

## Clip Application Versus Harmonic Scalpel in Sealing and Division of the Appendicular Stump during Laparoscopic Appendectomy in Children

IBRAHIM A.I. BEDIWY, M.Sc.; ANAS H.A. MASHAL, M.D. and MOHAMED EL AZAZY, M.D.

The Department of General Surgery Department, Faculty of Medicine, Ain Shams University

### Abstract

**Background:** Sutureless (clipless) appendectomy using endoscopic devices like the harmonic scalpel has emerged as a promising alternative for appendicular base closure in adults. However, there is a lack of sufficient studies in the pediatric population.

**Aim of Study:** This study aimed to assess the efficacy and complications of using the ultrasonic-activated device (harmonic) scalpel compared to titanium clip application for sealing and division of the appendicular stump during laparoscopic appendectomy in pediatric patients.

**Patients and Methods:** A prospective comparative study was conducted at Ain Shams University Hospitals and Mattaria teaching hospital on 40 pediatric patients diagnosed with acute appendicitis. The patients were randomly divided into two groups: Group 1 (n=20) underwent laparoscopic appendectomy with titanium clip application, and Group 2 (n=20) underwent laparoscopic appendectomy with harmonic scalpel usage.

**Results:** The demographic characteristics, clinical symptoms, pediatric appendicitis risk scores, and laboratory data showed no statistically significant differences between the two groups. However, the duration of surgery was significantly shorter in Group 2 (harmonic scalpel) than in Group 1 (titanium clip application). Postoperative pain scores were significantly lower in Group 2, and time to start oral fluids showed no significant difference between the groups. The occurrence of complications did not significantly differ between the two groups.

**Conclusion:** Both harmonic scalpel and clip application are effective methods for securing the appendicular stump during laparoscopic appendectomy in pediatric patients. Harmonic scalpel usage is advantageous due to its ease of use and time-saving benefits during surgery. However, the higher financial cost of the harmonic device remains a limitation. Laparoscopic appendectomy, overall, offers several advantages over open appendectomy in terms of reduced wound infection inci-

dence, shorter hospital stay, less need for post-operative analgesia, and faster patient recovery. Further extensive studies are recommended to evaluate the cost-benefit of harmonic scalpel application on the appendicular stump in pediatric patients.

**Key Words:** Sutureless appendectomy — Harmonic scalpel — Pediatric laparoscopic appendectomy — Appendicular stump closure — Complications.

### Introduction

**ABDOMINAL** pain is one of the most common symptoms of patients seeking medical attention. Acute appendicitis is the most common cause of acute abdominal pain, and distinguishing appendicitis from other disorders is sometimes difficult, particularly in young, preverbal children [1].

Diagnosis is found upon well recognized signs, symptoms as well as physician's practice. The signs and symptoms most prognostic of acute appendicitis is pain in right lower quadrant (RLQ) or pain around umbilicus and then transferring to RLQ presenting along with fever, nausea and vomiting. On abdominal examination there will be rigidity, tenderness and rebound tenderness in the right iliac fossa [2].

The reported incidence of acute appendicitis has increased over the last few decades potentially due to the increased use of computerized tomography (CT) imaging, with the rate of complicated appendicitis representing 25% of all cases [3].

Several diseases such as mesenteric lymphadenitis, pelvic inflammatory disease, ovarian cysts, cholecystitis and colonic perforation may mimic acute appendicitis, so proper imaging is mandatory in diagnosis of acute appendicitis [4].

Appendectomy is the most common surgical procedure performed in general surgery. For almost a century, open appendectomy, first described by

**Correspondence to:** Dr. Ibrahim A.I. Bediwy,  
[E-Mail: dr.bediwy@gmail.com](mailto:dr.bediwy@gmail.com)

Charles McBurney in 1889, has remained the gold standard treatment for acute appendicitis [5].

The introduction of Lap. Surgery has dramatically changed the field of surgery and Lap. Surgery has been widely used as a minimally invasive surgery. Lap. Appendectomy has emerged as a safe procedure with potential advantages including diagnostic and therapeutic values [6].

The acceptance of Lap. Appendectomy among surgeons is increasing. Lap. Appendectomy has been shown to be advantageous compared to open appendectomy in regard to early postoperative parameters such as postoperative pain and recovery of the bowel functions, and is also associated with a lower wound infection rate [7].

Criticism of Lap. Appendectomy includes higher cost compared to open appendectomy, due to expensive disposable equipment used during the procedure. The closure of the appendicular stump is an important step during Lap. Appendectomy, as most of the postoperative complications are caused by its inappropriate management [8].

The development of life-threatening events such as stercoral fistulas, postoperative peritonitis and sepsis are included among these complications [9].

Among the alternatives, studies advocate the use of an endo stapler, endo loop, infra corporeal suturing, extracorporeal sliding knot, titanium clips, polymeric clips and bipolar endo coagulation.

All these alternatives have advantages and disadvantages for the different clinical stages of acute appendicitis, but endo loops and endo staplers are used nowadays most frequently. In this study, the harmonic scalpel and titanium clips application would be used to secure the appendicular stump in Lap. Appendectomy [10].

In this study, outcomes between two laparoscopic techniques used for appendicular stump sealing have been compared harmonic scalpel and titanium clips application. Harmonic scalpel and clips application are two promising techniques to secure the appendicular stump in Lap. Appendectomy [11].

#### *Aim of the work:*

To assess the usage of ultrasonic-activated device (harmonic) scalpel versus titanium clip application in sealing and division of the appendicular stump during laparoscopic appendectomy in pediatric patients.

To compare the efficacy and complications of harmonic scalpel versus titanium clip application in sealing and division of the appendicular stump during laparoscopic appendectomy in pediatric patients.

## **Patients and Methods**

A prospective comparative study in Ain Shams University Hospitals and Mattaria Teaching hospital from December 2022 to May 2023 on patients who are admitted with suspected acute appendicitis to the Emergency Department of Ain Shams University Hospital and Mattaria Teaching Hospital.

*Inclusion criteria:* Patients presented with symptoms and signs of acute appendicitis and patients below 12 years old.

*Exclusion criteria:* Patients with congenital pulmonary or cardiac diseases (contra indicated for Lap. Surgery), appendicular mass which was diagnosed either by ultrasound, CT with IV contrast or be examination under anesthesia were excluded of the study and previous abdominal surgery.

*Ethical considerations:* The protocol and written consent were approved by the local ethical committee of Ain Shams University Department of general surgery for approval, all data will be only used for scientific purpose and will be only viewed by data collector and supervisors only and medical photography consent.

*Study design:* 40 patients diagnosed as acute appendicitis would be included and divided into two groups randomly (Block randomization).

- Group 1: Containing 20 patients using titanium clip application in sealing the appendicular stump during Lap. Appendectomy.
- Group 2: Containing 20 patients using harmonic scalpel (as a method of appendicular stump sealing).

A comparative analysis would be done for both techniques giving attention to time of surgery, the postoperative leakage, the post-operative pain, hospital stay, and post-operative surgical site infection.

*All patients were subjected to:* History taking, clinical examination, laboratory investigations, urine analysis in suspected cases of urinary tract infection and radiological investigation: Ultrasound (pelviabdominal US).

Ultrasonography was routinely done for all patients to help in confirmation of the clinical diagnosis and also helps in the diagnosis of complications like mass which was considered exclusion criteria; CT with intravenous contrast was requested in case of suspicion of complications that were not diagnosed definitely by ultrasound.

Prior to the surgical incisions, all the patients received a standard regimen of intravenous antibiotics (third generation cephalosporin and metronidazole the dosages were calculated according to the body weight of each child).

**Surgical techniques:** All surgeries were performed in supine position, combined with the Trendelenburg position and left lateral position. A CO<sub>2</sub> pneumoperitoneum was established using a Veress needle, through the supraumbilical incision. Depending on patients' body weight and age, the level of pneumoperitoneum was 10-12mmHg. After establishment of pneumoperitoneum, first, a 10-mm trocar was introduced through supraumbilical incision. A 10-mm laparoscope (Olympus, Tokyo, Japan) was used for inspection of the abdominal cavity. Second, a 5-mm trocar was placed under the right costal arch, and third, a 10-mm trocar was placed in the left lower abdomen at the level of an-

terior superior iliac spine. After identification of an appendix and dissection of peritoneal adhesions, the mesoappendix was secured using titanium clip and monopolar hook in group I. A harmonic scalpel (Lotus™, BOWA-electronic GmbH, Gomaringen, Germany) was used in group II.

In group I, titanium clips (Ligating Clips XL, Grena, Brentford, UK) were used for securing the appendiceal base and the appendix was dissected distally to the clip. In group II, harmonic scalpel was used to seal the appendiceal base. Repeated application of harmonic scalpel in a stepwise manner at output power 3 was performed to obliterate the lumen of the appendix (Gupta's technique).

v

Fig. (1): A harmonic scalpel.



Fig. (2): Titanium clips.

The procedure was deemed complete when a ring of constriction appeared at the site of harmonic scalpel application. The appendix was resected distal to the constriction ring. Each specimen was retrieved inside a disposable specimen retrieval bag (Ecosac EMP 70, Espiner Medical Ltd.) through a 10-mm trocar. After the procedure was done, the abdominal cavity was rinsed with normal saline solution and the appendiceal base was checked once again for detection of possible leakage from the stump.

All cases were given third generation cephalosporin and metronidazole just before the start of

the procedure. Patients were given sips of water after passing flatus, faeces or after hearing intestinal sounds to avoid paralytic ileus from early introduction of food or liquids. Postoperatively, all patients received analgesics in the form of paracetamol and NSAID.

**Follow-up:** After discharge from hospital, the patients were followed-up at seventh postoperative day at our outpatient service for removal of the stitches and detection of early complications and 1 month after the surgery for detection of any possible late complications.

**Complications:**

Patients were screened for surgical complications such as: Trocar site hematoma, wound infection, or fever lasting <72h or major bleeding any source of bleeding after surgical procedure, intra-abdominal abscess localized collection of the puss after appendectomy, diffuse peritonitis any intra-abdominal infection extending beyond the transverse mesocolon and postoperative ileus defined as the impairment of gastrointestinal motility after appendectomy, characterized by bowel distention, lack of bowel sounds, accumulation of gas and fluid, and delayed passage of flatus and stool.

**Statistical analysis:** The data collected was tabulated and analyzed by SPSS (statistical package for social science) version 25 (Armonk, NY: IBM Corp) on IBM compatible computer.

Two types of statistics were done:

**Descriptive statistics:** According to the type of data, qualitative data was represented as number

and percentage, quantitative data was represented by mean ± SD.

**Analytic statistics:**

**Student t-test:** Was used for comparison between two groups having quantitative variables with normal distribution (for parametric data).

**Mann-Whitney U Test:** Is a test of significance used for comparison between two groups having quantitative variables without normal distribution (for non-parametric data).

**Chi-square test (x<sup>2</sup>):** was used to study comparison and association between two qualitative variables.

A p-value of <0.05 was considered statistically significant & <0.001 for high significant result for two tailed tests.

**Results**

Table (1): Comparison between group (1) and group (2) as regards demographic Data.

|                     | Group (1)<br>(n = 20) |    | Group (2)<br>(n = 20) |    | Test of sig.          | p-value | Significance    |
|---------------------|-----------------------|----|-----------------------|----|-----------------------|---------|-----------------|
|                     | No.                   | %  | No.                   | %  |                       |         |                 |
| <b>Gender:</b>      |                       |    |                       |    |                       |         |                 |
| Male                | 15                    | 75 | 14                    | 70 | x <sup>2</sup> C1.125 | 0.723   | Non-significant |
| Female              | 5                     | 25 | 6                     | 30 |                       |         |                 |
| <b>Age (years):</b> |                       |    |                       |    |                       |         |                 |
| (Min. — Max.)       | (7-12)                |    | (8-12)                |    | H:I.520               | 0.606   | Non-significant |
| Mean ± SD.          | 1025±1.62             |    | 10.00±1.41            |    |                       |         |                 |
| <b>Weight (Kg):</b> |                       |    |                       |    |                       |         |                 |
| (Min. — Max.)       | (20-39)               |    | (24-40)               |    | H:I.036               | 0.972   | Non-significant |
| Mean ± SD.          | 29.40±4.65            |    | 29.35±4.16            |    |                       |         |                 |
| <b>Height (cm):</b> |                       |    |                       |    |                       |         |                 |
| (Min. — Max.)       | (115-160)             |    | (123-160)             |    | t=-0.604              | 0.549   | Non-significant |
| Mean ± SD.          | 137.00±12.99          |    | 139.45±12.65          |    |                       |         |                 |

(V): Chi-square Test. t: Student t-test. P: p-value for comparing between the studied groups.

Table (2): Comparison between group (1) and group (2) as regards duration of symptoms (h), and body temperature (°C) of patients

|                                  | Group (1)<br>(n = 20) |           | Group (2)<br>(n = 20) |           | U   | p-value | Significance    |
|----------------------------------|-----------------------|-----------|-----------------------|-----------|-----|---------|-----------------|
|                                  | Min — Max             | Mean ± SD | Min — Max             | Mean ± SD |     |         |                 |
| <b>Duration of symptoms (h):</b> |                       |           |                       |           |     |         |                 |
| Min — Max                        | 15.00-48.00           |           | 16.00-46.00           |           | 180 | 0.587   | Non-significant |
| Mean ± SD                        | 30.30±8.69            |           | 31.30±7.69            |           |     |         |                 |
| <b>Body temperature (r):</b>     |                       |           |                       |           |     |         |                 |
| Min — Max                        | 37.00-39.00           |           | 37.00-39.00           |           | 171 | 0.431   | Non-significant |
| Mean ± SD                        | 37.98±0.62            |           | 38.12±0.65            |           |     |         |                 |

U: Mann-Whitney U Test. p: p-value for comparing between the studied groups.

Table (3): Comparison between group (1) and group (2) as regards clinical data of patients.

|                            | Groups                |       |                       |       |       |       | X <sup>2</sup> | p-value | Significance    |
|----------------------------|-----------------------|-------|-----------------------|-------|-------|-------|----------------|---------|-----------------|
|                            | Group (1)<br>(n = 20) |       | Group (2)<br>(n = 20) |       | Total |       |                |         |                 |
|                            | No.                   | %     | No.                   | %     | No.   | %     |                |         |                 |
| <i>Vomiting:</i>           |                       |       |                       |       |       |       |                |         |                 |
| No                         | 9                     | 45.0  | 7                     | 35.0  | 16    | 40.0  | 0.417          | 0.519   | Non-significant |
| Yes                        | 11                    | 55.0  | 13                    | 65.0  | 24    | 60.0  |                |         |                 |
| <i>Pain in RLQ:</i>        |                       |       |                       |       |       |       |                |         |                 |
| No                         | 0                     | 0.0   | 0                     | 0.0   | 0     | 0.0   | 0.00           | 1.00    | Non-significant |
| Yes                        | 20                    | 100.0 | 20                    | 100.0 | 40    | 100.0 |                |         |                 |
| <i>Rebound tenderness:</i> |                       |       |                       |       |       |       |                |         |                 |
| No                         | 1                     | 5.0   | 2                     | 10.0  | 3     | 7.5   | 0.360          | 0.548   | Non-significant |
| Yes                        | 19                    | 95.0  | 18                    | 90.0  | 37    | 92.5  |                |         |                 |

(x2): Chi-square Test. p: p-value for comparing between the studied groups. \*: p-value <0.05 is significant.

Table (4): Comparison between group (1) and group (2) as regards pediatric appendicitis risk scores, and AIR score of patients.

|   | Group (1)<br>(n = 20) | Group (2)<br>(n = 20) | U   | p-value | Significance    |
|---|-----------------------|-----------------------|-----|---------|-----------------|
| <i>Pediatric appendicitis risk score:</i> |                       |                       |     |         |                 |
| Min—Max                                   | 3-9                   | 3-9                   | 199 | 0.978   | Non-significant |
| Mean ± SD                                 | 6.8±1.6               | 6.6±1.9               |     |         |                 |
| <i>AIR score:</i>                         |                       |                       |     |         |                 |
| Min—Max                                   | 6.00-9.00             | 6.00-9.00             | 193 | 0.841   | Non-significant |
| Mean ± SD                                 | 7.90±0.97             | 7.85±0.93             |     |         |                 |

U: Mann-Whitney U Test. p: p-value for comparing between the studied groups.

Table (5): Comparison between group (1) and group (2) as regards lab data of patients.

|                                       | Group (1)<br>(n = 20) | Group (2)<br>(n = 20) | U     | p-value | Significance    |
|---------------------------------------|-----------------------|-----------------------|-------|---------|-----------------|
| <i>Leukocytes (10<sup>9</sup>/L):</i> |                       |                       |       |         |                 |
| Min—Max                               | 13.00-18.00           | 11.00-17.00           | 138.5 | 0.096   | Non-significant |
| Mean ± SD                             | 15.05±1.54            | 14.10±1.83            |       |         |                 |
| <i>C-reactive protein (mg/L):</i>     |                       |                       |       |         |                 |
| Min—Max                               | 18.00-30.00           | 18.00-30.00           | 174   | 0.470   | Non-significant |
| Mean ± SD                             | 25.00±3.36            | 24.40±3.39            |       |         |                 |
| <i>Neutrophil granulocytes (%):</i>   |                       |                       |       |         |                 |
| Min—Max                               | 0.71-0.93             | 0.70-0.88             | 154.5 | 0.221   | Non-significant |
| Mean ± SD                             | 0.83±0.08             | 0.79±0.06             |       |         |                 |

U: Mann-Whitney U Test. p: p-value for comparing between the studied groups.

Table (6): Comparison between group (1) and group (2) as regards duration of surgery (min).

|                                   | Group (1)<br>(n = 20) | Group (2)<br>(n = 20) | U   | p-value | Significance |
|-----------------------------------|-----------------------|-----------------------|-----|---------|--------------|
| <i>Duration of surgery (min):</i> |                       |                       |     |         |              |
| Min—Max                           | 25.00-55.00           | 18.00-35.00           | 111 | 0.016   | Significant  |
| Mean ± SD                         | 35.25±8.41            | 28.70±5.42            |     |         |              |

U: Mann-Whitney U Test. p: p-value for comparing between the studied groups.

Table (7): Comparison between group (1) and group (2) as regards hospital stay (days).

|                              | Group (1)<br>(n = 20) | Group (2)<br>(n = 20) | U   | p-value | Significance    |
|------------------------------|-----------------------|-----------------------|-----|---------|-----------------|
| <i>Hospital stay (days):</i> |                       |                       |     |         |                 |
| Min— Max                     | 1.00-2.00             | 1.00-2.00             | 180 | 0.513   | Non-significant |
| Mean ± SD                    | 1.70±0.47             | 1.60±0.50             |     |         |                 |

U: Mann-Whitney U Test. *p*: p-value for comparing between the studied groups.

Table (8): Comparison between group (1) and group (2) as regards postoperative pain score.

|                                  | Group (1)<br>(n = 20) | Group (2)<br>(n = 20) | U  | p-value | Significance |
|----------------------------------|-----------------------|-----------------------|----|---------|--------------|
| <i>Postoperative pain score:</i> |                       |                       |    |         |              |
| Min— Max                         | 1.00-7.00             | 1.00-6.00             | 96 | 0.004   | Significant  |
| Mean ± SD                        | 3.85±1.66             | 2.35±1.53             |    |         |              |

U: Mann-Whitney U Test. *p*: p-value for comparing between the studied groups.

Table (9): Comparison between group (1) and group (2) as regards Time to start oral fluids (Hrs.).

|  | Group (1)<br>(n = 20) | Group (2)<br>(n = 20) | U     | p-value | Significance    |
|--|-----------------------|-----------------------|-------|---------|-----------------|
| <i>Time to start oral fluids (Hrs.):</i> |                       |                       |       |         |                 |
| Min— Max                                 | 4.00-24.00            | 4.00-16.00            | 117.5 | 0.531   | Non-significant |
| Mean ± SD                                | 9.45±4.68             | 8.40±4.1              |       |         |                 |

U: Mann-Whitney U Test. *p*: p-value for comparing between the studied groups.

Table (10): Comparison between group (1) and group (2) as regards fever postoperative data of patients.

| Fever    | Groups                |      |                       |      | Total |      | X <sup>2</sup> | p-value | Significance    |
|----------|-----------------------|------|-----------------------|------|-------|------|----------------|---------|-----------------|
|          | Group (1)<br>(n = 20) |      | Group (2)<br>(n = 20) |      | No.   | %    |                |         |                 |
|          | No.                   | %    | No.                   | %    |       |      |                |         |                 |
| >72 h    | 2                     | 10.0 | 2                     | 10.0 | 4     | 10.0 | 0.800          | 0.670   | Non-significant |
| 0-72 h   | 4                     | 20.0 | 2                     | 10.0 | 6     | 15.0 |                |         |                 |
| No fever | 14                    | 70.0 | 16                    | 80.0 | 30    | 75.0 |                |         |                 |

(V): Chi-square Test. *p*: p-value for comparing between the studied groups. \*: p-value <0.05 is significant.

Table (11): Comparison between group (1) and group (2) as regards the complications.

| Complications           | Groups                |       |                       |       | Total |       | X <sup>2</sup> | p-value | Significance    |
|-------------------------|-----------------------|-------|-----------------------|-------|-------|-------|----------------|---------|-----------------|
|                         | Group (1)<br>(n = 20) |       | Group (2)<br>(n = 20) |       | No.   | %     |                |         |                 |
|                         | No.                   | %     | No.                   | %     |       |       |                |         |                 |
| None                    | 16                    | 80.0  | 18                    | 90.0  | 34    | 85    | 0.784          | 0.676   | Non-significant |
| Intra-abdominal abscess | 2                     | 10.0  | 1                     | 5.0   | 3     | 7.5   |                |         |                 |
| Postoperative ileus     | 2                     | 10.0  | 1                     | 5.0   | 3     | 7.5   |                |         |                 |
| Total                   | 20                    | 100.0 | 20                    | 100.0 | 40    | 100.0 |                |         |                 |

(V): Chi-square Test. *p*: p-value for comparing between the studied groups.

## Discussion

Acute appendicitis is one of the most commonly encountered surgical emergencies worldwide. The peak incidence is seen in the second and third decades of life. The lifetime risk of acute appendicitis is 6.7% in females and 8.6% in men. The laparoscopic approach has replaced open appendectomy for managing acute appendicitis in current surgical practice. The advantages of laparoscopic appendectomy (LA) are early recovery, fewer wound complications, less pain and better cosmesis [2].

One of the most critical steps in LA is a secure appendicular stump closure. There can be life-threatening postoperative complications following suboptimal closure of the appendicular stump. Hence, the proper closure of the appendicular stump is essential for a successful LA. There are several methods to achieve this objective such as intra-corporeal knotting, endoloops, external corporeal knotting and pushing knot inside, endoscopic linear cutting stapler (endo GIA), and endoclips. A recent meta-analysis on the method of appendicular stump closure in LA failed to demonstrate the superiority of one technique over the other [12].

The use of endoloops and polymer clips for stump closure is common due to the ease of availability and affordable pricing while the use of Endo GIA is limited due to the high cost and the need for an additional 12mm port for introducing the Endo GIA device. The foreign materials used for securing the appendicular stump can induce intense inflammation inside the abdominal cavity leading to the development of adhesive intestinal obstruction [13].

In the past few years, many authors have evaluated sutureless appendectomy using devices like a harmonic scalpel (HS) and bipolar coagulation and Liga Sure. The advantage of this technique is the elimination of foreign material-related postoperative complications. The HS is an ultrasonic energy-powered instrument used in both open and laparoscopic procedures for tissue cutting and coagulation. It is a versatile instrument that performs dissection, cutting and sealing with a single-hand instrument. Its use is associated with limited thermal spread, lesser tissue charring and minimal smoke formation compared to traditional electrosurgical instruments [14].

Several reports demonstrate that HS can be a safe and handy instrument for sealing and resecting luminal structures such as the appendix and cystic duct. The base of the appendix is reported to be effectively sealed with an energy device like bipolar or ultrasonic coagulator set at lower power and in a staggered manner [in

Before its introduction to clinical application, the safety and efficacy of this technique were demonstrated in rats by Asian et al. [16] who reported that coagulation of the appendix stump with a bipolar

energy device did not allow any leakage of intraluminal contents. An ex vivo study by Yavuz et al. [17] evaluated the appendix stump opening pressure in the right colectomy and subtotal colectomy specimens. Following appendectomy, the stump closure was performed with either silk ligature or energy devices like Liga Sure and HS. They concluded that performing appendectomies using LigaSure and HS can be as effective as the conventional methods. Amidst the promising results of various studies favouring HS for sutureless appendectomy, Gozeneli et al. [18] reported incomplete appendix stump closure with ultrasonic instruments in their ex vivo study of 20 patients.

The aim of the study was to assess the usage of ultrasonic-activated device (harmonic) scalpel versus titanium clip application in sealing and division of the appendicular stump during laparoscopic appendectomy in pediatric patients and to compare the efficacy and complications of harmonic scalpel versus titanium clip application in sealing and division of the appendicular stump during laparoscopic appendectomy in pediatric patients.

This was a prospective comparative study that was conducted at Ain Shams University Hospitals and Mattaria teaching hospital on patients who are admitted with symptoms and signs of acute appendicitis to the emergency department of Ain Shams University hospital and Mattaria Teaching hospital. 40 patients diagnosed as acute appendicitis were divided into two groups randomly. Group 1: Containing 20 patients using titanium clip application in sealing the appendicular stump during Lap. Appendectomy. Group 2: Containing 20 patients using harmonic scalpel (as a method of appendicular stump sealing).

In this study, the gender was distributed in group 1 15 (75%) males, 5 (25%) females and in group 2 14 (70%) males, 6 (30%) females. The age in group 1 ranged from 7 to 12 years and the mean  $\pm$  SD was  $10.25 \pm 1.62$  years, while in group 2 the age ranged from 8 to 12 years and the mean  $\pm$  SD was  $10.00 \pm 1.41$  years with no statistically significant difference ( $p > 0.05$ ).

This also agreed with Elsayed et al. [11] who aimed to assess the feasibility of using the ultrasonic-activated device (harmonic) scalpel in sealing and division of the appendicular stump during laparoscopic appendectomy. They reported that, there was no significant difference between the first group and the second group with respect to difference in either age or gender.

Also, Gupta et al. [19] who aimed to assess the efficacy of HS in laparoscopic appendectomy for sealing the base of the appendix. Group 1 in which base was secured by endoloop and group 2 in which base of the appendix was sealed by HS in a stepwise manner. Both groups were age and gender matched.

The current study showed that, duration of surgery (min) in group 1 ranged from 25 to 55 minutes and the mean  $\pm$  SD was  $35.25 \pm 8.41$  minutes, while in group 2 ranged from 18 to 35 minutes and the mean  $\pm$  SD was  $28.70 \pm 5.42$  minutes. There was statistically significant decrease as regards duration of surgery in group 2 than group 1 ( $p < 0.05$ ).

This agrees with systematic review and meta-analysis done by Borkar et al. [20] who aimed to summarize the current evidence regarding the utility and safety of a harmonic scalpel in sutureless appendectomy. They reported that, the pooled analysis of the outcome measure of mean operative time has demonstrated statistically significant reduced operative time in the group where HS has been used for managing the appendiceal stump as compared to conventional techniques (pooled mean difference of  $-12.96$  with 95% CI  $-15.42, -10.50$ ).

According to Bajpai [14] who aimed to present our experience by harmonic scalpel enabled, single external port appendectomy using extracorporeally inserted 'pick and fix' stitch in three cases. They reported that the mean operating time of less than 30min in our cases is an improvement over single-incision laparoscopic surgery (SILS) procedure in other series as well as Cochrane review [21-23].

There is a large case series of 63 patients by Raza et al. [24] where appendiceal stump closure was performed with HS. The mean operative time for laparoscopic appendectomy was 31.4 minutes.

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 [25,26].

In a study done by Aydogan et al. [27] 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 when using the Harmonic scalpel.

Moreover, a study by Qaiser et al. [21] has shown that HS was better than suture ligation for managing the mesoappendix in laparoscopic appendectomy in terms of mean operative time. Its main advantages include precise dissection, reliable hemostasis, less lateral thermal spread and charring.

According to Elgohary et al. [28] who aimed 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. They reported that although the mean operative time was slightly short-

er 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 appendectomy and intra-corporeal ligation by the operating surgeons.

A study by Qaiser et al. [21] has shown that HS was better than suture ligation for managing the mesoappendix in LA in terms of control of intraoperative bleeding.

According to Pogorelie et al. [29] who aimed to investigate Harmonic scalpel performance in laparoscopic appendectomy for sealing the base of the appendix in children. They reported significantly shorter operative times were recorded in the clipless group as well, probably due to less and easier manipulation with an appendix.

Khanna et al. [30] reported the median duration of surgery was 25min with a median of hospital stay of 3 days.

Gupta et al. [10] performed the largest available comparative study with 210 patients with median age of 30 years. They compared the outcomes of treatment between the patients who received laparoscopic appendectomy using endoscopic loop ( $n = 102$ ) and the patients who received harmonic scalpel appendectomy in a stepwise manner ( $n = 108$ ). Operative time in their study was significantly lower in the harmonic scalpel group (28.5min) than in the group where endo-loop (43.3min) was used.

The use of HS for stump closure has the advantage over the other methods of appendiceal stump sealing. The division of the mesoappendix, as well as the appendix stump sealing and division, can be performed with a single shear of HS. So, HS obviates the need for a change of the hand instruments like needle holder, knot pusher, endoclips, and GL& stapler for stump closure. These factors contribute to the reduction in the mean operative time. The shear of HS can be introduced through a standard 5mm port in contrast to the need for a 10-12mm port for endo GL& application. It also avoids foreign body reactions and reduces the risk of postoperative adhesion formation [10].

In our study, there was no statistically significant difference in hospital stay between group 1 and group 2 ( $p > 0.05$ ).

This is in harmony with Borkar et al. [20] who showed that there is no significant difference between both the groups for hospital stay.

This also agreed with Elsayed et al. [11] who reported that, the length of hospital stay in their study was the same, and there was no significant difference between the two groups.

Elgohary et al. [28] reported that, the length of hospital stay was not significant in all of the three groups Group 1 (Intracorporeal ligation of mesoappendix combined with monopolar diathermy), group 2 (Division of mesoappendix by Harmonic scalpel), and group 3 (division of mesoappendix by monopolar diathermy) which are similar to the results reported by Lee and Hong (2014) [26].

However, a significantly shorter hospital stay has been reported by Pogorelic et al. (2022) [29].

In this study, fever lasted more than 72h in 2 (10.0%) in group 1, and 2 (10.0%) in group 2, while it lasted less than 72h in 4 (20%) in group 1 vs 2 (10%) in group 2, with no statistically significant difference between the two groups. All of patients resolved in response to antipyretics and antibiotics.

Pogorelic et al. [29] reported that, significantly higher incidence of postoperative fever in postoperative period was found in the polymeric clip group of patients which may be related with necrosis of the appendiceal stump above the clip.

This study revealed that, 16 (80%) cases had no complications, 2 (10%) cases had Intra-abdominal abscess, 2 (10%) cases had Postoperative ileus in group 1 in comparison to no complications in 18 (90%), 1 (5%) case had Intra-abdominal abscess, 1 (5%) case had Postoperative ileus in group 2. There was no statistically significant difference between the two groups as regards complications ( $p > 0.05$ ). All patients presented with complications were managed conservatively, only one of them (a case of intra-abdominal abscess) sent for US pigtail.

Similarly, Beldi et al. [31] did not show a significant difference between the harmonic scalpel and loop knots techniques with respect to intra-abdominal abscess formation.

Moreover, Elsayed et al. [32] reported that, there was no tendency toward a higher rate of stump insufficiency and intra-abdominal abscess formation due to inefficient closure of the base of the appendix among the two groups. In fact, our data showed that harmonic scalpel and loop knots tying were both safe for stump closure.

Elgohary et al. [28] reported that, complication rates were not significant in all of the three groups which are similar to the results reported by Lee and Hong (2014) [26].

Borkar et al. [20] reported that, a pooled analysis of the outcome measure of total complications shows that using HS for closure of appendiceal stump does not result in an increased incidence of complications as compared to the conventional technology of appendiceal stump closure.

There is a large case series of 63 patients by Raza et al. [24] where appendiceal stump closure

was performed with HS. None of the patients experienced any complications in this series.

According to Pogorelic et al. [29] reported that, clipless appendectomy with harmonic scalpel may be considered a safe and effective option for securing the appendiceal base in children, with significantly lesser number of postoperative complications compared to the techniques in which foreign material has been used for securing the base of the appendix. The patients who received laparoscopic appendectomy using polymeric clip had significantly higher number of postoperative complications (abscess or ileus), especially the patients with perforated appendicitis, compared to the clipless appendectomy group where no complications were recorded.

There was no recorded mortality occurred during our study. This is consistent with the majority of previous research studies carried on the same topic. The overall reported mortality of appendectomy is very low and was estimated in a review of a large administrative database at 0.05% for LA and 0.3% for OA [32], reinforcing the fact that appendectomy in the absence of peritonitis is a safe procedure, regardless of the technique performed.

#### Conclusion:

Both methods of Harmonic scalpel and clip application are cost effective in securing the appendicular stump. Harmonic scalpel technique is easier to the surgeon, more time saving during the operation. The only limitation of the harmonic device usage in laparoscopic appendectomy is the higher financial cost.

Laparoscopic appendectomy is safe and feasible, laparoscopic approach had several advantages over open appendectomy in that, it has lesser incidence of wound infection, shorter hospital stay, less need for post-operative analgesia and faster return of patients to normal activities. Moreover, it is very useful in reaching an exact diagnosis in equivocal cases. We must convert laparoscopic procedure to open surgery when indicated for the safety of the patient. A larger further study to evaluate the cost, benefit of harmonic scalpel application on the appendicular stump is recommended.

Harmonic scalpel is as safe as titanium clips for securing the appendicular stump and mesoappendix.

#### References

- 1- ERDOOAN A. and TOUCAN A.: Comparison of Hand-made Endoloop Versus Polymeric Endoclip for Stump Closure in Laparoscopic Appendectomy. *Cureus.*, 13 (7), 2021.
- 2- JASCHINSKI T., MOSCH EIKERMANN M., NEUGEBAUER EA.M. and SAUERLAND S.: Laparoscopic versus open surgery for suspected appendicitis. *Cochrane Database of Systematic Reviews*, (11), 2018.

- 3- ATHANASIOU C., LOCKWOOD S. and MARKIDES GA.: Systematic review and meta-analysis of laparoscopic versus open appendectomy in adults with complicated appendicitis: An update of the literature. *World J. Surg.*, 41 (12): 3083-99, 2017.
- 4- DALPIAZ A., GANDHI J., SMITH N.L., DAGUR G., SCHWAMB R., WEISSBART S J., et al.: Mimicry of appendicitis symptomatology in congenital anomalies and diseases of the genitourinary system and pregnancy. *Curr. Urol.*, 9 (4): 169-78, 2015.
- 5- SHARMA N., MISHRA M., TRIPATHI A. and RAI V.: Comparative study and outcome of open versus laparoscopic appendectomy: Case series of 60 patients. *International Surgery Journal*, 4 (9): 3129-35, 2017.
- 6- BASUNBUL Li., ALHAZMI L.S.S., ALMUGHAMISI S A., ALJUAIID N.M., RIZK H. and MOSHREF R.: Recent Technical Developments in the Field of Laparoscopic Surgery: A Literature Review. *Cureus*, 14 (2), 2022.
- 7- POGORELIC Z., KATIC J., MRKLIC I., JERONCIC A., ŠIŠIĆ T., JUKIC M., et al.: Lateral thermal damage of mesoappendix and appendiceal base during laparoscopic appendectomy in children: comparison of the harmonic scalpel (Ultracision), bipolar coagulation (LigaSure), and thermal fusion technology (MiSeal). *Journal of surgical research*, 212: 101-7, 2017.
- 8- MANNU G.S., SUDUL M.K., BETTENCOURT-SILVA J.H., CUMBER E., LI F, CLARK AB., et al.: Closure methods of the appendix stump for complications during laparoscopic appendectomy. *Cochrane Database of Systematic Reviews*, (11), 2017.
- 9- FEDERICO C., PAOLA F., MASSIMO S., ENRICO C., MARIA G.S., GIOACCHINO L., et al.: Conservative treatment of acute appendicitis. *Acta Bio Medica: Atenei Parmensis*, 89 (Suppl 9): 119, 2018.
- 10- GUPTA V., SINGH S.P., SINGH SP., BANSAL M. and PANDEY A.: Sutureless appendectomy by using harmonic scalpel: is it possible? *Journal of Laparoendoscopic & Advanced Surgical Techniques*, 30 (4): 429-32, 2020.
- 11- ELSAYED AA.I., HAMDY AA. and AYOUP M.F.L.: Loop knots versus harmonic scalpel in laparoscopic appendectomy. *Egypt J. Hosp. Med.*, 72 (3): 4109-12, 2018.
- 12- MANNU G.S., SUDUL M.K., BETTENCOURT-SILVA J.H., CUMBER E., LI F, CLARK A.B. and LOKE YK.: Closure methods of the appendix stump for complications during laparoscopic appendectomy. *Cochrane Database Syst. Rev.*, 11:0, 2017.
- 13- TAMURA K., NAKAYAMA H., KONO H., KUROKI R., MAEYAMA R., YAMAMOTO H., UEKI T., OKIDO M. and ICHIMIYA H.: Atypical clinical presentation of mechanical small bowel obstruction with superior mesenteric vein occlusion caused by a retained free intraperitoneal staple after laparoscopic appendectomy: A case report. *Asian Journal of Endoscopic Surgery*, Oct. 13 (4): 556-9, 2020.
- 14- BAJPAI M.: Technique of 'suture less' appendectomy by laparoscopy in children: Preliminary communication. *Journal of Indian Association of Pediatric Surgeons*, Jan. 19 (1): 28, 2014.
- 15- AI X.M., HO L.C., YANG N.Y., HAN L.L., LU J J., YUE X.A.: Comparative study of ultrasonic scalpel (US) versus conventional metal clips for closure of the cystic duct in laparoscopic cholecystectomy (LC): A meta-analysis. *Medicine (Baltimore)*, 97: 0, 2018.
- 16- ASLAN A., KARAVELI C. and ELPEK O.: Laparoscopic appendectomy without clip or ligature. An experimental study. *Surg. Endosc.*, 22: 2084-2087, 2008.
- 17- YAVUZ A., BULUS H., TAŞ A., AYDIN A.: Evaluation of stump pressure in three types of appendectomy: Harmonic scalpel, LigaSure, and conventional technique. *J. Laparoendosc. Adv. Surg. Tech. A.*, 26: 950-953, 2016.
- 18- GOZENELI O, TATLI F., YUCEL Y., OZGONUL A. and UZUNKOY A.: Can ultrasonic surgical devices be used to close the appendicular stump. *Ann. Ital. Chir.* Jan. 1; 88 (6): 562-66, 2017.
- 19- DAHDALEH F.S., HEIDT D. and TURAGA KK.: The appendix. *Schwartz's Principles of Surgery*, Brunicaudi F., Andersen DK., Billiar TR., Dunn DL., Kao L.S., Hunter J.G., Matthews J.B., Pollock R.E. (ed): McGraw-Hill, New York, 2019.
- 20- BORKAR N., SHARMA C., MOHANTY D. and SINGHA S.K.: A Systematic Review and Meta-Analysis of Harmonic Scalpel Versus Conventional Techniques of Appendiceal Stump Closure in Laparoscopic Appendectomy. *Cureus*, Sep. 3; 14 (9): e28759, 2022.
- 21- QAISER M.U., NAZIR A., KHAN M.S., BUTT H.K. and ANWAR M.: Comparison of ultrasonic dissection and suture ligation for mesoappendix in laparoscopic appendectomy. *Cureus*, 13: 0, 2021.
- 22- KOSSI J. and LUOSTARINEN M.: Initial experience of the feasibility of single incision laparoscopic appendectomy in different clinical conditions. *Diagn. Ther. Endosc.*, 2010: 240-60, 2010.
- 23- SAUERLAND S., LEFERING R. and NEUGEBAUER E.A.: Laparoscopic versus open surgery for suspected appendicitis. *Cochrane Database Syst. Rev.*, CD001546, 2004.
- 24- RAZA V.F., ARSHAD D., BHATTI LA., TALAL A., AHMAD S. and KHAN KJ.: Laparoscopic harmonic appendectomy: A novel approach. *Glob. J. Surg.*, 8 (2): 32-6, 2020.
- 25- SUCULLU I., FILIZ Ai., KURT Y., YILMAZ I. and YILDIZ M.: The effects of LigaSure on the laparoscopic management of acute appendicitis: "LigaSure assisted laparoscopic appendectomy". *Surgical Laparoscopy Endoscopy & Percutaneous Techniques*, Aug. 1; 19 (4): 333-5, 2009.
- 26- LEE J S and HONG T.H.: Comparison of various methods of mesoappendix dissection in laparoscopic appendectomy. *J. Laparoendosc. Adv. Surg. Tech. A.*, 24 (1): 28-31, 2014.
- 27- AYDOGAN F., SARIBEYOGLU K., SIMSEK O., SALIHOGLU Z., CARKMAN S., SALIHOGLU T., KARATAS

- A., BACA B., KUCUK O., YAVUZ N. and PEKMEZCI S.: Comparison of the electrothermal vessel-sealing system versus endoclip in laparoscopic appendectomy. *Journal of Laparoendoscopic & Advanced Surgical Techniques*, Jun. 1; 19 (3): 375-8, 2009.
- 28- ELGOHARY H., MIKHAEL R. and ELABBASSY I.: Evaluation of Intra-corporeal Ligation of the Mesoappendix during Laparoscopic Appendectomy versus the Use of Energy Devices: A Comparative Study. *Ain Shams Journal of Surgery*, Jul 1; 15 (2): 117-24, 2022.
- 29- POGORELIC Z., BEARA V., JUKIC M., RASHWAN H. and 'SL.T'S'IsTJAR T.: A new approach to laparoscopic appendectomy in children clipless/sutureless Harmonic scalpel laparoscopic appendectomy. *Langenbecks Arch. Surg.*, 407 (2): 779-87, 2022.
- 30- KHANNA S., KHURANA S. and VIJ S.: No clip, no ligature laparoscopic appendectomy. *Surgical Laparoscopy Endoscopy & Percutaneous Techniques*, Aug 1; 14 (4): 201-3, 2004.
- 31- BELDI G., MUGGLI K., HELBLING C. and SCHLUMPF R.: Laparoscopic appendectomy using endoloops: A prospective, randomized clinical trial. *Surgical Endoscopy and Other Interventional Techniques*, May 18: 749-50, 2004.
- 32- GULLER U., HERVEY S., PURVES H., MUHLBAIER L.H., PETERSON ED., EUBANKS S. and PIETROBON R.: Laparoscopic versus open appendectomy: Outcomes comparison based on a large administrative database. *Annals of Surgery*, Jan. 1; 239 (1): 43-52, 2004.

## دراسة مقارنة بين تأمين قاعدة الزائدة الدودية باستخدام المشبك المعدنى واستخدام جهاز الهارمونيك لتأمين القاعدة واستئصال الزائدة الدودية خلال عملية استئصال الزائدة الدودية بالمنظار الجراحى فى الأطفال

إن استئصال الزائدة الدودية هو الإجراء الجراحى الأكثر شيوعاً، ولمدة قرن تقريباً ظل استئصال الزائدة الدودية بطريقة الجراحة التقليدية والتي وصفت لأول مرة بواسطة تشارلز ماكبرنى فى عام ١٨٨٩ هو الإجراء الجراحى الأساسى لإستئصال الزائدة الدودية. لقد أحدث إدخال المناظير تغييراً كبيراً فى مجال الجراحة والتي استخدمت منذ ذلك الحين على نطاق واسع فى إجراء الجراحات المختلفة.

إن استئصال الزائدة الدودية بالمنظار برز كإجراء آمن مع المزايا المختلفة، بما فى ذلك القيم التشخيصية والعلاجية. وقد أجريت هذه الدراسة لتقييم نتائج تأمين وقطع قاعدة الزائدة الدودية باستخدام مشرط الموجات فوق الصوتية (هارمونيك) فى مقابل وضع مشبك معدنى على قاعدة الزائدة الدودية أثناء إجراء عملية استئصال الزائدة الدودية بالمنظار بشأن وقت إجراء الجراحة ونتائجها، ومضاعفات ما بعد الجراحة، والبقاء فى المستشفى والفترة اللازمة لعودة المرضى لمزاولة نشاطهم اليومى.

تُجرى الدراسة على ٤٠ مريضاً يتم تشخيص إصابتهم بالتهاب الزائدة الدودية الحاد من بين من يتم استئصالهم فى قسم الطوارئ بمستشفيات جامعة عين شمس ومستشفى المطرية التعليمى، جميع المرضى التى تُجرى عليهم الدراسة تقل أعمارهم عن اثنى عشر عاماً، يتم تشخيصهم بالتهاب الزائدة الدودية الحاد بالاعتماد على الفحص الإكلينيكي وأشعة السونار وارتفاع كرات الدم البيضاء فى الجسم من واقع نتائج فحص صورة الدم الكاملة.

يتم تقسيم المرضى بشكل عشوائى إلى مجموعتين، عشرين مريض لكل منهما، المجموعة الأولى هى مجموعة تأمين قاعدة الزائدة الدودية باستخدام المشبك المعدنى قبل فصلها باستخدام المقص الجراحى، يتم إجراء العملية الجراحية للمرضى عن طريق استئصال الزائدة الدودية بالمنظار وتأمين قاعدة الزائدة الدودية عن طريق مشبك التيتانيوم.

المجموعة الثانية هى مجموعة مشرط الهارمونيك، ويتم إجراء العمليات الجراحية للمرضى عن طريق استئصال الزائدة الدودية بالمنظار وتأمين قاعدة الزائدة الدودية قبل فصلها باستخدام جهاز الهارمونيك ودون الحاجة لتأمين القاعدة باستخدام الوسائل التقليدية كالربط داخل الجسم أو وضع مشبك التيتانيوم.

تهدف الدراسة لإثبات إمكانية إجراء الجراحة كاملةً باستخدام جهاز الهارمونيك، حيث يقوم الجراح بقطع الإمداد الدموى للزائدة الدودية وتأمين القاعدة واستئصال الزائدة الدودية باستخدام ذات الجهاز ما يوفر الجهد والوقت اللازمين لإجراء الجراحة. تستهدف الدراسة كذلك إجراء مقارنة بين المضاعفات المحتملة ما بعد الجراحة لكلا المجموعتين محل الدراسة، والوقت اللازم للمريض لخروجه من المستشفى والعودة لممارسة حياته الطبيعية بعد الجراحة.