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Impact of Monoploar Electrocautery Versus Ultrasonic Dissection On Gallbladder Perforation In Laparoscopic Cholecystectomy

Madeeha Shahid, Muhammad Khalid

ABSTRACT

Objective: To compare the outcomes of monopolar electrocautery and ultrasonic gallbladder dissection from the gallbladder bed during laparoscopic cholecystectomy in term of gallbladder perforation.

Study design and setting: This comparative, cross-sectional study conducted in the Department of Surgery, PAF Hospital Mushaf, Sargodha, from August 2021 to December 2022 after obtaining ethical committee approval.

Methodology: A total 320 patients with cholelithiasis undergoing laparoscopic cholecystectomy were divided into two groups. In group A, the dissection of gallbladder from its bed was done with an ultrasonic device that is harmonic scalpel, while in group B, conventional monopolar electrocautery was used. Patients were assessed for gall bladder perforation. A p-value < 0.05 was considered statistically significant.

Results: Out of 320 laparoscopic cholecystectomies, gallbladder perforation occurred in 7 (4.4%) patients in Group A and 28 (17.5%) patients in Group B, a difference that was statistically significant ($p < 0.001$). The mean age was 29.08 ± 8.09 years in Group A and 32.49 ± 9.36 years in Group B (range 20–45 years), with no statistically significant difference between the groups ($p = 0.481$). The male-to-female ratio was 1:4.5 in Group A and 1:7 in Group B, with no significant difference between the groups ($p = 0.792$).

Conclusion: This study revealed that a significantly lower frequency of gall bladder perforation with ultrasonic dissection as compared to monopolar diathermy among patients undergoing laparoscopic cholecystectomy. This can ultimately reduce the early and long-term complications of bile spillage and stone loss in peritoneal cavity.

Keywords: Cholelithiasis, Gallbladder perforation, Laparoscopic cholecystectomy, Monopolar electrocautery,

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INTRODUCTION:

The "gold standard" for treating symptomatic gallstone disease is laparoscopic cholecystectomy (LC). Even when the procedure is standardized, both emergency and elective surgeries can result in complications. After clipping of the cystic duct and artery during LC, gallbladder perforation during dissection from the liver bed leading to bile spillage and stone loss in the peritoneal cavity is a common surgical complication. It has been observed that 20% to 40% of LC procedures result in gallbladder perforation [1]. As the surgeon's competence determines the procedure's safety, it is essential to continuously improve surgical technique and identify any potential risks associated with the devices used.

Madeeha Shahid
Consultant Surgeon, Department of General Surgery
PAF Hospital Mushaf Sargodha
Email: madeeha_87s@hotmail.com

Muhammad Khalid
Consultant Anesthetist, Department of Anesthesiology
PAF Hospital Mushaf, Sargodha
Email: asrozs@yahoo.com

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Various instruments have been used in laparoscopic surgery to cut and coagulate tissue, including the ultrasonic scalpel, carbon dioxide laser, and bipolar and monopolar cautery. It is challenging to determine the precise frequency of collateral damage; nonetheless, during LC, 15% of biliary tract injuries and 90% of visceral injuries have been directly linked to the use of 18% monopolar electrocautery. Injuries can also result from stray electrical currents, direct interaction between the active electrode and metal tools or tissue, and insulation failure of the active electrode in electrosurgical equipment. Due to potential patient harm, additional research has been done on substitute instruments such as ultrasonic scalpels [2].

More than two decades have passed since the ultrasonically activated scalpel (Harmonic - Ethicon Endo-Surgery INC - Johnson & Johnson Medical SPA, Somerville, NJ 1992) was first used in clinical settings. Its technology is based on applying ultrasonic waves to tissues in the harmonic frequency range. This produces three interdependent effects: cavitation, cutting, and coagulation. Tissue damage is less likely when the temperature is attained and the lateral energy spreads are lower than those found when the monopolar hook is employed. According to FDA certification from

2006, the harmonic scalpel (HS) is also useful for closing biliary ducts and arteries with a diameter of 4 to 5 mm[3]. Friction is produced at the probe of this device by ultrasonic vibrations. It generates vibrations between 20,000 and 50,000 Hz, and when the temperature rises to 200ºC, tissue is transected with negligible collateral damage as a result of the friction that denatures proteins and causes coagulation[4].

The Monopolar diathermy hook is the most commonly used instrument to create a bloodless operating field during LC. However, local consequences such as injury to the liver or common bile duct, gallbladder perforation, and bile or stone leaking into the peritoneal cavity can result in both monopolar and bipolar electric coagulation. These issues can also affect the stomach or small bowel. When it comes to the safe replacement of a diathermy hook for hemostatic tissue dissection, ultrasonically activated HS has proven to be effective and more precise. The primary functions of the HS in LC have been the division of the artery to the cystic duct and the separation of the GB from the liver bed. The coagulating and cavitation effects that occur when various tissues come into contact with a rapidly vibrating blade served as the foundation for this innovative method of slicing tissues. Furthermore, the almost smokeless electronically driven HS maintains visibility of the operating field throughout the procedure, obviating the necessity for frequent lens cleanings or smoke expulsions to recreate the pneumoperitoneum [5].

By lowering the risk of gallbladder perforation and related intraoperative and postoperative complications, ultrasonic dissection of the gallbladder bed during LC may enhance the surgical technique [6]. Ultrasonic dissection's learning curve demonstrates that skill increases with practice, which could eventually lead to safer and more effective methods [7.] Recent studies also supports that harmonic device used for clipless cholecystectomy, ultrasonic shears provided more precision during dissection and reduced complications[8,9]. Recent local data are limited. Since gallbladder perforation can lessen both early and late difficulties linked to bile and gallstone spilling, the current study aimed to compare outcome of monopolar electrocautery and ultrasonic gallbladder dissection during laparoscopic cholecystectomy. It provide locally appropriate evidence and may help in the selection of energy devices in standard practice. It might be linked to better surgical results and easier recovery after surgery [10].

METHODOLOGY: After obtaining approval from the Ethical Committee (ERC: MSF(H)/308/IRB/48) this cross sectional study was conducted in the Department of General Surgery, PAF Hospital Mushaf, Sargodha from March 2021 to December 2022.

The calculated sample size based on gallbladder perforation rate 10% in electrocautery and 3% in ultrasonic dissection reported in a study[11] with 5 % level of significance and 80 % power of study. In this study, 320 patients who fulfilled the inclusion criteria admitted through the outpatient department were enrolled.

Inclusion criteria: All patients diagnosed as symptomatic cholelithiasis, age 20 – 45 years, including both sexes. Exclusion criteria: Patients with cirrhosis of the liver on ultrasound, symptoms of pain, fever, and tenderness in right hypochondrium within the last 05 days duration, Patient refusal for laparoscopic cholecystectomy, patients with evidence of choledocholithiasis, patients with carcinoma of the gallbladder.

After informed consent for this study, a detailed history was taken and a thorough physical examination was done. Ultrasonic evidence of symptomatic cholelithiasis was recorded. A routine laboratory investigation was advised and general anesthesia fitness was taken by the anesthetist. All patients underwent elective LC. Non-probability convenience sampling technique was used. And patient was divided into two equal groups on the patient's arrival at the operation theater. 160 patients in group A received laparoscopic surgery with a HS, and 160 patients in group B received treatment with monopolar electrocautery. The standard four ports laparoscopic cholecystectomy was performed by consultant surgeons with more than 5 years of laparoscopic experience, ensuring uniformity in dissection technique, port placement, energy device usage, and intraoperative decision-making. Procedure starts by creating a pneumoperitoneum using CO_2. Clipping of cystic artery and duct was done by using titanium clips after achieving a Calot's triangle. Dissection of gallbladder from its bed was done with a HS in group A and monopolar electrocautery in group B. During surgery, the patients were observed for outcome parameter i.e. gallbladder perforation or not. This is identified intraoperatively by the surgeon and documented in the operative notes. Gallbladder perforation is defined as any unintended breach or tearing of the gallbladder wall occurring during laparoscopic cholecystectomy, resulting in leakage of bile and/or gallstones into the operative field.

All patients received 3 doses of intravenous antibiotics, one dose at the time of anesthesia induction and the next two 8 hourly. All patients were discharged on the 1st or 2nd post-operative day depending upon the postoperative status of pain and would be followed in the outpatient department on 7th postoperative day. All collected data was recorded in predesigned proforma.

RESULTS

Statistical analysis of data was done by using SPSS version 22. For categorical data (Qualitative) like gender and patients outcome parameters chi-square test was used. Comparison of means between two independent group using student's t-test. P-value <0.05 was considered statistically significant.

Distribution of patients by age: The mean age of the patients in group A was 29.08 + 8.09 years. The mean age of the

patients in group B was 32.49+9.36 years [range 20 – 45 years]. On comparison, the difference between the two groups was not statistically significant (p =0.481) Shown in Table 1 Distribution of patients by gender: In group A, there were 29 male patients and 131 female patients. The male-to-female ratio in this group was 1:4.5. In group B, there were 20 male patients while 140 patients were female. The male-to-female ratio in this group was 1:7. On comparison, the difference between the two groups was not statistically significant (p=0.792). Show in Table 2. Patients by Outcome parameter: Gallbladder perforation:

In group A, gall bladder perforation was present among 7 (4.4%) patients, and in group B, it was present in 28 (17.5%) patients. A chi-square test was applied and the difference between the two groups was statistically significant (p-value 0.000). (Table 3)

DISCUSSION:

Traditionally, Laparoscopic cholecystectomy (LC) has been performed using monopolar electrocautery; however, the harmonic scalpel (HS) has recently emerged as an alternative dissection technique. High-frequency ultrasonic radiation is used by harmonic shears to cut, coagulate, dissect, and ligate tissues. It is thought that this energy source has a safer profile for artery and cystic duct closure, coagulation, and dissection. The device is FDA-approved for ligating blood vessels up to five millimeters [9]. It is associated with less blood loss, minimal smoke production, and a lower risk of gall bladder perforation, common bile duct injuries, and intestinal injuries[7,8].

Table 1: Showing Distribution of patients by age

Age (years)	Group A (n=160)	Group B (n=160)
20 – 25	19 (11.9%)	16 (10.0%)
26 – 30	30 (18.8%)	28 (17.5%)
31 – 35	48 (30.0%)	52 (32.5%)
36 – 40	34 (21.2%)	39 (24.4%)
41 – 45	29 (18.1%)	25 (15.6%)
Mean + SD	29.08 + 8.09	32.49 + 9.36
p-value*	0.481**	

Table:2 : Distribution of patient by gender

Gender	Group A (n=160)	Group B (n=160)
Male	29 (18.1%)	20 (12.5%)
Female	131 (81.9%)	140 (87.5%)
P-value	0.792*	

Table: 3 Gallbladder perforation

Gallbladder perforation	Group A	Group B
Yes	7 (4.4%)	28 (17.5%)
No	153 (95.6%)	132 (82.5%)
P-value	0.000*	

A consistent finding in the literature is the shorter operative time associated with HS. According to a study by Saad et al., HS has multiple uses because it may be used for dissection and vascular and cystic duct closure and it eliminates the need to switch out instruments like L hooks which safe significant time. This study stated mean operative time in electrocautery group was 42.2±8.93 minutes versus 35.7±4.85 minutes in harmonic group (p-value 0.001) [10]. Ibrahim et al. supported these findings in their comparative study, highlighting that ultrasonic dissection led to significantly lower operative time, reduced gallbladder perforation, and fewer intraoperative complications compared to electrocautery.[11] The literature suggests that the use of HS is associated with shorter operative times, although this variable was not assessed in our study.

Gallbladder perforation is a frequent complication during LC that can result in bile spillage, stone loss, and both early and delayed postoperative issues. In this regard, HS has shown clear benefits. In a study by Nashwan K et al, Gallbladder perforation occurred in 15% and lost bile stone in 7% in the EC group patient and 9% and 3% respectively in the HS group patient (P-value is 0.084 and 0.152 respectively). No common bile duct injury was recorded in either group.[12] Similarly, Nadim Khan et al, reported that the incidence of gall bladder perforation was significantly lower in the ultrasonic group than in the electrocautery group (10.9% vs. 29.7% p=0.007) [13]. We observed a similar result in our HS group 3 - 4 times less gallbladder perforation noted which cannot lead to early and long term complication related to bile and stone spillage [14].

An Egyptian study involving 42 children underwent LC; their average age was 8.4 +/- 3.25 years. Each surgery was carried out laparoscopically with HS; no open surgical conversion was observed. The postoperative recovery went well for every patient, except for two cases of gall bladder perforation during liver bed dissection. In all cases, postoperative abdominal ultrasonography revealed no signs of CBD damage or small or large bile leakage [15]. As in our study no significant difference was observed in different age groups.

Beyond operative time and gallbladder integrity, HS offers additional intraoperative and postoperative advantages. HS generates no surgical smoke, ensuring a clear visual field throughout the operation and eliminating the “snow-falling” effect seen with electrocautery. It also ensures effective hemostasis and often obviates the need for irrigation. In contrast, the EC group encounters challenges such as poor hemostasis, obscured vision due to smoke and prolonged operative times. These limitations may contribute to higher rates of gallbladder perforation, bile leakage, wound infections, and the need for drain placement. Postoperatively,

these complications often necessitate increased analgesic requirements, which in turn may lead to further adverse effects.[10]

Schietroma et al emphasized that surgical inflammation and tissue trauma in LC can be influenced by multiple intraoperative factors, including dissection technique. Their study, while focusing on oxygen concentration, indirectly reinforces the importance of minimizing surgical stress and inflammatory markers—an area where HS, with less thermal damage and mechanical trauma, may offer benefits.[16, 17] Jiang et al.'s meta-analysis reinforces these findings by showing that, as compared to electrosurgical methods, ultrasonic dissection consistently lowers gallbladder perforation, operating time, and discomfort following surgery [17].

Finally, ultrasonically operated scissors not only increase safety but also improve overall surgical ergonomics by enabling the surgeon to use both hands and maintain concentration in the operating field without constantly switching instruments. The common LC procedure involves several instrument changes, which could result in either dangerous operations carried out without visual guidance or frequent changes in the direction of the laparoscope to observe instrument insertion [18, 19]. Additionally, HS's enhanced sealing ability reduces micro-leakage from lymphatics and tiny capillaries, which may lessen the formation of seromas and postoperative collections [19]. It was also found that because of its accurate dissection and decreased heat distribution, HS may lead to fewer conversions to open surgery, especially in cases involving extensive adhesions or inflamed gallbladders [12,14].

Limitation of study: The results may not be widely acceptable because this study was only carried out at a single center and only one outcome is measured. The age restriction of 20-45 years is another limitation of our study. Furthermore, variables that might have affected the rate of gallbladder perforation were not examined, including variable gallbladder inflammation severity, surgeon experience, and operating time. In order to assess delayed consequences such abscess formation, retained gallstones, or adhesive intestinal obstruction linked to bile leakage or stone loss, a long-term follow-up of both groups was not conducted.

CONCLUSION:

In a nutshell in the skilled hands of a surgeon with expertise, gall bladder perforation during LC using a HS has been demonstrated to occur far less frequently than with traditional monopolar electrocautery. When dealing with some patients who have a significant risk of surgical morbidity, the HS may be preferred. The main obstacle to HS induction is its very high cost, particularly in struggling medical facilities [20]. A more comprehensive multicenter study with long-term follow up that evaluates these factors is recommended for stronger findings.

Conflicts of Interest: Nil

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Authors Contribution:
Madeeha Shahid: Research conception, data collection and Writing of final draft
Muhammad Khalid: Data collection and Analysis, Review of final draft

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