ORIGINAL ARTICLE

MULTI-DETECTOR COMPUTED TOMOGRAPHY FOR INTESTINAL OBSTRUCTION: VALIDATING DIAGNOSTIC PRECISION AGAINST OPERATIVE FINDINGS

Farzana Rahim,[1] Masroor Ahmad,[2] Pari Gul[3]

[1] Department of Radiology, Balochistan Institute of Nephrology Urology (BINUQ), Quetta, Pakistan.
[2] Department of Plastic Surgery, Bolan Medical Complex Hospital, Quetta, Pakistan.
[3] Department of Radiology, Bolan Medical Complex Hospital, Quetta, Pakistan.

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ABSTRACT

INTRODUCTION: With the ongoing developments in imaging techniques overtime, computed tomography (CT) has emerged as an excellent modality in the diagnosis of intestinal obstruction. CT scan not only reliably diagnoses intestinal obstruction but can also be of great help in determining the cause, severity, and the precise point of obstruction. **OBJECTIVES:** To determine the diagnostic accuracy of multi-detector computed tomography scan in diagnosing intestinal obstruction, taking operative findings as gold standard. **STUDY DESIGN:** Descriptive, cross-sectional. **STUDY DURATION:** 31st October 2023 to 30th June 2024. **SETTINGS:** Department of Radiology, Bolan Medical College, Quetta. **MATERIALS & METHODS:** A total of 301 patients with suspected intestinal obstruction, 25-65 years of age of both genders were included. Patients already operated for intestinal obstruction, allergy to contrast agents, pregnant females, CRF and CLD were excluded. Computed Tomography was performed on Toshiba Aquilion Multislice CT scanner before and after intravenous contrast administration. Each CT scan findings were interpreted by one consultant radiologist in order to control the bias and look for intestinal obstruction. MDCT scan findings were compared with operative findings. **RESULTS:** In MDCT positive patients, 166 (True Positive) had intestinal obstruction and 06 (False Positive) had no intestinal obstruction on operation. Among 129, MDCT negative patients, 10 (False Negative) had intestinal obstruction on operative findings whereas 119 (True Negative) had no intestinal obstruction on operative findings (p=0.0001). Overall sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy of multi-detector computed tomography scan in diagnosing intestinal obstruction, taking operative findings as gold standard was 94.32%, 95.20%, 96.51%, 92.25% and 94.68% respectively. **CONCLUSION:** This study concluded that multi-detector computed tomography scan is a highly sensitive and accurate non-invasive modality in detecting intestinal obstruction.

Keywords: Intestinal obstruction, multi-detector computed tomography, sensitivity.

Introduction

Bowel obstruction is frequently seen clinical problem and in suspected cases of acute abdomen morbidity across the world is approximately 20%.[1] In patients with crampy abdominal pain, distension, vomiting and altered bowel sounds suggesting intestinal obstruction, multiple radiological imaging are done to localize the cause of obstruction including conventional radiography, contrast studies like barium and CT scan.[2] Plain radio-

Correspondence : Dr. Farzana Rahim
Department of Radiology,
Balochistan Institute of Nephrology Urology (BINUQ),
Quetta, Pakistan.
Email: docfarzanarahim@gmail.com

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graphy has specificity of 57 % and sensitivity of 69% with accuracy between 46-80%.[1] In acute abdomen, first modality for confirmation is plain radiography because of cost effectiveness and easy availability.[3] Although plain X-ray abdominal evaluation still remains the investigation of first choice in cases of suspected intestinal obstruction due to its low cost and wide availability, it cannot reliably diagnose the exact level of obstruction and thus can only serve as a basis for triage for further imaging workup.[4] With the ongoing developments in imaging techniques overtime, computed tomography (CT) has emerged as an excellent modality in the diagnosis of intestinal obstruction. CT scan not only reliably diagnoses intestinal obstruction but can also be of great help in determining the cause, severity, and the precise point of obstruction.[5,6]
CT scanning is useful in making an early diagnosis of strangulated obstruction and in delineating the myriad other causes of acute abdominal pain, particularly when clinical and radiographic findings are inconclusive. It also has proved useful in distinguishing the etiologies of small-bowel obstruction (SBO), that is, in distinguishing extrinsic causes (such as adhesions and hernia) from intrinsic causes (such as neoplasms and Crohn disease). In addition, CT scanning differentiates the above from intraluminal causes, such as bezoars. The modality may be less useful in the evaluation of small bowel ischemia associated with obstruction. CT scanning is capable of revealingabscess, inflammatory process, extraluminal pathology resulting in obstruction, and mesenteric ischemia and enables the clinician to distinguish between ileus and mechanical small bowel obstruction in postoperative patients.[7]
Localizing the point of transition (POT) is empirical as it increases confidence in diagnosis, guides patient care, and thus helps in further management.[8] In a study,[9] intestinal obstruction was found in 73% patients and MDCT sensitivity as 85% and specificity as 70% in diagnosing bowel obstruction while in another study, the overall sensitivity, specificity and accuracy of 64 sliced MDCT to establish the diagnosis of intestinal obstruction were 96%, 100% and 97% respectively.10

Objectives & Operational Definitions

The objective of the study :

To determine the diagnostic accuracy of multi-detector computed tomography scan in diagnosing intestinal obstruction, taking operative findings as gold standard.

OPERATIONAL DEFINITIONS:

1. Diagnostic Accuracy: measured in terms of;

a. Sensitivity: Defined as the ability of MDCT scan to correctly identify those who had intestinal obstruction

$$= \frac{TP}{TP + FN} \times 100$$

b. Specificity: defined as the ability of MDCT scan to correctly identify those who had no intestinal obstruction

$$= \frac{TN}{TN + FP} \times 100$$

c. Positive predictive value: The probability that a patient with a positive MDCT scan result actually had intestinal obstruction $= \frac{TP}{TP + FP} \times 100$

d. Negative predictive value: The probability that a patient with a negative MDCT scan result actually had no intestinal obstruction $= \frac{TN}{TN + FN} \times 100$

2. True Positive: Patients with intestinal obstruction on MDCT scan as well as on operative findings.

3. True Negative: Patients with no intestinal obstruction on MDCT scan as well as on operative findings.

4. False Positive: Patients with intestinal obstruction on MDCT scan but absent on operative findings.

5. False Negative: Patients with no intestinal obstruction on MDCT scan but present on operative findings.

6. Suspected intestinal obstruction: Patients with crampy abdominal pain, distension of abdomen (outward expansion beyond the normal girth of the stomach and waist) on clinical examination, vomiting (>3 episodes/day), detected on auscultation by not hearing bowel sound and presence of air fluid level (accumulation of air and fluid proximal to the point of obstruction and absence of fluid and air distal to the obstruction) on plain x-ray.

7. Intestinal obstruction on MDCT: Bowel obstruction considered to be present when dilated loop measures >2.5 cm and length of segment is >10 cm.

Materials & Methods

STUDY DESIGN: Descriptive, Cross-sectional study.

SETTING: Department of Radiology, Bolan Medical College, Quetta.

DURATION OF STUDY: 31st October 2023 to 30th June 2024.

SAMPLE SIZE: Sample size of 301 cases has been calculated with 95% confidence level, and taking expected prevalence of intestinal obstruction i.e. 73%[9] and 10% desired precision for sensitivity of 85%9 and specificity of 70.0%[9] of MDCT scan in diagnosing intestinal obstruction.

SAMPLE TECHNIQUE: Non-probability, consecutive sampling.

SAMPLE SELECTION:

a. Inclusion Criteria:

• All patients with suspected intestinal obstruction (as per-operational definition) for last 24 hours.
• Patients 25-65 years of age.
• Both genders.

b. Exclusion Criteria:

• Patients already operated for intestinal obstruction (it interfere with results due to adhesions).
• Patients with allergy to contrast agents (MDCT cannot be done).
• Patients with chronic liver disease (assessed on history and medical record (s/creatinine >2.0 mg/dl) as ascites interfere with MDCT results.
• Patients with chronic renal failure (assessed on history and medical record (s/creatinine >1.1 mg/dl) as contrast cannot be given and also paralytic ileus may be present.
• Pregnant females (MDCT cannot be done).
• Claustrophobic patients (with fear of closed spaces), unable to undergo CT scanning.

DATA COLLECTION PROCEDURE:

After permission from local ethical review committee, total number of 301 patients who were presented to Bolan Medical College, Quetta and referred by clinician to the radiology department fulfilling the inclusion criteria was selected. After taking informed consent, computed Tomography was performed on Toshiba Aquilion Multislice CT scanner before and after intravenous contrast administration. Each CT scan findings were interpreted by one consultant radiologist in order to control the bias and he/she looked for intestinal obstruction as per-operational definition. All patients had undergone operation in the concerned ward. MDCT scan findings were compared with operative findings. All this data was recorded on a specially designed proforma. Effect modifiers were controlled through exclusion criteria.

DATA ANALYSIS PROCEDURE:

Collected data was analyzed through computer software SPSS 20.0. Mean and standard deviation were calculated for quantitative variables i.e. age and duration of disease. Frequency and percentage were calculated for qualitative variables i.e. gender, level of obstruction (small intestine/large intestine) and intestinal obstruction on MDCT scan and operative findings. 2 x 2 contingency table was used to calculate sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy of CT scan in diagnosing intestinal obstruction, taking operative findings as gold standard. Effect modifiers like age, gender, duration of disease and level of obstruction (small intestine/large intestine) were controlled by stratification. Post-stratification 2 x 2 contingency table was used to calculate sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy of MDCT scan in diagnosing intestinal obstruction.

Results

Age range in this study was from 25-65 years with mean age of 49.57 ± 10.25 years. Majority of the patients 63.79% were between 46-65 years of age
Out of these 301 patients, 167 (55.48%) were males and 134 (44.52%) were females with ratio of 1.2:1. Mean duration of disease was 12.86 ± 2.89 hours.
All the patients were subjected to multi-detector computed tomography scan and MDCT scan supported the diagnosis of intestinal obstruction in 172 (57.14%) patients and no intestinal obstruction in 129 (42.86%) patients. Operative findings confirmed intestinal obstruction in 176 (58.47%) patients and no intestinal obstruction in 125 (41.53%) patients. In MDCT

positive patients, 166 (True Positive) had intestinal obstruction and 06 (False Positive) had no intestinal obstruction on operation. Among 129, MDCT negative patients, 10 (False Negative) had intestinal obstruction on operative findings whereas 119 (True Negative) had no intestinal obstruction on operative findings (p= 0.0001) as shown in (Tab.1).

Overall sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy of multi-detector computed tomography scan in diagnosing intestinal obstruction, taking operative findings as gold standard was 94.32%, 95.20%, 96.51%, 92.25% and 94.68% respectively.

Stratification of diagnostic accuracy with respect to age groups has shown in (Tab.2 & 3). Gender stratification has shown in (Tab.4 & 5). Stratification of diagnostic accuracy with respect to duration of disease is shown in (Tab.6 & 7). Stratification of diagnostic accuracy with respect to level of obstruction is shown in (Tab.8 & 9).

	Positive result on operative findings	Negative result on operative findings	P-value
Positive result on MDCT	166 (TP)*	06 (FP)***	0.0001
Negative result on MDCT	10 (FN)**	119 (TN)****	

*-TP=True positive **-FP=False positive ***-FN=False negative ****-TN=True negative
Sensitivity: 94.32%, Specificity: 95.20%, Positive Predictive Value (PPV): 96.51%, Negative Predictive Value (NPV): 92.25%
Diagnostic Accuracy: 94.68%

Table 1: Diagnostic accuracy of multi-detector computed tomography scan in diagnosing intestinal obstruction, taking operative findings as gold standard.

	Positive result on operative findings	Negative result on operative findings	P-value
Positive result on MDCT	62 (TP)	03 (FP)	0.001
Negative result on MDCT	05 (FN)	39 (TN)	

Sensitivity: 92.54%, Specificity: 92.86%, Positive Predictive Value (PPV): 95.38%, Negative Predictive Value (NPV): 88.64%
Diagnostic Accuracy: 92.66%

Table 2: Stratification of age 25-45 years (n=109).

	Positive result on operative findings	Negative result on operative findings	P-value
Positive result on MDCT	104 (TP)	03 (FP)	0.001
Negative result on MDCT	05 (FN)	80 (TN)	

Sensitivity: 95.41%, Specificity: 96.39%, Positive Predictive Value (PPV): 97.20%, Negative Predictive Value (NPV): 94.12%,
Diagnostic Accuracy: 95.83%

Table 3: Stratification of age 46-65 years (n=192).

	Positive result on operative findings	Negative result on operative findings	P-value
Positive result on MDCT	84 (TP)	01 (FP)	0.001
Negative result on MDCT	06 (FN)	76 (TN)	

Sensitivity: 93.33%, Specificity: 98.70%, Positive Predictive Value (PPV): 98.82%, Negative Predictive Value (NPV): 92.68%
Diagnostic Accuracy: 95.81%

Table 4: Stratification of male gender (n=167).

	Positive result on operative findings	Negative result on operative findings	P-value
Positive result on MDCT	82 (TP)	05 (FP)	0.001
Negative result on MDCT	04 (FN)	43 (TN)	

Sensitivity: 95.35%, Specificity: 89.58%, Positive Predictive Value (PPV): 94.25%, Negative Predictive Value (NPV): 91.49%,
Diagnostic Accuracy: 93.29%

Table 5: Stratification of female gender (n=134).

	Positive result on operative findings	Negative result on operative findings	P-value
Positive result on MDCT	74 (TP)	05 (FP)	0.001
Negative result on MDCT	05 (FN)	57 (TN)	

Sensitivity: 93.67%, Specificity: 91.94%, Positive Predictive Value (PPV): 93.67%, Negative Predictive Value (NPV): 91.94%,
Diagnostic Accuracy: 92.91%

Table 6: Stratification of duration of disease ≤12 hours (n=141).

	Positive result on operative findings	Negative result on operative findings	P-value
Positive result on MDCT	92 (TP)	01 (FP)	0.001
Negative result on MDCT	05 (FN)	62 (TN)	

Sensitivity: 94.85%, Specificity: 98.41%, Positive Predictive Value (PPV): 98.92%, Negative Predictive Value (NPV): 92.54%,
Diagnostic Accuracy: 96.25%

Table 7: Stratification of duration of disease >12 hours (n=160).

	Positive result on operative findings	Negative result on operative findings	P-value
Positive result on MDCT	134 (TP)	02 (FP)	0.001
Negative result on MDCT	10 (FN)	74 (TN)	

Sensitivity: 93.06%, Specificity: 97.37%, Positive Predictive Value (PPV): 98.53%, Negative Predictive Value (NPV): 88.10%,
Diagnostic Accuracy: 94.55%

Table 8: Stratification of small intestine (n=220).

	Positive result on operative findings	Negative result on operative findings	P-value
Positive result on MDCT	32 (TP)	04 (FP)	0.001
Negative result on MDCT	00 (FN)	45 (TN)	

Sensitivity: 100.0%, Specificity: 91.84%, Positive Predictive Value (PPV): 88.89%, Negative Predictive Value (NPV): 100.0%, Diagnostic Accuracy: 95.06%

Table 9: Stratification of large intestine (n=81).

Discussion

Intestinal obstruction is a condition in which intestine is obstructed because of any mechanical or non-mechanical reasons. It accounts for 20% of all surgical admissions for acute abdomen.[11] Small bowel is specifically involved in 60-85% of intestinal obstruction cases.[12] The causes of bowel obstruction are variable and often require urgent management. Delay in diagnosis and management can result in bowel ischemia and death.[13] Diagnostic approaches include history, physical examination and radiological investigations in combination. Routinely X-ray abdomen in addition to history and physical examination is done for diagnosis of intestinal obstruction. Its diagnostic accuracy is about 40-80%.[14] This wide range in accuracy clearly reflects the limitation of plain film in diagnosing small bowel obstruction (SBO). To further enhance the diagnostic accuracy the clinicians had to resort various contrast studies in order to establish the diagnosis and ascertain the site of obstruction. This whole process may involve several hours before patient could be taken to emergency operating room for definitive procedure. Thus, the need for a more refined imaging study for immediate diagnosis of SBO is obvious.[15] Most of these patients require urgent laparotomy to establish accurate diagnosis and prevent intestinal ischaemia. Recent technological advances in imaging modalities, especially multi-planner computed tomography (CT) scan, have not only improved the ability to identify cases of bowel obstruction that require urgent surgery, but also those that can be managed conservatively. In adults this role of CT scan is well established.[16]

Age range of the study was from 25-65 years with mean age of 49.57 ± 10.25 years. Majority of the patients 63.79% were between 46-65 years of age. Out of these 301 patients, 167 (55.48%) were males and 134 (44.52%) were females with ratio of 1.2:1. All the patients were subjected to multi-detector computed tomography scan and MDCT scan supported the diagnosis of intestinal obstruction in 172 (57.14%) patients and no intestinal obstruction in 129 (42.86%) patients. Operative findings confirmed intestinal obstruction in 176 (58.47%) patients and no intestinal obstruction in 125 (41.53%) patients. In MDCT positive patients, 166 (True Positive) had intestinal obstruction and 06 (False Positive) had no intestinal obstruction on operation. Among 129, MDCT negative patients, 10 (False Negative) had intestinal obstruction on operative findings whereas 119 (True Negative) had no intestinal obstruction on operative findings (p=0.0001).Overall sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy of multi-detector computed tomography scan in diagnosing intestinal obstruction, taking operative findings as gold standard was 94.32%, 95.20%, 96.51%, 92.25% and 94.68% respectively.

In a study,[9] intestinal obstruction was found in 73% patients and MDCT sensitivity as 85% and specificity as 70% in diagnosing bowel obstruction while in another study, the overall sensitivity, specificity and accuracy of 64 sliced MDCT to establish the diagnosis of intestinal obstruction were 96%, 100% and 97% respectively.[10] One series of 32 patients reported a sensitivity of 93%, a specificity of 100%, and an accuracy of 94% for CT scanning in the detection of obstructions.[17] Another series reported a sensitivity of 92% and specificity of 71% in the correct identification of partial or complete SBO.[18] Additional studies have shown sensitivities above 95% for CT scanning in identifying obstructions and its complications.[19]

A cross-sectional study[20] of 59 patients with SBO who underwent 64-slice MDCT scans of the abdomen followed by surgery from 1 June 2008 to 31 January 2010 at a tertiary care center, out of 59 patients, 64-slice MDCT was able to detect the point of transition of SBO in 90% (53/59) of patients, while in 10% (6/59) of these patients the point of transition was not found on MDCT. Overall for detection of the point of transition of small bowel obstruction 64-slice MDCT has 93% sensitivity, 67% specificity, 98% positive predictive value, 33% negative predictive value and 92% accuracy, respectively.[20]

According to other studies conducted by Mallo et al. and Jafe et al., for high-grade small bowel obstruction, the sensitivity, specificity and accuracy of CT scan are reported to be 90-94%, 96% and 95%, respectively, and for low-grade obstruction, the accuracy of CT is reduced.[21,22] In a study done by Taylor et al., the sensitivity was 96% with 100% specificity.[23] High-density intra-abdominal free fluid (>10 HU) on CT has been determined to be significantly associated with the need for surgical intervention in patients with adhesive small bowel obstruction. In a study by Matsushima et al, sensitivity, specificity, positive predictive value, negative predictive value, and accuracy of high-density intra-abdominal free fluid to predict need for surgical intervention were 83.9%, 65.3%, 75.4%, 76.2%, and 75.6 %, respectively.[24]

In a local study, mean age of subjects was 39.6 ± 11.4 years. The female to male ratio in this study was 1:1. Intestinal obstruction was detected in 70% cases using CT scan while 73% cases were identified positive using the histopathological analysis. Overall sensitivity was found to be 95.1%, specificity 96.7%, and accuracy of 69.4% in this study. Among patients with age 40 years, sensitivity was 91.1%, specificity 100%, and cases with ages >40 years exhibited sensitivity of 100% and specificity of 94.7%. Whereas, among male patients sensitivity was 100% and specificity was 93.3% and in female patients the sensitivity was 90.2% and specificity was 100%.25

Conclusion

This study concluded that multi-detector computed tomography scan is a highly sensitive and accurate non-invasive modality in detecting intestinal obstruction, and has not only dramatically improved our ability of accurate diagnosis of intestinal obstruction but also improved patient care by timely and proper treatment. So, we recommend that multi-detector computed tomography (MDCT) should be used routinely as a prime modality for detecting intestinal obstruction which will result in proper and timely management for reducing the morbidity and mortality of these particular patients.

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