Evaluation of Intra-corporeal Ligation of the Mesoappendix during Laparoscopic Appendectomy versus the Use of Energy Devices: A Comparative Study

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Background: Studies showed that using Harmonic scalpel for devascularization of the mesoappendix in laparoscopic appendicectomy (LA) is quick and safe. However, in order to reduce the cost of the procedure, endo-clips or monopolar electrocautery are considered cheaper alternatives. The aim of our study was to evaluate the use of intra-corporeal ligation as an alternative safe and cost-effective way to devascularize the mesoappendix.

Methods: The study included 180 patients who were randomly divided into three equal groups: Group 1 (Intra-corporeal ligation of mesoappendix combined with monopolar diathermy), group 2 (Division of mesoappendix by Harmonic scalpel), and group 3 (division of mesoappendix by monopolar diathermy). All groups were compared regarding operative time, rate of conversion to open, intra-operative bleeding, postoperative pain, length of hospital stay (LOS), postoperative complications and the cost of consumables used.

Results: There was a statistical significant intra-operative bleeding in groups 2 and 3 compared to group 1. The cost of consumables used in group 1 were significantly cheaper compared to using Harmonic scalpel . There was no significant difference regarding the rest of the parameters.

Conclusion: Intra-corporeal ligation of the mesoappendix is safe and cost-effective when compared to the use of Harmonic scalpel or monopolar diathermy alone.

Key words: Laparoscopic appendicectomy, monopolar diathermy, Harmonic scalpel, mesoappendix.

Background

In the past, open approach of appendectomy was the gold standard for the treatment of acute appendicitis with low morbidity and mortality.[1] Laparoscopic appendectomy (LA) is now a well recognized and widely accepted method for the treatment of acute appendicitis because it has a lot of advantages when it is compared to the traditional open technique. As it has less postoperative pain, shorter hospital stay, faster recovery, less incidence of wound infections,[2,3] and facilitates better exposure of the abdominal cavity for the diagnosis of other pathologies that mimic the clinical picture of acute appendicitis.[4]

Adequate closure of the appendicular stump and proper ligation of the mesoappendix greatly affect the prevention of serious postoperative complications such as faecal fistula, peritonitis and bleeding.[5]

There are different instruments used for ligation of the mesoappendix, such as endoscopic gastrointestinal (GI) stapler, clips, monopolar diathermy, advanced vessel sealing devices like Harmonic scalpel and Ligasure,[6] however, the use of the latter ones is more expensive.[7-9] Monopolar diathermy is commonly used because it is almost available in every operating room, however, the disadvantage of its use is mainly the high lateral thermal spread and production of smoke,[10] unlike the energy devices, such as the Harmonic scalpel and Ligasure, they have significantly less lateral thermal spread and smoke production as they work through high- frequency mechanical energy for cutting and coagulating vessels at the same time.[11]

Studies comparing the use of the monopolar diathermy to the use of Harmonic scalpel in devascularization of the mesoappendix show that using the Harmonic is a quicker and safe method to do the procedure.[12,13] However, in order to reduce the cost of laparoscopic appendicectomy, simple ligature techniques, endo-clips or monopolar electrocautery are considered as cheaper alternatives.[14]

The aim of our study was to evaluate the use of intra-corporeal ligation as an alternative quick, safe and cost-effective way to devascularize the mesoappendix during LA and comparing it to the use of the Harmonic scalpel and monopolar diathermy alone.

Patients and methods

This is a prospective randomized comparative study that was done during the period between April 2017 and December 2020 in Helwan University Hospitals and Dar El-Shifa Hospital, Cairo, Egypt. The study included 180 consecutive patients who underwent

LA for acute appendicitis during the given period of time. The study was approved by the ethical committee and all the procedures were done by the same surgeons in both hospitals. Informed consent was obtained from all patients included in the study, and those who were less than 18 years, their parents signed the consent form. Patients who had appendicular mass, perforated appendix at the base or those who refused to sign the consent form were all excluded from the study.

Full history was taken from all patients and the Alvarado appendicitis scoring system was calculated.[15] **(Table 1).** A score of 7 raised the suspicion of acute appendicitis, however, a decision of appendicectomy was taken based on the clinical judgment.

Pelvi-abdominal ultra-sound was done to females in the childbearing period to rule out any gynaecological cause of their symptoms. Urine analysis was done for patients with associated urinary symptoms to rule out urinary tract infection. In patients older than 50 years old, computed tomography (CT) abdomen and pelvis was done to exclude other pathologies.

In addition to the clinical judgment, CT or ultrasound scans were considered as modalities to confirm the diagnosis for those who had them.

195 were initially eligible to be included in the study, however, 15 of them did not fit the inclusion criteria and were excluded **(Figure 1).**

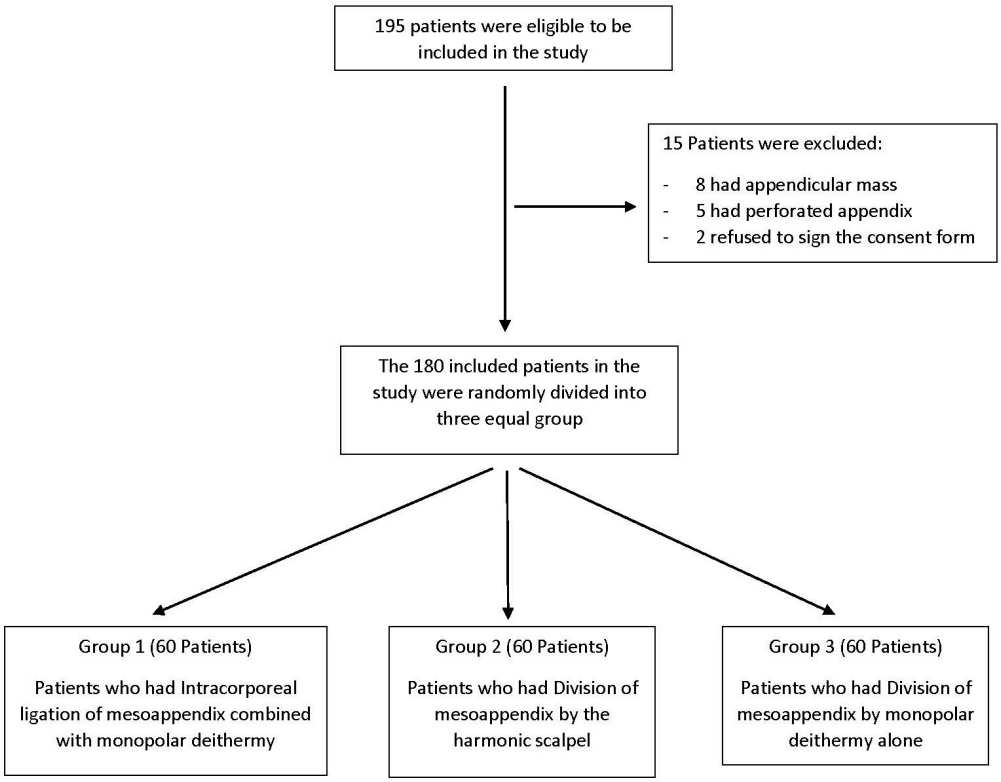

Fig 1: Consort diagram for patients included in the study.

Computer-generated randomization was done for the 180 patients included in the study and patients were randomly divided into three equal groups: group 1 (patients who had intra- corporeal ligation of mesoappendix combined with monopolar diathermy), group 2 (those who had division of mesoappendix by Harmonic scalpel), and group 3 (those who had division of the mesoappendix by monopolar diathermy alone). Randomization was done after induction of anesthesia and was stratified with a minimization procedure to ensure balance between the three allocated groups. Patients were blinded to the group they were allocated to and each group included 60 patients.

All groups were compared regarding operative time, rate of conversion to open approach, the incidence of intra-operative bleeding, postoperative pain using the visual analogue scale (VAS),[(16)] length of hospital stay and postoperative complications.

The operative time was calculated in minutes from the time of starting devascularization of the mesoappendix until the base of the appendix was reached. Intra-operative bleeding was identified visually during devascularization of the mesoappendix and the blood loss was estimated by the amount of blood in the gauzes used for mopping the bleeding.

Surgical technique

All patients underwent the procedure under general anaesthesia in supine Trendelenburg position with the left arm tucked beside the patient. The surgeon and the assistant were both standing on the patients' left side. All the patients received preoperative IV antibiotics at the induction of anaesthesia in the form of third generation Cephalosporines and Metronidazole.

Local anaesthetic was injected prior to the introduction of the ports. A 10-mm supra-umbilical camera port was first introduced using the open Hasson technique, this was followed by the introduction of a supra-pubic 5-mm port and another left iliac fossa 10-mm port under vision **(Figure 2)**.

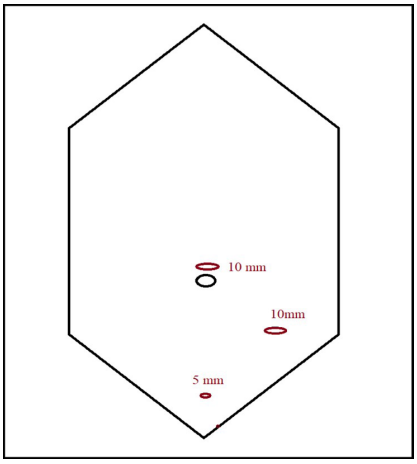

Fig 2: Port sites for laparoscopic appendicectomy.

The procedure was started by full laparoscopy of the four quadrants of the abdomen to confirm the diagnosis. The appendix was then localized by following the conjugation of the three tinea coli at the base of the appendix at the postero-medial part of the cecum.

In group 1, a window was created in the mesoappendix for intra-corporeal ligation by absorbable suture (Vicryl 2/0). This was followed by the division of the mesoappendix by monopolar diathermy **(Figures 3-5)**. In group 2, we used ultrasonic shears (Harmonic Scalpel, Ethicon Endo-Surgery Inc., Cincinnati, OH, USA) for the division of the mesoappendix **(Figure 6)**. In group 3, monopolar diathermy was used alone for mesoappendix division **(Figure 7)**. The base of the appendix in all groups was ligated using an endo-loop and finally, the appendix was removed within endo-bag through the left 10 mm port.

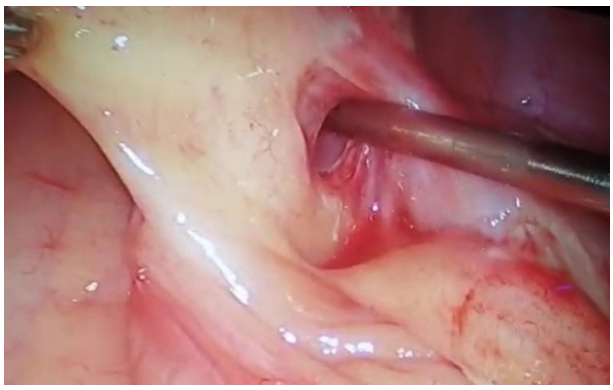

Fig 3: Creating a window in the mesoappendix.

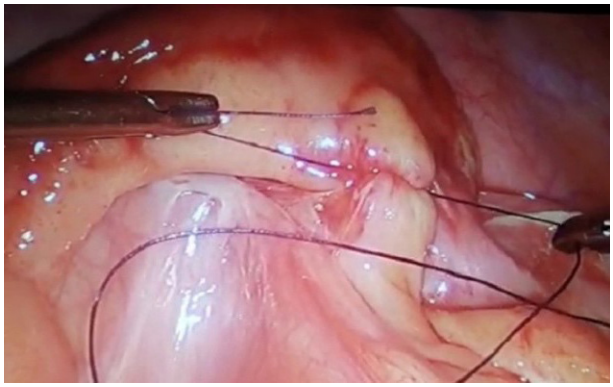

Fig 4: Intra-corporeal ligation of the mesoappendix.

Fig 5: Division of mesoappendix by monopolar diathermy.

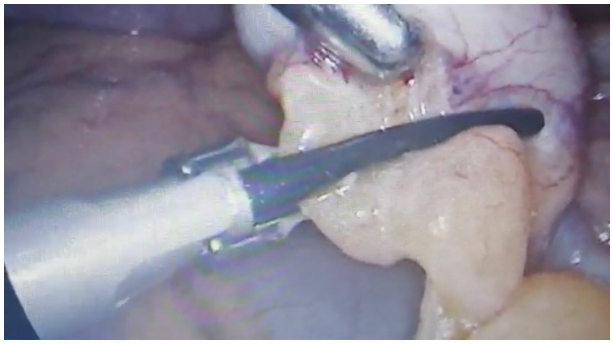

Fig 6: Ligation of mesoappendix by harmonic scalpel.

Fig 7: Ligation of the mesoappendix by monopolar diathermy.

After removal of the appendix, intra-abdominal irrigation with saline was done and intra- abdominal drain was placed in cases with perforated acute appendicitis and/or the presence of frank purulent peritonitis.

The umbilical fascia was closed with 0 Prolene suture and then all the wounds were closed with subcuticular absorbable suture (Monocryl 3/0) and sterile dressings were applied.

All specimens were sent for pathology for assessing the pathological diagnosis.

The financial costs of using intra-corporeal ligation along with the monopolar diathermy versus the use of Harmonic scalpel or monopolar diathermy alone were calculated.

Postoperative and follow up

All patients followed the ERAS (Enhanced Recovery After Surgery) protocol. Regular analgesics were prescribed and more analgesics were offered when required. Postoperative pain was evaluated using the VAS every four hours except during sleep and whenever patients complained of pain. VAS was graded from 0 to 10 by the attending nurse who was unaware of the study. In patients who had an intra-abdominal drain, it was removed when draining less than 50 ml/ 24 hours.

Patients were followed up on the 5th postoperative day at the outpatient clinic (OPC) and then after 14 days.

The primary outcome was to assess the outcome of using intra-corporeal ligation of the mesoappendix along with the monopolar diathermy compared to using the Harmonic scalpel or the monopolar diathermy alone.

The secondary outcome was to assess the cost of using the three different methods in devascularization of the mesoappendix.

Statistical analysis

Data were collected, revised, coded and entered into 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 with inter-quartile range (IQR) when nonparametric. Also, qualitative variables were presented as numbers and percentages. The comparison between groups regarding qualitative data was done by using the Chi-square test; the comparison between groups regarding quantitative data with parametric distribution was done by using the One Way Analysis of Variance (ANOVA) test and with nonparametric data was done by using the Kruskall-Wallis test. The confidence interval was set to 95% and the margin of error accepted was set to 5%. The p-value was considered significant at the level of < 0.05.

Results

The demographic data of the studied groups and the pathological types of the appendectomy specimens are shown in **(Table 2).** There was no statistically significant difference between the three groups regarding the operative time, rate of conversion to open approach and length of hospital stay, however, there was a statistical significance for minor intra-operative bleeding for the groups who had devascularization of the mesoappendix using the monopolar diathermy alone and those in which the Harmonic scalpel was used, compared to the intra-corporeal ligation of mesoappendix combined with using monopolar diathermy **(Table 3).** This minor bleeding was controlled by endo-clips in group III and by the Harmonic scalpel in group II.

All cases that were converted to open were related to having marked adhesions around the appendix and it was unsafe to continue the procedure laparoscopically.

According to the financial department of the hospital, the costs of consumables used during devascularization of the mesoappendix in cases of laparoscopic appendicectomy are shown in **(Table 4).**

There were no reported cases of postoperative bleeding in the three groups.

The mean postoperative pain score and the mean number of analgesic doses after surgery are shown in **(Table 5).**

CT scan was required postoperatively in two patients in the study (one from group 1, and the other from group 3) who developed persistent abdominal pain

and fever after the operation. Both patients were managed conservatively with antibiotics **(Table 5).**

During the follow-up visits, port-site wound infection was identified mainly at the port site from which the appendix was taken out with incidence of 1.7%, 3.3 % and 3.3 % in groups 1, 2 and 3, respectively (P> 0.05) **(Table 6).** All patients with wound infections were managed conservatively with daily dressing of the wounds.

Table 1: Alvarado appendicitis scoring system[15]

	Score
Symptoms	
Pain migrating to the right iliac fossa (RIF)	1
Anorexia	1
Nausea/Vomiting	1
Signs	
RIF tenderness	2
Rebound tenderness	1
Fever	1
Investigations	
Raised white blood cells (WBCs)	2
Shift of WBCs to the left	1
Total score	10

Table 2: Demographic data and pathology of appendicitis

	Group I Intra-corporeal ligation + Monopolar	Group II Harmonic Scalpel	Group III Monopolar only	Test value	P-value
	No. = 60	No. = 60	No. = 60		
Age (years)					
Mean ± SD	26.68 ± 9.33	30.07 ± 10.66	29.35 ± 9.74	1.943•	0.146
Range	10 – 53	15 – 55	13 - 54		
Sex					
Number of females (%)	29 (48.3%)	34 (56.7%)	39 (65.0%)	3.394*	0.183
Number of males (%)	31 (51.7%)	26 (43.3%)	21 (35.0%)		
Pathology of appendicitis					
Catarrhal	16 (26.7%)	21 (35.0%)	24 (40.0%)		
Suppurtive	30 (50.0%)	33 (55.0%)	23 (38.3%)	6.898*	0.141
Gangrenous	14 (23.3%)	6 (10.0%)	13 (21.7%)		

P-value > 0.05: Non significant. P-value < 0.05: Significant. P-value < 0.01: Highly significant.

*: Chi-square test. •: One Way ANOVA test.

Table 3: Operative data and length of hospital stay

	Group I Intra-corporeal ligation + Monopolar	Group II Harmonic Scalpel	Group III Monopolar only	Test value	P-value
	No. = 60	No. = 60	No. = 60		
Operative time (min)					
Mean ± SD	48.70 ± 15.73	45.77 ± 17.34	52.23 ± 18.32	2.131•	0.122
Range	30 – 100	25 – 100	25 - 90		
Number of cases converted to open (%)	1 (1.7%)	4 (6.7%)	6 (10%)	3.679*	0.158
Number of cases with intra-operative bleeding (%)	0 (0.0%)	3 (5%)	7 (11.6 %)	5.526	0.063
Blood loss (ml)	1.2± 0.50	3.00±2.35	3.20±2.45	18.548	0.000
Length of hospital stay (days)					
Median (IQR)	1 (1 – 1)	1 (1 – 2)	1 (1 – 2)	1.218≠	0.135
Range	1 – 7	1 – 5	1 – 6		

P-value > 0.05: Non significant. P-value < 0.05: Significant. P-value < 0.01: Highly significant.
*: Chi-square test. •: One Way ANOVA test. ≠: Kruskall-Wallis test.

Table 4: Cost of consumables used during devascularization of the mesoappendix in cases of laparoscopic appendicectomy

	Monopolar diathermy cable	Monopolar diathermy cable and 2/0 Vicryl ties for intra-corporeal ligation	Laparoscopic Harmonic hand piece	P value
Cost per case	Equivalent to $66.9	Equivalent to $70.8	Equivalent to $645	<0.001

Table 5: Postoperative pain score and analgesic doses

	Group I Intra-corporeal ligation + Monopolar	Group II Harmonic Scalpel	Group III Monopolar only	Test value	P-value
	No. = 60	No. = 60	No. = 60		
Pain score					
Median (IQR)	4 (4 – 6)	5 (4 – 6)	4 (4 – 6)	-0.865≠	0.615
Range	3 – 7	4 – 7	3 – 7		
The mean number of analgesic doses after surgery					
Mean ± SD	3.1 ± 0.45	2.9 ± 0.47	3.0 ± 0.48	2.753•	0.066
Range	2 – 4	2 – 4	2 - 4		

P-value > 0.05: Non significant. P-value < 0.05: Significant. P-value < 0.01: Highly significant.
IQR: Inter-quartile range. ≠: Kruskall-Wallis test; •: One Way ANOVA test.

Table 6: Postoperative complications

	Group I Intra-corporeal ligation + Monopolar	Group II Harmonic Scalpel	Group III Monopolar only	Test value	P-value
	No. = 60	No. = 60			
Postoperative bleeding	0 (0.0%)	0 (0.0%)	0 (0.0%)	–	–
Abdomino-pelvic minimal collection	1 (1.7%)	0 (0.0%)	1 (1.7%)	1.011*	0.603
Port-site and wound infection	1 (1.7%)	2 (3.3%)	2 (3.3%)	0.411*	0.814
Post operative ileus	0 (0.0%)	1 (1.7%)	2 (3.3%)	2.034*	0.362

P-value > 0.05: Non significant. P-value < 0.05: Significant. P-value < 0.01: Highly significant.

*: Chi-square test.

Discussion

Different studies in the literature discussed devascularization of the mesoappendix using monopolar diathermy and other costly equipment like endo-stapler, Ligasure and Harmonic scalpel,[17,18] however, devascularization of the mesoappendix using intra-corporeal sutures have not been discussed before.

In our study on 180 patients, we found that 11.6% had intra-operative bleeding in group III and 5% in group II, whereas, no bleeding was identified in the group in which the intra-corporeal ligation was used in combination of monopolar diathermy **(Table 3).** The amounts of blood loss while using the Harmonic or the monopolar diathermy alone in our study were similar to those reported in a study done by Khalid et al.[19] This minor bleeding was controlled by endo-clips in group III and by the Harmonic scalpel in group II.

Studies comparing the use of the monopolar diathermy to the use of the Harmonic scalpel in devascularization of the mesoappendix show that using the Harmonic is a quicker and safe method to perform the procedure.[12,13] However, in a study done by Khalid et al on 60 patients, they reported no significant difference in using monopolar diathermy and the Harmonic Scalpel in devascularization of the mesoappendix.[19]

In a study done by Aydogan et al, they compared the mean operative time between using monopolar diathermy, endoclips and the Harmonic scalpel. They reported no statistical difference in the mean operative time between using endo-clips and the monopolar diathermy, whereas, the mean operative time was significantly less using the Harmonic scalpel.[20] In our study, although the mean operative time was slightly shorter in the group in which the Harmonic scalpel was used, however, there was no statistical difference compared to the two other groups. This could be related to the more experience gained over time in laparoscopic appendicectomy and intra-corporeal ligature by the operating surgeons.

In our study, the length of hospital stay and complication rates were not significant in all of the three groups which are similar to the results reported by Lee JS et al.[13]

Although it might seem that doing intra-corporeal ligatures might be time-consuming, we can ligate a big chunk of tissues securely in a single ligature followed by safe division of the mesoappendix using the monopolar diathermy with almost no risk of bleeding. Therefore, with experienced hands, it will not take long and will provide a further safety technique compared to using the monopolar diathermy alone.

By comparing the cost of the different methods used in devascularization of the mesopappendix in our study, it is obvious that the use of intra-corporeal ligation of the mesoappendix combined with monopolar diathermy is cheaper and would save a lot of money without affecting the patients' risk of bleeding compared to the use of Harmonic scalpel which was also reported in other studies to be of high cost.[7-9] Although using intra-corporeal ligation adds a little bit more to the expenses of just using the monopolar diathermy alone, our results show that it is better in avoiding bleeding during the devascularization process.

Given the safety and the cost-effectiveness of using the intra-corporeal sutures in addition to the monopolar diathermy proven in our study, this technique could be considered by other surgeons in their practice, especially if bleeding is expected while using monopolar diathermy alone.

Conclusion

Intra-corporeal ligation of the mesoappendix is safe and cost-effective with almost the same

mean operative time when compared to the use of Harmonic scalpel or monopolar diathermy alone when used by skilful surgeons.

Funding

None.

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