



Comparison of Preoperative Imaging and Intraoperative Findings in Surgically Treated Acute Abdomen Patients: A Retrospective Study

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Received: 17 September 2025

Accepted: 27 December 2025

Abstract

Background: Acute abdomen is a common medical emergency characterized by sudden, severe abdominal pain lasting less than 24 hours, often necessitating urgent diagnostic and therapeutic evaluation. With the increasing availability of diagnostic tools, it is crucial to evaluate their sensitivity and accuracy to ensure their effective use. Plain abdominal X-rays and abdominal computed tomography (CT) scans are among the most frequently used diagnostic tools for assessing acute abdomen.

Methods: A total of 136 patients were enrolled in the study between April 2019 and March 2021. The sampling method was based on a comprehensive census of all patients presenting with acute non-traumatic abdominal conditions at Shahid Modarres Hospital. Initially, patients were clinically diagnosed, followed by a pre-operative diagnosis based on radiological findings, which were then compared with intra-operative results. Plain X-rays were performed for all patients, and CT scans were conducted for 75 of them. Fisher's exact test, t-test, and Chi-square test were used to study the associations between study groups.

Results: CT scans, both with and without contrast, demonstrated superior accuracy compared to X-rays, particularly in detecting bowel obstructions, with a sensitivity of 100% and excellent correlation with postoperative findings. While X-rays remain highly accurate and sensitive for diagnosing perforations, they are less effective for identifying obstructions and vascular causes.

Conclusion: Despite CT's high accuracy in diagnosing acute abdomen and its growing availability, abdominal X-rays remain the recommended first-line diagnostic tool due to their ability to detect many pathologies without further tests, as well as being cheaper and safer. However, in cases like obstructions or vascular pathologies, X-rays may be insufficient, making CT the preferred option. We advise physicians to use diagnostic studies purposefully, guided by clinical suspicion, and always after a thorough physical exam and patient interview.

Keywords: Pain, Abdominal, Abdomens, Acute, peritonitis, Ulcer perforations, Peptic, CT scan, X-ray.

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Please cite this paper as: Zeinalpour A, Ebrahimibagha H, Koosha S, Davari N. Comparison of Preoperative Imaging and Intraoperative Findings in Surgically Treated Acute Abdomen Patients: A Retrospective Study. Shahroud Journal of Medical Sciences 2026;12(2):75-80.

Introduction

Acute surgical abdomen is a common emergency, accounting for 5% to 10% of all emergency department visits. It presents with sudden, severe abdominal pain and symptoms that require immediate intervention, such as laparotomy^{1, 2}. The underlying causes include a broad range of conditions,

from appendicitis and perforated peptic ulcers to mesenteric ischemia and intestinal obstruction. Additionally, non-surgical conditions like diabetic ketoacidosis, myocardial ischemia, and renal colic can mimic these symptoms but do not necessitate surgery. Diagnosis is typically based on patient history and physical examination³⁻⁵.

Rapid and accurate diagnosis is critical, as delayed identification can lead to increased morbidity and mortality. Physical exam findings, particularly rebound tenderness and guarding, strongly suggest acute surgical abdomen and require emergency intervention. Given the diverse presentations and causes, diagnosing acute abdomen can be challenging, and para-clinical tools are often necessary⁶⁻¹⁰.

Historically, plain abdominal X-rays were the only diagnostic imaging tool available in U.S. emergency departments until 1972. By 1992, this reliance had decreased to about 30% due to the growing use of computed tomography (CT) scans¹¹. The standard abdominal radiographic series typically includes PA and upright abdominal X-rays and an upright chest X-ray¹². However, studies have shown that a high percentage of abdominal X-rays in acute abdomen cases reveal no significant pathology¹³.

While plain X-rays and ultrasound remain common first-line diagnostic tools for acute abdominal pain, CT scans with or without intravenous (IV) contrast and abdominal ultrasound are now the preferred modalities due to their greater accuracy and availability¹⁴. Despite advancements in imaging techniques, radiological findings in many cases remain non-diagnostic or non-specific, and pre-operative diagnoses often do not align with intra-operative findings¹⁵. Accurate preoperative diagnosis of acute abdomen remains challenging, with published rates of negative laparotomy ranging from 10% to 20% prior to the widespread use of advanced imaging¹⁶. Studies have shown that the introduction of CT scans can reduce negative laparotomy rates by up to 30%, improving diagnostic accuracy and guiding timely surgical intervention¹⁷. Despite these advancements, discrepancies between preoperative imaging and intraoperative findings persist, particularly for conditions such as appendicitis, bowel obstruction, and mesenteric ischemia. These observations underscore the need for real-world data evaluating the diagnostic performance of both plain radiographs and CT scans in acute surgical abdomen, which is the primary objective of our study¹⁸.



Studying the correlation between pre-operative diagnoses based on history, physical exams, and radiologic findings with intra-operative outcomes can improve diagnostic accuracy. This would help guide physicians in using these tools more effectively, reducing unnecessary imaging, cutting costs, and speeding up diagnosis. This study uniquely evaluates the diagnostic utility of X-rays and CT in a Middle Eastern population, addressing a gap in region-specific data. The accuracy of the data increased by surgeon direct observation. In this retrospective study, we compare the intraoperative findings of acute abdomen patients who underwent surgery with pre-operative imaging results, including standard abdominal X-rays and CT scans.

Accurate and timely diagnosis of acute abdomen is critical to reducing morbidity and mortality. While CT scans have become increasingly available, their high cost, radiation exposure, and variable availability in different regions make it essential to evaluate the diagnostic value of simpler imaging modalities such as plain abdominal X-rays. Moreover, data comparing preoperative imaging findings with intraoperative outcomes are limited, particularly in Middle Eastern populations. This study aims to assess the diagnostic accuracy of abdominal X-rays and CT scans in acute abdomen, providing evidence to guide appropriate imaging choices, reduce unnecessary procedures, and improve patient outcomes.

Materials and Methods

We conducted an observational, population based, analytical retrospective study on patients who presented with non-traumatic acute abdominal pain and underwent surgery at Shahid Modarres Hospital between April 2019 and March 2021. Non-traumatic acute abdominal pain is defined as the abrupt onset of significant abdominal discomfort in the absence of external physical injury or trauma. Demographic data were collected for all 136 patients included in the study. Abdominal X-ray series were performed for all patients and reviewed by radiologists, while CT scans with abdominopelvic protocol were obtained and analyzed for 75 patients. CT scans were performed selectively based on predefined clinical indications and at the discretion of the attending surgeon. Indications for

CT included clinical suspicion of bowel obstruction or mesenteric ischemia, such as persistent or severe abdominal pain, abdominal distension, vomiting, localized or generalized peritoneal signs, or failure to improve with initial conservative management. Laboratory findings supporting the need for CT included leukocytosis, metabolic acidosis, or elevated serum lactate levels. CT was also obtained in cases with an uncertain diagnosis following initial clinical evaluation and plain radiography or ultrasonography, when further anatomical clarification was required to guide management.

All the CT scans reported by one of the skilled radiologists of the hospital and rechecked by the surgeon. Among the 75 patients who underwent abdominopelvic CT scanning, contrast administration was determined by the attending surgeon in consultation with the radiologist, based on clinical presentation and patient safety considerations. IV contrast-enhanced CT was performed in 50 patients, oral contrast was administered in 10 patients, and 15 patients underwent non-contrast CT scanning. IV contrast was preferentially used in patients with clinical suspicion of vascular pathology, bowel ischemia, intra-abdominal abscess, or inflammatory conditions, provided renal function was adequate (serum creatinine within acceptable limits) and there was no history of contrast allergy. Non-contrast CT scans were performed in patients with impaired renal function, contrast hypersensitivity, hemodynamic instability, or when contrast administration was deemed unsafe. Oral contrast was selectively used when evaluation of bowel lumen or obstruction was required and when it would not delay urgent surgical management. The pre-operative diagnosis was determined by the attending surgeon, based on clinical assessment and para-clinical data, including radiologic findings and laboratory tests. Intra-operative findings were gathered from surgical reports. According to the principles of Helsinki declaration, the research ethics committee of the Shahid Beheshti university of medical sciences approved the study proposal with the ethical code IR.SBMU.REC.1400.163. Informed consent for the use of medical record data was obtained from patients during hospitalization, and only those who provided consent were included in the study (Table 1).

Table 1. Variables and measurement methods

| Variable | Variable type | Definition | Measurement method |
|--|---------------------|---|-------------------------|
| Abdominal series findings | Nominal independent | Abdominal series including plain and upright abdominal and chest X-rays | Reported by radiologist |
| Abdominal CT findings | Nominal independent | IV contrast abdominal CT | Reported by radiologist |
| Intra-operative findings/final diagnosis | Nominal independent | Intra-operative findings and conclusion | Reported by surgeon |

Statistical Analysis: Data were analyzed using SPSS software. Normality of continuous variables was assessed using the Shapiro–Wilk test. Group comparisons were performed using the unpaired t-test for normally distributed continuous variables. Qualitative data were presented using frequency and percentage tables. Associations between preoperative imaging findings and intraoperative observations were evaluated using Fisher’s exact test for categorical variables with low expected frequencies and the Chi-square test for categorical associations.

A P-value of less than 0.05 was considered statistically significant.

To sum up, here is a detailed stepwise procedure:

- **Patient Selection:** A total of 136 patients presenting with non-traumatic acute abdominal pain at Shahid Modarres Hospital between April 2019 and March 2021 were included.



- **Clinical Evaluation:** All patients underwent initial assessment including history, physical examination, and laboratory tests.
- **Radiologic Assessment:** Plain abdominal X-rays (upright and supine) were performed for all patients. Abdominopelvic CT scans were conducted for 75 patients, particularly when obstruction, mesenteric ischemia, or uncertain diagnosis was suspected.
- **Preoperative Diagnosis:** Determined by the attending surgeon based on clinical evaluation and imaging results.
- **Surgical Intervention:** Patients underwent surgery according to standard protocols. Intraoperative findings were recorded.

Data Collection and Analysis: Preoperative imaging diagnoses were compared with intraoperative results. Statistical

analysis was performed using Fisher's exact test, Chi-square test, and t-test; P-value<0.05 was considered significant.

Results

Total of 136 patients included this study. More acute abdomen was seen in male patients than female. Out of the studied patients with acute abdominal pain, appendicitis was identified in 39 cases as the most frequent cause, followed by gastric ulcer with perforation, which was the second most common etiology, identified in 34 cases (Table 2 and 3). CT imaging was predominantly utilized in patients with diagnostically uncertain presentations or suspected complex pathology, whereas patients with clear radiographic or clinical diagnoses were more likely to proceed directly to surgery without CT.

Table 2. Sex wise distribution of patients

| Gender | No of patients (%) |
|--------|--------------------|
| Male | 56% |
| Female | 44% |

Table 3. Distribution of diagnosis

| Diagnosis | No of patients |
|-------------------------|----------------|
| Appendicitis | 39 |
| Perforated peptic ulcer | 34 |
| Bowel obstruction | 24 |
| Mesenteric ischemia | 8 |
| Bowel perforation | 7 |
| Incarcerated hernia | 4 |
| Bowel volvulus | 3 |

All patients underwent upright and supine plain abdominal radiographs as the initial radiological evaluation, and 75 patients also underwent a CT scan. The majority of CT scans were conducted for patients suspected of having intestinal obstruction, while the fewest CT scans were performed for those with clinical suspicion of appendicitis. CT scans were primarily carried out for patients in whom the initial diagnosis was uncertain and when the overall clinical findings did not

provide a clear initial diagnosis. In the final diagnosis, CT scans were conducted for all patients diagnosed with mesenteric ischemia, volvulus, and strangulated hernia. This diagnostic approach using CT scans contributed to achieving a more precise initial diagnosis in these cases.

Abdominal series had total of 38.2% sensitivity, mostly accurate in diagnosis of perforated peptic ulcer with sensitivity of 82.3% and specificity of 100% (Table 4).

Table 4. Abdominal X-ray series and its accuracy

| Diagnosis | No of patients | No of performed series (%) | No of correct diagnosis based on series (%) | Negative predictive value-NPV (%) |
|-------------------------|----------------|----------------------------|---|-----------------------------------|
| Appendicitis | 39 | 100% | 7.6% | 72.9% |
| Perforated peptic ulcer | 34 | 100% | 82.3% | 93.3% |
| Bowel obstruction | 33 | 100% | 45.4% | 85.1% |
| Mesenteric ischemia | 11 | 100% | 0% | - |
| Bowel perforation | 9 | 100% | 55.5% | 97% |
| Incarcerated hernia | 6 | 100% | 0% | - |
| Bowel volvulus | 4 | 100% | 50% | 97.8% |



CT were generally more accurate and sensitive with total of 82.6% sensitivity and it were mostly accurate in diagnosis of bowel obstruction, perforated peptic ulcer and appendicitis with 100%, 85.7%, 81.8% sensitivity in order.

The sensitivity of X-ray and CT in diagnosing appendicitis was found to be 7.7% and 69.2%, respectively. Given the very low sensitivity of simple abdominal imaging, it is not helpful in evaluating patients with suspected appendicitis. Despite CT scans having a higher sensitivity, there is still a discrepancy with intraoperative findings in about 30.8% of cases. This highlights the importance of considering clinical presentation and other diagnostic tools in conjunction with imaging studies for a more accurate diagnosis in cases of suspected appendicitis.

In cases of a perforated peptic ulcer, simple abdominal X-ray shows a sensitivity of 82.3% and a negative predictive value (NPV) of 93.3%. CT scan has high diagnostic accuracy and sensitivity in diagnosing perforated peptic ulcer disease (PPUD). In our study, CT had a diagnostic accuracy of 85.7% and a NPV of 97.9% in diagnosing PPUD.

In 15 of 33 cases of bowel obstruction, plain abdominal X-rays were consistent with intestinal obstruction, yielding a diagnostic accuracy and sensitivity of 45.4% (NPV 85.1%). In

contrast, CT scans demonstrated perfect concordance with surgical findings and the final diagnosis in all 25 cases who underwent CT scan.

In our study of 11 patients diagnosed with mesenteric ischemia, both plain abdominal radiography and CT scans were performed. None of the plain abdominal radiographs showed pathological findings. In contrast, CT scans demonstrated a sensitivity of 63.6%, specificity of 100%, and positive and NPV of 100% and 96.9%, respectively.

Six patients were diagnosed intraoperatively with incarcerated hernia. Plain abdominal radiography was diagnostic in 2 of these cases, yielding a sensitivity of 33.3%. Abdominopelvic CT scans correctly identified incarcerated hernia in 3 out of 6 cases, corresponding to a sensitivity of 50%. Although CT demonstrated higher sensitivity than plain radiography, both modalities showed limited diagnostic performance for incarcerated hernia in this cohort (Table 5).

In 9 patients diagnosed with bowel perforation, plain abdominal X-rays were performed for all, while abdominal CT scans were conducted for 4 patients. Of these, X-rays showed findings consistent with the final diagnosis in 5 patients, and CT scans did so in 3 patients. Therefore, the sensitivity of X-rays was 55.5%, compared to 75% for CT scans (Table 5).

Table 5. Abdominal CT and its accuracy

| Diagnosis | No of patients | No of performed CT (%) | No of correct diagnosis based predictive on CT sensitivity (%) | Negative value-NPV (%) |
|-------------------------|----------------|------------------------|--|------------------------|
| Appendicitis | 39 | 28.2% | 81.8% | 96% |
| Perforated peptic ulcer | 34 | 41.1% | 85.7% | 97.9% |
| Bowel obstruction | 33 | 74.5% | 100% | 100% |
| Mesenteric ischemia | 11 | 100% | 63.6% | 96.9% |
| Bowel perforation | 9 | 44.4% | 75% | 99.1% |
| Incarcerated hernia | 6 | 100% | 50% | 100% |
| Bowel volvulus | 4 | 100% | 75% | 99.2% |
| Total | 136 | 75% | 82.6% | 97.8% |

Discussion

Acute abdomen is the most common surgical emergency and presents significant diagnostic challenges due to its complex pathophysiology and diverse range of causes. Despite advances in diagnostic tools and surgeon experience, accurately diagnosing acute abdomen can still be difficult.

While modern imaging techniques have improved decision-making and expedited diagnoses, they can also lead to misdiagnosis if not used appropriately. Therefore, studies that assess the accuracy of imaging techniques and compare them with intra-operative findings and final diagnoses are essential. Such research can provide valuable insights, helping physicians use these tools more effectively and appropriately.

In a 2009 study by Marjan Laal, plain abdominal radiography in 72 patients demonstrated a sensitivity of 83.3% and a specificity of 97% for diagnosing bowel obstruction¹⁹. Since the introduction of CT in the 1970s in the United States, there has been a significant reduction in hospitalizations and emergency diagnostic laparotomies for patients with acute abdominal pain. This benefit is especially notable in elderly Shahrud Journal of Medical Sciences 2026;12(2) | 78

and pediatric populations, where non-specific signs and symptoms often complicate the diagnosis of abdominal pain²⁰.

In a 2023 study by Satish Kumar and colleagues involving 176 patients, single-slice contrast-enhanced CT was performed in 22.4% of cases. After the final diagnosis, the study revealed that CT outperformed other imaging modalities like X-ray and ultrasound. The most common diagnosis was duodenal perforation, observed in 47.1% (n=82) of patients, followed by gastric perforation in 13.8% (n=24). The study demonstrated that CT could detect free gas and accurately identify the site of perforation with an accuracy of 86%²¹.

In a 2014 study by Alfonso Reginelli, CT demonstrated excellent accuracy in diagnosing acute abdomen in the elderly. Among 126 patients aged 65 and older, CT scans were performed and retrospectively reviewed by two radiologists. Both radiologists showed excellent agreement between the CT findings and the final diagnosis²².

In a 2023 study by Hiram Shaish and colleagues, the accuracy of unenhanced CT was compared to contrast-enhanced CT for evaluating acute abdomen. Among the 201



patients included, unenhanced CT had an overall accuracy of approximately 70%, making it about 30% less accurate than contrast-enhanced CT. However, these findings must be weighed against the risks of administering contrast to patients with kidney injury or hypersensitivity to contrast agents²³.

Our findings must be interpreted in light of several important methodological limitations, most notably selection bias. In this study, CT scans were preferentially performed in patients with equivocal clinical presentations or when the initial diagnosis based on history, physical examination, and plain radiography was uncertain. As a result, CT was disproportionately applied to more complex or advanced cases, particularly bowel obstruction and vascular pathologies. This selective use likely inflated the apparent diagnostic performance of CT in certain subgroups, such as the observed 100% sensitivity for bowel obstruction, and limits the direct comparability of CT and plain radiography.

Conversely, the low overall sensitivity of plain abdominal radiography (38.2%) reflects its inherent limitations in detecting early or subtle pathology, as well as its reduced ability to characterize inflammatory or vascular conditions. Plain radiographs were most useful in conditions associated with free intraperitoneal air, such as perforated peptic ulcer disease, where diagnostic accuracy was high. In contrast, their poor performance in appendicitis, mesenteric ischemia, and hernia is consistent with the limited soft-tissue contrast of this modality.

The moderate sensitivity of CT for appendicitis in our cohort (69.2%) may be explained by several factors, including early-stage disease, atypical anatomical presentations, and the lack of IV contrast in some cases. CT accuracy for inflammatory and vascular conditions is known to be significantly influenced by contrast enhancement protocols, and the absence of IV contrast likely contributed to underdiagnosis in selected patients, particularly those with mesenteric ischemia. These findings underscore that imaging results must be interpreted within the clinical context and that neither CT nor plain radiography should be used in isolation.

CT proved highly accurate in diagnosing bowel obstruction, perforated peptic ulcers, and appendicitis, but was less effective for mesenteric ischemia due to its vascular nature, particularly since CT was performed without contrast agents in our study. Our findings support those of Taourel et al. and Adam et al.^{24, 25}, affirming CT as the preferred diagnostic modality for acute abdomen in most patients. However, physicians should weigh the risks of CT in unstable patients and consider it as a confirmation tool only when diagnoses are already confidently established through history, physical examination, and other diagnostic data. For conditions like perforated peptic ulcers, where abdominal X-rays can be definitively diagnostic, CT may not be necessary. Physicians should also factor in the cost and radiation exposure of CT and evaluate whether it is cost-effective for each individual patient.

Our limitation in this study includes small sample size, single-center design, and lack of contrast in some CT scans. The sample size might not be adequate for accurately assessing diagnostic precision across various diagnostic subgroups, particularly for less common conditions such as mesenteric ischemia, volvulus, and hernia. The low number of patients in

these subgroups results in less precise estimates of sensitivity, specificity, and NPV, rendering these estimates unstable. A major limitation of this study is the unequal distribution of imaging modalities, as CT scans were performed selectively rather than universally. This introduces potential selection and verification bias, limiting direct head-to-head comparison between plain radiography and CT. CT was preferentially used in diagnostically complex or equivocal cases, which may overestimate its apparent diagnostic performance. Nevertheless, this approach reflects real-world clinical practice and provides meaningful insight into the practical role of imaging modalities in acute abdomen evaluation. Another important limitation of the present study is that only patients who ultimately underwent surgical intervention were included. Consequently, the diagnostic accuracy of plain radiography and CT reported here reflects performance within a definitively surgical subgroup of patients with acute abdomen. Patients who were managed conservatively or whose symptoms resolved without surgery were not included. Therefore, the findings should not be generalized to all patients presenting with acute abdominal pain in the emergency department. Nonetheless, focusing on surgically confirmed cases allows for a reliable reference standard based on intraoperative findings and provides valuable insight into imaging performance in patients for whom accurate preoperative diagnosis is most critical.

Conclusion: Based on our study, CT scan demonstrated an overall diagnostic accuracy of 82.6%, making it a significantly superior modality for evaluating acute surgical abdomen compared to plain radiography, which had an overall accuracy of 38.2%. Nevertheless, due to the high sensitivity of plain abdominal X-ray in detecting perforated peptic ulcer (82.3%), X-ray remains a rapid, safe, and cost-effective screening tool to rule out pneumoperitoneum. We recommend that X-ray be performed selectively when perforation is suspected. CT scanning with IV contrast should be considered the first-line imaging modality for patients with suspected bowel obstruction, mesenteric ischemia, or cases with diagnostic uncertainty. To improve diagnostic rigor and generalizability in future studies, we suggest employing standardized imaging protocols for all acute abdomen patients to minimize selection bias.

Ethical Considerations

According to the principles of Helsinki declaration, the research ethics committee of the Shahid Beheshti university of medical sciences approved the study proposal with the ethical code IR.SBMU.REC.1400.163. Informed consent for the use of medical record data was obtained from patients during hospitalization, and only those who provided consent were included in the study.

Acknowledgment

We sincerely thank the radiology team at Modares Hospital for their assistance in the scan report and image analysis.

Conflict of Interest

The authors declare that they have no conflict of interest.

Funding

None.



References

- Hyams JS, Burke G, Davis PM, Rzepski B, Andrulonis PA. Abdominal pain and irritable bowel syndrome in adolescents: a community-based study. *The Journal of pediatrics* 1996;129(2):220-6. doi: 10.1016/S0022-3476(96)70246-9
- Deherkar JA. Co-relation between preoperative imaging findings and peroperative findings in acute abdomen. *International Surgery Journal* 2019;6(9):3122-7. doi: 10.18203/2349-2902.isj20194043
- Heading RC. Prevalence of upper gastrointestinal symptoms in the general population: a systematic review. *Scandinavian Journal of Gastroenterology Supplement* 1999;231:3-8.
- Zeinalpour A, Aghili A, Gholizadeh B. Abdominal apoplexy due to rupture of inferior pancreaticoduodenal artery: A rare case of acute abdomen. *Caspian Journal of Internal Medicine* 2021;12(Suppl 2):S479.
- Singh S, Kumar A, Singh NP, Sidhu V. Comparative analysis of clinical, radiological and operative findings in Acute Abdomen Cases. *European Journal of Molecular and Clinical Medicine* 2021;8(3):3393-3402.
- Brewer B, Golden GT, Hitch DC, Rudolf LE, Wangenstein SL. Abdominal pain. An analysis of 1,000 consecutive cases in a University Hospital emergency room. *American Journal of Surgery* 1976;131(2):219-223. doi: 10.1016/0002-9610(76)90101-X
- Powers RD, Guertler AT. Abdominal pain in the ED: stability and change over 20 years. *The American Journal of Emergency Medicine* 1995;13(3):301-303. doi: 10.1016/0735-6757(95)90204-X
- Kamin RA, Nowicki TA, Courtney DS, Powers RD. Pearls and pitfalls in the emergency department evaluation of abdominal pain. *Emergency Medicine Clinics* 2003;21(1):61-72. doi: 10.1016/S0733-8627(02)00080-9
- An G, West MA. Abdominal compartment syndrome: a concise clinical review. *Critical Care Medicine* 2008;36(4):1304-1310. doi: 10.1097/CCM.0b013e31816929f4
- Sharma P, Sood R, Sharma M, Gupta AK, Chauhan A. Comparative study between clinical diagnosis, plain radiography and sonography for the diagnosis of nontraumatic acute abdomen. *Journal of Family Medicine and Primary Care* 2022;11(12):7686-7690. doi: 10.4103/jfmpc.jfmpc_624_22
- Karkhanis S, Medcalf J. Plain abdomen radiographs: the right view? *European Journal of Emergency Medicine* 2009;16(5):267-270. doi: 10.1097/MEJ.0b013e328323d6e5
- Flak B, Rowley V. Acute abdomen: plain film utilization and analysis. *Canadian Association of Radiologists Journal* 1993;44(6):423-428.
- De Lacey G, Wignall B, Bradbrooke S, Reidy J, Hussain S, Cramer B. Rationalising abdominal radiography in the accident and emergency department. *Clinical Radiology* 1980;31(4):453-455. doi: 10.1016/S0009-9260(80)80191-7
- Taourel P, Pradel J, Fabre J-M, Cover S, Seneterre E, Bruel J-M. Role of CT in the acute nontraumatic abdomen. Elsevier; 1995:151-164. doi: 10.1016/0887-2171(95)90007-1
- Priola AM, Priola SM, Volpicelli G, et al. Accuracy of 64-row multidetector CT in the diagnosis of surgically treated acute abdomen. *Clinical Imaging* 2013;37(5):902-907. doi: 10.1016/j.clinimag.2013.02.016
- Bower H. Laparoscopic hernia surgery linked to increased complications. *British Medical Journal (Clinical Research Edition)* 1999;319(7204):211a. doi: 10.1136/bmj.319.7204.211a
- Taourel P, Baron MP, Pradel J, Fabre JM, Seneterre E, Bruel JM. Acute abdomen of unknown origin: impact of CT on diagnosis and management. *Gastrointestinal Radiology* 1992;17(4):287-91. doi: 10.1007/BF01888571
- Raja AS, Wright C, Sodickson AD, et al. Negative appendectomy rate in the era of CT: an 18-year perspective. *Radiology* 2010;256(2):460-5. doi: 10.1148/radiol.10091570
- Laal M, Mardanloo A. Acute abdomen; pre and post-laparotomy diagnosis. *International Journal of Collaborative Research on Internal Medicine and Public Health* 2009;1(5):156.
- Rosen MP, Sands DZ, Longmaid III HE, Reynolds KF, Wagner M, Raptopoulos V. Impact of abdominal CT on the management of patients presenting to the emergency department with acute abdominal pain. *American Journal of Roentgenology* 2000;174(5):1391-1396. doi: 10.2214/ajr.174.5.1741391
- Kumar S, Tanwar P, Trivedi S, Sood R, Sharma P, Sharma M. An Assessment of the Etiologies Associated With Acute Abdomen Subjected to Exploratory Laparotomy: A Study From a Rural Area of Himachal Pradesh. *Cureus* 2023;15(1). doi: 10.7759/cureus.33285
- Reginelli A, Russo A, Pinto A, et al. The role of computed tomography in the preoperative assessment of gastrointestinal causes of acute abdomen in elderly patients. *International Journal of Surgery* 2014;12:S181-S186. doi: 10.1016/j.ijssu.2014.08.345
- Shaish H, Ream J, Huang C, et al. Diagnostic accuracy of unenhanced computed tomography for evaluation of acute abdominal pain in the emergency department. *JAMA surgery* 2023;158(7):e231112-e231112. doi: 10.1001/jamasurg.2023.1112
- Taourel Pa, Baron M, Pradel J, Fabre J, Seneterre E, Bruel J. Acute abdomen of unknown origin: impact of CT on diagnosis and management. *Gastrointestinal Radiology* 1992;17:287-291. doi: 10.1007/BF01888571
- Adams I, Chan M, Clifford P, et al. Computer aided diagnosis of acute abdominal pain: a multicentre study. *British Medical Journal (Clinical Research Edition)* 1986;293(6550):800-804. doi: 10.1136/bmj.293.6550.800

