Laparoscopically Assisted Anterior Resection for Diverticular Disease
Follow-up of 100 Consecutive Patients

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Purpose
The objectives of this study were to refine the technique of laparoscopically assisted anterior resection (LAR) for diverticular disease and to analyze the morbidity and mortality rates, and longer term follow-up of the first 100 consecutive patients.

Methods
Data were collected prospectively, and follow-up was performed by an independent assessor using a standardized questionnaire.

Results
The median duration of surgery was 180 minutes, the median time for passage of flatus was 2 days after surgery, and the median length of hospital stay was 4 days. Overall, the morbidity rate was 21%, and the wound infection rate was 5%. There were no deaths. Eight patients underwent open laparotomy. The rate of complications was significantly greater in the latter group of patients (75%) than in those who underwent laparoscopy (16%, p = 0.002). The comparison between the first 20 cases and the last 20 patients revealed a significantly shorter duration of surgery (median 225 min. vs. 150 min.; p < 0.0001) and decreased length of stay (6 days vs. 4 days, p < 0.0001). Apart from a nonsignificant increase in the length of surgery, there were no differences in other study parameters when comparisons were made between those patients who underwent LAR for complicated diverticular disease and those patients who underwent uncomplicated diverticular disease.

Follow-up
Ninety patients were available for follow-up at a median time of 37 months. Ninety-three percent of the patients reported that the surgery had improved their symptoms. No patient required hospitalization, and no one was treated with antibiotics for recurrent symptoms.

Conclusion
Laparoscopically assisted anterior resection for diverticular disease has acceptable morbidity and mortality rates and a median postoperative hospital stay of only 4 days. Follow-up investigations revealed no recurrence of diverticulitis, and patients reported satisfaction regarding cosmetic and functional results.

Despite the potential advantages to be gained by the patient and the community from laparoscopic colorectal surgery (e.g., reduced postoperative pain, early return of gastrointestinal function, shorter hospital stay, and earlier return to full activity),1 the technique has not been accepted widely by surgeons. The lack of acceptance may result from the increased complexity of laparoscopic techniques when applied to dissection or resection of the colon and rectum,2 the duration of surgery and of the learning curve,3,4 the concern with regard to portsite metastases in malignant disease,5 and the lack of data from randomized controlled trials.6

Laparoscopic techniques were extended to colorectal surgery in 1991. Since the middle of that year, our group at the Royal Brisbane Hospital has performed more than 450 such procedures with a high success rate.3,7 Diverticular disease has accounted for more than 120 of these procedures, most of which were elective, laparoscopically assisted, high anterior resections for recurrent diverticulitis.

The process of recurrent inflammatory episodes in diver-
ticulitis may cause distortion of the normal anatomy. The presence of a diverticular phlegmon, perforation, fistula formation, or involvement of adjacent structures all provide a challenge to performing a safe dissection and resection. This can be the case whether the surgery is performed by midline laparotomy or laparoscopically. As a benign process, however, the surgical management of diverticular disease may be eminently suitable to laparoscopic techniques.

This prospective consecutive study aims to refine the technique of laparoscopically assisted, anterior resection (LAR) for diverticular disease and to analyze the perioperative morbidity and mortality rates, return of bowel function and discharge, and longer term follow-up on the first 100 consecutive patients.

PATIENTS AND METHODS

From July 1991 to December 1996, more than 450 laparoscopic colorectal procedures were performed either at the Royal Brisbane Hospital or at nearby private hospitals; 120 consecutive patients were treated for symptomatic diverticular disease. A minimum requirement of a 6-month follow-up excluded 14 of 120 patients. Furthermore, six patients who underwent laparoscopic procedures other than anterior resection — one who required laparoscopic right hemicolectomy, two laparoscopic Hartmann’s procedures, and three who had required laparoscopic reversal of Hartmann’s — were excluded from the study.

Data were collected prospectively for age, sex, indication for surgery, previous abdominal surgery, duration of surgery, and amount of blood loss. Postoperative information also was collected for passage of flatus, passage of feces, hospital stay, and morbidity and mortality rates. Complicated diverticular disease was defined as either perforation (either at the time of surgery with purulent or fecal peritonitis or at examination of the pathologic specimen) or fistula (to the skin, small or large bowel, bladder, or vagina). Hospital death was defined as death within 30 days of surgery.

Comparisons of outcomes were made between those patients who underwent LAR for complicated diverticular disease with those who had undergone LAR for recurrent diverticulitis. The outcomes for the first 20 patients also were compared with outcomes for the last 20 patients.

Statistical analysis was performed using chi-square analysis, Fisher’s exact test, or Wilcoxon rank sum test. The 0.05 level of significance was used throughout, and all p values reported are two sided. Follow-up was performed by an independent surgeon assessment using a standardized questionnaire, by clinical review, or by telephone.

Technique

The technique of LAR has been described by this group and others. However, as our experience with laparoscopic colorectal surgery has progressed, the technique has been further developed and refined so that it seems appropriate to report its current status. Because the diseased segment of the colon is often inflamed and bulky, it is not practical, nor is it desirable, to remove the specimen through the anus. Instead, a small muscle split incision is used to remove the specimen and to place the anvil of the circular stapler. Apart from this step, the entire operation is performed intracorporately under video laparoscopic control.

Preparation

All patients undergo full standard bowel preparation, graduated compression stockings, subcutaneous heparin, and antibiotic prophylaxis (single intraoperative dose of cefotaxime). They are placed on a bean bag, and the legs are elevated in Allenstirups (Allen Medical Systems, Cleveland, OH). Both thighs should be level with the abdomen to enhance maneuverability of the instruments. An indwelling urinary catheter and orogastric tube are inserted; the latter is removed at the end of the procedure.

Modified total intravenous anesthesia (propofol infusion with oxygen and isoflurane) is the anesthetic of choice. Nitrous oxide should be avoided because its use has been implicated in intraoperative bowel distension.

Position of Ports

A curved infraumbilical incision is made for the insertion of the Hasson cannula by open technique. After carbon dioxide insufflation to achieve a maximum pneumoperitoneal pressure of 12 mm Hg, the abdominal viscera are inspected using a 10-mm 30° laparoscope. The main working port is 12 mm in diameter and is placed low and lateral in the right iliac fossa to allow for access to the pelvic floor and division of the vessels and bowel. Care is taken to avoid the inferior epigastric vessels.

A 5-mm port is placed in each flank. An optional 5-mm port can be placed in the midline immediately above the pubic symphysis if needed. All ports are secured with a stay suture to avoid untimely dislodgement during the surgery and to allow full insertion if necessary.

A floppy or bulky uterus can be elevated out of the pelvis by either the sucker-irrigator placed in the optional 5-mm suprapubic port or by securing it to the anterior abdominal wall by a Prolene suture. This is done by passing a 2-0 Prolene suture (Ethicon, Somerville, NJ) on a straight needle through the abdominal wall, grasping it intracorporeally with a needle holder, and passing it around the round ligament and back through the abdominal wall. The suture is tied over an abdominal pack to avoid skin trauma. The surgeon and the assistant stand on the patient’s right side, the scrub nurse stands between the legs of the patient, and the video monitor is positioned on the left (Figure 1).
Dissection

With the table tilted toward the right, the peritoneal attachments of the sigmoid and descending colon are divided using disposable 5-mm diathermy-scissors via the 12-mm port in the right iliac fossa. The colon is retracted with 35mm DeBakey-type bowel grippers via the right flank 5-mm port held in the surgeon's left hand. Further tension is placed on the area of dissection by the assistant who provides counter-traction with a DeBakey-type bowel grasper through the left flank 5-mm port held in the left hand.

The lateral peritoneal reflection is then divided to and around the splenic flexure, and the avascular plane between the mesocolon and perirenal fat pad is located. It is usually necessary to move the diathermy scissors to the left-flank 5-mm port to reach the splenic flexure (Figure 2).

Once the left colon has been mobilized, a steep Trendelenburg tilt is used to help keep the small bowel out of the lower abdomen. The inflamed segment of the colon is now addressed, and inflammatory adhesions are carefully divided. Often they are rotated from normal tissue planes to more densely inflamed areas until the easiest location for dissection is found. If a fistula is present (e.g., to either the bladder or the vagina), it can be divided under direct vision. The bladder fistula is usually small and rarely requires direct repair, but it can be sutured laparoscopically if necessary.

The root of the sigmoid mesocolon is dissected carefully to identify the left ureter. The sigmoid is then passed over to the left and held upward to expose the base of the right side of the sigmoid mesocolon. The peritoneum is divided with diathermy just anterior to the hypogastric nerves, and a window is developed to the other side, allowing visualization of the left ureter once more (Figure 3). The inferior mesenteric vessels are thus held forward, and the relatively avascular plane, between the vessels in front and the nerves behind, are taken to the origin of the inferior mesenteric artery. Care is taken to avoid damage to the hypogastric nerves.

After identification of the left colic artery, another window is made cephalad to allow division of the inferior mesenteric artery either above or below the left colic. This can be done with a 30- to 35-mm endoscopic linear stapler with a staple length of 2.8mm. The proximal pedicle is held with grasping forceps while the stapler is disengaged just in the event of a malfunction. If needed, the inferior mesenteric vein may be taken separately at the inferior border of the pancreas to gain extra colonic length.

With the vessels divided, pelvic dissection is begun by following the hypogastric nerves posteriorly and laterally in
the avascular plane, and it is continued laterally on both sides until the upper and middle rectum have been sufficiently mobilized.

Resection

With mobilization now complete, the rectum is held taut in a cephalad direction so the appropriate level of resection at the pelvic brim can be chosen. The peritoneum over the mesorectum is divided at this level, and the avascular plane is developed between the rectum and the mesorectum (Figure 4). The rectum is divided first with a 30- to 35-mm endoscopic stapler (staple length 3.8 mm), and the mesorectum is divided with a vascular reload of the stapler. Two serial applications of the bowel stapler usually are required to traverse the rectum. The 60-mm cartridge length is not used because of the larger port diameter required and limited pelvic space.

The divided proximal end of the colon is held with a traumatic grasper and delivered through a 35- to 50-mm muscle-splitting incision in the left iliac fossa, medial to the anterior superior iliac spine. It may be helpful to use a plastic wound protector to facilitate the delivery of a bulky and inflamed colon through the small wound.

The colon specimen is divided 50 mm above the skin and through the compliant nonhypertrophied bowel. The anvil of a 33-mm circular stapler is secured with a 2-0 prolene purse-string suture. A low profile anvil is preferred for easier insertion into the bowel and for maneuverability. The bowel and anvil are returned to the abdominal cavity, and the wound is closed to allow the re-creation of a pneumoperitoneum.

Under video laparoscopic control, the shaft of the circular stapler is passed through the rectum and the spike is brought through the stapled rectal stump, adjacent to the staple line. While taking care that the proximal colon is not twisted, the anvil is then docked onto the spike. The anastomosis is effected under direct vision before the circular stapler is disengaged. The colon is assessed for tension and the anastomosis is checked with a rigid sigmoidoscope for hemostasis and integrity. All port sites larger than 10 mm are closed with 0/- Dexon.

RESULTS

From November 1991 to June 1996, all patients more than 55 years of age who had at least two documented attacks of severe diverticulitis that required antibiotics and possibly hospitalization were offered the laparoscopic procedure. Any patient who had complicated diverticular disease, such as fistula or perforation, and patients younger than 55 years of age who had at least one attack that required antibiotics and possibly hospitalization also were offered surgery. One hundred consecutive patients underwent laparoscopically assisted anterior resection for symptomatic diverticular disease and at least a 6-month follow-up after surgery. The indications for surgery are shown in Table 1.

The mean age was 61 years (range, 35–84 years). The male-to-female ratio was 37:63. The mean weight was 74 kg (range, 49–105 kg). Of the 100 patients, 55 had previous major abdominal surgery. The median duration of surgery was 180 minutes (median range, 60–310 minutes). There were eight conversions to open laparotomy for various reasons (Table 2). There has been only one conversion to laparotomy in the last 50 patients and none in the last 20 patients. The median time to passage of flatus after surgery

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<tr>
<th>Table 1. INDICATIONS FOR SURGERY</th>
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<tr>
<td>Recurrent diverticulitis</td>
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<tr>
<td>Colovesical/colovaginal fistula</td>
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<tr>
<td>Perforation</td>
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<th>Table 2. REASONS FOR CONVERSION TO OPEN LAPAROTOMY</th>
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<tr>
<td>Anatomy not identified</td>
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<tr>
<td>Failure to progress</td>
</tr>
<tr>
<td>Hemorrhage</td>
</tr>
<tr>
<td>Perforation (colon)</td>
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<td>Equipment failure</td>
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* Initially, a time limit of 4 hours was adhered to.
was 2 days (range, 1–4 days) at which time a light diet was commenced. (Currently, a light diet is offered on day 1 regardless of the passage of flatus). The median length of hospital stay was 4 days (range, 2–33 days).

There were no deaths in this series. Twenty-one patients had postoperative complications (Table 3), among them four anastomotic leaks. One of these was caused by inadvertent disruption of the anastomosis at reoperation. The patient’s rectum had a small bleed on day 5 after surgery and became unwell. Rapid atrial fibrillation developed, and the patient’s abdomen became distended. At laparotomy, a small amount of clear fluid was found, but there was no evidence of an overt anastomotic leak. The colon was tensely distended with old blood. On closer examination of the anastomosis, it became disrupted by the surgeon; it had to be oversewn, and a diverting loop ileostomy had to be fashioned. The patient was discharged from the hospital on the 10th day after surgery. The remaining patients were treated successfully by conservative measures. Two of those treated conservatively were discharged on day 5, but were readmitted 4 days later. One patient had a left iliac fossa wound collection that later revealed a fecal fistula; the other patient had lower abdominal pain and a water-soluble contrast enema revealed a small, contained, posterior leak. A water-soluble contrast study showed that another patient still in the hospital had a contained posterior leak. All were treated successfully with antibiotics and total parenteral nutrition and were discharged home 19, 11, and 21 days later, respectively.

Six of the 8 patients who converted to laparotomy had complications (75%) which included the only respiratory events (3 in 100) in the series. Importantly, the other three complications in this group could not be directly attributed to technical problems created during the laparoscopic dissection, but may have been secondary to patient disease. This complication rate was significantly greater than the 16% seen in those patients who completed laparoscopically (15–92; p = 0.0002). There was no significant difference found in the number of complications occurring in the first 20 patients compared with the last 20 patients (Table 4).

However, comparison of other parameters between the first and last 20 patients did reveal a significant reduction in the duration of the operations (mean 230 vs. 150 minutes, p < 0.0001) and a significant reduction in length of hospital stay (median 6 vs. 4 days, p < 0.0001).

The outcome parameters of LAR for complicated cases were prospectively compared with those patients having LAR for uncomplicated diverticular disease. The median duration of operation was slightly longer in the complicated group (210 min.) than in the uncomplicated group, (180 min.) but this did not reach statistical significance. Similarly, there was no statistical differences in the rate of conversion to open laparotomy (8.7% vs. 7.8%), median length of hospital stay (5 days vs. 4 days), or complication rate (13% vs. 21%).

### Follow-Up

At a median time of 37 months (range 6–63), 90 of the 100 study patients were available for follow-up. Nine patients had since moved without forwarding address, and one patient had died from causes unrelated to surgery.

Eighty-four patients (93%) reported that the operation had dramatically improved their symptoms that had been attributed to diverticular disease. However, six patients who had undergone LAR for recurrent diverticulitis stated that there was little improvement in their symptoms. All of the patients with complicated diverticular disease felt that the operation was successful.

Overall, when asked if they had any further symptoms since their operation 72 patients (80%) reported no further abdominal symptoms, but 18 patients had occasional hypogastric pains or bloating. Again, these patients had undergone LAR for recurrent diverticulitis, while this was not reported in any patient who had either fistula or perforation.

No patient required hospitalization nor was any patient

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<th>Complication</th>
<th>First 20</th>
<th>Last 20</th>
<th>p</th>
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<tr>
<td>Duration of Surgery</td>
<td>230 min.</td>
<td>150 min.</td>
<td>0.0001*</td>
</tr>
<tr>
<td>Length of hospital stay</td>
<td>6 days</td>
<td>4 days</td>
<td>0.0001†</td>
</tr>
<tr>
<td>Conversion to laparotomy</td>
<td>4</td>
<td>0</td>
<td>0.11‡</td>
</tr>
<tr>
<td>Complications</td>
<td>9</td>
<td>6</td>
<td>0.32‡</td>
</tr>
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* Chi-squared test.
† Wilcoxon rank sum test.
‡ Fisher exact test, two-tailed.
treated with antibiotics for recurrent diverticulitis in the follow-up period.

Most patients (68%) felt that their bowel habit was more regular (spontaneous bowel action every day or second daily) when compared with their bowel habits before surgery, and a further 20% of patients felt that bowel habits remained unchanged. Bowel function was reportedly worse in 12% because of increased constipation, diarrhea, or bloating. There was a similar level of improvement in bowel function regardless of the indication for surgery.

Virtually all patients were very satisfied with the cosmetic result of the scars. Only two patients were not satisfied with the aesthetic result and both had been converted to an open laparotomy.

In an effort to establish the safety of the laparoscopic dissection with preservation of the hypogastric nerves, all of the men were asked if they had experienced any persistent trouble with sexual function that had not been a problem before the operation. Of the 37 men in the follow-up study, only 1 reported symptoms suggestive of retrograde ejaculation, and hence consistent with damage to the hypogastric nerves. The indication for surgery in this case had been for recurrent diverticulitis and occurred early in the series. (Another four patients stated they had occasional difficulties with erection, and one even reported increased curvature of the penis since the operation. However, the possible mechanism for this is unclear and probably not related to the procedure.)

**DISCUSSION**

Diverticulosis of the colon is present in more than one third of the population over 45 years of age and increases to two thirds over the age of 85 years. Most of these will remain asymptomatic. However, between 10% to 25% of these patients will develop symptoms of diverticulitis at some stage. With an increasing incidence of diverticular disease in the 20th century, and greater experience in the treatment of its complications, criteria for medical versus operative management are now well established. As the patient is less likely to respond to conservative medical therapy with each recurrent episode of documented diverticulitis (70% chance of response after the first attack vs. 6% chance after the third), resection is recommended after two attacks of uncomplicated diverticulitis. While diverticular disease is relatively uncommon in younger patients, a greater proportion of patients require urgent or emergency surgery, so the practice has been to recommend elective resection in otherwise healthy patients under the age of 55 years after one well-documented attack of diverticulitis that requires treatment with antibiotics. According to the Standards Task Force of the American Society of Colon and Rectal Surgeons, resection is also recommended after only one attack in patients with complicated diverticulitis. Further evidence was provided by Farmakis, Tudor, and Keighley who also were strongly in favor of such a policy. In a national audit to determine the 5-year natural history of complicated diverticular disease, they found that 32% of patients treated medically developed serious complications of diverticulitis after the original index admission, of whom 25% had died.

The extent of resection required has generally been accepted to include the sigmoid colon, which ensures that the distal anastomosis is in the rectum. It does not appear necessary to resect all of the diverticular-bearing proximal colon, provided that it does not appear to be thickened or inflamed. The reported incidence of recurrent diverticulitis after anterior resection ranges from 6% to 11% and up to 13% when resection ends in the distal sigmoid colon. In our series to date, there has been no recurrences of diverticulitis requiring treatment with antibiotics or hospitalization.

Of interest, however, has been the 18 patients who reported occasional abdominal pains or bloating. All of these patients had documented evidence of recurrent diverticulitis as the indication for resection, while none of the patients who had a fistula or perforation reported recurrence of abdominal pain. The reason for this remains unclear. It is feasible that some of these patients also had an element of irritable bowel syndrome which may have contributed to their symptoms. This phenomenon has been reported previously in 24% to 27% of the patients after open anterior resection for histologically proven diverticulitis.

There were four anastomotic leaks in this series. One of these was actually an anastomotic hemorrhage that, in presenting clinically as an acute abdomen, required a laparotomy and temporary defunctioning ileostomy. Although a 5% leak rate after anterior resection is acceptable when compared with open series in the literature, it is still of concern. In all patients, the splenic flexure was mobilized in an attempt to provide a tension-free anastomosis. After resection of the specimen, the blood supply to the proximal colon was deemed to be adequate. It may be that the resection has occasionally been more extensive than was needed. Hence, after the anastomosis has been effected laparoscopically, the degree of tension may be difficult to determine using only instruments and video appearance, without the tactile sensibilities available at open surgery.

The overall rate of conversion to open laparotomy in this series has been 8%, which compares favorably with rates of 12% to 53% reported in other studies for laparoscopic sigmoid colectomy. It is interesting to note the postoperative complication rate in those patients converted to laparotomy was nearly 60% greater than when the operation was successfully completed laparoscopically (p = 0.0002). Importantly, there were no respiratory or thromboembolic complications in the laparoscopically-completed group. The wound infection rate was also low and was of minor significance when it did occur because of the small size of the wound. Furthermore, no incisional herniae have been detected in the follow-up period.

For both uncomplicated and complicated diverticular dis-
ease, the safety of the dissection performed laparoscopically has been demonstrated in this series of 100 cases. The left ureter was always visualized, as were the hypogastric nerves. As a result, there were no ureteric injuries and only one case of hypogastric nerve damage which resulted in retrograde ejaculation. Ureteric stents were not used in this series. If the ureter cannot be visualized safely, the surgeon should convert to open laparotomy. If the splenic flexure has been mobilized laparoscopically first, before addressing the diseased sigmoid colon or identifying the left ureter, conversion to laparotomy may then only require a lower abdominal incision should conversion become necessary.

There is a learning curve for laparoscopic colorectal surgery, described previously, which is well illustrated here for laparoscopic anterior resection. There was a significant reduction in the length of the operation between the first 20 cases when compared with the last 20 (mean 230 min. vs. 150 min.; p < 0.0001). Over the same time, the number of patients converted to open laparotomy fell from 7 in the first 50, to 1 in the last 50, to zero in the last 20 patients. The median length of hospital stay was also significantly reduced from 6 days to 4 days (p < 0.0001). This may have been because of an evolution in attitude toward earlier feeding and mobilization as we became more comfortable with the procedure. It also may be a result of the shorter operative time and less handling of the bowel. While the number of postoperative complications also diminished, this did not reach statistical significance and is unlikely to have contributed to the observed reduction in hospital stay.

During the study period, no patient had undergone elective open anterior resection for diverticular disease in this unit. As compared with a historic control group or with results from another unit over the same period has obvious limitations, no attempt has been made to compare the outcome or cost of laparoscopic anterior resection versus open surgery for diverticular disease. There have been several smaller studies in the literature that used such methods of study design, which have tried to address these questions of outcome and cost with conflicting results. A retrospective study by Bruce et al. compared open (17 patients) versus laparoscopically-assisted anterior resection (25 patients) for diverticular disease performed by two units in the same hospital. They found that the laparoscopic group tolerated a diet earlier (3 days vs. 6 days, p < 0.001) and were discharged from the hospital earlier (4 days vs. 7 days, p < 0.001) than patients who had an open operation. However, because of a significantly longer operating room time in the laparoscopic group (397 min. vs. 115 min., p < 0.001), the overall costs were greater ($10,230 vs. $7068, p < 0.001) than the open surgery group. In a historic control study, Liberman et al. found similar advantages for 14 patients who had undergone laparoscopically-assisted sigmoid colectomy when compared with 14 matched patients who had open surgery. The length of hospital stay was slightly longer for both groups in this study (6 days laparoscopic group vs. 9 days open, p < 0.001). However, there was no significant difference in the mean operating time (192 vs. 183 min., p = 0.38). As a result, the mean total hospital charges were, in fact, less in the laparoscopic group ($29,981 vs. $36,745), although this did not reach statistical significance (p = 0.11). With conflicting reported results, once the learning curve has been mastered, there may be a need for a randomized controlled trial to properly quantify and compare the true cost.

**CONCLUSION**

The potential benefits of a laparoscopically-assisted operation, including early return of gastrointestinal function, minimal postoperative morbidity rates, better cosmesis, and shorter hospital stay have been achieved in this study. The duration of operating time is probably longer than when the same operation is done at open operation, but an experience in considerable reduction in time can be achieved.

The surgical treatment of diverticular disease by laparoscopically-assisted anterior resection has acceptable morbidity and mortality rates, with a median postoperative hospital stay of only 4 days being achieved in this series. Follow-up revealed no recurrence of symptoms and a high level of patient satisfaction with regard to cosmetic and functional results.

**References**