Cost-effectiveness of Laparoscopy in Children

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Background: Laparoscopy may offer fast recovery and improved cosmesis, but its cost has been perceived as excessive.

Objective: To analyze the total hospital costs of laparoscopy vs open surgery.

Design: Retrospective cost-effectiveness analysis evaluating all cases performed in a 36-month period (September 1995 to August 1998). Cases were evaluated for operative time, itemized cost of supplies, and length of hospitalization.

Setting: Operations performed by pediatric surgeons in a tertiary care children’s hospital.

Patients: Consecutive children undergoing laparoscopic or open appendectomies, cholecystectomies, fundoplications, and splenectomies. Patients were not randomized to laparoscopy or open surgery.

Interventions: Laparoscopic procedures performed with a core set of reusable equipment and a limited number of disposable instruments.

Main Outcome Measures: Cost surplus of laparoscopy was evaluated, and compared with savings associated with decreased hospital stay, to obtain cost-effectiveness of laparoscopy per procedure.

Results: There were 26 laparoscopic and 359 open appendectomies; 33 laparoscopic and 3 open cholecystectomies; 16 laparoscopic and 18 open fundoplications; and 16 laparoscopic and 7 open splenectomies. Excess operating costs per procedure were $442.00 for appendectomy, $634.60 for fundoplication, $847.50 for cholecystectomy, and $1551.30 for splenectomy. Hospital stay was decreased for all laparoscopies, resulting in an overall savings per laparoscopic procedure of $2369.90 for appendectomy, $5390.90 for fundoplication, $1161.00 for cholecystectomy, and $858.90 for splenectomy.

Conclusions: Laparoscopy is cost-effective, particularly for fundoplication, appendectomy, and cholecystectomy. Detailing the costs of supplies, operating time, and length of stay allows interinstitutional comparison and critical cost-analysis of laparoscopy. With a more selective use of reusable instruments and further shortening of operative time, the global savings of laparoscopy may increase.


Editor’s Note: I love advancing technologies that produce results like the ones shown in this study.

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LAPAROSCOPIC surgery was first described in children in 1971, but has since lagged behind its adult counterpart. While laparoscopic cholecystectomy took the adult surgical world by storm, the lack of a similarly common surgical indication in children prevented the widespread application of pediatric laparoscopy. As a result, adequately scaled-down instrumentation did not exist, further impairing the development of these techniques in small patients. In the past 5 years, however, many more indications for a laparoscopic surgical approach have emerged, small-caliber endoscopic instruments have become available, and ever-younger patients have been given access to this minimally invasive alternative.

As in adult surgery, laparoscopy has now become an integral part of pediatric surgical practice. While some of the claimed benefits of laparoscopy, such as decreased postoperative pain, have not been substantiated in blinded studies, this approach has demonstrated more rapid recovery and better cosmetic results, particularly where it replaces large incisions and extensive dissection. It
is generally accepted, however, that laparoscopic surgery is more expensive to perform. This is mostly related to the use of mechanically complex, fragile, and often expensive instruments, and the longer operative time required for laparoscopic procedures. When considering global cost analysis, the increased operating expenses should be offset by a shorter hospitalization associated with laparoscopy. The savings are proportionate to the difference in length of postoperative hospitalization between open and laparoscopic procedures.

The cost of laparoscopic surgery can be influenced in a variety of ways. Length of postoperative hospitalization is subject to physician bias and economical constraints, and has tended to shorten in recent years, no matter which operative approach is chosen. As a result, the promise of rapid discharge from the hospital associated with laparoscopy may often be moot. In children, hospital stay is generally shorter and recovery faster, making it more difficult for the proponents of laparoscopy to claim cost savings.

Cost containment can also be attempted by decreasing the direct expenses of laparoscopic surgery. This implies a rational use of laparoscopic equipment, and a responsible blend of disposable and reusable instruments. At our institution, we have come to rely on a limited number of mostly reusable instruments, supplemented by few single-use mechanical tools, such as clip appliers and endoscopic staplers. The present study was conducted to evaluate the cost-effectiveness of this approach in children, for different surgical indications. We attempted to itemize costs to identify potential needs for improvement and allow comparison between institutions.

PATIENTS AND METHODS

This study includes all consecutive patients undergoing laparoscopic or open appendectomy, cholecystectomy, splenectomy, and fundoplication (with or without concomitant gastrostomy) performed at Hasbro Children's Hospital, Providence, RI, between September 1995 and August 1998. Choice of open or laparoscopic approach was left to the individual surgeon, and patients were not randomized. Informed consent only addressed the specific procedure, not the choice between open surgery and laparoscopy. Demographic patient data were recorded, as were operative time (not including anesthesia) and postoperative length of hospitalization. Only the differences in direct operative costs were considered, i.e., the additional costs (not patient charges) of laparoscopic instruments and equipment. For reusable material with limited longevity, amortization was based on the number of procedures performed before repair or replacement of the instrument. Reusable instruments include 10- and 5-mm Hopkins rod-lens telescopes (Karl Storz Endoscopy, Culver City, Calif), endoscopic scissors and dissectors, graspers (all 5-mm diameter), accessory cannulas (5- and 12-mm diameter), needle holders, and knot pushers. Disposable equipment include initial (balloon-tipped) cannula, flexible 5-mm cannula, suction-irrigator setup, insufflation tubing and camera sheath, endoscopic clip appliers (5 mm) and staplers (12 mm), endoscopic specimen bags, and endoloop ties.

Hardware (monitors, cameras, and insufflators) are not considered additional costs, but are included in the overall charges for the use of the operating room. These charges are $293 per 15-minute segment, and were prorated based on the average duration of each procedure. Hospitalization charges comprise $1339 per day (acute hospitalization). Mean operative times and postoperative hospitalization were compared (laparoscopy vs open) using 2-tailed Mann-Whitney test for nonparametric data (P<.05 considered significant). Values are expressed as mean ± SD, where appropriate.

RESULTS

A total of 478 children, aged 3 weeks to 17 years (11.5±5.52 years; median, 13 years), weighing 2.5 to 85 kg (46.6±22.69 kg; median, 30 kg) were studied. No demographic differences were found between the open and the laparoscopic groups. Table 1 illustrates the number of open and laparoscopic procedures performed during the study period, and the mean operative times and length of hospitalization. All procedures, except cholecystectomy, were significantly longer when performed laparoscopically. By contrast, all patients undergoing laparoscopic procedures were discharged from the hospital earlier than their “open” counterparts (although not significantly so for laparoscopic splenectomies). Of note, only 3 open cholecystectomies were performed during the study period, attesting to the wide acceptance of laparoscopic cholecystectomy, and making true statistical inference difficult.

The itemized excess in operative costs of laparoscopy are detailed in Table 2. Not all instruments were used for each type of laparoscopic procedure. Initial port placement was through an open technique, using a disposable 5- or 10-mm diameter balloon cannula. Subsequent ports were reusable cannulas, except for a disposable, flexible cannula to accommodate a curved Babcock clamp during fundoplication. All reusable instruments were 5 mm (or 3.7 mm in infants). A 5-mm endoscopic clip applier, a 12-mm endoscopic stapler and cutter, and a 10- or 12-mm diameter specimen bag were used in selected operations. The amortization of endoscopic scissors is estimated at 30 cases and that of endoscopic dissectors at 60 cases. The price of endoscopic cannulas is not included, as their longevity is such that costs (including resharpening of the trocar every 10-20 procedures) is negligible.

The costs of excess operative time for laparoscopic procedures is calculated by prorating the fixed cost of $293 per 15 minutes, or $19.53 per minute. The bottom row of Table 2 represents the total excess in operating costs per laparoscopic procedure.

These values are divided by $1339 (the daily charge for hospitalization), to express them in terms of day-equivalents (Table 3). As such, they represent the reduction in hospitalization (in days) required by laparos-
copy for overall costs to be equal to those of an open procedure. Table 3 also summarizes the actual mean reduction in hospitalization achieved by laparoscopy in our series (from Table 1). This reduction, in days, is multiplied by $1339 to express it in actual costs. The difference between excess operating costs and reduction in hospitalization costs represents the actual savings per procedure achieved by laparoscopy for each of the 4 surgical indications.

**Comment**

Laparoscopy offers many advantages, including smaller and less conspicuous scars, faster recovery, and earlier return to work (for parents) or to school. Unfortunately, these seem to come at a cost. Endoscopic procedures usually take longer (particularly in one’s early experience), and require complex, fragile, and expensive instrumentation. The use of disposable equipment avoids the need for sharpening, repair, and maintenance, but has driven up the overall cost of laparoscopy. Now that the learning curve is flattening for most surgeons, it may be time to separate necessary from superfluous costs of laparoscopy.

Increased surgeon experience decreases operative time and reduces the risks (and costs) of complications, but the presence of a dedicated operating room system may be just as important. Kenyon et al showed that anesthesia time could be reduced by 30 minutes per case, and conversion rates were significantly lower when a designated nursing team helped perform the laparoscopic procedures. In general, it is to be expected that the time required to perform laparoscopic operations will continue to decrease, and some authors now report simi-
lar operating times for laparoscopic and open cholecystectomies,\textsuperscript{10} inguinal herniorrhaphies,\textsuperscript{12} fundoplications,\textsuperscript{8,18} and splenectomies.\textsuperscript{11} Still, laparoscopic procedures that require complex skills, such as fundoplication, are likely to take significantly longer to perform, increasing the direct operative costs.

While the use of disposable equipment is unavoidable, conscious efforts to rely on durable instruments can help reduce the costs of laparoscopy. In our system, all accessory cannulas (which are introduced under direct endoscopic control) are reusable and their trocar sharpened every 10 to 20 procedures. While actual price and cost may vary widely between institutions, Ransom et al.\textsuperscript{22} found that the cost of reusable cannulas (including maintenance) was 40 times less than the single-use equivalents. In our practice, scissors, graspers, and dissectors are reusable as well, but last only a limited time because of the fragility of their mechanism. The amortized cost of these instruments is still far less than the systematic use of disposables. Only clip appliers, endoscopic staplers, and, more recently, harmonic shears, are single-use (and not inexpensive) instruments. Thus, operations requiring a minimal number of these instruments will tend to be less costly: not surprisingly, these procedures are the very same that may require more advanced surgical skills, such as endoscopic suturing and knot-tying. Laparoscopic fundoplication, for example, requires very few mechanical instruments (whether the short gastric vessels are divided or not), but takes longer to perform. The net result, in our experience, was an excess cost, compared with open fundoplication, of only $635. In contrast, laparoscopic splenectomy is lengthy and dependent on clip appliers, harmonic shears, and/or stapling devices, and is therefore the most expensive procedure to perform: $1550 in excess costs over open splenectomy.

Ultimately, the cost-effectiveness of laparoscopy depends on the balance between excess operating costs and reduced hospitalization. In our experience, appendectomy and fundoplication were less expensive, overall, because of a significant reduction in hospital stay after laparoscopy. However, laparoscopic appendectomy was not performed for perforated appendicitis; if one excludes open appendectomy for perforated appendicitis, the difference in postoperative stay after open surgery or laparoscopy is only 1 day. Laparoscopic splenectomy was more cost-effective than open splenectomy, but not by much: the high operating costs could only be offset by a substantial difference in hospital stay, which we did not find (only 1.8 days, on average). Others have reported a similar experience in children,\textsuperscript{13} while most adult series have found more pronounced differences (13 and 2 days for open and laparoscopic splenectomy, respectively, in a series by Watson et al.\textsuperscript{13}) Finally, laparoscopic cholecystectomy is now so ingrained in our surgical culture that it has become difficult to find sufficient numbers of open cholecystectomies for comparison. In addition, open cholecystectomy is often performed in difficult circumstances (eg, dense adhesions, multiple operations), when laparoscopy is not feasible, creating a substantial bias.

In conclusion, responsible use of durable and disposable equipment allows laparoscopy to be cost-effective in 4 of the most commonly performed surgical procedures. Itemizing these costs should allow interinstitutional comparison and critical cost analysis.

**References**