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Research Article

Comparative Study of Laparoscopic Appendectomy *versus* Open Appendectomy for the Treatment of Acute Appendicitis

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Abstract

Background: Appendectomy is one of the most commonly performed procedures in abdominal surgery and the laparoscopic approach is gradually replacing open surgery for acute appendicitis. Aim of this study was to assess technical feasibility and safety of the laparoscopic technique in acute appendicitis and to compare its results with open appendectomy.

Methods: A total of 400 patients of acute appendicitis were operated, 200 by laparoscopic appendectomy and 200 by open method by a single surgeon at various private hospitals in Jammu and Kashmir, India over a period of three years from June 2017 to May 2020. The two groups were compared with respect to operative time, duration of hospital stay, post-operative pain, complication rate, time taken to resume routine activity and cosmetic satisfaction of the patients.

Results: Results were found to be better with the laparoscopic technique. There was significantly less pain in the postoperative period with faster recovery, early resumption to work, reduced postoperative complications and better cosmetic satisfaction of the patients operated by the laparoscopic appendectomy technique as compared to open surgery.

Conclusions: Laparoscopic appendectomy is safe and feasible technique in expert hands, for treatment of acute appendicitis with results comparable to the open appendectomy, with no obvious increase in complications and is definitely a procedure of choice for the management of acute appendicitis.

Keywords: Appendectomy; Acute appendicitis; Trocar; Laparoscopic appendectomy; Emergency

Introduction

Acute appendicitis is the most common intra-abdominal condition requiring emergency surgery and carries a lifetime risk of 6% to 7% [1]. It commonly presents with abdominal pain, fever, nausea and vomiting, although 40% of the patients lack this typical presentation. Diagnosis of acute appendicitis is mainly by clinical examination, supported by raised neutrophil count in blood.

Appendectomy is the most commonly performed operation in the world, 6% of all the surgical procedures and is done as emergency procedure wherever possible, the only exception is formation of appendicular mass or abscess. In these cases, interval appendectomy is performed as elective procedure.

For more than a century, open appendectomy remained the gold standard for the treatment of acute appendicitis. Laparoscopic appendectomy was first performed by Semm in 1983 in Germany and continued to evolve at such a rapid pace that it is now time to recommend this minimal access technique in the treatment of acute appendicitis, especially in the obese and when the diagnosis is uncertain [2]. Laparoscopic appendectomy gives a better evaluation of the peritoneal cavity than that obtained by open approach and also facilitates other differential diagnosis. Advantages of laparoscopic approach include less operative time, less postoperative pain, reduced analgesia, less surgery associated complications, shorter hospital stay, faster recovery, reduced wound infection and minimal scarring. Disadvantages of the laparoscopic operation are a steep learning curve, difficult hand eye coordination, 2-dimensional vision, limited freedom of movements and higher cost [3]. Aim of the study was to assess technical feasibility and safety of the laparoscopic technique in acute appendicitis and compare its results with open appendectomy.

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Methods

The study is a retrospective review of 400 patients of acute appendicitis operated by a single surgeon, Dr. Rajive Gupta, the corresponding author at various private hospitals in Jammu (Jammu and Kashmir), India over a period of three years from June 2017 to May 2020.

Inclusion criteria

Inclusion criteria was any case regardless of age and sex with clinical diagnosis of acute appendicitis including complicated appendicitis (gangrenous or perforated appendicitis).

Exclusion criteria

Presence of appendicular lump, appendicular abscess, generalized peritonitis, pregnancy, shock on admission, known coagulation

disorders, history of major lower abdominal operation and patients in whom laparoscopy is contraindicated like severe cardiopulmonary disease.

Patients were randomly divided into two groups (A and B). Group A comprising of 200 patients subjected to laparoscopy appendectomy and Group B comprising of 200 patients subjected to open appendectomy. Names of different hospitals along with distribution of cases into two groups are given in Table 1.

Table 1: Hospital wise and Group wise distribution of cases.

Name of the hospital	Number of cases (%)	Group A	Group B
Care & Cure Hospital, Trikuta Nagar	94 (23.5)	48	46
Maxxlyfe Hospital, Bathindi	92 (23.0)	45	47
Ganeshdaya Nursing home, Talab Tillo	72 (18.0)	35	37
Lochan Nursing Home, Trikuta Nagar	60 (15.0)	29	31
Goel Hospital, Canal Road	42 (10.5)	22	20
AV Nursing Home, Channi Himmat	40 (10.0)	21	19

Preoperative assessment

Thorough history, clinical examination, all routine laboratory and radiological investigations were recorded in both groups. Informed written consent was taken from all the patients. All patients were asked to empty urinary bladder prior to surgery. All patients were operated under general or spinal anesthesia by the same surgical team.

Operative technique

In laparoscopic appendectomy, primary 10 mm umbilical, second 5 mm suprapubic and third 5 mm left lower abdomen trocars were placed. Operating table was tilted 15-degree Trendelenburg position and tilted 15 degree to the left. The surgeon and camera man stood on the patient's left and monitor was positioned towards the patient's right side. After confirmation of the diagnosis, the appendix was held near its tip and retracted using grasper or Babcock forceps and the mesoappendix dissected using blunt dissection with Maryland dissector and appendicular artery thus isolated was coagulated and cut with scissors (Figure 1).

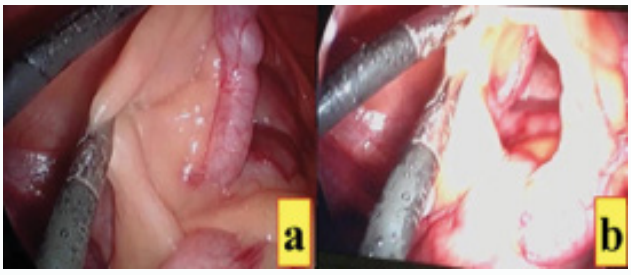

Figure 1(a,b): Dissecting mesoappendix.

Appendix was dissected free of mesoappendix up to the base. The closure of the appendiceal stump is an important step during laparoscopic appendectomy, because most of the postoperative life-threatening complications such as stercoral fistulas, postoperative peritonitis and sepsis are caused by its inappropriate method. In the study, appendiceal stump was secured with two handmade No. 0 silk or 00 vicryl endoloops prepared extra-corporeally and pushed into the abdomen and tightened with the help of a knot pusher and distal to the tied loops, appendix was cut with laparoscopic scissors leaving the appendiceal stump (Figure 2).

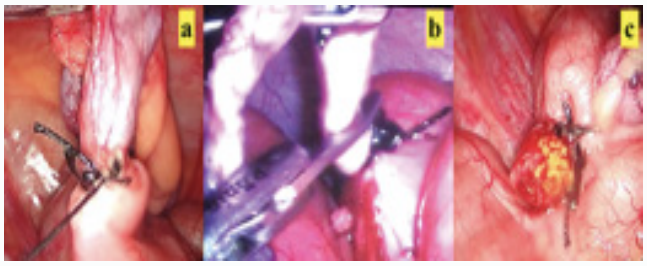

Figure 2(a-c): Loop ligature and cutting appendix.

The appendix was retrieved through the 10 mm umbilical trocar without touching the port, thus avoiding contamination. For this, table was straightened and supra-pubic and umbilical trocars were aligned in a straight line at 180 degree so that appendix held with a toothed grasper at its cut end could be placed into the umbilical trocar sleeve and pushed out by opening the valve of the trocar and extracted by pulling out with the help an artery forceps while trocar remained in place (Figure 3).

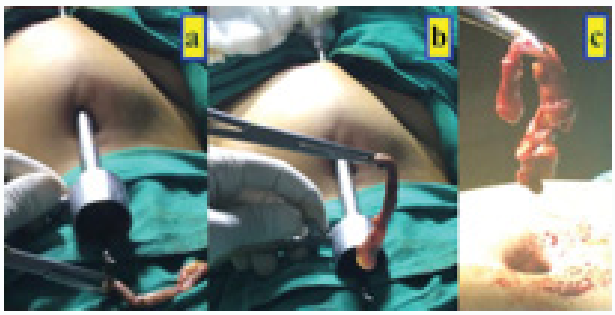

Figure 3(a-c): Extracting appendix from umbilical port.

In open appendectomy, Gridiron or Rutherford Morison incision was made followed by the routine operative steps to perform surgery. Specimens of appendix removed in both the groups are shown in Figure 4.

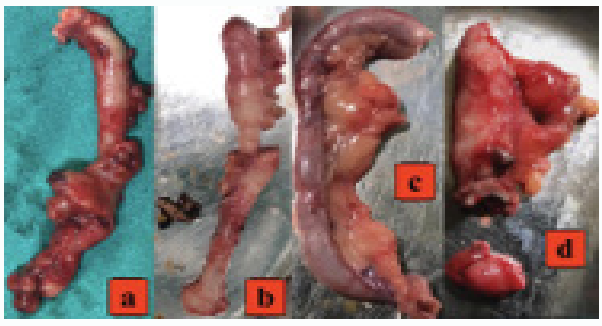

Figure 4(a-d): Specimens of appendix removed.

In both the groups, thorough peritoneal toileting was done with normal saline and betadine in cases of gangrenous or perforated appendix and a closed tube drain (ADK) No. 24 or 28 was kept in pelvis and brought out through the left abdominal port. All the patients were put on intravenous fluids during first 24 hours and were given intravenous antibiotics (ceftriaxone) at the time of induction of anesthesia along with tinidazole infusion postoperatively. Standard analgesia was prescribed to all patients in form of injection diclofenec

in intravenous infusion 8 hourly for three doses and thereafter on demand. Patients were monitored for pulse rate, blood pressure, temperature, respiratory rate, bowel sounds and urinary output. The appendix was sent for histopathological examination in all the cases. Patients were discharged the next morning in Group A and on 3rd day or later in Group B on oral antibiotics and analgesics for 5-7 days. Patients were advised to come for follow up at 1 week, 2 weeks and 4 weeks after surgery or in between if needed to assess intensity of pain, condition of the wound, any infection and cosmetic satisfaction.

Statistical analysis

Comparison of parameters between the two groups was done by using chi-square test, student's t test and Z test. Software used for statistical analysis was SPSS version 16.0 and 'p'-value less than 0.05 was considered as statistically significant.

Results

Various observations made during the course of the study are shown in Table 2.

Table 2: Comparison of study variables (NS=Non-significant; S=Significant).

Parameter	Group A	Group B	(p value)
Average age in years	22 (9-69)	24 (12-72)	NS
Sex ratio (M:F)	1.8:1	1.7:1	NS
Mean operative time in minutes	32 ± 8.60 (16-100)	38 ± 4.04 (18-74)	S*
Operative difficulty	55	57	NS
Conversion rate	4		
Intraoperative complications	27	26	NS
Postoperative complications	20	65	S*
Mean Post operative pain score	2.7	3.08	S*
Mean hospital stay (Days)	1.10 ± 0.12	2.16 ± 0.55	S*
Mean days to resume routine work	8.02 ± 0.553	10.16 ± 0.681	S*
Mean cosmesis satisfaction score	8.16 ± 0.37	7.36 ± 0.58	S*

Most of the patients were of less than 35 years of age. In Group A, 130 (65%) patients were male and 70 (35%) were female. On the other hand, in Group B, 126 (63%) patients were male and 74 (37%) were female.

Position of appendix

Different positions of appendix encountered in the two groups are shown in Figure 5. Great difficulty was faced while operating retrocecal cases of appendicitis. In 4 patients in the study, appendix was subserosal in location (beneath the serosa of caecum) and it was most difficult to find and dissect this type of appendix, leading to prolonged duration of surgery. In one patient of laparoscopic appendectomy with subserosal appendix, conversion to open surgery was done to find the appendix.

Duration of surgery

Mean operative time in laparoscopic appendectomy was lower than in open appendectomy and difference was statistically significant ($p<0.05$).

Operative difficulty and conversion

In Group A, intra-operative adhesions were found in 19 patients and appendix was gangrenous in 15 cases and perforated in 12 cases. In Group B, 17 patients had adhesions, 16 had gangrenous appendix and 14 had perforated appendix with peri-appendicular fluid. This difference was not significant, though adhesions and gangrenous changes lead to operative difficulty in both the groups. The incidence

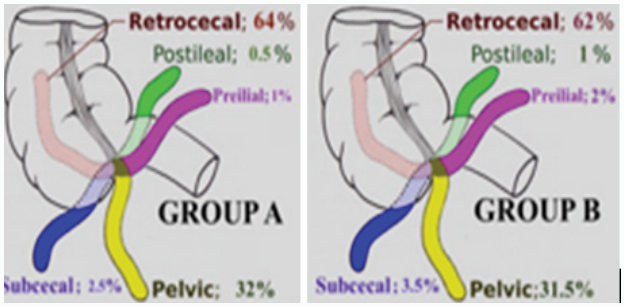

Figure 5: Position of appendix.

of conversions to open surgery in Group A was 2% (4) patients due to subserosal appendix, dense adhesions, bleeding and gangrenous changes at the base of appendix.

Intra and post-operative complications

There was no significant difference in the rate of intraoperative complications between the two groups ($p>0.05$). In Group A, 27 (13.5%) patients, while in Group B, 26 (13%) patients had intraoperative complications in the form of bleeding and perforation or rupture of appendix, while releasing adhesions. Bleeding was from the mesoappendix, omental vessels or retroperitoneum. In cases of leakage of purulent exudates from appendix at the time of operation, copious irrigation and suction was done to prevent the spillage of infected material into the peritoneal cavity.

Post-operative complications like prolonged ileus, fever, intra-abdominal abscess, intra-abdominal adhesions, seroma, wound infection/gape and incisional hernia were significantly less in Group A as compared to Group B (Table 3). Wound infection was recognized by erythema, fluctuation and purulent drainage from port sites and managed conservatively. None of the patients had leakage from the appendiceal stump. There was no case of postoperative adhesion in Group A, though 6 cases developed intra-abdominal adhesions post-operatively in Group B and were managed conservatively except in two cases which required re-exploration which accounted for increased morbidity and prolonged hospital stay.

Pain score after surgery

Postoperative pain was assessed by Visual Analogue Scale (VAS). The pain scores were calculated 4, 8, 12, 18, 24 hours postoperatively

Table 3: List of intra & post-operative complications in two Groups.

Complication	Total number	Percentage (%)	Group A	Group B
Hemorrhage	27	6.75	14	13
Perforation of Appendix	26	6.50	13	13
Paralytic ileus	22	5.50	6	16
Fever	20	5.00	5	15
Port site/ wound infection	16	4.00	4	12
Seroma	12	3.00	2	10
Intra-abdominal abscess	6	1.50	2	4
Intra-abdominal adhesions	6	1.50	0	6
Port site/incisional hernia	5	1.25	1	4
Wound Gape	4	1.00	0	4
Total	144	36.00	49	95

and at first and second week of follow up and difference in the pain score in early and late postoperative period between the groups was statistically significant (p<0.05) as shown in Table 4.

Table 4: Comparison of mean VAS pain score in two groups.

Mean VAS score	Group A	Group B
At 4 hours	2.88	3.18
At 8 hours	5.22	5.74
At 12 hours	4.24	4.70
At 18 hours	4.00	4.42
At 24 hours	2.34	2.84
At 1 week	0.16	0.44
At 2 weeks	0.08	0.24

Duration of hospital stay

The mean duration of hospital stay in Group A was 1.10 ± 0.12 days and in Group B was 2.16 ± 0.55 days and difference was statistically significant (p<0.05). Most of our patients in Group A were discharged after 24 hours, except 4 patients who needed conversion to open surgery and were discharged on 3rd post-operative day. Most of the patients in Group B were discharged on 3rd postoperative day, except 6 patients who developed intra-abdominal adhesions and were discharged on 8th post-operative day.

Time to resume routine work after surgery

The mean time taken to resume daily routine activities was 8.16 ± 0.553 days in Group A and 10.16 ± 0.681 days in Group B and the difference was statistically significant (p<0.05).

Cost

In this study, no specialized instrument was used and even handmade endoloop ligatures were applied for ligating appendiceal stump. As a result, there was not much difference in overall cost in the two groups.

Patient satisfaction level (subjective)

Subjective level of satisfaction score on scars was reviewed 4 weeks after surgery by using a 10 cm unscaled VAS (0, unsatisfied, 10 fully satisfied). In Group A, 160 (80%) of the patients were fully satisfied with the scar and cosmetic outcome, 30 (15%) patients were partially satisfied and 10 (5%) patients were unsatisfied due to poor scar. In Group B, 40 (20%) patients were fully satisfied with the cosmetic outcome, 50 (25%) were partially satisfied and 110 (55%) patients were unsatisfied. In the Group A, mean cosmesis satisfaction score was 8.16 ± 0.37 as compared to 7.36 ± 0.58 in the Group B and the difference was statistically highly significant (p<0.05).

Mortality

There was no mortality in the present study and majority of the patients expressed their satisfaction to the laparoscopic procedure. It could be due to lesser duration of surgery, shorter hospital stay, early resumption of work, fewer complications in the post-operative period and better cosmetic outcome among laparoscopic appendectomy group.

Discussion

Laparoscopic appendectomy is evolving as an operation of choice for acute appendicitis. Laparoscopy has enabled surgeons to decrease the rate of infection and complications that are often associated with the open procedure. This has been demonstrated in a number of studies [1-4]. The mean age of patients in the two groups follows similar pattern as reported by Chaudhari et al. [5]. There were 256 (64%) males and 144 (36%) females in the study; sex ratio was 1.77:1 which is lower than 1.96:1 as reported by Mishra et al. [6]. Retrocaecal (Overall 63%) was the commonest position of appendix found during surgery, while it was 46% in a study by Mishra et al. [6]. In this study, mean duration of surgery in laparoscopic appendectomy (32 ± 8.60 minutes) was lower than open appendectomy (38 ± 4.04 minutes) and the difference was statistically significant (p<0.05). Similarly, shorter duration of operation in laparoscopic appendectomy than open appendectomy was observed by Aziz, Athanasiou et al. [7] in their meta-analysis comparing both methods. Conversion to open surgery may be required in any laparoscopic procedure. In this study, only four patients (2%) were converted to open appendectomy, although some studies reported a rate of conversion from 10% to 39.7%. Conversion rate was 6% in a study by Utpal De [8]. There was no significant difference in the intra-operative complications between the two groups. Most of the studies also report that intra-operative complications are more related to severity of underlying pathology than the type of procedure. Katkhouda, Mason et al. [9] found similar intra-operative complication rates, irrespective of the technique. On the other hand, in this study post-operative complications were higher among open appendectomy than laparoscopic appendectomy. Similarly, Utpal De found more post-operative complications following open appendectomy. The risk of wound infection was less in laparoscopic appendectomy compared to the open procedure. A meta-analysis of randomized controlled trials has been reported with outcomes of 2877 patients included in 28 trials. Overall complication rates were comparable, but wound infections were definitely reduced after laparoscopy (2.3% to 6.1%). There is a strong controversy among surgeons regarding the use of the laparoscopic procedure in complicated appendicitis (gangrenous or perforated) due to the risk of intra-abdominal abscess formation [11,12]. Intra abdominal abscess is recognized by prolonged ileus, sluggish recovery, rising leukocytosis, spiking fever and tachycardia. Our result was similar to one trial conducted by Barkhausen S et al. [13] in which 930 patients were analyzed retrospectively. Conventional appendectomy was performed in 330 patients, laparoscopic in 554 patients and 46 patients required conversion after laparoscopy and the incidence of intra-abdominal abscess was 1.44% in the laparoscopic group versus 1.52% in open surgery group. Tang found a postoperative intra-abdominal abscess rate of 11% for perforated appendicitis treated laparoscopically compared with a rate of 3% treated by the open method. There is a large group of surgeons who believe that laparoscopic appendectomy is safe in all forms of appendicitis, even in perforated appendicitis [14-17]. Laparoscopic appendectomy leads to fewer intra-abdominal adhesions, whereas in open surgery, the tissue trauma of the incision increases the total inflammatory response, thereby inhibiting fibrinolysis and promoting fibroblast migration and collagen formation resulting into more adhesion formation. Garrard et al. [18] has also reported reduced adhesion formation after laparoscopic surgery like in our study. In the obese patients, laparoscopic appendectomy has shown advantage over the open procedure with a faster postoperative recovery. Similar observation was arrived in a study by Enochsson L et al. [19]. Less than 1% of all patients with suspected acute appendicitis are found to have an associated malignant process. During conventional appendectomy through a laparotomy incision, the caecum and the appendix are easily palpated and an obvious mass can be detected and properly managed at the time of appendectomy. The inability to palpate any mass in laparoscopic appendectomy is a disadvantage. There is a report of mucinous cystadenoma of the caecum missed at laparoscopic appendectomy by V Shayani [20].

There was significant difference in the degree of pain between laparoscopic and open procedure in this study which was in consistence with the results of some other studies. Jaschinski, Mosch, Eikermann et al. [21] and Rashid, Nazir et al. [22] also found pain score following laparoscopic appendectomy to be lower as compared to open appendectomy [21-23]. In our study, duration of hospital stay in laparoscopic appendectomy (1.10 ± 0.12 days) was lower than in open appendectomy (2.16 ± 0.55 days) and the difference was statistically significant ($p<0.05$). Similarly, Minne et al. [24] reported a median hospital stay of 1.1 *vs.* 1.2 days in laparoscopic appendectomy vs. open appendectomy compared with means of 5.3 *vs.* 7.6 days for Hebebrand et al. [25] in Germany and 4.9 *vs.* 5.3 for Mutter et al. [26] in France [24-26]. One of our patients in the laparoscopic group, who was converted to open surgery, had 6 days postoperative stay because of uncertainty about injury to cecum. Mean duration to resume daily routine work in laparoscopic appendectomy was lower than in open appendectomy and the difference was statistically significant ($p<0.05$). The results shown by other research workers in most of the studies also demonstrate earlier return to full activity following laparoscopic than open appendectomy (Utpal De and Rashid, Nazir).

Many studies have shown that laparoscopic appendectomy costs higher than open appendectomy. The increase in cost of laparoscopic appendectomy is attributed to the higher cost of specialized instrumentation such as disposable trocars, laparoscopic endostaplers, metallic clips and tissue-sealing devices such as Ligasure and Harmonic scalpel and by the use of commercially available pre-tied endoloop ligature for securing the appendiceal stump [27,28]. These devices may not be necessary in laparoscopic appendectomy, which can be performed by using reusable trocars, routine electrosurgical device, readily available LT clips and self-made endo-loops, thus reducing the overall cost of the procedures. In our study, hand-made No. 0 silk or 00 vicryl endo-loops (Roeder's Knot) were used for securing the base of the appendix. This technique is safe, simple, time saving and easier than intracorporeal knot tying and is cheaper than pre-tied endoloops which cost Rs 1000 each in India. Appendiceal stumps with a diameter up to 10 mm could be safely closed with endo-loops and the absence of any stump blowout or fistula favors their use in securing the appendiceal stump. Heikkinen TJ et al. [29] reported a randomized study for cost-effectiveness of laparoscopic appendectomy. The hospital cost for laparoscopic appendectomy was higher, but it offers significant cost savings from the rapid convalescence. Return to normal life and work was faster in the laparoscopic group (14 *versus* 26.5 days) [29].

There was no mortality reported in our study. Study done by Sartelli et al. [30] at global level reported mortality of less than one percent (0.28%) following appendectomy [30]. The overall reported mortality of appendectomy is very low and was estimated in a review of a large administrative database at 0.05% for laparoscopic appendectomy and 0.3% for open appendectomy, reinforcing the fact that laparoscopic appendectomy is a safe procedure.

Conclusion

Most cases of acute appendicitis can be treated laparoscopically. Laparoscopic appendectomy is equally safe as open appendectomy and can provide less postoperative morbidity in experienced hands. Laparoscopic appendectomy is a useful method for reducing hospital stay, complications and early return to normal activity. With better training in minimal access surgery now available, it can be recommended as a technique of choice for the management of acute appendicitis.

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