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Original Article

Laparoscopic Interval Appendectomy in Children – is it Still Relevant?

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Abstract

Introduction: Appendicitis is one of the most common conditions encountered by clinicians in pediatric population. Benefits of laparoscopic appendectomy in the acute setting have been largely advocated in the recent past due to significant post-operative complications seen with open appendectomy. However, gray areas remain as to when to go for laparoscopic interval appendectomy (LIA). In our study, we tried to identify a subset of pediatric patients who would benefit from LIA.

Purpose: The purpose of the study was to assess the role of Laparoscopy in Pediatric Interval Appendectomy at Department of General and Minimal Invasive Surgery, Government Medical College Srinagar.

Materials and Methods: A prospective and observational study involving 175 children who underwent management for acute appendicitis (AA) over a period of 2 years in our tertiary care institute.

Results: There were 175 children enrolled but only 51 were subjected to laparoscopy. Eight cases were excluded due to presence of additional intraoperative non-appendiceal findings. Rest 43 patients were included in the study and were subjected to LIA. All of them had previous history of an attack of AA. Age ranges from 2 to 14 years. There were 20 boys and 23 girls in the study group. Nineteen cases had some findings of AA at LIA and there were acceptable minor complications seen (three cases) during a mean follow-up period of 18 months.

Conclusions: LIA is safe and feasible surgical procedure which can be offered to patients where laparoscopy is not available in the emergency setting. LIA can be considered for as a day care procedure especially for the patients hailing from nearby places so as to decrease the in-patient hospital burden.

Key words: Appendicitis, Children, Laparoscopic interval appendectomy, Pediatric

INTRODUCTION

Appendicitis in the pediatric population remains the most common surgical condition.[1,2] The lifetime risk of developing appendicitis is reported to be 6.7% in females and 8.7% in males.[3] Acute appendicitis (AA) in children can be treated by conservative method or Surgical intervention based on the stage of appendicitis. Surgical intervention can be accomplished as an emergency procedure or as an elective procedure post-conservative management. In both situations, surgical intervention can be approached by the open appendectomy (OA), or the laparoscopic appendectomy (LA). In tertiary care institutions where the expertise is available, it can be accomplished by minimal invasive methods or by Robotics.[4] Benefits of LA in the acute setting have been largely advocated due to significant post-operative (PO) complications seen with OA.[5,6] LA in children in the acute setting has gained popularity within the last decade but require laparoscopic infrastructure and expertise available in the emergency setting. However, gray areas remain as to when to go for laparoscopic interval appendectomy (LIA). In our study, we tried to identify a subset of pediatric patients who would benefit from LIA.

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REVIEW OF LITERATURE

The first report on an operated case of appendix is described by Claudius Amyand (1681–1740).[7] In 1981, Semm performed the first LA.[8] Two German surgeons, Gotz *et al*. pursued Semm's purpose and established LA on a wide basis. Already in the early 90s, they had performed hundreds of appendectomies by this approach and perfected the technique. They even used it in patients with AA.[9] Kavic *et al*. concluded that in experienced hands, LA is a safe and efficient alternative to OA for the treatment of AA.[10] A systematic review of studies comparing laparoscopic and open appendectomies was performed by Sauerland *et al*. and published in 2002. The meta-analysis of 39 separate investigations concluded that wound infections were significantly reduced in LA (odds ratio 0.5), but abscess formation was significantly increased (odds ratio 2.8).[11] In the year 2011, Ching-Chung *et al*. retrospectively studied 177 children who underwent appendectomy from January 2000 to November 2004. The authors divided both groups of OA and LA into Simple appendicitis, perforated appendicitis, and appendicitis with abscess and found that the rate of complication was fewer in cases who underwent laparoscopic surgery among all stages but it took longer operating time (OT).[12] The British urologist Wickham was the first to use the term "minimally invasive surgery" and attracted significant attention when he published his visions about endoscopic procedures in 1987 in the British Journal of Urology. He predicted the paradigm shift in practical surgery that took place a little later: "Surgeons applaud large incisions and denigrate "keyhole surgery." Patients, in contrast, want the smallest wound possible, and we at Britain's first department of minimally invasive surgery are convinced that patients are right".[13]

MATERIALS AND METHODS

This was a prospective and observational study conducted in the Department of General Surgery, Government Medical College, Srinagar, Union Territory of Jammu and Kashmir from July 1st, 2020, to June 30th, 2022, for a period of 2 years. All patients in the pediatric age group from 6 months up to 14 years presenting with clinical, biochemical, and radiological evidence of appendicitis managed conservatively and were subjected to interval appendectomy were included. This also included patients of diagnostic laparoscopy where no cause of non-specific pain lower abdomen was found intraoperatively and appendectomy was done. Exclusion criteria included diagnostic laparoscopy where alternative cause of non-specific pain lower abdomen was found other than appendix, Parents/Guardian refusing consent for laparoscopic surgery, and any other medical condition contraindicating laparoscopic intervention.

Aims and Objectives

The aim of the study was to study the role of LIA in the management of pediatric appendicitis by studying parameters such as OT (minutes), total hospital stay (days), return to activity (usual playful), any additional intraoperative findings, requirement of PO analgesia, to determine early PO complications such as bleeding, infection, intra-abdominal abscesses, adhesion obstruction, and any other complication related to the procedure. All patients within the included age group were assessed by thorough history taking and clinical examination. The informant of the child was assessed for the reliability and was counseled properly. Clinical examination included general physical examination and per abdomen examination including inspection, palpation, percussion, and auscultation. Apart from base line investigations for general anesthesia such as complete blood count, kidney function tests with serum electrolytes, blood sugar, serology, electrocardiogram, and chest skiagram, patients were subjected to special investigation such as ultrasonogram abdomen (US), computerized tomography scan (CT), and magnetic resonance imaging whenever warranted. Parents/Guardian were counseled about the surgical intervention.

Pre-operative preparations for surgery included informed and written consent from the parents/guardian, patients were kept nil per oral 6 h before surgery, pre-anesthetic medication was given on the night before surgery, part preparation was done in the morning on the day of surgery, and single dose of IV Ceftriaxone was given at the time of induction. Surgical steps and technique of LA: The position of the patient, equipment and the surgical team: Supine Trendelenburg position (with his head down) sloping at 10°–15°, toward the operator. The operator and the assistant stood to the left of the patient, and the monitor was on the right of the patient. Procedures were performed under general anesthesia with Endotracheal Tube/Laryngeal mask airway. The bladder was emptied using a Foley catheter, which was removed immediately; older patients were advised to urinates immediately before the procedure. After making the umbilical incision, a pneumoperitoneum ranging from 6 mm Hg to 12 mm Hg depending on the age of the child was created with a Pediatric Veress needle. Classical 3 ports were placed as shown in the Figure 1a. Depending on the age of the child, one 5-mm/10-mm umbilical port was used for 5-mm/10-mm telescope, while the positions of the other ports vary according to the position of the appendix. Two working ports in triangulation, a 5 mm trocar in the upper right quadrant and a 5 mm trocar in the lower left quadrant were placed routinely or a supra-pubic trocar position, where a 5 mm trocar was placed in the lower right quadrant for the retrocecal positioned appendix.

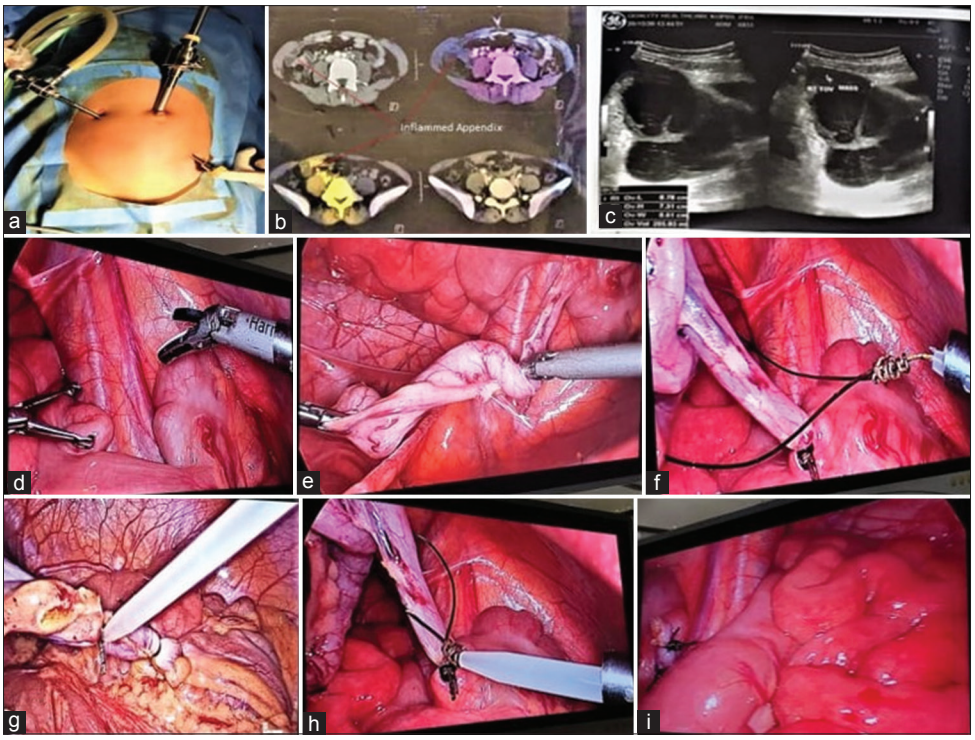

Figure 1: LIA picture (a) Port placements, (b) CECT abdomen, (c) USG abdomen, (d) localizing appendix, (e) taking down meso appendix, (f-h) securing endoloop, and (i) picture after appendectomy

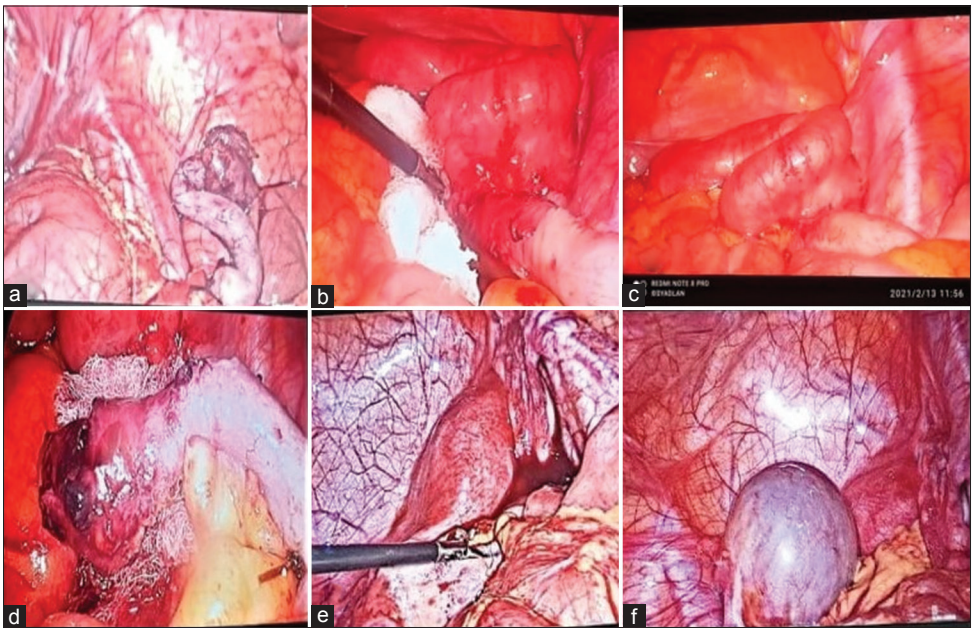

Figure 2: LIA with IO finding of AA or additional findings. (a-d) IO findings of acute appendicitis, (e) blood in pouch of Douglas, and (f) hemorrhagic ovarian cyst

Procedure: [Figure 1b-i and Figure 2a-d] the end of the appendix was seized by the grasper for the mesoappendix placed through the right lower abdominal 5 mm port. The mesoappendix was skeletonized from the top to the base using a 5 mm harmonic scalpel introduced through the left lower/supra-pubic trocar. After that, an endo-loop was introduced through the same trocar, two endo-loops/extracorporeal Roeder's knot using preformed polyglactin 910/chromic catgut sized 2-0/3-0 were passed over the tip of the appendix whereby the base is secured. Another endo-loops/extracorporeal Roeder's knot using preformed polyglactin 910/chromic catgut sized 2-0/3-0 was passed and secured 1 cm from the 2nd knot. The appendix was resected using harmonic

scalpel, leaving two ligatures on the base. The appendix was removed by introducing a sterile drip set cover through 5 mm supra-pubic/left lower quadrant trocar. The resected specimen was sent for the histopathological examination. PO Management: Antibiotic treatment was continued for 1-day postoperatively routinely, 2-day postoperatively if intra-abdominal serous fluid was signaled as intraoperative findings or 7 days along with amikacin and metronidazole when the appendix was found to be necrotic or gangrenous. Antimicrobial agents were eventually changed on the basis of the antibiogram report. PO analgesia requirement was guided by FLACC/Wong Baker pain scores. IV/IM analgesia was given till patient started taking orals. Oral analgesia was continued for as and when required; orals were started as the bowel movements returned; discharged once patient tolerated orals and wound was found to be healthy and healing well. Follow-up was done at week 1, week 3, and at 6-months PO. Stitch/clips were removed on week 1 follow-up. Check US was done at 3-week follow-up visit. Statistics: All the data were collected and analyzed for the parameters to be assessed and were compared with the global trends. The statistics were applied wherever indicated using Chi-square method and *P* value for statistical significance was calculated.

RESULTS AND OBSERVATIONS

Age of the patients in this study ranged from 2 years to 14 years with mean age of 8.23 years (98 months). There was a total of 20 (46.5%) male patients and 23 (53.5%) female patients. The male to female ratio was 1: 1.15. All patients presented with a history of pain abdomen during the acute episode of appendicitis. Thirty-five (81.3%) presented as pain RIF, 7 (16.2%) had history of classical migratory pain abdomen, and 1 (2.5%) patient had diffuse abdominal pain. Anorexia was documented in 8 (18.6%), nausea and vomiting in 22 (51.1%). Fever was seen in 17 (40%) patients. On examination, all 43 cases had tenderness on palpating RIF whereas only 10 (23.2%) patients had rebound tenderness. Thirty-four (79%) patients had their counts raised.

Based on the findings during intraoperative abdominal surfing, it was revealed that: In 19 patients, there were intraoperative findings suggestive of AA like congestion, engorged appendix, perforation at tip, flimsy adhesions with parities/omentum, peri-appendiceal adhesions, fluid/pus collection in pelvis, and around appendix. In rest of the 24 cases, the appendix appeared normal, long, mostly retrocaecal in position and in five patients, it was pelvic in position. Fecolith was present in eight cases with IO findings of AA and only in one case with no AA. ($P = 0.01$ Significant). The findings of AA were seen among younger children more than the older children. However, on applying statistics, it was found to be not significant ($P = 0.593$). When statistics were applied with respect to gender associated with intraoperative findings, it was again found to be not significant. ($P = 0.275$ for females and 0.242 for males). Eight cases excluded from the study due to additional findings belonged to older age group, majority (5/8 cases) were females. All three male cases had an open DIR of 2–3 mm. Three cases in this group had history of pigtail drainage during acute attack.

The overall mean surgical operative time calculated was 24.79 ± 4.9 min (SD). Mean surgical operative time was 27.10 ± 5.6 min (SD) for 19 patients having intraoperative findings of AA and 22.90 ± 4.58 min (SD) for cases with no such findings. Eight cases with additional findings who were excluded from the study had mean surgical operative timing of 32.90 ± 5.6 min (SD). There was no statistically significant difference in the OT for patients with and without intraoperative acute features of appendicitis ($P = 0.345$) but when statistics were applied for OT in cases with additional findings, it was found to be significant ($P = 0.01$) as shown in Table 1. There was a total of three PO complications seen during immediate PO period and all belonged to the group with IO findings of AA which included transient fever in one patient, port site infection in one case (history of positive for Severe acute respiratory syndrome (SARS) COVId in recent past) and PO pain abdomen without distension in one case. There were no intraoperative and long-term PO complications. Among the cases with additional findings, there were three complications seen. Two cases had transient fever and one case had PO ileus. Higher complication rates were seen among this group and when compared to the AA group, it was found to be statistically significant ($P = 0.044$) as shown in Table 1.

The mean hospital stays for study group patients who underwent LIA was 1.23 days. There was slight longer hospital stay for patients with additional findings (exclusion group) which was 1.62 days ($P = 0.001$, Significant). Nineteen cases with IO finding of AA required 76 doses whereas 24 cases with no finding suggestive of AA required 76 doses. ($P = 0.50$, Not Significant). Majority of the patients 26/43 (60.4%) were started with and tolerated oral feeds and were ambulatory 24 h postoperatively. Seventeen (39.5%) patients returned to normal activities by 12 h PO. One patient (2.32) took 36 h for return to his usual activities. This patient belonged to the group having features of AA intraoperatively. PO early return to activity at 12 h when compared between cases with different IO findings, it was found to be statistically significant ($P = 0.004$, Significant) but at 24 h, it was found to be not significant ($P = 1.0$) as show in Table 1.

Table 1: Operative time, complications, hospital stay, return to activity, and PO analgesia requirement

Laparoscopic interval appendectomy (Total 51 cases; 8 excluded from the study)			Intraoperative acute appendicitis	Intraoperative no acute appendicitis	Patients with additional findings
43			19	24	08
Mean operative time (Minutes)	24.79±4.9		27.10±5.6	22.90±4.58	32.90±5.6
Complications (Mean follow-up of 18 months)	Intraoperative	Bleeding hematoma injury to bowel	Nil	Nil	Nil
	Immediate post-operative	Transient fever	1	Nil	2
		Port site infection	1	Nil	Nil
		PO SAIO	Nil	Nil	1 (PO ileus)
	Late post-operative	PO Pain abdomen	1	Nil	Nil
		Port Site hernia	Nil	Nil	Nil
Total Complications Study group–3 (6.97%)			3	0	3
Hospital Stay (Overall 1.23 days)			1.42 days	1.08 days	1.62 days
PO Analgesia requirement (3.53 doses/patient)			4 doses/patient	3.1 doses/patient	4.1 doses/patient
Return to activity			5%<12 h 95%<24 h	65%<12 h 100%<24 h	0%<12 h 38%<24 h

*Statistics applied for additional findings w.r.t Operating Time (OT) was found to be significant (P=0.01), **No statistically significant difference in OT for patients with and without intraoperative acute features of appendicitis (P=0.345), ***Statistically significant complication rates were seen in additional finding group. (P=0.044)

DISCUSSION

AA in the pediatric population remains the most common surgical emergency[2] and the lifetime risk of developing appendicitis is reported to be 6%–8% among all ages and gender. The management varies from conservative, conservative followed by surgical and upfront surgical intervention which can be both by open or laparoscopic approach.[14] In this era of good antibiotics but non-availability of laparoscopy at peripheral health institutions patients with low Alvarado score can be offered LIA after conservative management of the acute episode.

OT

Multiple previous studies compared the OT of OA with LA and found OT for LA to be slightly longer. Majority of these studies involved complicated appendicitis. The OT in these studies for LA ranged from 30 min to just over an hour.[15-17] All 43 cases underwent LIA. The OT in our study was much less than the global trend due to the fact that we performed LIA in early stages even if the findings indicated AA as only 1 case revealed perforated appendicitis without overt clinical, biochemical, and radiological features. The OT is markedly increased during LA for perforated complicated appendicitis.[15] Eight cases with additional findings who were excluded from the study had longer mean surgical operative timing. The very fact that presence of additional IO findings especially in females increased the OT by almost 15 min. There was no statistically significant difference in the OT for patients with and without intraoperative acute features of appendicitis but when statistics were applied for OT in cases with additional findings, it was found to be significant.

PO Complications

There were a total of three complications seen during immediate PO period and all belonged to the group with IO findings of AA as shown in Table 1. The complication rate in our study is comparable to the LA for acute complicated appendicitis from the previous studies.[18-20] Among the cases with additional findings, there were three complications seen. Two cases had transient fever and one case had PO ileus. As expected, higher complication rates were seen among this group and was comparable to the complication rates for LA in acute complicated appendicitis.[21] When compared to the LIA group, it was found to be statistically significant. Our study had one case of port site infection which required incision and drainage. The same girl child had history of SARS Covid infection 3 months earlier. Current literature support increased pulmonary and non-pulmonary complication rate among patients who had SARS COVID infection.[22]

Hospital Stay

LA can be performed safely as an outpatient procedure in children with uncomplicated appendicitis. Complying with our institutional protocol all children undergoing operative intervention under general anesthesia were kept overnight for observation. In our study too, the mean hospital stays for study group patients who underwent LIA was 1.23 days. If we exclude 19 cases with IO findings of AA, it comes down to 1.08 days almost making it an out-patient procedure. There was statistically significant longer hospital stay for patients with additional findings (exclusion group) which was 1.62 days due to 2 days of hospital stay for such patients with PO minor complications which can be a factor for longer hospital stay as seen in few other studies.[23]

Requirement of PO Analgesia

LA is a common emergency pediatric surgery procedure accompanied by substantial pain (pain scores >4 for >60% of the time) in 33% of these patients.[24] This can be tackled by a bundle of pain management interventions

including local anesthetic infiltration at the incision site, intravenous (IV) opioids by patient-controlled analgesia and scheduled doses of IV, and oral analgesics. Majority of the patients in our study required only 3–4 doses of initially IV and later oral analgesia till the next morning of the day of surgery. The dose requirement was more for cases with IO findings of AA but was not statistically significant. Cases with additional findings required maximum doses but were in the exclusion group. The difference in dose requirement was also not dependent of the age and acute presentation of the patient.[12] This may be due to evenly distribution of the cases with IO findings of AA among different age groups. Overall, 43 cases in the study group required a cumulative 152 doses (mean 3.53 doses per patient).

Return to Activity

Return to activity was assessed based on the developmental milestones appropriate for the age. Acceptance of orals, joyful interactions with the parents and ambulation was considered as normal return to activity. Majority of the patients were started with and tolerated oral feeds and were ambulatory 24-h postoperatively. Many among them returned to normal activities by 12 h PO thus making us to think of considering LIA with no IO finding suggestive of AA a day care procedure as done by Akkoyun[25] One patient (2.32%) took 36 h for return to his usual activities. PO early return to activity at 12 h when compared between cases with different IO findings, it was found to be statistically significant (P = 0.004, Significant) but at 24-h, it was not significant (P = 1.0) and when compared among various age groups, it was again found to be statistically non-significant for children > 5 years of age. (P = 0.5). Since majority of our patients were having no IO evidence of AA the return to activity was much faster as compared to studies involving cases with AA.[12,23]

Clinical, Radiological and Intra-operative Findings

It was added information gathered by this study to analyze the results of the clinical examination, US, and intraoperative findings Despite being a relatively common condition, the diagnosis of appendicitis in children can prove to be challenging in many cases. Presenting signs and symptoms, laboratory tests, and imaging studies such as US and CT abdomen form the diagnostic work-up of appendicitis. In spite of various composite measures based on multiple sources of diagnostic information, as well as the utility of clinical pathways as a means to streamline the diagnostic process the diagnosis still remains on the clinical judgment of the treating physician with respect to mode of treatment whether conservative of surgical.[26] While CT is the most accurate mode of imaging in suspected appendicitis, the accompanying radiation is a concern. Ultrasound may help in the diagnosis while decreasing the need for CT in certain circumstances. The Alvarado Score has good diagnostic utility at specific cut-off points. Laboratory markers have very limited diagnostic utility on their own but show promise when used in combination. Further studies are warranted for laboratory markers in combination and to validate potential novel markers. We did not routinely do CT owing to the risk of radiation exposure to small children and performed only in case of diagnostic dilemma. In a study Calprotectin, Serum Amyloid A, C-reactive protein, and total leucocyte counts were significantly elevated in patients with AA. However, none had cutoff points that could accurately discriminate between AA and other pathology in patients with suspected AA. In our study, we relied on modified Alvarado score supplanted by US abdomen for diagnosing AA and managed the cases as per the algorithm mentioned in materials and methods [Figure 3] and subjected 43 cases to LIA. The difference in detecting acute features was statistically significant between intraoperative findings and radiology/clinical findings (P = 0.01 and 0.0007, respectively) but not significant when clinical examination was compared with radiology. (P = 0.27). As per the study done by Karakas *et al*., there is no statistical significance between the rates of diagnostic performance of US, CT, or their combination, nor between the negative appendectomy rates of each group, but the rate of perforation was significantly higher when CT was performed, alone or after US. Thus, CT should be done in cases with diagnostic dilemma or localized/diffuse peritonitis indicating perforation.[27] Cosmetic excellence: Laparoscopy scores significantly over scar formed after LIA in small children. Majority of the port site scars were found to be almost invisible at 12-week follow-up PO.

LA seems to be a more successful procedure for children, as long as their abdomens can physically support laparoscopic procedures. Another new area of potential benefit of laparoscopy is its ability to be diagnostic, especially with reference to gynecological conditions. A study looking at unnecessary appendectomies in women found that in situations where a healthy-looking appendix was found and a gynecological diagnosis existed. In a study by Sauerland R *et al*., non-appendiceal lesions were identified in 10% of patients.[28] In our study, we encountered additional findings in 19% of patients which included gynecological in females and open DIR in males. Conservative management of advanced complicated appendicitis in children is becoming more common. Mostly LIA is reserved for appendiceal mass or abscess in developed countries and metropolitan cities in developing countries.[29] Since India is at developing stage with respect to its health-care delivery system at peripheral health institutions and non-availability of laparoscopic infrastructure in emergency setting in such regions, LIA is

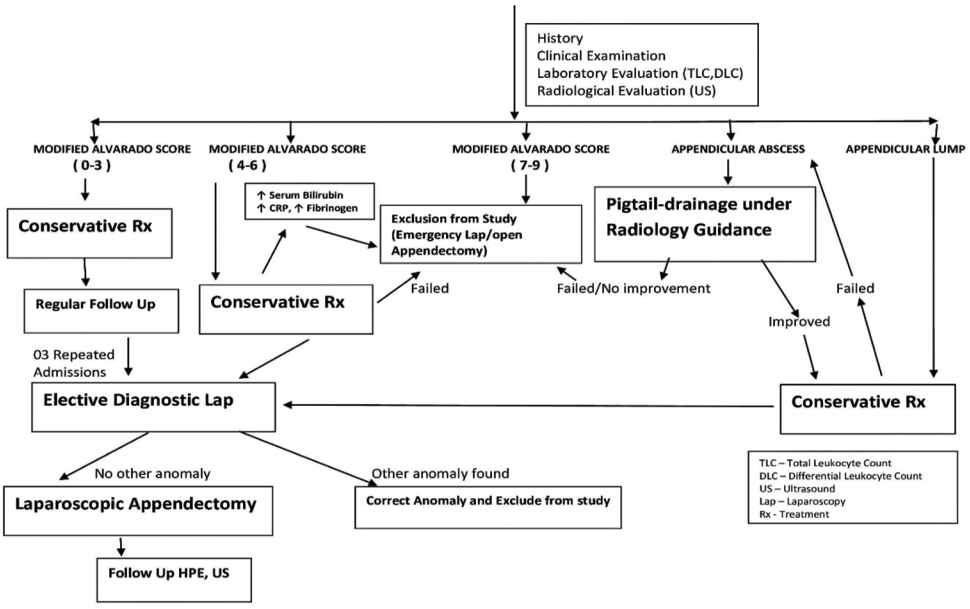

Figure 3: Highlighting management of pediatric appendicitis by Laparoscopic Interval Appendectomy (LIA)

a viable option available in the interest of the patient and health-care delivery where majority patients can be offered initial conservative methods to avoid all the complications of OA followed by LIA as seen in our study. Interval LA eliminates the risk of recurrent appendicitis too and serves to excise undiagnosed carcinoid tumors. In future, it may be possible to perform interval LA as a day-care procedure in selected patients.

CONCLUSION

AA in the pediatric population remains the most common surgical emergency and is reported among all ages and gender. Modified Alvarado Score supplanted by US abdomen is a useful pre-operative diagnostic tool in the treatment of pediatric appendicitis and non-specific pain lower abdomen. LIA has very good cosmetic outcome, less PO pain, early return to activity, acceptable PO complications, comparable operative time, and negligible requirement of intra/PO blood products. LIA is safe and feasible surgical procedure which can be offered to patients where laparoscopy is not available in the emergency setting. LIA can be considered for as a day care procedure especially for the patients hailing from nearby places so as to decrease the in-patient hospital burden.

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