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Original Research Article

Observational study of use of harmonic scalpel vs electrocautery in dissection and removal of gallbladder from gallbladder bed in laparoscopic cholecystectomy

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ABSTRACT

Background: The harmonic scalpel uses ultrasonic vibrations at a high frequency to cut tissue and coagulate blood vessels. Electrocautery uses electrical current to generate heat, which cuts tissue and coagulates blood vessels. Both energy sources are used for dissection of gallbladder with each having their own merits and demerits.
Objectives: To assess the outcomes and complications of using harmonic Scalpel vs electrocautery for laparoscopic cholecystectomy.
Methods: Observational retrospective study, conducted at a tertiary healthcare center (Sassson General Hospital, Pune). Data collection over 24 months (December 2022-December 2024), enrolled 100 patients diagnosed with cholelithiasis. The key outcomes measured - the average operating time, the average frequency of lens cleaning, the average VAS score on POD 1, the average length of stay postoperatively, duration of drain and number of complications.
Results: The average operating time using electrocautery vs harmonic scalpel was 55.67 vs 41.52 minutes, average frequency of lens cleaning 5 vs 3.24 times, average VAS score on post operative day 1 to be 4.321 vs 3.264, average length of stay post-surgery to be 3.58 vs 2.38 days, average duration of drain to be 2.681 vs 2.324 days, number of gallbladder perforations to be 5 vs 2.
Conclusions: The harmonic scalpel demonstrated improved patient outcomes for operating time, length of stay, duration of drain, drainage volume, postoperative pain and overall complications compared to electrocautery.

Keywords: Electrocautery, Harmonic scalpel, Laparoscopic cholecystectomy, Surgical outcomes

INTRODUCTION

Laparoscopic cholecystectomy (LC) was first introduced in 1987 by Mouret. It has many advantages over open surgery with shorter hospital stay, less postoperative pain, smaller surgical scar thus more of cosmetic value and lower cost. In September 1992 a NIH consensus conference held in Bethesda concluded that laparoscopic cholecystectomy was the treatment of choice for cholelithiasis. LC has now become the most common operation performed by general surgeons. During laparoscopic cholecystectomy it is important to identify the structures of calot's triangle at the time of cystic duct isolation. Cystic duct occlusion can be done with clips, intra or extra corporeal ligation, harmonic scalpel or ligature. When performing a laparoscopic cholecystectomy, surgeons often choose between the harmonic scalpel and electrocautery as their primary tools for dissection and haemostasis. Both methods have distinct characteristics, benefits and drawbacks.

Harmonic scalpel

Advantages

Minimal thermal damage: The harmonic scalpel generates lower temperatures (usually below 100°C) compared to electrocautery, leading to less thermal spread to

surrounding tissues. This reduces the risk of collateral damage, particularly important in delicate areas.[1]

Effective for both cutting and coagulation: It can simultaneously cut and coagulate, which can reduce the time needed for the procedure.[2]

Reduced smoke production: Since it operates at a lower temperature, it produces less surgical smoke, which improves visibility and reduces potential respiratory irritation for the surgical team.[3]

Precision: Provides precise cutting, which can be especially useful in areas with dense or inflamed tissues.[4]

Lower risk of electrical injury: Since it does not use electrical current through the patient's body, there is no risk of burns at grounding pad sites or unintended electrical injury to the patient.

Disadvantages

Cost: Harmonic scalpel devices are generally more expensive than traditional electrocautery tools. This includes the cost of the device and the disposable components that need replacement for each surgery.[5]

Learning curve: Surgeons may need additional training to become proficient with the harmonic scalpel, especially if they are accustomed to using electrocautery.

Electrocautery (monopolar and bipolar electrosurgery)

Advantages

Widely available and cost-effective: Electrocautery units are standard in most operating rooms, making them readily available and less expensive than the harmonic scalpel.

Effective haemostasis: It provides effective coagulation of blood vessels, especially for vessels larger than what the harmonic scalpel can seal. Bipolar devices, in particular, offer precise coagulation without significant thermal spread.

Versatility: Electrocautery can be used in a wide range of surgical procedures and is suitable for cutting, coagulating, fulgurating and desiccating tissue.

Disadvantages

Higher thermal damage: Electrocautery generates higher temperatures (up to 300–400°C), which can cause more extensive thermal damage to surrounding tissues.

This increases the risk of injury to nearby structures, such as bile ducts or the liver.[6]

Smoke production: Higher temperatures produce more surgical smoke, which can obscure the surgical field and pose health risks to the surgical team.

Risk of electrical injury: There is a small risk of burns at the grounding pad site or unintended injuries from electrical current traveling through the body, particularly with monopolar electrocautery.

Electrical interference: Electrocautery can interfere with other electronic devices, such as pacemakers, posing risks for patients with these devices.

METHODS

Study design

A retrospective observational study.

Study site

At a state-run tertiary care hospital (Sassoon General Hospital, Pune).

Study population

100 patients with diagnosis of cholelithiasis posted for laparoscopic cholecystectomy after due consent.

Inclusion criteria

It includes age 18-70 years, physical status class I or II according to ASA with diagnosis of cholelithiasis without cholecystitis, patients giving a written consent and willing to participate in the study would be included in the study

Exclusion criteria

Pregnant or lactating women. Patients with pre-existing morbid obesity, ASA class III or IV, complicated intrahepatic or extrahepatic bile duct stone, complicated acute pancreatitis, history of previous upper abdomen open surgery and co-morbid conditions as chronic obstructive pulmonary diseases, coagulopathies

Duration

Data collection was conducted over 24 months (December 2022-December 2024).

Statistical analysis

Data was collected prospectively in a Microsoft Excel database. Continuous baseline descriptive variables will be expressed as mean with standard deviation (SD) and was compared using the Mann-Whitney U test. Non parametric data was analysed using Kruskal Wallis test. A p value of <0.05 was considered statistically significant. 95% confidence intervals was used across all statistical tests.

Ethical considerations

Institutional Ethics Committee (IEC) approval obtained.

RESULTS

Average operating time.

The average operating time for laparoscopic cholecystectomy using electrocautery was found to be 55.67 minutes and that in harmonic scalpel group to be 41.52 minutes.

Average frequency of lens cleaning

The average frequency of lens cleaning during surgery in electrocautery group to be 5 times and in harmonic scalpel group to be 3.24 times.

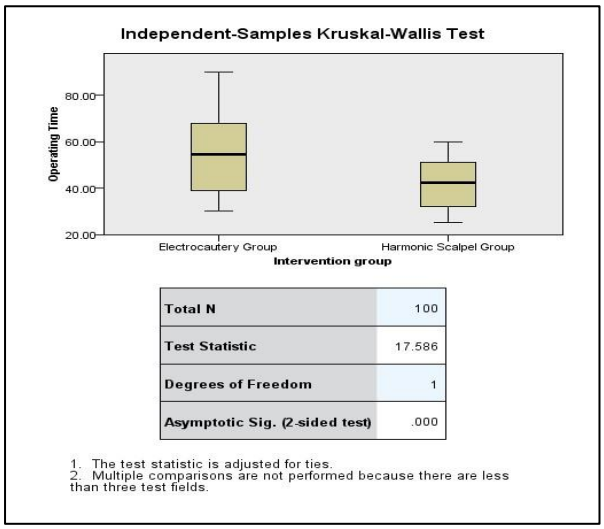

Figure 1: Average operating time.

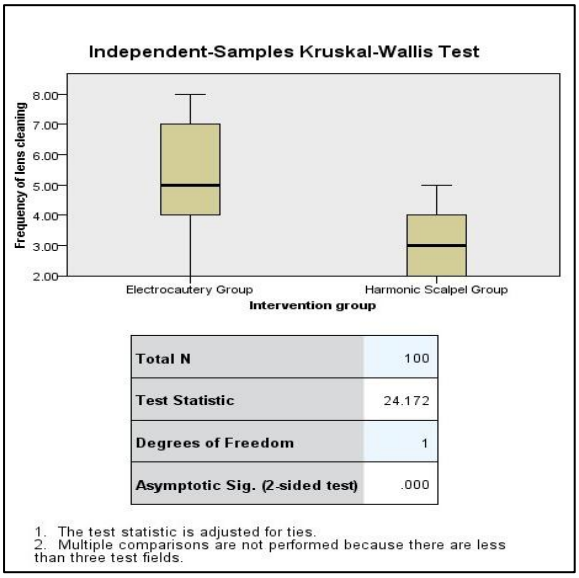

Figure 2: Average frequency of lens cleaning.

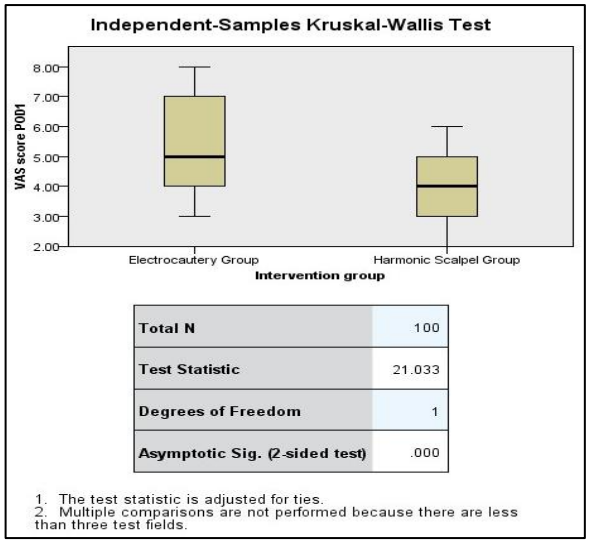

Figure 3: Average VAS score on POD 1.

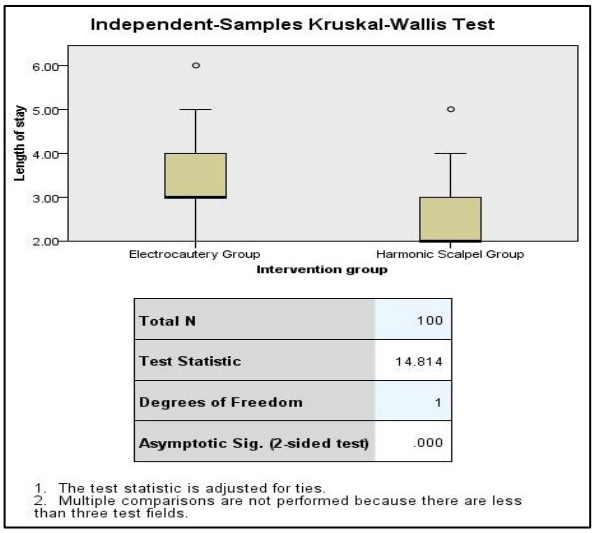

Figure 4: Average length of stay post-surgery.

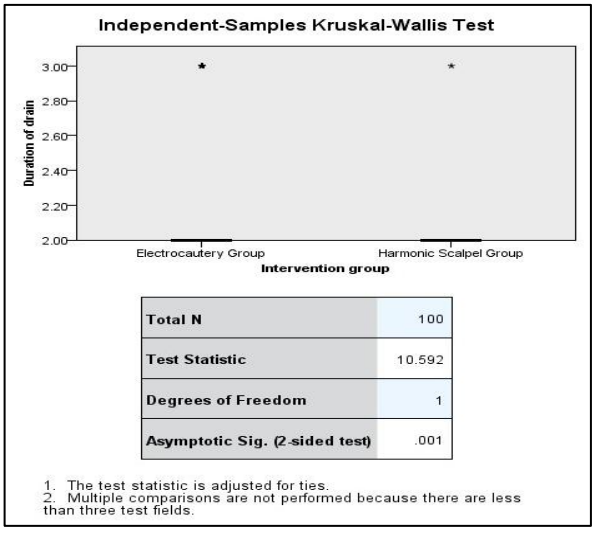

Figure 5: Average duration of drain post-surgery.

Average VAS score on POD 1

The average VAS score on post operative day 1 in electrocautery group to be 4.321 and in harmonic scalpel to be 3.264. Average length of stay post-surgery, Average duration of drain post-surgery and Number of gallbladder perforations during surgery.

The average length of stay post-surgery in electrocautery group to be 3.58 days and in harmonic scalpel to be 2.38 days. The average duration of drain in post operative period to be 2.681 days in electrocautery group and 2.324 days in harmonic scalpel group. The number of gallbladder perforations to be 5 in the electrocautery group and 2 in the harmonic scalpel group. Age and gender distribution and comorbidities (demographic data).

Table 1: Average operating time.

	Electrocautery	Harmonic scalpel
Average operating time (minutes)	55.67	41.52

Table 2: Average frequency of lens cleaning.

	Electrocautery	Harmonic scalpel
Average frequency of lens cleaning	5	3.24

Table 3: Average VAS score on POD 1.

	Electrocautery	Harmonic scalpel
Average VAS score on POD 1	4.321	3.264

Table 4: Average length of stay post-surgery, average duration of drain post-surgery and number of gallbladder perforations during surgery.

	Electrocautery	Harmonic scalpel
Average length of stay (in days)	3.58	2.38
Average duration of drain (in days)	2.681	2.324
Number of GB perforations	5	2

Table 5: Age and gender distribution and comorbidities.

	Female	Male	Grand total
Age (in years)			
21-30	9	1	10
31-40	21	11	32
41-50	16	8	24
51-60	12	9	21
61-70	8	1	9
71-80	4	0	4
Total	70	30	100
Comorbidities	**Female**	**Male**	**Total**
Bronchial asthma	0	2	2
Diabetes	7	7	14
Diabetes+HTN	1	3	4
Epilepsy	1	0	1
HTN	10	1	11
Hypothyroid	2	0	2
Ischaemic heart disease	1	1	2
None	48	16	64
Grand total	70	30	100

DISCUSSION

This study is a comparison between the two most commonly used energy sources in dissection of gallbladder and separation from gallbladder bed in laparoscopic cholecystectomy, namely the harmonic scalpel and electrocautery. The harmonic scalpel works by converting electrical energy into mechanical energy at an ultrasonic frequency (typically around 50,000 Hz). It can be used for cutting as well as coagulation and is associated with minimal thermal damage, reduced smoke production, making it a versatile tool in modern surgical practice. This translates into lower operative time, fewer side effects to surrounding tissues and early recovery and discharge from hospitals. This study has highlighted these points as well.

Operative time and frequency of lens cleaning

According to this study, the harmonic scalpel was associated with lower operative time as compared to the electrocautery. The average operating time in the study group using Electrocautery was 55.67 minutes while that with harmonic scalpel was 41.52 minutes. Thus, there was a time difference of 14.15 minutes. This was found to be statistically significant. The harmonic scalpel caused reduced smoke emission and hence the frequency of lens cleaning is lower as compared to electrocautery. This helps reduce operative time as well as post operative infection rate. In this study the average frequency of lens cleaning was 3.24 times while using harmonic scalpel while it was 5 times while using electrocautery which was found to be statistically significant.

These results align with those of Nakeeb et al which was a randomized trial comparing the harmonic scalpel to monopolar electrocautery and found that the harmonic scalpel reduced the operative time by about 15 minutes on average.[7] The reduced time was attributed to fewer instrument exchanges and better haemostasis. Similar results were also obtained in a meta- analysis by Singh et al that included 12 studies with over 1,200 patients.[8] The meta-analysis found that the harmonic scalpel reduced operative time by an average of 11 minutes compared to electrocautery. These results emphasize the point that harmonic scalpel is a faster method for dissection of gallbladder and separation from gallbladder bed in laparoscopic cholecystectomy.

Post operative pain and post operative length of stay

According to this study, the harmonic scalpel was associated with lower post operative pain in patients operated for laparoscopic cholecystectomy. The pain was assessed by visual analog scale (VAS) on post operative day 1. This scale analyses pain according to patient response and is hence sensitive and simple to use. The pain experienced post operatively was graded from “no pain” to “worst unimaginable pain” which was then converted to a numeric score from 0 to 10. The average VAS score in the study group using harmonic scalpel on post operative day 1 was 3.264 while that for the electrocautery group was 4.321 which was found to be statistically significant. The lower post operative pain translated to early discharge and a lower length of stay in the harmonic scalpel group. The average duration of post operative stay was 2.38 days in the harmonic scalpel group and 3.58 days in electrocautery group which was found to be statistically significant.

These results align with the randomized control trial conducted by Tsimoyiannis et al that demonstrated lower post-operative pain scores at 24 and 48 hours in patients treated with the harmonic scalpel compared to those treated with electrocautery.[9] Bessa et al also found significant reduction in pain scores with the harmonic scalpel, with patients requiring less post-operative analgesia and having shorter hospital stays.[10]

Complication rates and post operative drain duration

According to this study, the harmonic scalpel was associated with lower complication rates with gallbladder perforation seen in 2 out of 50 cases operated for laparoscopic cholecystectomy while the electrocautery group had a gallbladder perforation in 5 out of 50 cases. Neither of the groups were associated with severe complications like common bile duct injury and bowel perforation. This is owing to the minimal lateral thermal damage with minimum transfer of energy to surrounding structures while using a harmonic scalpel. The rapid vibration of the blade allows it to cut through tissue by breaking molecular bonds within the tissue. The motion of the blade generates frictional heat which helps to cut through tissue but not so hot as to cause extensive thermal damage like the electrocautery. At the same time the tissue is cut, the ultrasonic vibrations cause protein denaturation and coagulation, effectively sealing blood vessels up to 5 mm in diameter. This reduces bleeding in surgery. The duration of post operative drain is directly proportional to the intra operative complications.

Hence in the harmonic scalpel group, the average duration of drain post operatively was 2.324 days while in the electrocautery group it was 2.681 days which was statistically significant. In both groups the nature of drain content was found to be haemo-serous. Similar outcomes were obtained by Francesca et al which reviewed over 1,500 laparoscopic cholecystectomies and found that the harmonic scalpel group had a lower incidence of bile duct injuries and other complications compared to the electrocautery group.[11] Also, Jayne et al conducted a prospective study and reported a lower rate of bile leaks and post-operative infections in patients who underwent surgery with the harmonic scalpel.[12]

CONCLUSION

This study provides a comprehensive comparison between the most commonly used energy sources for laparoscopic cholecystectomy, focusing on operating time, length of stay, duration of drain, drainage volume, postoperative

pain and overall complications. The harmonic scalpel demonstrated improved patient outcomes for operating time, length of stay, duration of drain, drainage volume, postoperative pain and overall complications compared to electrocautery. It is the better option with regards to patient safety and post operative recovery which helps in efficient management and reduces burden on hospital management. Advanced energy sources, such as the harmonic scalpel, though expensive, may provide the advantage of shorter operating time by reducing smoke, bloodless dissection in the GB bed, lower risk of bleeding from the cystic artery due to secure vessel sealing and avoiding the use of a larger number of titanium clips. However, further evidence is needed to substantiate these findings.

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Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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