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DYNAMIC MANUSCRIPT

Laparo-endoscopic single-site (LESS) cholecystectomy with epidural vs. general anesthesia

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Abstract
Background Laparo-endoscopic single-site (LESS) surgery involves a single umbilical incision, lending itself to epidural anesthesia. This prospective, randomized study was undertaken to evaluate epidural anesthesia for patients undergoing LESS cholecystectomy, to assess the feasibility, and to analyze all intraoperative and postoperative complications. The secondary objectives were to determine differences in postoperative pain and time until PACU discharge-to-home readiness between patients.
Methods With institutional review board approval, 20 patients with chronic cholecystitis, cholelithiasis, and/or biliary dyskinesia were randomized to receive spinal epidural anesthesia ($n = 10$) or general anesthesia ($n = 10$). Postoperative pain at rest was recorded in the PACU every 10 min, and at rest and walking at discharge using the visual analog scale (VAS). Operative time and time until PACU discharge-to-home readiness were recorded. Results are expressed as mean ± SD.
Results Patient age, American Society of Anesthesiologists class, and body mass index were similar. There were no additional ports/incisions, conversions to "open" operations, or conversions to general anesthesia. There were no differences in operative duration. Time until postanesthesia care unit discharge-to-home ready was not significantly different. The most common postoperative adverse event was urinary retention (1 epidural and 3 general anesthesia patients). Resting postoperative VAS pain score at discharge was 4.7 ± 2.5 vs. 2.2 ± 1.6 ($p = 0.02$, general versus epidural anesthesia respectively); the stressed VAS pain score at discharge was 6.1 ± 2.3 vs. 3.1 ± 2.8 ($p = 0.02$, general versus epidural anesthesia respectively).
Conclusions LESS cholecystectomy with epidural anesthesia was completed with no operative or anesthetic conversions, and less postoperative pain at discharge. Epidural anesthesia appears to be a preferable alternative to general anesthesia for patients undergoing LESS cholecystectomy.

Keywords Epidural anesthesia · General anesthesia · Laparo-endoscopic single-site (LESS) surgery · Cholecystectomy · Single-incision laparoscopy

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Laparo-endoscopic single-site (LESS) surgery is an evolution in minimally invasive surgery from conventional multi-incision laparoscopy. LESS surgery is undertaken through a single incision made at the umbilicus, which offers improved cosmesis. At our institution, we have offered LESS cholecystectomy since 2007 and have reported that LESS cholecystectomy outcomes are comparable to those of conventional laparoscopy with improved cosmesis [1–3].

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Traditionally, regional anesthesia had been reserved for the patients who were too sick to tolerate general anesthesia, specifically, patients with severe chronic cardiopulmonary disease [4, 5]. Recently, however, the medical literature supports the use of regional anesthesia in healthy patients [6–10]. Combining a minimal-access operation with segmental anesthesia may further enhance the advantages of laparoscopic operations, such as cholecystectomy.

Regional anesthesia for laparoscopic cholecystectomy has been successfully undertaken with spinal anesthesia [4–11]. Regional anesthesia has the advantage of quicker recovery, reduced metabolic responses to surgical stress [12], muscle relaxation, and avoidance of tracheal intubation and related discomforts. Thoracic epidural anesthesia (TEA) provides a segmental, temporary motor and sensory block that offers advantages over lumbar spinal anesthesia, such as reducing morbidity and mortality by reducing cardiac and splanchnic sympathetic activity [13]. The anesthesiologist has more control over the anesthetic level by slowly titrating the desired amount of local anesthetic. Once an anesthetic level of T4 is attained, there is minimal motor activity, hence enhancing visualization. Initially, we had used lumbar levels and were unable to attain profound epidural anesthesia and analgesia compared with a high thoracic level. Even though we attained T2-T4 levels, there was minimal or no effects on cardiac accelerator fibers, hence heart rate was not affected [14]. Utilization of thoracic epidural anesthesia for LESS cholecystectomy may produce operative outcomes superior to those of LESS cholecystectomy with general anesthesia. However, a prospective, randomized clinical trial is necessary to demonstrate that LESS cholecystectomy undertaken with regional anesthesia is safe and efficacious for patients.

This paper represents the first prospective randomized pilot trial to assess the feasibility and safety of undertaking LESS cholecystectomy in adult patients who are anesthetized with epidural anesthesia versus general anesthesia. The purpose of this study was to determine differences in postoperative pain, time of PACU discharge-to-home readiness, quality of life, time to return to normal activity, and patient satisfaction between patients that receive epidural anesthesia versus general anesthesia. In undertaking this pilot study, we hypothesized that LESS cholecystectomy with epidural anesthesia could be undertaken safely and effectively with additional health benefits and shorter time spent in the operating room compared with LESS cholecystectomy with general anesthesia.

Materials and methods

After obtaining an institutional review board approval, a prospective, randomized, pilot study was undertaken. Twenty patients—17 patients with chronic cholecystitis, 10 of which additionally had cholelithiasis, and 3 patients with biliary dyskinesia—classified as either American Society of Anesthesiologists (ASA) I, II, or III physical status, aged 18–75 years, and scheduled for an elective LESS cholecystectomy gave consent for the study from June 2010 to July 2011. Patients were excluded if they had acute cholecystitis, body mass index > 35 kg/m^2, a contraindication for LESS surgery or epidural anesthesia, or currently taking chronic narcotic pain management.

The enrolled patients were randomly assigned to have a LESS cholecystectomy under epidural anesthesia ($n = 10$) or general anesthesia ($n = 10$) at a ratio of 1:1 using consecutively numbered and sealed envelopes, which were placed in the preoperative area and only opened at the time of the patient's arrival on the day of surgery.

All patients preoperatively received intravenous midazolam 2–4 mg, ondansetron 4 mg, and Zantac 50 mg. In the operating room, heart rate, intra-arterial blood pressure, respiratory rate, end-tidal carbon dioxide, and pulse oximetry were recorded every 5 min for both groups. All patients received an arterial catheter for beat-to-beat blood pressure monitoring and blood gas sampling. Arterial blood gases were collected at three intraoperative times: incision, 5 min after insufflation, and 5 min after closure. Partial pressure of arterial carbon dioxide (P_aCO_2), partial pressure of arterial oxygen level (P_aO_2), base excess (BE), arterial oxygen saturation (S_aO_2), sodium, potassium, glucose, and pH were measured and compared at each time interval. Anesthesia was administered and the operations were undertaken by the same team for all patients. Nasogastric tubes were not placed.

The patients that were randomized to undergo epidural anesthesia had an epidural catheter placed at thoracic level T4-6 in the preoperative holding area. While the patient was in the sitting position, the thoracic spine area was prepped and draped using sterile technique. A 17-gauge Tuohy needle was inserted at the appropriate thoracic space parallel to the spinous processes. The loss of resistance to air technique using a glass syringe was used to locate the epidural space. The syringe was removed and a catheter was threaded through the needle and advanced at least 8 cm into the epidural space by the same anesthesiologist. The needle was then withdrawn over the catheter. A test dose of local anesthetic solution (3 ml of lidocaine 1.5 % with epinephrine 1:200,000) was given to exclude intravascular or intrathecal injection. The catheter was taped to the patient's back with a sterile nonocclusive dressing. Appropriate catheter placement was confirmed using fluoroscopy in the operating room with intrathecal contrast (Omnipaque 240, GE Healthcare, Princeton, NJ) in all epidural cases. The video attached to this manuscript demonstrates the evolution of the epidural anesthesia

regimen used in LESS cholecystectomy. The final and optimized epidural anesthesia regimen illustrated with the 20th patient in the video was utilized in this pilot study. The epidural anesthesia regimen included 20–25 mL of lidocaine 2 % administered initially as a 5 mL bolus and then titrated in 5 mL boluses to produce and sustain a T2/T4 sensory blockade. Anesthetic level above a T4 dermatomal distribution was confirmed using sensory pinprick before the operation commenced. Once randomized into the epidural cohort, the ten patients had a choice to be completely sedated or not.

For patients in the epidural anesthesia cohort, pain, discomfort, and anxiety were managed upon the patient's request. Sedation was administered to all but one patient in the form of propofol (25–75 μg/kg/min), midazolam (0.05 mg/kg), or dexmedetomidine (0.04 μg/kg). Supplemental nasal cannula oxygen (2–4 L/min) and carbon dioxide sampling at the nares assured visual monitoring of respiratory rate and maintained saturation at greater than 98 % during the procedure. The one patient who did not receive sedation refused because she was afraid to receive general anesthesia.

Diaphragmatic irrigation with an anesthetic solution consisting of 250 mL of saline containing 75 mg of Marcaine was administered to patients receiving epidural anesthesia if they complained of shoulder pain. However, all patients received Marcaine irrigation at the completion of the cholecystectomy (same dose). In addition to Marcaine irrigation, patients were given fentanyl 50 μg as needed for continued pain and discomfort caused by shoulder pain. Pneumoperitoneal pressure was kept between 12 and 15 mmHg for all procedures. Pressures were lowered to 10–12 mmHg if patients complained of persistent discomfort after irrigation of the diaphragm with Marcaine solution.

Patients undergoing general anesthesia had anesthesia induced with intravenous propofol 2–3 mg/kg, lidocaine 100 mg, and fentanyl (1.5 μg/kg). Tracheal intubation was facilitated with rocuronium 50 mg IV. Anesthesia was maintained with a mixture of 50 % oxygen to air and Sevoflurane 1–2 %. Ventilation was controlled with a tidal volume of 5–10 ml/kg and ventilatory rate of 10–12 breaths per minute. At the end of the procedures, all patients received reversal of neuromuscular blockade (neostigmine 3 mg plus glycopyrolate 0.4 mg) and were extubated when meeting appropriate criteria.

LESS cholecystectomy was undertaken as previously described [1, 2] and as demonstrated in the attached video [Video]. Local anesthetic of 0.25 % Marcaine with epinephrine (1:200,000) was injected at the umbilicus. Briefly, a 1.2-cm, longitudinal incision was made through the umbilicus. Entry into the peritoneal cavity was obtained through the natural defect in the fascia at the umbilicus. A multi-trocar SILS Port® (Covidien, Norwalk, CT) or Triport plus® (Olympus, Center Valley, PA) port was placed through the incision and pneumoperitoneum was established. A 5-mm deflectable tip laparoscope (Olympus) was placed through the trocar at the 8 o'clock position, a bariatric length rigid grasper was inserted at the 4 o'clock position (to grasp the fundus), a bent grasper was placed at the 2 o'clock position (to grasp the infundibulum), and the working port was located at the 10 o'clock position. This arrangement of the instruments and the deflectable tip laparoscope minimized internal and external instrument clashing and allowed retraction of the gallbladder in a cephalad and lateral direction. A window was developed between the infundibulum of the gallbladder and the liver bed, which promoted the subsequent "critical view" of the cystic duct and artery. Both the cystic duct and artery were clipped and divided. The gallbladder was dissected off the liver bed. However, before disengaging the gallbladder from the liver bed, hemostasis was ensured. The diaphragm was irrigated with Marcaine solution to minimize postoperative pain. The umbilical defect was closed with an absorbable suture in a figure-of-eight fashion, and the skin was approximated.

After completion of the surgical procedure, the epidural catheter was removed and all patients were immediately transferred to the postanesthesia care unit (PACU) where a blinded assessor (an anesthesiologist unaware of the patient's group assignment) performed a physical examination, assessed and recorded vital signs (heart rate, respiratory rate, and blood pressure), and recorded concomitant medications and adverse events. The blinded assessor also completed an Aldrete postanesthesia recovery score for ambulatory patients (PARSAP) [15]. The PARSAP plus other factors (bleeding, pain) and the standard PACU discharge orders served as the basis to discharge patients from the PACU to a step-down unit to home. A PARSAP score of $\geq$ 18 was required for discharge from the step down unit to home. The patients were allowed to leave the hospital once they were able to micturate and were free from other complications, such as pain and nausea. We measured the amount of time that was required for each patient to reach a PARSAP score of 18, at which time the patient was determined eligible for discharge home.

Postoperative pain management was not standardized in the postanesthesia care unit but was individualized to each patient's needs. Patients were treated with single or multiple doses of the same opioid or a combination of opioids, such as IV morphine, fentanyl, hydromorphone, or oral oxycodone hydrochloride and acetaminophen 5/325-mg tablets. For analytical purposes, all consumed opiates were converted to morphine IV equivalent doses using a conversion calculator [16]. The rescue medication for nausea

was ondansetron 4 mg as needed. For shivering, the patients were treated with meperidine 12.5–50 mg. After hospital discharge, all patients received oxycodone hydrochloride/acetaminophen 5/325-mg tablets for pain as needed per the surgeon.

Adverse events were assessed throughout the perioperative period and included shoulder pain, urinary retention, pruritus, neurologic sequelae, nausea, and vomiting. The Visual Analog Scale (VAS) 10-cm line was used to assess and quantify pain every 10 min in the PACU while the patient was resting and again at time of discharge. Postoperative stressed pain was assessed while the patient was walking at the time of discharge using the VAS. Operative time and time until PACU discharge-to-home readiness were recorded.

All subjects completed a follow-up phone call on postoperative days (POD) 1 and 6 and office visits at 1 week, 1 month, and 3 months after cholecystectomy. The follow-up visits and phone calls included an assessment of pain, recovery, and degree of satisfaction using a standardized quality of life questionnaire (SF-8 and -12) and VAS score given by an independent physician or nurse who was blinded to the patient's type of anesthesia. The SF-8 was used for POD 1, 6, and 7. The SF-12 was used for the 1-month and 3-month follow-up assessments. Pain was assessed at each follow-up visit using the VAS.

Sample size selection was based on the feasibility of completing a small number of patients in a pilot study to be used in the development of a larger study, including sample size determination with power analysis. Data were analyzed by using SPSS 20.0 (SPSS Inc., Chicago, IL). Distributions were examined for normality using visual inspection of box plots and the Shapiro–Wilk test of normality. Group comparisons were conducted by using Fisher exact and Chi square for categorical variables and Mann–Whitney U and t test for continuous variables. Results are expressed as mean ± standard deviation (SD) for normally distributed values or median for nonparametric values. A p value <0.05 was considered statistically significant.

Results

Twenty patients were enrolled in the study and were randomized to receive either epidural or general anesthesia for their LESS cholecystectomy. There were no significant differences between the groups with regard to age, gender, body mass index, or ASA status (Table 1). The comparability of the groups was found to be adequate, because there were no significant differences in history of postoperative nausea and vomiting (PONV), motion sickness, or smoking preference. All procedures were completed with the LESS approach and with the randomized method of anesthesia, because there were no conversions from epidural to general anesthesia or from single to multiple ports/incisions for the laparoscopic surgical approach. The total operative time was similar for both groups with a median of 53 min for the procedure undertaken with general anesthesia and 67 min for epidural anesthesia ($p = 0.68$; Table 1).

The primary objective of the study was to assess the feasibility and safety of undertaking LESS cholecystectomy procedures under epidural anesthesia as measured by intraoperative and postoperative adverse events. The most common intraoperative adverse event was shoulder pain, which was reported by three patients in the epidural anesthesia cohort. One patient in the general anesthesia cohort experienced bradycardia and hypotension at the start of insufflation. In this case, ephedrine 10 mg IV was administered and hemodynamics were stabilized. No other adverse events were recorded intraoperatively. In an effort to prevent or alleviate shoulder pain, the diaphragm was

Table 1 Patient characteristics

	General	Epidural	p value
No. of subjects	10	10	
Gender (male/female)	3/7	2/8	NS
Age (yr), mean ± SD	39.4 ± 11.7	44.9 ± 12.5	NS
BMI (kg/m^2), mean ± SD	25.1 ± 4.6	26.1 ± 5.5	NS
History of PONV, yes [n (%)]	3 (30 %)	1 (10 %)	NS
History of motion sickness, yes [n (%)]	0 (0 %)	1 (10 %)	NS
Nonsmoker, yes [n (%)]	8 (80 %)	8 (80 %)	NS
ASA class (1/2/3)	1/6/3	3/5/2	–
ET CO_2 before irrigation	35.9 ± 2.1	34 ± 12.6	NS
ET CO_2 after irrigation	35 ± 3	28.7 ± 14.6	NS
Length of surgical procedure (min), mean ± SD (median)	65.2 ± 25.1 (53)	64.5 ± 21.5 (67.5)	NS
Time until PACU discharge ready (min), mean ± SD (median)	201.5 ± 106.2 (200)	134 ± 77.2 (110)	NS

Change in ET CO_2 within each group before and after irrigation of the diaphragm with Marcaine was not significant: general anesthesia, $p = 0.102$; epidural anesthesia, $p = 0.248$

BMI body mass index; *PONV* postoperative nausea and vomiting; *NS* not significant

irrigated with diluted Marcaine for all study patients. Three patients who were randomized to epidural anesthesia complained of persistent discomfort despite irrigation of the diaphragm with Marcaine solution. In an attempt to reduce these patient discomforts, insufflation pressures were lowered from 12 to 15 mmHg to 10–12 mmHg and fentanyl 50 μg was administered.

Before irrigation of the diaphragm, the average end tidal CO_2 was 35.9 ± 2.1 in the general anesthesia cohort and 34.0 ± 12.6 in the epidural cohort ($p = 0.48$). After irrigation, the average end tidal CO_2 was 35.0 ± 3.0 and 28.7 ± 14.6 for general anesthesia and epidural anesthesia respectively ($p = 0.27$). The change in end tidal CO_2 after irrigation was not significant when compared between or within the cohorts (Table 1).

Arterial blood gases were collected at three intraoperative time points: at incision, 5 min after insufflation, and 5 min after closure (Fig. 1). pH was significantly higher for patients who underwent general anesthesia compared with epidural anesthesia at incision and 5 min after insufflation (7.5 vs. 7.4, $p = 0.001$) but not after closure (Fig. 1A). Arterial carbon dioxide levels were significantly higher with epidural anesthesia compared with general anesthesia at the time of incision (43.8 vs. 29.7, $p = 0.017$) and 5 min after insufflation (44.8 vs. 31.8, $p = 0.011$) but not after closure (Fig. 1B). Partial pressure of arterial oxygen level (P_aO_2) was significantly lower with epidural anesthesia at all time points compared with general anesthesia (Fig. 1C). Oxygen saturation (S_aO_2) was significantly higher in the general anesthesia cohort compared with the epidural cohort at incision and closure (99.7 vs. 98.4, $p = 0.002$; 99.7 vs. 98.6, $p = 0.001$; Fig. 1D). Base excess was similar for both cohorts at all time points (Fig. 1E). There were no differences in sodium or potassium (Fig. 1F, G). The general anesthesia cohort had significantly higher glucose levels at closure (147.7 vs. 124.5, $p = 0.011$; Fig. 1H).

Pain was assessed upon arrival to the PACU, at 5 min after arrival, and every 15 min thereafter until discharge ready status was achieved. Patients who received epidural anesthesia had significantly lower pain scores upon arrival compared with patients who received general anesthesia (4.2 ± 3.0 vs. 8.4 ± 1.1, $p = 0.02$; Fig. 2). Pain also was significantly less for the epidural anesthesia cohort at 20 and 35 min postoperatively. Resting and stressed pain scores were significantly lower in the epidural anesthesia cohort compared with the general anesthesia cohort when measured immediately before discharge from the hospital ($p = 0.02$; Fig. 2). Four patients (two patients in the general anesthesia cohort and two patients in the epidural cohort) did not require analgesia in the postanesthesia care unit. For the patients who received supplemental analgesia, the average (median) morphine IV equivalent dose was 13.9 ± 10.6 (12.0 mg) for patients who received general anesthesia and 9.1 ± 14.5 (4.0 mg) for patients who received epidural anesthesia ($p = 0.41$).

Pain also was assessed on POD 1, 6, and 7 and at 1 and 3 months postoperative. On POD 1, patients in the epidural anesthesia group experienced significantly less pain with an average pain score of 4.4, whereas patients in the general anesthesia group had an average pain score of 6.3 ($p = 0.018$). On POD 6 and 7 and at the 1- and 3-month follow-up visits, the reported pain scores for both groups were low and not significantly different (Fig. 2).

Postoperative adverse events assessed in the postanesthesia care unit included shoulder pain in five patients: four of whom received epidural anesthesia and one patient who received general anesthesia. Nausea was reported in one patient who received epidural anesthesia and three patients who received general anesthesia. Urinary retention requiring catheterization occurred in three patients who had general anesthesia and one patient who received epidural anesthesia. In the general anesthesia cohort, one patient experienced severe abdominal pain. Two patients in the general anesthesia group experienced shivering in the PACU. Dizziness was reported in two patients in the epidural anesthesia group (Table 2).

Discharge criteria from PACU included a postanesthesia recovery score for ambulatory patients in combination with the standard discharge orders. The patient was then sent to a step-down unit and then discharged home. Patients who received epidural anesthesia achieved "discharge-ready" status at a median time of 110 min compared with 200 min for patients who received general anesthesia ($p = 0.14$; Table 1). All patients were discharged on the same day of surgery except for one patient (incidental finding) in the epidural anesthesia cohort who was kept for observation for preexisting abnormal liver function tests (elevated AST, ALT, and T-bilirubin). A CT of the abdomen with contrast revealed a large stone in the distal common bile duct. Postoperatively, an ERCP with stone retrieval was undertaken and the patient's LFTs normalized. The discharge time reported for this patient reflected the time at which he met the PACU discharge criteria and fulfilled a score of 18 on the PARSAP.

Physical and emotional health was assessed on POD 1, 6, and 7 and 1 and 3 months after surgery using standardized quality of life health surveys (SF-8 and SF-12) and satisfaction scores. For all time points assessed, there were no significant physical or emotional symptoms reported between the two study cohorts, which may have impacted the return to normal physical activity and daily routine. All patients were equally satisfied with their anesthesia and surgical outcomes.

Patients also were assessed for their satisfaction of the incisional scar. Ninety-five percent of patients were satisfied with their cosmetic outcomes following LESS cholecystectomy (Fig. 3).

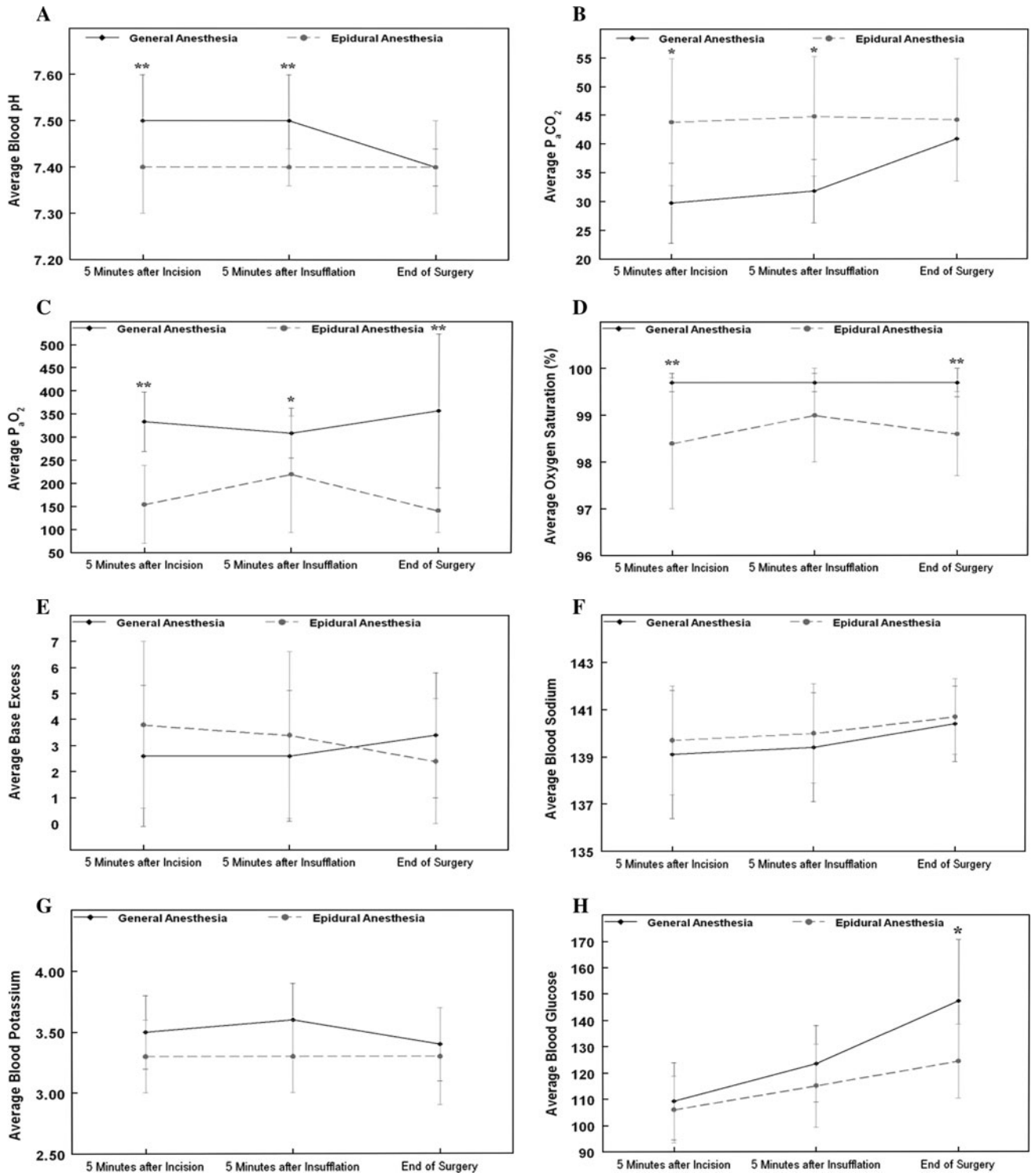

Fig. 1 Blood gas measurements collected 5 min after incision, 5 min after insufflation, and 5 min after closure of incision

Discussion

The majority of laparoscopic cholecystectomies in the United States are undertaken with the conventional multi-incision laparoscopic approach (four incisions) and under general anesthesia with tracheal intubation to avoid aspiration and respiratory complications secondary to pneumoperitoneum. We have previously reported that LESS cholecystectomy outcomes are comparable to those of conventional laparoscopy with improved cosmesis [1–3].

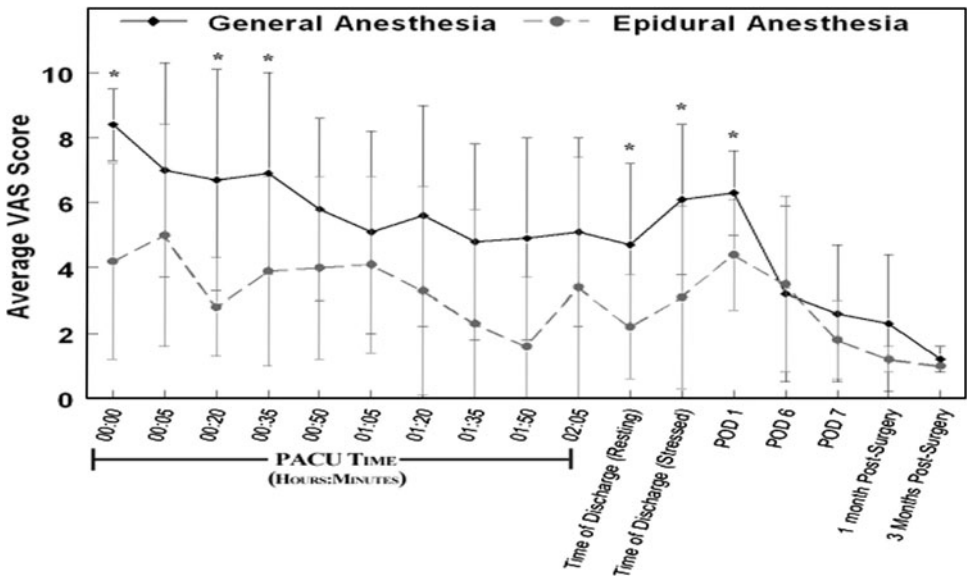

Fig. 2 Postoperative Visual Analog Scale (VAS) scores. Six points between the immediate postoperative period and postoperative day 1 demonstrate significant differences in the pain level between the epidural and general anesthesia cohorts. *$p < 0.05$

Table 2 Postoperative adverse events

	General	Epidural	*p* value
Shoulder pain	1	4	NS
Severe abdominal pain	1	0	NS
Urinary retention	3	1	NS
Shivering	2	0	NS
Nausea	3	1	NS
Dizziness	0	2	NS

Although regional anesthesia has been previously utilized with conventional laparoscopic cholecystectomy, it appears that LESS cholecystectomy is particularly amenable to the use of epidural anesthesia, because it involves a simple incision at the umbilicus. This pilot study documents that LESS cholecystectomy in adult patients can be safely undertaken with thoracic epidural anesthesia. The outcomes also suggest superiority of epidural anesthesia for immediate postoperative pain control in the PACU and POD 1 compared with general anesthesia.

In our study, a very small number of patients who underwent thoracic epidural anesthesia experienced right shoulder pain after insufflation, which was aided by irrigation of the diaphragm with 75 mg of Marcaine. Postoperatively, a minority of patients complained of shoulder pain in the epidural cohort. The referred shoulder pain is a common adverse event reported at rates of 12–50 % during laparoscopic procedures conducted under neuroaxial anesthesia [8–10, 17, 18] and is attributed to irritation of the lower surface of the diaphragm by carbon dioxide during pneumoperitoneum [19, 20]. Several studies treated intraoperative shoulder pain with IV fentanyl 25–100 μg [8–10, 18, 21]. Others irrigated the diaphragm with lidocaine 1–2 % [8, 17, 22]. Lal and colleagues treated mild shoulder pain in 9 of 22 male patients who underwent laparoscopic total extraperitoneal inguinal hernia repair with midazolam 1–1.5 mg IV and found a positive response [17]. This is probably due to the sedative effect, because midazolam has no local anesthetic effect. Pursani and colleagues noted that shoulder pain occurred in two of six patients, and it was easily managed with the narcotic alfentanil [23].

Prevention and/or management of pneumoperitoneum are key to preventing conversions to general anesthesia as anesthetic conversions were reported in several studies [6, 8, 17, 18, 24]. In our study, insufflation pressures of 12–15 mmHg were used for patients who underwent epidural anesthesia and pressures were lowered to 10–12 mmHg (while maintaining exposure and ensuring safety) if the patient complained of persistent discomfort after Marcaine irrigation of the diaphragm. Lower pressures cause less distension of the abdomen and diaphragm, resulting in less stretching of pain fibers resulting in less pain. In the few patients who required reduction in their insufflation pressures (10–12 mmHg), exposure of the surgical site was slightly more challenging but visualization remained adequate. Others recommend using pressures of 8–10 mmHg, which were commonly reported for laparoscopic surgeries under regional anesthesia [6, 9, 10, 18, 19, 23]. Another recommendation is to use higher concentrations of intraperitoneal aerosolization with local anesthetic. Park and colleagues [25] investigated the efficacy of ropivacaine 1 mg/kg diluted in 50 ml of saline for shoulder and postoperative pain with laparoscopic colectomy. Application of ropivacaine occurred immediately after creation of the pneumoperitoneum and again just before elimination of the pneumoperitoneum and was

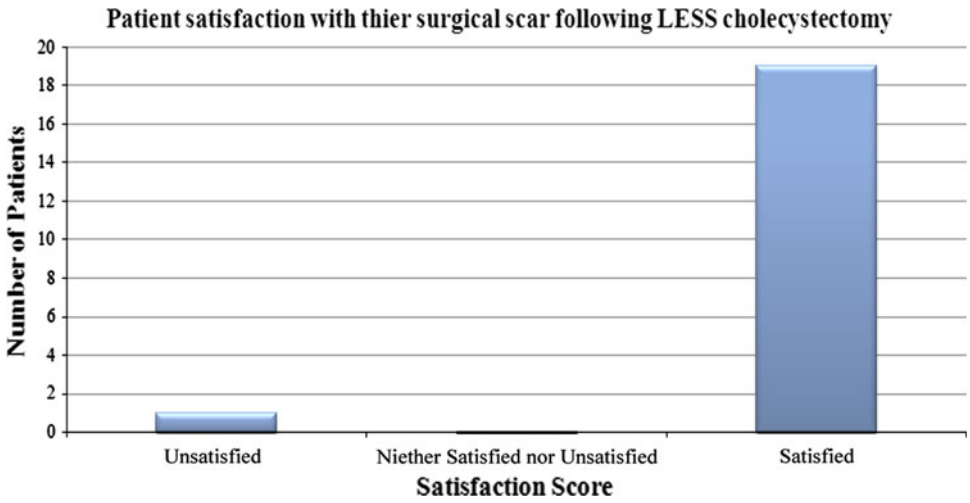

Fig. 3 Satisfaction score of cosmetic outcome following LESS cholecystectomy

effective in reducing pain [25]. The use of pulmonary recruitment maneuvers, postoperatively before closing the incision, to remove residual CO_2 from the peritoneal cavity also have been found to reduce the incidence of late shoulder pain [26].

Controlled ventilation is recommended for laparoscopic operations as several factors may induce hypercapnia, such as absorption of CO_2 from peritoneum and impairment of ventilation from the pneumoperitoneum. Although not experienced in our study, respiratory difficulty is a common issue with thoracic epidural anesthesia and assisted masked ventilation is recommended [19]. We measured arterial blood gases at the start of surgery, after insufflation, and after closure of the wound and found that P_aO_2 and P_aCO_2 remained within normal limits during the procedure, which confirmed that epidural anesthesia can be safely undertaken with pneumoperitoneum. The partial arterial carbon dioxide pressure has been reported to increase after CO_2 pneumoperitoneum for spontaneously breathing patients [24, 27–29] while P_aO_2 decreased [27, 28]. Similar to our results, Sinha and colleagues reported no significant variations in P_aO_2 or P_aCO_2 during surgery with epidural anesthesia in six patients with chronic respiratory disease [6]. Ciofolo concluded that epidural anesthesia for laparoscopy does not cause ventilatory depression [30] and our study reconfirmed that finding.

The occurrence of postoperative nausea and vomiting (PONV) is more common after general anesthesia compared with epidural anesthesia and was experienced by 10 % of our patients who received epidural anesthesia versus 30 % of our general anesthesia patients. Sinha and colleagues [6] reported PONV rates of 2 % for patients who underwent spinal anesthesia for laparoscopic cholecystectomy, whereas 29 % of patients who received general anesthesia experienced PONV. Urinary retention has been reported at rates of up to 20 % with regional anesthesia [31, 32]. Regional anesthesia may interrupt the micturition reflex [33], whereas general anesthesia interferes with the autonomic nervous system both resulting in urinary retention [34]. Tzovaras and colleagues [9, 10] reported a 6 % urinary retention rate in patients who underwent laparoscopic cholecystectomy with spinal anesthesia. Ten percent of our patients who underwent thoracic epidural anesthesia developed urinary retention requiring catheterization compared with 30 % in the general anesthesia cohort. In this small pilot study, although 20 % of patients reported to have urinary retention, in our entire experience with LESS cholecystectomy we have found only a 1 % rate of patients with urinary retention.

Pain assessed at multiple postoperative time points was significantly lower in patients who had epidural anesthesia compared with patients who had general anesthesia. Several studies report lower levels of postoperative pain for laparoscopic procedures undertaken with spinal or epidural anesthesia compared with general anesthesia [10, 20, 35]. One potential mechanism for pain reduction with regional anesthesia is residual analgesia and/or preemptive analgesia, a pharmacologic blockade of the somatosensory pathways before surgical incision. In a study by Shir and colleagues [36], 97 male patients scheduled to undergo radical retropubic prostatectomy were randomized to receive general anesthesia only, epidural anesthesia only, or combined general and epidural anesthesia. Epidural anesthesia was initiated preoperatively when administered alone and initiated after the start of surgery when combined with general anesthesia. Patients who received epidural anesthesia alone required less postoperative analgesia and reported less pain than patients who received general anesthesia or combined epidural and general anesthesia [36].

Thoracic epidurals block afferent sympathetic pathways and have been reported to elicit a minimal stress response compared with general anesthesia, which also may contribute to lower postoperative pain. Aono and colleagues

[37] investigated the stress response elicited from three different anesthetic approaches for laparoscopic cholecystectomy with CO_2 insufflation: general anesthesia, general anesthesia with fentanyl, and general anesthesia with a thoracic epidural placed before induction. Blood samples were collected immediately before surgical incision and 30 min after incision and tested for cortisol, epinephrine, and norepinephrine. Serum cortisol rose significantly after incision for all anesthetic groups. Plasma epinephrine and norepinephrine rose significantly after incision for the general anesthesia and general anesthesia with fentanyl groups but not for the thoracic epidural group.

Conclusions

Despite higher incidences of shoulder pain, most studies, including ours, report high satisfaction rates regarding comfort of the operation [8]. The experience of intraoperative shoulder pain is outweighed by the superior postoperative pain control afforded by thoracic epidural anesthesia. LESS cholecystectomy can be undertaken safely with epidural anesthesia in a selective patient population. Ventilation can be well maintained by spontaneous breathing during LESS cholecystectomy with adequate exchange of carbon dioxide and oxygen. Our study has shown that thoracic epidural anesthesia for LESS cholecystectomy provided better pain control during the immediate postoperative period and on POD 1 compared with general anesthesia.

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