Conditions simulating air under the diaphragm

Chilaiditi syndrome (fig 9)—
Interposition of hepatic flexure between liver
and diaphragm
Subphrenic abscess
Subdiaphragmatic fat
Basal curvilinear atelectasis

FIG 9—Chilaiditi syndrome—interposition of colon between liver and diaphragm. Air is seen under the right hemidiaphragm but bowel markings are evident.

The properitoneal line adjacent to the lateral margin of the liver can be mistaken for a pneumoperitoneum in a left lateral decubitus view. Air in the biliary tree can be due to previous sphincterotomy or surgery (fig 5). Pelvic phleboliths can often be differentiated from distal ureteric stones by their characteristic appearance; they are round with a radio-opaque halo surrounding a small central lucent nidus.

Summary

Diagnostic quality
Alignment of bones
Bone margins and density
Cartilage and joints
Soft tissues
Bowel gas pattern
Pneumoperitoneum
Air in the biliary tree or portal vein
Size of organs
Fat-tissue interfaces
Abnormal calcification

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Minimally Invasive Surgery

Advanced techniques in abdominal surgery

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This is the second in a series of articles on minimally invasive surgery

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Almost every abdominal organ is now amenable to laparoscopic surgery. Laparoscopic appendectomy is a routine procedure which also permits identification of other conditions initially confused with an inflamed appendix. However, assessment of appendiceal inflammation is more difficult. Almost all colonic procedures can be performed laparoscopically, at least partly, though resection for colonic cancer is still controversial. For simple patch repair of perforated duodenal ulcers laparoscopy is ideal, and inguinal groin hernia can be repaired satisfactorily with a patch of synthetic mesh. Many upper abdominal procedures, however, still take more time than the open operations. These techniques reduce postoperative pain and the incidence of wound infections and allow a much earlier return to normal activity compared with open surgery. They have also brought new disciplines: surgeons must learn different hand-eye coordination, meticulous haemostasis is needed to maintain picture quality, and delivery of specimens may

be problematic. The widespread introduction of laparoscopic techniques has emphasised the need for adequate training (operations that were straightforward open procedures may require considerable laparoscopic expertise) and has raised questions about trainee surgeons acquiring adequate experience of open procedures.

At the end of the 1980s, when the first laparoscopic techniques were described, few could have predicted the developments that have occurred since then. Far from being limited to the removal of uninflamed gallbladders, laparoscopic techniques have been applied to almost every abdominal organ: oesophagus, stomach, duodenum, small and large bowel, liver, spleen, kidney, ureters, and pancreas have all been either resected or repaired.

The development of high quality video imaging systems has been the single biggest advance in recent years that has allowed many of these new procedures to be developed. For practising surgeons, however,

Surgeons must learn new hand-eye coordination for laparoscopy

training in the hand-eye coordination required for endoscopic surgical procedures has been the major limiting factor in surgical progress. A further restriction has been the range of available instruments: five years ago this was limited to simple graspers and scissors. Since then, many traditional surgical instruments have been adapted for laparoscopy to allow many more procedures to be contemplated. Instruments have become more versatile by being able to rotate 360° and to bend up to 90°, and the advent of linear stapling devices has allowed structures such as bowel and large blood vessels to be divided and anastomosed safely with the insertion of rows of titanium staples. These changes have brought their own controversies, mostly of an economic nature. Because instrument design changes rapidly much of this equipment has been manufactured in a disposable form to be used only once. Therefore, the widespread introduction of laparoscopic techniques and use of these instruments will have considerable economic implications. Some of these increased costs may be offset by shorter stays in hospital and reduced time off work, but transfer of these savings to the hospital services will probably remain a problem.

The term minimally invasive treatment has been borrowed by general surgeons from specialties such as radiology, urology, and orthopaedics, which have been using endosurgical techniques for many years. In

Surgeons' hands cannot be used to manipulate tissues and structures and are replaced by grasping instruments

abdominal surgery, however, this term is really a misnomer: many of the advanced laparoscopic techniques such as colonic resection or oesophagectomy are not minimally invasive, but are major resectional procedures performed through a smaller incision than before. Although the scar may be smaller and the level of postoperative discomfort may be less, the operation otherwise remains essentially unchanged with the same list of potential complications—and a few new ones thrown in for good measure. The term minimal access surgery might therefore be more appropriate.

The small scars of the operations bring some problems of their own. In many instances all that a patient (and general practitioner) sees after an operation is a few stab marks so that deciding which organ has been removed can be reduced to guesswork. Education of patients and communication with doctors in the community and primary care sector are therefore particularly important after laparoscopic operations. Unfortunately, many surgeons still allow their patients to leave hospital unaware of the details of the surgery they have just survived. Patient information sheets are very useful in this regard, and improved communication with general practitioners is vital when their patients return to the community sometimes just a few hours after major surgery. This trend towards shorter stays in hospital has important implications: many of the potential postoperative complications that would previously have occurred during inpatient stays may now present to doctors in primary care, many of whom may be unable to cope adequately; and undergraduate education may have to be modified to give more emphasis to this new surgical load being transferred to the community.

Principles of laparoscopic surgery

Essentially, all laparoscopic surgical techniques should adhere to all the basic surgical tenets of open procedures: if something would not be done that way in open surgery it should not be done that way laparoscopically. The temptation to take short cuts must be avoided. From this basic point, however, some side issues arise.

Selection of patients—All advanced laparoscopic operations are performed under general anaesthetic, and patients' cardiovascular fitness is obviously essential. Previous abdominal surgery may be a contraindication to laparoscopic surgery. For operations such as cholecystectomy a history of appendicectomy or hysterectomy should not prevent a successful laparoscopic procedure, but care must be taken during initial insufflation and port placement to avoid injury to the underlying bowel, which may be adherent to the abdominal wall. Previous upper abdominal surgery such as gastrectomy, however, may prevent laparoscopic cholecystectomy because of formation of severe adhesion. A history of major abdominal procedures such as colectomy or aortic surgery generally implies widespread formation of adhesion, thereby precluding most laparoscopic procedures. All patients, however, should be considered individually, and an initial laparoscopy with an open technique for port insertion will quickly establish a patient's suitability.

Disciplines of laparoscopic surgery—The excellent picture quality and magnified image provided by modern video endoscopy systems allow surgeons to perform more careful and delicate dissections, especially in some of the more inaccessible areas such as deep in the pelvis. For the operations to be successful a careful technique of tissue retraction and dissection is required. Unfortunately, the surgeon's hands are not available in the abdomen to distract tissues and structures and are replaced by carefully positioned grasping instruments. These instruments are less

efficient than fingers and hands and are substantially more traumatic. Thus, great care must be taken to avoid damage to structures such as the gastrointestinal tract. In addition, laparoscopic surgery demands meticulous haemostasis: any pooled blood is tedious to aspirate, and the haemoglobin rapidly leads to absorption of light with resultant loss of picture quality. Of course, open surgery is better performed in a blood free operative field, but laparoscopic operations exert a new discipline in this regard.

Delivery of specimens—For tissue specimens of a benign nature such as a scarred hydronephrotic kidney it is acceptable to place the specimen in a tissue bag in the abdomen and to remove it piecemeal with the aid of an ultrasonic dissector. This technique has also been applied to the spleen. For malignant tissue such as colon cancer, however, this procedure is clearly unacceptable. Firstly, an intact specimen is required for adequate histological examination to allow diagnosis and staging. Secondly, there is the danger of implantation of malignant cells in the abdomen and abdominal wall if a tumour is broken up. Removal of an intact specimen generally requires a small laparotomy incision to allow delivery of the specimen while avoiding contamination of the wound.

Surgical training

As minimal access surgery develops the issue of postgraduate training becomes more pressing. The widespread and unlegislated introduction of laparoscopic cholecystectomy has already resulted in an excess of injuries to the bile duct and, in New York state, has led to the implementation of legislation determining who is permitted to perform these operations.¹ If such a development is to be avoided in Britain then adequate training must be provided. In Britain it is not possible to use animal models for direct surgical training, but simulators have been developed that can provide experience in the use of instruments and in performing some techniques. In addition, some form of proctering for initial cases is a useful adjunct and should perhaps be more widely adopted. Whether surgeons should be required to submit to formal accreditation, however, remains controversial as this is not generally required in other specialties.

The increasing impact of minimal access surgery on surgical practice has other implications. For example, nearly all patients requiring cholecystectomy now undergo a successful laparoscopic procedure, and this has reduced the exposure of surgical trainees to the open operation. This raises a question about their ability to perform the open procedure when the occasion demands. There is some evidence that this may be less of a problem than was first thought. The excellent anatomical view provided by video endoscopy is often superior to that possible with open surgery so that when the operation is converted to an open procedure little difficulty is encountered. Although this may be true for cholecystectomy and appendicectomy, it may not be for other procedures such as hernia repair and colectomy. In the case of hernia repair the anatomical approach and method of repair undertaken laparoscopically is quite different to that of the open procedure. Therefore, these operations at least will have to be taught separately, starting with the open procedure. For colonic surgery, open surgery will remain an important element of surgical training. At least 20% of colonic resections cannot be done laparoscopically for various reasons including acute intestinal obstruction, adhesions from previous surgery, and acute inflammatory conditions and perforations.² It therefore follows that all surgeons will still have to be skilled in the traditional operation before embarking on endosurgical procedures.

Surgical procedures

APPENDICECTOMY

Laparoscopic appendicectomy is frequently performed and has several advantages over open procedures, although there are some apparent disadvantages as well. Exposure is usually better as laparoscopy avoids the common problem of a small misplaced incision in the right iliac fossa. Furthermore, the appendix can usually be delivered through one of the laparoscopic ports to avoid direct contact with and possible infection of the wound, the commonest complication of the open procedure. Another advantage is the easier diagnosis and treatment of other conditions that may have led to diagnostic confusion. Tubo-ovarian conditions such as salpingitis or ovarian cysts can be dealt with through a traditional incision in the right iliac fossa, but laparoscopy also allows the surgeon to deal with conditions such as a perforated duodenal ulcer or acute cholecystitis without making further incisions. Although open appendicectomy is well tolerated by adolescents, elderly patients greatly benefit from the early mobilisation and reduced post-operative discomfort associated with the laparoscopic approach.

A series of more than 100 laparoscopic appendicectomies performed in our unit has revealed other important points. Firstly, it can be difficult to determine the degree of inflammation (if any) of an appendix. Examination with the naked eye is a very accurate way of diagnosing appendiceal inflammation, but this is not so with video laparoscopy, when variables such as the settings of television monitors and picture resolution render colours and tones somewhat artificial. Secondly, the operation requires considerable laparoscopic expertise, sometimes more than that needed for laparoscopic cholecystectomy, and is not the straightforward training operation for junior surgeons that the open procedure usually is. This raises some critical dilemmas. The emergency nature of acute appendicitis means that surgery is often performed by junior surgeons in training, to whom the operation offers one of the first steps in a surgical career. If a laparoscopic appendicectomy requires the operating skills of a senior registrar or consultant to be performed safely then either senior staff will have to undertake more night time operations or many patients will have to undergo a period of conservative management before having the operation on the next elective list.

The current procedure requires three ports placed in the lower abdomen, and the average time taken for the operation is 30 minutes. Although it is rarely quicker than the open procedure, many centres have now shown that operative times differ little between the two approaches. With experience even the most difficult appendicectomies can be completed successfully by laparoscopy.

COLONIC PROCEDURES

Virtually the full range of colonic operations can, at least in part, be performed laparoscopically (see box)

Laparoscopic Colonic Procedures

- Left or right hemicolectomy
- Subtotal colectomy
- Sigmoid colectomy
- Formation of diverting colostomy
- Anterior resection of rectum
- Abdominoperineal resection of rectum
- Rectopexy for rectal prolapse
- Reduction or resection of sigmoid volvulus
- Left sided resection with transanal specimen delivery

though some procedures are more suited to this approach than others. For example, both right hemicolectomy and abdominoperineal resection of the rectum can almost always be successfully completed laparoscopically. In contrast, resection of lesions in the transverse colon can prove difficult if not impossible due to the greater omentum preventing mobilisation of the colon. Varying amounts of an operation may be performed laparoscopically depending on a surgeon's skill, time, availability of equipment, and the individual requirements of a case. Thus, at one extreme, colonic mobilisation may be all that is performed laparoscopically, leaving delivery of the colon, division of the mesenteric vessels and bowel, and reanastomosis to be performed outside the abdomen in the traditional fashion.

The laparoscopic operation should be essentially the same as the open procedure. A series of ports are placed in the four quadrants of the abdomen after placement of the initial subumbilical port for the camera. Through these ports grasping forceps are used to retract the bowel to allow mobilisation by means of a combination of sharp dissection and diathermy. All vital structures such as the duodenum and ureters must be identified and preserved as in the open operation. Although transanal delivery of segments of colon is possible in certain cases, most colonic resections require a small laparotomy incision 5-7 cm long for delivery of resected specimens. Through this same incision the bowel and its vascular attachments may be divided extracorporeally if this has not been done laparoscopically. Re-anastomosis of the bowel can also be completed before closure of the abdomen. With this technique a right hemicolectomy can be performed through a 5 cm incision (in addition to several stab wounds), and a subtotal colectomy requires a lower abdominal transverse incision of no more than 7-10 cm. Apart from the cosmetic advantages of this approach, it considerably reduces postoperative discomfort and allows a much quicker return to mobility.

These operations are generally more time consuming than open procedures, and there is controversy as to whether laparoscopic resection for cancer gives adequate clearance of the tumour. In a series of nearly 70 cases in our unit, which has special expertise in this operation, we found that the excellent views provided by the video images have sometimes led to improved tumour clearance. This procedure remains under evaluation, however, and should be restricted to centres with special expertise in the operation. One feature of laparoscopic colectomy performed for neoplastic disease is worthy of special note. Because the bowel cannot be palpated in the traditional manner it may be difficult to identify the lesion to be removed. This is particularly true when resection is being performed for large soft polyps or cancers that do not involve the serosa. Consequently, the lesion must be accurately located before surgery. Colonoscopy is not sufficient and may be incorrect in more than half of cases. Preoperative contrast studies must be considered a minimum and may be supplemented by intraoperative colonoscopy if required. An alternative aid we have used with some success is injection of the lesion or the adjacent mucosa with methylene blue at the time of colonoscopy. The blue colour can last for several days and can be seen quite easily at laparoscopy to aid localisation.

REPAIR OF PERFORATED DUODENAL ULCER

Perforated duodenal ulcers are becoming more common in elderly and frail patients taking non-steroidal anti-inflammatory agents.³ For simple patch repair of the perforation the laparoscopic approach is ideal: complete peritoneal lavage is improved, and the lack of an upper midline abdominal incision—the

Abdominoperineal resection of rectum does not require a large incision when performed laparoscopically

most painful of all abdominal incisions—substantially improves postoperative recovery. The patch repair can now be done with a special stapler rather than by the tedious and time consuming suture repair done by laparotomy. Most repairs take less than 30 minutes, which is certainly no longer than the open operation.

UPPER ABDOMINAL PROCEDURES

All the traditional operations for peptic ulcer disease can be performed laparoscopically, including bilateral truncal vagotomy with or without drainage, highly selective vagotomy, truncal vagotomy with seromyotomy, and even partial gastrectomy. The procedures are identical to the open operations but take a considerable amount of time to perform. Consequently, most centres prefer the quicker and technically easier operation of posterior truncal vagotomy and anterior seromyotomy when some definitive procedure is indicated.⁴ This has been performed in both emergency and elective cases but has mainly been restricted to the elective setting.

Other upper abdominal procedures performed laparoscopically include fundoplication for gastro-oesophageal reflux. The procedure is identical to the open operation, and there is some evidence that the shortened hospital stay and rapid return to normal activity associated with this operation may see a re-emergence of the surgical treatment of complicated reflux disease. More experimental procedures include splenectomy and segmental liver resection, in which delivery of the resected specimen remains an unresolved issue, although morcellation of the tissue in a plastic bag and subsequent aspiration are often possible. These operations are also technically challenging in terms of adequate haemostasis.

REPAIR OF GROIN HERNIA

One of the commonest surgical procedures performed by general surgeons is repair of a groin hernia, usually inguinal. When performed laparoscopically, this presents the surgeon with some unique problems. The anatomy of the inguinal canal as seen from the inside of the abdomen is unfamiliar to most surgeons, in contrast to other laparoscopic procedures such as cholecystectomy and appendicectomy, in which the anatomical approach is identical to that of the open procedure. Early attempts to perform inguinal hernia repair laparoscopically were associated with unacceptably high rates of recurrence.⁵ Advances in instrumentation, however, have made it possible and practical to produce a satisfactory tension free repair using synthetic mesh as a patch to cover not only the hernial defect but also other areas of possible herniation.

Right direct inguinal hernia...

... and its repair with a patch of synthetic mesh

Results have been encouraging with low rates of recurrence and, most importantly, an early return to normal activity.⁶

The laparoscopic approach is ideal for the repair of bilateral hernia as no further port insertion is required and both sides are visualised equally well. For those patients with recurrent defects after open repair, the peritoneal approach of the laparoscopic operation is considerably easier than a groin approach because all the tissues dissected are free from the considerable fibrosis associated with a hernia repair (the original operation would have been largely restricted to more superficial layers). Postoperative management remains much the same as before though with some specific additions. Because synthetic mesh is used to complete repairs prophylactic antibiotics are always administered in order to reduce the risk of infection of the foreign material. With some large hernial defects a

portion of the sac is deliberately left behind because full excision is not necessary for successful repair. Blood may sometimes collect in this sac remnant and present as a tender lump in the groin. This can be mistaken for an early recurrence, but ultrasound scanning of the groin has proved useful in clarifying any diagnostic difficulties. Such sac haematomas can be successfully managed conservatively and resolve over one or two weeks.

As with most laparoscopic procedures, the early return to normal activity probably represents the greatest advantage of laparoscopic hernia repair, and, although immediate and long term results and complications may be expected to be similar to those of open surgery, laparoscopy also reduces postoperative discomfort and gives better cosmetic results. Many patients may have a traditional open hernia repair performed under local anaesthetic as a day case, but the groin wound provides a source of considerable discomfort for several weeks. In contrast, laparoscopic hernia repair requires general anaesthetic so that an overnight stay is often necessary, but many patients are pain free within 48 hours and have returned to normal activity in less than a week. It should be noted, however, long term follow up is not available for such patients, and the optimum time of avoiding strenuous activity to prevent recurrence is not known. Seven days seems a reasonable time since most patients are reluctant to remain inactive for any longer.

These points have significant economic implications for hospital practice since the universal adoption of laparoscopic hernia repair will more than double the use of laparoscopic equipment compared with cholecystectomy.⁷ Hospitals' costs are likely to be substantially higher for the laparoscopic approach, but these may be offset by patients' much earlier returns to normal productive activity. The absence of a formal groin incision should also reduce postoperative pain and the incidence of wound infections. Many randomised trials are now in progress to address these issues.

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UNDERSTANDING EPIDEMIOLOGY

Confounding

In an ideal laboratory experiment the investigator alters only one variable at a time, so that any effect he observes can only be due to that variable. Most epidemiological studies are observational, not experimental, and compare people who differ in all kinds of ways, known and unknown. If such differences determine risk of disease independently of the exposure under investigation, they are said to *confound* its association with the disease.

For example, several studies have indicated high rates of lung cancer in cooks. Though this could be a consequence of their work (perhaps caused by carcinogens in fumes from frying), it may be simply because professional cooks smoke more than the average. In other words, smoking might confound the association with cooking.

Confounding determines the extent to which observed

associations are causal. It may give rise to spurious associations when in fact there is no causal relation, or at the other extreme, it may obscure the effects of a true cause.

Two common confounding factors are age and sex. Crude mortality from all causes in males over a five year period was higher in Bournemouth than in Southampton. However, this difference disappeared when death rates were compared for specific age groups. It occurred not because Bournemouth is a less healthy place than Southampton but because, being a town to which people retire, it has a more elderly population.

From Geoffrey Rose, D J P Barker, D Coggon. *Epidemiology for the Uninitiated*, 3rd edition, 1993. Available from the BMJ Bookshop, price £6.95.