Comparative study between monopolar diathermy versus LigaSure for securing mesoappendix during laparoscopic appendectomy

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Background
Laparoscopic appendectomy (LA) is an effective and a safe procedure for treatment of acute appendicitis. Various methods are used for securing mesoappendix during LA like LigaSure, harmonic scalpel, monopolar diathermy, and endoloops and endoclips, the use of which affects the duration of operation and the overall cost.
Aim
The aim of this study was to compare between the use of monopolar electrocoagulation versus LigaSure (Covidien) in securing of mesoappendix during LA regarding operative and postoperative findings as well as the overall cost.
Patients and methods
In total, 80 patients, diagnosed as acute appendicitis and scheduled for LA, were randomly grouped into two groups according to the instrument used for securing the mesoappendix: group A: monopolar diathermy was used and group B: LigaSure was used.
Results
Both methods were comparable regarding operative and postoperative findings; however, using LigaSure markedly decreased the operative time compared with using monopolar diathermy (mean 60.45 vs. 51.9 min, $P<0.001$) and using monopolar diathermy markedly decreased the cost of operation compared with LigaSure (868.75 vs. 1962.5 Egyptian pounds, $P<0.001$).
Conclusion
Within the limitations of this study, we conclude that the use of monopolar diathermy in securing the mesoappendix during LA is as safe as and is more cost-effective than using LigaSure.

Keywords:
laparoscopic appendectomy, LigaSure, mesoappendix, monopolar

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Introduction

Laparoscopic appendectomy (LA) is gaining popularity due to the proven advantages of laparoscopic surgery, for example, lower incidence of wound infection, shorter hospital stay, less postoperative pain, and better quality-of-life scores when compared with open appendectomy [1–3]. Another advantage is that the laparoscopic approach allows a full exploration of the peritoneal cavity, thus representing an important diagnostic tool in case there is only suspicion of acute appendicitis [4].

Although LA is one of the most performed operations, the operation procedures vary widely according to the surgeon. Various instruments are being used for securing the mesoappendix, such as endostapler, endoclips, endoloops, Harmonic scalpel (Ethicon Endo-surgery, Cincinnati, Ohio, USA), monopolar and bipolar diathermy, and LigaSure (Covidien) [5].

LigaSure is a preferred instrument for securing the mesoappendix in a highly inflamed appendix with thick edematous tissue. Despite the potential advantage, LigaSure represents a high-cost option [6,7].

The use of less expensive instruments in developing countries like Egypt seems logical, once the safety and effectiveness of such instruments are proven. In a study by Perrin *et al.* [8], they proved that the use of monopolar electrocoagulation was safe, quick, and related to very low rates of complications or conversion to open appendectomy.

Aim

The aim of this study was to compare between using monopolar electrocoagulation versus LigaSure (Covidien) in securing the mesoappendix during LA regarding

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Operative findings

(1) Time.
(2) Bleeding.
(3) The effectiveness and rate of applying the drain.
(4) Conversion rate.

Postoperative findings:

(1) Postoperative fever.
(2) Hospital stay.
(3) Port-site infection.
(4) Analgesics requirement.
(5) Postoperative bleeding (bloody collection not serosanguinous through the drain).
(6) Overall costs.

Patients and methods

The present study was a comparative randomized study that was performed on 80 patients suffering from acute appendicitis admitted to the emergency unit, Menoufia University Hospital, Menoufia University, Shebin El-Kom, Egypt and Damanhour Medical National Institute, Damanhour, Egypt. The study started in August 2020.

Informed consent was obtained from each patient. Approval of the ethical committee in both hospitals was obtained. Indication for surgery was the diagnosis of acute appendicitis confirmed by clinical examination performed by the attending surgeon and confirmed by the appropriate laboratory and radiological investigations. Patients were randomized consecutively by closed-envelope technique as follows:

Group A: 40 patients chosen to have LA done using monopolar diathermy (low intensity: average 30) for securing the mesoappendix (Fig. 1).

Group B: 40 patients chosen to have LA done using LigaSure (Covidien, Mansfield, Massachusetts, USA) for securing the mesoappendix (Fig. 2).

LA was done according to the standardized procedure (adopting the open technique in creation of pneumoperitoneum), except for the step of securing the mesoappendix, where our two techniques applied. The base of the appendix was secured by knots in all cases.

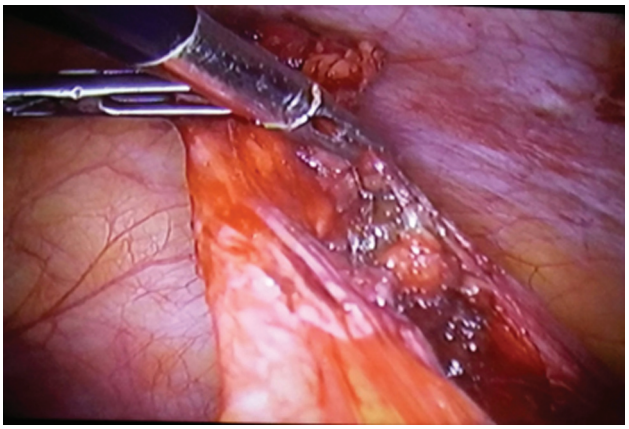
Exclusion criteria

(1) Bleeding disorders.
(2) Hematological diseases.
(3) Severe liver cirrhosis and/or portal hypertension.
(4) Appendicular mass.
(5) Cardiopulmonary diseases.

The following data were collected in each operation:

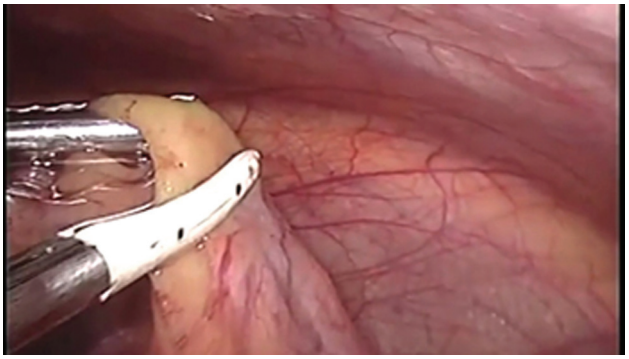
(1) Operative findings:
  (a) Time.
  (b) Bleeding: in our study, we consider bleeding as follows:
    (1) Nature: arterial (pulsating).
    (2) Color: bright red.
    (3) Amount: average 50 ml (we used standard-size gauze that contains 25 ml when soaked completely to determine the amount of bleeding). In our study, we only used not more than two standard-size gauzes in cases of bleeding.
    (4) Control: in our study, mostly we used the monopolar (meriland) or Ligasure itself; if control failed, we used clip applying after grasping the bleeding points, which was a

Figure 1



Monopolar diathermy during laparoscopic appendectomy.

Figure 2



Laparoscopic appendectomy using Ligasure for securing the meso-appendix (pictures taken during our study operations by our team).

very effective method, except in the only case of postoperative bleeding that was treated by conservative treatment with antibleeding medications and discharged from hospital after 2 days.

(c) Rate of applying the drain, any inadvertent complications.
(d) Conversion rate.

(5) Postoperative findings:
(a) Postoperative fever.
(b) Hospital stay.
(c) Port-site infection.
(d) Analgesics requirement.
(e) Postoperative bleeding (bloody collection not serosanguinous through the drain).
(f) Overall costs.

Statistical analysis

Data were fed to the computer and analyzed using IBM SPSS software package, version 20.0 (IBM Corp., Armonk, New York, USA). Qualitative data were described using number and percent. The Kolmogorov–Smirnov test was used to verify the normality of distribution. Quantitative data were described using range (minimum and maximum), mean, and SD. The results were considered statistically significant at *P* value less than or equal to 0.05.

The used tests were:

(1) χ^2 test: for categorical variables to compare between different groups.
(2) Fisher's exact: correction for χ^2 when more than 20% of the cells have expected count less than 5.
(3) Student *t* test: for normally distributed quantitative variables.
(4) Mann–Whitney test (*U*) for abnormally distributed quantitative variables.

Results

Table 1 reveals that in this study, sex (male : female ratio) was about 1 : 1 with totally 42 male patients and 38 female patients and age range between 18 and 62 years old with a median value of 33 years.

Table 2 reveals that 52.5% of cases of this study had intraperitoneal collection and 32.5% of cases of this study had perforation or gangrene of the appendix. Also, it reveals that 17.5% of cases of this study had appendicular abscess.

No case of inadvertent complication was encountered. There was a statistically significant difference in operative time between using LigaSure and monopolar diathermy in LA ($P<0.001$). Table 3 also reveals that there was no significant difference in the rate of applying drain ($P=0.077$). Also, there was no statistically significant difference between the two groups regarding conversion rate.

According to Table 3, bleeding in cases of group A (monopolar) was more in comparison with cases of group B (LigaSure), yet this difference had no statistically significant importance ($P=0.264$). Table 3 also reveals that the probability of inserting the drain was comparable in both groups ($P=0.077$).

Table 4 reveals that there were no statistically significant differences between the two groups in postoperative fever, hospital stay, port-site infection, analgesic use, and postoperative bleeding.

Table 5 reveals that there was a highly significant difference between the two groups in the overall costs, using monopolar diathermy was significantly less expensive.

Discussion

Worldwide, the standard operative treatment for acute appendicitis is open appendectomy; however, the choice between an open and a laparoscopic approach continues to be challenged in the medical literature [9–11].

Historically, the RLQ incision of open appendectomy has persisted essentially unchanged since it was

Table 1 Comparison between the two studied groups according to demographic data

	Total (*N*=80) [*n* (%)]	Group A (Monopolar) (*N*=40) [*n* (%)]	Group B (LigaSure) (*N*=40) [*n* (%)]	Test of significance	*P*
Sex					
Male	42 (52.5)	20 (50.0)	22 (55.0)	χ^2=0.201	0.654
Female	38 (47.5)	20 (50.0)	18 (45.0)		
Age (years)					
Minimum–maximum	18.0–62.0	18.0–58.0	18.0–62.0	*t*=1.044	0.300
Mean±SD	34.92±14.36	33.25±13.58	36.60±15.09		

Table 2 Comparison between the two studied groups according to collection, abscess, and perforation or gangrene

	Group A (monopolar) (*N*=40) [*n* (%)]	Group B (LigaSure) (*N*=40) [*n* (%)]	χ^2	*P*
Collection				
Negative	18 (45.0)	20 (50.0)	0.201	0.654
Positive	22 (55.0)	20 (50.0)		
Abscess				
Negative	36 (90.0)	30 (75.0)	3.117	0.077
Positive	4 (10.0)	10 (25.0)		
Perforation or gangrene				
Negative	28 (70.0)	26 (65.0)	0.228	0.633
Positive	12 (30.0)	14 (35.0)		

Table 3 Comparison between the two studied groups according to intraoperative data

Intraoperative	Group A (monopolar) (*N*=40) [*n* (%)]	Group B (LigaSure) (*N*=40) [*n* (%)]	Test of significance	*P*
Bleeding				
Negative	30 (75.0)	34 (85.0)	χ^2=1.250	0.264
Positive	10 (25.0)	6 (15.0)		
Applying drain				
Negative	30 (75.0)	36 (90.0)	χ^2=3.117	0.077
Positive	10 (25.0)	4 (10.0)		
Conversion				
Negative	40 (100.0)	40 (100.0)	–	–
Positive	0	0		
Operative time (min)				
Minimum–maximum	48.0–90.0	41.0–65.0	*t*=4.418*	<0.001*
Mean±SD	60.45±10.24	51.90±6.71		

P: *P* value for comparing between the two groups. *Statistically significant at $P \leq 0.05$.

Table 4 Comparison between the two studied groups according to postoperative findings

Postoperative	Group A (monopolar) (*N*=40) [*n* (%)]	Group B (LigaSure) (*N*=40) [*n* (%)]	Test of significance	*P*
Postoperative fever				
Negative	24 (60.0)	35 (75.0)	χ^2=2.051	0.152
Positive	16 (40.0)	5 (25.0)		
Hospital stay (days)				
1	34 (85.0)	36 (90.0)	χ^2=0.457	0.499
2	6 (15.0)	4 (10.0)		
Port-site infection				
Negative	38 (95.0)	38 (95.0)	χ^2=0.0	^{FE}P=1.000
Positive	2 (5.0)	2 (5.0)		
Analgesics (NSAIDs in mg)				
Minimum–maximum	50.0–200.0	50.0–150.0	*U*=706.0	0.318
Mean±SD	87.50±42.53	77.50±34.32		
Postoperative bleeding (bright-red collection not serosanguinous through the drain)				
Positive	1 (2.5)	0	1.013	^{FE}P=1.000
Negative	39 (97.5)	40 (100.0)		

Table 5 Comparison between the two studied groups according to mean overall cost

Mean of overall cost	Group A (monopolar) (*N*=40)	Group B (LigaSure) (*N*=40)	*t*	*P*
Minimum–maximum	850.0–1100.0	1950.0–2200.0	79.919*	<0.001*
Mean±SD	868.75±66.69	1962.50±55.18		

P: *P* value for comparing between the two groups. *Statistically significant at $P \leq 0.05$.

pioneered by McBurney in the 19th century [12], while the use of laparoscopy in the surgical management of acute appendicitis was first described in 1983, with a continued increasing trend in its use [11].

LA has many advantages over open appendectomy because of lower incidence of wound infection, shorter hospital stay, less postoperative pain, and better quality-of-life scores when compared with open appendectomy [1–3].

However, this must be objectively contrasted to the open procedure, which already involves minimal risk, extremely short length of hospital stay, and a low rate of complications. Additional disadvantages of laparoscopy include increased cost and longer operating times [10].

The two groups we included in this study were comparable, regarding the demographic data as well as the intraoperative findings with no statistically significant differences between the two groups regarding age, sex, collection, abscess, perforation, or gangrene ($P>0.05$) (Tables 1 and 2). This proves that both groups are homogeneous and there is no bias toward a certain group.

Both techniques (monopolar and LigaSure) were safe (Table 3). No inadvertent intraoperative complication was documented in the 80 patients included in the study without any difficulty or failure to control the mesoappendix in the monopolar group even in edematous mesoappendix because of thrombosis of the terminal blood vessels. It is understandable that using monopolar diathermy may cause thermal damage at the base of the appendix or the adjacent tissues, but we did not encounter any such damage. Electrosurgery utilizes an electric current to generate the desired tissue effect and is being used increasingly for open and laparoscopic procedures [13,14]. Monopolar and bipolar diathermy are the most commonly utilized modalities, with the latter though capable of more accurate control of electric current, thereby limiting the spread of thermal energy to the surrounding tissues with low rate of energy-induced intestinal injury. Newer instruments, such as the harmonic scalpel (Ethicon Endo-Surgery) and Ligasur (Valleylab, Boulder, Colorado, USA), are thought to be safer than traditional diathermy [13,15]. The Ligasure utilizes a combination of pressure-generator and current-generator methods to melt the collagen and elastin contained within blood vessel walls, thereby sealing the vessels [16]. There is evidence that the use of electrosurgery may lead to inadvertent damage to the nearby structures through the lateral spread of thermal energy [17]. This could result in delayed injuries to the surrounding structures, such as bowel, nerves, blood vessels, or bile ducts; the degree of lateral thermal spread may depend on the type of instrument, power settings used, and the duration of application [18]. Diamantis *et al.* [13] compared LigaSure and harmonic scalpel with monopolar electrocoagulation and bipolar coagulation: the first two caused more minimal thermal injury for the surrounding tissue than other techniques. Recently, significantly higher thermal damage was found on the mesoappendix and appendicular base in patients treated by LigaSure than in patients for whom harmonic scalpel was used during LA [19], in our study, there is no any energy-induced intestinal injury that happened. This is in accordance with Perrin *et al.* [8] and Ponsky and Rothenberg [20], who proved that using the cautery alone can be as safe as using the more expensive devices and debated that the use of LigaSure or the harmonic scalpel (Ultracision, Ethicon Endo-surgery) is unwarranted.

In our study, there was a slight increase in intraoperative (pulsating) bleeding in the monopolar group, yet this was statistically insignificant ($P>0.05$) (Table 3). This was the case with drain insertion: we apply drains only in cases of incomplete control of pulsating bleeding of terminal blood vessels of the mesoappendix or in severely edematous mesoappendix. In our study, we tried to follow the recent recommendations that in adult patients, the use of drains after appendectomy for perforated appendicitis or abscess/peritonitis should be discouraged, unless clearly indicated. Drains are of no benefit in preventing intraabdominal abscess and lead to longer length of hospitalization [21,22]. There is no significant difference between the two groups in applying drain ($P=0.077$). No case in both groups was converted to open surgery. The adopted open establishment of pneumoperitoneum proved to be safe, rapid, and easy. This is consistent with Bonjer *et al.*'s [23] study of 1244 cases that proved the technique to be safe when compared with the closed technique.

As expected, the operating time was affected greatly by using the LigaSure. The operating time was significantly lower with group B (LigaSure) (mean ±SD: 51.90±6.80 min), than group A (monopolar) (mean±SD: 60.45±10.37 min), with P value of 0.004. This is due to the difference in the mechanism of action of both the monopolar and the LigaSure. Another factor may be the tendency of the surgeon using the monopolar to be slower, trying to be as careful as

possible to identify the appendicular artery and/or its branches, grasp it, and secure it at more than one level. LigaSure works more quickly; there is no need to identify the appendicular artery. This result is comparable to the study by Macario *et al.* [24], who stated that 'using LigaSure can reduce the operative time when compared with using monopolar electrocautary in LA.'

LigaSure is the preferred instrument for securing the mesoappendix in a highly inflamed appendix with thick edematous tissue with less incidence of postoperative bleeding. Despite the potential advantage, LigaSure represents a high-cost option and it may be logical to use endoclips or endoloops if the mesoappendix is not edematous [6,7].

It is unquestionable that using LigaSure is useful for decreasing intraoperative bleeding more than monopolar electrocautery in many surgical operations like hepatic surgery, splenectomy, abdominoplasty, and hysterectomy, because in these operations, the surgeon deals with large vessels [25], but when we deal with vessels like those of the mesoappendix, this advantage of LigaSure is decreased. The efficacy of monopolar diathermy on small-diameter vessels has almost the same effect like LigaSure [24]. In our study, there was no statistically significant difference between the two groups regarding postoperative findings (Table 4).

When comparing both groups, *P* value was more than 0.05 regarding fever, hospital stay, port-site infection, analgesic need, and postoperative bleeding (Table 4). In our study, the comparison between the two studied groups according to postoperative bleeding reveals that there is no statistically significant difference between the two studied groups, which reflects the safety of using monopolar diathermy in LA. This is similar to the results reported by other researchers [5].

Many studies found that monopolar electrocoagulation is safe, quick, and related to very low rates of complications and conversion to open appendectomy can be considered the most cost-effective method for mesoappendix dissection in LA [8,26].

In our study, when we compared between the two groups according to the overall cost, we found that in group A (monopolar), the mean cost is (868.75 Egyptian pounds) and the mean cost in group B (LigaSure) is 1962.5 Egyptian pounds ($P<0.001$) (Table 5), which reflects that using LigaSure is relatively expensive in comparison with using monopolar diathermy during LA. The reduction in operative time does not compensate for the higher costs of the LigaSure. Keeping in mind that appendectomy is a common procedure; using monopolar diathermy can lead to a significant saving without affecting the patient's safety.

Conclusion

Using the monopolar diathermy is as safe as and less expensive than using LigaSure during LA. Using LigaSure in LA can reduce the operative time if compared by using monopolar diathermy.

Recommendations

Within the limitations of this study, we recommend the use of monopolar diathermy in securing the mesoappendix during LA in uncomplicated appendicitis as it is safe and more cost-effective than using LigaSure.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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