The difference between harmonic shear versus electrocautery in fundus-first laparoscopic cholecystectomy in acute cholecystitis: a comparative study

Islam Khaled[a,b], Amr Dorgham[b], Ahmed Hassan[a], Ahmed H. Hussien[a], Gad M. Behairy[c]

[a]Department of Surgery, Faculty of Medicine, Suez Canal University Hospitals, Ismailia, [b]Department of Surgery, Saudi German Hospital, Jeddah, Saudi Arabia, [c]Department of Surgery, Faculty of Medicine, Ain Shams University Hospitals, Cairo, Egypt

Correspondence to Gad M. Behairy, MD, Department of Surgery, Faculty of Medicine, Ain Shams University, Ramses Street, Abbasia Square, Cairo, 1181, Egypt. Mob: 01000065645; fax: 24346041; e-mail: gad_mo@med.asu.edu.eg

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Backgrounds
Laparoscopic cholecystectomy (LC) may be complicated by biliary duct injury in acute cholecystitis. In this study, we compared conventional electrocautery with the harmonic scalpel in patients undergoing LC for acute cholecystitis.
Patients and methods
The current study was carried out as a comparative study among 148 patients with acute calculary cholecystitis who were presented to the Surgery Department in the Suez Canal University Hospitals, Ain Shams University Hospitals, and Saudi German Hospital, Jeddah. The studied patients were recruited into two groups; both were subjected to LC within the first 5 days of the attack. A total of 69 patients were allocated to fundus-first LC with a harmonic scalpel, whereas 79 were recruited to fundus-first LC using electrocautery.
Results
Concerning intraoperative characteristics, the operation lasted an average of 51 ±5 min and 63±6 min for the harmonic scalpel and electrocautery, respectively ($P<0.001$). Blood loss, gall bladder perforation, and hospital stay were significantly lower in the harmonic scalpel group compared with the electrocautery group. Operation conversion was applied in 12.7% of the patients in the electrocautery group, compared with 4.3% in the harmonic scalpel group ($P<0.001$). Pain reporting at 12, 24, and 36 h was significantly lower in patients who underwent harmonic scalpels. The incidence of overall morbidity was significantly higher in the electrocautery group (15 vs. 5%, $P<0.001$).
Conclusion
The findings showed that the harmonic scalpel is a safe, feasible, and promising technique and is associated with less intraoperative and postoperative morbidities.

Keywords:
acute cholecystitis, laparoscopic cholecystectomy, ultrasonic fundus first

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Introduction

Since its clinical introduction, laparoscopic cholecystectomy (LC) has grown to replace open surgery and become the gold standard procedure for symptomatic gallstones and cholecystitis [1,2]. Nowadays, LC is considered one of the most frequently performed surgical procedures in the world [3]. Despite the known benefits of LC, there are still some concerns about many severe complications such as injury of the bile duct [1,4]. Therefore, many investigators proposed a new technique to reduce the risk of surgical complications in LC.

Acute cholecystitis, an inflammatory disorder of the gall bladder, is a prevalent condition that is usually caused by gall bladder stone [5]. If not properly managed, acute cholecystitis can lead to several complications such as gangrenous cholecystitis and septic shock [6]. Initial results had advocated late LC for acute cholecystitis due to lower risk of conversion to open procedure and morbidities; nonetheless, with the advance in LC techniques, the current body of evidence demonstrates superior outcomes of early LC over late procedure [6]. Previous reports noted that the inflammation does not usually involve the triangle of Calot within the first 3 days of disease onset; thus, surgical intervention during this period is feasible owing to lack of organized adhesions [7]. Extending the LC timing to 7 days was associated with the similar outcomes of the traditional approach of 72 h, according to recent studies [8]. However, early acute cholecystitis that starts by Calot's triangle can be complicated owing to difficult

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visualization in selected cohorts of the patients. Removing the gall bladder from the fundus to the cystic duct (fundus-first approach) technique has gained popularity over the recent two decades, especially in case of difficult visualization of the cystic duct. This technique is frequently used during an open cholecystectomy before the advent of LC and is commonly used when surgeons now convert to the open technique [9]. This technique allows dissecting from known anatomy (fundus) to unknown anatomy (potentially difficult anatomy in the Calot triangle) [10]. LC was also associated with collateral injury, which may result from the instruments used to cut and coagulate tissue using several energy sources such as monopolar and bipolar cautery, CO_2 laser, and ultrasonic scalpel [11–14].

Conventional electrocautery is a widely available, easy-to-use, and cheap method for blood vessel sealing during surgery. However, according to the survey that was conducted by the Society of American Gastroendoscopic Surgeons (SAGES), 18% of the physicians experienced a patient receiving electrosurgical burns during LC procedure [15]. Furthermore, the application of monopolar electrocautery may associate with stray electrical currents or insulation failure of the active electrode, which are directly associated with 90% of visceral injuries and 15% of the biliary tract injuries during LC [16,17]. Therefore, alternative devices such as ultrasonic scalpels have been investigated further.

Harmonic scalpel has recently gained momentum, mainly in the setting of laparoscopic surgery, as an effective tool for intraoperative bleeding reduction [18]. Previous reports showed more favorable postoperative outcomes following harmonic scalpel, compared with monopolar diathermy, in various types of surgeries [19,20]. In this study, we compared electrocautery to the harmonic scalpel in patients undergoing fundus-first LC for acute cholecystitis.

Patients and methods

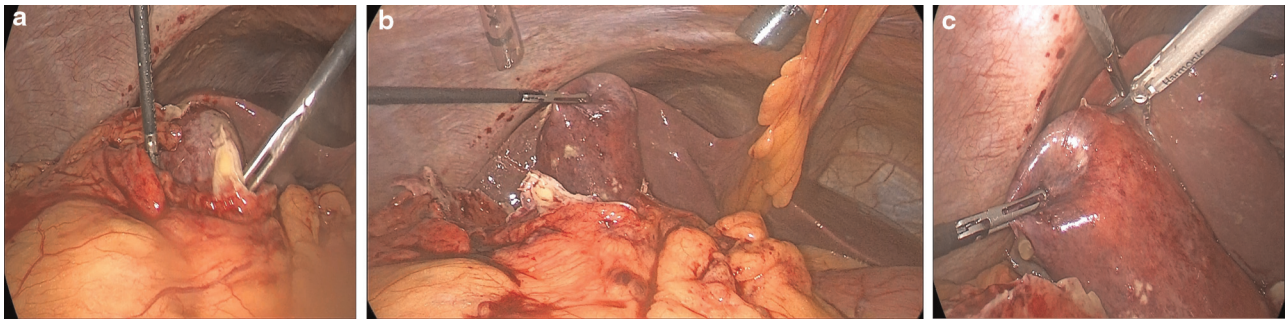
The current study was carried out as a comparative study among 148 patients with calculary cholecystitis who presented to the Surgery Department in the Suez Canal University Hospitals, Ain Shams University Hospitals, and Saudi German Hospital, Jeddah, between June 2018 and June 2020. A verbal and written informed consent was obtained from all participants after the approval of each institution's ethics committee. Patients were deemed eligible if they were diagnosed with acute calculary cholecystitis according to Tokyo guidelines 2018 [21]. Other inclusion criteria included pain and symptoms that lasted for up to 5 days before the operation and good general performance (ASA I–III). We excluded patients with associated biliary pancreatitis, common bile duct stones, and those who refused to sign the informed consent.

The studied patients were recruited into two groups; both were subjected to fundus-first LCC within the first 5 golden days of the symptoms and the attack of acute calculary cholecystitis. After application of inclusion criteria was done, 69 patients were allocated to fundus-first LC with a harmonic scalpel, whereas 79 were recruited to fundus-first LC with electrocautery. All patients were assigned to full history taking, clinical assessment, abdominal ultrasound for diagnosis, and preoperative preparation.

All patients were operated on by senior consultant surgeons who are experts in performing LC and were premedicated with intravenous paracetamol (50 mg/kg), oxycodone 20 mg, and rofecoxib 50 mg. Muscle relaxation was induced using atracurium. General anesthesia was achieved and maintained using propofol.

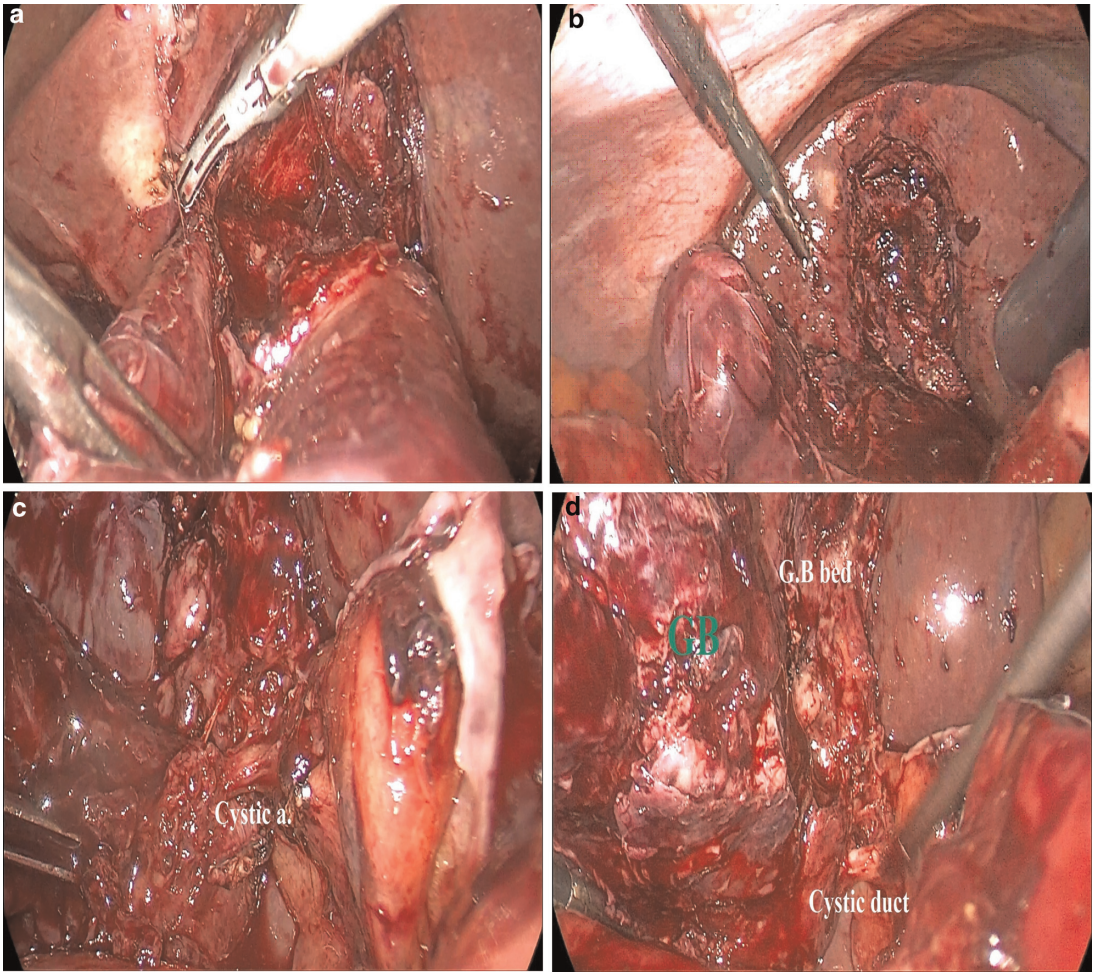
During operation, the intrabdominal pressure was maintained at 15 mmHg. The operations started with placing a 10-mm trocar near the umbilicus. It was fixed for 30 angle telescopes. Another port was inserted below the xiphoid process. In the upper right quadrant, two ports with 5-mm in diameter were applied laterally. Traction on the gall bladder was achieved through a grasper in the lateral port. In the case of a hugely distended gall bladder, aspiration was done using a needle aspirator to relieve the distention and allow for adequate grasping. Any omental and/or bowel adhesions are freed consequently to identify the gall bladder fundus. The surgeon started dissection by retraction of the liver with a soft grasper, and the peritoneum overlying the fundus was elevated. Then, the gall bladder was dissected in an antegrade way to be freed from the undersurface of the liver, and the dissection was continued using a harmonic scalpel (Fig. 1) in the one group and using the monopolar diathermy in the other one. The cystic artery and/or the cystic duct was identified and dissected using the dedicated instrument in both groups. Clearance of Calot's triangle over a completely dissected gall bladder from its bed allowed an easy clipping and division of both cystic duct and artery (Fig. 2). Levobupivacaine (40–60 ml) was injected in the port

Figure 1



(a) Aggressive adhesion to acutely inflamed gall bladder. (b) Acute cholecystitis with gall bladder wall edema and surrounding omental adhesions. (c) Fundus-first approach with harmonic dissection started from the fundus.

Figure 2

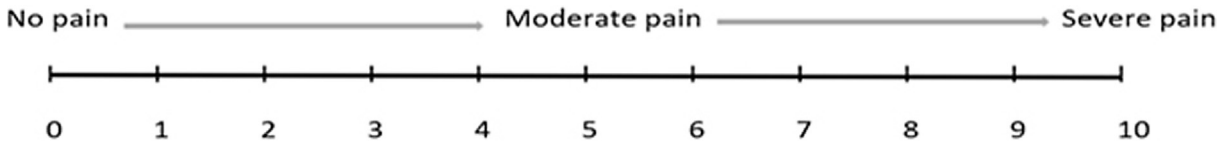


(a) Harmonic dissection throughout the whole gall bladder (GB) bed. (b) GB dissected completely from its bed. (c) Cystic a is the last attachment to the GB in dome-down approach. (d) Identification of cystic duct in fundus first approach after complete dissection of gall bladder.

sites, right diaphragm, and liver bed, in addition to 2–5 mg of ketobemidone that was injected intravenously.

Operative time (time between skin opening and skin closure) and blood loss in the operation were calculated and recorded. Any operative alternation to the open approach was considered as an operative conversion, where the surgeon found adhesions, edema, or fibrosis, and any gall bladder perforations were documented. Patients were assigned to report their pain after operation utilizing a 10-point visual analog scale (VAS) (Fig. 3) at 12, 24, 36 h, and 7 days after the operation. Moreover, the patients were required to record their nausea and vomiting 24 and 48 h after the operation. In addition, three complications were

Figure 3



VAS scoring system. VAS, visual analog scale.

registered including wound infection, postoperative collections, and pulmonary effects.

Statistical analysis

The collected data were analyzed using SPSS, version 22 (SPSS Inc., Chicago, Illinois, USA). Quantitative variables were summarized into mean and SD if the data were normally distributed. If not, the continuous variables were presented in the median and interquartile range. Qualitative variables were presented by numbers and percentages. Fisher exact test was applied in comparison of qualitative variables between the studied groups. Besides, an independent sample *t* test and Mann–Whitney *U* test were performed to test the hypothesis of the continuous data. Multivariate logistic regression was conducted to predict postoperative pain based on the type of surgery performed.

Results

A total of 148 patients were recruited in our study between April 2018 and December 2018. The baseline characteristics and operative features of both groups are summarized in Table 1. Patients in the electrocautery group had a higher body mass index, higher frequency of smokers, history of jaundice, and drains ($P>0.05$).

Concerning intraoperative characteristics, the operation lasted on average of 51±5 min and 63 ±6 min for the harmonic scalpel and electrocautery, respectively ($P<0.001$). Blood loss, gall bladder perforation, and hospital stay were significantly lower in the harmonic scalpel group compared with the electrocautery group. Operation conversion was applied in 12.7% of the patients in the electrocautery group, compared with 4.3% in the harmonic scalpel group ($P<0.001$; Table 2).

Pain reporting at 12, 24, and 36 h was significantly lower in patients who underwent harmonic scalpels. Moreover, pain scores of the VAS were reported in lower values in patients who had harmonic scalpels compared with the electrocautery approach. Additionally, records of postoperative nausea and vomiting were significantly lower in patients of the harmonic scalpels after 24 and 48 h. The incidence of overall morbidity was significantly higher in the electrocautery group than the harmonic scalpel group (15 vs. 5%, respectively, $P<0.001$; Table 3).

Wound infection, postoperative collection, and pulmonary complications were documented as postoperative complications. For harmonic scalpels, only four patients experienced wound infections; no other complications were registered. On the contrary, for the electrocautery group, about five patients had wound infections, three patients had collections, and two patients had pulmonary complications (Table 3).

Mixed model logistic regression revealed that harmonic scalpel technique was independently correlated with lower pain records after 12, 24, and 36 h (Table 4).

Discussion

In the past, difficult cases of cholecystectomy were converted immediately to an open approach, but many cases have been saved from the morbidity of big incision thanks to the fundus-first LC approach [9,22,23]. The main advantage of this approach is the ability to display and classify anatomy in a step-by-step manner as dissection proceeds from a clear region (gall bladder fundus) into a densely hidden region [24]. Most studies concluded that this technique is safe and feasible, with a low risk of injury of the bile duct and open conversion rate [25–29]. However, the use of the fundus-first approach is usually accompanied by the use of various devices. In this study, we compared electrocautery with the harmonic scalpel in patients undergoing fundus-first LC for acute cholecystitis.

In terms of operative time, our study reported a shorter operative time for the harmonic scalpel group and the electrocautery group (51 vs. 63 min, respectively), compared with Mattila *et al.* [30] (45 min) and Kassem *et al.* [24], who reported an average of 102.8 min, which significantly reduced to 60 min with increasing learning curve. In agreement with Mattila findings, Cengiz *et al.* [31] showed that the

Table 1 Baseline characteristics for study groups

	Electrocautery (*N*=79)	Harmonic (*N*=69)	*P*
Age (years)	47.6±11.2	41.6±11.2	0.131‡
Sex ratio (male : female)	17 : 62	23 : 46	0.106†
BMI (kg/m^2)	30.83±5.22	29.13±5.90	0.023‡
Diabetes mellitus	19.0	8.7	0.073†
Hypertension	20.3	10.1	0.090†
Smoking	25.3	1.4	<0.001†
History of jaundice	17.7	4.3	0.011†
Drain	25.3	7.2	0.003†

Values are mean±SD and percentage. ‡Independent *t* test. †Fisher exact test.

Table 3 Postoperative pain and complications

	Electrocautery (*N*=79)	Harmonic (*N*=69)	*P*
Pain 12 h	69.6	43.5	0.001†
Pain 24 h	59.5	33.3	0.001†
Pain 36 h	43.0	23.2	0.011†
Pain 7 day	10.1	7.2	0.537†
VAS 12 h	3 (2–4)	2 (2–3)	<0.001‡
VAS 24 h	3 (3–4)	2 (1–3)	<0.001‡
VAS 36 h	2 (1–2)	1 (1–3)	<0.001‡
VAS 7 days	1 (0–1)	1 (0–1)	<0.001‡
Vomiting 1st day	5.1	4.3	<0.001†
Vomiting 2nd day	1.3	1.4	<0.001†
Wound infection	6.3	5.8	<0.001†
Postoperative collection	3.8	0.0	<0.001†
Pulmonary complications	2.5	0.0	<0.001†
Overall morbidity	15	5	<0.001†

Values are median (interquartile range) and percentage. VAS, visual analog scale. ‡Mann–Whitney *U* test. †Fisher exact test.

main operation time was 74 min in the fundus-first electrocautery. They concluded that the fundus-first approach with ultrasonic dissection is associated with shorter operative time compared with the standard technique. Neri *et al.* [32] also recommended the fundus-first LC be the preferred strategy, as it was simple with a shorter time. Gupta *et al.* [22] compared fundus-first LC with conventional LC and noted that the mean operating time in the fundus-first LC was 15 min lower than the conventional cholecystectomy group (89.8 vs. 104.8 min, respectively). In comparison with electrocautery dissection, the ultrasonic fundus-first dissection showed a lower postoperative pain score with reduced operative time and hospital stay, according to Cengiz *et al.* [29]. On the contrary, Catena *et al.* [33], reported no significant difference between both techniques regarding operative time. This difference can be explained by the increased incidence of difficult cholecystectomy in Egypt owing to the delayed presentation [24,34,35].

Table 2 Operative details for the study group

	Electrocautery (*N*=79)	Harmonic (*N*=69)	*P*
Operative time	63±6	51±5	<0.001‡
Blood loss (ml)	87.7±18.2	57.5±22.9	<0.001‡
Conversion rate	10 (12.7)	3 (4.3)	0.030‡
Gall bladder perforation	12.7	2.9	0.030†
Hospital stay (days)	2.7±3	2.1±3	<0.001‡

Values are mean±SD, *n* (%), and percentage. ‡Independent *t* test. †Fisher exact test.

Table 4 Multivariate logistic regression analysis for with dome-down approach and conventional approach as predictors for postoperative pain

	Regression coefficient	SE	95% confidence interval
Pain 12 h	2.97	0.345	1.52–5.85
Pain 24 h	2.93	0.343	1.49–5.76
Pain 36 h	2.50	0.365	1.25–5.12
Pain 7 days	1.44	0.596	0.45–4.63

Concerning the hospital stay, our findings demonstrated a significant reduction in the hospital stay in all patients who underwent the fundus-first approach; however, the reduction was more notable in the harmonic scalpel group compared with the electrocautery group (2.1 vs 2.7 days, $P<0.001$). This period was slightly lower than those of Kassem *et al.* [24], who reported a mean of 2.5 days. The interval of hospital stays was occasionally affected by the baseline characteristics of included patients; elderly patients with diabetes mellitus are associated with longer duration [36]. In addition, we found a significant reduction in terms of intraoperative blood loss in the harmonic scalpel group compared with the electrocautery group (57.5 vs. 87.7 ml, respectively, $P<0.001$). The amount of blood loss in our study was not high. However, Cengiz *et al.* [31] reported that the mean blood loss in the harmonic scalpel group was 12 ml compared with 53 ml in the electrocautery group. In contrast, Catena *et al.* [33] showed that the rate of blood loss in both groups was comparable ($P=0.45$).

Conversion to open surgery is a major intraoperative complication. Previous figures from the United Kingdom and the United States highlighted a conversion rate of 9.4 and 5–10%, respectively, in patients undergoing LC [37]. Harmonic scalpel can potentially reduce the risk of conversion by ensuring adequate dissection and short operative time. In this report, we found that the operation conversion was applied in 12.7% of the patients in the electrocautery

group, compared with 4.3% in the harmonic scalpel group ($P<0.001$). This was in line with Catena *et al.* [33], who showed that the rate of conversion was lower in the harmonic scalpel group, compared with electrocautery. Other reports showed similar findings [17,38].

Regarding the gall bladder perforation, two (2.9%) patients were presented with gall bladder perforation in the harmonic group versus 10 (12.7%) patients in the electrocautery group ($P=0.03$). In this study, pain scores assessed by VAS were reported in lower values in patients who had ultrasonic operation compared with the electrocautery approach. In agreement, Cengiz *et al.* [31] reported a significant reduction in the VAS at 4 and 24 h in the harmonic scalpel group compared with electrocautery group ($P=0.002$ and 0.003, respectively). High VAS values in electrocautery can be explained by the associated tissue damage and more loss of nerve function. Another report of Cengiz *et al.* [29] showed that both groups were comparable at 1 h, and the reduction was observed in the harmonic scalpel group at 2, 4, and 6 h.

Our findings indicated that postoperative nausea and vomiting were significantly lower in patients of the harmonic scalpel after 24 and 48 h. Both reports of Cengiz *et al.* [29,31], showed similar findings.

We acknowledge that the present study has a number of limitations, such as a small sample size, which can further affect the generalizability of our findings. The significant difference between the demographic baseline of both groups in terms of BMI, smoking, and history of jaundice may aggravate the risk of selection bias.

Conclusion

This study showed that the fundus-first LC approach is a safe, feasible, and promising technique. We also found that the use of harmonic scalpel was associated with less operation time and blood loss, fewer gallbladder perforations, less pain and nausea, fewer gallbladder perforations, and shorter hospital stay than the electrocautery.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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