masks.

The patient is shown how to inhale and pre-breathes for a minute or so as the endoscopist prepares to start the procedure, with the intention of achieving loading gas saturation of the body tissues. Thereafter it takes only 20–30 s of gas breathing, when needed, to obtain a 'high' which makes short-lived pain significantly more tolerable. Nitrous oxide/oxygen inhalation should prove useful for some flexible sigmoidoscopies and is sufficient for motivated patients having total colonoscopy by a skilled endoscopist. Scared patients, prolonged or difficult examinations and examinations by inexpert endoscopists require conventional sedation.
Intravenous sedation

The ideal sedative for colonoscopy would last 5–10 min with a strong analgesic action but no respiratory depression or after-effects. The nearest approach to the ideal at present is given by the combination of a benzodiazepine hypnotic such as midazolam (Versed 2.5–5 mg) or diazepam (Valium or Diazemuls 5–10 mg) either alone or with an opiate such as pethidine (meperidine 25–75 mg). The injection is given slowly over a period of at least 1 min, ‘titrating’ the dose to some extent by observing the patient's conscious state and ability to talk coherently — some patients merely become loquacious. Half dosage is used for older, sicker patients but the amount required is unpredictable; if in doubt it is safer to underdo the titration and give more later if necessary. Benzodiazepine contributes anxiolytic, sedational and amnesic effects whilst the opiate contributes analgesia and, in the case of pethidine, a useful sense of euphoria. In general, only a small dose of benzodiazepine should be given unless the patient is very anxious. For pathologically anxious or neurotic patients, premedication may occasionally be helpful before arriving in the endoscopy suite (giving, for instance, a beta-blocker (propranolol 40 mg or equivalent orally) or an intramuscular injection of pethidine (meperidine 75 mg)).

If increments of medication are needed during insertion it is usually best to use extra opiate rather than more benzodiazepine — which makes some patients even more restless and in any case has no pain-killing properties. Benzodiazepines and opiates potentiate each other, not only in effectiveness but also in side-effects such as depression of respiration and blood pressure, which can be sudden or gradual, and potentially serious. Pulse oximetry should therefore be routinely available and used in elderly, at-risk or heavily sedated (non-bronchitic) patients; if in doubt oxygen should be administered. Although it is increasingly suggested that pulse oximetry and low-dosage (2 litres/min) nasal oxygen should be used in all examinations where sedation is employed, we prefer to be selective, relying — in patients who are unsedated or only lightly medicated, comfortable and able to converse normally — on deliberately minimizing the overt technical complexity of the procedure and concentrating on its human aspects.

Benzodiazepines.

Benzodiazepines have, as well as their anxiolytic effects, an additional mild smooth-muscle antispasmodic action. Diazepam (Valium) is poorly soluble in water and the injectable form is therefore carried in a glycol solution which can be painful and cause thrombophlebitis, especially if administered into small veins. If a hand vein is to be used, and also for paediatric practice, it is better either to use water-soluble midazolam (Versed) or diazepam in lipid emulsion (Diazemuls, where available), both of which are less irritant. Midazolam causes a greater degree of amnesia, which can be useful to cover a traumatic experience but unfortunately also 'wipes' any explanation of the findings, which must be repeated later on.

Opiates.

Opiates, in addition to analgesic efficacy, can also variably induce a useful sense of euphoria. Pethidine may cause pain when administered through small veins, particularly in children, but this can largely be avoided by diluting the injection 1 : 10 in water. Some endoscopists prefer to give pethidine (meperidine) intramuscularly 1 h beforehand, which we do not favour. Pentazocine (Fortral) is a weaker analgesic, more hallucinogenic and seems to have little to recommend it. Fentanyl (Sublimaze) is a very short-lived opiate, but has the disadvantage of significant respiratory depressant effects without giving any sense of well-being.
Neurolept analgesia combinations. These combinations, usually haloperidol and droperidol, have been used by some, especially in France, but have the disadvantage of prolonged after-effects.

Propofol. Propofol (Diprivan), a short-lived intravenous emulsion anaesthetic agent, is widely used for colonoscopy in France and sporadically in other countries. It should ideally be administered by an anaesthetist because of the significant risk of marked respiratory depression but, with appropriate training and safeguards, has been employed by endoscopists alone. Its short duration of action, giving full recovery within about 30 min, is an advantage over excessive doses of conventional sedatives. On the other hand, the patient is rendered insensible and so unable to co-operate with changes of position or to give early warning of excessive pain. The routine use of propofol for all cases cannot, therefore, be commended.

Antagonists Availability of antagonists to benzodiazepines (Anexate) and opiates (naloxone) provide an invaluable safety measure for occasions when inadvertent oversedation has occurred. Some endoscopists routinely give them (intravenously and/or intramuscularly) to speed up the recovery period, which suggests mainly that their routine dosage is excessive. We use Anexate extremely infrequently, but periodically administer naloxone intramuscularly on reaching the caecum in a patient who has requested or needed extra sedation. The patient is then conveniently awake by the time the examination is finished, without the risk of later 'rebound' re-sedation that is reported after intravenous naloxone wears off.

Antispasmodics Either hyoscine N-butylbromide (Buscopan 20 mg) i.v. or Glucagon (0.5–1 mg) i.v. produce good colonic relaxation for at least 5–10 min and are helpful in improving the view during examination of a hypercontractile colon. The ocular side-effects of hyoscine may continue for several hours and the patient should not drive if vision is impaired, although cholinesterase-inhibitor eye drops will rapidly restore normality. Fears about anticholinergics initiating glaucoma are misplaced since patients previously diagnosed are completely protected by their eye drops, and those with undiagnosed chronic glaucoma are best served by precipitating an acute attack, which will cause the diagnosis to be made. Glucagon is more expensive, but has no ocular or prostatic side-effects.

The relatively short duration of action of intravenous antispasmodics leads some endoscopists to give them when the colonoscope is fully inserted; experienced endoscopists, sure of a rapid procedure, may give them at the start. There is an unproven suspicion that a bowel rendered more redundant and atonic by antispasmodics will be more difficult to examine; to the contrary, we find that the view is improved and insertion thereby speeded up after using hyoscine. Diazepam has a weak antispasmodic effect, relaxing most colons except for those which are 'irritable' or spastic; in the unsedated patient, therefore, antispasmodics may be particularly helpful — and can also be a useful placebo for those who cannot have routine sedation because they need to drive home, but expect an 'injection' to cover the procedure.

Patients with functional bowel disorder or diverticular disease may suffer from increased air retention after using antispasmodics, with the sudden onset of colic or abdominal discomfort an hour or more after the procedure when the pharmacological effects wear off.
Antibiotics

It is well proven from studies in which multiple blood cultures are taken during colonoscopy that transient bacteraemia occurs while the instrument is being inserted through the sigmoid colon. Both aerobic and anaerobic organisms can be released into the bloodstream at this time. Patients with ascites or on peritoneal dialysis have been reported to develop peritonitis following colonic instrumentation, presumably by transmural passage of bacteria as a result of local trauma. At-risk patients (including those with heart-valve replacements, cyanotic heart disease or previous endocarditis) and immunosuppressed or severely ill patients (especially immunocompromised infants) should have a suitable antibiotic combination administered beforehand so as to give therapeutic blood levels at the time of the procedure. The topic is more fully addressed in Chapter 3. Ampicillin 3 g orally 1 h beforehand (or 1 g in 2.5 ml 1% lignocaine i.m. just beforehand) plus another 0.5 g orally 6 h later and gentamicin 120 mg i.m. 1 h before (or intravenously just beforehand) is a possible adult regimen. Alternatively, a single intravenous dose of gentamicin (80 mg) and ampicillin (500 mg) before premedication has been advised. Vancomycin (20 mg/kg by slow i.v. infusion over the 60 min prior to the procedure) can be substituted for ampicillin in patients with a history of penicillin sensitivity. Children under 10 years of age receive half the adult dose of amoxycillin and gentamicin — 2 mg/kg body weight. In high-risk subjects it may be wise to continue antibiotics for up to 24–48 h.

Equipment

Colonoscopy room

The only special requisite for a colonoscopy room is good ventilation to overcome the evidence of occasional poor bowel preparation. In a few patients with particularly difficult and looping colons, it can be helpful to have access to X-ray facilities, particularly in teaching institutions. In the future, electronic imaging systems should become commercially available to show the endoscope configuration without X-rays. Until then most units perform colonoscopies in the ordinary endoscopy area, and either never use X-rays or arrange to have access to a mobile image intensifier or to an X-ray screening room on the rare occasions that it is needed.

Colonoscopes

Colonoscopes are engineered somewhat similarly to upper gastrointestinal endoscopes. They have a more flexible shaft, CO₂ insufflation and syringe-operated lens-washing facilities. The bending section of the colonoscope tip is also longer and so more gently curved, to avoid impaction in acute bends such as the splenic flexure. Ideally the colonoscope's control-section ergonomics will be modified (with a tracker ball or similar mechanism controlling power-steering facilities) to make one-handed steering and activation of the different buttons and switches easily possible, leaving the right hand free to manage the shaft. Present control mechanisms are almost unchanged from those of early gastrocameras and gastroscopes and are far from ideal for the more finicky steering required during colonoscopy.

Ignoring the slight variations between different makes of colonoscope, there are significant advantages in choosing the 'right colonoscope for the job' both at the stage of purchase and for particular patients. Long colonoscopes (165–180 cm) are able to reach the caecum even in redundant colons and are our preferred choice; the longer shaft needs careful handling and accessories take longer to insert. Intermediate-length instruments (130–140 cm) are considered by many to be a good compromise, and almost always reach the caecum. The 70 cm instruments used for flexible sigmoidoscopy have the advantage that the endoscopist knows from the onset that he is doing a quick procedure and is not
tempted to go further and prolong it. However, flexible sigmoidoscopy can be performed with a longer instrument, so there is little need for a flexible sigmoidoscope in an endoscopy unit compared to its essential role in the office of a primary-care physician or a general clinic facility.

**Paediatric colonoscopes**, of intermediate length and smaller diameter (9–10 mm) are ideally available with either standard or 'floppy' shaft characteristics. They are invaluable for the examination of babies and children up to 2–3 years of age (see pp. 266–267) but also have a role to play in adult endoscopy. As well as allowing examination of strictures, anastomoses or stomas impassable with the full-sized colonoscope, they are often much easier to pass through areas of tethered postoperative adhesions or severe diverticular disease. Floppy paediatric instruments are particularly comfortable and easy to insert to the splenic flexure, tending to conform to the loops of the colon and to form a spontaneous 'alpha' loop which avoids difficulty in passing to the descending colon. The smaller diameter of the shaft is, however, less easy to torque or twist and is more easily damaged if used routinely for more extensive examination. For limited adult examinations, as for strictures or diverticular disease, a paediatric gastroscope can also be used (and has the bonus of an even shorter bending section, but the disadvantage of limited downward angling capability). Its very stiff shaft makes it less suitable for total colonoscopy in small children and babies than the paediatric colonoscope.

**Video-colonoscopes**, since they do not need to be held near the endoscopist's face, have both positional and hygienic advantages as well as allowing everyone to see and bringing all the benefits of high-resolution electronic-image handling. Nonetheless, a fibre-colonoscope used with a new generation 'video adaptor' or charged couple device (CCD) camera brings many of the same benefits.

**Large channel size** has particular advantages during colonoscopy. It permits aspiration of fibrous food residues or polyp fragments which would otherwise cause blockage and allows fluid aspiration whilst standard accessories (snare, biopsy forceps, etc.) are in place; dilatation balloons can be introduced with less trauma and larger accessories passed, such as the clipping device or the 'jumbo' forceps (for more certain diagnosis of malignancy or inflammatory disease). Larger or double-channel instruments usually have a marginally greater shaft diameter and consequent slightly stiffer handling characteristics. Doubtless, engineering skills will in future allow increased channel size without this small penalty, which is in any case of less concern during colonoscopy than in upper endoscopy.

**Stiffness of the colonoscope shaft** is generally an advantage to an expert but in the hands of an inexpert endoscopist can overstretch loops painfully and necessitate a routine of heavy sedation — which further removes any need for subtlety. Stiff or 'hard' colonoscopes are therefore not ideal for everyone. Floppier or 'soft' shaft instruments perhaps tend to loop more easily, but when they do will conform more easily to the colon and cause less stretch pain, and respond more easily to dexterity in handling. Selection of colonoscope shaft characteristics is therefore a matter of opinion. Ideally the anatomy of the individual patient would also be a factor; this is inapparent until the first examination, but a recommendation can sometimes be made for subsequent visits. Thus, a patient with a very redundant colon is best examined with a stiff instrument, whereas a floppier instrument will do better in a short colon with adhesions.

Few endoscopists have the luxury of having a variety of instruments available. It is therefore important when buying a colonoscope to consider its likely major use, and in the individual patient to select one with regard to the clinical situation and the distance to be examined (and the tortuosity of the colon if a previous barium enema is available). The most experienced endoscopists are the least worried by changing instruments, but vary amazingly in their opinions as to what is the ideal — longer/shorter, more or less stiff — which suggests that there will never be such a thing as a single 'ideal' colonoscope. A physician who will want to be sure of being able to examine the proximal colon must either have a long instrument or have an intermediate-length instrument with a split overtube and/or fluoroscopy
available. A busy unit needs at least two functional colonoscopes used alternately to permit adequate disinfection during a routine list; a third standard instrument should be available as a backup during any period of breakdown. A surgeon who is only interested in occasional and left-sided examinations or peroperative procedures will be satisfied with a single instrument of intermediate length. Ideally any endoscopist should also have access to a paediatric endoscope for special cases.

**Accessories**

All usual accessories such as biopsy forceps, snares, retrieval forceps or baskets, sclerotherapy needles, cytology brushes, washing catheters, dilating balloons, etc. are used down the colonoscope. Long- and intermediate-length accessories work equally well down shorter instruments, so it is sensible to order all accessories to suit the longest instrument in routine use. Other manufacturers’ accessories also work down any particular instrument and, since some are better than others, it is worth taking advice when buying replacements.

The only specialized accessory in colonoscopy is the stiffening tube, stiffener or split overtube, the use of which is described later (p. 246). Although not used by many endoscopists, and potentially hazardous if wrongly used, it is still very occasionally invaluable in avoiding recurrent loop formation of the sigmoid colon, for exchange of instruments or for retrieving multiple polyps.

**Carbon dioxide**

Most colonoscopes have CO\(_2\) buttons, but few colonoscopists use CO\(_2\) insufflation. This is because, with the exception of bowel preparation using mannitol (and other similar agents such as sorbitol, lactulose or lactitol), colonoscopic bowel preparation has been shown to leave no residual explosive gas in the colon as a polypectomy hazard. However, even for routine examinations, the use of CO\(_2\) offers the striking advantage that it clears 100 times faster than air (through the circulation, to the lungs and then breathed out). This means that after CO\(_2\) insufflation the colon and small intestine are free of any gas in 15–20 min, whereas air distension can remain and cause abdominal discomfort for many hours, especially in patients with functional bowel symptoms. Colonoscopy with CO\(_2\) insufflation can, therefore, be followed immediately by a DCBE or scanning, whereas residual air distension, especially if antispasmodics have been used, will increase the amount of barium needed to fill and then coat the colon and may degrade the quality of the examination. In the unlikely event of perforation or gas leak (pneumoperitoneum), air under pressure would add to the hazard whereas rapidly absorbed CO\(_2\) and a well-prepared colon should markedly reduce it. Any patient with ileus, pseudo-obstruction, strictureing, severe colitis, diverticular disease or functional bowel disorder should benefit from the added safety and comfort of using CO\(_2\) rather than air insufflation.

In some instruments it is now possible to fit a CO\(_2\) insufflation button (Fig. 9.2) as a replacement in the usual air button position, which makes instrument handling easier than activating an alternatively sited CO\(_2\) button. Cheaper low-pressure, metered-flow CO\(_2\) delivery systems are also becoming available, which removes the previously valid objection that CO\(_2\) was cumbersome to use and expensive to install.
Principles of colonoscopy ▲▼

Embryological anatomy ▲▼

The embryology of the colon is complex, especially in terms of mesenteries and attachments, which explains the extraordinarily variable configurations which can result during colonoscopy. The fetal intestine and colon lengthen into a U-shape on a longitudinal mesentery (Fig. 9.3a) but, as the whole embryo at that stage is only 1 cm long, become forced out into and rotate within (Fig. 9.3b) the umbilical hernia which is normal at this 5-week stage (Fig. 9.3c). The gut loop thus differentiates into the small and large intestine outside the abdominal cavity. By the third month of development the embryo is 4 cm in length and there is room within the peritoneal cavity for first the small and then the large intestine to be returned into the abdomen. This occurs in a fairly predictable manner, with the end result that the colon is rotated around so that the caecum lies in the right hypochondrium and the descending colon on the left of the abdomen (Fig. 9.4a). With further elongation of the colon, the caecum normally 'migrates' down to the right iliac fossa. At this stage, the mesentery of the transverse colon is free but then the mesenteries of the descending and ascending colon, pushed against the peritoneum of the posterior abdominal wall, fuse with it and are absorbed so that the ascending and descending colon become retroperitoneal (Fig. 9.4b).

In some cases incomplete fusion of the mesocolon and posterior wall occurs and a variable amount of the original mesocolon remains, resulting in variable mobility of the right and left colon. How often this incomplete fusion occurs is not clear from the literature, but a persistent descending mesocolon has been found in postmortem studies in 36% and an ascending mesocolon in 10% of subjects. The persistence of a descending mesocolon explains most of the strange configurations caused by the colonoscope in the left colon and splenic flexure (Fig. 9.5). Occasionally the caecum fails to descend and becomes fixed in the right hypochondrium (Fig. 9.6); in others, where a free mesocolon persists, the caecum remains completely mobile (Fig. 9.7). Peroperative studies that we have undertaken show that colons in Oriental subjects are more predictably fixed than those in Western subjects.

The musculature surrounding the colon develops as three external longitudinal muscle bundles or taeniae coli and, within these, the circular muscles. Both muscle layers are sometimes visible to the endoscopist (Fig. 9.8), one or more of the taeniae as an inward longitudinal bulge and the circular musculature as fine reflective indenting in the mucosal surface. Haustral folds segment the interior of the colon; those that are prominent in the proximal colon sometimes create 'blind spots' whereas their muscular hypertrophy in diverticular disease can also create mechanical difficulties for the endoscopist.

Instrument characteristics ▲▼

There are various basic points relevant to colonoscope handling that are worth highlighting before considering the anatomical variations and complexities that are encountered in practice.

Colonoscopy involves the insertion of a long flexible tube with a steerable tip through a long flexible cylinder which is elastic and can move around unpredictably. It is thus no surprise that the technique and its results are also unpredictable, multifactorial and dynamic — changing from moment to moment in a way that is often difficult to understand, let alone to simplify sufficiently to explain in print or to teach. Effectively, the endoscopist is like a puppeteer propelling a snake puppet by the tail, with control of its head, a view through its eyes, but scant idea of what is happening to its body because this is invisible within the abdomen.
Some of the problems of colonoscopy, and the tricks for overcoming them, relate primarily to the instrument characteristics. For instance the clinician used to rigid proctosigmoidoscopy is not used to the perverse tendency of the colonoscope to flex when it is pushed; he therefore tends to lose patience, use force and is surprised that insertion becomes increasingly difficult (and painful) as loops inevitably form.

1 **Straight is good** is therefore a cardinal principle in colonoscopy. A straight instrument will respond instantly to delicate shaft movements, whether in/out or rotational, with no force. If this responsive feeling is lost, because of looping, it can easily be regained by the simple expedient of pulling back — as one would need to do repeatedly if forced to push a flexible hosepipe (something which, in other circumstances, no sane person would think of doing).

2 **Pulling back is the most important move in colonoscopy.** Any fool can push, and most do — relentlessly. When pulling back, the shaft straightens so that it, the angling wires within it and the controls all become more responsive; conversely the colon shrinks or convolutes, reducing peritoneal and mesentery stretch and so making the patient more comfortable.

3 **Twisting the shaft only affects the tip when the shaft is straight** ([Fig. 9.9](#)). When a loop is present in the shaft, twisting forces applied will be lost within it (as well as moving the loop of colon). When the shaft is straight, twist becomes an excellent way to corkscrew or 'slalom' around bends. This is particularly useful if the angle to be traversed is acute or fixed, because simply trying to push around will encounter severe resistance (and so often result in looping rather than progress).

4 **Twist will have the most steering effect when the tip is angled, and the same twist will have an opposite steering effect depending on whether the tip is up or down** ([Fig. 9.10](#)).

5 **Steering with the control knobs has least effect when the tip is already angled.** Try this outside the patient. When one control knob is fully angulated, applying the other one swivels the bending section a little but hardly affects the degree of angulation ([Fig. 9.11](#)). Vicious steering movements are therefore rarely helpful (but can damage the angling control wires).

6 **A fully angulated tip will not slide along the colon.** It is easy to forget, in the quest to get a view around bends, that overangling can be counterproductive (the 'walking-stick handle' phenomenon) ([Fig. 9.12](#)).

7 **An impacted tip cannot be steered.** Try it yourself. Hold the very tip of the bending section firmly and operate the angling control(s); the shaft will move because the tip cannot ([Fig. 9.13](#)). This is a limiting factor of flexible endoscopes, and is why the endoscopist is sometimes so impotent in fixed diverticular disease or a tight stricture.

8 **Twisting often increases or decreases a loop.** Loops formed by the colonoscope within the colon usually have a 3D spiral configuration, clockwise or anticlockwise. Try out on the table top the effect of twist. Clockwise twist applied to a clockwise spiral will tend to straighten it (or progress it forward if the tip is free to slide) ([Fig. 9.14a](#)). Anticlockwise twist of the same loop will do the opposite and make the spiral worse (or cause it to slide back if it is not fixed) ([Fig. 9.14b](#)). Applying the appropriate steady twisting force (torque) to the shaft can sometimes therefore be very helpful in either progressing, straightening or keeping it straight.
**Instrument handling** ▲▼

The majority of skilled endoscopists favour, as we do, the 'single-handed' or 'one-man' approach, but there are still experts working successfully with the 'two-man' method, using an assistant to manipulate the shaft.

**Single-handed colonoscopy. ▲▼**

This depends on the endoscopist managing the colonoscope controls mostly or wholly with the left hand, leaving the right hand free to hold the shaft (Fig. 9.15). The endoscopist should stand relaxed (see also p. 54), with the control section held in whatever position is comfortable and the shaft gripped 25–30 cm away from the anus (to avoid too frequent changes of grip and jerky insertion which result from holding close to the anus, as many do).

For those with a reasonably large hand it is practicable for the left thumb to reach both the up/down and the lateral control knob (Fig. 9.16). Single-handed steering is made easier if the first finger alone operates the air/water or suction buttons and the second finger (forefinger) acts as 'helper' to the thumb in managing the angling controls. In practice, the skilled single-hander mostly achieves lateral movement by shaft rotation transmitted to the up- or down-angulated tip rather than bothering with the lateral control knob. The result is to 'slalom' or twist around bends, particularly those in the distal colon, in a surprisingly fluent manner (providing the instrument can be kept reasonably straight).

Those with a small hand may be unable to reach the lateral control knob and may need, from time to time, to use the right hand for this purpose. This means briefly letting go of the instrument shaft whilst the angulation is made. Some endoscopists position the patient so that they can lean and trap the shaft transiently against the couch whilst the right hand is otherwise occupied. If the right hand is used too often the endoscopist is not using rotatory movements enough; if it is too long away from the shaft and working the lateral knob he is being indecisive — it takes at most a second or two to make an angling adjustment.

Shaft grip should at all times be with a paper towel or gauze square, for the combined reasons of hygiene and better grip. The most dexterous grip is, as when rolling a cigar, mainly between the thumb and two fingers (Fig. 9.17), rather than the more restricted and clumsy control which results from holding the shaft in the clenched fist. If you do not believe this, try rolling a pen maximally around in your fingers, and compare this with the half-rotation which is the most that can be accomplished in the fist — which is effectively a wrist movement.

**Two-man colonoscopy. ▲▼**

This allows the endoscopist to use the control body of the instrument in the way that it is, unfortunately for the colonoscopist, currently designed — namely with the left hand working the up/down control (and air/water/suction buttons) and the right hand kept for the right/left angulation control knob. The assistant performs the role ascribed to the right hand of the single-handed endoscopist, pushing and pulling according to the spoken instructions of the endoscopist. A good assistant learns to feel the shaft to some extent and to apply some twist. More often, an assistant pushes with concealed gusto, causing unnecessary loops that are inapparent to the endoscopist.

It is perfectly possible to get the best of both worlds if the endoscopist takes over the shaft from the assistant from time to time, particularly when the shaft is being withdrawn, so getting a 'feel' of the situation and being able to make his own judgements. Unless the endoscopist/assistant team is well-honed and interactive the two-man approach to colonoscopy can be as illogical and clumsy as would be
expected of two people attempting any intricate task, neither knowing fully what the other is doing.

**Handling the colonoscope**

Our rationale for preferring the *single-handed* approach to colonoscopy has been covered previously (pp. 212–214). With so many different instruments, techniques, hand sizes and degrees of dexterity, it is pointless to suggest that there is only one method of handling an endoscope, although the single-handed method seems to us the most logical and is favoured by most skilled colonoscopists. Others prefer an assistant to advance and withdraw the instrument, especially during the learning phase and difficult phases of insertion. The exact handling technique is unimportant if it is relaxed, gentle and effective. However, anyone who achieves less than 95% total colonoscopy (when indicated), hurts patients, needs to use heavy sedation or has complications during diagnostic colonoscopy needs to re-assess their technique.

*The stance* should be relaxed for what can be a prolonged examination and the endoscopist should also hold the colonoscope in a relaxed manner. Colonoscopy mostly requires fine and fluent movements, like those of a violin player, and similarly balanced position and handling are needed.

*Hand control and finger skills* are of paramount importance. For single-handed endoscopy, each hand is disciplined to fulfil only its appropriate tasks; the left hand holds the instrument in balance, manages the air/water/suction buttons and up/down control knob (see Fig. 9.15) with minor adjustments of left/right angling as well (see Fig. 9.16), while the right hand controls the shaft of the instrument with only occasional major alterations to the lateral control knob. Because the colon is a continuous series of short bends requiring multiple combinations of tip and shaft movement and frequent air/water and suction button activations, small delays and unco-ordinated movements rapidly summate to prolong the procedure unnecessarily. Handling efficiency can be considerably increased by the simple means of disciplining the fingers of the left hand (Fig. 9.18) so that (as detailed above) the left forefinger alone activates the air/water/suction buttons and only the left thumb and left middle finger control the up/down angling knob. By using just the two littlest (third and fourth) fingers to grip the control body, the middle finger assumes an invaluable role as 'helper' to the thumb in managing the angling controls; this role is especially important for major up or down angulations, for which purpose the middle finger steadies the control knob when the thumb needs to shift position.

A table-top dexterity test which can be done to demonstrate the problems, or to check the efficiency of left-hand angling technique, is to time five full bending section retroflexions from maximally up to maximally down (with no help from the right hand); it can be done in around 20 s (Fig. 9.19). Adding full lateral angulation at each maximal up and maximal down position, skewing the tip first in one direction and then in the other, challenges the one-hand finger control of even the most dexterous. Such extreme movements are not often needed except for the occasional difficult polypectomy or awkward bend when the right hand is otherwise occupied, but the training exercise is useful in showing up limitations in finger skills.

*Shaft handling* must be equally dexterous. Whereas in gastroscopy the instrument runs a short and fixed course, so that looping and twisting of the shaft is of less relevance, in endoscopic retrograde cholangiopancreatography (ERCP) the need for the mechanical efficiency of a straight endoscope position is well recognized; it is just as important in colonoscopy, if inward push is to be transmitted to the tip and if the endoscope is to work to maximal efficiency. The mechanical construction of an endoscope, with its protective wire claddings and four angling wires, means that each shaft loop both increases the resistance of the instrument to twisting/torquing movements and decreases tip angulation by causing friction in the angulation wires. Shaft loops are also as counterproductive *outside* the patient
as inside the abdomen. Thus the shaft should be made to run in an easy curve to the anus, without unnecessary bends, and any loops forming outside the patient should be derotated and straightened. This is best done by rotating the control body to transfer the loop to the umbilical, which can accommodate up to three to four loops without harm to its internal structures (Fig. 9.20). Where possible the shaft of the long colonoscope should be arranged on the table so as to make it easy to twist clockwise, since this is such a frequent action.

The right hand makes rotational twisting/torquing movements of the shaft and also feels whether the shaft moves easily (is straight) or there is resistance (due to looping). To feel and manipulate the shaft deftly, hold it in the fingers (see Fig. 9.17) as you would any other delicate instrument (and not in the fist like a hammer or an offensive weapon). Rolling the shaft between the fingers and thumb allows major steering rotations with minimal effort. Quick, almost reflex, logical responses and co-ordination between the right and left hands develop with practice; colonoscopy, from slow deliberate beginnings, thus becomes a rapid and fluent procedure.

Concentration is also vital. Whilst being relaxed in stance and instrument handling, obsessional attention to keeping the endoscopic view at all times is a key aspect of efficient and accurate colonoscopy. The endoscopist, if he is not to lose orientation or miss diagnostic minutiae, must learn to be able to suppress normal social reflexes such as looking at the patient or endoscopy room staff when talking to them. It is perfectly possible to converse or give instructions without eye contact and often important to do so. Some acute bends or small polyps, for instance, may slip from view in the moment that the endoscopist looks away and then take a surprising time to find again. Intense concentration, on both mechanical and visual aspects of the procedure, makes colonoscopy quicker and more efficient. It takes all the endoscopist's faculties to assess the view, predict the correct action, keep a running mental log of decisions taken and their result, so as constantly to optimize the situation or to reverse it rapidly when necessary. Colonoscopy is an algorithm of small responses to ever-varying situations and it takes alertness, motivation and concentration to make the best of it.

Anus and rectum ▲▼

Endoscopic anatomy ▲▼

The anal canal, 3 cm long, is lined with sensitive squamous epithelium to the squamocolumnar junction or 'dentate line'. Sensory innervation, and so mucosal pain sensation, may in some subjects extend several centimetres higher into the distal rectum. Around the canal are the anal sphincters, normally in tonic contraction. The anus may be deformed, scarred or made sensitive by present or previous local pathology, including haemorrhoids or other conditions — and normal subjects may be sore from the effects of bowel preparation.

The rectum, although reaching only 15 cm proximal to the anal verge, may have a capacious 'ampulla' in its midpart as well as three or more prominent folds (valves of Houston) which create potential blind spots, in any of which the endoscopist can miss significant pathology. Digital examination, direct inspection and, where appropriate, a rigid proctoscope are needed for complete examination of the area. Prominent, somewhat tortuous veins are a normal feature of the rectal mucosa and should not be confused with the rare, markedly serpiginous veins of a haemangioma or the distended, tortuous ones in some cases of portal hypertension.

The rectum is extraperitoneal for its distal 10–12 cm, making this part relatively safe for therapeutic manoeuvres such as removal or destruction of sessile polyps; proximal to this it enters the abdominal cavity, invested in peritoneum.
**Insertion**

Pre-check the endoscope and equipment. All functions of the endoscope, light source and accessories should be thoroughly checked before insertion. In particular make sure that air (or CO\(_2\)) insufflation is fully operational, with no rinse water remaining in the air channel. The tip should bubble briskly when held underwater (if in doubt wrap a rubber glove around the tip and watch it inflate). It is very easy during the examination to think the colon is hypercontractile and difficult to inflate when in fact one of the connections is loose, the insufflation button misplaced or faulty, or the air outlet semi-obstructed, any of which will result in decreased pressure and so only partial function. Polishing the objective lens with a silicone stick or spectacle lens fluid helps to keep it clean during the examination.

Insertion through the anus should be gentle. The instrument tip is unavoidably blunt (the necessity for flat lenses means that it cannot be streamlined), so too fast or forcible an insertion may be quite uncomfortable for patients with tight sphincters or sore anal epithelium. The squamous epithelium of the anus and the sensory mechanisms of the anal sphincters are the most pain-sensitive areas in the colorectum, and digital examination or insertion of the endoscope should be done carefully. The patient is in the left lateral position, lying as comfortably as possible, and the endoscopist dons examination gloves. A clear water-soluble jelly (e.g. K-Y or local anaesthetic lubricating jelly) is best but some use oil or even silicone liquid, which is messier; additional lubrication may be needed from time to time during the procedure to minimize friction and so keep a good 'feel' of the shaft.

Many start with two gloves on the right hand and perform a digital examination with a generous amount of lubricant before inserting the instrument, both to check for pathology in this potentially 'blind' area and to prelubricate and relax the anal canal. Alternatively, a large blob of lubricant jelly can be squeezed out over the anal orifice and the instrument inserted directly through it ([Fig. 9.21a](#)), which saves a glove and a few seconds; inflating air down the endoscope whilst pressing the tip into the anal canal gives direct vision and facilitates insertion. Sometimes the instrument tip will pass in more easily if pressed in obliquely, supported by the examiner's forefinger until the sphincter relaxes ([Fig. 9.21b](#)). Alternatively, the examiner can use his thumb to push the tip inward along the line of his examining forefinger as this withdraws from the anal canal ([Fig. 9.21c](#)). The tendency of the bending section to flex can be avoided by starting with it straight, fixing the control knob brakes and pressing in gently.

Particularly tight or tonic sphincters may take some time to relax; asking the patient to 'bear down' is said to help this. Allowing an extra 15–20 s, if necessary, for sphincter relaxation is a humane start to proceedings, especially for a patient with anorectal pathology or anismus; the sphincters of colitis patients are noticeably more tonic than normal, presumably because of the longstanding need to keep control.

**Video-proctoscopy**

If a rigid proctoscope is used the patient can be shown the appearances by the simple expedient of inserting the video-endoscope tip up the proctoscope once the insertion trocar is removed. The colonoscopy simultaneously provides a convenient source of illumination and an excellent close-up view. The endoscopist can perform video-proctoscopy ([Fig. 9.22](#)) entirely from the monitor view, with the opportunity of taking tape or videoprints — which in many cases of 'unexplained bleeding' persuasively show the patient and referring doctor the likely (haemorrhoidal) origin.

**Rectal insertion**

After the scope has been inserted into the rectum there is usually little to see except a 'red-out' because
the rectal mucosa is pressed against the lens. At this point, the following steps should be performed in sequence:

1 **Insufflate air** to distend the rectum.

2 **Pull back and** angulate or rotate slightly to find the lumen (this is the first of many times during the examination when withdrawal, inspection and cerebration bring success more quickly than following instinct and pushing blindly).

3 **Rotate the view so that any fluid lies inferiorly.** The suction port of the colonoscope tip lies just below the bottom right-hand corner of the image (Fig. 9.23) and should be selectively placed in the fluid before activating the suction button. To do this co-ordination will be required between forcible shaft rotation with the right hand and synchronous compensatory up or down angulation with the left hand so as to keep the view. During examination a skilled single-handed endoscopist often uses twist to steer or 'corkscrew' the tip; the capacious rectum is the ideal place in which to practise this; the need to suction fluid efficiently is a good reason to do so.

4 **Aspirate fluid or residue** to avoid any chance of anorectal leakage during the rest of the examination, when instrument pressure, in/out movements and air insufflation often combine to give the patient a distressing illusion of being incontinent.

5 **Push in,** finally, only when an adequate view has been obtained, and only as fast as a reasonable view can be obtained.

6 **Corkscrew or 'slalom' round the first few bends,** using up or down angulation and shaft-twist alone to achieve most lateral movements, rather than unnecessarily using the lateral angulation control. This is an economic way of steering in at this stage and demonstrates the efficacy of finger twist when the shaft is straight — which it inevitably is in the rectosigmoid region.

**Retroversion** can be important since the rectum, often being very capacious, can be surprisingly difficult to examine completely. Care is needed to combine angling and twist movements sufficiently to see behind the major folds or valves. In a capacious rectum the most distal part is a potential blind spot but the generous size of the rectal ampulla will make tip retroflexion easy. Look around to choose the widest part, angulate both control knobs fully and push gently inward to invert the tip towards the anal verge (Fig. 9.24). Retroversion is not always possible in a small or narrowed rectum, but in a narrow rectum the wide-angled (140°, nearly 'fish-eye') lens of the endoscope should see everything without risk of blind spots.

**Sigmoid and descending colon** ▲▼

**Endoscopic anatomy** ▲▼

The distal colon, needing to cope with formed stools, has a thick circular musculature which results in a tubular appearance (Fig. 9.25) broken by the ridged indentations of the haustral folds. The three external taeniae coli or longitudinal muscle bundles are only seen to indent if the sigmoid or descending colon are unusually capacious. From the internal view, extracolonic structures, probably muscle tissue, are occasionally seen as a blue-grey discoloration through the colonic wall (less obviously than the spleen or liver more proximally); vascular pulsations of the adjacent left iliac artery are frequently visible in the mid- or proximal sigmoid.
The sigmoid is 40–70 cm long when stretched by the instrument during insertion, although it will crumple down to only 30–35 cm once the instrument is straightened fully — which is why careful inspection is important during insertion if lesions are not to be missed during the withdrawal phase. The sigmoid colon mesentery is inserted in a V-shape across the pelvic brim, but is very variable in both insertion and length, and also quite frequently modified by adhesions from previous inflammatory disease or surgery. In elderly subjects the sigmoid colon anatomy is often narrowed and deformed internally by the thickened circular muscle rings of hypertrophic diverticular disease, and sometimes also fixed externally by pericolic post-inflammatory processes. The redundant and prolapsing mucosal folds overlying the muscular rings in diverticulosis often appear reddened from traumatization and sometimes focally inflamed as well (Plate 9.1). After hysterectomy the distal sigmoid colon can also be angulated and fixed anteriorly onto the area previously occupied by the uterus.

The 3D anatomy of the distal colon is relevant to understanding both the spiral loops that can form and the basis of the rotatory movements and tricks with which they can be managed. The inserted colonoscope may stretch the bowel to the limits of its attachments or the confines of the abdominal cavity. The shape of the pelvis, with curved sacral hollow and the forward-projecting sacral promontory, cause the colonoscope to pass anteriorly (Fig. 9.26a) so that the shaft can often be felt looped onto the anterior abdominal wall before it passes posteriorly again to the descending colon in the left paravertebral gutter (Fig. 9.26b). The result is that an anteroposterior loop occurs during passage of the sigmoid colon and, since the descending colon is usually laterally placed, it forms a clockwise spiral loop (Fig. 9.27); the importance of this will be discussed later (see pp. 235–6). When the sigmoid loop runs anteriorly against the abdominal wall it is possible partially to reduce or modify the sigmoid looping of the colonoscope by pressing against the left lower abdomen with the hand (Fig. 9.28).

The descending colon is normally bound down retroperitoneally and ideally runs in a fixed straight line which is easy to pass with the colonoscopy, except that there is usually an acute bend at the junction with the sigmoid colon (Fig. 9.29). This junction is only a theoretical landmark to the radiologist but, once the sigmoid colon is deformed upwards and outwards by the inserted colonoscope shaft, becomes a very real challenge to the endoscopist. The acuteness of the sigmoid–descending angle depends on anatomical factors, including how far down in the pelvis the descending colon is fixed, and also on colonoscopic insertion technique. A really acute hairpin bend results when the sigmoid colon is long or elastic enough to make a large loop and the retroperitoneal fixation of the descending colon happens also to be low in the pelvis (Fig. 9.30). Sometimes, when the sigmoid colon is long an alpha loop occurs, which avoids any angulation at the sigmoid–descending junction. The 'alpha' is the fluoroscopic description of the spiral loop of sigmoid colon twisted around on its mesentery or sigmoid mesocolon in what is, in effect, a partial iatrogenic volvulus (Fig. 9.31). Formation of the loop depends on the anatomical fact that the base of the sigmoid mesocolon on its short inverted 'V' at the pelvic brim allows easy rotation (Fig. 9.31).

Mesenteric variations from the norm occur in at least 15% of subjects because of partial or complete failure of retroperitoneal fixation of the descending colon in utero (see p. 209). The result is persistence of varying degrees of descending mesocolon, which in turn has a considerable effect on what shapes the colonoscope can push the colon into during insertion; the descending colon can, for instance, run up the midline (Fig. 9.32) or allow a 'reversed alpha' loop to form (Fig. 9.33). Surgeons are well aware that there is great patient-to-patient variation in how easily the colon can be mobilized and delivered outside the abdominal cavity; occasionally the whole colon can be lifted out without dissection. A mobile colon which is 'easy' for the surgeon is, however, often extremely unpredictable and difficult for the endoscopist.
The objective is to insert the endoscope gently, but in a reasonably short time, because it is the push and mesenteric (or peritoneal) stretch of the insertion phase that is uncomfortable or painful for the patient. Full inspection should be on the return journey — although better views of some areas are obtained on the way in when the colon is stretched; any small polyps seen should therefore be destroyed during the insertion phase, as they can easily be missed in the shortened colon on the way back. The paradox of flexible endoscopy is that aggression and attempts at speed are often self-defeating because of a combination of factors: the tendency of the instrument tip to get bent up in folds, of its shaft to flex into counterproductive loops and of the colon to be squashed into impossibly tight configurations. If the object of the examination is a limited view up the sigmoid these factors are often less important, but if the intention is to reach the caecum it is fundamental to understand the principles for efficient insertion and how to avoid or remove the loops that can form.

In nine patients out of 10 (the exceptions being those with colons fixed by adhesions or impossibly long and loopy or, worst of all, a combination of both) colonoscopy can be made a virtually painless, even enjoyable, experience. The sigmoid colon is an elastic tube (Fig. 9.34). Inflated it becomes long and tortuous; deflated it is significantly shorter. When stretched by a colonoscope the bowel forms loops and acute bends (Fig. 9.35) but if shortened down by the same colonoscope it can be telescoped into a few convoluted centimetres (Fig. 9.36) (rather like pushing a coat- or shirt-sleeve up to expose the arm). The following are simple principles for comfortable and safe insertion.

1 **Suction air frequently and fluid infrequently.** Whenever fully distended colon is seen or if the patient feels discomfort it takes only a second or two to suction off excess air until the colon outline starts to wrinkle and collapse, making it shorter and also easier to manipulate. In contrast, after having evacuated fluid from the rectum, only aspirate fluid during the rest of the insertion phase when absolutely necessary to keep a view, and only do so when there is enough air present and a good enough view to suction accurately (sucking blind when already immersed is usually rather ineffectual). During insertion there will be numerous local 'sumps' or pools of residual fluid; aspirating each one wastes a lot of time, loses the view and requires reinflation. It is usually possible to inflate a little and steer in over the fluid level rather than plunging into it and having to suction. Even solid stool can often be successfully passed, deliberately angling the tip to slide along the mucosa for a few centimetres rather than impacting against a bolus, which can coat the lens irrevocably. Any residue can easily be suctioned or removed from view by changes of patient position on the way back when a perfect view is important.

2 **Insufflate as little as possible.** Gentle air insufflation is needed throughout the examination, except when there is an excellent view. The policy is 'as much as necessary, as little as possible'; it is essential to see, but counterproductive and uncomfortable to overinflate. Remember that bubbles are caused by insufflating under water, which can usually be avoided by the simple means of angling above it. If fluid preparation and bile salts do result in excessive bubbles, these can be dispersed instantly by injecting an antifoam preparation solution containing particulate silicone down the instrument channel.

3 **Use all visual clues.** A perfect view is not needed for progress; but the correct direction or axis of the colonic lumen should be ascertained before pushing in. The lumen when deflated or in spasm is at the centre of converging folds (Fig. 9.37). With only a partial or close-up view of the mucosal surface, there are usually sufficient clues to detect the luminal direction. Aim towards the darkest area, worst illuminated because it is furthest from the instrument and nearest the lumen (Fig. 9.38). The convex arcs formed by visible wrinkling of the circular muscles (Plate 9.2), the haustral folds or the highlights reflected from the mucosa over them, all indicate the centre of the arc as the correct direction in which to angle (Fig. 9.39). The slight bulge of the underlying longitudinal muscle bundles (taeniae coli) is
another, occasionally useful, clue. The expert can make his steering decisions on evidence which would be inadequate for the beginner. On the other hand, each time the expert is 'lost' for more than 5–10 s he pulls back quickly to regain the view and re-orientate, whereas the beginner can flounder around blindly for a minute or more in each difficult spot and is surprised that the overall examination takes so long.

4 _Steer carefully and cautiously._ Steering movements should be early, slow and exact (rather than jerky and erratic). A slow start to each angulation movement allows it to be terminated at once, within a few degrees of travel, if it proves to be moving the tip in the wrong direction. A rapid steering movement in the wrong direction can simply lose the view altogether, quite unnecessarily, and then tends to be corrected by another large movement so that the effect is to flail around — often hopelessly, certainly inelegantly. Each individual movement should be slow and purposive and every action during insertion should be thought out and executed in response to the view, or whatever visual clues there are to suggest the correct luminal direction.

5 _If there is no view, pull back at once._ If lost at any point in the examination, keep the control knobs still or let them go entirely, insufflate and then gently withdraw the instrument until the mucosa and its vascular pattern slips slowly past the lens in a proximal direction (Fig. 9.40); follow the direction of slippage by angling the controls or twisting the shaft and the lumen of the colon will come back into view. Thrashing around blindly with the instrument rarely works; _pulling back_ must do, for the bending section self-straightens if left free to do so.

6 _Rehearse steering actions before bends while there is a good view._ Unlike the stomach, where there is usually sufficient room to see what is happening during steering manoeuvres, colonic bends are unforgivingly tight and it is very easy to become unsighted and uncertain when angling around them. Stop before any acute bend and try out, whilst stationary and still able to see, the best steering movements to use within it.

7 _Use the lateral angling knob as little as possible._ There are a limited number of possible tip-steering movements for the single-handed endoscopist:

(a) the easiest is up/down thumb control (left hand);

(b) the next easiest is clockwise/anticlockwise twist (right hand);

(c) the least convenient is left/right angling (by the thumb on the lateral knob or taking the right hand off the shaft to activate the lateral control knob).

Thus, when steering, first angle up or down as appropriate; next, rather than using the right/left control knob, try rotating the instrument shaft clockwise or anticlockwise with the right hand. Because the tip is already slightly angled this rotation should corkscrew it around laterally (see Fig. 9.10), precisely and quickly, and will often make use of the lateral control knob unnecessary.

8 _Use twist and torque._ With the single-handed method, twisting the shaft becomes second nature and a most essential part of the colonoscopist's range of tricks and manoeuvres. It should be appreciated, however, that there are three different twisting effects:

(a) _twisting with the shaft and tip straight_ rolls the instrument around on its axis. This can be useful to re-orientate the biopsy forceps, injection needle or polypectomy snare into the ideal quadrant to target a particular lesion, or to place the suction channel precisely over a fluid pool to be aspirated (Fig. 9.41).
When approaching a bend, twisting may adjust the axis of the instrument so that up/down angulation alone will steer around the bend. Appreciating the 'free and easy' feel and responsiveness of a really straight colonoscope to twist and push/pull movements is an essential part of skilled colonoscopy;

(b) **twisting with the shaft straight but the tip angulated** deviates the tip very rapidly according to the direction of twist and angulation. Thus with the tip angled up, twisting clockwise moves it right (see Fig. 9.10); with the tip down, the same clockwise twist will move it left (droop or cock your wrist and then rotate the forearm one way or the other to simulate this). Such corkscrewing movements are particularly effective when the colon is fixed, as by adhesions or diverticular disease, or when the tip is already acutely angulated in a sharp bend;

(c) **twisting with a loop in the shaft will alter the position of the loop**, and often its size and configuration as well. Because the course of most sigmoid colon loops is spiral (usually a clockwise spiral due to shaft passage anteriorly from the pelvis and curving laterally and posteriorly into the descending colon (see Fig. 9.27)), twist is particularly effective in this region. Since the colonoscope is free to move within the colon, but the colon itself is fixed at the rectum and retroperitoneally in the descending region (as well as being constrained by the anterior and lateral abdominal wall), a clockwise twist will also usually shorten (pleat/accordion) the mobile sigmoid over the shaft, whilst the tip moves forward up the fixed descending colon. Other spiral loops (large alpha, large N, reversed splenic or 'gamma' loops) need to be first reduced in size by pulling back before they can be successfully twisted about and straightened in the confined space of the abdominal cavity.

9 **Torque is the application of continued twist** whilst inserting or withdrawing the instrument. Clockwise torque is a major help in keeping the colonoscope shaft straight in the sigmoid colon whilst advancing up the descending colon, but also in controlling the sigmoid (and other potential loops) during the later phases of insertion. Whether to torque/twist clockwise or anticlockwise is an empirical decision according to results, but with conventional mesenteric anatomy clockwise is the more likely to help. Remember that if torque is being applied in one direction (e.g. clockwise) to affect a loop, any attempt to use corkscrewing or twist steering movements in the opposite direction will be counterproductive.

10 **Push little and slowly, pull often and fast.** The challenge to the endoscopist is to progress the instrument tip without losing the view or causing the shaft to flex unnecessarily. For both reasons pushing movements should start slowly, giving time for simultaneous twist or steering movements and also allowing the endoscope to slide in (rather than just buckle and loop, as tends to happen with a rapid push). By contrast, withdrawal movements needed to straighten out loops in the shaft and colon must be vigorous to be fully effective. The commonest mistake of the less experienced endoscopist is to be overcautious in pulling back, compared to the expert who will start withdrawal movements very quickly and only slow down when the tip starts to slip back excessively, the shaft feels straighter and more responsive or the 'catapult' feel of pulling against the hooked tip becomes apparent.

11 **Be aware of the 'feel' of the straight endoscope.** For much of the insertion the colonoscope should feel as free and responsive in the fingers as a gastroscope does. The endoscopist should expect to feel the same precise and easy responsiveness to shaft movement or twist that a pool or snooker player gets from his cue. If this 'free and easy' feeling is lost, a loop has been formed and should be removed as soon as possible, for the sake of the patient's comfort and easier insertion.

12 **'Set up' bends so that steering around them is easy.** During ERCP, orientation of the endoscope tip into the midline axis is an essential preliminary to easy cannulation; similarly in upper gastrointestinal endoscopy, when passing around the greater curve to the gastric antrum and pylorus, the instrument is
made to run in the midline (see Figs 4.21 and 6.14). Similarly, the colonoscopist should, whenever possible, adjust the instrument so that an acute bend can be passed with its axis upwards or downwards (for easy thumb steering), as well as optimizing mechanical efficiency by having the colonoscope shaft straight (for better push) and the bending section not overangled (to help it slide around). A good 'racing line' is fundamental to ski and car racing and, at infinitely slower speed, is just as applicable to atraumatic flexible endoscopy.

**Sigmoid colon 'slalom' or corkscrewing technique** ▲▼

Single-handed manoeuvring is particularly useful in the multiple bends of the sigmoid, where co-ordination with an assistant can be difficult. Each of the succession of serpentine bends requires a conscious steering decision. The quicker and more accurately each decision is made, the faster the whole examination will be. It is easier to judge direction around a bend from afar, so the tip should not be rushed into it. First observe the bend carefully from a distance; it will be seen as a bright semilunar fold of mucosa against the shadowed background (Fig. 9.42). Having decided on the direction to be taken, try out in mini-movement rehearsal (a few millimetres or degrees of movement are enough) the best combination of angling and rotation needed to steer around correctly when subsequently pushing through the bend, often close-up and relatively blind. If finger rotation of the shaft is used much of the sigmoid can be traversed with little or no use of the lateral angling knob, the angled tip corkscrewing first one way and then the other round the succession of bends.

**Acute and mobile bends** ▲▼

Having angled in the correct direction, if the view is poor gently pull back the angled/hooked tip, which should simultaneously reduce the angle, shorten the bowel distally, straighten it out proximally and disimpact the tip to improve the view (Fig. 9.43). If all fails, de-angle, pull back below the bend again and re-check its direction more carefully; the colon can rotate on its attachments and the nature of bends may change during manoeuvring, any rotation being visible in close-up as a rotation of the visible vessel pattern (Fig. 9.44; Plate 9.3); watching the direction towards which the vessels rotate indicates in which direction to follow a mobile bend.

**Hook and withdraw frequently** ▲▼

As soon as an acute bend is passed and a luminal view is regained, the instrument should be withdrawn again to shorten the loop that forceful insertion will inevitably have caused. Trying to pull back repeatedly and as much as feasible (bearing in mind the small possibility of damage) after every major bend is at the basis of colonoscopy. 'Hook and withdraw' is the concept; the practicality is that steering around an acute bend automatically produces a 'hooked' tip, so the bend is the best landmark for trying withdrawal. Pulling back, especially having just pushed in, is instinctively unnatural to most endoscopists, and yet one of the most important points of technique. However much of a struggle has been involved in rounding a bend, as soon as the tip is well past it, the instrument is withdrawn until catapult-like shaft resistance is felt and the tip is beginning to slide back, indicating that the shaft is as straight as possible.

**Corkscrew during withdrawal** ▲▼

As the endoscope straightens out the tip will start to respond to shaft twist but also, if there is any spiral element, it will often advance slightly without any need to push. At any major bend try first pulling back fairly forcibly and then applying twist one way or the other. When this works it makes the most of the 3D configuration of the colon and minimizes the need to push and so form unnecessary loops. The classic expression of this pull-and-twist approach (deflating also helps) is at the sigmoid–descending
junction, where the anatomy often favours clockwise twist both to corkscrew round into the descending colon and to hold the sigmoid straight. The result is a most satisfying feeling for the endoscopist of 'getting something for nothing', quite apart from avoiding pain for the patient.

**Check the inserted shaft distance from time to time ▲▼**

As well as the responsive 'feel' of the straightened shaft, the appropriate depth of insertion for the probable anatomical location is a valuable cross-check. The straightened endoscope at the sigmoid–descending junction should be at 40–45 cm; any greater distance means that a significant sigmoid loop remains, which will make direct insertion into the descending colon more difficult than necessary. Similarly, the straight endoscope at the splenic flexure is at around 50 cm only, and the caecal pole should be at 70–80 cm.

**Avoid overangulation ▲▼**

At all times manoeuvre the instrument until the best reasonable view of the bend or lumen ahead is obtained with the minimum of angulation. Overangling into a 'walking-stick handle' position (see Fig. 9.12) inevitably means that it is going to be difficult to persuade the tip to slide around that particular bend. Taking a few seconds at any bend, even a minute or so at a major bend, to optimize the view but minimize angulation pays dividends in avoiding the need to push forcefully and the tendency to re-loop the shaft.

**If necessary push hard — but then withdraw again ▲▼**

As an absolutely last resort, if it is quite certain that the instrument is pointing in the correct direction but attempts at angling and twisting and simultaneous gentle pull or push have not given a luminal view, it is permissible simply to push blind for a few centimetres around a bend. Providing the tip is pointing correctly, it should slip gradually over the mucosa with the 'slide by' appearance of the mucosal vascular pattern traversing the field of view. Continue to push if 'slide by' continues smoothly; stop if the mucosa blanches (indicating excessive local pressure) or if the patient experiences pain (indicating undue strain on the bowel or mesentery).

Similarly, if repeated attempts at a more subtle approach have failed but the direction is certain, it may be better to warn the patient and push in calculatedly than to struggle on indefinitely or to abandon the procedure when clinical indications for it are strong. It should not be necessary to push strongly and uncomfortably like this for more than 20–30 s at the most; the instrument can then be straightened back rapidly, taking the strain off the colon and its attachments and making the patient comfortable.

**How does an 'expert' make insertion look so easy? ▲▼**

Much of sigmoidoscopy (and colonoscopy) is a matter of patience — 'two steps forward and one step back'. Impatience or relentless pushing tend to result in loops, pain and a slower examination in the end. The more experienced colonoscopist, being more careful and rational, and using less air, ends up with fewer acutely angled bends. He also steers accurately in spite of the more restricted view of an only partially inflated and shorter bowel. He is more fluent because he chooses the right combination of movements to move the tip in the desired direction, with simultaneous twist, push or pull as necessary to straighten the bowel or advance the tip, without losing control or sense of luminal direction. He slows down, or even pulls back, before an acute bend to maintain a view at all times. Whilst he does nothing fundamentally different from the beginner, there are fewer mistakes, little waste of time and effort, and the colonoscope seems magically to snake up the colon.
In the learning phase the two commonest reasons for becoming 'stuck', particularly in the sigmoid colon, are either that the instrument has become looped and jammed in a bend (it should be withdrawn as far as possible both to straighten it out and get a proper view) or simply that, having manoeuvred into the right position, the endoscopist has not the courage of experience to 'slide by' through the difficult area. Warn the patient of stretch pain and then push hard for a few seconds to get around the bend — before pulling back to straighten it out again.

Be prepared to abandon

A caveat is called for. Not every sigmoid colon can be safely intubated. Operative or peridiverticular adhesions may fix the pelvic colon so as to make the attempt impossible or dangerous. If there is difficulty, if the instrument tip feels fixed and cannot be moved by angling or twisting and the patient complains of pain during attempts at insertion, there is a danger of perforation and the attempt should be abandoned. Sometimes a different endoscope (e.g. paediatric) or another endoscopist may succeed, but only a very experienced colonoscopist with very good clinical reasons should risk the patient and instrument under these circumstances; usually the most experienced are the most prepared to stop.

Adhesions and diverticular disease

Adhesions, as after hysterectomy, cause angulation and difficulty but rarely result in failure because of the ability of the colon to straighten over the instrument. Even in severe diverticular disease, where there are the difficulties of a narrowed lumen, pericolic adhesions and problems in choosing the correct direction (Fig. 9.45a), once the instrument has been laboriously inched through the area, the 'splinting' effect of the abnormally rigid sigmoid usually facilitates the rest of the examination. In the presence of diverticular disease the secret is extreme patience, with care in visualization and steering, combined with greater than usual use of withdrawal, rotatory or corkscrewing movements. It helps to realize that a close-up view of a diverticulum means that the tip must be deflected to a right angle (by withdrawal and angulation or twist) to find the lumen (Fig. 9.45b). Using a thinner and more flexible paediatric colonoscope or gastroscope may make an apparently impassable narrow, fixed or angulated sigmoid colon relatively easy to examine — which sometimes also saves the patient from surgery.

In some patients with very hypertrophic circular musculature in diverticular disease, and redundant mucosal folds as well, it can be very difficult to obtain an adequate view. An occasionally useful trick is to distend the segment with water; the water jet has the combined advantages of being non-compressible, remaining in the dependent sigmoid colon (rather than the tendency of air to rise and distend the proximal colon) and holding the mucosal folds away from the lens to keep at least a partial view.

Sigmoid–descending junction

All colonoscopists occasionally, and the inexperienced frequently, have trouble in passing into the descending colon because, having rounded the sigmoid with panache, they probably have stretched up a large sigmoid spiral N-loop (Fig. 9.46) and created iatrogenic difficulty. An endoscopist who has been more careful, using less air and frequent withdrawals should be rewarded by a straighter or even direct passage from the sigmoid to descending colon (Fig. 9.47). On the other hand a large spiral alpha loop may be formed during insertion, intentionally or unintentionally, but nonetheless resulting in easy passage (see p. 237). So much depends on the anatomy of the particular patient that anything can happen and the colonoscopist may need all his skills and some luck to pass this region reasonably quickly and without undue pain. The sigmoid–descending colon junction is often the most difficult part of colonoscopy and the greatest challenge to the endoscopist.
Although the endoscopist may not be certain when he has reached the proximal sigmoid, the appearance of an acute bend at approximately 40–70 cm is suggestive evidence, particularly (in the left lateral position) if it is water-filled. The sigmoid–descending junction can be so acute as to appear at first to be a blind ending, especially if the bowel is overinflated. In a capacious colon there may be a longitudinal fold pointing towards the correct direction of the lumen, caused by the muscle bulk of a taenia coli (Fig. 9.48 & Plate 9.4); follow the longitudinal fold closely to pass the bend.

'Direct passage' to the descending colon ▲▼

It can prove difficult to wriggle the tip around the sigmoid–descending bend, particularly when it has been made acute by a large N-loop. As soon as the tip is even partially round these steps should be followed:

1 Pull back the shaft to reduce the loop, which creates a more favourable angle of approach to the junction and also optimizes the instrument mechanics.

2 Apply abdominal pressure, the assistant pushing on the left lower abdomen so as to compress the loop or reduce the abdominal space within which it can form.

3 Deflate the colon (without losing the view) to shorten it and make it as pliable as possible and help to relax the flap-like inner angle of the sigmoid–descending bend.

4 'Pre-steer' into the bend, the tip being steered at the mucosa just before the inner angle (Fig. 9.49), so that on pushing in the pre-steering causes the tip to slip past the angle to point straight at the lumen of the descending colon.

5 Try shaft twist in case the configuration allows corkscrewing force to be applied to the tip, which may have the very satisfying effect of swinging it around the bend with no inward push pressure required.

6 Changing the patient to the right lateral position can improve visualization of the sigmoid–descending junction (air rises, water falls) and may sometimes also cause the distal descending colon to drop down into a more favourable configuration for passage.

7 Use of force to 'push through' the loop should be the last resort. Having warned the patient to expect discomfort, a few seconds of careful 'persuasive pressure' may slide the instrument tip successfully around the bend and then allow straightening again.

'Clockwise twist and withdrawal' manoeuvre ▲▼

Once the tip is successfully hooked into the descending colon the colonoscope must be straightened to allow direct upwards passage of the shaft too. Pulling back is effective in doing this because the tip is now retroperitoneal and relatively fixed (Fig. 9.50a). An inevitable, but unwanted, consequence of pulling back is that the hooked tip will impact into the mucosa. A complex simultaneous movement is needed, combining withdrawal with tip steering towards the lumen of the descending colon (Fig. 9.50b). A wrong move at this point will lose the critical retroperitoneal fixation and the instrument will fall back into the sigmoid. Careful interpretation of the close-up view, minimal insufflation, twist, delicate steering movements and patience are all needed to pass in without re-looping (Fig. 9.50c), which results from excessive push or tip impaction. The importance of using clockwise torque rotation to prevent re-looping of the straightened instrument is such that this method of direct passage has been called by Shinya the 'right twist (clockwise) withdrawal' manoeuvre. The 3D looping of the sigmoid
colon, with both left/right and anteroposterior components creating a clockwise spiral is illustrated (Fig. 9.51) to show why twisting is so important at this stage.

*N' or spiral sigmoid looping

Some degree of looping of the endoscope in the sigmoid is unavoidable. The usual N-loop in the sigmoid colon can be anything from a minor deviation (which may, however, be fixed and not straightenable) following hysterectomy or previous diverticulitis, to a huge loop reaching towards the diaphragm in some patients with a redundant or megacolon. The exact shape will vary from moment to moment according to the constraints of the abdomen, the mesenteries and the activities of the endoscopist propelling or twisting the colonoscope. Although based on its typical anteroposterior fluoroscopic appearance, the loop is conventionally described as an N-loop; it is actually a 3D spiral of which the N-type is mainly rotated to occupy the left side of the abdomen, whilst the alpha-type is rotated more to the right side. Most N-loops can eventually be straightened out completely by including a degree of forcible twisting (usually clockwise) to assist in undoing the spiral element. For shorter loops it is worth attempting this during passage through the sigmoid colon, or certainly when the sigmoid–descending junction is reached, so as to attempt direct or 'straight scope' passage to the descending colon, as described above.

With a longer colon, complete removal of the N-loop may be difficult until the instrument tip has reached nearly to (or around) the splenic flexure, so as to give adequate purchase at the bending section, for forcible withdrawal. With some colons that seem to have no acute bends to angle around, it may even be necessary to fix both control knobs in maximum angulation, simply wedging the tip against the colon wall to get a hold and allow straightening without slippage. However, as for direct passage, manual pressure by the assistant in the left lower abdomen will often help by reducing or minimizing the size of the loop (see Fig. 9.28), acting as a buffer to transmit some of the inward push on the shaft laterally towards the descending colon. If the assistant can actually feel the loop, the objective is to reduce it back towards the pelvis (i.e. with downward, as well as inward, pressure). Although it is worth the endoscopist trying one or two withdrawal movements to shorten the N-loop, especially near the apex of the sigmoid colon but also at any obvious fold or bend which allows 'hooking', often there is little to be done until the sigmoid junction is reached and an attempt can be made at the 'clockwise twist and withdrawal' manoeuvre, described above.

The troublesome N-loop

Most of the difficulties experienced later in the examination whilst passing the proximal colon (splenic flexure, transverse colon and hepatic flexure) also stem from recurrent or persistent N-looping in the sigmoid. This removes the motive power of the endoscopist's inward push unless the loop can be avoided, removed or at least minimized. It is for this reason that repeated straightening, clockwise shaft twist and assistant hand pressure over the sigmoid colon can still be important when inserting through the proximal colon. N-looping is also the major cause of pain during colonoscopy.

Pain in the sigmoid

Remember that if the patient experiences excessive pain there is a potential danger of damage to the bowel or mesentery. In the longest colons there may be a sufficient length of sigmoid colon and mesentery to let the instrument loop below the sigmoid–descending junction and to pass relatively easily into the descending colon without the acute hairpin bend usually formed when an N-loop is present (Fig. 9.52). Having to use force or cause pain is inelegant and to be avoided if possible. However, it may be preferable for the patient to suffer briefly and get the instrument into the descending colon quickly and successfully rather than to struggle on and on with repeated failed
attempts at gentle passage, particularly as the analgesic effects of i.v. pethidine diminish considerably by about 5 min after administration. Before using force, and at any stage during colonoscopy when pushing in may cause pain due to looping, the patient is warned beforehand (e.g. 'this will hurt for a few seconds, but there is no danger'). Inward push should also be applied gradually, avoiding any sudden shoves and should be limited to a tolerable time — no more than 20–30 s. Looping pain stops at once when the instrument is withdrawn slightly. There is no excuse for long continued periods of pain, even in those miserable examinations when recurrent looping cannot be avoided.

The alpha loop and manoeuvre

When the colonoscope is passed through the sigmoid colon it can form spontaneously into the configuration known as an alpha loop (Fig. 9.53). From the endoscopist's point of view, the formation of an alpha loop is a blessing, as there is no acute bend between the sigmoid and descending colon and the splenic flexure can always be reached. If, during insertion, no particularly acute flexure is encountered in the sigmoid colon and the instrument appears to be sliding in a long way without problems or acute angulations, it can be suspected that an alpha loop is being formed. If so (especially if confirmed on fluoroscopy or the imager) it is better to spend a little time and care passing to the proximal descending colon or splenic flexure at 90 cm (sometimes even around the splenic flexure into the transverse colon) before trying any withdrawal/straightening manoeuvre. Straightening half-way round an alpha loop can cause the alpha configuration to flop across and form back into the more difficult N-loop.

The alpha manoeuvre is the intentional formation of an alpha loop. This was originally always performed using fluoroscopy and was an important dodge in the 1970s when first colonoscopes would only angulate 90° or less, making it sometimes impossible to steer around into the descending colon. If the colon is known to be long or feels long and mobile during normal insertion into the distal sigmoid colon, it is worth trying to make an alpha loop so as to avoid the greater problems of an N-loop. The principle is to twist the sigmoid colon around into a partial volvulus (see Fig. 9.31), which is easy to demonstrate but difficult to explain. As soon as the instrument is felt to be angling upwards into the distal sigmoid colon at around 15–20 cm from the anus (Fig. 9.54a), start to rotate the shaft firmly counterclockwise at every opportunity, so that the angled tip swings anteriorly across the pelvic brim to point towards the caecum, pulling the sigmoid colon across with it (Fig. 9.54b). Continue the insertion through the sigmoid with as much counterclockwise twist as possible at all stages and avoid clockwise twist (so that the loop does not swing back to the 'N'-position). Equally, do not withdraw or attempt to straighten the shaft (even if the patient has mild stretching pain) but push (Fig. 9.54c) and steer carefully until the tip has passed through the fluid-filled descending colon to the splenic flexure, reached at 90 cm (Fig. 9.55).

It is not always possible to achieve the alpha manoeuvre. Endoscopists who claim 'always' to do so are shown, when they demonstrate their technique under fluoroscopy, equally often to form an unrecognized N-loop, which they pass with elan (and extra sedation because of the pain). A short or fixed sigmoid mesocolon probably prevents the formation of an alpha loop; thus patients with diverticular disease or any other cause of pericolic adhesions are not suitable for the manoeuvre, and are most unlikely to form a spontaneous alpha loop.

Straightening an alpha loop

Any loop puts some stress and limitation on tip angulation due to friction in the control wires, as well as often being uncomfortable for the patient, so it is logical to remove the alpha loop at some stage. Opinions differ concerning the correct time to do so. With current very flexible and full-angling
instruments, it is occasionally better to attempt to pass straight on into the proximal transverse colon with the alpha loop in position rather than to straighten it at the splenic flexure and then have difficulty with re-looping.

Most colonoscopists prefer to straighten out the alpha loop as soon as the upper descending colon is safely reached and to pass the splenic flexure with a straightened instrument. However, every colonoscopist has also experienced the chagrin of struggling to reach the descending colon and the frustration of seeing the tip slide back out of the descending colon when an attempt is made, too early, to withdraw and straighten the shaft. A reasonable compromise is to pass the tip up to, but not necessarily around, the splenic flexure at about 90 cm and then to take care that it does not slip back excessively during removal of the alpha loop. If fluoroscopy is used the whole alpha loop cannot be seen in one fluoroscopic field and the best plan is to centre the view over the point where the looped shaft crosses itself. If the instrument is seen to be slipping back too far down the descending colon, it is quickly advanced again and the tip hooked or wedged around the splenic flexure for extra support before repeating the straightening manoeuvre.

The alpha loop is straightened by combined withdrawal and clockwise derotation. Slightly withdrawing the shaft initially reduces the size of the loop and makes derotation easier, but the tip can start to slide down the descending colon; derotation alone will undo the alpha volvulus of the sigmoid into the 'N' position, but does not reduce the size of the loop. The two actions must be combined by simultaneously pulling back and twisting the whole instrument (Fig. 9.56). Strong clockwise twist during straightening will tend to push the tip up towards the splenic flexure and any tendency of the tip to slip back can usually be stopped by applying more twist and less pull. Twisting forces are not harmful to the colonoscope.

Again there is a caveat. Derotation should be easy and atraumatic; if straightening the loop proves difficult or the patient has more than the slightest discomfort the situation should be re-assessed. Adhesions can make derotation difficult and occasionally impossible. Do not use force. The sigmoid loop that has formed may not be a true alpha loop but a 'reversed alpha', which can form when there is persistent descending mesocolon and freely mobile left colon (see Fig. 9.33). This reversed loop may need counterclockwise derotation during straightening and, in the absence of imaging, the endoscopist must judge this by feel (and results).

Loops in the external shaft and umbilical ▲▼

Having rotated the colonoscope 180° or more in the process of straightening an alpha loop, and probably having made previous clockwise twisting movements as well, it is likely that there will be a resultant loop in the shaft external to the patient. Because of the negative effect that this has on instrument handling, it is my practice to rotate the control body to transfer this loop to the umbilical (see Fig. 9.20) and keep the external shaft straight at all times. Several loops can be accommodated in the umbilical without harm, but sometimes it may be necessary to unplug the instrument from the light source and unravel the umbilical. The alternative for the dexterous, and if the instrument is straight, is to derotate the external shaft loop whilst steering the tip into the lumen so that the colonoscope rotates on its axis within the colon; however, if the shaft is not straight the instrument tends to slip back in the process.

Descending colon ▲▼

The conventional descending colon is normally traversed in a few seconds as a 20 cm long 'straight'. For the gravitational reasons described above, when the patient is in the left lateral position, there is
characteristically a horizontal fluid level within it (Fig. 9.57). Often there is sufficient air interface above the descending colon fluid (or blood in emergency cases) so that the tip can be steered above it. If fluid makes steering difficult, it may be quicker, rather than wasting time suctioning and re-inflating, to turn the patient onto the right side to fill the descending colon with air. Apart from this positional trick, and the frequent use of clockwise twist or hand pressure to minimize sigmoid colon re-looping, no particular skills or manoeuvres are needed in the average descending colon. Sometimes the descending colon is far from straight and the endoscopist, having struggled through a number of bends and fluid-filled sumps believes the tip to have reached the proximal colon when it is in fact only at the splenic flexure.

**Distal colon mobility and 'reversed' looping ▲▼**

In the absence of the normal fixation of the descending colon, all normal control and sense of anatomy can disappear; at the most extreme, the colonoscope may run through the 'sigmoid' and 'descending' distal colon straight up the midline (see Fig. 9.32), resulting inevitably in a 'reversed splenic flexure' and consequent mechanical problems later in the examination.

The endoscopist is alerted to the probability that there is partial fixation, with a descending mesocolon allowing the descending colon to deviate medially when *counterclockwise* rotation seems to help insertion at the sigmoid–descending junction. This indicates that an unconventional counterclockwise spiral loop or 'reversed alpha' has been able to be formed by the instrument (see Fig. 9.33), with the corollary that other oddities may occur during insertion. If possible, the endoscopist tries to use this counterclockwise twist and the springiness of the colonoscope shaft to push the mobile descending colon outwards against the lateral margin of the abdominal cavity. This regains the conventional configuration so that the instrument runs medially (rather than in reverse) around the splenic flexure, and is able to adopt the favourable question-mark shape to reach the caecum. Such apparently mysterious manipulations are understandable to anyone who has done colonoscopy under fluoroscopic control or used the electromagnetic imager; they can also be achieved, unknowingly, by an experienced endoscopist without these aids by the simple expedient of responding to the 'feel' of the endoscope, and empirically using whichever twisting movement (in this case counterclockwise) makes the instrument insert most easily.

**Splenic flexure and transverse colon ▲▼**

**Endoscopic anatomy ▲▼**

*The descending colon*, after running up the paravertebral gutter, bends medially and anteriorly around the splenic flexure. The splenic flexure is situated beneath the left costal margin, and so is inaccessible to hand pressure. Its position is variably fixed according to the degree of mobility of the fold of peritoneum called the phrenicocolic ligament, which attaches it to the diaphragmatic surface (Fig. 9.58). In some subjects the splenic flexure is relatively tethered up into the left hypochondrium, in others it is relatively free and can be pulled down towards the pelvis (Fig. 9.59). A lax phrenicocolic ligament, a common feature of redundant colons, makes control of the transverse colon difficult by depriving the endoscopist of any fixed point or fulcrum with which to exert leverage during withdrawal manoeuvres (the cantilever or 'balance beam' effect). The configuration of the splenic flexure is also affected by the patient's position, principally because of the effects on it of the transverse colon, sagging down in the left lateral position but pulling on it in a right lateral position (see Fig. 9.66).

The *transverse colon*, which lies anteriorly just beneath the abdominal wall, is held forward by the vertebral bodies, the duodenum and pancreas and relates to the left and right lobes of the liver
(Fig. 9.60). It is enveloped in a double fold of peritoneum called the transverse mesocolon (Fig. 9.61) which originates from the posterior wall of the abdomen and hangs down posterior to the stomach, varying considerably in length. In a barium enema study, the transverse colon of 62% of females drooped down into the pelvis, compared to only 26% of males. This longer transverse loop largely accounts for the 10–20 cm greater mean colon length found in women despite their smaller stature (total colon length was 80–180 cm) and probably also contributes to our experience that 70% of difficult colonoscopies are in females (previous hysterectomy making only a small contribution). The depth of the looped transverse colon also affects the angle at which the endoscope approaches the hepatic flexure, in the same way that the size of the sigmoid colon loop causes an acute sigmoid–descending bend. Because the transverse mesocolon (Fig. 9.62a) is broad-based it does not usually allow a gamma loop to form (Fig. 9.62b). From an anatomical and endoscopic viewpoint, the hepatic flexure is a nearly 180° hairpin bend, similar in many respects to the bend at the sigmoid–descending junction but more constant in its fixation and more voluminous.

The characteristic triangular configuration of the transverse colon (Fig. 9.63 and Plate 9.5) depends on the relative thinness of the circular muscles compared to the longitudinal muscle bundles of the taeniae coli (Fig. 9.64). In some patients (such as those with longstanding colitis but also some normals) the circular musculature is thicker and the transverse colon can be tubular. Both at the mid-transverse flexure and at the hepatic flexure a true 'face-on' view may be obtained of the haustral folds, which present a characteristic knife-edge appearance (Fig. 9.65); it is therefore easy to confuse the mid-transverse flexure with the hepatic flexure. The mid-transverse bend should be less voluminous, show no blue liver patch and may show transmitted cardiac or aortic pulsation; it can also be distinguished by imaging, local palpation of the anterior abdominal wall or transillumination (if the room is darkened).

**Insertion ▲▼**

The splenic flexure represents the 'half-time' point during colonoscopy and is an excellent moment at which to ensure that the instrument is properly straightened to 50 cm from the anus and under control before tackling the proximal colon. The commonest reason for experiencing problems in the proximal colon is because the colonoscope has been inadequately straightened at the splenic flexure; persistence of loops make the rest of the procedure progressively more difficult or impossible. If the splenic flexure is passed with straight shaft configuration at 50 cm using the above rules, the rest of a total colonoscopy insertion should usually be finished within a minute or two. Anyone who frequently finds the proximal colon or hepatic flexure difficult to traverse should apply the '50 cm rule' at the splenic flexure, and is likely to find most of the problem solved.

Passage of the splenic flexure is usually obvious when the instrument has passed around the apex of the splenic flexure, because it emerges from fluid into the air-filled, often triangular, transverse colon (see Fig. 9.63 & Plate 9.5). However, whilst the flexible and angled tip section of the colonoscope passes around without effort, the stiffer segment at 10–15 cm at the leading part of the shaft does not follow so easily. This problem is accentuated in the left lateral position, because drooping of the transverse colon causes the splenic flexure to be acutely angled (Fig. 9.66a) compared to its configuration when opened out by gravity in the right lateral position (Fig. 9.66b).

To pass the splenic flexure, without force or re-looping, follow these rules:

1. Ensure that the colonoscope is truly straight and therefore mechanically efficient. Pull back with the tip hooked around the flexure until the instrument is 40–50 cm from the anus, which both straightens any sigmoid loop and pulls down and rounds off the flexure. Note that splenic avulsions or capsular tears have been reported, so be gentle.
2 Avoid overangling the tip. Full angulation of a colonoscope can result in the bending section effectively impacting in the splenic flexure, preventing further insertion (the 'walking-stick handle' effect). Having obtained a view of the transverse colon and pulled back, consciously de-angulate a little so that the instrument runs around the outside of the bend (see Fig. 9.12), even if this means worsening the view somewhat — but avoid the tip impacting in the haustral folds.

3 Deflate the colon slightly to shorten the flexure and make it malleable.

4 Apply assistant hand pressure over the sigmoid colon. Any resistance encountered at the splenic flexure is likely to result in stretching upwards of the sigmoid colon into an N- or alpha loop, which dissipates more and more of the inward force applied to the shaft as the loop increases (Fig. 9.67). It is immediately obvious to the single-handed endoscopist that such a loop is forming, because the 1:1 relationship between insertion and tip progress is lost — in other words, the shaft is being pushed in but the tip moves little or not at all. Pull back again to re-straighten the shaft if this occurs.

5 Use clockwise torque on the shaft. As explained above, the clockwise spiral course of the sigmoid colon from the pelvis to its point of fixation in the descending colon means that applying clockwise torque to the colonoscope shaft tends to counteract any looping tendency in the sigmoid colon whilst pushing in (Fig. 9.68). Clockwise torque will only be effective on the shaft if the colonoscope has previously been straightened, if the descending colon is normally fixed and if any sigmoid loop is small. (Because the tip is angulated, applying clockwise shaft torque inevitably loses or affects the luminal view into the transverse colon, and readjustment of the angling controls may be needed).

6 Finally, push in, but slowly. Obviously the instrument tip will not advance around the splenic flexure without inward push, so as well as clockwise twist, continued gentle inward pressure is needed (aggressive pushing simply reforms the sigmoid loop). Firm, but nearly isometric, inward pressure on the shaft causing a gradual millimetre-by-millimetre slippage of the tip into the transverse colon is all that is needed for success. Whilst pushing in it may be possible to deflate again, or it may be necessary to make compensatory movements of the steering controls. A combination of these various manoeuvres, together or in sequence, whilst using the control knobs to 'squirm' the bending section, or the suction button to aspirate a little more, may help the tip and the stiffer shaft behind it to slide around the splenic flexure.

7 If it does not work, pull back and start again. If the tip is not progressing but, from the amount of shaft being inserted, it is obvious that a sigmoid loop is reforming, pull back, run through all the above actions again before pushing in once more. It may take two or three attempts to achieve success.

Position change ▲▼

If it still does not work, change position. As pointed out earlier, the left lateral position used by most endoscopists has the undesirable effect of causing the transverse colon to flop down (see Fig. 9.66a) and make the splenic flexure acutely angled. Turning the patient to the right lateral position has the opposite effect, the transverse colon sags to the right side and, together with gravity, pulls the splenic flexure into a smooth curve without any apparent 'flexure' at all (see Fig. 9.66b). Even having the patient turn supine has a significant gravitational effect and, since this is an easier move to make, is worth trying before a fully-fledged right lateral move.

The first angulation encountered by the instrument on passing round the splenic flexure, after a change to the right lateral position, is usually the mid-transverse colon or even the dependent and fluid-filled hepatic flexure. Change of position is almost invariably and immediately effective in passing the
splenic flexure, but it does take a few seconds to achieve, and the patient has to be returned to the left lateral position to inflate and visualize the proximal colon properly and to reach the caecum. It is also cumbersome if the patient is obese, disabled or oversedated. We therefore change position if ‘stuck’ at the splenic flexure for over 60 s or so, allowing several attempts at direct passage, first in the left lateral position, then the supine, before full rotation to the right. The ability to perform postural changes easily is an additional reason for reducing routine sedation (or avoiding it altogether when possible).

Position changing should be a simple routine. Except for heavily sedated or otherwise immobile patients, position change can be quick and effortless. It helps to have a routine. Mine (CBW) involves changing to hold the instrument control body in the right hand, the endoscopist's left hand lifts the patient's lowest foot off the couch, the shaft is slid through to the other side and the patient can then turn over. Providing the shaft is kept away from the patient's heel (and perhaps rotated a little as the body rotates) there is nothing to go wrong and the whole manoeuvre takes at most 20–30 s.

The stiffening or 'overtube'

If all this fails (perhaps one case in 500–600 in our hands) use of a stiffening overtube, sometimes called a 'splinting device', is almost guaranteed to hold the sigmoid colon straight and allow easy passage into the proximal colon. An overtube can only be inserted when the sigmoid colon has been completely straightened and the tip of the instrument is in the proximal–descending colon or splenic flexure.

The original, extremely stiff wire-reinforced overtubes had disadvantages which have discouraged most endoscopists from using them routinely; the tube must be on the instrument before starting (or the endoscope completely withdrawn before it can be put on) and insertion can be traumatic and requires fluoroscopy. The principle of a soft-plastic split overtube overcomes all of these disadvantages, especially new atraumatic versions made of frictionless and very flexible plastic material (Gortex, Olympus). The split overtube is softened in hot water and placed over the shaft of the colonoscope after this has been straightened to 50 cm at the splenic flexure (Fig. 9.69a). The overtube split is sealed with adhesive tape and lubricated with jelly (Fig. 9.69b), then inserted (without fluoroscopy) as far into or through the shortened sigmoid colon as proves easy and comfortable for the patient (Fig. 9.69c).

Resistance to insertion of an overtube means impaction against a fold, loop or flexure and discomfort means the same — both are indications that further insertion or use of force could be dangerous (the same rules apply even when fluoroscopy is used). The tube is 45 cm long to accommodate long colons, but 'successful' insertion is usually only to around 30–40 cm, the handle of the overtube then being held by the assistant and the shaft of the colonoscope pushed in through it (Fig. 9.70). As soon as the colonoscope has been passed in satisfactorily (or at once if the overtube cannot be inserted successfully) it takes only a few seconds to remove the split overtube again, strip off the tape and to return to normal handling of the instrument.

As well as its use for stiffening a looping sigmoid colon, the overtube can be invaluable for exchanging colonoscopes or removing multiple polypectomy specimens.

The 'reversed' splenic flexure

In about one patient in 20, if imaging is available, the instrument tip will be seen to pass laterally rather than medially around the splenic flexure, because the descending colon has moved centrally on a mesocolon (Fig. 9.71) (see p. 209). This is of more than academic interest because, having passed laterally round the flexure and displaced the descending colon medially, the advancing instrument
forces the transverse colon down into a deep loop. The instrument is then mechanically under stress and
difficult to steer, and the hepatic flexure is approached from below at a disadvantageous angle which
makes it difficult to reach the caecum and virtually impossible to steer into the ileocaecal valve. Even
when the instrument tip can be hooked onto the hepatic flexure, the sheer bulkiness of the reversed loop
configuration at the splenic flexure actively holds down the transverse loop and stops it being
straightened and lifted up into the ideal 'question-mark' shape.

Derotation of a reversed splenic flexure loop will avoid these problems later in the examination. This
can be done by twisting the shaft strongly counter-clockwise (rather than the usual clockwise twist),
usually after withdrawing the tip to the splenic flexure; the subsequent examination is so much quicker,
and also more comfortable for the patient, that the time spent is worthwhile. Counterclockwise
derotation makes the tip pivot around the phrenicocolic suspensory ligament and swing medially
(Fig. 9.72a). After that, by maintaining counterclockwise torque while pushing in, the instrument can be
made to pass across the transverse colon in the usual configuration, forcing the descending colon back
laterally against the abdominal wall (Fig. 9.72b).

Although this counterclockwise straightening manoeuvre is most easily performed under imaging, it is
also quite feasible without fluoroscopy, using these guidelines and a little imagination whenever
atypical looping is suspected in the proximal colon. A reversed splenic flexure/mobile descending
colon is the most frequent reason for an unexpectedly difficult adult or paediatric colonoscopy. It
happens more commonly in children due to the relative elasticity of the attachments of the colon in
childhood. Sometimes the best solution, if the problem is suspected but imaging is not available and
attempts at counterclockwise derotation have failed, is simply to get a move on, push harder than usual
(if necessary with extra sedation) and to stop as soon as a reasonable view of the right colon has been
obtained. If a reversed splenic loop is present, for the reasons given above, it is rare to be able to enter
the ileum without successful derotation, because the looped and stressed instrument will not angulate
sufficiently. If ileoscopy is essential and a reversed loop is present it is likely to be necessary to pull the
instrument out to 50 cm at the splenic flexure, attempt counterclockwise derotation and pass in again;
simply trying to angulate the tip forcibly without doing so is likely to stress the bending section, but not
to succeed.

Transverse colon ▲▼

Insertion through the transverse colon should present little problem if the sigmoid colon does not bow
up into an N-loop and so reduce the transmitted pressure, but in the mid-transverse colon there is often
a surprisingly sharp bend where the colonoscope tip can push downwards into the pelvis. A drooping
transverse colon, frequently found in females and those with long colons, inevitably results in greater
friction resistance to passage; the force required then results in sigmoid looping as well. This
combination can be a major obstacle to those who have not learned to shorten and control colonic
loops.

In a voluminous transverse colon the antimesenteric taeniae coli may infold into the colon, acting as a
useful pointer to the correct longitudinal axis to follow — rather like the white line down the centre of a
road (Fig. 9.73 & Plate 9.4). Appreciating this is particularly helpful at acute angulations, where a
taenia coli can be followed blindly to push round the bend and see the lumen beyond (Fig. 9.74).

Having passed the mid-point of the transverse, it may be slow and difficult to 'climb the hill' up the
proximal limb of the looped transverse colon (Fig. 9.75a). The most important manoeuvre is to pull
back repeatedly. The tip, being hooked around the transverse loop, lifts up and flattens the transverse
(Fig. 9.75b) and the tip often advances as the shaft is withdrawn — the phenomenon of 'paradoxical
movement'. Substantial and repeated in-and-out movements (like playing a trombone) may be needed, the instrument advancing little by little towards the hepatic flexure. Hand pressure can be helpful, whether over the sigmoid colon during inward push or in the left hypochondrium to lift up the transverse loop. Deflation of the colon, torquing movements and even change of position (usually to the left lateral position, sometimes to the supine, right lateral or even prone positions) can all also help. When the tip is established in the proximal transverse colon counterclockwise torque often helps it to advance towards the hepatic flexure; this useful phenomenon results from flattening out of the counterclockwise spiral formed by the shaft running anteriorly and medially around the splenic flexure from the descending colon to the transverse colon.

Effect of a mobile splenic flexure

During these 'lift' manoeuvres, the fulcrum or cantilever effect (sometimes called 'balance beam' effect) of the phrenicocolic ligament fixing the splenic flexure is crucial. In some patients this attachment is lax, allowing the splenic flexure to be pulled back to 40 cm (rather than the usual 50 cm) (Fig. 9.76a); the colon is then found to be hypermobile and unresponsive to any of the normally effective withdrawal or twisting movements (Fig. 9.76b). When this occurs the use of force is ineffectual, but deflation, hand pressure, posturing (usually to the right lateral position) and gentle perseverance will eventually coax the tip up to the hepatic flexure.

Gamma looping of the transverse colon

In occasional patients with a very redundant transverse colon, the formation of a spontaneous gamma loop can be seen (Fig. 9.77); this is rarely removable because the instrument falls back when withdrawn. If it is removed, this is by combined withdrawal and strong clockwise twist to lift up the transverse colon into a more conventional position. It is usually impossible to enter the ileocaecal valve with a gamma loop in position, since friction stops the instrument tip angulating sufficiently.

Hand pressure

Since the major mechanical problem of colonoscopy is to stop the flexible shaft of the scope looping within the confines of the abdominal cavity, and to encourage it by any means to proceed straight onto the caecum in an easy curve (the 'question-mark' configuration), it is scarcely surprising that external hand pressure is valuable. The rationale for pressure in the lower left abdomen over the looping sigmoid colon has been described (see Fig. 9.67). The tendency of the sigmoid to re-loop at all stages of the examination has also been mentioned. Because of this tendency, hand pressure over the sigmoid colon is a good bet whenever the instrument is looping, and its application has therefore been called 'non-specific' hand pressure.

Other loops also cause problems which can be reduced by appropriate hand pressure, notably the drooping of the transverse colon into a deepening loop which results in 'paradoxical movement' so that the tip slips back more and more as the instrument shaft is pushed in. Pulling back when this occurs reverses the slippage, so that the tip approaches the hepatic flexure again and aspiration collapses the colon and brings it nearer still. At this point changing the assistant's hand pressure empirically to the left hypochondrial region to lift the loop and the tip across the abdomen towards the hepatic flexure, or in the mid-abdomen to counteract the sagging transverse colon, can be the final critical additive action to reach the flexure (Fig. 9.78). When such hand pressure fails to help, in the transverse colon or elsewhere, it is well worth the endoscopist optimizing both the view and the position of the instrument (by push, pull, rotation, deflation, angulation, etc.) and then either the endoscopist or assistant palpating the patient's abdomen with the other hand to attempt to push the tip further in. This manoeuvre has been called 'specific' hand pressure. At any time in the proximal colon that a few extra centimetres of
insertion are needed, but cannot be achieved, try abdominal hand pressure, first 'non-specific' (in the left lower abdomen) but, if this fails, 'specifically' according to the results of local palpation.

Hepatic flexure

One of the most frustrating problems for the colonoscopist is to be able to see the hepatic flexure but not be able to reach it. If the flexure is only 2–3 cm away in spite of a reasonably straight colonoscope (around 70–80 cm), hand pressure and clockwise torque, there is a sequence of actions which should ensure rapid passage around the hepatic flexure:

1 **Assess from a distance** the correct direction around the flexure for, after the tip reaches into it, it will be so close to the opposing mucosa that it is very difficult to steer except by a predetermined plan. At all costs avoid impacting the tip forcibly against the opposing wall or it will catch in the haustral folds and there will be no view at all.

2 **Aspirate air carefully** from the inflated hepatic flexure, to collapse it towards, but not actually onto, the tip as it moves around (Fig. 9.79).

3 **Steer the tip blindly in the previously determined direction** around the arc of the flexure. Since the hepatic flexure is very acute, it takes some confidence to angulate nearly 180° around in the same direction without seeing well (Fig. 9.80). Use both angling control knobs simultaneously to achieve full angulation; adding clockwise twist may be helpful.

4 **Withdraw the instrument** substantially for up 30–50 cm to lift up the transverse colon and straighten out the colonoscope (Fig. 9.81a,b) for passage into the ascending colon.

5 **Aspirate air again** once the ascending colon is seen, in order to shorten the colon and drop the colonoscope down towards the caecum (Fig. 9.81c).

In practice, a combination of these manoeuvres is used simultaneously, so that aspiration brings the hepatic flexure towards the tip until the inner fold of the flexure can be passed, the colonoscope is withdrawn (either by manipulation of the shaft or by the endoscopist pulling the colonoscope out, using both hands on the control body simultaneously working both angling controls) whilst the tip is steered maximally around until it can be sucked down into the ascending colon. A parallel has already been drawn between the 'hook, withdraw and clockwise twist' situation in the transverse loop and hepatic flexure and the 'right twist and withdrawal' method of shortening the sigmoid N-loop at the sigmoid–descending colon angle; the same instrument manoeuvres apply to both, except that they must be exaggerated at the hepatic flexure because of its larger dimensions.

When things do not go according to plan, other tricks which help coax the colonoscope tip into and around the hepatic flexure, apart from pressing in the left hypochondrium to lift the transverse colon, are to get the patient to inspire deeply (to lower the diaphragm and thus the hepatic flexure too), to use the split overtube to control the sigmoid colon or to change position (to supine, prone or sometimes even right lateral positions) if the usual left lateral position has been ineffective. Using brute force rarely pays off, since the combined sigmoid and transverse colon loops can take up most of the length of the colonoscope shaft. With the instrument really straightened at the hepatic flexure, only about 70 cm of the shaft should remain in the patient; this is one of the situations where a distance check helps to ensure a straight colonoscope and to result in easy and painless insertion.

A final, embarrassing, point is that if things are not working out at the hepatic flexure after applying the
various tips, the colonoscope may actually still be in the splenic flexure. In a redundant colon it is possible to be over-optimistic and hopelessly lost.

**Ascending colon and ileocaecal region ▲▼**

**Endoscopic anatomy ▲▼**

The ascending colon is posteriorly placed at its origin from the hepatic flexure, but then runs anteriorly so that where it joins the caecum it is just under the anterior abdominal wall and is accessible to finger palpation or transillumination. In 90% of subjects, the ascending colon and caecum are predictably fixed retroperitoneally but the remainder may be mobile on a persistent mesocolon, with correspondingly variable positions.

At the pole of the caecum the three taeniae coli fuse down into the appendix (Fig. 9.82); between the taeniae coli and the marked caecal haustra there can be cavernous outpouchings which are difficult to examine. The appendix orifice is normally an unimpressive slit (Plate 9.6), which is often crescentic because the appendix is folded around the caecum. Only rarely is the appendix orifice tubular, and it may be unobvious in a local whirl of mucosal folds. The operated appendix usually looks no different unless it has been invaginated into a stump, when it can sometimes resemble a polyp (take care — by all means take a biopsy but do not attempt polypectomy!).

The ileocaecal valve is situated on the medial part of the prominent ileocaecal fold which encircles the caecum about 5 cm from its pole. Unfortunately for the endoscopist, the orifice of the valve is often a slit on the invisible 'caecal' aspect of the ileocaecal fold. The most the endoscopist normally sees is the slight bulge (Plate 9.7) of the upper lip — much as the mouth would look if seen by an endoscope emerging from the nose. It is therefore rare to see the orifice directly without specific close-up manoeuvres.

**Insertion ▲▼**

On seeing the ascending colon from around the hepatic flexure the temptation is to push in, but this usually results in the transverse loop re-forming and the tip sliding back. The secret is to deflate; the resulting collapse of the capacious hepatic flexure and ascending colon will drop the tip downwards towards the caecum (see Fig. 9.81c); it also lowers the position of the hepatic flexure relative to the splenic flexure and with this mechanical advantage, pushing inwards should become effective. Make short aspirations and steer carefully down the centre of the deflating lumen, then push the last few centimetres into the caecum. If it proves difficult to reach the last few centimetres to the caecal pole, change the patient's position to prone (even a partial position change may help) or, if that does not work, to supine. Once in the caecum, the bowel can be reinflated to get a view.

The caecum can be voluminous and its pronounced haustral infoldings and tendency to spasm may make it confusing to examine. In particular, it is possible to be mistaken about whether the pole has actually been reached. One catch is that the ileocaecal valve fold, the major circumferential fold at the junction of the ascending colon and the caecum — on which is situated the give-way bulge of the valve — has a tendency to be in tonic spasm. The fold in spasm can easily be mistaken by the unwary for either the appendix orifice or the ileocaecal valve. Insufflating and pushing in with the instrument tip and/or using extra intravenous antispasmodic medication will reveal the cavernous caecal pole beyond.

The endoscopist should therefore be very careful about assuming that true 'total colonoscopy' has been performed. The appendix orifice or ileocaecal valve should be identified as landmarks, with or without
imaging; also use right iliac fossa transillumination (Fig. 9.83) or finger palpation indenting the caecal region (Fig. 9.84) to confirm location of the tip. At the same time the colonoscope should, after withdrawal, be at 70–80 cm. The caecal pole is often difficult to examine, is not always completely clean and is sometimes in tonic spasm; a 'too good to be true' appearance may therefore actually be only the ascending colon or even the hepatic flexure. Inability to locate the ileocaecal valve opening and noting that the shaft distance on withdrawal is only at 60–70 cm should warn of this possibility.

**Entering the ileocaecal valve ▲▼**

First find the valve. Pull back about 8–10 cm from the caecal pole and look for the first prominent circular haustral fold, around 5 cm back from the pole; somewhere on this 'ileocaecal' fold will be the tell-tale thickening or bulge of the valve. A common mistake is to look for the valve when the endoscope tip is in the caecal pole, rather than pulling back to the mid-ascending colon to get a proper overall view from a distance. Looking at this ileocaecal fold, with the caecum moderately inflated, one part of it should be seen to be less perfectly concave than the rest. It may be simply flattened out, bulge in (especially on deflation, when it often bulges more obviously and may bubble or issue ileal contents), show a characteristic 'buttock-like' double bulge or, less commonly, have obvious protuberant lips or a 'volcano' appearance (Fig. 9.85 & Plate 9.7). It is rather uncommon to see the actual slit orifice or pouting lips of the valve straight on, because the opening is normally on the caecal side of the ileocaecal fold. The best the endoscopist can usually achieve is a partial, close-up and tangential view, and only often after careful manoeuvring. Change of patient position may be helpful if the initial view is poor or disadvantageous for tip entry.

Consider pre-inserting the biopsy forceps to the instrument tip, especially if an ileal biopsy may be required. The forceps will insert easily when the endoscope is straight in the ascending colon, but may not do so at all (or only with undesirable force) when the tip is angulated into the ileum. It is particularly aggravating to have to withdraw back out of the ileum to insert the forceps if it has been a struggle to get in — and the forceps can in any case be helpful in this, as described below.

After these preliminaries there are three ways to enter the ileocaecal valve.

**Direct entry with the instrument tip. ▲▼**

To do this there is a sequence of actions to follow so as to angle in towards the valve and enter it:

1. **Rehearse at a distance** (about 10 cm back from the caecal pole) the easiest movements, preferably combining shaft twist and down-angulation to point the tip towards the valve (Fig. 9.86a). If possible rotate the endoscope so that the valve lies in the downward (6 o'clock) position relative to the tip, because this allows entry with an easy downwards angulation movement (lateral or oblique movements are awkward single-handedly) and because the tip air outlet is situated below the lens, but needs to enter the valve first in order to open up the ileum on insufflation.

2. **Pass the colonoscope tip in** over the ileocaecal valve fold in the region of the valvular bulge and angle in towards the valve (Fig. 9.86b). Overshoot a little, so that the action of angling directs the tip into the opening, not short of it.

3. **Deflate the caecum partially** to make the valve supple (Fig. 9.86c).

4. **Pull back the scope, angling downwards** until the tip catches in the soft lips of the valve, resulting in a 'red-out' of transilluminated tissue (Fig. 9.86c), typically with the tell-tale granular appearance of the
villus surface in close-up (as opposed to the pale shine of colonic mucosa).

5 On seeing the 'red-out', freeze all movement, insufflate air to open the lips (Fig. 9.86d) and wait — gently twisting or angling the scope a few millimetres if necessary until the direction of the ileal lumen becomes apparent; if considerable angulation has been used to enter the valve de-angulation may be needed to straighten things out and let the tip slide in.

6 Multiple attempts may be needed for success in locating the valve and entering the ileum, if necessary rotating to slightly different parts of the ileocaecal fold, hooking over it and pulling back to pass the area repeatedly. On each successive attempt try to learn from the problems of the previous one, fining down tip movements to a centimetre or two and a few degrees either way. Change of position may also help.

Using the biopsy forceps as guidewire. ▲▼

If only a distant, partial or uncertain view can be obtained of the ileal bulge or opening, it is usually possible to use the biopsy forceps to locate and then pass into the opening of the valve (Fig. 9.87), either to obtain a blind biopsy or to act as an 'anchor'. The forceps fix the position of the tip relative to the valve and facilitate endoscope passage through it on the guidewire principle. Even if entry into the ileum is not intended, the opened forceps can be used to hook back the bulge of the upper lip of the valve to visualize the ileal opening and make identification certain; suggestive bulges or flattenings can be identified misleadingly on more distal folds.

Entry into the ileum in retroflexion. ▲▼

The retroversion approach is particularly useful when the ileocaecal valve is slit-like and invisible from above (Fig. 9.88). Retroverting the tip to visualize and then enter the valve from below (Fig. 9.89a) can also occasionally be successful if direct approaches to enter the valve have failed, especially if the caecum is capacious and the colonoscope is straight and responsive. Very acute angulation of the colonoscope tip is needed, with maximum up/down and lateral angulation, and often some twist of the shaft as well. Fairly forceful inward push may be needed to impact low enough in the caecal pole to visualize the valve; with some video-endoscopes the extra length of the bending section may preclude this. Once the valve is located, pull back to impact the tip within it (Fig. 9.89b), then insufflate to open the lips and de-angulate and pull back further to enter the ileum, with or without use of the forceps (Fig. 9.89c).

Problems in finding or entering the ileocaecal valve. ▲▼

This can occur for a number of reasons. The endoscope may be in the hepatic flexure, not the caecum. Even if the tip is in the right place, the chosen 'bulge' on the ileocaecal valve may not be correct; some valve openings are entirely flat and slit-like, effectively invisible on the reverse side of the fold. Aiming the lens at the centre of the endoscope tip exactly at the slit may mean that the rest of the tip impacts against the upper lip and cannot pass in (Fig. 9.90), which is why overshooting the opening slightly will let the angled tip edge in successfully even though the initial view is less good.

Those cases of inflammatory disease where the colonoscopist wants to see the terminal ileum are those where the valve is most likely to be narrowed and, although a limited view may be possible and biopsies taken, the valve may be impassable.
Terminal ileum

The terminal ileum surface characteristics are variable; it looks granular or matt in air, but under water small finger-like villi are seen projecting (Plate 9.8). It is often studded with raised lymphoid follicles resembling small polyps or aggregated into plaque-like Peyer's patches (Plate 9.9). Sometimes the ileum is surprisingly colon-like with a pale shiny surface and visible submucosal vascular pattern. After colon resection the difference between colon and ileum may be imperceptible because of villus atrophy. Using the dye spray technique (1:4 dilution of washable blue ink, 0.1% indigo carmine or 5% methylene blue) to highlight the surface detail will rapidly discriminate between the granular or 'sandpaper' appearance of the ileal mucosa and the small circumferential grooves of the colonic surface, which give a 'fingerprint' effect.

The ileum is soft, peristaltic and collapsible compared to the colon, and should be handled more like the duodenum. Greater distances can be travelled by gentle steering and deflation — so that the intestine collapses over the colonoscope — than will be achieved by force, which simply stretches it. At each acute bend it is best to deflate a little, hook round, pull back and then steer gently (if necessary almost blindly) around and inwards before pulling back again to re-find the view — the 'two steps forward and one step back' approach which applies throughout colonoscopy. Once the colonoscope tip is in the ileum, it can often be passed for up to 30–50 cm with care and patience, although this length of intestine may be folded on to only about 20 cm of instrument. Air distension in the small intestine should be kept to a minimum since it is particularly uncomfortable and slow to clear after examination — another reason for routinely using CO$_2$.

Examination of the colon

Better views are obtained during withdrawal than on insertion and the more painstaking examination is usually performed on the way out. However, in many areas, especially around bends, a different and sometimes better view is obtained on insertion. For this reason when a perfect view is obtained of a polyp or other lesion during insertion (especially a small one) it is better to deal with it at once (snare, biopsy or video print) rather than have the humbling experience of not being able to find it again on the way out and thereby to waste time. A convincing example of the difference between insertion and withdrawal is in the number of diverticular orifices seen in travelling around bends, compared with the few seen on coming out with the colon straightened.

The view is better on the way back because the colonoscope is in the centre of the lumen and is straight. However, the colon has been shortened during the insertion, and during withdrawal the most convoluted parts, such as the transverse and sigmoid colon, can spring off the tip at such speed that it is difficult to ensure a complete view. At sharp bends or marked haustrations there may, therefore, be blind spots during a single withdrawal; careful scanning and twisting movements should be used in an attempt to survey all parts of each haustral fold or bend, and some may need to be re-examined several times. At a flexure the outside of the bend may be seen on the first pass, but the colonoscope often has to be reinserted and hooked to get a selective view of the other side. Acute bends, including the hepatic and splenic flexures, the sigmoid–descending colon junction and the capacious parts of the caecum and rectum are potential blind spots where the endoscopist needs to take particular care to avoid 'misses' (Fig. 9.91).

Changes of position can also help to improve the completeness of inspection. The splenic flexure and descending colon are rapidly filled with air and emptied of fluid by asking the patient to rotate towards the right lateral position. In patients where accuracy is particularly important, such as those with
increased risk of polyps or possible bleeding points, it is our policy to rotate them to the right oblique position for inspection of the left colon, then back to the left lateral position again for a better view of the sigmoid colon and rectum.

The single-handed technique (the endoscopist managing both controls and shaft) comes into its own during inspection on withdrawal. The endoscopist has precise control and the corkscrewing movements he makes by twisting the shaft are the quickest way of scanning a bend or haustral fold so that he can reflexly re-examine a problem area several times. With an assistant, difficulties of communication and co-ordination make it more difficult to be thorough and accurate.

As well as being obsessional the endoscopist must be honest, reporting not only what he sees but also when his view has been imperfect due to technical difficulty or bad bowel preparation. Even during an ideal examination, the endoscopist probably misses 5% of the mucosal surface and in a problematic examination he may miss up to 20–30% (although he is unlikely to miss large protuberant lesions).

**Localization**

One of the endoscopist's most serious problems, especially during flexible sigmoidoscopy or limited colonoscopy, but even during supposed 'total' colonoscopy, is uncertainty of localization. This can be misleading in judging where the instrument has reached, and therefore which manoeuvres to employ; and catastrophic if the surgeon is given wrong information on which to plan a resection.

Distance of insertion of the instrument is sometimes used by inexperienced colonoscopists to express the position of the instrument or of lesions found ('the colonoscope was inserted to 90 cm', 'a polyp was seen at 30 cm', etc.). The elasticity of the colon makes this information meaningless; at 70 cm the instrument may be in the sigmoid colon or in the caecum. On withdrawal, however, providing no adhesions are present and the mesenteric fixations are normal, the colon will shorten and straighten predictably (Fig. 9.92) so that measurement gives approximate localization. On withdrawal, the caecum should be at 80 cm, the transverse colon at 60 cm, the splenic flexure at 50 cm, the descending colon at 40 cm and the sigmoid colon at 30 cm (Fig. 9.93). The last two figures depend, of course, on the sigmoid colon being straightened. It is sometimes difficult to convince enthusiasts for rigid proctosigmoidoscopy that at 25 cm their instrument may still be in the rectum, whereas the flexible colonoscope (on withdrawal) may be in the proximal sigmoid colon. Equally, it is sometimes possible for the colonoscope to be withdrawn to 55–60 cm when the tip is in the caecum.

In a personal series, anatomical location during limited colonoscopy (when judged by withdrawal distance) was wrong in almost half the cases when checked on fluoroscopy. In 25%, a persistent loop (alpha or N) caused the endoscopist to judge the tip location to be at the splenic flexure when actually at the sigmoid–descending colon junction. In 20%, a mobile splenic flexure pulled down to 40 cm from the anus, causing the endoscopist wrongly to judge the instrument to be at the sigmoid–descending colon junction (see Fig. 9.59).

The internal appearances of the colon have already been described, but they too can be misleading. In the sigmoid and descending colon the haustra and the colonic outline are generally circular (see Fig. 9.25), whereas the longitudinal muscle straps or taeniae coli cause the characteristic triangular cross-section often seen in the transverse colon (see Fig. 9.63); the descending colon, however, may look triangular or the transverse colon circular in outline.

Fluid levels can be surprisingly useful clues to localization, especially after oral lavage. Just as the radiologist rotates the patient into the right lateral or left lateral position to fill the dependent parts of
the colon with barium (Fig. 9.94), the endoscopist (with the patient in the usual left lateral position) knows that the instrument tip is in the descending colon when it enters fluid, and is in the transverse colon when it leaves the fluid for the triangular and air-filled lumen of the transverse colon (see Fig. 9.57).

Visible evidence of extracolonic viscera normally occurs at the hepatic flexure where there is seen to be a bluish indentation from the liver (Plate 9.10), but a similar appearance may sometimes occur at the splenic flexure or descending colon. The combination of an acute bend with sharp haustra and blue coloration is thus characteristic of the hepatic flexure and is a useful, but not infallible, endoscopic landmark. Pulsion of adjacent arteries are seen in the sigmoid colon (left iliac) and transverse colon (aorta) and sometimes in the ascending colon (right iliac).

The ileocaecal valve is, in the final analysis, the only definite anatomical landmark in the colon, but it has been stressed already that it is not always easy to find and mistaken identification is possible unless the ileum is entered or the orifice visualized.

Transillumination of the abdominal wall by instruments with bright enough illumination (not all video-endoscopes have this facility) can be very helpful if other imaging modalities are not available, but in obese patients may necessitate a darkened room. It should be remembered that the descending colon is so far posterior that no light is usually visible and that the surface marking of the splenic and hepatic flexures is by transillumination through the rib cage posteriorly. Light in the right iliac fossa is suggestive, but not conclusive, that the instrument is in the caecum; similar appearances can be produced if the tip stretches and transilluminates the sigmoid or mid-transverse colon.

Finger indentation, palpation or ballotting can be effective, particularly in the ascending colon or caecum, where close apposition to the abdominal wall should make the impression of a palpating finger easily visible to the endoscopist, unless the patient is fat. If in doubt indent in several places and beware the possibility of transmitted forces giving, literally, misleading impressions.

Reporting of localization of the instrument tip or lesions found in the colon should therefore be made by the endoscopist in broad anatomical terms (e.g. 'the polyp was seen on withdrawing the instrument at 30 cm in the proximal sigmoid colon'), or even omit the measurement altogether so that there is no chance of confusion in the mind of someone unfamiliar with the shortening of the colon possible during flexible endoscopy. Inaccurate localization can occur even when fluoroscopy is employed and the endoscopist usually needs to rely on a combination of assessments — distance inserted, distance after withdrawal and straightening of the shaft, appearances and visualization of palpating fingers or transillumination. Knowing the pitfalls and being careful should make localization reasonably accurate, but even experienced endoscopists can mistake the sigmoid colon for the splenic flexure, or the splenic flexure for the hepatic flexure, which can be a serious error if localizing a lesion before surgery.

Normal appearances

The form and internal anatomy of the colon have been considered earlier. The colonic mucosa normally shows a generalized fine, ramifying vascular pattern which can often be seen to be composed of parallel pairs of vessels comprising a venule (larger, bluer) and an arteriole (Plate 9.11). The veins become particularly prominent in the rectum, notably so in the anal canal if a proctoscope is used to impede venous return, and distend the haemorrhoidal plexus. The vessel pattern in the colon depends on the transparency of the normal colonic epithelium, since the vessels seen are in the submucosa. If the epithelial capillaries are dilated (as may occur after bowel preparation) the vascular pattern may be partly obscured. If hyperaemia is marked (as in inflammatory bowel disease) there is no visible pattern.
If the epithelial layer is thickened (as in the 'atrophy' of inactive chronic inflammatory disease) the mucosa appears pale and featureless even though biopsies may be essentially normal. The most convincing demonstration of how poorly the endoscopist normally sees the epithelial surface is to spray dye (25% dilution of washable blue ink or 0.2% indigo carmine) onto the colonic mucosa. Small irregularities and lymphoid follicles stand out and there is a fine interconnecting pattern of circumferential 'innominate grooves' on the surface into which the dye sinks, providing there is no excess of mucus on the surface.

There is a considerable size range of normal submucosal vessels; even if they seem unusually prominent they should not be thought of as abnormal, and they are not likely to be haemangiomatous, unless the vessels are tortuous or serpentine. It is not surprising that there can be areas of mucosal trauma (Plate 9.12) during insertion of the colonoscope, and red or even haemorrhagic patches may sometimes be seen on withdrawal, especially in the sigmoid or where the looped sigmoid colon has impinged on the upper descending colon; sometimes it may be wise to take biopsies to ensure that these appearances are not evidence of inflammatory change.

**Abnormal appearances**

It is not the purpose of this book to cover more than the most obvious points of endoscopic pathology. Fortunately for the endoscopist, nearly all colonic abnormalities are either mucosal, with characteristic discoloration, or project into the lumen so that they are easy to see and excise or biopsy. Submucosal lesions which may be very difficult to diagnose include secondary carcinoma, endometriosis, a few large-vessel haemangiomas and carcinoma in chronic ulcerative colitis. The endoscopist has a poor appreciation of colonic contour due to the nearly fish-eye lens and flat illumination of modern endoscopes. He may also see nothing, or remarkably little compared to the radiologist, of extracolonic communications such as tracks or fistulae. Any experienced endoscopist has also, through bitter experience, learnt humility in visual interpretation and takes care to provide appropriate specimens for pathological opinion as well.

**Polyps**

The normal colonic mucosa is pale, so that submucosal abnormalities projecting into the lumen such as hamartomatous polyps, lipomas (Plate 9.13) or gas cysts may be pale. The very smallest polyps (of whatever histology) are also pale; those of 1–3 mm diameter may be transparent and invisible except on light reflex or by the dye spray technique. In polyps 4–6 mm in diameter, there may be little difference in appearance between a normal mucosal excrescence and a metaplastic, adenomatous or any other type of polyp, although small adenomas are more often red and frequently have a matt-looking or even 'sulcal' surface in close-up view (Plate 9.14). The combination of high-resolution or zoom endoscopes with vital straining (methylene blue) or surface enhancement by dye spraying (indigo carmine) stands in future to give the endoscopist nearly microscopic views, but the clinical impact that this will have is uncertain. Adenomatous polyps over about 7–8 mm in diameter, being vascular, have a characteristic red colour which makes them easy to see. Even the smallest polyps are easy to pick out if the patient has been a purgative taker, since the dusky appearance of melanosis coli (often most marked in the right colon) does not stain either polyps, which stand out like pale islands, or the ileocaecal valve.

Flat, sessile, villous adenomas are also usually pale, soft and shiny, but these are rare above the rectum except in the caecum. Apart from lipomas or shiny, worm-like inflammatory polyps, which sometimes have a cap of white slough, all other polyps are best removed. Macroscopic differentiation is inaccurate and there is no sure way of anticipating which polyp will prove histologically to be malignant. A malignant polyp may be obviously irregular, may bleed easily from surface ulceration or be paler and is
usually firmer than usual to palpation with the biopsy forceps. Such signs of possible malignancy in a stalked polyp warn the endoscopist to electrocoagulate the base thoroughly, to obtain a histological opinion on the stalk and to localize and tattoo the polyp carefully in case subsequent surgery is indicated. Carcinomas are usually very obvious (Plate 9.14). They are larger and have a more extensive irregular base; carcinomatous ulcers are uncommon in the colon but look like malignant gastric ulcers. Conditions which can mimic malignancy are granulation tissue masses at an anastomosis, larger granulation tissue polyps in chronic ulcerative colitis, and (rarely) the acute stage of an ischaemic process. Biopsy evidence should always be obtained, bearing in mind that the pathologist may only be able to report 'dysplastic tissue' since there may not be diagnostic evidence of invasive malignancy in the small pieces presented to him, which is why either a large-forceps biopsy or snare-loop specimen should be taken whenever possible. Even with standard forceps, a surprisingly large specimen can be taken by the 'avulsion' or 'push biopsy' approach; the instrument is then withdrawn with the forceps at the tip so as not to shear off parts of the tissue by pulling it back through the biopsy channel.

**Inflammatory bowel disease ▲▼**

The degree of mucosal abnormality in different forms of inflammatory bowel disease can vary enormously. The mucosa can even appear normal with an intact vascular pattern or show the most minute haziness of vascular pattern, slight reddening or tendency to friability, and yet the pathologist may find very significant abnormality on the biopsies. The endoscopist is, therefore, wise not to rely too much on his eyes and must have an extremely low threshold for suspecting abnormality and taking biopsies, particularly if there is diarrhoea or any clinical suspicion of inflammatory disease.

Colonoscopic biopsies unfortunately rarely yield diagnostic granulomas in Crohn's disease, whereas the appearance of multiple, small, flat or volcano-like 'aphthoid' ulcers set in a normal vascular pattern are characteristic. The differential diagnosis of the various specific and non-specific inflammatory disorders may not be easy; infective conditions, ulcerative, ischaemic, irradiation (Plate 9.15) and even Crohn's colitis can look amazingly similar in the acute stage but biopsies will usually differentiate them. Collagenous colitis, a rare cause of unexplained diarrhoea due to an extensive 'plate' of collagen deposition of unknown aetiology just under the epithelial surface, shows normal mucosa visually and the diagnosis can only be made histologically. The ulcer from a previous rectal biopsy or a solitary ulcer of the rectum can look endoscopically identical to a Crohn's ulcer, while tuberculous ulcers are similar but more heaped up, and amoebic ulcers more friable. Ulceration can also occur in chronic ulcerative colitis and ischaemic disease but against a background of inflamed mucosa. The endoscopic appearances must be taken together with the clinical context and histological opinion. In the severe or chronic stage it is often impossible for either endoscopist or pathologist to be categoric in differential diagnosis.

**Unexplained rectal bleeding, anaemia or occult blood loss ▲▼**

Blood loss is a common reason for undertaking colonoscopy. Although colonoscopy gives an impressive yield of radiologically missed cancers and polyps, 50–60% of patients will show no obvious abnormality, which raises the spectre of whether anything has been missed. Haemorrhoids can be seen with the colonoscope (by retroversion in the rectum if necessary), but a proctoscope should be used for a proper view and the endoscope tip can be inserted within it to show the patient or take prints at video-proctoscopy. Haemangiomas (Plate 9.16) are rare, but they can assume any appearance from massive and obvious submucosal discoloration with huge serpentine vessels to telangiectases or minute solitary naevi, which could easily be missed in folds or bends. Angiodysplasias (Plate 9.17) mainly occur in the caecum or ascending colon, but also in the small intestine or very rarely in the distal bowel; they have variable appearances and are always bright red, but they can be small vascular plaques, spidery
telangiectases or even a 1–2 mm dot lesion; they may be solitary or numerous.

**Special circumstances ▲▼**

**Pain mapping ▲▼**

Functional bowel disturbance in the apparently normal colon can take many forms, and 'spastic colon' pain may present with equally variable referred-pain radiation patterns — to the right or left loin, back or even into the thighs. An occasionally useful and very simple colonoscopic procedure is to map the pain experienced during distension at different sites in the colon produced by inflating a small balloon taped alongside the tip of the colonoscope (Fig. 9.95). A child's balloon, finger-cot or the cut-off finger of a rubber glove is bound with fine thread at the end of a small-bore flexible tube (include a short length of rigid tube inside the end to stop it collapsing during binding). The bound neck of the balloon is taped to the junction of the shaft and bending section — placing the balloon at the tip can obscure the view — and two or three additional tapes secure it along the shaft. With a three-way tap and a 50 ml Luer-fitting syringe it is easy to inflate and deflate the balloon in representative sites during withdrawal of the colonoscope.

The balloon should not be inflated above 200 ml volume in the proximal colon and 100 ml distally, or mucosal stretch damage will occur. Because of the variability in colon size, quantification of the volume inflated to the pain experienced in different patients is unpredictable, but some patients with irritable bowel syndrome/spastic colon are notably hypersensitive to even 12–25 ml distension in the sigmoid colon. At each inflation site ask the patient about the quality and site of any pain experienced, and use this to map out referred-pain radiation sites and their correlation with the patient's 'usual' symptoms.

**Colostomies, ileostomies and fistulae ▲▼**

Providing that a finger can be inserted into the stoma, a standard or paediatric colonoscope will also pass into a colostomy or ileostomy without trouble. The first few centimetres through the abdominal wall are sometimes difficult to negotiate and also to examine, partly because of the continual escape of insufflated air. It is quite normal for the stoma to change to an unhealthy-looking cyanotic colour and even for there to be a little local bleeding, but no harm ensues.

Through an ileostomy, the distal 20 cm of ileum are easily examined but further insertion depends on whether adhesions have formed. As in the sigmoid colon, the secret of passage through the small intestine is to pull the instrument back repeatedly as each bend is reached, which convolutes the intestine onto the instrument and straightens out the next short segment; thus even though only 30–40 cm of instrument can be inserted, as much as 50–100 cm of intestine may be seen. Since the sigmoid colon will usually have been removed in a colostomy patient, examination of the proximal colon is usually very easy; if there is a loop colostomy both sides can be examined providing they have been suitably prepared.

Limited examination of an ileal conduit or continent (Kock's) ileostomy is also possible providing that an acutely angling endoscope is available; a paediatric gastroscope or colonoscope is ideal. Pelvic ileoanal pouches are easy to examine with a standard instrument. Cholangioscopes have also been used to examine fistulous tracts and doubtless further endoscopic/radiological frontiers will be broached in the future.
Paediatric colonoscopy

Neonatal examinations are best performed with a thinner (1 cm), and preferably extra-flexible, paediatric colonoscope; but from the age of 2 years upwards adult colonoscopes can be used if necessary. The infant anus will accept an adult finger and so will take an endoscope of the same size, but the sphincter first requires gentle dilatation over a minute or two, using any small smooth tube (such as a nasogastric tube or a ballpoint pen cover). The main advantage of a purpose-built paediatric colonoscope is more the extra flexibility or 'softness' of its shaft than its small diameter, because it is easy with stiffer adult colonoscopes to overstretch the mobile and elastic loops of a child's colon. It is a mistake to use a paediatric gastroscope, which is thinner but much stiffer. An adult 13–15 mm colonoscope, although useable, is nonetheless too clumsy to be ideal in the colon of a small child — and stunting from disease means that age alone is a poor guide. The steering difficulties and looping problems that can ensure if a purpose-built smaller instrument is not available are reminiscent of driving a large articulated truck through small alleyways — uncomfortable for all concerned.

Bowel preparation

in children is usually very effective. Pleasant-tasting oral solutions such as senna syrup or magnesium citrate are best tolerated. A saline enema will cleanse most of the colon of a baby. Children of any age can be colonoscoped without general anaesthesia providing that generous premedication is used (except for neonates, who may sometimes be more safely examined with no sedation at all). A suitable oral sedative premedication (such as antihistamine or pethidine) can be useful so that a particularly anxious child is relaxed before the procedure. A small dose of i.v. benzodiazepine (Diazemuls 2–5 mg or midazolam 1–3 mg) is usually combined with a larger dose of pethidine (meperidine) 25–50 mg i.v., slowly titrated according to response and body weight. When the child is somnolent and tolerates digital examination easily, the rest of the colonoscopy will be equally well tolerated.

Peroperative colonoscopy

Peroperative colonoscopy is normally only justified if attempts at colonoscopy have failed in a patient with known polyps, where the small intestine is to be examined in a patient with continued blood loss, or where the colon proximal to a constricting neoplasm is to be inspected to exclude synchronous lesions.

For non-obstructed patients, oral lavage or full colonoscopy bowel preparation must have been used, as most standard preoperative preparation regimens leave solid faecal residue. If the bowel has been completely obstructed, it is possible to perform on-table lavage through a temporary caecostomy tube or through a purse-string colotomy proximal to the obstructing lesion. During peroperative colonoscopy, overinsufflation of air can fill the small intestine and leave the surgeon with an unmanageable tangle of distended loops. This can be avoided if the endoscopist uses CO₂ insufflation instead of air, or if the surgeon places a clamp on the terminal ileum and the endoscopist aspirates carefully on withdrawal.

To examine the small intestine at laparotomy (see Chapter 11 for a fuller account), the long colonoscope can be used either per orally by the usual route or through an intestinal incision; 70 cm of instrument is required to reach either the ligament of Treitz per orally or the caecum per anally. It helps for the surgeon either to mobilize or manually support the fixed part of the duodenum (see Fig. 11.3) if the colonoscope is passed orally. The small intestine must be very gently handled on the endoscope to avoid local trauma or postoperative problems. A very flexible single channel endoscope (colonoscope or 'push enteroscope') is used to minimize stretching and it is also important to insufflate as little as possible. Clamps are sequentially placed on each segment of small intestine after it has been evacuated. The surgeon inspects the transilluminated intestine from outside (with the room lights turned off) whilst
the endoscopist inspects the inside. The surgeon marks any lesion to be resected with a stitch whilst the endoscopist can perform conventional snare polypectomies as appropriate. A major source of confusion tends to be the artefactual submucosal haemorrhages which occur from handling the small intestine.

**Hazards and complications**

Colonoscopy is certainly more hazardous than barium studies (one perforation per 1700 colonoscopic examinations in published series against one perforation per 25 000 barium enemas), however these figures are likely to be pessimistic in view of the generally excellent safety record of modern colonoscopes, also bearing in mind the high mortality rate after intraperitoneal barium leakage. Nonetheless, inexpert or occasional endoscopists can perforate the colon, which makes it all the more important to certify for endoscopic skills and ensure that the potential for endoscopic cancer prevention is not besmirched by unnecessary morbidity or mortality.

**Instrument or shaft tip perforations.**

Perforations reported in the past were usually due to inexperience and the use of excessive force when pushing in or pulling out. In a pathologically fixed, severely ulcerated or necrotic colon, however, forces may be hazardous that would be safe in a normal colon. Either the tip of the instrument or a loop formed by its shaft can perforate. When surgery is performed soon after colonoscopy, small tears have been seen in the antemesenteric serosal aspect of the colon as well as haematomas in the mesentery. In several reported cases the spleen has been avulsed during overaggressive straightening manoeuvres with the tip hooked around the splenic flexure.

**Air pressure perforations.**

Perforations have also occurred from air pressure, including 'blow-outs' of diverticula; and unexplained pneumoperitoneum or ileocaecal perforation has followed colonoscopy limited to the sigmoid colon. Instruments with single-button control of both air and water can produce dangerously high air pressures if the tip is impacted in a diverticulum or if insufflation is continued for excessively long periods, as for instance when trying to distend and pass a stricture. Use of CO₂ insufflation effectively removes any chance of these serious sequelae since it is so rapidly absorbed. Great care and light finger pressure on the air button are indicated in the presence of diverticular disease. Diverticula are thin walled and have also been perforated with biopsy forceps or by the instrument tip; it is surprisingly easy to confuse a large diverticular orifice with the bowel lumen.

**Hypotensive episodes.**

Hypotensive episodes and cardiac or respiratory arrest can be provoked by the combination of oversedation and intense vagal stimulus from instrumentation. Hypoxia can occur in elderly patients who are oversedated or suffer a vasovagal reaction during colonoscopy. These hazards too should be a thing of the past now that pulse oximetry is widely available. Except in occasional patients with chronic airways disease who might be disadvantaged, it may be wise to administer oxygen prophylactically to elderly, ill or heavily sedated patients.

**Prophylactic antibiotics.**

Prophylactic antibiotics can be important in certain groups of patients, as has already been mentioned (p. 34) (for those with heart valve replacements, immunosuppressed or immunodepressed patients, especially babies, or those with ascites or peritoneal dialysis fluid). Gram-negative septicaemia can result from instrumentation (especially in neonates or the elderly) and unexplained pyrexia or collapse
should be investigated with blood cultures and managed appropriately.

**Electrosurgery and snare polypectomy.**

These contribute additional specific hazards (see Chapter 10).

Safety during colonoscopy lies in being aware of possible complications and in avoiding pain (or oversedation which masks the pain response, as well as contributing pharmacological side-effects). Before starting a colonoscopy it is impossible to know if there are adhesions, whether the bowel is easily distensible and whether its mesenteries are free-floating or fixed; pain is the only warning that the bowel or its attachments are being unreasonably strained and the endoscopist must respect any protest from the patient. A mild groan in a sedated patient may be equivalent to a scream of pain without sedation. Total colonoscopy is not always technically possible, even for the experts. If there is a history of abdominal surgery or sepsis, or if the instrument feels fixed and the patient is in pain, the correct course is usually to stop. The experienced endoscopist learns to take his time, to be obsessional in steering correctly and to be prepared to withdraw from any difficult situation, and if necessary to try again. Too often the beginner has a relentless 'crash and dash' approach, and may be insensitive to the patient's pain because he causes it so often.

Despite the potential hazards, skilled colonoscopy is amazingly safe; it is certainly justified by its clinical yield and the high morbidity of colonic surgery (which would often be the alternative).

**Instrument trouble-shooting**

Colonoscopy can be difficult enough without adding problems in instrument performance. Ideally the functions of all instrument controls should have been checked before the examination, because they can be difficult to spot or tedious to remedy during it.

**Vision**

Check the illumination and clarity of view beforehand. Is the light source functioning properly and the brightness control turned up? Is the view crisp or is there debris on the lens or light-bundle lenses which may need washing, polishing or even gentle scratching off? Colonic mucus and debris can be solidified by the protein-denaturing effects of strong antiseptics such as glutaraldehyde. Use a hand-lens to inspect the tip optics closely and to help with local cleaning.

**Air**

If there is no insufflation from the tip, check the light source — is the air pump switched on, are the umbilical and water-bottle connections pushed in fully and the water bottle screwed on? Is the rubber O-ring in place on the water-bottle connection? Is the air/water button in good condition and seated properly and the CO\textsubscript{2} button in position (where relevant), since it will otherwise allow air leakage? As already mentioned, proper air insufflation is difficult to assess by bubbling under water, but very obvious when blowing up a rubber glove or balloon placed over the tip. It is easy to miss the fact that there is inadequate air flow during an examination, which then becomes technically difficult and the colon apparently 'hypercontractile' because it collapses continually and inflates with difficulty. A great deal of wasted time can be avoided by noticing this defect before starting, or by withdrawing the scope at an early stage to check and rectify the problem.
Organic debris and mucus is the usual cause of poor insufflation, since this tends to reflux under the positive pressure within the colon back up the air channel when it is not in active use (and therefore at atmospheric pressure). A particular culprit is the small, angled air (or air plus water) nozzle at the tip of the instrument. A single plug or an accretion of layers of proteinaceous material can solidify within this nozzle, especially after glutaraldehyde exposure. Paradoxically, the units with the greatest 'air-blockage' problems are often those with the highest cleaning standards, where full antisepsis is rigorously employed. The problem can be minimized by careful water-flushing of the air channel for at least 30–40 s immediately after each examination. Preferably, this should be achieved with a single-channel flushing device, since any adaptor which flushes both the air and water channels simultaneously will simply by-pass an absolute or partial blockage in one channel without this being apparent. Using enzyme detergents is also very effective in the cleaning process, including domestic non-foaming versions for endoscope washing machines.

If a complete or partial blockage has occurred in the air channel of an instrument with a separate CO$_2$ button, the quickest remedy is to try forcing first air, and if this fails water, by syringe down the CO$_2$ channel — remembering to press the CO$_2$ button at the same time. The CO$_2$ system connects directly with the air channel and so gives convenient access to it for flushing purposes. Water is preferable for forced perfusion since it is non-compressible and a smaller (5–10 ml) syringe gives greatest pressure. Some manufacturers have special 'flush buttons' which allow direct pressure syringing after replacing the usual air/water button. A messy alternative is to activate the regular air button, put a finger over the water-bottle port on the umbilical to avoid leakage and then to syringe through the air-input channel at the end of the umbilical using a suitable syringe attachment, such as a micropipette tip cut to size.

The angled metal air nozzle at the instrument tip is often the logical place for a direct attack on a blockage problem. First try probing its slit-like opening, or even water-injecting this using a fine-gauge intravenous needle. If this proves ineffective it is possible, as a last resort, to remove the air nozzle altogether. Although it may be more diplomatic to have this done by the manufacturer's service department, or at least by skilled technicians, removal, cleaning and reinsertion are actually an easy matter. A small jeweller's screwdriver is necessary and the covering layer of soft silicone sealant must be prised off, but under this will be found a simple slotted grub-screw which can be unscrewed for a turn or two, releasing the air nozzle The channel or nozzle are ram-rodded with a fine wire (such as the stilet of an ERCP cannula) or can be syringe perfused until all debris is removed, rapidly solving the problem.

If the air channel cannot be unblocked during the process of an examination, a simple dodge is to empty the water bottle, then to activate the water button to achieve air insufflation (use the water syringe attachment if lens washing is needed).

To check that the air pump itself is working properly (the lamp must be ignited in some light sources before the air pump will operate), insert any syringe into the rubber air-output tube and the syringe plunger will rapidly blow out, demonstrating high pressure.

**Water ▲▼**

Failure of the water system is relatively unusual, because mucus or debris do not reflux back up the filled water system as easily as up the empty air channel. None-the-less, particles of the rubber O-ring or other matter can become lodged in the water system. They should be quickly cleared by water-syringing with a micropipette tip into the small hose that normally lies underwater within the water bottle — remembering to press the water button simultaneously to allow flow.
**Suction**

Particulate debris can also block the suction channel. If in the shaft, this can be dislodged by watersyringing through the biopsy port. Removing the suction button and covering the opening on the control head with a finger is a quick way of improving suction pressure and can result in rapid clearance of the whole system (as when sucking polyp specimens). Applying the sucker tube directly to the suction-channel opening can also be effective in clearing particulate debris. As a final resort the whole suction system can be cleared by retrograde-syringing using a 50 ml bladder syringe to wash through tubing attached to the suction port on the umbilical. Push the suction button and also cover the biopsy port during this procedure to avoid unpleasant (refluxed) surprises.

**Further reading**

**General sources**


**Bowel preparation**


Techniques and indications


### Sedation, hazards and complications


Hussein, AMJ, Bartram, CI & Williams, CB. Carbon dioxide insufflation for more comfortable colonoscopy. *Gastrointest Endosc* 1984; 30, 68–70. PubMed


