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A COMPARATIVE STUDY BETWEEN CLINICAL DIAGNOSIS AND OPERATIVE FINDINGS OF SMALL BOWEL OBSTRUCTION

Original Research

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ABSTRACT

Background: Small bowel obstruction (SBO) is a significant surgical condition requiring timely and accurate diagnosis to guide appropriate management. While computed tomography (CT) is widely regarded as the most reliable imaging modality, its availability remains limited in resource-constrained settings. In such cases, plain abdominal X-rays and ultrasound serve as alternative diagnostic tools. However, their accuracy varies, necessitating further validation against intraoperative findings, which remain the gold standard for SBO diagnosis.

Objective: To compare the diagnostic accuracy of plain abdominal X-rays, ultrasound, and CT scans for detecting small bowel obstruction using intraoperative findings as the reference standard.

Methods: This validation study was conducted at Combined Military Hospital, Lahore, from July 2024 to December 2024. A total of 126 patients presenting with clinical symptoms of SBO were included. All patients underwent abdominal X-rays (erect and supine), ultrasound, and contrast-enhanced CT scans. Findings from these imaging modalities were compared with intraoperative diagnoses to determine true positive, false positive, true negative, and false negative cases. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy were calculated using 2×2 contingency tables.

Results: The median age of patients was 57.00 years (range: 18.00–80.00), with 76 males (60.32%) and 50 females (39.68%). Diagnostic parameters for abdominal X-rays were sensitivity 60.00%, specificity 71.43%, PPV 91.30%, NPV 26.32%, and accuracy 61.90%. For ultrasound, these values were 79.05%, 76.19%, 94.32%, 42.11%, and 78.57%, respectively. CT demonstrated the highest diagnostic performance, with sensitivity 90.48%, specificity 90.48%, PPV 97.94%, NPV 65.52%, and accuracy 90.48%.

Conclusion: Ultrasound and CT abdomen are highly effective for diagnosing small bowel obstruction before surgery, with CT providing the highest diagnostic accuracy. While X-rays remain widely available, their moderate sensitivity limits their reliability as a standalone tool. These findings support the use of ultrasound as a viable alternative in settings where CT is not accessible, optimizing diagnostic efficiency in surgical decision-making.

Keywords: Abdominal X-ray, Computed Tomography, Diagnostic Imaging, Intestinal Obstruction, Laparotomy, Sensitivity and Specificity, Ultrasonography.

INTRODUCTION

Laparotomy is a time-sensitive surgical procedure performed across diverse patient populations. Despite being a common intervention, its mortality rate remains considerably high, estimated at approximately 15%, which is significantly greater than that associated with many other surgical procedures (1,2). This operation is indicated in various critical conditions, including gastrointestinal perforation, blunt abdominal trauma resulting in visceral injury, complicated appendicitis, ruptured peptic ulcers, and gangrenous hernias (3,4). Another major indication is small bowel obstruction, a condition arising from multiple etiologies such as abdominal tuberculosis, intussusception, hernias (umbilical, incisional, and inguinal), foreign body ingestion, inflammatory bowel disease, bezoars, postoperative adhesions, tumors, gallstone ileus, inflammatory strictures, ileo-sigmoidal knot formation, and volvulus (5,6). Regardless of the underlying cause, the definitive treatment for small bowel obstruction frequently necessitates surgical intervention to relieve the blockage. However, this is a highly invasive procedure with substantial risks, including significant morbidity and potential complications. Given the severity of the condition and the risks associated with surgical correction, accurate preoperative diagnosis is imperative. Clinicians rely on multiple diagnostic modalities to identify small bowel obstruction, including plain abdominal X-rays, abdominal ultrasound, and computed tomography (CT) scans (7,8).

The general assumption in medical practice is that advanced imaging techniques offer superior diagnostic accuracy (8). However, in resource-limited settings such as underdeveloped regions of Pakistan, access to high-end radiological investigations like CT scans remains limited, particularly in smaller cities (9). In such circumstances, alternative diagnostic modalities become essential for effective clinical decision-making (10). This study aims to compare the diagnostic accuracy of different imaging techniques—including plain abdominal X-rays, abdominal ultrasound, and CT scans—against operative findings, which serve as the gold standard. By evaluating the efficacy of these modalities, this research seeks to provide evidence-based insights into the reliability of both conventional and advanced diagnostic tools for small bowel obstruction. The findings will contribute to refining diagnostic strategies, particularly in settings where access to advanced imaging remains a challenge, ultimately enhancing patient outcomes through informed clinical decision-making.

METHODS

This validation study was conducted at Combined Military Hospital, Lahore, from July 2024 to December 2024, following approval from the institutional ethical committee. The sample size was determined using the WHO sample size calculator, considering a confidence level of 95%, an absolute precision of 8%, and a reported sensitivity of 69.7% for plain abdominal X-rays, yielding a required sample size of 126 (9). A non-probability consecutive sampling technique was employed for patient selection. Patients aged 18 years or older presenting with clinical symptoms suggestive of small bowel obstruction were included in the study. Exclusion criteria encompassed patients receiving ongoing treatment for abdominal tuberculosis, pregnant women, individuals with impaired renal function (serum creatinine >1.3 mg/dL), those with pre-existing chronic morbidities such as diabetes, hypertension, or ischemic heart disease, and individuals with traumatic abdominal injuries. Hemodynamically unstable patients were excluded only if their condition necessitated immediate surgical intervention, precluding preoperative imaging assessments. Hemodynamically unstable patients who could undergo diagnostic imaging before surgery were included in the study.

Before participation, written informed consent was obtained from all patients. Baseline characteristics, including age, gender, body mass index (BMI), and presenting symptoms, were recorded. Each patient underwent a standardized sequence of imaging assessments, beginning with plain abdominal X-rays (erect and supine), followed by abdominal ultrasound, and finally, an abdominal computed tomography (CT) scan with intravenous contrast. Diagnoses of small bowel obstruction were based on predefined imaging criteria. On plain abdominal X-rays, obstruction was diagnosed if the small bowel was dilated (>2.5 cm in diameter), the colon appeared normal (<6 cm in diameter), and there was no gas shadowing in the colon. On ultrasound, obstruction was indicated by small bowel dilation (>2.5 cm), absence of peristalsis, and thickened valvulae conniventes. On CT scans, small bowel obstruction was diagnosed based on small bowel dilation (>2.5 cm), normal colonic diameter (<6 cm), and the presence of a transition point. Imaging studies were interpreted independently by two consultant radiologists, each with at least five years of experience in abdominal imaging. The radiologists were

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blinded to each other's interpretations and the patients' clinical and surgical outcomes to minimize bias. Discrepancies between the two readings were resolved by consensus or consultation with a third senior radiologist.

Patients with positive imaging findings for small bowel obstruction underwent surgery as per institutional protocol. Intraoperative findings were considered the gold standard for confirming the presence or absence of small bowel obstruction. For patients with negative imaging results, a 48-hour observation period was implemented. If symptoms failed to resolve or worsened, surgical exploration was performed to confirm or exclude obstruction. In cases where intraoperative findings were ambiguous, the final determination was made based on a combination of direct surgical assessment, intraoperative bowel decompression response, and, when necessary, histopathological examination of resected tissue. Diagnostic accuracy for each imaging modality was assessed by classifying patients into true positive (TP), false positive (FP), true negative (TN), and false negative (FN) categories based on intraoperative findings. A TP result indicated that small bowel obstruction was identified on imaging and confirmed at surgery, while an FP result indicated positive imaging findings without intraoperative confirmation. A TN result indicated a negative imaging study with no obstruction found at surgery, whereas an FN result referred to cases where imaging was negative despite intraoperative evidence of obstruction. The same classification system was applied to all three imaging modalities.

Statistical analysis was conducted using the Statistical Package for Social Sciences (SPSS) version 22. Quantitative variables, such as age and BMI, were assessed for normality using the Shapiro-Wilk test. As these variables were not normally distributed, they were presented as medians with interquartile ranges (IQRs). Qualitative variables, including gender, presenting symptoms, and imaging-based diagnoses, were presented as frequencies and percentages. Standardized 2×2 contingency tables were constructed to determine sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall diagnostic accuracy for each imaging modality. By incorporating these methodological refinements, the study ensures a more rigorous evaluation of diagnostic accuracy, minimizes potential biases, and enhances the reliability of findings in both resource-limited and well-equipped clinical settings.

RESULTS

In this study, 126 patients were included, with a median age of 57.00 years (range: 18.00–80.00). Among them, 76 (60.32%) were male, and 50 (39.68%) were female. The median body mass index (BMI) was 23.10 kg/m² (range: 15.90–37.70). The most commonly reported symptom was vomiting, observed in 56 patients (44.44%), followed by abdominal pain in 30 (23.81%), abdominal guarding in 22 (17.46%), and constipation in 18 (14.29%). Findings from abdominal X-rays revealed small bowel obstruction (SBO) in 69 patients (54.76%), while 57 (45.24%) had no radiographic evidence of obstruction. Intraoperative findings confirmed SBO in 105 patients (83.33%), whereas 21 (16.67%) were found to be negative. Based on these results, plain abdominal X-rays had 63 true positives (50.00%), 6 false positives (4.76%), 42 false negatives (33.33%), and 15 true negatives (11.91%). Abdominal ultrasound detected SBO in 88 patients (69.84%), whereas 38 (30.16%) showed no evidence of obstruction. Surgical findings confirmed SBO in 105 cases (83.33%), with 21 (16.67%) being negative. This resulted in 83 true positives (65.87%), 5 false positives (3.97%), 22 false negatives (17.46%), and 16 true negatives (12.70%). Abdominal CT scans indicated SBO in 97 patients (76.98%), while 29 (23.02%) had no evidence of obstruction. Surgical confirmation was positive for SBO in 105 patients (83.33%) and negative in 21 (16.67%). This yielded 95 true positives (75.40%), 2 false positives (1.59%), 10 false negatives (7.94%), and 19 true negatives (15.08%).

Diagnostic accuracy parameters showed that abdominal X-rays had a sensitivity of 60.00%, specificity of 71.43%, positive predictive value (PPV) of 91.30%, negative predictive value (NPV) of 26.32%, and overall accuracy of 61.90%. Abdominal ultrasound demonstrated a sensitivity of 79.05%, specificity of 76.19%, PPV of 94.32%, NPV of 42.11%, and accuracy of 78.57%. Abdominal CT had the highest diagnostic performance, with a sensitivity of 90.48%, specificity of 90.48%, PPV of 97.94%, NPV of 65.52%, and overall accuracy of 90.48%. False positive and false negative rates varied among the imaging modalities, influencing their diagnostic reliability. Abdominal X-ray had the highest false negative rate (40.00%) and a false positive rate of 28.57%, indicating a higher likelihood of missing true cases of small bowel obstruction (SBO) while also misidentifying some patients as positive. Abdominal ultrasound demonstrated a lower false negative rate (20.95%) and a false positive rate of 23.81%, reflecting improved sensitivity and specificity compared to X-ray. Abdominal CT showed the lowest false negative rate (7.94%) and the lowest false positive rate (9.52%), reinforcing its superior diagnostic accuracy. Statistical analysis revealed significant differences in sensitivity and specificity between X-ray and CT ($p < 0.05$), as well as between ultrasound and CT, supporting the conclusion that CT is the most reliable diagnostic tool. No significant difference was observed between X-ray and ultrasound in terms of specificity, although ultrasound performed significantly

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better in terms of sensitivity. These findings highlight the variability in diagnostic reliability among different modalities, emphasizing the importance of selecting the most appropriate imaging technique based on clinical availability and patient factors.

Table- 1: 2x2 contingency table for TP, FP, FN and TN cases on abdominal x-ray (n = 126)

	SBO on surgery	**No SBO on surgery**
SBO on abdominal X-ray	63 (50.00%) TP	6 (4.76%) FP
No SBO on abdominal X-ray	42 (33.33%) FN	15 (11.91%) TN

Table 2: 2x2 contingency table for TP, FP, FN and TN cases on abdominal ultrasound (n = 126)

	SBO on surgery	**No SBO on surgery**
SBO on abdominal USG	83 (65.87%) TP	5 (3.97%) FP
No SBO on abdominal USG	22 (17.46%) FN	16 (12.70%) TN

Table 3: 2x2 contingency table for TP, FP, FN and TN cases on abdominal CT (n = 126)

	SBO on surgery	**No SBO on surgery**
SBO on abdominal CT	95 (75.40%) TP	2 (1.59%) FP
No SBO on abdominal CT	10 (7.94%) FN	19 (15.08%) TN

Table 4: Diagnostic accuracy parameters of different methods of clinical diagnosis for small bowel obstruction (n = 126)

Parameter	**Abdominal X-ray**	**Abdominal USG**	**Abdominal CT**
Sensitivity	60.00%	79.05%	90.48%
Specificity	71.43%	76.19%	90.48%
PPV	91.30%	94.32%	97.94%
NPV	26.32%	42.11%	65.52%
Accuracy	61.90%	78.57%	90.48%

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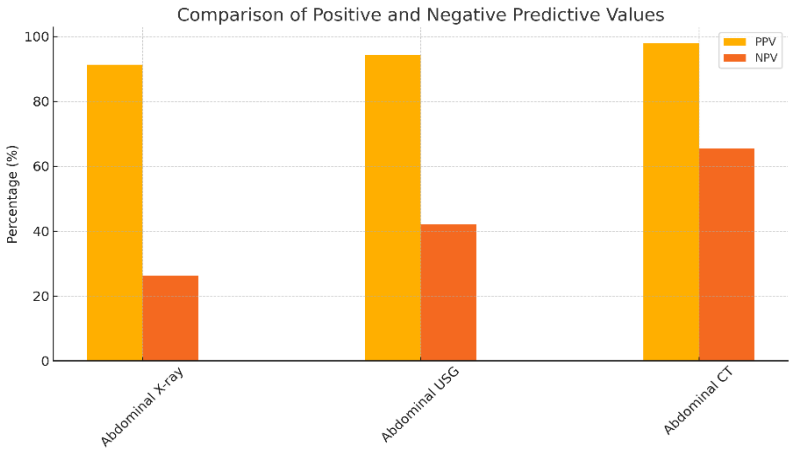
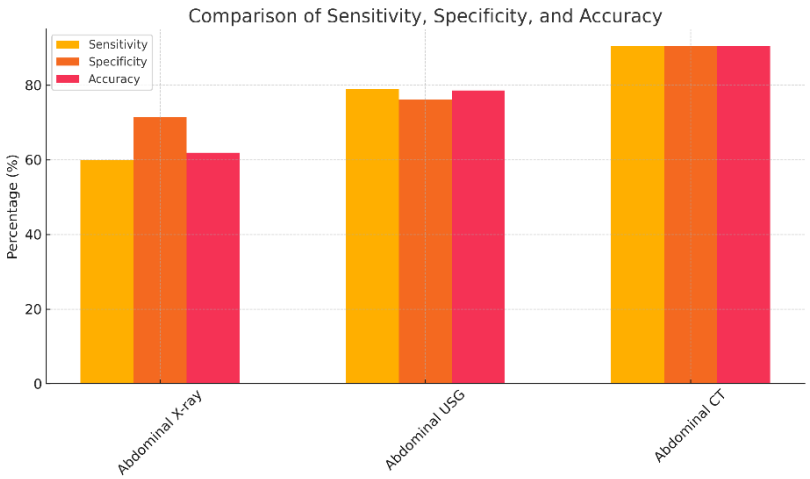
Table 5: Diagnostic Accuracy Analysis

	Value
X-ray FPR	28.571
X-ray FNR	40
USG FPR	23.81
USG FNR	20.952
CT FPR	9.524
CT FNR	9.524
X-ray vs USG Sensitivity p-value	0.004
X-ray vs USG Specificity p-value	1
USG vs CT Sensitivity p-value	0.035
USG vs CT Specificity p-value	0.408
X-ray vs CT Sensitivity p-value	0
X-ray vs CT Specificity p-value	0.238





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DISCUSSION

Small bowel obstruction (SBO) is a critical surgical condition that, if not promptly diagnosed and managed, can lead to life-threatening complications such as perforation and peritonitis. Despite its potential severity, a considerable proportion of patients can be managed conservatively through nasogastric decompression or administration of water-soluble contrast without requiring surgical intervention (11). This highlights the necessity of accurate and efficient diagnostic tools to differentiate cases requiring immediate surgery from those that may benefit from non-operative management. The present study focused on evaluating the diagnostic accuracy of abdominal X-rays, ultrasound, and computed tomography (CT) scans for SBO, using intraoperative findings as the gold standard (12). The study population comprised individuals with a median age of 57 years, predominantly from the middle to older age group. This age distribution aligns with previous findings that suggest elderly individuals are at a higher risk of developing SBO due to factors such as increased prevalence of hernias, chronic constipation, bowel malignancies, and dietary modifications (13). A notable male predominance was observed, with 60.32% of the study population being male. This finding is consistent with previous reports indicating a higher incidence of SBO among males, which may be attributed to gender-based differences in lifestyle, occupation-related physical strain, and predisposition to hernias (13,14).

Abdominal X-rays demonstrated an accuracy of 61.90% for the diagnosis of SBO, falling within the broad range of reported values in previous studies, which vary between 50% and 80%. The sensitivity and specificity of abdominal X-rays in this study were 60.00% and 71.43%, respectively, comparable to reported values of 69.7% and 61%. While X-rays are widely used due to their accessibility and cost-effectiveness, their moderate sensitivity and high false-negative rate (40.000%) limit their reliability as a standalone diagnostic tool, particularly in cases with ambiguous clinical presentations. Ultrasound exhibited superior diagnostic accuracy compared to X-rays, with sensitivity and specificity values of 79.05% and 76.19%, respectively. These findings, though lower than some previously reported values exceeding 90%, reflect variations in study methodologies, including differences in operator expertise, patient population, and comparison standards (15). One study reported ultrasound sensitivity and specificity at 92.31% and 94.12%, respectively, but it utilized CT as the reference rather than intraoperative findings (15,16). Another meta-analysis reported pooled sensitivity and specificity values of 93% and 80%, respectively, supporting the premise that ultrasound remains a valuable diagnostic tool, particularly in resource-limited settings where CT may not be readily available (17).

CT scans demonstrated the highest diagnostic accuracy, with sensitivity and specificity values of 90.48% each, along with a remarkably low false-negative rate (7.940%) and false-positive rate (9.524%). These findings are in agreement with prior studies, which have reported CT scan accuracy values around 89.9% to 89.4% (18). The ability of CT to detect transition points, assess bowel viability, and identify underlying causes such as adhesions, tumors, or ischemic changes makes it the most reliable imaging modality for SBO diagnosis (19). However, its higher cost, limited availability in smaller healthcare centers, and potential risks associated with contrast administration, particularly in patients with renal impairment, present practical limitations (20). The findings of this study emphasize that while X-rays remain a commonly used initial diagnostic tool due to their widespread availability, they lack sufficient accuracy for definitive SBO diagnosis. Ultrasound offers a significant improvement in diagnostic capability and is a viable alternative in settings where CT is not accessible. However, CT remains the gold standard, demonstrating the highest accuracy and reliability. The major limitation of this study was the lack of detailed analysis regarding the underlying causes of SBO, which could have provided additional insights into the diagnostic performance of each modality based on etiology. Additionally, interobserver variability among radiologists, although minimized by the study's methodology, could still have influenced the diagnostic interpretations. Future studies should aim to incorporate larger, multicenter cohorts and explore the integration of artificial intelligence-assisted imaging analysis to enhance diagnostic precision, particularly in settings with limited radiology expertise.

CONCLUSION

In conclusion, this study highlights the importance of selecting the most effective diagnostic tools for identifying small bowel obstruction before surgery. While abdominal X-rays remain widely used due to their accessibility, their limited accuracy makes them less reliable for definitive diagnosis. Ultrasound provides a more accurate and non-invasive alternative, particularly in resource-limited settings where advanced imaging may not be available. However, CT remains the most reliable modality, offering superior diagnostic precision and aiding in surgical decision-making. These findings reinforce the need for an optimized diagnostic approach to ensure timely and accurate identification of small bowel obstruction, ultimately improving patient outcomes and reducing unnecessary surgical interventions.

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Author Contribution

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Muhammad Irtaza Sherazi	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Mahnoor Ahsan Bhoon	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Roshan Hameed Mughal	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Zoha Aslam	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Sher Afgan Raisani	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published

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