



Laparoscopic Cholecystectomy: Which is Better Ultrasonic Energy or Monopolar Electrosurgical Energy Dissection?

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Abstract: Background: Gallstones remain one of the commonest surgical problems in the developed world and despite of major therapeutic advances in recent years there has been no progress in the prevention of gallstone development and it may lead to serious complication that may affect patient quality of life. **Aim of the work:** The aim of the study is to assess the safety and benefits of ultrasonic energy as a single alternative tool in the dissection of the gall bladder during laparoscopic cholecystectomy versus monopolar electrosurgical energy. **Patients and Methods:** The present study was carried out on 60 patients admitted with symptomatic gall bladder stones with sonographic diagnosed chronic calculous cholecystitis. They were divided into 2 groups. Group A (30 patients) for those patients laparoscopic cholecystectomy was done using harmonic scalpel as the sole instrument for dissection after application of safety metallic clip on the bile duct due to defective imaging studies that are able to detect cystic duct diameter preoperatively. Group B (30 patients) for these patients laparoscopic cholecystectomy was done with electrocautery and hemostatic clips. **Results:** Follow-up (6-month maximum), none of our patients suffered from postoperative biliary stricture as determined by ultrasound scan. The main disadvantage of ultrasonic dissection is instrument cost which is particularly high if the surgical unit is equipped with reusable instruments. Nevertheless, some authors believe that compared with combined cost of using multiple disposable instruments (scissors, a clipper, an electrocautery hook and a grasper). In our study no mortality occurred. **Conclusion:** Laparoscopic cholecystectomy using ultrasonic energy is safe and feasible. The method offers several considerable advantages, such as the utilization of a single instrument both for dissection of the gallbladder from the hepatic bed and division of the artery and duct. The superiority of ultrasonic dissection over electrocautery in causing fewer perforations a shorter operating time and an improved laparoscopic view.

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1. Introduction

Nowadays, laparoscopic cholecystectomy (LC) is undoubtedly considered the “gold standard” in the surgical treatment of symptomatic gallstones, gallbladder adenomas and acute cholecystitis (Zanghi et al., 2014).

Genetic and environmental factors contribute to gallbladder disease. Female gender, previous pregnancies and family history of gallstone disease are highly correlated with cholelithiasis. Approximately 60% of patients with acute cholecystitis are women; however, the disease tends to be more severe in men. Estrogen increases cholesterol and its saturation in bile and promotes gallbladder hypomotility. Diminished gallbladder motility is commonly seen during pregnancy (Stinton et al., 2012).

The diagnosis of cholelithiasis, cholecystitis, and other gallbladder diseases can be confirmed via a number of different imaging techniques. Ultrasonography and cholescintigraphy are the imaging studies most commonly used to diagnose cholelithiasis and cholecystitis. Positive findings upon ultrasonography include stones, thickening of the gallbladder wall, pericholecystic fluid, and Murphy's sign (i.e., pain) upon contact with the ultrasonographic probe. Ultrasonography performed in the fasting state reveals the correct diagnosis in more than 90% of cases, but bile-duct stones may be missed in 50% of cases (Reddy et al., 2016).

Since 1987, LC has largely replaced conventional open cholecystectomy. Monopolar electrocautery remains the main energy form used during laparoscopic dissection, representing the

preferred method in more than 85% of surgeons (Zanghì et al., 2014).

Cystic duct and cystic artery are commonly occluded by clips and cut by scissors; linear staplers, end loops or sutures have been proposed over time as alternative techniques for cystic duct ligation, however, without significant diffusion (Katkhouda et al., 2010).

Even if laparoscopic cholecystectomy is considered a safe procedure, some risks are associated with the use of monopolar electric scalpel, such visceral injuries on thermal basis, thus, leading to the search for alternative forms of energy. Moreover, visceral injuries could be caused by the frequent instrument exchange (scissors, dissectors), and bile leakage caused by the slippage of the clips (Chew et al., 2000).

Among the alternative energy sources proposed, the ultrasonic energy has been frequently adopted, however, without a widespread acceptance among surgeons for routine or emergency laparoscopic cholecystectomy (Zanghì et al., 2014):

The ultrasonically activated scalpel technology (Harmonic – Ethicon Endo Surgery INC – Johnson & Johnson Medical SPA, Somerville, NJ, USA) relies on the application of ultrasound to tissues to obtain three purposes synergistically: coagulation, cutting, and cavitation (Sanawan et al., 2017)

The majority of electro-surgical injuries manifests late or goes unrecognized. The incidence of accidental burns caused by unintentional energy transmission during a LC ranges between 0.06% and 0.3%. However, only one or two patients in 1,000 are recognized (Kandil et al., 2010).

Several studies have described the use of ultrasound dissection technology in the LC, which concluded that ultrasonic dissection was safe and easy to use. Few studies reported the harmonic scalpel, though superior, is not immune from causing undesirable biological effects on the body. However, current available studies on LC using harmonic ultrasonic dissector are too small to determine any statistically significant difference in outcomes between traditional LC and LC with harmonic (Chan et al., 2017).

Aim of the work

The aim of the study is to assess the safety and benefits of ultrasonic energy as a single alternative tool in the dissection of the gall bladder during laparoscopic cholecystectomy versus monopolar electro-surgical energy.

2. Patients and Methods

Patients:

This study was include 60 patients with gallbladder lesions who will undergo laparoscopic

cholecystectomy over one year starting from August 2018 till January 2019 in Ain shams university hospitals. Patients was reviewed in two groups:

Group 1: include 30 patients was undergo laparoscopic cholecystectomy with the use of harmonic dissection.

Group 2: include 30 patients was undergo laparoscopic cholecystectomy with the use of electro-surgical monopolar energy in dissection of gallbladder.

Choice of patients was done through closed envelopes.

• Inclusion criteria:

- Both male and female with no age limits.
- Patients fit for general anesthesia.
- Patients with certain gallbladder lesions include (gallstones and gallbladder polyps).

• Exclusion criteria:

- Patients unfit for general anesthesia.
- Patients with medical condition interfering with the use of laparoscope (cardiac –chronic liver disease – chest diseases).
- Laparoscopic converted to open cholecystectomy.
- Patients with gallbladder carcinoma.

Methods:

All patients was subjected to:

Preoperative work up:

- Full laboratory analysis (CBC - full coagulation profile - full liver function assessment - kidney function - viral markers).
- Pelviabdominal ultrasound with full comment on biliary tree and liver status.
- Chest X-Ray.
- ECG for those who were older than 40 years old.
- Echocardiography for those who were older than 60 years old or with significant cardiac history.

Intraoperative:

○ All patients was receive dose of third generation cephalosporin prior to induction of anesthesia, in group 1 we was use harmonic in gallbladder dissection while in group 2 we was use traditional monopolar electro-surgical energy in dissection of gallbladder.

○ Subhepatic tube drain was used in all patients.

○ Any intraoperative event was documented as regard gallbladder perforation, bile duct injury, bleeding, biliary spillage and liver or intestinal injury.

Operative procedures

Clipping cystic artery technique in laparoscopic cholecystectomy (**Group 1**):

Patient positioning:

The patient was lying supine and the surgeon was positioned on the patient's left side (North

American positioning). The camera operator stands on the patient's left and to the left of the surgeon, while the assistant stands on the patient's right. The video monitor was positioned on the patient's right above the level of the costal margin. Exposure can be improved by tilting the patient in the reverse Trendelenburg position and rotating the table with the patient's right side up. Gravity pulls the duodenum, the colon, and the omentum away from the gallbladder, thereby increasing the working space available in the upper abdomen.

Technique:

Either an open or closed technique can be used to establish a pneumoperitoneum. With the open technique, a small incision was made at the umbilicus, and a blunt cannula (Hasson cannula) was inserted into the peritoneal cavity and anchored to the fascia. A 10-mm trocar was inserted through the supraumbilical incision once a pneumoperitoneum was established. A 30-degree telescope was then inserted through the umbilical port, and an examination of the peritoneal cavity was performed. A 10-mm operating port was placed subxiphoid, and two additional 5-mm trocars were positioned subcostally in the right upper quadrant in the midclavicular and anterior axillary lines. The two 5-mm ports were used for grasping the gallbladder and exposing the gallbladder and cystic duct. The infundibulum retract it laterally to further expose the triangle of Calot. Traction on the fundus should be upward toward the patient's head, and traction on the Hartmann pouch laterally to the right. This combination "dis-aligns" the common duct and cystic duct so that they appear as distinct structures. Incorrect traction aligns the ducts so that they appear as a continuous structure and as a consequence the chance of biliary injury was increased. The junction of the gallbladder and cystic duct was identified by

stripping the peritoneum off the gallbladder neck and removing any tissue surrounding the gallbladder neck and proximal cystic duct. This dissection is continued until the triangle of Calot is cleared of all fatty and lymphatic tissue and the gallbladder infundibulum was elevated off of the liver bed. Visualization of this "critical view" was important in preventing injury to the bile ducts. At this point two structures (cystic artery and cystic duct) should be seen entering the gallbladder. Once the cystic duct was identified, ligating clip proximally on the cystic duct, two clips were placed distally on the cystic duct, which is then divided.

Postoperative:

- All patients was receive third generation cephalosporin.
- Follow up drain amount, color and time of drain removal.
- Hospital stay.
- Postoperative pelviabdominal ultrasound after 2 weeks and three months.
- Postoperative full laboratory assessment after 2 weeks and three months.

Statistical Analysis

Data were collected, revised, coded and entered to the Statistical Package for Social Science (IBM SPSS) version 23. The quantitative data were presented as mean, standard deviations and ranges when parametric and median, inter quartile range (IQR) when data was non parametric. Also qualitative variables were presented as number and percentages. So, the p-value was considered significant as the following: P-value > 0.05: Non significant (NS), P-value < 0.05: Significant (S), P-value < 0.01: Highly significant (HS).

3. Results

Table (1): Time of op. (min.)

		Group A	Group B	Test value	P-value	Sig.
		No. = 30	No. = 30			
Time e of op (min.)	Mean ± SD	83.40 ± 11.57	135.33 ± 13.83	-15.778*	0.000	HS
	Range	63 – 115	110 – 170			

Mean operative time+SD in harmonic scalp (Group A) was **83.40 ±11.57** range 63:115min. Mean operative time+SD in electro cautry (group B), was **135.33± 13.83** rang from 110:170min. In group A: patient complicated with seroma (00.0%) In group B: 3 patient complicated with seroma (10.0%)

Table (2): Comparison between Group A and Group B regarding 24h pain score, wound infection and Seroma

		Group A	Group B	Test value	P-value	Sig.
		No. = 30	No. = 30			
24h pain score	Median (IQR)	4.00 (3 – 5)	5.00 (4 – 7)	-1.661≠	0.097	NS
	Range	3 – 7	3 – 7			
Wound infection	No	27 (90.0%)	25 (83.3%)	0.577*	0.448	NS
	Yes	3 (10.0%)	5 (16.7%)			
Seroma	No	30 (100.0%)	27 (90.0%)	3.158*	0.076	NS
	Yes	0 (0.0%)	3 (10.0%)			

Table (3): Comparison between Group A and Group B regarding Financial cost

		Group A	Group B	Test value	P-value	Sig.
		No. = 30	No. = 30			
Financial cost	Mean \pm SD	12.17 \pm 0.91	9.07 \pm 2.41	6.598•	0.000	HS
	Range	10 – 15	8 – 17			

In group A: cost of op. rang from 10:15 thousand with Mean \pm SD 12.17 \pm 0.91. In group B: cost of op. rang from 8:17 thousand with Mean \pm SD 9.07 \pm 2.41.

Table (4): Comparison between Group A and Group B regarding return to work

		Group A	Group B	Test value	P-value	Sig.
		No. = 30	No. = 30			
Return to work	Mean \pm SD	5.13 \pm 1.31	6.87 \pm 3.06	-2.854•	0.006	HS
	Range	3 – 8	3 – 17			

4. Discussion

Laparoscopic surgery in general is now an established surgical procedure all over the world. Laparoscopic cholecystectomy in particular has printed its name as the most successful of all laparoscopic surgical procedures. It is considered as a key point from which several other surgical procedures have been successfully lunched (**Haidy et al., 2014**).

Laparoscopic cholecystectomy is accepted as the gold standard surgical treatment of gall stones due to postoperative quality of the patient's life and it's optimal short and long term result. Several benefits were gained such as less postoperative pain, early ambulation, less analgesia, early return to normal daily activity, less hospital stay and of course the great benefit of no large abdominal scar which is highly demanded (**Mehrvarz et al., 2012**).

Laparoscopic cholecystectomy is indicated mainly in patients with symptomatic gallstone disease, acute cholecystitis and after ERCP in cases of calculi obstructive jaundice. At the present time most of the patients undergoing Laparoscopic Cholecystectomy should have been already undergone ultrasonography to study the gall bladder condition and the number and size of the stones (**Haidy et al., 2014**).

Electrocautery remains the main energy form used during laparoscopic dissection. However, because of it's documented risks especially those related to visceral injury search for alternative forms of energy that can be used in laparoscopic dissection and even coagulation and sealing vessels and ducts began very early during the evolution of laparoscopic cholecystectomy itself among these alternative energy sources are ultrasonic energy and laser energy (**Lee et al., 2013**).

In contrast to high frequency Electro-diathermy, harmonic scalpel technology does not cause electromagnetic interference with electro sensible implants or other instruments in the operation theatre. Therefore, it is recommended for use in patients with a pacemaker, implanted cardiac devices or cochlear

implants which may malfunction during the use of high frequency electro surgery (**Stephen et al., 2001**).

It has been reported that with ultrasonic energy there is a minimal lateral spread of vibration current in the surrounding tissues minimizing the risk of injury compared with monopolar electrocautery which is associated with 90% of visceral injuries and 15% of biliary tract injuries during laparoscopic cholecystectomy (**Sasi., 2010**).

Although some authors argue that the safety of the ultrasonic dissector may be enhanced by the reduced need for instrument replacement during surgery others demonstrated that ultrasonic dissection is not as safe because it has been initially perceived.

In this study 60 patients presented with symptomatic cholelithiasis were operated with Laparoscopic Cholecystectomy through two groups. The 1st group laparoscopic cholecystectomy was done using harmonic scalpel as the sole dissecting tool (ultrasonic as a method under investigation) and the 2nd group laparoscopic cholecystectomy was done using the ordinary monopolar electrocautery tools and hemostatic clips for both cystic duct and artery (as the standard method currently used in practice). Tsimoyiannis performed their study upon 200 patients divided into two groups and Bessa did their study upon 120 patients again divided into two groups and Cengiz et al. did their study upon two groups the 1st group includes 40 patients and the 2nd group includes 33 patients. Wetter did their study upon two groups the 1st group includes 37 patients and the 2nd group includes 21 patients. Sietses performed their study upon 18 patients divided into two groups (**Gelmini et al., 2012**).

Intraoperative bleeding that leads neither to hemodynamic instability nor to increase transfusion requirements may pose a particular problem during laparoscopic cholecystectomy. Even minimal bleeding decreases the visualization and accurate discrimination of structures directly because of the pooling of small volumes of blood and indirectly because of reduced illumination due to light adsorption by the blood. Because significant concerns

have been raised regarding the safety of diathermy in laparoscopic surgery and the use of laser in laparoscopic surgery has failed to gain acceptance. we decided to evaluate the potential advantages of ultrasonic dissection for the performance laparoscopic cholecystectomy (**Nashwan et al., 2013**).

The absence of either minor or major bile leaks from the cystic-duct stump in the group A denoting that the harmonic shears are as safe and efficient as simple metal clips in achieving the closure of the cystic-duct stump in the laparoscopic cholecystectomy. In the Bessa trial, no minor or major bile leaks were reported in the drains postoperatively.

As described by Tsimoyiannis there were no patients with postoperative bile leakage in the ultrasonic group but 3 patients in the electrocautery group developed postoperative bile leak was observed during the first 24 postoperative hours while in the third patient bile leakage continued for 6 days. In all endoscopic retrograde cholangiopancreatography (ERCP) confirmed bile leakage from the gallbladder's liver bed (**Bessa et al., 2008**).

Such a finding provides further evidence to the conclusions of others who demonstrated that the harmonic shears are capable of producing a safe and efficient closure and division of the cystic duct during the laparoscopic cholecystectomy (**Nashwan et al., 2013**).

Bessa reported no bile leaks from the cystic-duct stump in his study upon 60 patients in whom the closure and division of the cystic duct was achieved solely by the harmonic shears. **Westervalt** reported no bile leaks from the cystic-duct stump in his 100 patients in whom the closure and division of the cystic duct was achieved solely by the harmonic shears. Similar findings were reported by **Tebala**. In the study by **Huscher et al.**, bile leaks were encountered in 7 of the 331 patients (2.1 %) in whom the closure and division of the cystic duct was achieved by the harmonic shears alone compared to 3 of the 130 patients (2.3%) in whom the closure and division of the cystic duct was achieved by the harmonic shears with the cystic-duct stump further secured with an endo-loop of absorbable suture material. This 2.1 % cystic-duct leakage rate is comparable to the 2% rate reported in the literature when using other cystic-duct closure techniques. Although all but one of these bile leaks occurred in the hands of "surgeons-in-training" (i.e. surgeons who performed less than 50 laparoscopic cholecystectomy procedures and surgeons who had never used ultrasonically activated devices), the relatively high rate of bile leaks in this study may in part be explained by the method of application of the harmonic shears. **Huscher et al.** stated that the blades were first applied more proximally for a few seconds to achieve a simple

sealing of the lumen then they were applied a few millimeters distal to the previous application site holding the grasp until the division of the duct was accomplished (**Fullum et al., 2005**).

In the present study, as well as in the **Bessa et al**, **Westervalt et al** and **Tabala et al** studies the harmonic shears were applied to only one site on the cystic duct where sealing and division were achieved with no bile leaks from the cystic-duct stump encountered in any of the four studies. It is our belief that a double application of the harmonic shears to the cystic duct is unnecessary and may be an unsafe practice. That is agreed with the previous mentioned studies.

Bowel injury had not occurred in this study. Yet, **Hunter** stated that many of the lethal complications of laparoscopic surgery have resulted from unrecognized intestinal injury during extensive lysis of adhesions. He indicated that certain findings during trial dissection should trigger the decision to convert specifically dense adhesions of the omentum, duodenum or the transverse colon to the abdominal wall, the liver and gall bladder. He had set a time limit on trial of dissection of 30 minutes after which the surgeon should consider open conversion if no progress was achieved under such circumstances. Open conversion represents good judgment and the mature laparoscopic surgeon would be the one who learn to recognize which procedure cannot be completed laparoscopically (**Fullum., 2005**).

The use of open pneumoperitoneum methods for insufflation under vision had made the chance of bowel injury so small. Also the delicate dissection and the proper hemostasis had played a major role in prevention of any bowel injury (**Fullum, 2005**).

The present results corroborate with those of **Bessa et al.**, **Huscher et al.** and **Janssen et al.** studies which demonstrated a shorter operating time and fewer intraoperative complications using ultrasonically activated shears compared with electrocautery in laparoscopic cholecystectomy (**Sasi., 2010**).

The duration of operating time is statistically shorter with ultrasonic dissection. The total time of laparoscopic cholecystectomy for group A per patient was ranged from 63 – 115minutes with the mean time was 83 minutes.

The total time of laparoscopic cholecystectomy for group B per patient was ranged from 110-170 minutes with the mean time was 135 minutes.

The present results corroborate with those of **Bessa et al.**, **Huscher et al.** and **Janssen et al.** studies which demonstrated a shorter operating time and fewer intraoperative complications using ultrasonically activated shears compared with

electrocautery in laparoscopic cholecystectomy (**Sasi, 2010**).

The statistically significant shorter mean operative time in the harmonic group can be attributed to several factors; (1) the statistically significant lower incidence of gallbladder perforation in the harmonic group with subsequent avoidance of time loss in abdominal lavage and spilled stones retrieval and (2) the Harmonic Shear is a multifunctional instrument. It replaces four instruments routinely used in the laparoscopic cholecystectomy, namely, the dissector, clip applier, scissors, and electrocautery hook or spatula. Its use therefore prevents the frequent blind extraction and reinsertion of these different instruments with the subsequent avoidance of time loss. Finally, the activation of the Harmonic ACE does not form smoke although mist may be generated by vibration therefore allowing the surgeon to work in a clear operative field throughout the operation. On the other hand, the use of electrosurgery causes smoke formation in the abdominal cavity are visibility. Moreover, smoke must be evacuated by opening the valves of the trocar thus causing repeated loss of the pneumoperitoneum and a subsequent loss of time.

The amount of analgesia required in the first 24 hours postoperatively was ranging 0-50 mg. Patients whom required analgesia of group A was for 65 % of patients and of group B was 76 % of patients of whom the surgery was done without open conversion. In the **Cengiz et al** trial at the first and fourth hours of recovery are statistically lower with ultrasonic dissection. Pain scores at 24 hours of recovery from **Cengiz** and **Tsimoyiannis** trials were combined with a lower estimate in the ultrasonic dissection group trials is statistically significant (**Sasi, 2010**).

Wound sepsis from the port which the gall bladder was removed through occurred in two patient within each group which is in agreement with most international figures of wound sepsis at gall bladder extraction port. Bessa et al. stated that two patients had wound infection for Harmonic Shear group and three patient with port site infection for monopolar group. So the use of sterile bag to remove the gall bladder within it had shown great effect in prevention of such complication (**Sasi, 2010**).

The main disadvantage of ultrasonic dissection is instrument cost which is particularly true if the surgical unit is equipped with reusable instruments. Nevertheless, some authors believe that compared with combined cost of using multiple disposable instruments (scissors, a clipper, an electrocautery hook and a grasper), the Harmonic scalpel may provide a cost-effective options (**Nashwan et al., 2013**).

Laparoscopic cholecystectomy performed with an ultrasonically activated scalpel is feasible and

effective. The method offers several considerable advantages, such as the utilization of a single instrument both for dissection of the gallbladder from the hepatic bed and division of the artery and duct. Furthermore, because of the minimal thermal dispersion, the use of the Harmonic reduces the risk of injuries and reduces the operative time. Nevertheless, the main obstacle hindering the applicability of the procedure is the cystic duct size: If it exceeds 6 mm in diameter which exceeds the recommended size to apply the Harmonic scalpel.

Conclusion

- Laparoscopic cholecystectomy using ultrasonic energy is safe and feasible. The method offers several considerable advantages, such as the utilization of a single instrument both for dissection of the gallbladder from the hepatic bed and division of the artery and duct.
- The superiority of ultrasonic dissection over electrocautery in causing fewer perforations a shorter operating time and an improved laparoscopic view.
- In the present study, the use of ultrasonic technology in the closure of the cystic duct has proved to be as safe and effective as the commonly used simple metal clips. Neither minor nor major bile leaks attributed to the use of ultrasonic technology were encountered throughout the study period.
- The use of ultrasonic technology is considered to have a positive impact on operative technique, time, economy and possibly a reduction of postoperative pain.
- The main obstacle hindering the applicability of the procedure is the cystic duct size: if it exceeds 5-6mm in diameter, an additional ligature or clip is necessary.
- The main disadvantage of the use of ultrasonic technology in laparoscopic cholecystectomy is the cost. Yet within disposable instruments based centers it is not a disadvantage.
- The use of ultrasonic technology in laparoscopic cholecystectomy provides an alternative to the currently used electrocautery and surgical clips.

Recommendation

Laparoscopic cholecystectomy using ultrasonic energy is safe and feasible. The method offers several considerable advantages, such as the utilization of a single instrument both for dissection of the gallbladder from the hepatic bed and division of the artery and duct. The superiority of ultrasonic dissection over electrocautery in causing fewer perforations a shorter operating time and an improved laparoscopic view. In the present study, the use of ultrasonic technology in the closure of the cystic duct

has proved to be as safe and effective as the commonly used simple metal clips. Neither minor nor major bile leaks attributed to the use of ultrasonic technology were encountered throughout the study period. The use of ultrasonic technology is considered to have a positive impact on operative technique, time, economy and possibly a reduction of postoperative pain. The main obstacle hindering the applicability of the procedure is the cystic duct size: if it exceeds 5-6mm in diameter, an additional ligature or clip is necessary. The main disadvantage of the use of ultrasonic technology in laparoscopic cholecystectomy is the cost. Yet within disposable instruments based centers it is not a disadvantage. The use of ultrasonic technology in laparoscopic cholecystectomy provides an alternative to the currently used electrocautery and surgical clips.

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