# Spinal/epidural block as an alternative to general anesthesia for laparoscopic appendectomy: a prospective randomized clinical study

**Vuslat Muslu Erdem[1], Turgut Donmez[2], Sinan Uzman[3], Sina Ferahman[4], Engin Hatipoglu[4], Oguzhan Sunamak[5]**

[1]Department of Anesthesiology, Lutfiye Nuri Burat State Hospital, Istanbul, Turkey

[2]Department of General Surgery, Lutfiye Nuri Burat State Hospital, Istanbul, Turkey

[3]Department of Anesthesiology, Haseki Training and Research Hospital, Istanbul, Turkey

[4]Department of General Surgery, Cerrahpasa Medicine Faculty, Istanbul, Turkey

[5]Department of General Surgery, Haydarpasa Numune Training and Research Hospital, Istanbul, Turkey

## Abstract

*Introduction:* Laparoscopic appendectomy (LA) has been generally performed under general anesthesia. Laparoscopic appendectomy is rarely performed under regional anesthesia because of pneumoperitoneum-related problems.

*Aim:* To compare spinal/epidural anesthesia (SEA) and general anesthesia (GA) during LA with respect to perioperative and postoperative adverse events and postoperative pain.

*Material and methods:* Fifty patients, aged 18–65, who underwent LA, were randomly allocated to two groups: the GA (n = 25) and SEA (n = 25) groups. Perioperative and postoperative adverse events, postoperative pain level, and patient satisfaction were compared between the groups.

*Results:* None of the patients needed conversion to an open procedure or conversion from SEA to GA. In the SEA group we encountered shoulder pain in 6 (24%) patients, abdominal discomfort/pain in 4 (16%) patients, anxiety in 4 (16%) patients, and hypotension in 2 (8%) patients intraoperatively. Also, post-spinal headache was observed in 5 (20%) patients in the SEA group. Postoperative right shoulder pain was significantly higher in the GA group compared to the SEA group (32% vs. 8%; p = 0.037). In the SEA group the incidence of urinary retention and in the GA group the incidence of postoperative nausea and vomiting (PONV) were higher, but these differences were not statistically significant. The postoperative surgical pain level was significantly lower in the SEA group (p < 0.001).

*Conclusions:* Spinal/epidural anesthesia is effective and safe in ASA I healthy patients undergoing LA. Less postoperative pain, PONV and shoulder pain are the advantages of SEA compared to GA.

*Key words:* laparoscopic appendectomy, epidural anesthesia, spinal anesthesia, shoulder pain.

## Introduction

Appendectomy is one of the most frequently performed surgical procedures worldwide [1]. Laparoscopic appendectomy (LA) became a popular surgical procedure recently, now accounting for 38.1% of all appendectomies [2, 3]. Fewer wound infections and hospitalization days, less postoperative pain, faster recovery and better cosmetic results are the accepted advantages of LA compared to open conventional appendectomy [4–8].

Laparoscopic appendectomy is performed under controlled ventilated general anesthesia (GA) with en-

**Address for correspondence**

Turgut Donmez MD, Department of General Surgery, Lutfiye Nuri Burat State Hospital, 50.yıl Mh.A blok 2106 sok., Sultangazi, 34300 Istanbul, Turkey, phone: +90 5347400967, e-mail: surgeont73@hotmail.com

dotracheal intubation in order to prevent aspiration, abdominal and/or respiratory discomfort, and hypercapnia due to carbon dioxide pneumoperitoneum [9–12]. Compared to GA, less postoperative pain, postoperative nausea/vomiting and surgical stress have been observed in laparoscopic procedures under spinal/epidural anesthesia (SEA) such as laparoscopic cholecystectomy and laparoscopic inguinal hernia repair. Also, eliminating the intubation complications led us to think of the availability of regional anesthesia for LA [13–15].

There are very few reports concerning LA under regional anesthesia [16, 17]. We did not encounter any published studies that compared SEA with GA for laparoscopic appendectomy.

## Aim

We aimed to compare SEA and GA during LA with respect to perioperative and postoperative adverse events and postoperative pain. In this study we evaluated the effectiveness, safety and adverse events of SEA and compared those with GA.

## Material and methods

### Study design and patient selection

This study is a prospective randomized clinical study that compares SEA with GA for laparoscopic appendectomy. Following the local hospital ethics committee approval (date/no: 07/22/2014 – 234) and obtaining patients' written and oral informed consent, we performed the study at a tertiary referral hospital in Istanbul, Turkey between July 2015 and September 2015, adhering to the guidelines of the Helsinki Declaration. As this is a clinical trial, it was registered with the Turkish National Clinical Trial Number and Republic of Turkey Ministry of Health (No 62560444-900/4747). Criteria for excluding patients were: contraindications for pneumoperitoneum or spinal anesthesia, unwillingness to participate, an American Society of Anesthesiology (ASA) physiologic state ≥ III, allergic history with anesthetics or narcotic analgesic, or history of abdominal surgery and pregnancy. A surgeon who was not in the surgical team generated the random allocation sequence, enrolled participants, and assigned participants to interventions.

### Preoperative evaluation and grouping

All laparoscopic operations and general or spinal/epidural anesthesia procedures were performed with the same anesthesiologist and surgical team. Patients were randomly grouped via a computer program into two groups: general anesthesia (GA group) and spinal/epidural anesthesia (SEA group). An anesthesiologist informed all patients during a preoperative visit about the possibility of anxiety, shoulder pain and abdominal discomfort. Also, patients were informed that if these side effects could not be relieved with intravenous midazolam or analgesics, or if the patient preferred, the operation could be altered to use general anesthesia.

### Anesthesia procedure

Premedication was not used for either group. In the preparation room 10 ml/kg Ringer's lactate solution was used for 30 min. In the GA group propofol 2–2.5 mg/kg and fentanyl 1 µg/kg were used for induction. Later, rocuronium 0.6 mg/kg was used for muscle relaxation for intubation. After the intubation, lung ventilation was performed with an anesthesia device (Dräger Primus, Dräger Medical Systems, Inc. Danvers, MA, USA) in volume control ventilation (VCV) mode. In VCV mode, tidal volume was set as 6–8 ml/kg and respiration frequency was set to maintain PETCO$_2$ at 32–36 mm Hg. Anesthesia maintenance was performed with sevoflurane (1.5–2%) with an oxygen-air mixture (FiO$_2$ = 0.4) and repetitive rocuronium dosages (0.015 mg/kg). After the end of the operation, neostigmine 2–2.5 mg and atropine 1 mg were applied for antagonism of residual neuromuscular block.

For the SEA group, a needle-through-needle technique was used for combined spinal/epidural anesthesia. After the patient assumed a sitting position, the lumbar skin region was sterilized and covered with a sterile cover. For local anesthesia 2 ml of lidocaine 2% was applied intradermally to the needle entrance point. A Tuohy 18-G needle was inserted with midline approach to the L3–L4 epidural space with the saline resistant loss technique. After this a 26-G pencil point spinal needle was inserted through the Tuohy needle and free cerebrospinal fluid flow was observed and 10 mg of hyperbaric bupivacaine 0.5% and 10 µg of fentanyl were injected for 30 s and finally spinal anesthesia was achieved. After removing the spinal needle a 20-G epidural catheter was inserted through the Tuohy needle and pushed forward in the cephalic direction and stabilized at 4 cm. For epidural anesthesia 10 ml of bupivacaine 0.5%, 25 µg of fentanyl and 5 ml of isotonic saline were ap-

plied via this catheter. Then patients were positioned in a 15-degree Trendelenburg position and sensorial block was controlled with the pinprick test at 1 min intervals. The operation started after the sensorial block reached the T4 level. The epidural catheter was removed after the operation. We planned to convert the operation to general anesthesia if anesthesia was not sufficient or if shoulder pain, abdominal discomfort or anxiety was unresponsive to medical treatment.

## Surgical procedure

After the anesthesia procedure, povidone iodine 1% was applied to the surgical field and covered with a sterile cover. An infra-umbilicus 1 cm incision was performed and a Veress needle was inserted into the abdomen. 10 mm Hg intra-abdominal pressure was applied via $CO_2$ insufflation through this needle. Then a 10 mm trocar was inserted and a 30-degree 10-optical camera inserted through it. Later, the 10 mm trocar was inserted at the right inferior quadrant and a 5 mm trocar was inserted in the left inferior quadrant. In the GA group, patients were place in the Trendelenburg position and turned at 15° to the left of the positioned surgeon. In the SEA group, patients were supine and positioned turned at 15° to the surgeon. After the acute appendicitis diagnosis was verified at exploration, an appendectomy procedure was started. The appendix was hung with an Endoclinch through a 10 mm trocar and Endo-Ligasure (LigaSure, Covidien, Boulder, CO) through the 5 mm trocar was used to cauterize and drop the mesoappendix. The radix of the appendix was revealed, then the endoloop was inserted through the 5 mm trocar and placed to the radix and sutured. The endoclip was inserted through the 10 mm trocar and the clip was placed above the suture. Then it was cut and the appendectomy was finished. The endobag was inserted through the 10 mm trocar and the appendix was removed from the abdomen via the endobag. The fascia of the 10 mm trocar entrance points was closed with 0 vicryl suture and the skin was closed with 4/0 rapid vicryl intracutaneously.

## Monitoring and data collection

All patients were closely monitored with continuous electrocardiography (ECG), noninvasive arterial blood pressure (NIBP), heart rate (HR) and peripheral oxygen saturation ($SpO_2$). All parameters were recorded for both groups after the patients entered the operation hall during preoperative volume replacement for baseline levels. (All parameters were recorded 3 times at 1-minute intervals at rest). All these parameters were recorded at anesthesia induction for the GA group and after the anesthesia procedure for the SEA group. Later monitoring continued during the operations and following surgery for 24 h during inpatient services. All demographic features, ASA classification, comorbidities, hospitalization duration, operation time (from incision to last suture), total time (from anesthesia induction for the GA group, from spinal puncture for the SEA group to recovery room), and also maximum sensory block (MSB) level were recorded for the SEA group. We searched for intraoperative hypotension (> 30% decrease in baseline mean arterial pressure or systolic arterial pressure < 90 mm Hg), bradycardia (heart rate < 50 beats/min) and hypoxemia ($SpO_2$ < 90%) in both groups. Also, the complaints of patients in the SEA group about nausea/vomiting, right shoulder pain, anxiety and abdominal discomfort were recorded. Surgical field pain level was evaluated with the Visual Analogue Scale (VAS; 0 = no pain, 10 = severe pain). VAS levels were first recorded in the postoperative recovery room with the cooperation of patients (VAS0) and at 6 (VAS6), 12 (VAS12) and 24 (VAS24) h after the operation. Undesirable postoperative events such as headache, nausea/vomiting, right shoulder pain, anxiety, abdominal discomfort, and urinary retention were recorded from both groups. All patients were asked to evaluate their satisfaction with the procedure as good, normal, or bad. An independent anesthesiologist blinded to the study recorded all data.

## Statistical analysis

Statistical analysis was performed with the SPSS software package for Windows (Statistical Package for Social Sciences, version 17.0, SPSS Inc., Chicago, Illinois, USA). Quantitative variables – age, weight, height, body mass index (BMI), surgery time, total procedure time, hospitalization duration, and postoperative pain scores (VAS) – were evaluated as mean ± standard deviation (SD) and/or median (min–max). Categorical variables – sex, ASA, MSB level, drain usage, pathologic diagnosis, intraoperative and postoperative adverse events, and patient satisfaction – were evaluated as patient numbers and percentages. Based on a previous study [6], VAS on

the 1st postoperative day was 1.61 ±0.95 after the laparoscopic appendectomy under general anesthesia. Power analysis with α = 0.05 and β = 0.2 for detecting 50% reduction in VAS after laparoscopic appendectomy under spinal/epidural anesthesia revealed that each group required a minimum of 22 patients. Quantitative variables were analyzed with the Kolmogorov-Smirnov test. Normally distributed variables were compared with Student's *t*-test and variables without a normal distribution were compared with the Mann-Whitney *U* test. Categorical variables were compared with $\chi^2$ and Fisher's exact tests; $p < 0.05$ was considered as statistically significant.

## Results

Sixty-one patients with acute appendicitis were included this prospective study. Their history, physical examination and abdominal ultrasonography were used for the diagnosis. Eleven patients were excluded from the study: 5 of them due to data and follow-up loss; 4 due to an inability to cover the inclusion criteria; and 2 were unwilling to participate in the study. A total of 50 patients were randomized with a computer program and grouped into two groups: the GA group (*n* = 25) and the SEA group (*n* = 25) (Figure 1). All surgical operations were completed successfully with the laparoscopic technique. In the SEA group, all anesthesia procedures were completed successfully and none of the patients needed to convert to GA.

### Patients' features

There was no significant difference between the two groups with respect to demographic features, ASA physiologic state score, or hospitalization duration (Table I).

The diagnosis was acute appendicitis for 44 patients, perforated appendicitis for 5 patients and carcinoid tumor for 1 patient. Patients were discharged at postoperative days 1–3 and controlled daily for 1 week. A drain was administered to the Douglas space in 3 patients in the GA group, and in 4 patients in the SEA group due to a perforated appendicitis or hemorrhagic leakage. All drains were discharged on postoperative day 5 or 6. In the SEA group, 1 patient with perforated appendicitis developed an intra-abdominal abscess at postoperative day 12 after the drain removal. This patient was managed with antibiotic treatment. Also, 2 patients in both groups developed skin infections at the trocar entrance site. These infections were managed with antibiotic treatment over 2–4 days. There was no significant difference between the groups in the manner of drain usage, pathological diagnosis, or surgical complications (Table I).

### Duration of operation and total procedure

There was no significant difference in the duration of the surgical operations between the groups (*p* = 0.459), but total procedure time was significantly longer in the SEA group (*p* < 0.001) (Table I).

### Patient satisfaction

As for patients' satisfaction with their operations, there was no significant difference between the two groups (*p* = 0.125) (Table I).

### Intraoperative adverse events in SEA group

Intraoperative adverse events in the SEA group are shown in Table II. Abdominal discomfort/pain and/or shoulder pain was observed in 8 patients
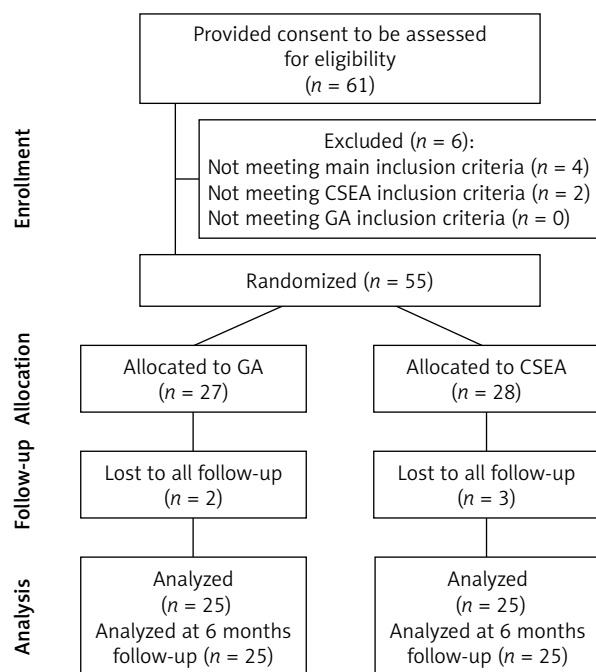


**Figure 1.** CONSORT diagram of recruitment to the study. Laparoscopic appendectomy under general anesthesia (GA); laparoscopic appendectomy under combined spinal epidural anesthesia (CSEA)

and managed with 1–2 µg/kg intravenous fentanyl. Four patients suffered from anxiety, which was managed with 0.015-0.030 mg/kg intravenous midazolam. Three of these 4 anxious patients also developed abdominal discomfort/pain and 1 of them developed shoulder pain that required both midazolam and fentanyl treatment. Abdominal discomfort/pain was observed to be significantly higher among anxious patients compared to non-anxious patients (75% vs. 4.8%, $p$ = 0.007), but there was no significant difference in shoulder pain between the anxious and non-anxious patients (50% and 19% respectively, $p$ = 0.234). Neither midazolam nor fentanyl was needed by 16 (64%) patients. Hypotension was observed in 2 patients, who easily recovered within 5 min following a 250 ml saline infusion and there was no need for vasopressor treatment. Bradycardia did not occur in any patients. Nausea was observed in 1 patient, who recovered with 8 mg IV ondansetron.

## Postoperative adverse events

All surgical and anesthetic adverse events were observed and recorded in postoperative 24 h and are summarized in Table III. We found that incidence of postoperative shoulder pain was significantly higher in the GA group ($p$ = 0.037) and frequency of headache was significantly higher in the SEA group ($p$ = 0.025). Patients in the SEA group also experienced more urinary retention and in the GA group experienced more PONV, but these differences were not statistically significant.

## Postoperative pain evaluation

All patients received 1 l of Ringer lactate and 1 l of isotonic saline within 24 h after the operation for

**Table I.** Patient characteristics

| Parameter | GA group | SEA group | P-value |
|---|---|---|---|
| Age [years] | 26 ±9 | 29 ±10 | 0.152 |
| Sex (M/F) ($n$) | 22/3 | 21/4 | 0.684 |
| Weight [kg] | 67 ±9 | 71 ±13 | 0.224 |
| Height [cm] | 171 ±7 | 173 ±9 | 0.450 |
| BMI [kg/m$^2$] | 22.9 ±3.2 | 23.6 ±3.4 | 0.433 |
| ASA I/II (n) | 24/1 | 25/0 | 0.500 |
| MSBH (T$_2$/T$_3$/T$_4$) ($n$) | – | 2/18/5 | – |
| Surgery time [min] | 25.8 ±3.7 | 24.8 ±6.1 | 0.459 |
| Total procedure time [min] | 46.7 ±3.3 | 52.9 ±6.0 | < 0.001 |
| Hospital stay [days] | 1 (1–3) | 1 (1–3) | 0.429 |
| Drain (+) | 3 (12%) | 4 (16%) | 0.334 |
| Diagnosis: | | | 0.549 |
|   Acute appendicitis | 22 (88%) | 22 (88%) | |
|   Perforated appendicitis | 3 (12%) | 2 (8%) | |
|   Carcinoid tumor | 0 (0%) | 1 (4%) | |
| Surgical complications: | | | |
|   Abdominal abscess | 0 (0%) | 1 (4%) | 0.600 |
|   Trocar site skin infection | 2 (8%) | 2 (8%) | |
| Patient satisfaction: | | | 0.125 |
|   Good | 18 (72%) | 14 (56%) | |
|   Moderate | 3 (12%) | 9 (28%) | |
|   Poor | 4 (16%) | 2 (8%) | |

*GA – general anesthesia, SEA – spinal epidural anesthesia, ASA – American Society of Anesthesiologists, MSBH – maximal sensorial block height (dermatomal level).*

**Table II.** Intraoperative adverse events in the SEA group

| Intraoperative adverse events | GA group, $n$ (%) | SEA group, $n$ (%) | P-value |
|---|---|---|---|
| Shoulder pain | – | 6 (24) | – |
| Abdominal discomfort | – | 4 (16) | – |
| Anxiety | – | 4 (16) | – |
| Hypotension | 0 (0) | 2 (8) | 0.245 |
| Nausea/vomiting | – | 1 (4) | – |
| Bradycardia | 0 (0) | 0 (0) | < 0.999 |
| Respiratory discomfort/ depression | – | 0 (0) | – |

*SEA – spinal epidural anesthesia, GA – general anesthesia.*

**Table III.** Postoperative adverse events

| Adverse event | GA group $n$ (%) | SEA group $n$ (%) | P-value |
|---|---|---|---|
| Headache | 0 (0) | 5 (20) | 0.025 |
| Shoulder pain | 8 (32) | 2 (8) | 0.037 |
| Urinary retention | 0 (0) | 3 (12) | 0.117 |
| Postoperative nausea/ vomiting | 4 (16) | 0 (0) | 0.055 |

*GA – general anesthesia, SEA – spinal epidural anesthesia.*

fluid replacement. If postoperative VAS ≥ 4, tramadol 50 mg in 100 ml saline infusion intravenously was administered for 30 min. Postoperative pain evaluation for the two groups is summarized in Table IV. We observed significantly lower postoperative VAS scores in the SEA group immediately after the operation and at 12 and 24 h after the surgery ($p < 0.001$). However, the VAS score at 6 h was not significantly different ($p = 0.274$). In the GA group all patients needed tramadol infusion for analgesic treatment after the VAS0 and VAS6 evaluation. None of the patients needed analgesic treatment in the SEA group in the first 6 h. However, VAS6 scores were between 4 and 6 and all needed tramadol treatment in the sixth hour. After this, none of the patients needed analgesic treatment.

## Discussion

This study is the first study comparing SEA and GA for laparoscopic appendectomies. Laparoscopic appendectomies are usually performed under controlled ventilated GA with endotracheal intubation. This study shows that SEA may be an alternative technique to GA for laparoscopic appendectomies and reinforces previous feasibility studies [16–19]. It has been reported that sensorial block level should be at least the T4–T6 level for LA under spinal anesthesia [16, 17]. Unlike previous studies, we applied the SEA technique and despite the higher sensorial block reaching to the T2–T4 dermatomal level we did not observe any serious side effects related to SEA.

The main finding of this study was that the SEA technique proved superior to GA in cases of postoperative pain control. We think that this result is related to the continuous effect of local anesthetics and analgesics applied to subarachnoid space and epidural space after surgery. Until now general anesthesia was preferred due to aspiration risk, abdominal discomfort and hypercapnia secondary to carbon dioxide pneumoperitoneum [9–12]. However, now there are many reported studies that support the safety of regional anesthesia for laparoscopic operations [13, 14]. Yet there are only limited studies about LA under regional anesthesia. We observed intraoperative right shoulder pain, abdominal discomfort, anxiety and nausea/vomiting in combined SEA patients related with pneumoperitoneum. Right shoulder pain incidence for LA under spinal anesthesia was reported between 25% and 30.8%, and

**Table IV.** Postoperative pain evaluation

| Measurement time | VAS [cm] | | P-value |
| --- | --- | --- | --- |
| | GA group | SEA group | |
| VAS0 | 8.20 ±0.41 | 0.20 ±0.41 | < 0.001 |
| VAS6 | 4.24 ±0.44 | 4.40 ±0.58 | 0.274 |
| VAS12 | 2.28 ±0.46 | 1.80 ±0.41 | < 0.001 |
| VAS24 | 1.20 ±0.41 | 0.24 ±0.44 | < 0.001 |

*GA – general anesthesia, SEA – spinal epidural anesthesia, VAS – visual analogue scale.*

this result is similar to other laparoscopic operations [13–17]. Shoulder pain is a referred pain related to phrenic nerve irritation due to carbon dioxide pneumoperitoneum [18]. This pain may be light and insignificant in some cases or may be so serious that it needs to be treated with opioids in some cases [11, 12]. However, patients rarely need to convert to GA for this pain [18, 20–22]. Similar to previous studies, we observed the occurrence of shoulder pain in 24% of the SEA group. All patients were managed with IV fentanyl and none needed to convert to GA.

Intra-abdominal pressure increase secondary to pneumoperitoneum may result in abdominal discomfort/pain, and this may reduce the tolerance of laparoscopic surgery under regional anesthesia. Abdominal discomfort/pain was observed in LA under spinal anesthesia with 12.5–23.1% incidence [16, 17, 19]. In our study, we observed that abdominal discomfort/pain might result in anxiety in awake patients. Also the treatment of abdominal discomfort with sedative analgesia midazolam and fentanyl supports this theory.

Another adverse event in the SEA group was hypotension. Hypotension is one of the serious complications of regional anesthesia and is related to peripheral vasodilatation and a decrease in venous return due to the sympathetic block [22, 23]. Hypotension incidence in LA under spinal anesthesia was reported as 6.1–12.5% [16, 17, 19]. In our study we observed minimal cardiovascular changes. Hypotension was managed with intravascular fluid replacement and no need for vasopressor treatment. Also, we did not observe bradycardia in any patient.

The cardiovascular system effects of spinal anesthesia and pneumoperitoneum balance each other. Hemodynamic changes due to pneumoperitoneum have two different mechanisms: the first involves renin-angiotensin aldosterone system stimulation

Vuslat Muslu Erdem, Turgut Donmez, Sinan Uzman, Sina Ferahman, Engin Hatipoglu, Oguzhan Sunamak

due to an intra-abdominal pressure increase; the second is the case of sufficient intravascular volume, in which pneumoperitoneum under 10 mm Hg pressure directs the splanchnic flow to the central venous system and increases the venous return and cardiac output [24, 25]. There is a close relationship with severity of hypotension and sensorial block level [26]. In this study we obtained a spinal block level up to T2–T4 at which all spinal segments are responsible for sympathetic outflow, but there was no severe hypotension. This might be explained by volume preloading before SEA and maintenance of fluid infusion during the surgery and effects of lower pneumoperitoneum pressure.

Shoulder pain was the most common undesirable postoperative event. Postoperative shoulder pain is related to residual carbon dioxide under the diaphragm similar to the intraoperative cause [27, 28]. In this study, we observed that post-laparoscopic shoulder pain was significantly greater in the GA group than the SEA group. Postoperative shoulder pain in LA is reported as 61.3% incidence under GA [29]. But postoperative shoulder pain incidence in LA under regional anesthesia is not reported exactly. Mane *et al.* [16] reported post-laparoscopic shoulder pain in a limited numbers of cases: about 1 in 8 cases (12.5%), which was similar to our results. Carbon dioxide that is used for pneumoperitoneum during laparoscopy passively diffuses into the blood and is ventilated from the body [30]. Regional anesthesia has a minimal effect on intraoperative and postoperative pulmonary functions. Also, spinal and epidural anesthesia leads to an increase in the respiratory response to hypercapnia [31]. Shoulder pain incidence was lower in the SEA patients, which may be related to better elimination of residual carbon dioxide in SEA patients.

Postoperative nausea and vomiting (PONV) incidence was almost half that of LA under GA and also one of the important events causing the higher number of hospitalization days [32–34]. The PONV risk for LA decreases with spinal anesthesia [16, 17]. In our study we did not observe PONV in the SEA group and, as a result, we found SEA superior to GA in preventing nausea and vomiting.

Another frequently observed postoperative complication for spinal anesthesia is post-spinal puncture headache (PSPH) and urinary retention. Although the incidence of spinal induced headache was lower than 5%, the headache may last a few days following the surgery and may increase the number of hospitalization days [34]. Although we used a 26-G pencil point needle, we found higher PSPH incidence than earlier similar studies did. This higher incidence of PSPH was associated with two independent factors: younger age and lower BMI [35]. Also, an additional 1 l isotonic saline and tramadol 50 mg infusion were sufficient for management of the headache. Postoperative urinary retention incidence was reported as 0.41–10%. Urinary catheterization and possible urinary system infection may increase hospitalization duration [34–36]. Forty times higher urinary retention incidence with regional anesthesia compared to GA is one of the important disadvantages of regional anesthesia. In our study we found slightly higher incidence of urinary retention. All those affected were treated with urinary catheterization. None of the patients needed lengthy catheterization and we did not observe any complications.

Moreover, in our previous feasibility study we also found that similar rates of perioperative and postoperative adverse events related to spinal/epidural anesthesia and pneumoperitoneum in LA patients [19].

A longer total procedure time in the SEA group was associated with longer preparation and application time of regional anesthesia. Regarding patient satisfaction, there were not any significant difference between the anesthetic techniques.

The present study has several limitations. The first limitation of the present study was that it included a limited number of perforated appendicitis patients. Although 10 mm Hg of pneumoperitoneum pressure was sufficient in the case of simple appendicitis, that amount may be inadequate for complicated appendicitis operations. Adverse effects caused by higher intra-abdominal pressure in awake patients may not be controlled satisfactorily. However, SEA may not be feasible in complicated cases of appendicitis and obese patients. A second limitation was the small number patients in the study. Moreover, all except one was ASA I. Therefore, it is difficult to generalize about patients with co-existing diseases.

## Conclusions

Spinal/epidural anesthesia should be preferred because it is associated with less surgical field pain, longer postoperative pain-free period, and less nausea and vomiting. Intraoperative adverse events

related to pneumoperitoneum such as shoulder pain and anxiety can be managed easily in awake patients. However, SEA may be an alternative method to GA for laparoscopic appendectomies in ASA I healthy subjects.

## Acknowledgments

## Conflict of interest

The authors declare no conflict of interest.

### References

1. Agresta F, Ansaloni L, Catena F, et al. Acute appendicitis: position paper, WSES, 2013. World J Emerg Surg 2014; 9: 26.
2. Ingraham AM, Cohen ME, Bilimoria KY, et al. Comparison of outcomes after laparoscopic versus open appendectomy for acute appendicitis at 222 ACS NSQIP hospitals. Surgery 2010; 148: 625-35.
3. Markar SR, Penna M, Harris A. Laparoscopic approach to appendectomy reduces the incidence of short-and long-term postoperative bowel obstruction: systematic review and pooled analysis. J Gastrointest Surg 2014; 18: 1683-92.
4. Jaschinski T, Mosch C, Eikermann M, Neugebauer EA. Laparoscopic versus open appendectomy in patients with suspected appendicitis: a systematic review of meta-analyses of randomised controlled trials. BMC Gastroenterol 2015; 15: 48.
5. Minutolo V, Licciardello A, Di Stefano B, et al. Outcomes and cost analysis of laparoscopic versus open appendectomy for treatment of acute appendicitis: 4-years experience in a district hospital. BMC Surg 2014; 14: 14.
6. Mantoğlu B, Karip B, Mestan M, et al. Should appendectomy be performed laparoscopically? Clinical prospective randomized trial. Ulus Cerrahi Derg 2015; 31: 224-8.
7. Donmez T, Sunamak O, Ferahman S, et al. Two-port laparoscopic appendectomy with the help of a needle grasper: better cosmetic results and fewer trocars than conventional laparoscopic appendectomy. Videosurgery Miniinv 2016; 11: 105-10.
8. Gunes ME, Ersoz F, Duzkoylu Y, et al. Hybrid appendectomy with classic trocar on McBurney's point. Videosurgery Miniinv DOI: https://doi.org/10.5114/wiitm.2017.70323.
9. Johnson A. Laparoscopic surgery. Lancet 1997; 349: 631-5.
10. Kazama T, Ikeda K, Kato T, Kikura M. Carbon dioxide output in laparoscopic cholecystectomy. Br J Anaesth 1996; 76: 530-5.
11. Tiwari S, Chauhan A, Chaterjee P, Alam MT. Laparoscopic cholecystectomy under spinal anaesthesia: a prospective, randomised study. J Minim Access Surg 2013; 9: 65-71.
12. Tzovaras G, Fafoulakis F, Pratsas K, et al. Spinal vs general anesthesia for laparoscopic cholecystectomy: interim analysis of a controlled randomized trial. Arch Surg 2008; 143: 497-501.
13. Sinha R, Gurwara AK, Gupta SC. Laparoscopic surgery using spinal anesthesia. JSLS 2008; 12: 133-8.
14. Lal P, Philips P, Saxena KN, et al. Laparoscopic total extraperitoneal (TEP) inguinal hernia repair under epidural anesthesia: a detailed evaluation. Surg Endosc 2007; 21: 595-601.
15. Das W, Bhattacharya S, Ghosh S, et al. Comparison between general anesthesia and spinal anesthesia in attenuation of stress response in laparoscopic cholecystectomy: a randomized prospective trial. Saudi J Anaesth 2015; 9: 184-8.
16. Mane RS, Patil MC, Kedareshvara KS, Sanikop CS. Combined spinal epidural anesthesia for laparoscopic appendectomy in adults: a case series. Saudi J Anaesth 2012; 6: 27-30.
17. Jun GW, Kim MS, Yang HJ, et al. Laparoscopic appendectomy under spinal anesthesia with dexmedetomidine infusion. Korean J Anesthesiol 2014; 67: 246-51.
18. Olonisakin RP, Sotunmbi PT, Afuwape OO, et al. Regional anaesthetic technique for laparoscopic appendectomy in Ibadan. Afr J Med Med Sci 2014; 43: 219-23.
19. Uzman S, Donmez T, Erdem VM, et al. Combined spinal-epidural anesthesia in laparoscopic appendectomy: a prospective feasibility study. Ann Surg Treat Res 2017; 92: 208-13.
20. Tsai HW, Chen YJ, Ho CM, et al. Maneuvers to decrease laparoscopy-induced shoulder and upper abdominal pain: a randomized controlled study. Arch Surg 2011; 146: 1360-6.
21. Imbelloni LE, Fornasari M, Fialho JC, et al. General anesthesia versus spinal anesthesia for laparoscopic cholecystectomy. Rev Bras Anesthesiol 2010; 60: 217-27.
22. Kar M, Kar JK, Debnath B. Experience of laparoscopic cholecystectomy under spinal anesthesia with low-pressure pneumoperitoneum: prospective study of 300 cases. Saudi J Gastroenterol 2011; 17: 203-7.
23. Brown DL. Spinal, epidural and caudal anesthesia. In: Miller's Anesthesia. 7th ed. Miller RD (ed.). Churchill Livingstone Elsevier, Philadelphia, PA, USA 2010; 1611-38.
24. Gutt CN, Oniu T, Mehrabi A, et al. Circulatory and respiratory complications of carbon dioxide insufflation. Dig Surg 2004; 21: 95-105.
25. Dexter SP, Vucevic M, Gibson J, McMahon MJ. Hemodynamic consequences of high- and low-pressure capnoperitoneum during laparoscopic cholecystectomy. Surg Endosc 1999; 13: 376-81.
26. Hartmann B, Junger A, Klasen J, et al. The incidence and risk factors for hypotension after spinal anesthesia induction: an analysis with automated data collection. Anesth Analg 2002; 94: 1521-9.
27. Sarvestani AS, Zamiri M. Residual pneumoperitoneum volume and postlaparoscopic cholecystectomy pain. Anesth Pain Med 2014; 4: e17366.
28. Fredman B, Jedeikin R, Olsfanger D, et al. Residual pneumoperitoneum: a cause of postoperative pain after laparoscopic cholecystectomy. Anesth Analg 1994; 79: 152-4.
29. Shin HY, Kim SH, Lee YJ, Kim DK. The effect of mechanical ventilation tidal volume during pneumoperitoneum on shoulder pain after laparoscopic appendectomy. Surg Endosc 2010; 24: 2002-7.
30. Cunningham AJ. Anesthetic implications of laparoscopic surgery. Yale J Biol Med 1998; 71: 551-78.

Vuslat Muslu Erdem, Turgut Donmez, Sinan Uzman, Sina Ferahman, Engin Hatipoglu, Oguzhan Sunamak

31. Bernards CM, Hostetter LS. Epidural and spinal anesthesia. In: Clinical Anesthesia. 7th ed. Barash PG (ed.). Lippincott Williams & Wilkins, Philadelphia, PA, USA 2013; 905-37.

32. do Amaral PC, Filho Ede M, Galvao TD, et al. Factors leading to long-term hospitalization after laparoscopic appendectomy. JSLS 2006; 10: 355-8.

33. Lee SJ, Lee JN. The effect of perioperative esmolol infusion on the postoperative nausea, vomiting and pain after laparoscopic appendectomy. Korean J Anesthesiol 2010; 59: 179-84.

34. Sinha R, Gurwara AK, Gupta SC. Laparoscopic surgery using spinal anesthesia. JSLS 2008; 12: 133-8.

35. Jabbari A, Alijanpour E, Mir M, et al. Post spinal puncture headache, an old problem and new concepts: review of articles about predisposing factors. Caspian J Intern Med 2013; 4: 595-602.

36. Singh RK, Saini AM, Goel N, et al. major laparoscopic surgery under regional anesthesia: a prospective feasibility study. Med J Armed Forces India 2015; 71: 126-31.