An economic evaluation of laparoscopic versus open inguinal hernia repair

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Abstract

Background The rapid and widespread introduction of minimal access surgery has major implications for the National Health Service. It cannot be assumed that replacing an open procedure with a minimal access alternative will be cost-effective. Laparoscopic inguinal hernia repair is a procedure for which the potential economic benefits are particularly unclear. It is currently being adopted in many centres, although limited evidence on its clinical and cost-effectiveness exists.

Methods This economic comparison of laparoscopic versus open hernia repair was undertaken on data collected on 104 patients undergoing surgery on a day case basis, in the context of a randomized controlled trial.

Results The mean total health service cost of laparoscopic repair was £1074 versus £489 for open repair [mean difference in total health service costs £583; 95 per cent confidence interval (CI) £265–£904]. This difference was largely accounted for by the difference in theatre costs. Laparoscopic repair remained significantly more expensive for most but not all of the scenarios explored in the sensitivity analysis. The direction of the cost-effectiveness ratio was not sensitive to assumptions about long-term recurrence. Neither was it sensitive to halving the operating time in the laparoscopic arm of the trial. When both operating time and the costs of consumables were reduced, laparoscopic repair remained more expensive, but results for this scenario did not achieve statistical significance on this sample size.

Conclusions Laparoscopic hernia repair appears an expensive option in most plausible situations. Furthermore, many uncertainties still exist about long-term outcome after the procedure and about the conditions necessary to maximize cost-effectiveness. Large-scale randomized studies to evaluate laparoscopic hernia repair are currently under way to address these issues. We suggest that further evidence is awaited before this technology is further diffused.

Keywords: inguinal hernia, laparoscopy, costs and cost analysis, randomized controlled trial

Introduction

It has been forecast that in ten years time 70 per cent of surgical interventions in the National Health Service will be undertaken using minimal access techniques. Benefits to patients of minimal access interventions arise from reduced post-operative trauma and faster post-operative recovery. These advantages may benefit some groups of patients more than others. For example, those for whom a long period of absence from employment has a high personal opportunity cost, or individuals with dependent children or relatives, may be particularly affected. Whether these short-term benefits are achieved at the expense of longer-term outcome is largely unresolved.

Health service costs may also be affected by minimal access treatments. Length of hospital stay is often reduced compared with open surgery, with a reduced requirement for hospital beds, but potentially more primary care support. Increased operating time is frequently required for minimal access surgery, particularly when a new technique is being introduced. Shifts in the production function may be necessary, from hospital beds to operating theatre time, and from secondary to primary care services.

Economic implications may arise from increased demand following the introduction of minimal access techniques.
surgery\textsuperscript{3,4} because of a reduced threshold for surgical intervention.

It cannot be assumed that replacing an open operation by a minimal access intervention will be cost-effective. Inguinal hernia repair is already a procedure commonly performed as a day case,\textsuperscript{5} so that economic advantages to the health service from reductions in length of stay will not arise. It has been suggested that economic advantages to society may arise from speedier return to work post-operatively after laparoscopic hernia repair, but it is not clear that this can be attributed to reductions in post-operative morbidity rather than to the outdated advice many patients receive after open hernia repair.\textsuperscript{6} Despite such uncertainties, the introduction of minimal access procedures has rarely been accompanied by formal evaluation of patient outcome or a full economic assessment. Where such assessments have been undertaken they have sometimes lacked timeliness – being undertaken too late in the diffusion of a new technology to have a major impact on the pattern of care subsequently delivered.

This study examines the comparative health service costs of undertaking laparoscopic versus open inguinal hernia repair. To make the economic comparison realistic, the study was undertaken for day case surgery. The NHS undertakes 64 000 inguinal hernia repairs each year,\textsuperscript{7} so that an economic comparison of open with minimal access techniques is particularly important.

Methods

Design

A multi-disciplinary study was designed as a prospective economic evaluation undertaken at the same time as a randomized controlled trial of laparoscopic versus open inguinal hernia repair. Detailed description of the design of the trial and the impact of the two techniques on patients have been reported elsewhere,\textsuperscript{8} and the economic analysis reported here has largely been performed from the perspective of the health service. A parallel analysis of the impact on patients' reported post-operative pain has also been included.

Economic data were collected on the first 104 patients randomized between December 1992 and September 1993. Inclusion criteria for the trial were that patients should meet the local criteria for day surgery (age 18–70 years; ASA grade 1 or 2), that they should have a unilateral hernia, and that they should not have undergone previous major abdominal surgery. One hundred and two patients underwent surgery. One patient in the open group was found to have a femoral hernia at the time of surgery and has been excluded from the analysis. This analysis was therefore performed on 48 patients undergoing laparoscopic and 53 undergoing open repair. Laparoscopic repair was undertaken using a transabdominal approach with the placement of preperitoneal mesh. Patients were questioned about their pain at day 1, day 10, and 6 weeks postoperatively.

Resource use data

The resource use data can be described under four headings: pre-operative costs, peri-operative theatre costs, hospital hotel costs, and post-operative outpatient and community health service costs. Pre-operative resources include premedication drugs and any pre-operative investigations ordered. Peri-operative theatre resources comprise gowns, gloves, intravenous transfusion equipment, sutures, disposable laparoscopic equipment, anaesthetic agents, analgesics, breakages of disposable equipment, and costs of operating time (staff costs, theatre overheads, capital charges). Operating time is costed as the time from a patient entering the operating theatre to leaving it. There is no reason to expect differences between the two groups in the clearing up time after a procedure, and it is assumed that this is the same in both arms of the study. Hotel resource use was estimated as the standard cost of one bed day in the day surgery unit, and the extra costs for any patients admitted to hospital overnight. Resource use of the community health services post-operatively, recorded via a patient questionnaire, included the number of general practitioner (GP) visits, practice nurse visits, and hospital outpatient attendances in the first six weeks post-operatively. Collection of resource use data was not undertaken beyond the first six post-operative weeks as it was felt that any large differences between the two procedures in resource use would arise in the first six weeks, and collecting resource data beyond that point would have substantially increased the practical burden of the economic part of the study.

Valuing resource use data

The staff present in theatre for the open procedure were a G grade nurse, an E grade nurse, a consultant surgeon, and a consultant anaesthetist. The staff present for the laparoscopic procedure are the same, but also include a surgical registrar as an assistant. Theatre staff costs have been based on the mid-point of the relevant salary scale with an additional 13 per cent for employers' costs.

The number but not the duration of practice nurse attendances in the community was recorded. A 10-minute consultation with an F grade nurse was assumed, taking the mid-point on the salary scale and
adding 14 per cent for employers' costs. This is in accordance with the current practice of Oxfordshire Family Health Service Authority. The cost of a consultation with a GP was costed from government expenditure plans for 1992–1993.9 This estimated the average cost of a 10-minute consultation as £9.46.

All consumables were costed using 1992–1993 market prices including value added tax (VAT). Laparoscopic consumables were costed assuming the use of disposable AutoSuture equipment which was used for laparoscopic repairs undertaken as part of the trial.

Overheads for theatre facilities and day unit and in-patient wards were allocated variously: for heating and lighting they were allocated on the basis of floor area; for personnel, nursing administration, training and payroll by a head count; and for management, finance, and administration pro rata across the hospital. Items were valued using 1992–1993 costs provided by the finance department at the Churchill Hospital, Oxford, where the patients were treated. The capital costs of building space were costed according to the values attached by the District Health Authority’s auditor. Charges for capital equipment shared by different specialties in theatre were allocated to specialty on the basis of use.

The cost of re-treating patients with a recurrent hernia is estimated using the mean values for resource use in the relevant arm of the trial, i.e. it is assumed that patients developing recurrent hernias are re-treated using the method employed for their original treatment. It is also assumed that the variation about the mean in terms of resource use in each group is the same in retreated patients as in patients undergoing treatment on the first occasion. Future costs have been discounted by applying the Treasury’s recommended discount rate of 6 per cent.

In addition to a straightforward cost comparison of each group, the relative cost-effectiveness of the two procedures was compared using pain-free days as the measure of outcome. Full details of the assessment and results of the pain measures used in the trial are reported separately.8 Patient-completed categorical pain scores were administered daily for ten days post-operatively, and the chronic version of the short-form 36 (which contains a pain dimension and assesses health over the previous month) was administered at six weeks. From these, the total number of pain-free days in a six week period was calculated for each patient.

Statistical analysis

Data were analysed using Microsoft Excel software. Mean health service costs in each group were calculated, together with the mean difference in cost between the laparoscopic and open arms of the trial. The mean difference in the number of pain-free days between open and laparoscopic groups was calculated up to six weeks post-operatively, and divided by the mean difference in cost to arrive at a mean cost per additional pain-free day.

Sensitivity analysis

Changes in the economics of surgical technologies as a technique is introduced have been previously documented.10 A sensitivity analysis has explored the potential effects of this. The costs of consumable equipment for the laparoscopic repair and operating time may vary in this way, the latter particularly with operator experience.

It is currently unclear how the long-term outcome of laparoscopic repair will compare with the open procedure when such assessment is made in a randomized manner. Long-term hernia recurrence rates in the trial are not known, and the study was designed primarily to examine short-term outcome. The sample size is sufficient to detect only large differences in recurrence between the two arms of the trial.

A sensitivity analysis was performed to examine the implications of making different assumptions about:

1. consumable equipment costs - costs of consumables were varied using the results of a previously published study of laparoscopic hernia repair,11 estimating the consumable costs at £168; costs of using reusable equipment are estimated at £30;
2. operating time - operating time was halved in the laparoscopic group;
3. long-term recurrence rates - conservative estimates of recurrence rates in the laparoscopic group were used, whereas the mean difference in health service cost was plotted against an increasing long-term recurrence rate (at two years and ten years) in the open group;
4. different discount rates were applied to the costs of long-term recurrence (a discount rate of 0 per cent and the Treasury’s recommended discount rate of 6 per cent were applied).

Results

Cost comparison

Trial data

The total mean health service cost of treating a patient with a hernia laparoscopically (£1074) was significantly higher than for open surgery (£489) [mean difference £583; 95 per cent confidence interval (CI) £265–£904; p < 0.001]. Use of hospital hotel and community health services were similar in the two groups. Three patients
TABLE 1  Theatre costs

<table>
<thead>
<tr>
<th>Costs</th>
<th>Non-varying theatre</th>
<th>Variable theatre items</th>
<th>Staff, overheads, + capital theatre</th>
<th>Total theatre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open mean</td>
<td>£41</td>
<td>£82</td>
<td>£145</td>
<td>£268</td>
</tr>
<tr>
<td>Laparoscopy mean</td>
<td>£417</td>
<td>£94</td>
<td>£339</td>
<td>£850</td>
</tr>
<tr>
<td>Mean difference</td>
<td>£376</td>
<td>£12</td>
<td>£194</td>
<td>£582</td>
</tr>
<tr>
<td>SE difference</td>
<td>£0.00</td>
<td>£82</td>
<td>£62</td>
<td>£114</td>
</tr>
<tr>
<td>Lower 95% CI mean difference</td>
<td>£376</td>
<td>£150</td>
<td>£70</td>
<td>£355</td>
</tr>
<tr>
<td>Upper 95% CI mean difference</td>
<td>£376</td>
<td>£175</td>
<td>£318</td>
<td>£809</td>
</tr>
</tbody>
</table>

Significance of difference in mean total health service costs between laparoscopic and open repair: $p < 0.001$.

in the laparoscopic group and two in the open group required overnight admission (hotel costs: mean cost open £268, mean cost laparoscopic £220; community health services: mean cost open £3.22, mean cost laparoscopic £3.83). Most of the difference in cost was accounted for by the difference in theatre costs (mean difference in total theatre cost: £582; 95 per cent CI £355–£809; $p < 0.001$). Differences in theatre costs arose both from consumables and overheads owing to operating time (mean operating time 72 minutes, 95 per cent CI 67–75 minutes in the laparoscopic group; versus 32 minutes, 95 per cent CI 30–34 minutes in the open group). A more detailed breakdown is provided in Table 1, where the difference in staff and overhead costs reflects the difference in operating time between the two procedures, whereas the difference in non-varying consumables reflects the cost of the disposable laparoscopic equipment.

Sensitivity analysis

1. Effect of recurrence. Even making the most conservative 1 per cent estimate of recurrence at two years in the laparoscopic group, it remains the most expensive alternative until very high recurrence rates are postulated for open surgery (lower 95 per cent CI shows that a 64 per cent recurrence rate is required in the open group at two years before the laparoscopic group is cheaper) (Fig. 1).

2. Effect of operating time and recurrence. When laparoscopic operating time was halved, laparoscopic repair still remained more expensive unless two-year recurrence rates of at least 15 per cent occurred after open repair (Fig. 2).

3. Effect of operating time, recurrence and consumable costs. If operating time is halved and cheaper disposable laparoscopic equipment is used, recurrence rates of 33 per cent in the open group would be required before the mean difference in cost showed laparoscopic surgery to be cheaper. However, the results did not achieve statistical significance for this scenario (Fig. 3). Similar pictures are obtained when the costs of reusable rather than disposable laparoscopic equipment are used.

![FIGURE 1 Mean difference in cost if laparoscopy recurrence rate is 1 per cent.](https://academic.oup.com/jpubhealth/article-abstract/18/1/41/1561588)
LAPAROSCOPIC VERSUS OPEN HERNIA REPAIR

(Fig. 4); or when ten-year rather than two-year recurrence rates are assumed and an annual discount rate of 6 per cent is applied (Fig. 5).

(4) Cost-effectiveness. Although the laparoscopic procedure is more costly than the open surgery in the baseline analysis and for most plausible scenarios examined in the sensitivity analysis, it could still prove a more cost-effective option if it achieved significantly superior outcomes. A greater percentage of patients in the laparoscopic than the open group were pain free at ten days and six weeks post-operatively. The mean additional cost per additional pain-free day in the laparoscopic group was £109 (95 per cent CI £41–£393).

Discussion

The average extracontractual referral price quoted by NHS providers for treating a day case inguinal hernia by the open route is £349.12 The mean health service cost of £489 generated by our trial is slightly greater than this, but falls within one standard deviation of the

FIGURE 2 Mean difference in THS if recurrence laparoscopy is 1 per cent, assuming mean operating time half observed.

FIGURE 3 Mean difference in cost if laparoscopy recurrence rate is 1 per cent, assuming laparoscopy consumables are £168 and laparoscopy operating time is halved.
mean of NHS providers. The differences between centres may be accounted for by a number of factors, including variations in capital charges and staff costs. In some centres, however, open hernia repair is undertaken using local rather than general anaesthetic, which is not possible with laparoscopic repair. If this had been the case in our centre the relative increase in cost brought about by laparoscopic repair might have been even greater than demonstrated. There may also be hidden costs arising from laparoscopic repair. Currently, it is a procedure largely undertaken by consultant surgeons, although most hernia repairs performed in the NHS are undertaken by more junior staff. Major complications arising from laparoscopic hernia repair were not reported in our study, but have been described elsewhere. One complication such as a bowel perforation would have a significant impact on costs and would make laparoscopic repair even more expensive. A further factor which needs consideration is the fact that this study was undertaken on a day case basis. In many centres patients are still admitted as inpatients for their hernia repair, and this increases costs. If it were possible to move a further cohort of patients currently being offered in-patient hernia repair into the day surgery setting by using laparoscopic repair, this might be an advantage. However, this appears unlikely.
as the laparoscopic technique requires general anaesthesia and the administration of muscle relaxants, and may prove to increase length of stay. The relative cost-effectiveness of laparoscopic repair will be different for bilateral hernias, where open repair involves two skin incisions, and frequently two operations or two surgeons to treat a patient. The laparoscopic approach may therefore have particular advantages in this instance, and a further study examining this is required.

Information on the distribution of costs arising from laparoscopic repair is not available across providers at this stage in its development, and changes in resource use as a surgical technique develops are well documented. In the case of laparoscopic hernia repair, an extraperitoneal approach to placement of the mesh, using reusable equipment, has recently grown in popularity. This increases the importance of the sensitivity analysis in examining the generalizability of trial results.

Laparoscopic hernia repair was more expensive than open repair for most of the scenarios used in the sensitivity analysis. Laparoscopic repair using disposable equipment is always likely to be more expensive than open treatment of unilateral hernias, even if operating time is reduced. It is also likely to be more expensive if operating time is half that of our study and reusable equipment is used, although the results did not achieve statistical significance for this scenario.

Laparoscopic hernia repair does reduce post-operative pain, although this does not appear to be the major influence in determining time back to work or normal activity – a highly variable outcome dependent on a range of other factors. Whether the reduction in pain justifies the increased health service costs is a judgement which must be made after consideration of long-term patient outcomes such as recurrence, and of the potential benefits arising from alternative uses of the same health service resources.

If additional funding for laparoscopic hernia repair appears justified, further work is required to determine the best way of maximizing cost-effectiveness. Cost-effectiveness will vary depending on where a surgeon is on the learning curve for a procedure. Information about the surgeon’s learning curve will therefore be required to determine whether physician specialization or centralization of facilities is appropriate.

Experience with other minimal access interventions such as laparoscopic cholecystectomy suggests that laparoscopic hernia repair may diffuse rapidly, and evidence about how best to maximize cost-effectiveness needs to be assembled early if it is to influence patterns of care. It was therefore appropriate to incorporate such evaluation into the earliest trials of the procedure. The results of this analysis are strong arguments against its widespread introduction until further evidence on long-term outcome becomes available. Large-scale studies of the various techniques of laparoscopic hernia repair are currently under way, and we would suggest that their results are awaited before this technology is widely diffused.

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