

EVALUATING ULTRASONIC SHEARS IN LAPAROSCOPIC CHOLECYSTECTOMY: A STEP FORWARD IN MINIMALLY INVASIVE SURGERY

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ABSTRACT

Background: Gallstone disease is a prevalent condition requiring surgical intervention, with laparoscopic cholecystectomy (LC) as the gold standard. Conventional laparoscopic cholecystectomy (CoLC) uses titanium clips for cystic duct and artery ligation but has complications such as clip migration and bile leakage. Clipless laparoscopic cholecystectomy (CLC) is an emerging alternative that employs advanced energy-based devices to achieve vessel sealing and hemostasis without clips. **Objective:** To compare CLC and CoLC in terms of intraoperative safety, postoperative outcomes, operative time, and cost-effectiveness. **Methods:** A prospective, randomized controlled trial was conducted in a tertiary care hospital between April 2020 and November 2020. A total of 100 patients with symptomatic gallstone disease were randomly assigned into two groups: Group A (CLC, n=50) using ultrasonic shears and Group B (CoLC, n=50) using conventional electrocautery. Postoperative pain, analgesic consumption, operative time, complications, and hospital stay were analyzed. **Results:** CLC significantly reduced operative time (48.35 ± 7.92 min vs. 62.74 ± 11.68 min, $p < 0.05$), hospital stay (1.45 ± 0.65 days vs. 2.62 ± 0.81 days, $p < 0.05$), and postoperative pain scores (VAS Day 0: 2.45 ± 1.16 vs. 4.82 ± 1.38 , $p < 0.05$). CLC also resulted in lower blood loss, fewer gallbladder perforations (7 vs. 15, $p < 0.05$), and reduced need for drain placement (10 vs. 28, $p < 0.05$). **Conclusion:** CLC is a safe and effective alternative to CoLC, offering advantages such as reduced complications, faster recovery, and improved patient outcomes. Despite higher initial costs, its long-term benefits make it a valuable surgical approach.

Keywords: Laparoscopic cholecystectomy, clipless surgery, harmonic scalpel, gallstone disease, bile duct injury, surgical outcomes.



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INTRODUCTION

Gallstone disease is one of the most prevalent conditions necessitating surgical intervention, with laparoscopic cholecystectomy (LC) widely considered the gold standard for managing symptomatic cholelithiasis. Conventional laparoscopic cholecystectomy (CoLC), which relies on titanium clips to occlude the cystic duct and

artery, has been the standard technique for decades due to its simplicity and proven efficacy. However, complications such as clip migration, bile leakage, and bile duct injuries have raised concerns, encouraging the exploration of alternative approaches.(1)

In response to these concerns, clipless laparoscopic cholecystectomy (CLC) has emerged as an innovative alternative. This technique replaces traditional clips with advanced energy-based devices, such as harmonic scalpels and bipolar energy systems, to achieve secure vessel sealing and hemostasis without the use of foreign materials. CLC offers several advantages, including eliminating clip-related complications, improving precision during dissection, and reducing the risk of bile duct injury.(2)

Studies by Kandil et al. and Yano et al. have shown that CLC may reduce postoperative complications and enhance outcomes, particularly in complex cases involving severe inflammation or adhesions.(3,4) Abdelhady MH and Salama AF reported that using harmonic shears resulted in a lower incidence of gallbladder perforation compared to the traditional clip-based method.(5) Additionally, the use of ultrasonic shears was associated with shorter operative times, reducing overall anesthetic exposure and increasing the number of procedures performed within a standard surgical schedule.(5)

Despite these potential benefits, CoLC remains the preferred technique in many centers due to its lower cost and well-established safety record. Previous studies, such as those by El Nakeeb et al. (2010) and Bhut et al. (2020), have emphasized the need for high-quality evidence to support the routine adoption of CLC.(6,7)

This prospective randomized clinical trial aims to directly compare CLC and CoLC in terms of intraoperative safety, postoperative outcomes, operative time, and cost-effectiveness. By addressing these key parameters in a controlled clinical setting, this study seeks to provide valuable insights into the relative advantages and limitations of both techniques, helping to guide future clinical practice.

MATERIAL AND METHODS

A prospective, randomized controlled trial was carried out in the Department of Surgery at our tertiary care hospital between April 2020 and November 2020. The study included 100 patients, aged 18 to 70 years, diagnosed with symptomatic gallstone disease. Patients were excluded if they had abnormal liver function tests, a history of jaundice or pancreatitis, concomitant common bile duct (CBD) stones, acute cholecystitis, cholangitis, empyema of

the gallbladder, or a CBD diameter exceeding 5 mm on ultrasonography.

The patients were randomly assigned into two groups:

- **Group A (n=50):** Underwent surgery using ultrasonic shears
- **Group B (n=50):** Underwent surgery using conventional electrocautery

Institutional ethical clearance was obtained, and written informed consent was collected from all participants before the study began.

Laparoscopic cholecystectomy was performed using the four-port American technique.

- **Group A (Clipless Laparoscopic Cholecystectomy):**

The dissection of Calot's triangle was performed with ultrasonic shears. The cystic artery and duct were ligated using the harmonic shear at a power level of 2. The shears were kept in place until the ligated ends of the vessel separated spontaneously. Before sealing the cystic duct, its diameter was assessed by comparing it with the CBD using the open jaws of the shear as a reference. The surgeons carefully examined the cystic duct for stones by sliding the jaws of the ultrasonic scalpel along its length. The incision was made at a safe distance from the CBD to avoid injury, and the harmonic shear was activated with the jaws secured in a stationary position until the duct separated without traction.

The gallbladder was dissected from the liver bed using ultrasonic shears set at a power level of 5, resulting in minimal bleeding. The gallbladder was removed through the epigastric port. Drains were placed in cases with significant bleeding, oozing from the gallbladder fossa, or bile spillage due to gallbladder perforation.

- **Group B (Conventional Laparoscopic Cholecystectomy):**

Dissection of Calot's triangle was performed using a Maryland dissector. The cystic artery and duct were ligated with titanium clips, and the gallbladder was dissected from the liver bed using a hook and electrocautery.

The gallbladder was removed through the epigastric port. The total duration of surgery (from skin incision to closure) and the time taken for gallbladder removal from the liver bed were recorded.

Parameters Assessed:

1. **Postoperative Pain** — Measured using Visual Analog Scale (VAS) at 6, 24, and 48 hours
2. **Analgesic Consumption** — Number of doses and total quantity of analgesics required
3. **Postoperative Complications:**
 - Gallbladder perforation
 - Need for drain placement
 - Estimated blood loss

Follow-up Schedule:

Patients were followed up at 1 week, 3 weeks, and 6 months post-surgery to monitor recovery and assess for complications.

RESULTS

This study presents a comparative analysis of intraoperative and postoperative parameters between patients undergoing clipless laparoscopic cholecystectomy (CLC, Group A) and conventional laparoscopic cholecystectomy (CoLC, Group B). A total of 100 patients were included in the study, with 50 patients each in Group A (CLC) and Group B (CoLC). The mean age and male-to-female ratio were similar between the two groups ($p > 0.05$). However, significant differences were observed in key clinical outcomes. Group A had a notably shorter mean surgical duration (48.35 ± 7.92 minutes) compared to Group B (62.74 ± 11.68 minutes; $p < 0.05$). The length of hospital stay was also significantly reduced in Group A (1.45 ± 0.65 days) versus Group B (2.62 ± 0.81 days; $p < 0.05$). Gallbladder removal time was shorter in the CLC group, reflecting the improved efficiency of the technique ($p < 0.05$).

Postoperative pain scores were consistently lower in Group A, with significant differences observed at both Day 0 and Day 1 ($p < 0.05$). Furthermore, Group A experienced less reduction in hemoglobin and hematocrit levels compared to Group B ($p < 0.05$), indicating reduced blood loss during surgery.

This resulted in fewer postoperative complications and a reduced need for analgesics, with Group A requiring fewer doses (1.89 ± 0.62) than Group B (2.38 ± 0.71 ; $p < 0.05$). Overall, the findings highlight the clinical advantages of clipless laparoscopic cholecystectomy in terms of shorter operative time, faster recovery, and reduced postoperative pain and complications.

Table 1: Comparison of Parameters Assessed Between Group A (CLC) and Group B (CoLC)

Parameters Assessed	Group A (CLC)	Group B (CoLC)	P-value
Age (years)	43.18 ± 9.87	47.42 ± 10.36	$p > 0.05$
Male: Female	18:32	20:30	$p > 0.05$
Duration of Surgery (minutes)	48.35 ± 7.92	62.74 ± 11.68	$p < 0.05$
Duration of Hospital Stay (days)	1.45 ± 0.65	2.62 ± 0.81	$p < 0.05$
Time to Remove Gallbladder from Bed (minutes)	3.94 ± 2.35	7.58 ± 2.91	$p < 0.05$
VAS Score Day 0	2.45 ± 1.16	4.82 ± 1.38	$p < 0.05$
VAS Score Day 1	1.25 ± 0.78	3.24 ± 0.89	$p < 0.05$
Fall in Hemoglobin (g%)	0.47 ± 0.49	1.21 ± 0.72	$p < 0.05$
Fall in Hematocrit (%)	1.48 ± 2.23	2.42 ± 1.17	$p < 0.05$
Analgesic Requirement (doses)	1.89 ± 0.62	2.38 ± 0.71	$p < 0.05$

Table 2 highlights the complications encountered in both groups, with notable differences in gallbladder perforation and the need for drain placement. The incidence of gallbladder perforation was significantly lower in Group A (CLC), with only 7 cases compared to 15 cases in Group B (CoLC) ($p < 0.05$), indicating improved control and precision with the use of ultrasonic shears during dissection.

Additionally, 28 patients in Group B required drain placement, compared to only 10 patients in Group A ($p < 0.05$). This suggests a higher occurrence of bile spillage and bleeding in the conventional technique group, further emphasizing the safety and effectiveness of the clipless approach.

Table 2: Postoperative Complications Encountered in Group A (CLC) vs. Group B (CoLC)

Complications Assessed	Group A (CLC)	Group B (CoLC)	P-value
Gallbladder Perforation (n)	7	15	< 0.05
Number of Patients Requiring Drains (n)	10	28	< 0.05

DISCUSSION

Laparoscopic cholecystectomy (LC) has firmly established itself as the gold standard for managing gallstone disease, owing to its minimally invasive nature and faster recovery compared to open cholecystectomy. Within LC, two primary techniques are commonly employed: clipless laparoscopic cholecystectomy (CLC) and conventional laparoscopic cholecystectomy (CoLC). While CoLC involves the use of titanium clips to ligate the cystic duct and artery, CLC relies on advanced energy-based devices, such as the harmonic scalpel, to perform dissection and achieve hemostasis without the need for clips.

In the current study, the female predominance in both groups is consistent with the known higher incidence of gallstone disease among women. The mean age of patients was similar in both groups, indicating no significant age-related difference. One notable finding was the significantly lower fall in hemoglobin and hematocrit levels in the CLC group compared to the CoLC group ($p < 0.05$), indicating reduced intraoperative blood loss. This can be attributed to the superior precision of ultrasonic shears, which allow for dissection along natural tissue planes, minimizing vascular injury and bleeding. Several studies, including those by Jain et al. (2011) and Awake et al. (2019), have reported

similar findings, highlighting the safety of ultrasonically activated scalpels in reducing blood loss and maintaining better hemostasis.(10,11)

The operative time in the CLC group was significantly shorter than in the CoLC group ($p < 0.05$). This reduction in surgical duration can be explained by the multifunctionality of energy-based devices, which simultaneously dissect, coagulate, and seal tissues in a single step. Similar observations were made by Yano et al. (2021), who noted that CLC shortens operative time compared to CoLC, where additional steps are required to apply and secure multiple clips.(4) However, it is worth noting that surgeons unfamiliar with these energy devices may initially experience longer operative times due to the learning curve associated with CLC.

Hospital stay was also significantly shorter in the CLC group ($p < 0.05$), which can be linked to fewer complications, such as bile spillage and gallbladder perforation. The lower incidence of gallbladder perforation in the CLC group resulted in fewer cases of localized peritonitis, allowing for faster recovery and earlier discharge. Similar findings were reported by Kandil et al. (2010), who observed reduced rates of bile leakage and shorter hospital stays in patients undergoing CLC.(3,)

The safety of CLC is further underscored by the absence of clip-related complications, such as clip migration, which can lead to bile duct injuries or strictures in CoLC. Bhut et al. (2020) highlighted that while clip migration is rare, it can result in significant morbidity.(7) CLC eliminates this risk by sealing the cystic duct and artery with energy devices, avoiding the use of foreign material. However, it is essential to emphasize that both techniques are safe when performed by experienced surgeons, with a low overall incidence of major complications.

Postoperative outcomes favor CLC, with lower rates of bile leakage, fewer cases requiring drain placement, and reduced pain scores. The improved outcomes in CLC can be attributed to minimal thermal spread and more precise tissue handling by energy devices. Studies by Nakeeb et al. (2010) and Kandil et al. (2010) have similarly demonstrated that CLC results in fewer complications and quicker recovery compared to CoLC.(3,6)

The cost of the two techniques is an important factor to consider. CoLC remains more economical and

widely accessible due to the affordability of titanium clips, making it the preferred option in resource-limited settings.(10,11) On the other hand, the higher initial cost of energy devices in CLC can be a barrier to its adoption. However, proponents of CLC argue that its long-term benefits, such as reduced complications, shorter hospital stays, and faster recovery, may ultimately offset the higher upfront expense.

Finally, the surgeon's experience plays a crucial role in determining the choice of technique. While CoLC remains the standard in many institutions due to its long-established practice, adequate training can enable surgeons to adopt CLC successfully.(12,13) El Nakeeb et al. (2010) highlighted that with proper guidance and experience, surgeons can achieve better outcomes with CLC, particularly in challenging cases.(6) Although CLC may have a steeper learning curve, this can be overcome with time and practice, making it a valuable alternative to conventional methods.

CONCLUSION

This study highlights the advantages of clipless laparoscopic cholecystectomy (CLC) over conventional laparoscopic cholecystectomy (CoLC) in terms of reduced intraoperative blood loss, shorter operative time, faster recovery, and fewer postoperative complications. The use of ultrasonic shears offers better precision, minimizing tissue trauma and eliminating the risk of clip-related complications. Patients in the CLC group experienced significantly less pain, shorter hospital stays, and reduced need for drain placement. While CLC may involve higher initial costs, its long-term benefits make it a safe and effective alternative to CoLC, especially in experienced hands, enhancing patient outcomes and overall surgical efficiency.

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