

Future developments in day-case laparoscopic surgery

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Laparoscopic surgery is entering a phase of maturation and consolidation. Besides offering very early return of function after herniorrhaphy, the laparoscopic approach is likely to bring a large tranche of major abdominal surgery, such as cholecystectomy and some other upper gastrointestinal surgery, within the reach of day-case management. The length of stay of other major abdominal surgery will be reduced. There is likely to be a convergence between day-case and inpatient units, and laparoscopic surgery will become concentrated in relatively few centres.

Key words: Laparoscopic surgery, ambulatory surgery, future developments

Introduction

The introduction of the laparoscopic approach to major abdominal surgery is widely regarded as having been the most dramatic and far-reaching single development in general surgery in the professional lifetime of the present generation of surgeons. The first laparoscopic cholecystectomy was performed seven years ago. The extent of the subsequent development would have been inconceivable before then and this acts as a deterrent to any would-be soothsayer today! Nevertheless, it is possible to make some predictions for the short and medium terms, particularly as the rate of development is slowing somewhat as laparoscopic surgery enters a phase of consolidation and maturation. A more stable pattern of practice is beginning to emerge and the strengths and limitations of the techniques of laparoscopic surgery are becoming more apparent.

The two significant advantages that the laparoscopic approach to abdominal surgery confer are a reduction in pain and its associated morbidity and a reduction in postoperative ileus. The domination of the recovery from surgery by wound pain had previously been insufficiently appreciated by surgeons. The introduction of the laparoscopic approach to abdominal surgery has coincided with a significant thrust towards improved pain control throughout all reaches of surgery. However, the laparoscopic approach achieves a reduction in, rather than a

control of, pain and this avoids any disadvantages arising from the methods of pain control.

The reduction in hospital stay which a reduction in pain and ileus following surgery should allow is now becoming a reality. At the same time, some day-case units are developing '23 hour' facilities. Even inpatient units, of necessity, are beginning to acquire and exercise the skills and disciplines in case and bed management which have been learned by day-case units.

There is therefore a convergence in the reducing lengths of stay and clinical and bed management issues which may well make the distinction between day-case, '23 hour' or early discharge inpatient surgery less clearly defined. At the same time, the introduction of major abdominal surgery to the day-case environment will require the importation of the skills of managing this type of surgery currently exercised by inpatient units. In the context of this convergence, developments across a wide range of laparoscopic surgery may become relevant, particularly in their potential to shorten hospital stays, and will therefore be discussed.

Advancing human and technical resources

The laparoscopic approach to major surgery was enabled by the development of the 'chip' camera. The development of this type of surgery continues to be dependent on, and constrained by, developments in the technical devices used and the human abilities to use them. These together determine the types of surgery which can be attempted. Developments in televisual technology, instrumentation, the psychomotor skills of surgeons and the challenges of individual types of surgery will therefore be discussed in turn.

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Televisual technology

While the view afforded by modern laparoscopic cameras would have seemed remarkable a few years ago, there are still considerable restrictions on vision. Resolution and colour reference are not as good as that of the naked eye. The view remains, for the moment, monoscopic and it is coaxially lit. The angles of visual approach to the operative field are limited to port positions.

Angled or flexible telescopes allow a limited ability to 'see round corners', but problems for the operator arise when there are large angles between the visual axes in the monitor and the physical axes on the table (in which the instrument handles are manipulated). Rotational transformations are difficult to accommodate beyond 30°. Large angular transformations can be accommodated with time, but changing the angular transformation required frequently and within a short time span is difficult for the operator, particularly if the transformation is greater than 90°, so that the sense of the movement of instruments, as seen on the monitor, is reversed. The possible solutions to these problems will be discussed in turn.

Resolution, colour reference and three dimensions

The most important single characteristic of a televisual channel for the surgeon is its resolution. This far transcends any other characteristic, and resolution has improved rapidly in the last few years. The 'chip' camera produces a digital signal and this lends itself to computer image enhancement. It has become more sensitive to light, which has permitted a reduction in telescope aperture, with a consequent reduction in distortion and an improvement in depth of focus. High intensity light sources and solid glass optical pathways have contributed to this improvement. 'Three chip' cameras, where the light image is split three ways, for chips sensitive to red, green and blue light, improves colour reference and also resolution, but sometimes not to an extent sufficient to justify the increase in weight of the camera.

Within the next year, usable three dimensional systems will become available. Early systems divided the optical pathway, with a consequent reduction in resolution, but a recently developed system uses a single, full sized, internally reflecting telescope, with the two cameras looking, at an angle to each other, into the single telescope. Resolution almost equal to current monoscopic systems should be achievable. This system also projects the polarized images from a single screen continuously, which appears, at least to this author, to be superior to the alternative technique of projecting left and right images alternately, with the surgeon's right and left eyes being 'blacked out' alternately by liquid crystal diode (LCD) spectacles under infrared control.

High definition television is at last appearing in the market place. The improvement in resolution and colour reference is remarkable. Camera systems are still too heavy for practical use for laparoscopy, but their weight is reducing rapidly. The systems are also very expensive

and likely to remain so until their introduction into domestic markets allow for mass production to offset development costs.

For the future, one would hope to see wider angles of view without loss of resolution, and smaller chip cameras carried into the abdomen on articulated arms to liberate the surgeon from the present restrictions of port access.

Extended imaging

One of the restrictions of the laparoscopic approach is the limitation of feel. Other imaging modalities can, in part, compensate for this. High definition C-arm screening equipment is now becoming widely available. It is useful for cholangiography, but this technique requires cannulation of the biliary tree and is therefore invasive.

Laparoscopic ultrasonography is non-invasive and carries no biological penalty. The direct application of the transducer arrays to the point of interest allows high resolution to be achieved. It is useful, for example, for guiding dissection in difficult cholecystectomies. The equipment is, as yet, in its infancy. Becoming available shortly are steerable probes, bi-directional linear and phased arrays and colour Doppler.

Currently available computer technology would, in principle, allow integrated displays of visual data and data from other imaging modalities. The limitation will be the cost of what must be dedicated equipment coupled with the small size of the market.

Instruments

The laparoscopic televisual systems have benefited from the huge development market outside medicine. Instrumentation cannot share this benefit and laparoscopic instrumentation has lagged behind in comparison with the televisual systems. Quite simple developments – such as multifunctional systems which will allow simultaneous suction, irrigation or diathermy alongside scissors and graspers – are only just beginning to appear. This limited capability is holding back surgical development.

There are now instruments which can adopt a curve within the abdomen, in an attempt to escape from the restrictions of limited port access, but they are not yet truly articulated. Angling stapling devices are eagerly awaited. In some respects the restriction is one of cost. For example, dividing fat mesenteries remains a problem. It can easily be overcome by using several linear stapling and cutting devices, but the cost is prohibitive at present.

Scissors and diathermy remain the principal instruments for cutting and coagulation. Other modalities of tissue destruction and coagulation, such as lasers and ultrasonics, have been investigated. The pulse dye laser is useful for the destruction of inaccessible stones in the common bile duct and ultrasonic dissectors are useful for dissecting the liver. However, apart from limited applications, these modalities have proved disappointing so far.

The most exciting prospect in this field is the develop-

ment of micromanipulators and articulated arms. These are developing from the technology used for the manipulation of objects in dangerous environments. Advances in engineering allow small motors and gear trains to be constructed in the same way as, and integral with, the chips which are controlling them, decreasing size and cost and increasing reliability. Arms have been constructed which can sense resistance, thus preventing inadvertent damage to tissues. There are now sophisticated input devices, such as the electronically wired glove which can sense the position of the hand and fingers, transmit them to a manipulator and feed back the pressure with which an object is grasped.

It is possible to speculate that in the future multiple articulated arms and manipulators will be carried into the abdomen, accompanied by high definition three dimensional cameras, able to retract and to dissect on any axis and to mimic the movements of the surgeon's fingers. This will liberate the surgeon from the frustrations caused by the limitations of the present instruments and the restrictions of port access.

Surgeons

The introduction of laparoscopic surgery was greeted with enormous enthusiasm and there was a rush to acquire the basic techniques. These techniques required mature surgeons to acquire new psychomotor skills, needing abilities for which they had not been selected during their training and which were therefore possessed in varying degree. There was a learning curve and there were, largely anecdotal, reports of errors. Many of these reports were without a denominator and it is likely that in most instances the good sense, maturity and experience of trained surgeons protected patients from harm.

It is interesting to observe that, now the basic techniques have been acquired, there seems to be a reluctance to extend skills to cover the full armamentarium which would be considered necessary for the safe performance of open surgery. For example, among surgeons regularly performing laparoscopic cholecystectomy, relatively few are prepared to suture within the abdomen laparoscopically, or to explore the common bile duct. Advanced laparoscopic surgery is still restricted to relatively few institutions.

This factor is compounded by the current increase in subspecialization, so that specialist surgeons, such as the coloproctologist, may not have been exposed to cholecystectomy as a training ground. These two factors alone suggest that some current predictions of the proportion of abdominal surgery which will be performed via a laparoscopic approach within the next few years are optimistic.

It may be that the full development of the laparoscopic approach will not occur until a new generation of surgeons, selected and trained from the outset on laparoscopic techniques, have come to maturity. In training courses, it is very noticeable that younger surgeons, perhaps exposed to computer games from an early age,

often take to the techniques of laparoscopic surgery with far greater ease than their older colleagues.

While the development of sophisticated simulators is in its infancy, they are not required for the practice of most techniques, such as suturing. There is currently an insufficient culture of off-line practice in surgery, in contrast to other activities requiring high levels of psychomotor skills, such as sport. Recently, an eminent professional golfer, on being congratulated on a lucky shot, replied: "It's a funny thing, the more I practise, the luckier I get". This philosophy needs to be imported into surgery.

Overall, therefore, it appears that the limited availability of surgeons with the full range of skills required for a wide range of laparoscopic major general abdominal surgery will be a constraint on its development in the short and medium term.

Risk management

Institutions are increasingly using credentialling and proctoring (the overseeing of the initial operations of a surgeon by an experienced colleague) to protect themselves from liability for damage due to inexpert surgery. It is becoming apparent that the safe practice of this surgery is surgeon-dependent to a high degree and that the practising surgeon needs intensive experience and continued collegial support and auditing. A momentum to develop local support networks is beginning to develop.

Institutions are also increasingly faced with dilemmas stemming from expensive technical developments and the early obsolescence of expensive equipment. Many developments, such as high definition and three dimensional visual systems, will make the surgeon's task easier and this will increase the margin of safety. The increase is hard to quantify, but, on the other hand, the errors which it may prevent, although rare, are very costly if they occur. If an error is perpetrated and less than state-of-the-art equipment was in use, liability would be almost inevitable. This presents institutions with the need for the frequent updating of an increasingly expensive line-up of equipment.

Faced with a limited availability of surgical skills and the considerable expense of the equipment, there is a strong probability that laparoscopic surgery will become concentrated in relatively few institutions.

General surgical principles

The likely influence of laparoscopic surgery over the transfer to day-case management of individual operations will depend on their suitability for the laparoscopic approach, now, or in the light of expected development. The great successes of the laparoscopic approach have been in operations where access and exposure are not problems and where the field of the operation is narrow – cholecystectomy being the prime example. It is less successful where a wide sweep of anatomy is required, where rummaging is needed or where loops of small bowel with fat mesenteries need to be retracted from the field. Tech-

nical difficulties may then prolong an operation unacceptably. Most of these technical difficulties should be susceptible to the technological improvements detailed above and the pace of the development of the surgery will be determined by this.

In excisional surgery, there is also usually the problem of the removal of the specimen. Abdominoperineal excision of the rectum is the exception to this. Specimens from anterior resection of the rectum have been removed through the intact distal rectum and anus, but this carries the risk of tumour implantation into the splits in the anus that the required dilatation produces. Implantation has also been reported in port wounds.

Possible solutions to this problem are under investigation. When specimens are removed through small wounds made for the purpose, they can be enclosed in fluid-tight bags to reduce the risk of implantation. If an intact specimen is not required, it may be placed in a bag and 'morcellated' or even liquidized. An intermediate process is to place the specimen into a bag, bring the neck of the bag through a port, pass a telescope and dissectors into the bag to dissect the specimen definitively for samples, and then to liquidize the remainder. A solution acceptable to surgeons and pathologists has yet to emerge and this continues to restrict wholly laparoscopic cancer surgery.

Day-case management of major abdominal surgery – general considerations

The reduction in wound pain achieved by using the laparoscopic approach is usually startling. Pain from port sites can almost always be controlled without the use of strong analgesia, using a combination of local anaesthetic infiltration, non-steroidal anti-inflammatory drugs and simple analgesia. Occasionally a patient will suffer a more general abdominal or subdiaphragmatic pain. This is sometimes due to the presence of blood or residual carbon dioxide irritating the parietal peritoneum, but often the precise cause is difficult to define. It will sometimes need morphine-like drugs for its control and such cases are not usually ready for same-day discharge from hospital.

The reduction in ileus can also be startling – and even unnerving, when an anastomosis is tested by peristalsis and evacuation on the day of surgery.

The laparoscopic approach minimizes the pain-associated cardiorespiratory complications associated with upper abdominal incisions. Complications which must be considered relate to the individual operations and will be discussed with them. They may not declare themselves within the first few hours following surgery, and early discharge following major operations must be accompanied by easy access to experienced advice and perhaps some degree of domiciliary monitoring after discharge.

The proportion of the patients who satisfy the general criteria for day-case surgery in whom same-day discharge can actually be achieved should therefore be high. Currently, the proportion of patients undergoing major surgery being treated as day cases is low in most centres.

This is in part a reflection of how much of the learning curve individual surgeons have negotiated, and there is a natural reluctance to relinquish patients unless the surgeon has absolute confidence in the surgery, based on long personal experience. There is also a lack of individual experience of the finer details of day-case management when it is being applied to major surgery. The limits of the possible in laparoscopic surgery are being tested and extended in all directions and the extension of day-case management must proceed *pari passu*.

Review contribution of the laparoscopic approach to specific disease groups

Cholecystectomy for gallstone disease

Gallstones become increasingly common with age. By the age of 80 yr, about one-quarter of all women and one-sixth of all men in the UK have gallstones. The potential caseload is therefore enormous and cholecystectomy is by far the most common major abdominal operation performed by general surgeons. Fortunately, only 10–20% of patients with gallstones develop symptoms and only patients with symptoms should be treated. Complications, such as empyema, common duct stones and ascending cholangitis, become more common and more serious with age. There is thus a relatively high proportion of elderly patients among those undergoing cholecystectomy. This will tend to reduce the proportion of patients who fall within the criteria for day-case management.

The rate of conversion to open surgery where the surgeon is practised falls to under 2% of cases and many of these relate to problems with common duct stones. With the use of ultrasonography, cholangiography and specific techniques such as dissection with the gallbladder opened and evacuated, there are very few gallbladders which cannot be safely removed laparoscopically by an experienced surgeon. Conversion precludes same-day discharge from hospital. Where septic complications of gallstone disease have been present, it will usually be inappropriate to discharge the patient on the day of surgery, but since these patients are usually old, they fall outside the criteria for day-case management anyway.

Apart from these exceptions, most cases that satisfy the general criteria for day-case management would be suitable for same-day discharge. The precise proportion of cases this represents will vary widely with the practice environment, but rates in excess of 50% are now conceivable. This figure will rise as perceptions within the general population and pressures from funding organizations regarding day-case surgery change. Nothing like this proportion is currently realized in most centres, for the reasons stated above.

The principal complications of cholecystectomy are haemorrhage, inadvertent perforation of a hollow viscus and the leakage of bile, with or without major ductal damage. Haemorrhage will normally declare itself in a carefully monitored patient within the first few hours after surgery. Small biliary leaks can occur in the best

regulated circles and such collections can usually be drained percutaneously under ultrasound control.

Perforations, biliary leaks and ductal damage may not declare themselves until 24 or 48 hr after surgery. The best management of major ductal damage is, of course, to avoid it altogether by skilled and meticulous surgery, but if it does occur, then the crucial aspect of management, if it is to be successful, is the immediate or early detection of the damage followed by a meticulous repair. Immediate recognition of damage is, in this author's opinion, one of the many reasons for performing pre-operative cholangiography. The potential for the early detection of damage must imply that the patient has easy access to a skilled team in the event of even relatively minor symptoms.

Cholecystectomy is the most common major general abdominal operation performed in the majority of developed countries and the laparoscopic approach should produce a major shift in management from an inpatient to a day-case environment within the next few years.

Inguinal hernia repair

Laparoscopic inguinal herniorrhaphy had an uncertain start, with a number of weird and wonderful techniques being described. Practice is now stabilizing to the placement of preperitoneal patches of non-absorbable mesh, using either a transperitoneal or a preperitoneal approach.

The advantages of this operation are that patches distribute their fixation over a wide area, that foci of stress (which are inimicable to biological tissues) are avoided and that, if the boundaries of the patch are extended to well beyond the inguinal area, it is very unlikely that recurrences will find their way round the patch. An audit of my first 100 herniorrhaphies, where about half of the patches were fixed with staples and half not, suggested that fixing patches with staples was a cause of pain, which was significant in the context of what is otherwise a relatively painless procedure. I therefore insert large patches without fixation. The reduction in pain immediately following surgery is great and return to full function is rapid, so much so that the general criteria for the acceptance of patients for day-case surgery in my practice has been extended.

The technique, particularly if performed transperitoneally, is open to the potential of inadvertent damage to other structures. This implies that the surgery must be performed by a skilled and experienced surgeon, in ideal surroundings. It is currently performed under general anaesthesia, although regional anaesthesia or even local blocks may become possible.

The pain reduction and early return of function of the laparoscopic approach has to be compared with the pain reduction of the Lichtenstein repair and the improved pain control achievable nowadays in all open groin herniorrhaphies. There are well known and substantial difficulties in constructing valid controlled trials to compare pain and time to return to full function. Assessment of the long-term success – freedom from recurrence – is,

ipso facto, a long-term process. Funding authorities may be influenced solely by intra-hospital costs and, in turn, influence practice. It is therefore too early to say what proportion of herniorrhaphies will eventually be performed laparoscopically. If the laparoscopic approach is used, then it will encourage day-case management in a large proportion of patients.

Peptic ulceration, reflux oesophagitis and achalasia of the cardia

Oesophagomyotomy for achalasia of the cardia is more simply performed laparoscopically or thoracoscopically than by an open approach. The laparoscopic approach to this operation is very satisfactory, as access to a considerable length of oesophagus can be visualized with great ease through the hiatus telescopically. Disturbance of the anatomy is minimal and reflux, without an anti-reflux procedure, does not appear to be a problem. Return of function is immediate and day-case management should be possible. The condition is, however, relatively uncommon and the impact of a change to day-case management would be slight.

In many countries the treatment of uncomplicated peptic ulceration and reflux oesophagitis has come to be dominated by drug therapy. In other countries the funding organizations prohibit repeated courses of drug therapy and there is a call for surgical treatment. As the effectiveness of the laparoscopic approach to the surgery of these conditions becomes established, the former situation may change.

Variations on the Nissen fundoplication are the most commonly employed option for the treatment of hiatal hernia in both open and laparoscopic surgery. The operation converts well to the laparoscopic approach and operating time in experienced hands is in the region of 1 hr. Recovery of gastric function is almost immediate and very early discharge is now possible.

Highly selective vagotomy for recurrent or unresponsive duodenal ulceration can be performed laparoscopically. The Taylor operation – posterior truncal vagotomy and anterior seromyotomy – has been validated in open surgery and is simple and far less tedious to perform laparoscopically. Return of gastric function is again very rapid. Certainly, very early discharge occurs now.

Gastrectomies for gastric ulceration have been performed laparoscopically. They can be technically demanding, particularly in the present state of instrument development, and they fall outside the scope of early discharge surgery.

Of the complications of peptic ulceration, perforation of duodenal ulcers is ideally treated laparoscopically. Laparoscopy confirms the diagnosis and, at least in my practice, the condition is often associated with heavy smoking and alcohol habits. Pyloric stenosis can be treated with a truncal vagotomy and a pyloroplasty or a gastrenterostomy, both easily performed laparoscopically. Bleeding from a duodenal ulcer can be treated with

pyloroplasty and underrunning of the ulcer, together with a vagotomy.

Oesophageal, gastric and pancreatic cancer

Operations for these cancers have been performed laparoscopically, or with laparoscopic or thoracoscopic assistance. They are very much at the leading edge of development and are not within range of early discharge at the moment.

Colorectal disease and prolapse of the rectum

In applying the laparoscopic approach, the colorectal surgeon can encounter all the difficulties detailed in the general section above. It is possible to see deep into the pelvis with a detail which is unsurpassed, but in a fat male with a narrow pelvis and a large rectal tumour this can be virtually impossible. The need to make an incision to remove a tumour gives the opportunity to perform part or all of the anastomosis outside the abdomen, using conventional techniques, the so-called 'laparoscopically assisted' operation. Oncological concerns have been expressed regarding laparoscopically performed or assisted operations, but there is no reason why these operations should achieve a clearance which is less complete than an open operation – indeed, in some circumstances, the reverse may be true.

Right hemicolectomies can mostly be performed laparoscopically assisted. Abdominoperineal resection of the rectum, subject to the restrictions of access detailed above, are ideally performed laparoscopically. Extensive left-sided colon surgery, anterior resections and operations for inflammatory bowel disease and rectal prolapse can provide considerable problems for the laparoscopic approach and will continue to do so until there are substantial developments in the overall technology. Conversion rates for these operations will remain far higher than for other forms of laparoscopic surgery. Recovery from ileus is rapid, pain reduction is considerable and hospital stay is reduced. Some patients recover very rapidly indeed following right hemicolectomy or surgery for rectal prolapse, but major colorectal surgery is, for the most part, not going to be a day-case or short-stay procedure in the foreseeable future.

Node dissection

Pelvic node dissection is becoming a more common procedure again, either for treatment or for staging, for example, for prostatic carcinoma. Provided no other procedure, such as an inguinal node dissection, has been combined with the pelvic dissection, disturbance is minimal and same-day discharge can be considered.

Upper thoracic sympathectomy for hyperhidrosis

The thoracoscopic approach greatly simplifies this operation and it can be performed as a day-case procedure.

Emergency surgery

The huge benefit which laparoscopy provides in the emergency situation is the establishment of a diagnosis without the need for an incision. This applies to inflammatory conditions, such as appendicitis, and to abdominal trauma. Increasingly, it is possible to establish a diagnosis in, and to discharge after a few hours in a 23-hr admitting ward, patients who otherwise would have needed observation for one or more days in an inpatient unit. Recovery from therapeutic procedures, such as appendicectomy or the division of band adhesions, can be so rapid that discharge home from the admitting ward is possible.

Conclusions

In the past a major part of the reason for keeping surgical patients in hospital has been the need for pain control in, and physical support of, patients disabled by their surgery. Already, improved pain control, coupled with the clinical and management skills learned in the day-case environment, has created the potential for transferring the major part of intermediate general surgery to the day-case unit. The laparoscopic approach to intermediate surgery, chiefly herniorrhaphy, by offering reduction in pain and even more rapid return of function, will help in this process.

The revolution currently promised by laparoscopic surgery is the transfer of a large tranche of commonly performed major abdominal surgery into the day-case unit. The implications for day-case units are substantial. Major surgery has a greater potential for serious complications and access to advice and even monitoring after discharge must be improved. Care teams will need ongoing experience in the management of major abdominal surgery, particularly in the early detection of complications.

At the same time inpatient units will have an increasing interest in the pooling of resources with day-case units, regarding the provision of training and experience in the management of major surgery, the very early discharge of postoperative patients, the rapid turn-round of emergency patients and in providing monitoring and easy access to hospital-based advice for recently discharged patients.

This revolution is tied to the development of laparoscopic surgery. The predicted concentration of laparoscopic surgery into fewer units, coupled with the convergence between day-case and inpatient units which major day-case and early discharge surgery will stimulate, is likely to work against the tendency for day-case units to be dispersed into the community and to stand alone.

Laparoscopic surgery seemingly has brought day-case surgery to the threshold of another major step forward. This may be accompanied by considerable changes in the way in which day-case units are organized and used.