Acute Appendicitis - Study of Role of Ultrasound and CT Scan in Decision Making for Surgery in a Tertiary Care Government Hospital in Eastern India

Jainendra Kumar[1], Akriti Komal[2]

[1, 2] Department of General Surgery, Patna Medical College Hospital, Patna, Bihar, India.

ABSTRACT

BACKGROUND

Acute appendicitis (AA) is one of the commonest causes of acute abdominal emergencies. Accurate diagnosis and earlier surgery is imperative in such cases. Ultrasonography (US), and computed tomography (CT), are main stays accurate diagnosis of this disease. This study was conducted to compare the accuracy of US and CT in the diagnosis of AA and reduce number of negative appendectomies.

METHODS

This prospective study was done after approval from institutional ethical committee and obtaining written consent. 164 patients with clinical features suggestive of AA, were selected from emergency department of Patna Medical College, Patna India during the period from January 2019 to December 2020. 98 were males and 66 females, mean age being 18.08 years. 142 patents (86.58 %) underwent surgery, and 22 patients (13.41 %) were kept on clinical observation in hospital after imaging. After detailed clinical workup and laboratory investigations, all patients were subjected to both US and CT examination. Each patient was reevaluated clinically, and a clinical correlation was done between both sets of results. Based on these, final decision was made. Accuracy was decided based on intra-operative findings in appendectomy group and were correlated with imaging findings later with histopathologic findings.

RESULTS

Males outnumbered females, abdominal pain was present in 100%. The sensitivity, specificity, positive predictive value, negative predictive value and overall accuracy of US in diagnosis of AA in our study were 92.6 %, 76.4 %, 95.3%, 71.0% and 88.9 % respectively. The sensitivity, specificity, positive predictive value, negative predictive value and overall accuracy of CT in diagnosis of AA were 99.1 %, 90.5 %, 98.6%, 87.8% and 97.8 % respectively.

CONCLUSIONS

US should be the first-line imaging modality as it is free from radiation. CT is recommended as additional imaging tool to raise accuracy in diagnosis except in pregnancy and selected pediatric patients.

KEYWORDS

Acute Appendicitis, Computed Tomography, Ultrasound

Corresponding Author:
Dr. Jainendra Kumar,
G 17, P.C. Colony Kankarbagh,
Patna - 800020, Bihar, India.
E-mail: drjk17@yahoo.co.in

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BACKGROUND

Acute appendicitis (AA) is among one of the commonest surgical emergencies. Causes of appendicitis with atypical presentation may be difficult to distinguish from a myriad of gastrointestinal, genitourinary, and gynaecological conditions.[1,2] The diagnosis of AA is usually made based on history, physical examination and supported by laboratory investigations. Imaging Modalities like US and CT helps in increasing the diagnostic accuracy. The applicability and accuracy of US is operator dependent.[3,4] Although the base of appendix is attached to the cecum, but its tip may lie in different locations (eg, retrocecal, pelvic, subcecal, preileal, retroileal, and ectopic appendix.[5,6] Pitfalls in the sonographic diagnosis of appendicitis include failure to identify segmental or tip appendicitis and overestimation of an increased appendiceal diameter leading to a false positive diagnosis. Anatomical variation further complicates diagnosis. Higher sensitivity, specificity and precision of CT scan seems encouraging; however, the risk of ionizing radiation is a disadvantage, especially in younger patients.[7,8,9]

Due to common prevalence of acute appendicitis in general surgical practice, a surgeon is often confronted with a diagnostic dilema. Surgical intervention is not only a major undertaking from surgeon's point of view but also from the perspective of patients and their relatives. They often insist on avoiding surgery if possible. These circumstances demand accurate diagnosis of AA to avoid negative appendicectomy, i.e., removing normal appendix.

Aim

To evaluate the relative accuracy of these modalities in making accurate diagnosis of AA and to enable the surgeon to decide appropriate management modality.

Objectives

Primary

This study was conducted to compare the role and relative accuracy of US and CT in the diagnosis of AA and hence to reduce number of negative appendectomies.

Secondary

Treatment modality of AA has lot of bearing not only on cost but also loss of patient's working days. Unwanted surgical procedure leads to sufferings like pain, and other possible morbidities and long term complications in addition to cost. Thus accurate diagnosis of AA is imperative to avoid all these factors.

METHODS

Present study is a prospective cross sectional study performed on 164 patients which presented with signs and symptoms suggestive of AA. Out of this 98 were males and 66 females. They were randomly selected from Emergency Department of Patna Medical College Hospital, Patna India during two years period from January 2019 to December 2020. The study protocol was approved by hospital's ethical committee for human studies. Patients suspected to have AA were admitted to the hospital either for observation or for surgery and they were asked to participate in this study.

Exclusion Criteria

Patients who needed urgent surgery were excluded as no imaging was possible due to urgent need of surgery, were also excluded from this study.

The radiological procedures and logistics of the study were explained to the patients, and informed consent was obtained from all cases. Patients underwent US and CT examinations before undergoing surgery or during the first 24 hour of observation. The decision regarding surgical intervention was relied on the clinical and laboratory parameters. US was performed in all. Direct US signs of AA were: Dilatation and non-compressibility of the appendix, diameter > 6 mm, single wall thickness ≥ 3 mm, target sign, hypoechoic fluid-filled lumen, hyperechoic mucosa/ submucosa, hypoechoic muscularis layer appendicolith, hyperechoic with posterior shadowing. Color Doppler and contrast-enhanced US: Hypervascularity in early stages of AA. Indirect US signs of acute appendicitis: Free fluid surrounding appendix, local abscess formation, increased echogenicity of local mesenteric fat, enlarged local mesenteric lymph nodes, thickening of the peritoneum, signs of secondary small bowel obstruction, appendicular mass formed by dilated oedematous intestinal loops with thick oedematous mesentery. All patients having a complaint of acute abdominal pain suspected of AA underwent CT examinations following a single identical protocol. Patients were placed in the supine position and scanned from the diaphragm to the symphysis pubis by 160 slices multidetector scanner. Non-contrast images were routinely incorporated in the given protocol in order to make an alternative diagnosis of urinary stone.

CT images were reconstructed with 5-mm slice thickness in the transverse plane and 4-mm in the coronal plane. In all the patients, a single-phase contrast- enhanced scan was performed and was acquired 65 seconds after starting the administration of IV contrast agent. Oral or rectal contrast material was not administered. In this study, CT findings were interpreted as positive for acute appendicitis with, enlarged appendix (≥ 6 mm in outer diameter), appendiceal wall thickening (≥ 3 mm), appendiceal wall hyperenhancement, periappendiceal fat stranding, periappendiceal abscess which usually indicated perforated appendicitis and is associated with extraluminal air, ileocecal inflammation, and localized peritonitis in the right lower quadrant. Ancillary signs of appendicitis including right lower quadrant inflammation, appendicoliths lymphadenopathy and appendicular mass which appears as complex right iliac mass composed of edematous caecal wall and loops of dilated small intestine with thickened mesentery. CT findings were interpreted as negative if the appendix was visualized with intraluminal air. An appendix less than 6 mm in outer diameter was also diagnosed as normal. If an appendix was

not visualized and ancillary signs were not present, the findings were interpreted as negative. The diagnosis of acute appendicitis at surgery was established on the basis of macroscopic findings. All excised appendixes were microscopically analyzed by histology.

Statistical Analysis

The data were coded, entered and processed on an IBM-PC compatible computer using SPSS (version 20). Descriptive analysis was performed. Data are reported as frequencies and percentages. Sensitivity, specificity, and negative and positive predictive values of each imaging pathway for diagnosis of appendicitis were determined by using contingency tables.

RESULTS

Out of the 164 patients included in the study, 98 males and 66 females, ranging in age from 12 to 36 years (mean, 18.56 years). Most patients 142 (86.58 %) underwent surgery immediately or within 24 hours of observation after imaging. The decision to perform surgery was only undertaken after thorough discussion with relatives about the disease condition, possible risks and complications of surgery. The resultant loss of working days and economical loss were well explained to patient and legal attendants. The risk of continuation of non-operative modality in cases requiring surgery was well explained and consent thereof obtained in writing to avoid disputes litigation. The clinical findings of studied cases are presented in Table (1). 17 cases (15.9%) were hospitalized for clinical observation after imaging. Routine non-operative treatment protocol like intravenous fluids, antibiotics, analgesics as per need and monitoring of vitals were carefully performed. The results of US and CT in these 17 patients were presented in Table (2). 12 patients (11.2 %) were discharged from the hospital after observation confirmed by negative US and CT findings.5 cases (4.7 %) of the observed patients presented with positive CT findings underwent surgery (Table 2).The overall number of diagnosed cases underwent surgery after imaging is 142 cases (88.8%).

In 103 (72.6 %) of the 142 patients with appendicitis at surgery, the US showed signs of acute appendicitis. 4 patients (4.2 %) appeared to have no acute appendicitis at surgery, although US showed positive findings for appendicitis. 6 patients (6.3 %) appeared to have acute appendicitis at surgery, although US showed negative findings for appendicitis. In 16 (16.8 %) patients without signs of appendicitis at surgery, US also did not reveal appendicitis.

CT results for the patients who underwent surgery are listed in Table 4. In 126 (88.7%) of the 142 patients with appendicitis at surgery, the CT showed signs of acute appendicitis. One patient (1.4%) had no AA at surgery, although the CT showed positive findings for appendicitis. One patient (1.4 %) appeared to has acute appendicitis at surgery, although the CT showed negative findings for appendicitis.

In 12 (8.4 %) of the patients without signs of appendicitis at surgery, CT also did not reveal appendicitis (Table 4). Histopathologic Findings -Appendicitis was confirmed in 86 patients (90.5 %) by histopathological examination in the form of acute appendicitis (n = 98), gangrenous appendicitis (n = 2), sub-acute appendicitis (n = 4), periappendicular abscess (n = 4) and acute appendicitis with oxyurius (n = 1). Out of them perforated appendix was found in 6 patients during surgery. Perforation was found near the base of appendix in all the case. In 3 cases faecolithe was found protruding from the perforation. The number of appendicectomies with negative appendicitis were 9 with a negative rate of (9.5 %) (Table 4).

Diagnostic role of US and CT was evaluated by calculating sensitivity, specificity, positive predictive value, negative predictive value and overall diagnostic accuracy using standard formulae and values obtained are shown in Table 4. After appendectomy, the final situation revealed that the diagnostic accuracy of US was 88.9% success rate in diagnosis of AA while CT showed diagnostic accuracy of 97.8% success rate in diagnosis of AA.

	Parameters	Value
	Age (years) mean	18.08
	Range	12 – 36
Gender	males	98 (59.7%)
	Females	66 (40.24 %)
Outcome	Operation	142 (86.58 %)
	Observation	22 (13.33%)
Clinical findings	Abdominal pain	164 (100 %)
	Low grade fever	124(75.60 %)
	Leucocytosis (>10 x103 /ml)	122 (74.39 %)
	Anorexia with vomiting	116 (70.73 %)
	Nausea	104 (63.41 %)
	Diarrhea	28 (17.07 %)
	Raised Urinary frequency	8(4.87 %)

Table 1. Demographic and Clinical Parameters of Studied Cases (N=164)

Findings	US Findings		CT Findings		Total	
	No	%	No	%	No	%
Positive	4	18.18	1	4.54	5	22.72
Negative	3	13.64	14	63.64	17	77.27
Total	**7**	**31.82**	**15**	**68.18**	**22**	**100**

Table 2. Correlation of US and CT in the Diagnosis of Acute Appendicitis in 22 Observed Patients

Surgical Findings	Pathologic Findings					
	Normal n=10	AA n=120	SAA n=4	GA n=3	PAA n=4	Others n=1
Normal	10 (100%)	10 (8.3%)	1 (25.0%)	-	-	1 (100%)
Inflammation	-	98 (81.6%)	2 (50.0%)	-	-	-
Perforation	-	12 (10.0%)	1 (25.0%)	1 (33.3%)	-	-
Gangrene	-	-	-	2 (66.6%)	-	-
Periappendicular abscess	-	-	-	-	4 (100%)	-

Table 3. Distribution of Various Pathological Subgroups According to Intra-Operative Gross Evaluation (n = 142)

AA, acute appendicitis; SAA, subacute appendicitis, GA, gangrenous appendicitis; PAA, periappendicular abscess, others = oxyurius

Histopathological Findings/ US and CT	True Positive		False Positive		True Negative		False Negative	
	No	%	No	%	No	%	No	%
US	103	72.5	5	3.5	23	16.2	10	7.0
CT	126	88.7	2	1.4	12	8.4	2	1.4

Table 4. Results of Radiological Studies in Diagnosis of Acute Appendicitis Proved by Surgical or Histopathological Findings (no = 142)

US and CT/Parameters	US	CT
Sensitivity	92.6	99.1
Specificity	76.4	90.5
Positive Predictive Value	95.3	98.6
Negative Predictive Value	71.0	87.8

Table 5. Sensitivity, Specificity and Accuracy of Radiological Maneuvers in Diagnosis of AA

DISCUSSION

Acute appendicitis is one of the commonest acute abdominal emergencies presenting to surgeons. Accurate diagnosis is imperative to institute appropriate timely treatment to achieve best possible results complications. Now-a-days numerous investigation modules are available for treating surgeons for the diagnosis of acute appendicitis. X-ray abdomen was the only imaging modality available in the past. But with the tremendous advances made in imaging technology in recent few decades, several imaging modalities are available to facilitate accurate diagnosis of appendicitis.[10] Ultrasonography has been used since last three to four decades with varying degree of success and accuracy. Recent introduction of CT scan has substantially changed the scenario of diagnosis of AA in recent years.[11] Imaging methods like US and CT improves the clinical outcome by increasing the accuracy of diagnosis. Normal US findings does not rule out the presence of AA. US has the advantage of being harmless as it is free from radiation but disadvantage is that it is operator dependant.[6,12] In certain anatomical positions like retrocaecal appendix, it has limited sensitivity. In morbidly obese patients, Accuracy of US is futher reduced due to poor localization of the organ due to increased depth between probe and the organ. CT can overcome these limitations and has raised sensitivity in the diagnosis of AA.[13]

Early detection by US and surgical intervention in AA reduces complications and mortality. US in still increasingly used for the diagnosis of AA due to absence of radiation. But, being highly operator dependent, reported sensitivity in literature varies widely (44%–100%).[14,15,1,16] Some workers consider CT to be the gold standard for diagnosis of AA with higher sensitivity and specificity than US.[8] The advantages of CT include less operator dependence, easier visualization of retrocecal appendix, less interference of bowel gas, obesity, and less patient's pain during the procedure.[6] The present study was conducted on 164 patients suspected to have acute appendicitis and observed that males (59.7%) affected than female (40.24%). Our findings of male predominance is approximately similar to 60 - 72% in male in several other reports in the literature.[1,17,18,19,20,21] The peak incidence of acute appendicitis in literature worldwide varies between 10 and 30 years of age.[1,22,19] This is similar to our study that shows that acute appendicitis is common in young adults with a mean age of 18.08 years. Presentation with abdominal pain in 100 %, fever in 75.6 % and vomiting in 70.7 % of the patients is somewhat lower than that reported by other workers 99 %, 76 % and 56 % respectively.[18,23] Pelvic appendicitis is known to cause urinary symptoms which was found in 8%, which no other worker has reported specifically. Predominant presenting symptoms were right iliac fossa pain (95 %), nausea (80 %), and vomiting (73 %), with 63 % of patients presenting 2 days after onset of symptoms.[19] Low grade fever was present in 15% .Only 31% of patients gave atypical history of AA like vague periumbilical pain. Histopathological examination of removed appendectomy specimen confirms the diagnosis of appendicitis. This is especially important when it is not obvious at the time of surgery, as apparently normal looking appendix may have inflammation on microscopic observation.[24] We also found grossly normal looking appendices turned out to be pathologically inflammed. Other advantage of routine histological examination is that non inflammatory conditions like small carcinoid tumour may be diagnosed. Crohn's disease may also involve appendix along with other parts of gut. Thus some other pathologic conditions may be diagnosed on routine histology of appendicectomy specimen.[25,26,27] Moreover, other pathologies such as inflammatory bowel disease, parasitic infections, endometriosis, and mycobacterial infection may be retrieved from appendectomy specimens.[28] The relative sensitivity, specificity, positive predictive value and negative predictive value of the analysed data reported in the literature varies widely. The sensitivity, specificity, positive predictive value, negative predictive value and overall accuracy of US in diagnosis of AA in our study were found to be 92.6 %, 76.4 %, 95.3%, 71.0% and 87.9 % respectively. While, the sensitivity, specificity, positive predictive value, negative predictive value and overall accuracy of CT in diagnosis of AA were 99.1 %, 90.5 %, 98.6%, 87.8% and 97.9 % respectively. Our results were comparable to other studies which reported sensitivity varying from 75%–98%, specificity 86%–100% with positive and negative predictive values of 91%–100% and 89%–99%.[15,14,29] On the other hand few studies reported significantly lower sensitivity and specificity for US compared with CT scan.[30,31,32]

A large systematic review on 9121 patients of 25 studies reported a sensitivity of 83.7 %, a specificity of 95.9 %, an accuracy of 92.2 %, a positive predictive value (PPV) of 89.8 % and an NPV of 93.2 % for the US diagnosis of AA.[30] The overall pooled estimates for the diagnostic value of CT were: sensitivity 93.4%, specificity 93.3 %, accuracy 93.4 %, PPV 90.3 % and NPV 95.5 %. CT was found more sensitive (88.4 % vs 76 %) and a little bit more specific (90.4 % vs 89.4 %) than US.[30] Sensitivity of 98.5 % and a specificity of 98 % for the diagnosis of AA was reported in 2871 patients.[31] Widely variable diagnostic accuracy of US with sensitivities ranging from 44% to 100 % and specificities ranging from 47 % to 100 % was reported by other workers[33,34] who reported high sensitivity of 94.4%, with a specificity of 80% and PPV and NPV of 97.7% and 61.53 % respectively. On the other hand CT depicted a sensitivity of 82 %, with a specificity of 83% and PPV and NPV of 98.1 % and 68.4% respectively.[13] Thus majority of studies point towards the increased sensitivity and specificity of CT over US. But in practical terms, the limiting factor of CT as compared to US remains its potential of radiation hazard, which limits its application in females of reproductive age. Acute appendicitis is not uncommon in pregnancy. Although cost factor of both imaging modality is only marginally different, operator dependence of US is limiting factors for US. Major advantage of US continues to

be its radiation free application in all ages and sex including pregnant women. Hence US continues to be important first line imaging modality.

CONCLUSIONS

Accurate preoperative diagnosis of acute appendicitis is mandatory to avoid negative appendicectomies. CT undoubtedly is the gold standard imaging modality to diagnose AA in modern era, but there are good reasons to choose US as first line imaging tool of choice in AA. Reason being US is not only non-invasive but has short acquisition time, relatively low cost and most important, free from ionized contrast agent or oral preparation, and free from radiation exposure. It can be performed on children even with some degree of motion, is totally safe during pregnancy, has high pickup rate for diagnosis of alternative conditions mimicking acute appendicitis and is easily available in most institutions.

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REFERENCES

[1] Chaudhari YP, Jawale PG. Prevalence of appendicitis at surgery inpatient department of a tertiary care hospital: a descriptive study. Int Med J 2015;2(11):768-770.
[2] El-Deek AF, El-Sayaad IM. et al. Ultrasonography versus computed tomography in diagnosis of acute appendicitis. Al-Azhar Med J 2017;46(4):981-994.
[3] Lee JH, Jeong YK, Park KB, et al. Operator dependent techniques for graded compression sonography to detect the appendix and diagnose acute appendicitis. Am J Roentgenol 2005;184(1):91-97.
[4] Hernanz-Schulman MCT. CT and US in the diagnosis of appendicitis: an argument for CT. Radiology 2010;255(1):3-7.
[5] Ghorbani A, Forouzesh M, Kazemifar AM. Variation in anatomical position of vermiform appendix among Iranian population: an old issue which has not lost its importance. Anatomy Research International 2014;2014:313575.
[6] Salwe NA, Kulkarni PG, Sinha RS. Study of morphological variations of vermiform appendix and caecum in cadavers of western Maharashtra region. Int J Advanced Physiology Allied Sci 2014;2(1):31-41.
[7] Des Plantes CMP, van Veen MJF, der Palen JV, et al. The effect of unenhanced MRI on the surgeons' decision-making process in females with suspected appendicitis. World J Surg 2016;40(12):2881-2887.
[8] Hernanz-Schulman MCT. CT and US in the diagnosis of appendicitis: an argument for CT. Radiology 2010;255(1):3-7.
[9] Kim K, Kim YH, Kim SY. Low dose abdominal CT for evaluating suspected appendicitis. The New England Journal of Medicine 2012;366(17):1596-1605.
[10] Thirumoorthi AS, Fefferman NR, Ginsburg HB, et al. Managing radiation exposure in children-re-examining the role of ultrasound in the diagnosis of appendicitis. J Pediatr Surg 2012;47(12):2268-2272.
[11] Kim K, Kim YH, Kim SY, et al. Low-dose abdominal CT for evaluating suspected appendicitis. N Engl J Med 2012;366:1596-1605.
[12] Summa M, Perrone F, Priora F, et al. Integrated clinical-ultra-sonographic diagnosis in acute appendicitis. J Ultrasound 2007;10(4):175-178.
[13] Saito JM, Yan Y, Evashwick TW, et al. Use and accuracy of diagnostic imaging by hospital type in pediatric appendicitis. Pediatrics 2013;131(1):1-12.
[14] Ayaz AM, Lubana MV, Tanvir K, et al. Diagnostic accuracy of Alvarado score in the diagnosis of acute appendicitis. Pakistan Journal of Medical Sciences 2009;25(1):118-121.
[15] Al-Ajeraemi Y. Sensitivity and specificity of ultrasound in the diagnosis of acute appendicitis. East Mediterr Health J 2012;18(1):66-69.
[16] Monajemzadeh M, Hagghi-Ashtiani MT, Montaser-Kouhsari L, et al. Pathologic evaluation of appendectomy specimens in children: is routine histopatholgic examination indicated? Iran J Pediatr 2011;21(4):485-490.
[17] Estey A, Poonai N, Lim R. Appendix not seen: the predictive value of secondary inflammatory sonographic signs. Pediatr Emerg Care 2013;29(4):435-439.
[18] Kamath P, Rai R, George L, et al. A clinico-pathological study of appendicectomy cases in a tertiary care hospital in south India. Indian J Applied Research 2015;5(9):285-286.
[19] Pickhardt PJ, Lawrence EM, Pooler BD, et al. Diagnostic performance of multidetector computed tomography for suspected acute appendicitis. Ann Intern Med 2011;154(12):789-796, W-291.
[20] Scott AJ. Risk stratification by the appendicitis inflammatory response score to guide decision making in patients with suspected appendicitis. Br J Surg 2015;102(5):563-572.
[21] Van Randen A, Bipat S, Zwinderman AH, et al. Acute appendicitis: meta-analysis of diagnostic performance of CT and graded compression US related to prevalence of disease. Radiology 2008;249(1):97-106.
[22] John M, Kirkwood KS. Sabiston Textbook of Surgery. Biological basis of modern surgical practice. Philadelphia: Saunders/ Elsevier 2008: p. 1333-1317.
[23] Nshuti R, Kruger D, Luvhengo TE. Clinical presentation of acute appendicitis in adults at the Chris Hani Baragwanath academic hospital. Int J Emerg Med 2014;7(12):1-13.
[24] Jones AE, Phillips AW, Jarvis JR, et al. The value of routine histopathological examination of appendicectomy specimens. BMC Surg 2007;7:17.
[25] Mostbeck G, Adam EJ, Nielsen MB. How to diagnose acute appendicitis: ultrasound first. Insights Imaging 2016;7(2):255-263.
[26] Seetahal SA, Bolorunduro OB, Sookdeo TC, et al.

Negative appendectomy: a 10-year review of a nationally representative sample. Am J Surg 2011;201(4):433-437.
[27] D'Souza N, D'Souza C, Grant D, et al. The value of ultrasonography in the diagnosis of appendicitis. International Journal of Surgery 2015;13:165-169.
[28] Chang YJ, Chao HC, Kong MS, et al. Misdiagnosed acute appendicitis in children in the emergency department. Chang Gung Med J 2010;33(5):551-557.
[29] Raval MV, Deans KJ, Rangel SJ, et al. Factors associated with imaging modality choice in children with appendicitis. J Surg Res 2012;177(1):131-136.
[30] Al-Khayal KA, Al-Omran MA. Computed tomography and ultrasonography in the diagnosis of equivocal acute appendicitis. A meta-analysis. Saudi Med J 2007;28(2):173-180.
[31] Pipal DK, Kothari S, Shrivastava H, et al. To evaluate the diagnostic accuracy of Alvarado score, C- reactive protein, ultrasonography and computed tomography in acute appendicitis and to correlate them with operative and histological findings. Int Surg J 2017;4(1):361-367.
[32] Noguchi T, Yoshimitsu K, Yoshida M. Periappendiceal hyperechoic structure on sonography: a sign of severe appendicitis. Journal of Ultrasound in Medicine 2005;24(3):323-327. Quiz 328-330.
[33] Doria AS, Moineddin R, Kellenberger CJ, et al. US or CT for diagnosis of appendicitis in children and adults? A meta-analysis. Radiology 2006;241(1):83-94.
[34] Terasawa T, Blackmore CC, Bent S, et al. Systematic review: computed tomography and ultrasonography to detect acute appendicitis in adults and adolescents. Ann Intern Med 2004;141(7):537-546.