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# Comparative Study of Laparoscopic Appendectomies With Application of Different Techniques for Closure of the Appendicular Mesoappendix and Stump

**Mohend A.N. Al-Shalah**
*Department of Surgery, College of Medicine, Babylon university, Babylon*
Mohend_alshalah2@yahoo.com

## Abstract

**Background**: Laparoscopic appendectomy(LA) has gained a wide safe acceptance and effective method for treatment of acute appendicitis and can be considered as a gold standard. The aim of the study was to evaluate the results of LA performed with the use of different techniques.

**Method**: Prospective randomized comparative study was carried out in a Babylon General Teaching Hospital. Patients diagnosed with acute appendicitis between December 2011 and December 2015 and agreed to do LA were included in this study. In Group A , the mesoappendix and the base of appendix is ligated using titanium clips while in group B ,the mesoappendix was cut with the application of monopolar diathermy very near to the appendix wall and the base of appendix is ligated using vicryle endoloop. In. Primary outcomes were assessed which include mortality ,intra and post-operative complication rate, reinterventions, and converted laparoscopic appendectomies to open .Secondary outcomes were time of hospitalization, duration of operation, wound infection and intra-abdominal abscesses formation rate, hospital charges.

**Result**: A total of 284patients underwent LA. 146 (51.4%) of them ,LA were done by clipping of mesoappendix and base of appendix by titanium clips, while the other 138 (48.6%) of patients LA were done by using monapolar diathermy to the mesoappendix and base of appendix secured by vicryle endoloop. The overall mean age of all patients with appendectomy was (26.42±11.05) years old and (38.7%) of patients were aged between 20-30 years. (52.5%) of patients were males. The overall mean weight, height and BMI for patients with appendectomy were (74.29±12.14) kg, (1.68±0.09) m and (26.68±8.84) kg/m2, respectively. (45.4%) of patients were overweight. The overall mean duration of operation was (31.01±12.48) min and (68.7%) of patients spent less than 30 min operative time, meanwhile, the mean of hospitalization after operation was (22.11± 17.96) hours and (71.8%) of patients stayed less than 20 hours in hospital. Only (8.5%) of patients had complicated appendicitis and complication post-operation, while, (4.9%) of patients had complicated appendectomy. (45.1%) of operations' cost were 450 US $. There were significant associations between type of appendectomy with duration, complicated operation and price of operation.

**Conclusion**: Laparoscopic appendectomies can be considered a safe treatment of complicated and non complicated appendicitis. Application of monopolar diathermy very near to the wall of appendix to cauterize the small vessels of mesoappendix is useful and safe and considered costly effective and less complication rate than application of Titanium clips.

**Keywords:** Laparoscopic appendectomy**,** Titanium clips**,** Monopolar diathermy.

## الخلاصة

**الخلفية** : استئصال الزائدة الدودية بالمنظار ( LA ) اكتسبت قبولا واسعا ,آمنا ووسيلة فعالة لعلاج التهاب الزائدة الدودية الحادة ويمكن اعتبارها بمثابة معيار الذهب. الهدف من الدراسة هو تقييم طرق مختلفة لاستئصال الزائدة الدودية عن طريق الناظور البطني.

**الطريقة** :تم تنفيذ دراسة مقارنة عشوائية مستقبلية في مستشفى بابل التعليمي العام . أدرج المرضى الذين شخصوا بالتهاب الزائـــدة الدودية الحاد بين كانون الأول 2011 وكانون الأول عام 2015 والذين وافقوا على إجراء العملية بمنظار البطن في هذه الدراسة . في المجموعة الأولى فقد تم عقد مساريق الزائدة وأساسها بواسطة كلبسي التيتانيم أما المجموعة الثانية فقد تم قطع مسار يق الزائدة بواسطة الإنفاذ الحراري أحادي القطب قريبة جدا من جدار الزائدة مع عقد أساس الزائدة باستخدام انشوطة داخلية من الفكريل. تم تقييم النتائج الأساسية التي تشمل الوفيات، المضاعفات داخل و بعد العملية، إعادة التداخل، وتحويل استئصال الزائدة الدودية بالمنظار الى الفتح. أما النتائج الثانوية فكانت الوقت للاستشفاء ، مدة العملية، التهاب الجرح، الخراجات داخل البطن وتكلفة العملية.

**النتائج** : ما مجموعه 284 مريض خضع لعملية استئصال الزائدة الدودية بمنظار البطن 146 (51.4٪) منهم أجريت لهم عن طريق عقد مساريق الزائدة وأساسها بواسطة كلبسي التيتانيم ، في حين 138 (48.6 %) من المرضى الذين أجريت لهم العملية فقد تم قطع مسار يق الزائدة بواسطة الإنفاذ الحراري أحادي القطب قريبة جدا من جدار الزائدة مع عقد جذع الزائدة باستخدام انشوطة داخلية من

الفكريل . وكان متوسط أعمارهم الشامل لجميع المرضى الذين يعانون من استئصال الزائدة الدودية (11.05 ±26.42) سنة و(38.7٪ ) من المرضى تراوحت أعمارهم بين 30 - 20 سنة (52.5 ٪ ) من المرضى من الذكور .كان الوزن الإجمالي المتوسط والطول ومؤشر كتلة الجسم لمرضى استئصال الزائدة الدودية ( 74.29±12.14 ) كغم، ) (1.68± 0.09 ) م و ( 26.68±8.84 ) كجم / م 2 ، وعلى التوالي (45.4٪ ) من المرضى الذين يعانون من زيادة الوزن . وكانت مدة المتوسط العام للعملية 31.01±12.48) ( دقيقة و (68.7 ٪ ) من المرضى مدة العملية كان اقل من 30 دقيقة. وفي الوقت نفسه، كان معدل بقاء المريض في المستشفى بعد العملية (22.11±17.96) ساعة و (71.8 ٪ ) من المرضى بقي أقل من 20 ساعة في المستشفى (8.5٪ ) من المرضى كان التهاب الزائدة الدودية معقدا و (8.5 ٪) من المرضى قد تعرضوا الى المضاعفات بعد العملية، في حين أن(4.9 ٪) من المرضى كانت عملية استئصال الزائدة الدودية معقدا . وكانت (45.1 ٪) من ا المرضى تكلفة العمليات 450 دولار أمريكي.

لم يكن هناك ارتباط كبير بين آلية استئصال الزائدة الدودية وكل من العمر، الجنس، الوزن، الطول، مؤشر كتلة الجسم ومدة الرقود في المستشفى . كان هناك ارتباط كبير بين نوع استئصال الزائدة الدودية مع مدة العملية والتكلفة والمضاعفات أثناء وما بعد العملية.

**الاستنتاجات**

يمكن اعتبار استئصال الزائدة الدودية بالمنظار علاج آمن في حالات التهاب الزائدة الدودية المعقدة وغير المعقدة .تطبيق الإنفاذ الحراري أحادي القطب لقطع مسارىق الزائدة الدودية بالقرب من جدارها هو مفيد وآمن و يعتبر أقل تكلفة ونسبة مضاعفات من التيتانيم كلبس.

**الكلمات المفتاحية :**استئصال الزائدة الدودية بالمنظار، كلبسات التيتانيم، الإنفاذ الحراري أحادي القطب.

# Introduction

Nowadays laparoscopy is used frequently in emergencies surgery including acute appendicitis and not only in elective surgery [Bobrzyński, 2002; Strzałka , 2008; Strzałka , 2009]. Laparoscopic appendectomy (LA) has gained wide acceptance over the last 15 years and considered a safe and effective method for treatment of non complicated appendicitis and may be used as an alternative to standard open appendectomy.[Hellberg, A1999; Katkhouda,2005; Sauerland,2010].When comparing between laparoscopic and open appendectomy, laparoscopic appendectomy had a longer time of surgery, a shorter hospital stay, and no difference in complications and can be considered the "gold standard" [Heinzelmann,11995]. There is very little Level I evidence comparing particular techniques in doing LA however some Level II and III evidence suggests that developing a dependable method decreases costs , operative time and complications [Ng WT, 2004].

The aim of the study was to evaluate the results of LA performed with the use of titanium clipping to the mesoappendix and base of appendix in group A, in compare with monopolar diathermy to the mesoappendix and endoloop to the base of appendix in group B.

# Materials and Methods

## Study design/Study Location

This hospital-based prospective randomized comparative study was carried out in a tertiary General Teaching Hospital.

## Study population

All patients with diagnosed appendicitis in emergency room, wards and outpatients general surgery clinic in Babylon general teaching hospital between December 2011 and December 2015 and agreed to do LA were included in this study. Complicated and non complicated appendicitis were included in the study. The complicated appendicitis included intra operative diagnosis of gangrenous appendicitis, and perforated appendix.

Complicated operation include all the complication that occurred intra operatively in complicated and non complicated appendicitis.

**Exclusion Criteria**

All patients presented with appendicular mass, preoperative diagnosis of perforated appendix with generalized peritonitis, pregnant patient and previous abdominal surgery were excluded from study. LA with ovarian cystectomy, meckeles diverticulum, colonic tumours were excluded from the study. Patient with a pacemaker in situ and patients refusal for LA were also excluded from the study.

Laparoscopic appendectomy was performed using classic three port technique. The patient was lying on Supine position, the operating surgeon and assistant were standing at the left side and the laparoscopy unit with the monitor were placed at the right side of the patient. Pneumoperitoneum was created using closed technique. The first trocar, through which the laparoscope was introduced, with the diameter of 11 mm, was placed in the umbilicus. The second, 10 mm port was localized in the right upper quadrant in the midclavicular line. The third trocar with a diameter of 5mm was inserted in left lower quadrant at the Mc Burney point .

Then, the patient positioned in the Trendelenburg with a left tilt, to facilitate the exposure of the right lower quadrant. After confirming the diagnosis of acute appendicitis, In Group A, the mesoappendix and the base of appendix was ligated using titanium clips. In group B, the mesoappendix was cut with the application of monopolar diathermy very near to the appendix wall while the base of appendix is ligated using vicryle endoloop. Patients received 1 g of cefitriaxone every 8 hours intravenously from the time of diagnosis until surgery. Patients found to have a complication (gangrenous or perforated appendicitis) during surgery were treated with triple antibiotic (ampicilin, gentamycin and metronidazole) ,patients allergy to penicillin received vancomycin.

Primary outcomes were mortality, intra and post-operative complication rate, reinterventions, and converted laparoscopic appendectomies to open. Secondary outcomes were time of hospitalization, duration of operation (from skin to skin), wound infection and operation cost.

This study had been authorized by Babylon health directorate /Babylon general teaching hospital as well as this study has been acknowledged by College of Medicine University of Babylon.

Consent form has been obtained from all patients who agreed to participate in this study.

Randomization is done by choosing the type of surgery by the patient. The patient select one of the lines of treatment (Either the use of titanium clipping to the mesoappendix and base of appendix Or the use of monopolar diathermy to the mesoappendix and endoloop to the base of appendix )which were written on a paper in a closed envelope.

**Statistical Analysis**

Statistical analysis was carried out using SPSS version 20. Categorical variables were presented as frequencies and percentages. Continuous variables were presented as means with their 95% confidence interval (CI). The Pearson's **chi-square test** ($x^2$) test was used to determine the associations between categorical variables. A *p*-value of $\leq 0.05$ was considered as statistically significant.

**Results :**There was no mortality in this study

Distribution of patients with appendectomy by Age and Sex. The overall mean age of all patients with appendectomy was (26.42±11.05) years old and (38.7%) of patients were aged between 20-30 years (Figure 1).

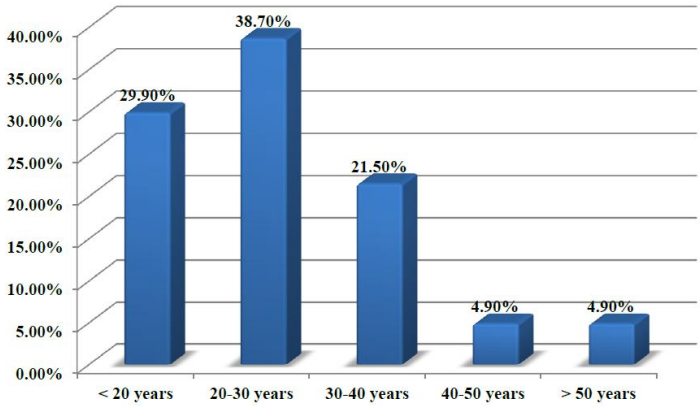


**Figure 1: Distribution of patients with appendectomy by age groups**

**Figure 2** shows the distribution of patients with appendectomy by sex. (52.5%) of patients were males.

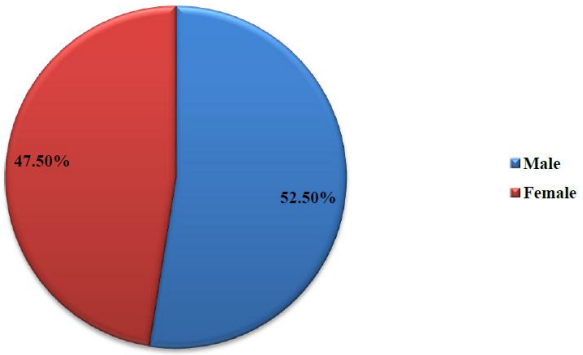


**Figure 2: Distribution of patients with appendectomy by sex**

The overall mean weight, height and BMI for patients with appendectomy were (74.29±12.14) kg, (1.68±0.09) m and (26.68±8.84) kg/m2, respectively. (45.4%) of patients were overweight. The overall mean duration of operation was (31.01±12.48) min and (68.7%) of patients spent less than 30 min in theatre, meanwhile, the mean of hospitalization after operation was (22.11±17.96) hours and (71.8%) of patients stayed less than 20 hours in hospital. Only (8.5%) of patients had complicated appendicitis and complication post-operation, while, (4.9%) of patients had complicated appendectomy. (45.1%) of operations' cost were 450 US $ (Table 1).

**Table 1: Distribution of Patients with Appendectomy by Weight, Height, BMI, Duration of Operation, Hospitalization Complicated appendicitis , Complicated operation, Post Operative Complications and cost of operation.**

| Variable | Mean± SD | Frequency (%) |
|---|---|---|
| Weight | 74.29±12.14 | |
| Height | 1.68±0.09 | |
| BMI | | |
| Underweight (<18.5 kg/m²) | | 3 (1.1%) |
| Normal weight (18.5-24.9 kg/m²) | 26.68±8.84 | 102 (35.9%) |
| Overweight (25-29.9 kg/m²) | | 129 (45.4%) |
| Obese (≥ 30 kg/m²) | | 50 (17.6%) |
| Duration of operation | | |
| < 30 min | 31.01±12.48 | 195 (68.7%) |
| ≥ 30 min | | 89 (31.3%) |
| Hospitalization | | |
| < 20 hours | 22.11±17.96 | 204 (71.8%) |
| ≥ 20 hours | | 80 (28.2%) |
| Complicated appendicitis | | |
| yes | | 24 (8.5%) |
| no | | 260 (91.5%) |
| Complicated operation | | |
| yes | | 14 (4.9%) |
| no | | 274 (95.1%) |
| Complication post- operation | | |
| yes | | 24 (8.5%) |
| no | | 260 (91.5%) |
| Price of operation | | |
| 250 $ | | 124 (43.7%) |
| 270 $ | | 14 (4.9%) |
| 450 $ | | 128 (45.1%) |
| 470 $ | | 12 (4.2%) |
| 500 $ | | 6 (2.1%) |

**Distribution of Patients with Appendectomy by Type of Operation**

Figure 3 shows the Distribution of Patients with Appendectomy by Type of Operation. (51.4%) of patients underwent clipping mesoappendix at base of appendix, meanwhile, the other (48.6%) of patients underwent Monapolar diathermy of mesoappendix and vicryle endoloop for base of appendix.

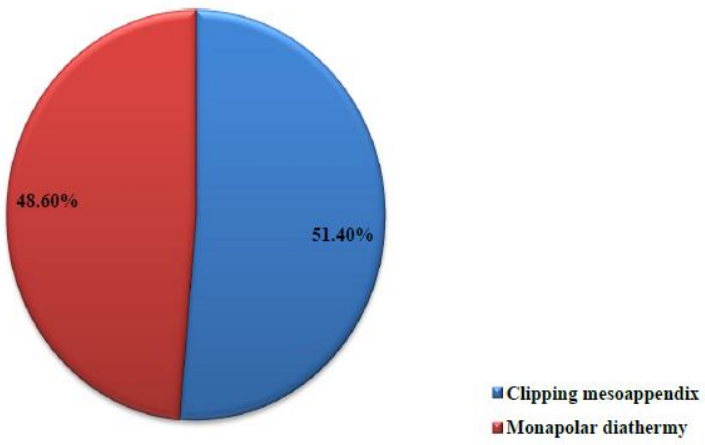


**Figure 3: Distribution of Patients with Appendectomy by Type of Operation**

**Association of Type of Appendectomy with Age and Sex**

Table 2 shows the Association of Type of Appendectomy with Age and Sex. There was no significant association between type of appendectomy and each of age or sex.

**Table 2: Association of Type of Appendectomy with Age and Sex**

| Variable | Type of Appendectomy | | $\chi^2$ | *P* values |
|---|---|---|---|---|
| | Group A (%) | Group B (%) | | |
| Age Groups (years) | | | | |
| < 20 years | 47 (32.2) | 38 (27.5) | | |
| 20-30 years | 53 (36.3) | 57 (41.3) | | |
| 31-40 years | 31 (21.1) | 30 (21.7) | 1.176 | 0.882 |
| 41-50 years | 7 (4.8) | 7 (5.1) | | |
| > 50 years | 8 (5.5) | 6 (4.3) | | |
| Sex | | | | |
| Male | 76 (52.1) | 73 (52.9) | 0.020 | 0.887 |
| Female | 70 (47.9) | 65 (47.1) | | |

*p value of ≤0.05 is significant

**Association of Type of Appendectomy with Weight, Height, BMI, Duration of Operation, Hospitalization ,Complicated appendicitis Complicated operation and cost.**

Table 3: shows the Association of Type of Appendectomy with Weight, Height, BMI, Duration of Operation, Hospitalization Complicated appendicitis Complicated operation and cost.

There were significant associations between type of appendectomy with duration, complicated operation and price of operation.

**Table 3: Association of Type of Appendectomy with Weight, Height, BMI, Duration of Operation, Hospitalization Complicated appendicitis Complicated operation and cost.**

| Variable | Type of Appendectomy | | $\chi^2$ | *P* values |
|---|---|---|---|---|
| | Group A (%) | Group B (%) | | |
| BMI | | | | |
| Underweight (<18.5 kg/m$^2$) | 2 (1.4) | 1 (0.7) | | |
| Normal weight (18.5-24.9 kg/m$^2$) | 54 (37.0) | 48 (34.8) | 0.549 | 0.908 |
| Overweight (25-29.9 kg/m$^2$) | 64 (43.8) | 65 (47.1) | | |
| Obese (≥ 30 kg/m$^2$) | 26 (17.8) | 24 (17.4) | | |
| Duration of operation | | | | |
| < 30 min | 81 (55.5) | 114 (82.6) | **24.266** | **<0.001*** |
| ≥ 30 min | 65 (44.5) | 24 (17.4) | | |
| Hospitalization | | | | |
| < 20 hours | 103 (70.5) | 101 (73.2) | 0.244 | 0.621 |
| ≥ 20 hours | 43 (29.5) | 37 (26.8) | | |
| Complicated appendicitis | | | | |
| yes | 12 (8.2) | 12 (8.7) | 0.021 | 0.885 |
| no | 134 (91.8) | 126 (91.3) | | |
| Complicated operation | | | | |
| yes | 11 (7.5) | 3 (2.2) | **4.350** | **0.037*** |
| no | 135 (92.5) | 135 (97.8) | | |
| Price of operation | | | | |
| 250 $ | 0 (0.0) | 124 (89.9) | | |
| 270 $ | 0 (0.0) | 14 (10.1) | **284.00** | **<0.001*** |
| 450 $ | 128 (87.7) | 0 (0.0) | | |
| 470 $ | 12 (8.2) | 0 (0.0) | | |
| 500 $ | 6 (4.1) | 0 (0.0) | | |

*p value of ≤ 0.05 is significant

## Association of Type of Appendectomy with Complications post Operation

### Association of Type of Appendectomy with intra and post Operation Complications

Figure 4 shows the association of type of appendectomy with intra and post operation complications. 7 patients developed intra operative bleeding in group A, while only 2 patients developed this complication in group B. On the other hand bleeding from slipped clips occurred in group A which need laparotomy for the controlling of the bleeding vessels.

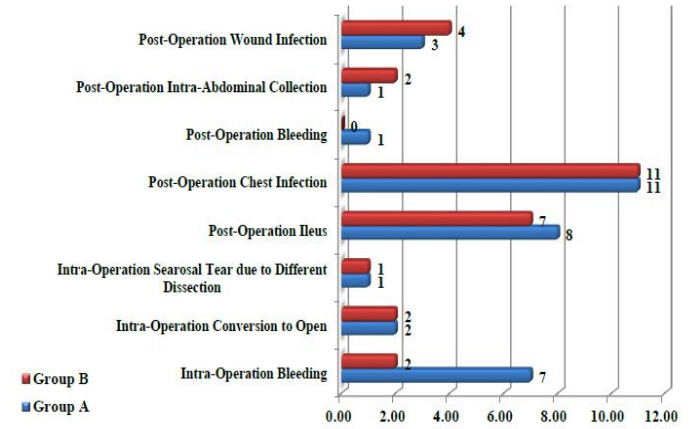


Figure 4: Association of type of appendectomy with intra and post operative complications

**Figure 4: Association of type of appendectomy with intra and post operative complications**

## Discussion

Regarding distribution of patients with appendectomy by age, the overall mean age of all patients with appendectomy was (26.42±11.05) years old and (38.7%) of patients were aged between 20-30 years .This agrees with [Noudeh,2007 ; Körner, 1997] and that can be explained by the possession of appendix of larger amount of lymphoid tissue in young subjects. Lymphoid hyperplasia can be caused by any obstruction occurring in the lumen of the appendix and this can develop into appendicitis. That's why appendicitis is more frequently in young people and only 5% of acute appendicitis cases are seen in the elderly.

In our study (52.5%) of patients were males. There was no significant difference in age incidence between males and females at any age although the incidence is marginally higher in males. This agrees with [Körner ,1997; Ergul, 2007; AL-Fahad 2002; Oguntola ,2010]. Although in other articles [Noudeh ,2007; Al-Omran ,2003] 74.4% ,58% were males respectively.This difference can be explained by laparoscopic appendectomy was dominated by women in which the hospital protocol recommend starting with a laparoscopic approach in women to exclude gynecological pathology. In men, open and laparoscopic approaches were supported and the type of approach depended on the available laparoscopic expertise and time in the out of office hours situation.

The overall mean weight, height and BMI for patients with appendectomy were (74.29±12.14) kg, (1.68±0.09) m and (26.68±8.84) kg/m2, respectively. (45.4%) of patients were overweight. With increasing BMI ,there is an increase incidence of incorrect and delay diagnosis and decreasing sensitivity when using US but the

sensitivity and specificity of CT for appendicitis are excellent regardless of BMI [Abo ,2011; Johansson ,2007]. In overweight patients, surgical time in LA considered as a hallmark of technical challenge although its associated with lower wound infection , post-operative complication rate , shorter hospital stay when compared with open appendectomy [Andrea,2014 ; Enochsson ,2001].

The overall mean duration of operation was (31.01±12.48) min and (68.7%) of patients spent less than 30 min operative time. This can be explained by ,Several surgeons have defined a learning curve for laparoscopic procedures after which the rate of complications plateau and the time necessary to complete a procedure note a decrease from the first cases to the last[Moore ,1995; Voitk ,1998; Litwin,1997].

The mean of hospitalization after both type of operation was (22.11± 17.96) hours and (71.8%) of patients stayed less than 20 hours in hospital .This agreed with Li X (2010) in which LA produced less pain, shorter hospital stays than open appendectomy and allowed more rapid return to full activities.

There were no differences between the two groups regarding age, sex, weight, height, BMI, time of hospitalization, operative diagnosis of complicated and non complicated appendicitis.

(8.5%) of patients had complicated appendicitis.This disagree with Wu HS (2011) in which complicated appendicitis form 18%, may be because we exclude perforated appendix with generalized peritonitis from the study. LA is applicable in complicated appendicitis as well as non complicated appendicitis. There is no evidence that LA is contraindicated for patients with either complicated appendicitis or a history of abdominal surgery [Wullstein, 2001; Wu, 2007]. On the other hand, preoperative assortment of complicated cases is difficult, as CT.

findings of appendiceal abscess and extraluminal gas are associated with a high specificity but a low sensitivity in relation to perforated appendicitis[Bixby ,2006].

The overall post-operative complication rate were (8.5%) and that comparable with other studies and considered lower than open appendectomy [Wu ,2011; Wullstein, 2001; Katsuno, 2009; Kapischke, 2005].

Over all complicated appendectomy were (4.9%). There were significant associations between type of appendectomy with the complicated operation in which bleeding intra operatively were more common in group A than in group B, additionally Post operative bleeding occurred in another patient in group A. This statistically significant result between the type of appendectomy in favorable of appendectomy with group B because of less serious complications.

The mean durations of the surgical procedures and the cost of operation in both groups were different in which group B has shorter operative time and less operative cost than group A. This agreed with Strzałka (2014) in which the average duration of the surgical procedure with the use of titanium clips was 66 min.

This can be explained by the need for multiple clips for secure haemostasis of mesoappendix and significant rate of bleeding which occur while dissection in group A and in addition to that the need for more anesthetic drugs because of longer operation time. The hypothesis beyond using monopolar diathermy and cauterize mesoappendix near the wall of appendix ,that we securely coagulate the small end arteries and be away from the large vessels in the base of mesoappendix.

In our study ,there were no difference between clipping and endoloop application in base of appendix in regard to complication rate, Although on other studies, Endo-loops considered more secure and costly effective than clip application on the base of appendix. [Gonenc, 2012; Alis, 2012; Rickert,2012; Ates, 2012; Sajid,2009)]

There are several techniques used to close the appendicular stump during laparoscopic appendectomy. The most commonly used surgical methods are Endo loop ligature, laparoscopic staplers, metal or polymer clips or application of purse string suture with the invagination of the appendicular base into the cecum, as in the classic surgery [Sajid ,2009; Kazemier ,2006; Costa-Navarro ,2013; Partecke, 2010; Delibegovic,2009;Gonenc,2012]. However, the optimal technique of the appendicular stump closure still seems to be controversial. Although, laparoscopic staplers Of Endo-GIA type are is the safest option, but at the same time the most expensive. [Kazemier ,2006 ; Partecke ,2010].

**Limitation of study**

Blinding of patients and the data interpreter is very important factor when studying subjective variable . In the absence of masking ,Bias can occur and markedly influenced by the enthusiasm for the new technique. Our aim was to role out early postoperative complications in the hospital and after discharge so we miss the long term complication like small bowel obstruction. We concentrate on laparoscopic appendectomy and compare two method for mesoappendix haemostasis and ligation of base of appendix but we didn't include the open appendectomy which is still the standard operation.At the present time, Laparoscopic appendectomy has been simplified by the advancement ultrasonic dissectors, Ligasure and endoscopic staplers in addition to improvement of camera optics. In our study ,We tried to do cost-effective and safe laparoscopic appendectomy technique.

## Conclusion

Laparoscopic appendectomies can be considered a safe treatment of complicated and non complicated appendicitis. Application of monopolar diathermy very near to the wall of appendix to cauterize the small vessels of mesoappendix is useful and safe and considered costly effective and less complication rate than application of Titanium clips.

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