A Comparative Study of Ultrasonic Dissection versus Suture Ligation for Mesoappendix in Laparoscopic Appendectomy

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Abstract
Background: Laparoscopic appendectomy (LA) is widely favored for its minimally invasive approach. However, effective techniques for mesoappendix dissection are critical to prevent complications such as excessive bleeding or the need for open surgery conversion. This study evaluates and compares ultrasonic dissection and suture ligation regarding operative time, intraoperative bleeding, and post-operative complications.
Methods: A prospective study was conducted at Meenakshi Medical College Hospital and Research Institute, Kanchipuram, between January and July 2024. A total of 90 patients diagnosed with acute appendicitis were randomly allocated to either the ultrasonic dissection group (n=44) or the suture ligation group (n=45). Primary outcomes, including operative time, intraoperative bleeding, and post-operative complications, were assessed and analyzed using SPSS version 23.0.
Results: The mean operative time was significantly shorter in the ultrasonic dissection group (63.57 ± 9.90 minutes) compared to the suture ligation group (84.79 ± 11.24 minutes; $p<0.001$). No significant differences were observed between the groups in terms of intraoperative bleeding. Similarly, post-operative complications were minimal in both groups and did not show statistical significance.
Conclusion: Ultrasonic dissection is a more time-efficient technique for mesoappendix dissection during laparoscopic appendectomy compared to suture ligation. Both methods demonstrated comparable safety profiles with no significant differences in post-operative outcomes.
Keywords: Laparoscopic Appendectomy, Ultrasonic Dissection, Suture Ligation

Introduction:

Laparoscopic appendectomy (LA), first introduced by Kurt Semm in 1983, has evolved into a widely accepted technique for the removal of the appendix, particularly because of its numerous advantages over open appendectomy. The key benefits of LA include minimal incisions, which translate into reduced postoperative pain, better cosmetic outcomes, and faster recovery. Additionally, the enhanced visualization of the peritoneal cavity during laparoscopic surgery allows for safer exploration and the identification of potential complications, such as bowel injuries or abscesses, which might not be as easily

detected with an open approach. LA also promotes better wound healing and allows patients to return to normal activities much sooner compared to the traditional open technique. (1)

One of the most critical steps in laparoscopic appendectomy is the dissection of the mesoappendix. The mesoappendix contains the blood vessels that supply the appendix, and any damage or excessive bleeding at this stage can result in severe complications, including the need for conversion to open surgery. Such complications often arise if the instruments fail or if the dissection is not performed with precision. Therefore, a safe and effective method of mesoappendix dissection is essential to minimize risks during the procedure. (2)

Over the years, several techniques for mesoappendix dissection have been introduced, each with its own set of advantages and challenges. These techniques include the use of endostaplers, LigaSure (Covidien, Boulder, CO), endoclip (EC), Harmonic scalpel (HS), LigaSure (Covidien, Mansfield, MA), and monopolar electrocautery (ME). Each technique relies on different mechanisms to cut and seal the tissue, and their effectiveness varies based on factors such as tissue thickness, vascularity, and the surgeon's experience with the equipment. (2,3)

The Harmonic scalpel, for example, uses ultrasound technology to produce high-frequency mechanical vibrations within the range of 20,000Hz to 60,000Hz. These vibrations allow the instrument to simultaneously cut and coagulate tissue, sealing blood vessels as it cuts through the mesoappendix. The primary advantage of the Harmonic scalpel is its ability to denature proteins, which helps to seal vessels at lower temperatures than traditional electrosurgical techniques. This reduces the risk of thermal injury to surrounding tissues, making it a safer option for mesoappendix dissection. The Harmonic scalpel’s ability to control bleeding while providing precise dissection has made it a popular choice in laparoscopic surgeries. (4)

On the other hand, suture ligation remains a more traditional method of mesoappendix dissection, though it is often viewed as more time-consuming. This technique involves using laparoscopic scissors to carefully cut through the mesoappendix and then suturing the vessels to prevent bleeding. While suture ligation can be effective, it requires a high level of skill and precision, and the learning curve can be steep for less experienced surgeons. The additional time required to complete the suturing process can lead to longer operative times and may increase the overall risk of complications during surgery. (3)

Given the complexity and variability of these two techniques, this study aims to compare ultrasonic dissection with suture ligation for mesoappendix dissection in laparoscopic appendectomy. Specifically, we will evaluate the operative time required for each technique, the amount of intraoperative bleeding, and the incidence of postoperative complications such as wound infections, abscess formation, and the need for reoperation. By systematically comparing these techniques, we hope to provide further insight into which method may offer the best outcomes in terms of safety, efficiency, and patient recovery.

Ultimately, the goal is to identify the technique that minimizes the risks associated with mesoappendix dissection, ensures better surgical outcomes, and enhances the overall patient experience during laparoscopic appendectomy. By providing comparative data, this study aims to assist surgeons in making informed decisions when selecting a dissection method based on their specific surgical environment and patient needs.

Materials & Methods:

This prospective, randomized controlled trial was conducted at the Department of Surgery, Meenakshi Medical College Hospital and Research Institute between January and July 2024. A total of 90 patients participated in the study. Group B included 45 patients who underwent suture ligation for mesoappendix dissection. The total operative time, peroperative bleeding, and postoperative complications were measured for both groups and analyzed.

Surgical Procedure: All patients received preoperative analgesics and intravenous antibiotics (Piperacillin and Tazobactam). Surgeries were performed by a single surgeon, using identical laparoscopic techniques in both groups. Preoperative assessments for surgical fitness were completed a day before the procedure. In the operating theatre, patients were placed in the supine position with a slight Trendelenburg tilt. A Foley's catheter was inserted for bladder decompression to improve visualization. A 10 mm trocar was placed at the umbilicus, with two additional 5 mm ports inserted at the suprapubic region (2 cm above the pubic symphysis) and the left lower quadrant (3 cm superior and medial to the anterior superior iliac spine). The ultrasonic dissector (for Group A) or extracorporeally prepared knots (for Group B) were introduced through the left lower quadrant port. The appendix stump was closed using the endoloop method in both groups. The appendix was transected and retrieved using a grasper in both groups. Postoperative samples of the appendix were sent for histopathological analysis, excluding any pathologies other than acute appendicitis before final data analysis.

Patients presenting with acute appendicitis, confirmed by an Alvarado score greater than 5 and positive ultrasound findings, and within the age range of 15-45 years, were included in the study. Those deemed unfit for laparoscopic surgery or with conditions involving other intra-abdominal procedures were excluded. After obtaining written informed consent, patients were randomly assigned to two groups using computer-generated random numbers. Group A, consisting of 44 patients, underwent mesoappendix dissection with an ultrasonic dissector, while Group B underwent suture ligation.

Data Analysis: Statistical analysis was conducted using SPSS 26.0. Categorical variables were expressed as frequencies and percentages, while continuous variables were presented as mean ± standard deviation (SD). Comparisons between the two groups were made using the unpaired t-test, while categorical variables were analyzed using the Chi-square test. A p-value of less than 0.05 was considered statistically significant.

Operative Time and Preoperative Bleeding: Operative time was defined as the duration taken to separate the mesoappendix. This time was measured from the introduction of the ultrasonic dissector or suture through the port to the complete separation of the

mesoappendix. Preoperative bleeding was qualitatively assessed by the principal investigator as either present or absent, based on visual assessment. Blood loss occurring specifically during the dissection of the mesoappendix was considered in this evaluation.

Results:

Demographic Data: The average age in Group A was 29.4 ± 8.9 years (IQR: 22–37), while in Group B, it was 33.7 ± 13.5 years (IQR: 21–44.2). The p-value of 0.079 indicated no significant difference in age between the two groups. In terms of gender distribution, Group A had 37.7% females and 62.3% males, whereas Group B had 33.3% females and 66.7% males, with a p-value of 0.872, showing that the gender distribution was similar across both groups. (Table 1).

		Ultrasonic Dissection	**Suture Ligation**	**p-value**
Age		29.386±8.9 (22-37)	33.695±13 (21-44.2)	0.07
Gender	Female	17(37.7%)	15(33.3%)	0.87
	Male	28(62.3%)	30(66.7%)	

Table 1: Showing distribution of age and gender

Therefore, the mean age in the Ultrasonic Dissection group was 29.4 ± 8.9 years (IQR: 22–37), and in the Suture Ligation group, it was 33.7 ± 13.5 years (IQR: 21–44.2). The p-value of 0.079 suggests no significant age difference between the two groups. Regarding gender, the Ultrasonic Dissection group consisted of 37.7% females and 62.3% males, while the Suture Ligation group had 33.3% females and 66.7% males (p = 0.872), indicating similar gender distribution in both groups.

Operative Time: The average operative time in Group A was 63.6 ± 9.9 minutes (IQR: 56.5–77.5 minutes), while in Group B, it was 84.8 ± 11.2 minutes (IQR: 77.0–96.0 minutes). The operative time was significantly longer in Group B with a p-value of <0.001. (Table 2).

Table 2: Comparison of operative time

In the Ultrasonic Dissection group, the mean operative time was 63.6 ± 9.9 minutes (IQR: 56.5–77.5 minutes), while in the Suture Ligation group, it was 84.8 ± 11.2 minutes (IQR: 77.0–96.0 minutes). The operative time in the Suture Ligation group was significantly higher, with a p-value of <0.001.
Per-Operative Bleeding: Preoperative bleeding occurred in 0.9% of patients in Group A and 17.8% of patients in Group B. The p-value for this comparison was 0.135, indicating no statistically significant difference in bleeding between the two groups. (Table 3)

Table 3: Comparison of pre operative bleeding

		Ultrasonic Dissection	Suture Ligation	p value
Preoperative bleeding	No	41(91.1%)	37(82.2%)	0.123
	Yes	4(0. 9%)	8(17.8%)	

In the Ultrasonic Dissection group, 91.1% of patients did not experience preoperative bleeding, while 82.2% of patients in the Suture Ligation group had no preoperative bleeding. Preoperative bleeding occurred in 0.9% of Group A and 17.8% of Group B, with a p-value of 0.135, showing no significant difference between the two groups.
The average Alvarado score in Group A was 7.13 ± 1.53 (IQR: 6.0–8.0), while in Group B, it was 7.21 ± 1.35 (IQR: 7.0–8.0). (Table 4)

Table 4: Comparison of Alvarado score

	Ultrasonic Dissection	Suture Ligation	p value
Operative time	63.568±9.89 (56.5-77.5)	84.788±11.23 (77.0-96.0)	P<0.001
	Ultrasonic Dissection	Suture Ligation	p value
Alvarado score	7.133±1.53 (6.0-8.0)	7.213±1.352 (7.0-8.0)	0.954

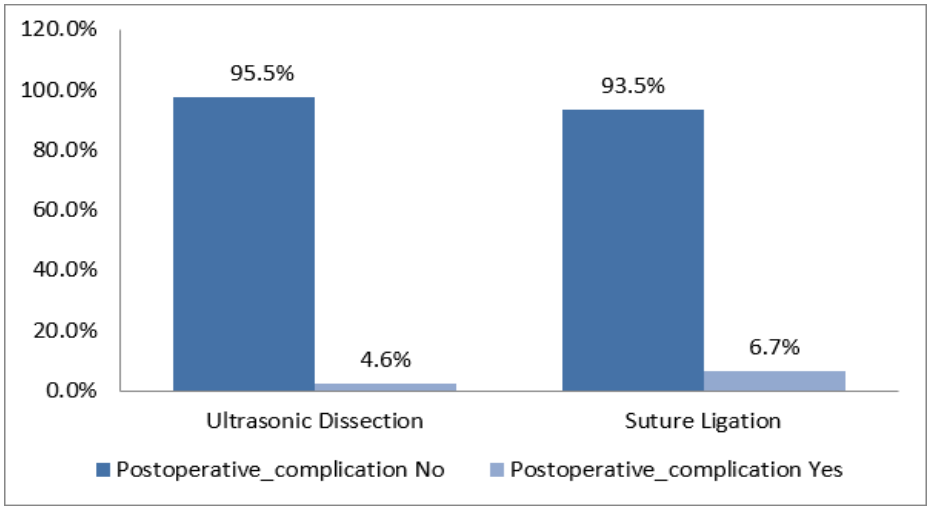
The Alvarado score for the Ultrasonic Dissection group was 7.13 ± 1.53 (IQR: 6.0–8.0), and for the Suture Ligation group, it was 7.21 ± 1.35 (IQR: 7.0–8.0). The p-value >0.05 suggests there was no significant difference in the Alvarado scores between the two groups.

Postoperative Complications: In the Suture Ligation group, complications included slippage of the ligature (n = 1, 2.3%) and mechanical bowel obstruction (n = 2, 4.4%). In the Ultrasonic Dissection group, 2 cases experienced mechanical bowel obstruction (4.4%). However, this difference in postoperative complications between the two groups was not statistically significant, as the Chi-square test yielded a value of 0.846 and a p-value of 0.359. (Fig-3 bar graph representation of complications)

Follow-up was conducted for 3 months postoperatively.

Table 5

Figure 1: Representation of post OP complications



Postoperative Complication	Group		Chi square	p value
	Ultrasonic Dissection	Suture Ligation		
No	43	42	0.846	0.359
	95.5%	93.3%		
Yes	2	3		
	4.6%	6.7%		

The Chi-square test comparing postoperative complications between the

Ultrasonic Dissection and Suture Ligation groups revealed no significant difference (Chi-square = 0.846, p = 0.359). In the Ultrasonic Dissection group, 4.4% of patients experienced complications, with mechanical bowel obstruction occurring in 4.4%. In the Suture Ligation group, 6.7% experienced complications, including 4.4% with mechanical bowel obstruction and 1.1% with ligature slippage. A total of 95.6% of patients in the Ultrasonic Dissection group and 93.3% in the Suture Ligation group had no complications.

Table 6: Cross tabulation for complication

	No complication	**Caecal perforation**	**Mechanical Bowel obstruction**	**Slipp age of ligature**	**Total**
Ultrasonic Dissection	43	0	2	0	45
	95.6%	0.0%	4.4%	0.0%	100.0%
Suture Ligation	42	0	2	1	45
	93.3%	0%	4.4%	2.3%	100.0%
Total	86	0	2	1	90
	95.6%	0%	2.2%	1.1%	100.0%

Discussion

The ultrasonic dissector (HS) operates with high-frequency vibrations (55,000 Hz), enabling precise tissue cutting with minimal surgical smoke. It can effectively coagulate and cut vessels up to 7 mm in diameter while producing negligible collateral damage[5,6] Unlike traditional electrosurgical tools, the HS does not use electrical currents within the patient's body, reducing the risk of electrical injuries.[7]

HS has become an integral tool in both conventional and laparoscopic surgeries, such as mastectomies, thyroidectomies, and hemorrhoidectomies. Its use is linked to reduced intraoperative blood loss, postoperative pain, and shorter operative times. Previous studies have explored various techniques for dissecting the mesoappendix and managing the appendicular stump in laparoscopic appendectomy (LA).[8,9,10]

For instance, a 2018 study comparing titanium clips and monopolar diathermy revealed that titanium clips led to longer surgical times due to the need for multiple applications to

achieve hemostasis. This method was also associated with higher risks of intraoperative and postoperative bleeding, rendering it less cost-effective.[11]

In Croatia, a study evaluating the harmonic scalpel (Ultracision™), bipolar coagulation (LigaSure™), and thermal fusion technology (MiSeal™) in pediatric LA showed that the HS and MiSeal caused significantly less lateral thermal damage to the mesoappendix compared to LigaSure. LigaSure was also deemed the least cost-effective option among the three.[12]

Gupta et al. utilized the harmonic scalpel for securing the base of the appendix during LA, demonstrating that this "sutureless" approach eliminated the need for instrument changes, reduced the risk of foreign body contamination (common with titanium clips, staples, or sutures), minimized operative time, and provided comparable recovery outcomes to conventional methods.[13]

Yuvaz et al. evaluated stump pressure in appendectomies and found no differences between the harmonic scalpel, LigaSure, and conventional silk suturing, reinforcing the safety of the HS for such procedures.[14]

In our study, the use of the ultrasonic dissector resulted in significantly shorter operative times compared to suture ligation. Similar findings were reported by Qaiser et al., who also highlighted reduced intraoperative bleeding with HS. However, in our analysis, no significant difference was observed in terms of per-operative bleeding between the two techniques.[15]

Another investigation demonstrated that the harmonic scalpel reduced operating time compared to loop knots, with no marked difference in complication rates. In our study, postoperative complications were less frequent in the HS group than in the suture ligation group, although the difference was not statistically significant.

Further research with extended follow-up periods is essential to address gaps in knowledge related to late complications, postoperative recovery, conversion rates, and cost-effectiveness.

Conclusion

The ultrasonic dissector proves to be a safer and more efficient alternative to conventional sutures for mesoappendix management during laparoscopic appendectomy. Although no significant difference in per-operative bleeding was observed between the techniques, the HS offers clear advantages in operative efficiency. Further studies with longer follow-ups are recommended to better understand its long-term outcomes and economic impact.

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