Evaluation of laparoscopy in the management of the suspected cases of acute appendicitis

Elsayed Abdullah[a], Selmy Awad[b], Saleh Alghamdi[b], Shaker Alfaran[b], Khaled Alsubaie[b], Nawal Alotaibi[b], Mohamed S.A. Sheishaa[a]

[a]Department of General Surgery, Mansoura University Hospitals, Mansoura, Egypt, [b]Department of General Surgery, King Faisal Medical Complex, TAIF/Saudia Arabia

Correspondence to Selmy Awad, MD, MRCS, Department of General Surgery, Mansoura University Hospitals, Mansoura 35516, Egypt. Tel: +20 966 556 466 097/+20 103 003 6362; fax: +2 050 2202834; e-mail: selmysabry2007@yahoo.com

Received: 28 August 2020
Revised: 17 September 2020
Accepted: 18 September 2020
Published: 18 May 2021

The Egyptian Journal of Surgery 2021, 40:63–72

Context
Differential diagnosis of right lower quadrant abdominal pain is a major public health problem. The clinical features and special investigations are all nonspecific, and the list of differential diagnosis is long indeed. One-third of unnecessary appendectomies performed in women of child-bearing period are avoidable by emergency diagnostic laparoscopy.
Aim
The aim was to evaluate the role of laparoscopy in diagnosis of causes of acute lower abdominal pain, which mimic acute appendicitis and perioperative outcome.
Settings and design
During the period from April 2014 to April 2018, this prospective study was conducted at Mansoura Emergency and University Hospitals, Department of General Surgery, on 60 patients having suspected acute appendicitis.
Patients and methods
Laparoscopy was done for all patients of suspected acute appendicitis for diagnostic and therapeutic purposes.
Statistical analysis used
Careful analysis of the data was done using Statistical Package for the Social Sciences program, version 26.
Results
Diagnostic laparoscopy was able to settle the correct diagnosis in 58 (96.6%) patients with high diagnostic accuracy. Moreover, it was able to save patients from unnecessary explorations. Operative time for the studied patients was a mean of 35.1±4.9 min.
Conclusion
Clinical diagnosis and laparoscopy were complementary in diagnosis of acute appendicitis and acute right lower abdominal pain. Laparoscopic assessment was advantageous in cases of diagnostic uncertainty. laparoscopic appendectomy caused fewer complications, diminished pain, shortened convalescence, and reduced hospital stay. Removal of an apparently normal appendix was recommended if no other pathology was found at laparoscopy.

Keywords:
acute appendicitis, laparoscopy, management, suspected

Egyptian J Surgery 40:63–72

1110-1121

Introduction

Appendicitis is the most common acute surgical condition of the abdomen. Approximately 7% of population will have appendicitis in their life time, with the peak incidence lying between the ages of 10 and 30 years [1]. Early in the fourth decade in this century, Sir Zachary Cope [2] advised extension of abdominal exploration for doubtful cases of acute abdomen.

The clinical diagnosis of acute appendicitis is unreliable in spite of numerous attempts to improve diagnostic accuracy. The rate of negative exploration of young females is still in the range of 25–30%. Although open appendectomy (OA) is considered a minor operation, it is associated with postoperative pain and affects daily activities [3].

Although advances in surgical science in the last decades have dramatically diminished the mortality related to appendicitis, the operation of appendectomy itself is still unchanged since 1880. Recently, laparoscopic techniques have been applied to a variety of abdominal procedures that were performed traditionally via an open technique [4,5].

The use of laparoscopy in the differential diagnosis of acute abdominal pain syndrome is well established. Laparoscopic appendectomy (LA) has been

recommended to overcome the many cases of difficult diagnosis. Many factors and conditions may contribute toward the misdiagnosis of the reported incidence of negative laparotomy of acute appendicitis; therefore, abnormal position, basal pleurisy, right renal colic, and, especially in female patient, disease of right pelvic adnexa add to the difficulties of differential diagnosis [6]. Laparoscopy has long been a standard form of investigation for gynecologic disease but has only recently been introduced in general surgery [7].

Despite the rapid proliferation of laparoscopic technology into various specialties of general surgery, LA has not shared the widespread acceptance of laparoscopic cholecystectomy. Perhaps the most fundamental reason is skepticism concerning its ability to improve upon the traditional small incision generally employed for OA. Generally, patients do not demand LA as they do for laparoscopic cholecystectomy [8].

However, the use of laparoscopic technique in patient with acute low abdominal pain affords many advantages, as it has been shown that up to 30% of appendectomies are unnecessary. The use of diagnostic laparoscopy has been reported to be a safe, simple, and efficient method in the evaluation of patients with an acute abdomen. It is highly precise in detecting pathology and can be used as a therapeutic tool [9].

Moreover, recent literature studies have demonstrated that diagnostic laparoscopy can lower the number of negative laparotomies for suspected acute appendicitis. Moreover, LA emphasizes the advantage of laparoscopic surgery, through decreased hospitalization, paralytic ileus, postoperative pain, and wound complications, including infection [10]. The aim of this prospective study was to evaluate the role of laparoscopy in diagnosis of acute appendicitis and other causes of acute lower abdominal pain which mimic acute appendicitis and also to evaluate the LA regarding operative time, hospital stay, postoperative discomfort, and complications.

Patients and methods

During the period from April 2014 to April 2018, this prospective study was conducted at Mansoura Emergency and University Hospitals, Department of General Surgery, on 60 patients having suspected acute appendicitis. The clinical study was approved by the Ethics Committee of Mansoura Faculty of medicine and was conducted according to the declaration of Helsinki. All participants granted written informed consent prior to enrollment in this study. All patients who were suspected to have acute appendicitis (the classic features of acute appendicitis were lacking, Alvarado score 4–6 or less), had fitness for laparoscopy, and had age of 15–45 years old were included in the study. Definite cases of appendicitis (clinical and laboratory) (Alvarado score $\geq$7), complicated appendicitis, and unfitness for laparoscopy were excluded from the study.

All admitted patients were subjected to the following: full clinical assessment, general examination for all systems of the body, abdominal examination, routine laboratory investigation including complete blood count (including total and differential leukocytic count) and C-reactive protein (CRP), and abdominal ultrasound (US) and plain radiography of the abdomen. The Alvarado [11] score was used to assist in diagnosis of definite appendicitis. A total of 10 points are assigned for eight factors, with two points assigned to the most impactful (right lower quadrant tenderness and leukocytosis) as follows: right lower quadrant tenderness (+2), leukocytosis (>10k) (+2), migration, left shift, temperature (>37.3), anorexia-acetone, nausea-vomiting, rebound pain, and rectal tenderness.

After these clinical, laboratory, and radiological evaluations of all these patients, a provisional diagnosis was settled, and according to it, treatment was determined as follows:

(1) Patients who fulfilled the exclusion criteria, non-laparoscopic management was done (either conservative or open surgery).
(2) Patients who fulfilled the inclusion criteria, laparoscopic management was done. Laparoscopic diagnosis was done for patients in whom diagnosis was not confirmed or still equivocal by clinical, laboratory, and radiological examination.

All the diagnostic laparoscopies were done under general anesthesia with muscle relaxation and controlled ventilation. The peritoneal cavity was insufflated by a controlled amount of CO_2 gas delivered through an open or closed technique within the area of the umbilicus. The main trocar '10 mm' was inserted in the 1ry site of the insufflation. The laparoscope was inserted through the trocar cannula. Another two or three 5-mm trocars were inserted under direct laparoscopic vision.

The cecum was manipulated and displaced to visualize the appendix. The appendix was inspected for criteria

of inflammation. The female genital system was examined for detection of any pathology. If nothing was found, the gallbladder was also examined. Once the diagnosis of acute appendicitis was confirmed, an appendectomy was done. Laparoscopic criteria of acute appendicitis included the following [12]:

(1) Congested edematous appendix.
(2) Acute gangrenous appendix.
(3) Inflamed cecal pole.
(4) Adherent greater omentum in the right iliac fossa without any other visible cause.
(5) Turbid fluid in the pelvis without any other cause.

Operative assessment, including diagnosis, operative time, and operative details, was done. Postoperative care and follow-up were as follows:

(1) Histopathological examination of the removed appendix was done.
(2) Routine postoperative care regarding antibiotics, analgesia, fluid therapy, and initiation of oral intake was done, and the patient was discharged after one day unless morbidity was seen.
(3) Follow-up of the patients for 3 months was done in the surgical outpatient clinic regarding wound infection and port site hernia.

Careful analysis of the data was done using Statistical Package for the Social Sciences program, version 26 (IBM SPSS Statistics for Windows, Version 26.0. Armonk, NY: IBM Corp.). The quantitative data were presented in the form of mean and SD, and Student *t*-test was used as a test of significance in the study. The qualitative data were presented in the form of number and percentage, and χ^2 test was used as a test of significance in the study. Sometimes, some quantitative data were transformed into qualitative data. Significance was considered when *P* value less than 0.05.

Results

During the period from April 2014 to April 2018, this prospective study was conducted at Mansoura Emergency and University Hospitals, Department of General Surgery, on 60 patients having suspected acute appendicitis.

Clinical evaluation results

History

(1) Regarding sex, this study included 60 patients, comprising 36 (60%) females and 24 (40%) males, as shown in Table 1.
(2) Regarding age, it ranged from 15 to 45 years, with a mean of 28.7±8.3 years, as shown in Fig. 1.

Symptoms

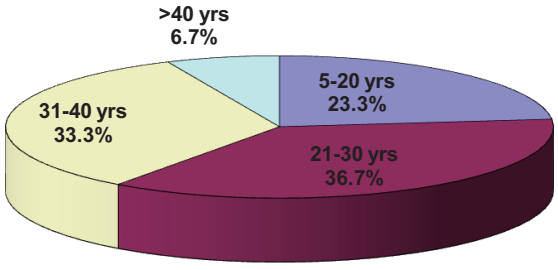
All patients complained of acute pain in the right lower abdominal quadrant. Most of the studied patients complained of one or more of the upper gastrointestinal symptoms; nausea was the most frequent. Lower gastrointestinal symptoms and urological symptoms were infrequent. Gynecological symptoms were not common. These symptoms are shown in Table 2. Classic migratory pain (which starts centrally around the umbilicus then shifts to RLQ) was absent in our studied group, and if it was present, it was considered as significant exclusion criteria, and the patients were excluded from the study, and non-laparoscopic management was done.

Clinical examination results

General signs:

(1) Temperature: the temperature of studied patients ranged from 36.5–39°C. The mean temperature was 37.2±0.7°C. Table 3 shows the temperature distribution in the studied patients. Most of the patients were afebrile, whereas 33.3% had moderate elevation of body temperature.

Figure 1



Age distribution of the studied patients.

Table 1 Sex distribution of the studied group correlated with their final diagnosis

Number of patients (60 patients)	%	Appendicitis			
		Positive cases	%	Negative cases	%
36 females	60	30	83.5	6	16.5
24 males	40	22	91.5	2	8.5

Table 2 The presenting symptoms of the studied patients

Symptoms	All cases [*n* (%)]	Appendicitis [*n* (%)]
Right lower quadrant pain	60 (100)	52 (100)
Anorexia	32 (53.3)	28 (53.8)
Nausea	40 (66.6)	34 (65.4)
Vomiting	40 (66.6)	34 (65.4)
Loose motions	14 (23.3)	12 (23.1)
Constipation >24 h	14 (23.3)	14 (26.9)
Dysuria	8 (13.3)	8 (15.4)

Table 3 Temperature pattern in the studied patients

Temperature	Total cases [*n* (%)]	Appendicitis [*n* (%)]
Normal (36.5–37.2°C)	38 (33.3)	30 (57.69)
Fever (37.3–38.5°C)	20 (33.3)	20 (38.46)
Fever >38.5°C	2 (3.3)	2 (3.84)

(2) Pulse: the pulse rate of the studied patients ranged from 70 to 110 beats/min. The mean pulse rate was 86.8±6.6 beats/min. Approximately two-thirds of the patients had normal pulse rate (60–90 beats/min). The pulse rate distribution is shown in Table 4.

Abdominal signs: The physical signs in the studied patient are illustrated in Table 5. Right iliac fossa tenderness was found in most of the patient (83.3%). Cough tenderness was present in ~70% of cases.

Investigations

(1) Laboratory investigation results: laboratory findings for all patients' fitness were within normal fulfilling the inclusion criteria.

The following laboratory tests were used as diagnostic tests for appendicitis:

Total leukocytic count: it was within normal average of 10 000 cells/mm^3 in seven patients, and it was above normal average in 23 patients, as shown in Table 6.

Neutrophils percentage

The neutrophils were within normal average in two patients and more than normal average in 28 patients, as shown in Table 7.

CRP

CRP was done for all patients. It was normal in four patients and above normal in 26 patients, as shown in Table 7.

(1) Radiological investigation results: ultrasonography and plain radiography of abdomen were done for all patients, and they were normal in all studied patients.

Table 4 The pulse rate of the studied patients

Pulse rate	Total cases [*n* (%)]	Appendicitis [*n* (%)]
70–90/min	38 (63.3)	30 (57.69)
91–100/min	20 (33.33)	20 (38.46)
>100/min	2 (3.3)	2 (3.84)

Table 5 Abdominal signs in the studied group

Abdominal signs	Total cases [*n* (%)]	Appendicitis [*n* (%)]
Tenderness in right iliac fossa	50 (83.3)	44 (84.6)
Cough tenderness	42 (70)	40 (76.9)

Table 6 Distribution of total leukocytic count in the studied group

	<10 000 cells/mm^3 [*n* (%)]	>10 000 cells/mm^3 [*n* (%)]
Total leukocytic count	14 (23.5)	46 (76.3)

Table 7 Distribution of neutrophils in the studied group

Parameters	Normal average	%	Above normal average	%
Neutrophils	4	6.5	56	93.5
CRP	8	13.5	52	86.5

CRP, C-reactive protein.

Laparoscopic management results

(1) Diagnostic laparoscopy: it was done for all patients (60 patients) and the laparoscopic diagnostic criteria results of the appendix are shown in Table 8.
(2) LA: it was done for all patients (60 patients) to evaluate the histopathological examination of the specimens and the role of laparoscopy as diagnostic and therapeutic tool.

Operative assessment results

(1) Intraoperative complications: one (1.7%) case had a major intraoperative complication during introduction of the trocars of laparoscopy, leading to severe intraperitoneal hemorrhage, so completion of laparoscopy was impossible, and conversion to open procedure to control bleeding was mandatory.
(2) Operative time: operative time for our studied patients ranged from 25 to 45 min, with a mean of 35.1±4.9 min.

Postoperative care and follow-up results

(1) Postoperative complications: two (3.3%) cases of our studied patients were complicated by spread of

Table 8 The laparoscopic diagnostic criteria results of the appendix

Pathology	*n* (%)
Noninflamed	10 (16.6)
Inflamed [12]	50 (83.4)

Table 9 Postoperative complications

Postoperative complication	*n* (%)
Spread of infection	2 (3.3)
Fever	6 (10)
Distension	10 (16.7)
Vomiting	14 (23.3)
Port site infection	8 (13.3)

Table 10 Hospital stay, introduction of diet and return to work

	Minimum	Maximum	Mean	SD
Hospital stay (h)	24	168	32.8	27.2
Introduction of diet (h)	6	20	11.5	3.5
Return to work (weeks)	1	3	1.8	0.4

infection that manifested by postoperative elevating of body temperature to higher degrees and mild amount of free fluid in the abdomen (by US), and this case was treated conservatively. All patients of our study were complicated by mild postoperative pain that was relieved by greater than or equal to 2 injections of Diclofenac sodium ampoules. Need for Diclofenac ampoules ranged from 2 to 4 ampoules, with mean of 2.7±0.5 ampoules, as shown in Table 9.

(2) Postoperative care:
   (a) Regarding the hospital stay (h), it ranged from 24 to 168 h, with a mean of 32.8±27.2 h.
   (b) Introduction 3 of diet was started postoperatively once intestinal sounds were heard. Usually, it was started in the range of 6–20 h postoperatively, with a mean of 11.5±3.5 h.
   (c) Return to work was encouraged postoperatively in a period ranged from 1 to 3 weeks with a mean of 1.8±0.4 weeks, as shown in Table 10.

Histopathological examination results of the appendix

The removed appendix was histopathologically examined, and the results of all specimens (60 specimens) are shown in Table 11.

Causes of RLQ pain in negative cases

The causes of pain in our four histopathologically negative cases for appendicitis are shown in Table 12.

Correlation of results

(1) Laboratory results and histopathological examination results

Table 11 The histopathological examination results of the appendix

	n (%)
Acute catarrhal inflammation	24 (40)
Acute suppurative	24 (40)
Acute gangrenous	4 (6.5)
Noninflamed normal appendix	8 (13.5)

Table 12 Causes of RLQ pain in negative cases

Diagnosis	*n* (%)
Right simple ovarian cyst	4 (6.5)
Nonspecific diagnosis	4 (6.5)

RLQ, right lower quadrant.

Histopathological examination was done for all cases to confirm the diagnosis, and the appendix was positive in 52 patients and negative in four patients.

   (a) For the histopathological positive cases, the laboratory investigations are shown in Table 13.
   (b) For the histopathologically negative cases,
      (i) In two patients, total leukocytic count (TLC) and neutrophil and CRP were all negative.
      (ii) In four patients, the neutrophil only was high, whereas TLC and CRP were normal. In these four patients, right simple ovarian cysts were discovered during operation.
      (iii) In the last two patients, neutrophil and CRP were high and TLC was normal.
   (c) Clinical significance of laboratory parameters: sensitivity, specificity, positive predictive value, and negative predictive value of TLC, neutrophil, and CRP are shown in Table 14.

(2) Laparoscopic diagnostic criteria results and histopathological examination results:

The histopathological examination confirmed the diagnosis in all laparoscopically inflamed appendices, but in the five cases considered laparoscopically non-inflammed, the histopathological examination concluded the presence of mild inflammation 'catarrhal' only in one case, as shown in Table 15.

Discussion

Although acute appendicitis is the most common acute abdominal disorder requiring urgent surgery, its diagnosis in many occasions is often difficult. The ultimate goal in the management of acute right lower abdominal pain is to have a nearly perfect diagnosis and to have the surgical intervention

done – if needed – in the appropriate time. Unfortunately, the classic features of acute appendicitis are often lacking, and negative appendectomy rates of 20% are not uncommon [13].

No other area of general surgery reports a comparable rate of misdiagnosis as acute appendicitis, which is quite challenging. The reasons for these errors are as follows: first, acute appendicitis can clinically mimic a large variety of conditions; and second, before sonography, there was no specific imaging modality that could accurately determine the diagnosis, but it is not totally reliable [14].

In an attempt to increase the diagnostic accuracy rates of acute appendicitis, many diagnostic tools have been evaluated; the clinical diagnosis is usually assisted by routine white cell count and urine examinations. Careful hospital observation in selected cases of suspected appendicitis has been demonstrated to involve minimal risk for the patient. If the symptoms then do not improve, or if they progressed, surgical intervention is indicated. Such a conservative approach in the management has resulted in decreased rate of negative laparotomy cases, without increased morbidity or perforation rate [15].

A review of the preoperative signs and symptoms failed to identify one factor that was universally present or absent in all those with appendicitis. Several authors have attempted to improve diagnostic accuracy by means of a symptom/physical signs score [16].

In our study, all patients admitted to emergency department underwent clinical, laboratory, and radiological evaluation. A provisional diagnosis was settled, and according to it, treatment was determined accordingly.

Classic findings for acute appendicitis consist of peri-umbilical pain that migrates to the right lower abdominal quadrant and physical findings that reveal focal peritoneal signs over Mc Burney's point. Although an elevated temperature is often associated with intra-abdominal infections, the sensitivity and specificity of this test vary greatly. There is insufficient evidence to correlate temperature with the cause of abdominal pain [3].

In our study, all patients complained of acute pain in the right lower abdominal quadrant. Most of the patients were afebrile, whereas 33.3% had moderate elevation of body temperature. The pulse rate of the studied patients ranged from 70 to 110 beats/min. The mean pulse rate was 86.8±6.6 beats/min. Approximately two-thirds of the patients had normal pulse rate (60–90 beats/min). Right iliac fossa tenderness was found in most of the patient (83.3%). Cough tenderness was present in ~70% of cases. All of the previous data were insignificant in diagnosis.

Table 13 Laboratory investigations for histopathological positive cases (52 patients)

Parameters	*n* (%)
Increase in TLC alone	2 (3.8)
Increase in neutrophil alone	0
Increase in CRP alone	6 (11.5)
Increase in TLC and neutrophil	4 (7.7)
Increase in TLC and CRP	8 (15.5)
Increase in neutrophil and CRP	2 (3.8)
Increase in TLC and neutrophil and CRP	30 (57.7)
Normal range of TLC and neutrophil and CRP	0
Total	52 (100)

CRP, C-reactive protein; TLC, total leukocytic count.

Table 15 The correlation between laparoscopic criteria results and histopathological examination results

Histopathological results	Laparoscopic diagnostic results	
	Positive cases [*n* (%)]	Negative cases [*n* (%)]
Acute catarrhal	11 (36.6)	1 (3.3)
Acute suppurative	12 (40)	0
Acute gangrenous	2 (6.6)	0
Noninflamed normal appendix	0	4 (13.3)

Table 14 The correlation between the parameters

Groups	Parameters	Sensitivity (%)	Specificity (%)	Positive predictive value (%)	Negative predictive value (%)
1	TLC	44	50.2	60.5	29
2	Neutrophil	47.8	70	85.1	21.3
3	CRP	64.1	75.2	93.2	20.6
4	TLC and neutrophil	82	71	92.7	41.2
5	TLC and CRP	80	75	91.4	40.9
6	Neutrophil and CRP	74.2	87	89.3	39.2
7	Neutrophil and TLC and CRP	41	88.5	95.7	19.3

CRP, C-reactive protein; TLC, total leukocytic count.

Preoperative laboratory tests often aid surgeon with decision making in patients with appendicitis. Measuring body inflammatory agents such as CRP, interleukin-6, phospholipase A2, leukocyte elastase, and white cell count may avoid unnecessary operations by up to 30–40% [17].

The total white cell count is commonly used in the diagnosis of right iliac fossa pain. Results of its diagnostic role vary from useful to misleading. Elevated neutrophil ratio supports the diagnosis of acute appendicitis [18]. In five previous studies [17], the sensitivity of the total white cell count in acute appendicitis has been between 60 and 90% and the specificity between 41 and 84%.

In our study, the upper limit of normal total white cell count was taken as 10×10^9/IL in accordance with local reference values. The sensitivity and the specificity of the total white cell count in acute appendicitis were 44 and 50.2%, respectively, and these attributed well to the values from the previous study and were not significantly different from it. Moreover, the study showed that the elevation of neutrophil count was observed, and the probability of acute appendicitis was increased in patients in the clinically suspected acute appendicitis. Thus, neutrophil count appears to be a good parameter for diagnosis of acute appendicitis in primary health care setting because it is 47.8% sensitivity and 70% specificity.

CRP has been noted to be significantly elevated quantitively in clinically and histopathologically confirmed cases of acute appendicitis, with sensitivity between 64 and 75% and a specificity between 56 and 82% [17]. In our study, with the elevation of CRP in patients with clinically suspected acute appendicitis, the sensitivity was 64% and the specificity was 75%, and positive predictive values increased in diagnosis of acute appendicitis.

An elevated CRP level, in combination with an elevated white blood cells count and neutrophil, is highly sensitive (95–100%). The triple test is recommended as a help in avoiding significant rate of negative laparotomies in patient suspected of having acute appendicitis [19]. In our study, the TLC, neutrophils count, and CRP when increased together in the patient with suspect acute appendicitis, the sensitivity was 41% and specificity was 88.5%, and positive predictive values increased in diagnosing acute appendicitis.

In 1987, Seymour Schwartz [20] warned, 'We will have to see whether the routine use of US improves the accuracy of clinical diagnosis in the treatment of acute appendicitis'. A protocol of this study was designed to perform plain x-ray of the abdomen and ultrasonographic examination to all patients with suspected acute appendicitis. Both of them were of limited value in our study; moreover, most of the findings were nonspecific.

Since endoscopic examination of the peritoneal cavity was introduced by Kelling, it has become part of the gynecological practice, but its widespread use awaited development of better instruments and the introduction of fiberoptics in the mid-1960s [21].

Laparoscopy now is well established in emergency and elective gynecology, but general surgeons with a few exceptions have been reluctant to adopt the technique. It is recommended in all patients especially young fertile women with suspected appendicitis. If the surgeon is clinically certain of the diagnosis in a male, then he/she is justified in performing an appendectomy. In a female, he or she is advised to re-examine the evidence [22–24].

Several authors examined the value of diagnostic laparoscopy in acute abdominal pain that is suspected as acute appendicitis. Laparoscopy detected the correct diagnosis 85 of 85 times to give a sensitivity of 100% [25].

Leape and Ramenofsky [26] performed preoperative diagnostic laparoscopy for 32 cases of query appendicitis, and the disease was proved endoscopically in 53%, other diagnosis was found in 25%, whereas 22% were normal. The negative appendicectomy rate was decreased from 10 to 1%. Olsen *et al*. [27] studied the role of preoperative laparoscopy in cases of acute appendicitis and found that the unnecessary appendicectomy in sure clinical appendicitis cases without laparoscopic diagnosis was 11 out of 30 cases (36.67%), whereas it was two (6.67%) cases of the laparoscopied 30 cases.

In our study, laparoscopy was done for all cases for two purposes: diagnostic and therapeutic. Laparoscopy successfully diagnosed 50 of 60 cases as having an inflamed appendix; the other 10 cases were diagnosed as noninflamed appendix. The possible cause for abdominal pain in the 10 cases having noninflamed appendix was a right simple ovarian cyst in four female cases and the other six cases had no specific pathology.

Inability of laparoscopy to make a correct diagnosis of appendicitis when the serosa is not involved was reported. One study noted a small (3%) but real incidence of false-negative laparoscopic examination for appendicitis [28,29].

A previous study has supported the tendency to remove an apparently normal appendix, and the authors were satisfied with diagnostic laparoscopy to exclude appendicitis [30]. In our study, all macroscopically positive cases for appendicitis (50 cases) by laparoscopy had confirmed pathologically. There was a false-negative case of the macroscopically negative cases (10 cases) by laparoscopy, confirmed pathologically to be affected. Based on this result, we cannot rely on to take the decision of appendix removal owing to the little number of the cases of the study, and this necessitates a wide survey of the study on a large number of cases. The hands of relatively inexperienced laparoscopists also may be a cause.

LA has been reported in the literature [31] in more than 1200 patients with acute appendicitis and was found to be a safe technique and revealed that conversion rate varied from 0 to more than 27% [32]. In our study, there was no real incidence of technical difficulties encountered during the procedure, as it was easy to find and to dissect the appendix safely. In our study, there was a minor bleeding in 59 cases which did not affect the procedure and was easily controlled, and no conversion to open procedure was thus required. The only case, in our study, developed major complication in the form of life-threatening internal hemorrhage during placement of the suprapubic trocar, and this necessitated conversion to open where successful hemostasis was done and the patient passed well.

No other major complication was encountered. There was no inadvertent puncture to any viscera or electro-cautery injuries. In our study, the conversion rate was 1.7%. It was mandatory to control the life-threatening intraoperative hemorrhage. This percent was not sufficient enough to judge the conversion rate in our study because of the small number of the studied patients.

Reports of very short operative time in cases of LA may be misleading; some may exclude times taken to set up equipment, establish a pneumoperitoneum, and carry out diagnostic laparoscopy [31]. In our study, we had calculated the operative time from the start of induction of pneumoperitoneum till the placement of intra-abdominal drain and closure of the tinny slits of the ports, excluding times taken to set up equipment. Besides, like any other new surgical procedure, the operative procedure is more time consuming during the early learning curve.

The operating times have generally decreased as surgeons gained experience with the procedure. Several studies have shown that experience gained by the surgeon with each LA decreases the duration of the operation [31]. In our study, the operative time decreased from about 45 min early in the study with the first 10 cases to ~25–30 min with the last 10 cases. This was owing to gaining more experience with the progress of the study.

A comparative study showed that the operative time was similar between the OA and LA groups, and the length of the hospital stay was equivalent [33]. In this study, operative time was ranged from 25 to 45 min, with mean of 35.16±4.99 min, and this time was not significantly different from the previous reported study [30]. In the current design of the study, we planned for evaluation of the technique and not to compare it with OA. In our study, return to work was encouraged postoperatively in a period ranged from 7 to 21 days, with a mean of 12.6±2.8 days, and this time was not significantly different from a previous reported study [30].

LA caused less pain and less demonstration of required analgesia than that of the acute post-surgical settings. The incidence of postoperative symptoms of nausea, vomiting, and ileus was minimal in LA. Early toleration of regular diet was early in LA, as there was rapid return of intestinal function [34]. In the present study, our findings support these results.

The incidence of postoperative intra-abdominal abscess formation following LA had been reported. As LA is performed within the abdominal cavity, the contamination at the time of appendiceal traumatization may contribute to intra-abdominal abscess formation [32]. In this study, two cases developed spread of infection (3.33%), and both cases were treated by intensive course of antibiotic for 5–7 days and passed very well. The difference was not statistically significant with that reported by the previous study.

One of the most important argument for LA has therefore been reduction in wound infection. Richards *et al*. [35] detailed the incidence of wound infection after LA and OA and clearly demonstrated

the paucity of wound infection after LA. In OA, the appendix is removed either outside the abdominal wound, and contamination of the field is likely to cause a wound infection. The reported incidence of wound infection in adult patients undergoing OA is widely varying, and the lowest incidence was 4%.

In our study, port site infection was reported in four (13.3%) cases and was minimal. This observation was significantly different from the previous study owing to a small number of cases in our study, the hands of relatively inexperienced laparoscopists, and the absence of a suitable bag for appendix removal.

One previous study [36] concluded that LA significantly reduces the length of stay for appendicitis as the postoperative length of stay for acute appendicitis was affected by the surgical technique used, and it was 3.9 ±3.5 vs 2.3±1.8 days for OA and LA, respectively ($P<0.001$). The limiting factors bound to determine the hospital stay were the need for administering intravenous antibiotic for patients with appendicitis until they are afebrile and have normal leukocytic count [35]. In our study, the hospital stay ranged from 1 to 6 days, with a mean of 1.9±1.8 days. There is an agreement with the previous study.

This current study aimed to examine the value of clinical, laboratory, and laparoscopic diagnosis in the management of patients with acute right lower abdominal quadrant pain who were suspected to have acute appendicitis. Laboratory assessment was done for all the study patients, including white cell count, total differential count, and CRP, besides the routine ones. We believe that with these laboratory diagnostic tools available today the negative appendectomy rate could be significantly reduced without increasing the risk of perforation.

All the study patients underwent laparoscopic examination after clinical and laboratory assessment. The laparoscopic diagnosis was supportive and confirmative to the clinical diagnosis. Final diagnosis was made based on laparoscopic diagnosis together with histological examination of the removed specimen.

Diagnostic laparoscopy was able to settle the correct diagnosis in 58 patients with high diagnostic accuracy (96.6%). Moreover, it was able to save patients from unnecessary explorations. There was one patient (1.7%) who developed internal hemorrhage that was easily controlled after conversion to open procedure (1.7%).

Our recommendation is the study has to be extended owing to a small number of patients (limitation of the study), building-up of technique mastering, and short-term follow-up.

Conclusion

Clinical diagnosis and laparoscopy were complementary in diagnosis of acute appendicitis, and their combination was able to settle the diagnosis in most of the patients with acute right lower abdominal pain. Laparoscopic assessment was advantageous in cases of diagnostic uncertainty.

LA caused fewer complications, diminished pain, shortened convalescence, decreased wound infection rate, and modestly reduced hospital stay. Removal of an apparently normal appendix if no other pathology is found at laparoscopy was recommended to avoid further postoperative confusion if symptoms recur, to prevent progression of subclinical appendicitis in the postoperative period.

Good surgical judgment was the key of safe performance of laparoscopic surgical procedure. The decision of LA for acute appendicitis may have to be determined by the individual preference of patients and surgeons and depending on the resources available.

Acknowledgements

E.A.[2,3] and S.A.[1–3], the principal authors, made substantial contributions to the conception and design of the work, the acquisition of the data, and analysis; S.A.[2,3], Sh.A.[2,3], K.A.[2,3], and N.A.[2,3] contributed toward the creation a new software used in the work and have drafted the work; M.S.A.[2,3] substantively revised the work; all authors were involved in (1) the conception and design of the study, acquisition of data, as well as analysis and interpretation of the data; (2) drafting the article or revising it critically for important intellectual content; and (3) final approval of the version to be submitted.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1 Hardin DM Jr. Acute appendicitis: review and update. Am Fam Physician 1999; 60:2027–2034.

2 Slade D. Cope's early diagnosis of the acute abdomen (21st edn). Ann R Coll Surg Engl 2006; 88:248.

3 Humes DJ, Simpson J. Acute appendicitis BMJ 2006; 333:530–534.

4 Lin HF, Lai HS, Lai IR. Laparoscopic treatment of perforated appendicitis. World J Gastroenterol 2014; 20:14338–14347.

5 Gomes CA, Nunes TA, Soares CJr, Gomes CC. The appendiceal stump closure during laparoscopy: historical, surgical, and future perspectives. Surg Laparosc Endosc Percutan Tech 2012; 22:1–4.

6 Schick KS, Hüttl TP, Fertmann JM, Hornung HM, Jauch KW, Hoffmann JN. A critical analysis of laparoscopic appendectomy: how experience with 1,400 appendectomies allowed innovative treatment to become standard in a university hospital. World J Surg 2008; 32:1406–1413.

7 Kelley WE Jr. The evolution of laparoscopy and the revolution in surgery in the decade of the 1990s. JSLS 2008; 12:351–357.

8 Blum CA, Adams DB. Who did the first laparoscopic cholecystectomy?. J Minim Access Surg 2011; 7:165–168.

9 Ilce Z, Yildiz T, Isleyen M. The role of laparoscopy in suspicious abdomen pain in children. Pak J Med Sci 2013; 29:1042–1045.

10 Jaschinski T, Mosch CG, Eikermann M, Neugebauer EA, Sauerland S. Laparoscopic versus open surgery for suspected appendicitis. Cochrane Database Syst Rev 2018; 11:CD001546.

11 Alvarado A. A practical score for the early diagnosis of acute appendicitis. Ann Emerg Med 1986; 15:557–564.

12 Clarke PJ, Hands LJ, Gough MH, Kettlewell MG. The use of laparoscopy in the management of right iliac fossa pain. Ann R Coll Surg Engl 1986; 68:68–69.

13 Lewis FR, Holcroft JW, Boey J, Dunphy E. Appendicitis. A critical review of diagnosis and treatment in 1,000 cases. Arch Surg 1975; 110:677–684.

14 Mirsha RK. Frequently asked questions about laparoscopic appendectomy, printed from Laparoscopy Hospital Website at laparoscopyhospital.com.2005. Last access may 2020.

15 White JJ, Santillana M, Haller JA Jr. Intensive in-hospital observation: a safe way to decrease unnecessary appendectomy. Am Surg 1975; 41:793–798.

16 Dunn EL, Moore EE, Elerding SC, Murphy JR. The unnecessary laparotomy for appendicitis-can it be decreased?. Am Surg 1982; 48:320–323.

17 Eriksson S, Granström L, Olander B, Wretlind B. Sensitivity of interleukin-6 and C-reactive protein concentrations in the diagnosis of acute appendicitis. Eur J Surg 1995; 161:41–45.

18 Lau WY, Ho YC, Chu KW, Yeung C. Leucocyte count and neutrophil percentage in appendicectomy for suspected appendicitis. Aust N Z J Surg 1989; 59:395–398.

19 Grönroos JM. Too many unnecessary appendectomies. Leukocyte count and CRP value for safer diagnosis. Lakartidningen 2002; 99:891–893.

20 Schwartz SI. Tempering the technological diagnosis of appendicitis. N Engl J Med 1987; 317:703–704.

21 Kum CK, Sim EK, Goh PM, Ngoi SS, Rauff A. Diagnostic laparoscopy: reducing the number of normal appendectomies. Dis Colon Rectum 1993; 36:763–766.

22 Deutsch AA, Zelikovsky A, Reiss R. Laparoscopy in the prevention of unnecessary appendicectomies: a prospective study. Br J Surg 1982; 69:336–337.

23 Olmi S, Magnone S, Bertolini A, Croce E. Laparoscopic versus open appendectomy in acute appendicitis: a randomized prospective study. Surg Endosc 2005; 19:1193–1195.

24 Walker SJ, West CR, Colmer MR. Acute appendicitis: does removal of a normal appendix matter, what is the value of diagnostic accuracy and is surgical delay important?. Ann R Coll Surg Engl 1995; 77: 358–363.

25 Connor TJ, Garcha IS, Ramshaw BJ, Mitchell CW, Wilson JP, Mason EM, *et al.* Diagnostic laparoscopy for suspected appendicitis. Am Surg 1995; 61:187–189.

26 Leape LL, Ramenofsky ML. Laparoscopy for questionable appendicitis: can it reduce the negative appendectomy rate?. Ann Surg 1980; 191:410–413.

27 Olsen JB, Myrén CJ, Haahr PE. Randomized study of the value of laparoscopy before appendicectomy. Br J Surg 1993; 80:922–923.

28 Nowzaradan Y, Westmoreland J, McCarver CT, Harris RJ. Laparoscopic appendectomy for acute appendicitis: indications and current use. J Laparoendosc Surg 1991; 1:247–257.

29 Lee M, Paavana T, Mazari F, Wilson TR. The morbidity of negative appendicectomy. Ann R Coll Surg Engl 2014; 96:517–520.

30 Schroder DM, Lathrop JC, Lloyd LR, Boccaccio JE, Hawasli A. Laparoscopic appendectomy for acute appendicitis: is there really any benefit? Am Surg 1993; 59:541–547. discussion 547–548.

31 Tate JJ, Dawson JW, Chung SC, Lau WY, Li AK. Laparoscopic versus open appendicectomy: prospective randomised trial. Lancet 1993; 342:633–637.

32 Ortega AE, Hunter JG, Peters JH, Swanstrom LL, Schirmer B. A prospective, randomized comparison of laparoscopic appendectomy with open appendectomy. Laparoscopic Appendectomy Study Group. Am J Surg 1995; 169: 208–212. discussion 212–213.

33 Cothren CC, Moore EE, Johnson JL, Moore JB, Ciesla DJ, Burch JM. Can we afford to do laparoscopic appendectomy in an academic hospital? Am J Surg 2005; 190:950–954.

34 Guller U, Hervey S, Purves H, Muhlbaier LH, Peterson ED, Eubanks S, Pietrobon R. Laparoscopic versus open appendectomy: outcomes comparison based on a large administrative database. Ann Surg 2004; 239:43–52.

35 Richards W, Watson D, Lynch G, Reed GW, Olsen D, Spaw A, *et al.* A review of the results of laparoscopic versus open appendectomy. Surg Gynecol Obstet 1993; 177:473–480.

36 Towfigh S, Chen F, Mason R, Katkhouda N, Chan L, Berne T. Laparoscopic appendectomy significantly reduces length of stay for perforated appendicitis. Surg Endosc 2006; 20:495–499.