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RESEARCH ARTICLE

EXTRA CORPOREAL KNOTTING VS HARMONIC SCALPEL FOR APPENDICULAR STUMP LIGATION IN LAPAROSCOPIC APPENDECTOMY

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ABSTRACT

Background*:** Acute appendicitis is one of the most common cause of surgical abdomen requiring emergency surgery, with a life time incidence of about 6% to 8%. One of the most important steps in appendectomy procedure is closure of appendix stump. In laparoscopic appendectomy extra corporeal or intra corporeal knotting are used for stump ligation. Harmonic scalpel is an energy device that can be used to deal with appendicular stump. ***Materials and Methods: This prospective randomized comparative study was conducted in Post Graduate Department of Surgery, Government Medical College Jammu. All patients with clinical evidence of acute appendicitis, recurrent appendicitis and patients dated for interval appendectomy were included in this study and laparoscopic appendectomy was performed in all. Patients with clinically apparent perforation, appendicular lump and co morbid condition contraindicating surgery under general anaesthesia were excluded from this study group. 84 patients were taken up for the study but data of four patients were excluded from study as they needed conversion to open surgery. Rest of the 80 patients were randomly divided into two groups. Group A included 40 patients in whom appendicular stump was dealt with extracorporeal knotting and group B included 40 patients in whom appendicular stump was dealt with harmonic scalpel. Results**:** Mean age of patients in extracorporeal knotting group was 27.6 years (7-62 years) and in harmonic scalpel group it was 26.9 years (8-64 years) with M:F ratio in extracorporeal knotting group (Group A) being 1.5:1 and in Group B (Harmonic scalpel) it was 1.7:1. Mean Operative time in Group B was 35.44 minutes and it was 50.8 minutes in Group A. The difference in operating time was statistically significant ($p < 0.00001$).Mean appendicular stump closure time in harmonic scalpel group was 44.6 seconds and in extracorporeal knotting group was 295.6 seconds and difference was statistically significant ($p<0.0001$). Post operative ileus was present in 5% (n=2) patients in knotting group and in harmonic group it was present in 7.5% (n=3) patient. Statistically difference in two groups was not significant (p=1.000). Mean pain score as observed was 4.12 in Group A and 3.8 in Group B. In majority of the patients in both groups; only 02 doses of analgesics were required. Port site infection was observed in 2.5% (n=1) patient in harmonic group and 7.5% (n=3) in knotting group (P=0.609). The mean duration of post operative hospital stay was 3.12 days (2-5 days) in knotting group and 2.76 days (2-4 days) in harmonic group. The mean interval to return to daily routine was 7.4 days in knotting group and 7.64 days in harmonic group. There is no statistically significant difference between two groups (p=0.513). ***Conclusion*:** The technique of laparoscopic appendectomy by harmonic scalpel is very simple and safe that is changing surgeons' performances to refined, quicker and efficient procedures. In view of the results available from the present study it is concluded that harmonic scalpel appendicular stump closure is safe, time saving, easily accessible and simple when compared with extracorporeal knotting closure of appendicular stump. In situations where facilities of harmonic scalpel are available patients of appendicitis must be extended the benefit of ligating appendicular stump with harmonic scalpel.

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INTRODUCTION

Acute appendicitis is one of the most common cause of surgical abdomen requiring emergency surgery, with a life time incidence of about 6% to 8% (Dey *et al.,* 2010; Rickert *et al.,* 2012). Appendicitis is disease of young, with 40% of the patients between the age groups of 10 to 29 years. Currently, the mortality rate for acute appendicitis with treatment is less than 1% (Shivamallaiah, 2014). One of the most important steps in appendectomy procedure is closure of appendix stump. A traditional method of dealing with the appendix stump is to crush it, ligate it, divide and then invaginate it, carbolisation of the stump prior to invagination was included as an added safeguard method against infection (Miles and Wilkie, 1993). First reported laparoscopic appendectomy was done in 1983 as an alternative approach to open surgery (Semm, 1983). Various methods have been described for dealing with meso appendix and closure of appendicular stump during laparoscopic appendectomy like stapler, endoloop, clips, suture knots, bipolar cauterization, ligature, harmonic scalpel, endo-ring applicator and fallope rings (Ali and Maliekkal, 2009; Hue *et al.,* 2013; Doke *et al.,* 2016). Laparoscopic suturing and knot tying are among the most basic, but also the most challenging, skills required of the laparoscopic surgeon. The oldest technique is Intracorporeal suturing and knot tying. The technique requires skill to manipulate the needle, pass it from 1 needle driver to the next, and execute a series of knots. Extracorporeal knot tying techniques were later introduced as an alternative to intracorporeal knot tying (Honnie *et al.,* 2004). Suture closure of appendix base is simple and is done in

similar way as in open surgery with disadvantage of prolonging time for laparoscopic appendicular surgery (Mayir *et al.,* 2013). The recent introduction of alternative energy based devices in surgery and their use in laparoscopic appendectomy shortened the duration of operations but these devices are generally used for meso appendix dissection. These devices did not receive wide acceptance among surgeons as there is not enough evidence confirming their use in appendicular lump operations (Yavuz *et al.,* 2016). Harmonic scalpel is one such energy source that can be used to deal with appendicular stump ligation. It is a high power system which works at frequency of 55,500 vibrations/ sec. The shear can coagulate vessels up to 5mm, where the hook and blade is only 2 mm in diameter. The harmonic scalpel probe reach the temperature of 8°C and even on prolonged use stays below 250 °C which is far less than other electrosurgical sources resulting in reduced lateral thermal spread and charring. Vibration of active probe prevents sticking of coagulated tissues over it however mist production could minimally affect visibility. Its use in cauterization and cutting appendicular stump has been reported in many studies (Obonna *et al.,* 2014; Bajpai *et al.,* 2014; Yauger *et al.,* 2005). In laparoscopic appendectomy complications like haemorrhage, caecal burn, fistulae etc. were overcome when it replaced other electric coagulation system especially harmonic scalpel like energy sources (Shahidulla *et al.,* 2011). The present study was undertaken to assess efficacy of harmonic scalpel appendicular stump closure with respect to its safety, accessibility, and technicality and advantage over the conventional extra corporeal knotting of appendicular stump.

MATERIALS AND METHODS

This prospective randomized comparative study was conducted in Post Graduate Department of Surgery, Government Medical College Jammu. All patients with clinical evidence of acute appendicitis, recurrent appendicitis and patients of appendicitis dated for interval appendectomy were included in this study and laparoscopic appendectomy was performed in all. Patients with clinically apparent perforation, appendicular lump and co morbid condition contraindicating surgery under general anaesthesia were excluded from this study group. In our study there were total 84 patients and data of four patients were excluded from study as they needed conversion to open surgery due to dense adhesions and intra operatively detected appendicular lump. Rest of the 80 patients were randomly divided into two groups. Group A included 40 patients in whom appendicular stump was dealt with extracorporeal knotting and group B included 40 patients in whom appendicular stump was dealt with harmonic scalpel. All patients included in the study were subjected to the preoperative investigations and work up including pre anaesthetic check up prior to surgery. The primary outcome parameters assessed were operative time, time for stump closure, need for drain, pain score, need for analgesic, postoperative ileus, postoperative peritonitis, hospital stay and return to work.

RESULTS

Mean age of patients in extracorporeal knotting group was 27.6 years (7-62 years) and in harmonic scalpel group it was 26.9 years (8-64 years). In both groups majority of the patients were male with M:F ratio in extracorporeal knotting group (Group I) being 1.5:1 and in Group II (Harmonic scalpel) it was 1.7:1.In both the groups majority of patients were having acute appendicitis as presenting complaints (extracorporeal knotting group=80%, harmonic scalpel group 85%). The patients who presented for Interval appendectomy were 28% in knotting group and 16% in harmonic group whereas patients who presented as recurrent appendicitis were 8% and 24 % in both groups respectively. Intra operative findings in majority of patients in knotting group (48%) comprised of severe oedema with thick appendicular stump where as in that of harmonic scalpel group (56%) were mild hyperaemia and oedema of the appendicular stump. Omental adhesions were present in 32% in knotting group and 44% in harmonic scalpel group. Whereas, there was no appendicular base necrosis in either of the groups. Appendicular faecolith was present in 16% patients (n=4) in knotting group where as in 8% patients (n=2) in the harmonic scalpel group.

Table 1 Mean Time (in seconds) for mesoappendix dissection in two Groups

	Group A	Group B	P value =0.513 >0.05 Statistically insignificant
Mean time	106.6 sec	100.2 sec	
Range	50 sec -180 sec	15 sec - 120 sec	
SD	41.14	25.87	

There was no statistically significant difference in time for meso appendix dissection between both the groups. This could be explained by the fact that harmonic scalpel was used for dissection of mesoappendix in both groups.

Table 2. Mean Time (in seconds) for ligation of appendicular stump in two groups

	Group A (in seconds)	Group B (in seconds)	
Mean time for appendicular stump closure	295.6	44.6	P< 0.0001 (Significant)
Range	240-410	30-60	
SD	7.99	9.67	

Mean appendicular stump closure time in harmonic scalpel group was 44.6 seconds and in extracorporeal knotting group was 295.6 seconds. Difference between the time taken for ligation of appendicular stump in the two groups was statistically significant (p<0.0001).

Table 3. Operating time (in minutes) in both groups

Operative time	Group A (in minutes)	Group B (in minutes)
Mean	50.8	35.44
SD	7.17	6.37
Range	30-60	20-40

Mean Operative time in harmonic scalpel group was 35.44 minutes and in extracorporeal knotting group was 50.8 minutes. There was statistically significant difference between the operating times of the two groups (p < 0.00001).

Table 4. Comparison of intra operative finding.

IOF	Group A (n=40)	%age	Group B (n=40)	%age
Normal	4	10%	4	10%
Hyperemia mild edema	10	25%	25	62.5%
Severe edema and thick stump	20	50%	6	15%
Base necrosis	0	0%	0	0%
Omental adhesions	6	15%	5	12.5%
Total	40	100%	40	100%

Intra operative findings in majority of patients in knotting group (50%) comprised of severe oedema with thick appendicular stump where as in that of harmonic scalpel group

(62.5%) were mild hyperaemia and oedema of the appendicular stump. 10% in each group were having normally appearing appendix intr-operatively.

Table 5. Position of appendix in both groups

	Group A (n=40)	%age	Group B n=40	%age
Retrocaecal	16	40	12	30
Pelvic	10	25	16	40
Others	6	15	4	10
Position not well defined due to adhesion/severe inflammation	8	20	8	20
Total	40	100	40	100

Most common position of appendix in group I was retrocaecal in 40% of patients (n=16), whereas; in group II it was pelvic position which was seen in 30% of patients (n=12). In 20% of patients in each group the exact position of the appendix could not be ascertained either due to omental adhesion or severe inflammatory process in and around appendix.

Table 6. Comparison of mean size of appendicular stump (in mm)

	Group A (Extracorpreal knotting)	Group B (Harmonic scalpel)
Mean size of appendicular stump	8.84	8.12
Range	6-11	6-10
SD	1.57	1.12

Mean size of appendicular stump was comparable in both the groups (p-value 0.06)

Table 7. Intraperitoneal Drainage in both groups

	Group A n= 40	%age	Group B n=40	%age
Drain kept	16	40%	26	65%
Drain not kept	24	60%	14	35%
Total	40	100%	40	100%

Intraperitoneal drain was kept in 40% patients (n=16) in knotting group and 65% (n=26) in harmonic scalpel group. Statistically difference was not significant (p=0.089).

Table 8. No. of patients having Post operative ileus

	Group A (n=40)	%age	Group B (n=40)	%age
Post op ileus	2	5%	3	7.5%

Post operative ileus was present in 5% (n=2) patients in knotting group and in harmonic group it was present in 7.5% (n=3) patient. Statistically difference in two groups was not significant (p=1.000)

Table 9. Commencement of oral feeding in patients post operatively in two groups

	Group A n=40	%age	Group B n=40	%age
1st	36	90%	36	90%
2nd	2	5%	2	5%

In 90% (n=36) patients in both the groups, the oral feeding was started on 1st post operative day. By 2nd post operative day 95% of patients had taken oral feeding. In only 02 patients in harmonic scalpel group oral feeding was withheld beyond second post operative day. The difference between two groups was statistically insignificant (p=1.000). In our study post-operative pain was assessed according to the demand of analgesics by the patients using Visual Analogue Scale and Mean pain score as observed was 4.12 in knotting group and 3.8 in harmonic group. Majority of the patients in both groups; knotting group (n=15) and harmonic group (n=12) required only 02 doses of analgesics. Maximum of 05 doses were required in 01 patient in knotting group, while in harmonic group maximum of 04 doses were required in 1 patient. Port site infection was observed in 2.5% (n=1) patient in harmonic group and 7.5% (n=3) in knotting group (P=0.609). There was no case of iatrogenic bowel injury, small bowel obstruction, abdominal abscess, stump blow out or leak in both groups. None of patient required readmission or exploration in follow up period. However there was one case of bleeding from port site in group B and one case of bleeding from mesoappendix in group A that were managed. The mean duration of post operative hospital stay was 3.12 days (2-5 days) in knotting group and 2.76 days (2-4 days) in harmonic group. The mean interval to return to daily routine was 7.4 days in knotting group and 7.64 days in harmonic group. There is no statistically significant difference between two groups (p=0.513).

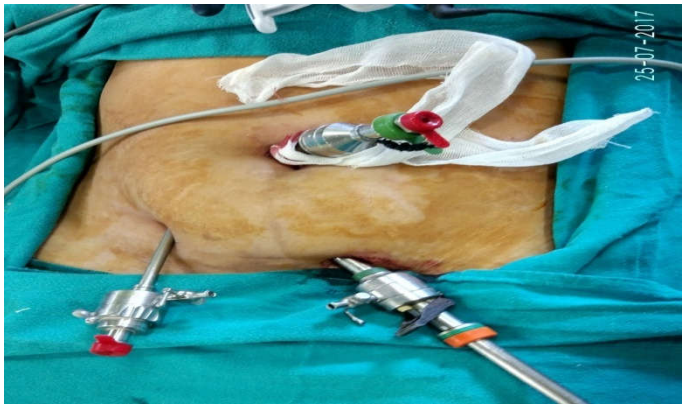

Fig 1: Post Position in Laparoscopic Appendectomy

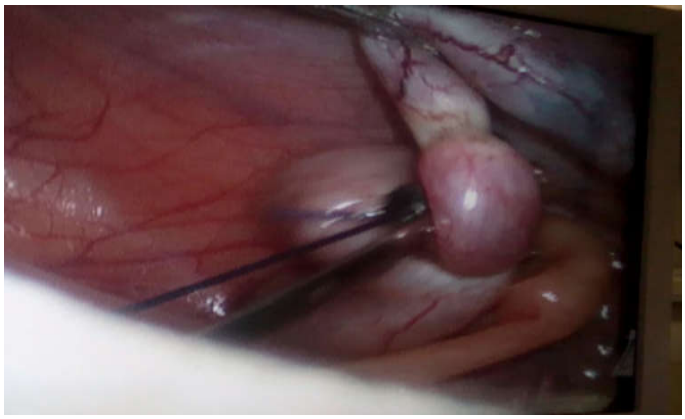

Fig 2: Extracorporeal Knotting in Laparoscopic Appendectomy

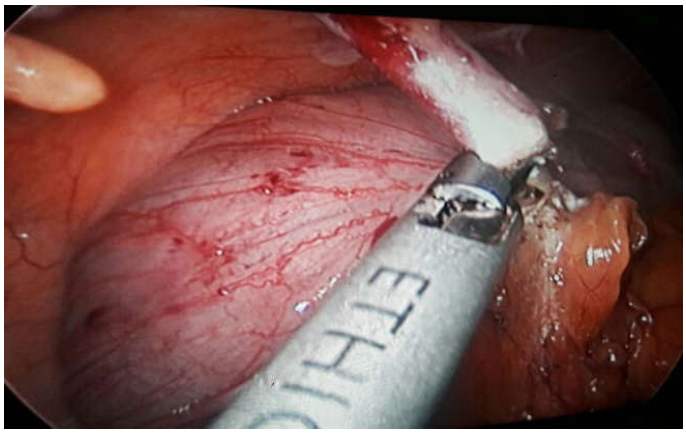

Fig 3: Harmonic Cutting & Ligation of Appendicular Base during Laparoscopic Appendectomy

DISCUSSION

Laparoscopic procedures have become well established modality of treatment in many surgeries and appendectomy is no exception. Advantages of laparoscopic appendectomy over open appendectomy are clearly defined in terms of superiority in cases of diagnostic uncertainty and obesity, better visualization of peritoneal cavity, less pain, faster recovery and better cosmetic results. But at the same time it is associated with longer operative time, expensive instruments and need of technical expertise. Closure of appendix base is decisive step in the incidence of intra-abdominal infections, faecal fistulas and surgical site infection both in case of open and laparoscopic appendectomies. Base closure is more important in laparoscopic appendectomy; because initial experience showed laparoscopic appendectomies to have higher incidence of intra-abdominal infections especially in cases of perforated appendicitis and because of non availability of gold standard techniques to close the base. The present study was undertaken to find out differences in two commonly practised techniques of appendicular stump treatment in appendectomy i.e. extracorporeal knotting and harmonic scalpel. In our study there were total 84 patients, however 4 patients were excluded from study as they needed conversion to open surgery due to dense adhesions or intra operatively detected appendicular lump. Rest of patients were randomly divided into two groups. Group A included 40 patients in whom appendicular stump was dealt with extracorporeal knotting and group B included 40 patients where harmonic scalpel ligation of appendicular stump was done.

The two groups were similar in terms of age and sex. Mean age of patients in Group A (extracorporeal knotting) was 27.6 years (7-70 years) and in group B (harmonic scalpel) was 26.9 years (8-68 years) with maximum number of patients in age group of 11-20 years in both. Mean age in our was consistent with similarly situated studies in the literature (Mayir *et al.,* 2015; Scott-Conner *et al.,* 1992; Strzalka *et al.,* 2016). There was male predominance in both extracorporeal knotting (60%) and harmonic scalpel groups (64%) in our study with Male: Female ratio of 1.6:1. Similar male predominance has been seen in study by Scott-Conner *et al.* (1992) with male to female ratio of 1.3:1. In study by Mayir *et al.* (2015) there was also male predominance with 1.5:1. Likewise in study by Strzałka *et al.* (2016) male to female ratio was 1.3:1. In group A, 32 patients were admitted as a case of acute appendicitis, 7 were for interval appendectomy while 1 patient was admitted as case of recurrent appendicitis. In group B, 34 patients were admitted as case of acute appendicitis, 2 for interval appendectomy and 4 were admitted as recurrent appendicitis. In study by Khanna *et al.* (2004), there were total 60 patients undergoing laparoscopic surgery, 41 patients were having acute appendicitis and 13 had recurrent appendicitis. In study by Yang *et al.* (2005) laparoscopic appendectomy using the Ligasure was attempted in 15 patients who were admitted as case of acute appendicitis. Doke and Gadekar (2016) did a study where they included 40 patients of acute appendicitis and recurrent appendicitis. Intra operatively in group A, 3 patients had normal appendix, 4 patients had mild hyperaemia, and 20 patients had severe oedema with thick stump. Adhesions with omentum and peritoneum were seen in 6 patients. While in group B, 4 patients had normal appendix, 25 patients had mild hyperaemia, 6 patients had severe oedema and 5 patients had adhesions. None of patients in both groups had necrosis of base. Two patients in harmonic scalpel group had faecolith in appendix while four patients of extracorporeal knotting group had faecolith. It is clear from above discussion that there were more patients with severe oedema and erythema were taken up for extra corporeal knotting rather than for harmonic scalpel ligation. This observation is statistically significant with P value of 0.04. In study by Gomes *et al.* (2013) 34% patients had segmental necrosis of appendix, 9.2% had appendicular base necrosis, 25% had abscess, 17 % had regional peritonitis. Ashour-Abou (2014) noted normal appendix in 6 patients, hyperaemia with oedema in 75 patients severe oedema and thickening in 15 patients and base necrosis in 1 patient in knotting group. In study by Yang *et al.* (2002) 2 patients had normal appendix, 10 patients had inflamed appendix, perforation was seen in 3 patients and one had caecal inflammatory mass.

Abdominal drain was kept in 16 patients with extracorporeal knotting group while it was kept in 26 patients with harmonic scalpel group. Drains were kept more frequently for patients of Harmonic scalpel Group, as we were sceptical about stump leak in harmonic group but the apprehension is not backed by literature evidence. Mean size of appendicular stump was 8.36 mm in group A as compared to 7.76 mm in group B. So patients with thick appendicular base were preferred for extra corporeal knotting group over harmonic scalpel ligation. In study by Abou-Ashour (2014) the mean diameter of appendix stump was 10 mm with a range of (10-15) mm in both groups of knotting and clip. In our study, mean operative time in harmonic scalpel group was 35.44 minutes versus 50.8 minutes in extracorporeal knotting. The difference between mean operating time in two groups was statistically significant ($P<0.001$). In study by Martin-del-Olmo *et al.* (2002) mean operative time with ultrasonic activated scalpel was 42.3 minutes. Bajpai (2014) performed 18 appendectomies using harmonic scalpel and noted a mean operative time of 30 minutes. In study by Khanna *et al.* (2004) the mean operative time was 25 minutes. Yang *et al.* (2005) used Ligasure for closing appendicular stump and noted a mean operative time of 47 mins (22 mins to 120 mins). Galatioto *et al.* (2013) in their study noted a mean operative time of 57.1 min (10 min to 225 min). Time for closure of appendicular stump in harmonic scalpel group was 44.6 seconds vs. 294.4 seconds in extracorporeal knotting group in our study. In study by Khanna *et al.* (2004) they coagulated appendicular stump 3-5mm away from caecum by bipolar cautery. The duration of bipolar coagulation was 60-180 seconds with a median of 90 sec. However there was no major difference observed in mean time for mesoappendix dissection in both groups which is 106.6 sec in Knotting group and 100.2 sec in harmonic scalpel group (P value 0.577). The difference was statistically insignificant due to the fact that in both groups Harmonic scalpel was used for meso appendix dissection. Visual analogue score for pain was slightly higher in patients of extracorporeal knotting group 4.12 when compared with harmonic scalpel group where it was 3.8. However there was no statistically significant difference between two groups. When number of analgesics doses required was compared in both groups most of patients required 2 doses of analgesic in both groups. However a second peak was observed in patients of knotting group with 4 doses and in harmonic scalpel group with 3 doses. The data is statistically significant ($p= 0.03$) showing more analgesics was demanded by patients of extracorporeal knotting group. Although reason could not be established, yet it is presumed that due to excessive inflammation of appendicular base/stump taken up for knotting and irritation of appendicular stump with

knot could cause more demand of analgesic doses in knotting group patients. There were 3 cases of port site infection in extracorporeal knotting vs. 1 case of infection in harmonic scalpel group. All these patients were managed conservatively with local wound dressing. Kazimier *et al.* (2006) in their study also noted a higher port site infection with endoloops as compared to stapler. Abou-Ashour, (2014) in their study noted a higher rate of port site infection with knotting group vs stapler group. In study by Doke and Gadekar, (2016) 1 patient had port site infection out of 40 patients. Stump in this patient was closed by endoloop. In study by Khanna *et al.* (2004) reported 2 cases of wound infection in their study of 60 patients. In both group oral feed was started in 1st post op day except for 3 patients in whom oral feeding was started on 2nd post op day. Both groups were comparable in case of oral feeding without statistically significant difference. In study by Khanna *et al.* (2004) median time to start oral feeding was 12 hrs (12 to 36 hrs). Post operative ileus was noticed in one patient in extracorporeal knotting group (4%) and two patients in Harmonic scalpel group (8%). In study by Doke and Gadekar, (2016) there were 3 patients who had post-operative ileus. In 2 patients stump was closed with bipolar cautery and in 1 endoloop was used. Nadeem *et al.* (2016) noted an incidence of ileus of 2.8% in knotting group and 6.3% in clipping group Ashour-Abou (2014) noted one case of ileus in metal clip closure group. No case of ileus was seen in knotting group in their study. In our study one patient had bleeding from port site intra operative, while other patient had bleeding from meso appendix, both these patients were managed intraoperative and were stable in post-operative period. No case of iatrogenic bowel injury, small bowel obstruction, stump blowout or leak and abdominal abscess were seen in both groups. Ashour-Abou, (2014) in their study also didn't see any complications like bleeding, bowel injury, obstruction, post-operative abscess formation or stump blowout.

Mean hospital stay in group A was 3.12 days while it was 2.76 days in group B. Intergroup comparison statistically was not significant. Scott-Conner *et al.* (1992) noted a mean post op hospital stay of 2.5 days. Galatioto *et al.* (2013) in their study noted a mean post-operative stay of 2.7 days. In study Khanna *et al.* (2004) the mean post op hospital stay was 3 days. Mean post-operative hospital stay of 1.3 days was noted by Mayir *et al.* (2015) with a range of 1-2 days. Elshoura *et al* (2017) in their study noted an average hospital stay of 1.73 days, 1.8 days and 2.3 days in stapler, extracorporeal sliding knot and intracorporeal knotting respectively. Mean number of days to return to normal routine was 7.4 days in extracorporeal knotting versus 7.64 in harmonic scalpel group, without any statistical significance.

Conclusion

The technique of laparoscopic appendectomy by harmonic scalpel is very simple. There was no need of changing instruments while closing base of appendix with harmonic. Similarly for closing appendicular stump there was no need of cumbersome handling of suture while placing it through the appendix and there was minimal handling of bowel during harmonic scalpel closure of appendicular stump, hence minimizing the chance for iatrogenic injury as well as post-operative ileus. Hence, harmonic scalpel is considered as safe latest surgical instrument that is changing surgeons' performances to refined, quicker and efficient procedures. Apart from reduction in operation time compared to extracoporeal knotting group, it also allows the patients to take less anaesthetic drugs and its related haphazard. In view of the results available from the present study it is concluded that harmonic scalpel appendicular stump closure is safe, time saving, easily accessible and simple when compared with extracorporeal knotting closure of appendicular stump. In situations where facilities of harmonic scalpel are available patients of appendicitis must be extended the benefit of ligating appendicular stump with harmonic scalpel in view of its added advantages over knotting.

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