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Original Article

Radiology Section

Role of Multidetector Computed Tomography in Evaluation of Intestinal Obstruction with Surgical Correlation- A Prospective Cohort Study

MANUPRATAP NARAYANA[1], VINAYA MANOHARA GOWDA[2], HAGALAHALLI NAGARAJEGOWDA PRADEEP[3], B SRIVIRUTHI[4]

ABSTRACT

Introduction: Intestinal obstruction is a common surgical emergency that is encountered in general surgery units and it contributes to substantial patient morbidity and healthcare costs. Computed Tomography (CT) has emerged as an invaluable diagnostic tool in the evaluation of bowel obstruction and helps in deciding early surgery. The CT gives information on the cause for obstruction, its location, and complications like closed loop obstruction, bowel ischaemia.

Aim: 1. To evaluate the accuracy of CT in diagnosing the presence, level and cause of intestinal obstruction. 2. To detect the presence of complications and demonstrate threatening signs of bowel non-viability. 3. To relate CT findings with intraoperative findings.

Materials and Methods: A prospective cohort study was done at the Department of Radiology, Mysore Medical College and Research Institute, Mysore, India from April 2021 to September 2021. A total of 40 patients, ≥18 years of age with clinical suspicion of intestinal obstruction, were subjected to Contrast-Enhanced Computed Tomography (CECT) of the abdomen. The sensitivity , specificity, positive and negative predictive values of Muti-detector Computed Tomography (MDCT) were calculated. Data analysis was carried out using Statistical Package for Social Science (SPSS) version 18.5 software.

Results: Total of 40 patients were analysed (25 males and 15 females ; mean age: 50.5 years). Small bowel obstruction constituted 75% of cases and large bowel obstruction constituted 25% of the cases. Ileum was the most common site of obstruction. Adhesions were the leading cause seen. Closed loop obstruction with bowel ischaemia and gangrene were observed in five patients (12.5%). Comparison of CT and per-operative findings showed that CT has a high sensitivity, specificity, accuracy of 97.44%, 100%, 97.50%; 92.31%, 100%, 92.50% and 100%, 94.12%, 95%, respectively for determining the level, cause and complications of obstruction.

Conclusion: The MDCT has high diagnostic accuracy in diagnosing the level, cause and complications of intestinal obstruction with the highest of 97.50% for identifying the cause of obstruction. CT is 100% sensitive in picking up complications like bowel ischemia. Thus, MDCT were in concordance with intra operative findings for the diagnosis of intestinal obstruction and can guide surgeons in the management of these patients.

Keywords: Acute abdominal pain, Large bowel, Multiplanar imaging, Small bowel

INTRODUCTION

Intestinal obstruction is a common cause of surgical emergencies that are encountered in general surgery units and it contributes to substantial patient morbidity and healthcare expenditure. Over the last 10 decades, the anatomical location of intestinal obstruction has remained unchanged; however, the aetiological factors have changed significantly because of change in lifestyle and food habits. Peritoneal adhesions are the leading causes of intestinal obstruction followed by abdominal wall hernias and malignancy [1,2].

The clinical manifestations are variable. Abdominal pain, vomiting, abdominal distension, constipation are the most common symptoms [3]. Laboratory and radiological investigations should be considered along with clinical presentation when deciding on treatment of intestinal obstruction [2].

The most important aspect in the management of these patients is to segregate the cases who need either conservative treatment or emergency surgery. Surgical intervention is indicated for cases who present with acute intestinal obstruction due to organic pathology, closed loop obstruction, complications like strangulation or perforation. The diagnosis of strangulation is rarely possible before gangrene has already set in. Recent radiological developments have promised early detection of at-risk patients and thereby help in decreasing delayed exploration and negative laparotomies [4].

Plain abdominal radiography remains the primary imaging modality for evaluation of patients with intestinal obstruction, because of its easier accessibility, lower cost and availability in peripheral setups. However, it has a poor sensitivity of 46% to 69% and specificity of 57% to 67% [5,6]. Computed Tomography (CT) has emerged as a valuable diagnostic tool in the evaluation of bowel obstruction and has reported a higher sensitivity of 93%, specificity of up to 100% and accuracy of 94% in diagnosing intestinal obstruction. CT not only confirms the diagnosis, but also gives sufficient information about critical conditions like closed loop obstruction, pneumatosis intestinalis which require immediate surgery. The important CT signs which predict the requirement of emergency surgical intervention are- presence of the “small bowel faeces sign”, mesenteric oedema, intraperitoneal free fluid, hypoenhancing bowel walls [5].

Studies have been conducted in the past to study the diagnostic role of Multi-Detector Computed Tomography (MDCT) in the diagnosis of intestinal obstruction, most of which concentrated on the western population [6,7] and Northern parts of India [8-11]. This study was done to analyse the pattern of intestinal obstruction in the population of Mysore of Karnataka of South India. Most of the previous studies [8,12] have compared the diagnostic accuracy of

CT with other imaging modalities like X-ray and ultrasound. Only a handful of studies have been done to compare the diagnostic accuracy of CT with laparotomy, which is the gold standard in the diagnosis.

In the present study, the primary aim was to evaluate the diagnostic accuracy of CT in diagnosing the presence, level and cause of intestinal obstruction. Also, detect the presence of complications, demonstrate threatening signs of bowel non viability and to relate CT findings with intraoperative findings.

MATERIALS AND METHODS

A prospective cohort study was done at the Department of Radiology in Krishna Rajendra tertiary care hospital attached to Mysore Medical College and Research Institute, Mysore, Karnataka, India for a duration of six months from April 2021 to September 2021. Institute Ethics Committee approval was obtained (EC REG: ECR/134/Inst/KA/2013/RR-19). Based on the inclusion and exclusion criteria, a total of 40 patients were selected after obtaining informed consent.

Inclusion criteria: Patients ≥18 years of age with clinical suspicion of intestinal obstruction who are referred from emergency or Outpatient Department (OPD) for Contrast Enhanced Computed Tomography (CECT) and those diagnosed of having intestinal obstruction by preliminary investigations either by ultrasonography or abdominal radiography were included in the study.

Exclusion criteria: The patients whose age <18 years, who are haemodynamically unstable, those with deranged renal function tests, allergic to contrast media, pregnant females, patients with ileus, those managed conservatively and the patients refusing consent were excluded from the study.

Study Procedure

Scanning protocol: All patients were subjected to CECT of the abdomen which was performed on a 128 slice single source dual energy MDCT scanner (Somatom Definition Edge, Siemens Healthcare, Germany) as per our hospital protocol. Following imaging parameters were used: Pitch of 0.8, collimation of 128x 0.6mm and gantry rotation time of 0.5 second with multiplanar reconstruction. The factors used were 120 kV and 260 mAS. A postcontrast study was obtained after intravenous administration of 80 to 100 mL of non ionic contrast medium (Iohexol) containing 300 mg/mL of iodine as a single bolus and CT was done in a single breath-hold or quiet respiration. Positive or neutral oral contrast was also given depending upon the clinical condition.

Assessment: The images were read by an experienced radiologist. The presence or absence of intestinal obstruction was confirmed on MDCT; if obstruction was present, then the site of the transition zone, underlying cause for obstruction and complications like bowel ischaemia and perforation were further assessed. Radiological diagnosis was related with the intraoperative findings and histopathological diagnosis.

STATISTICAL ANALYSIS

The sensitivity and specificity of MDCT to the clinical diagnosis were determined. In addition to sensitivity and specificity, the positive and negative predictive values were calculated. Data analysis was carried out using Statistical Package for Social Science (SPSS) version 18.5 software. The results of the study are presented in tables and figures.

RESULTS

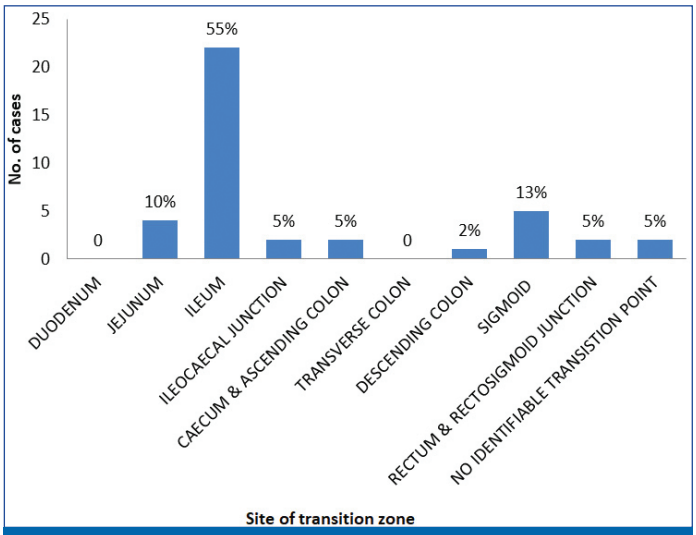
The present study included total of 40 patients. Of these, 25 (62%) patients were males and 15 (38%) patients were females with a male-to-female ratio of 1.66:1 [Table/Fig-1]. The maximum number of patients presenting with intestinal obstruction were in the age group of 46-60 years (40%) [Table/Fig-1]. The youngest patient in the study group was aged 24 years whereas the oldest was of 75 years and the mean age was 50.5 years.

Demographic variables	No. of patients	Percentage
Gender		
Male	25	62.5%
Female	15	37.5%
Age group (years)		
18-30	2	5%
31-45	14	35%
46-60	16	40%
61-75	8	20%

[Table/Fig-1]: Demographic details of all study participants; Total N=40 patients.

Value of MDCT in the diagnosis of the level of obstruction/ transition point: Small bowel obstruction was seen in 30 patients (75%) with ileum being the most common site of obstruction seen in 22 patients (55%). Jejunal obstruction was seen in four patients (10%) and obstruction at the level of the ileocaecal junction was seen in two patients (5%).

Ten patients (25%) had large bowel obstruction with sigmoid colon involvement seen as the most common site in five patients (13%). Caecum/ascending/transverse/ descending colon was the site of obstruction in three patients (7%). Rectum and recto-sigmoid was the site of obstruction in 2 (5%) patients. The site of obstruction of the bowel is given in [Table/Fig-2]. No definite site of obstruction could be identified in two patients (5%) amongst which one patient had multiple dense adhesions attached to the abdominal wall at the site of the previous incision, hence the zone of transition was indeterminate on CT. The other patient had colonic pseudo-obstruction with no identifiable transition zone. The concordance of MDCT with intraoperative findings in assessing the level of obstruction is given in [Table/Fig-3].



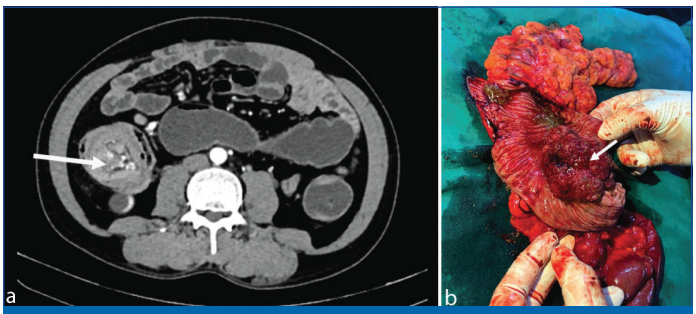
[Table/Fig-2]: Bar graph showing the distribution of level of intestinal obstruction.

Level of obstruction observed in MDCT	Intra-operative relation (n=40)	
	Identified	Not-identified
Identified	38	0
Not-identified	1	1

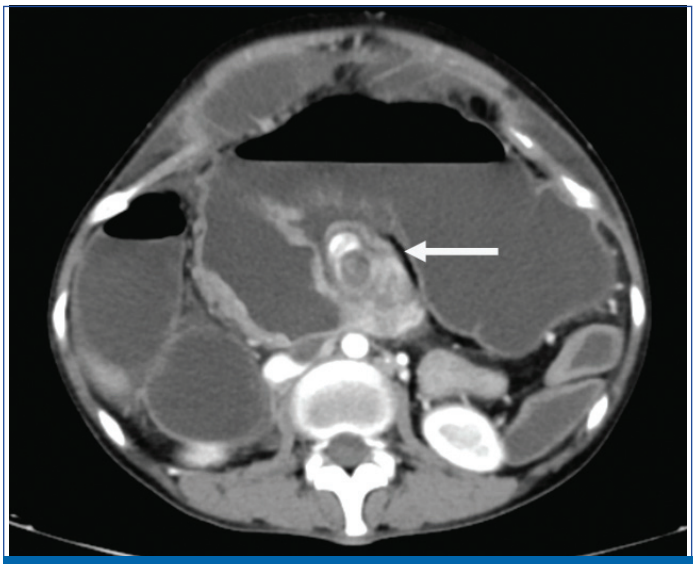
[Table/Fig-3]: Multi-detector computed tomography (MDCT) against intra-operative findings in assessing the level of obstruction.

Value of MDCT in the diagnosis of aetiology: On MDCT, out of a total of 40 patients, an extrinsic cause of obstruction was present in 19 patients (54%), of which adhesions were the leading cause seen in 14 patients (35%). Carcinoma was the most common intraluminal cause of obstruction seen in 9 patients (22.5%). On postsurgical histopathological examination, the malignant growth was found

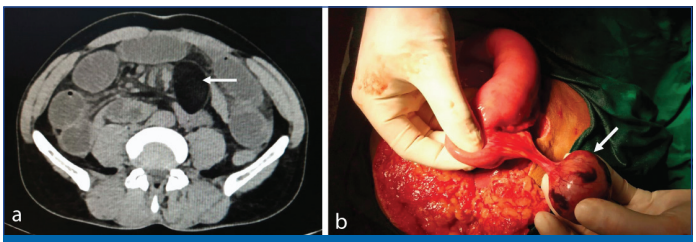
to be adenocarcinoma in all nine patients. A benign stricture was identified in five patients (12.5%). Hernia, intussusception and volvulus were the other causes, noted in two patients each (5%). Both the patients had obstructed indirect inguinal hernia. One case of intussusception was an ileo-ileal type with no definite lead point. Another case was ileocaecal intussusception with an adenomatous polyp as the lead point [Table/Fig-4a,b]. Two cases had midgut volvulus secondary to malrotation [Table/Fig-5]. One case of mesenteric lipoma was encountered as the cause for small bowel obstruction (2.5%) [Table/Fig-6a,b].



[Table/Fig-4]: a) Axial Contrast-Enhanced CT image showing heterogeneously enhancing polypoidal lesion (white arrow) involving ileocaecal junction, caecum and ascending colon with ileocaecal intussusception and proximal small obstruction; b) Surgical image of the polypoidal lesion in the colon (white arrow).



[Table/Fig-5]: Axial Contrast-Enhanced CT image showing midgut volvulus causing closed loop obstruction complicating a case of intestinal malrotation. Twisting of the mesentery (whirl sign) noted (white arrow).



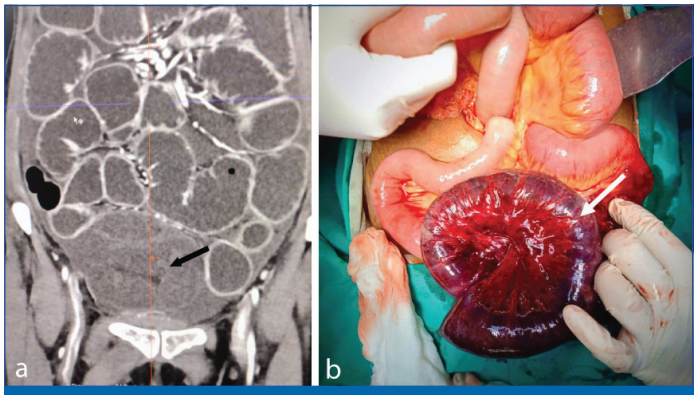
[Table/Fig-6]: a) Axial Contrast-Enhanced CT image showing a fat density lesion in mesentery suggesting lipoma (white arrow) as the cause for small bowel obstruction; b) Intra-operative image of mesenteric lipoma (white arrow) causing intestinal obstruction.

Extrinsic compression by a mass was the cause in one patient (2.5%) which turned out to be a gastrointestinal stromal tumour on histopathology. Hence, we were able to identify the cause of obstruction in 36 patients (90%) on CT. The cause was indeterminate in four patients (10%), of which two patients had adhesions and one patient had a passable ileal stricture intraoperatively. The other case which had no identifiable cause of both CT and laparotomy was found to be idiopathic colonic pseudo-obstruction. The concordance of MDCT with intraoperative findings in assessing the cause of obstruction is given in [Table/Fig-7].

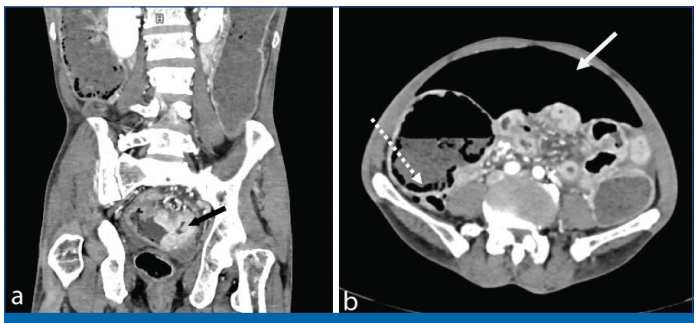
Cause of obstruction on MDCT	Intraoperative relation (N=40)	
	Present	Absent
Present	36	0
Absent	3	1

[Table/Fig-7]: Multi-detector computed tomography against intra-operative findings in assessing the cause of obstruction.

Value of CT in bowel ischaemia and other complications: Closed loop obstruction with signs of bowel ischaemia and gangrene were observed in five patients (12.5%) [Table/Fig-8a,b]. One patient of Post hemicolectomy for carcinoma colon with adhesions had pneumoperitoneum. Intraoperatively, the breach was noted at splenic flexure [Table/Fig-9a,b]. The same patient had inferior vena cava thrombosis and pulmonary thromboembolism. Another patient with midgut volvulus had superior mesenteric artery thrombosis. The venous and arterial thrombosis picked up on MDCT cannot be justified intraoperatively in the absence of bowel ischaemia. Concordance between MDCT and surgical findings in identifying intestinal and extra-intestinal complications are given in [Table/Fig-10].



[Table/Fig-8]: a) Coronal Contrast-Enhanced CT section showing closed loop obstruction with long segment infarction of ileal loops (black arrow); b) Intra-operative finding confirmed MDCT finding of gangrenous changes in the ileum (white arrow) for a length of 20 cm with closed loop obstruction due to an adhesive band.



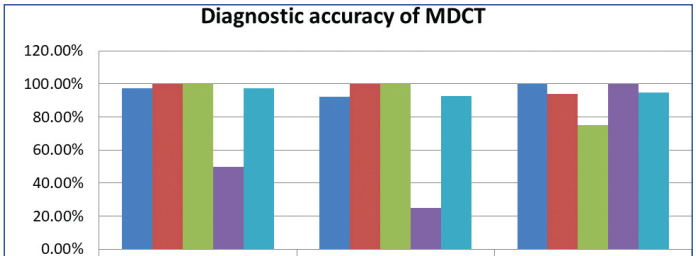
[Table/Fig-9]: a) Coronal contrast-enhanced CT image showing large bowel obstruction due to an asymmetric enhancing lesion (black arrow) in the sigmoid colon. Histopathological Examination (HPE) proven adenocarcinoma; b) Axial Contrast-Enhanced CT section of the same case showing gross pneumoperitoneum (white solid arrow) and pneumatosis intestinalis (white dashed arrow). Intraoperatively, a breach was noted at the splenic flexure of the colon.

Complications on MDCT	Intra-operative relation (N=40)	
	Identified	Not identified
Identified	6	2
Not identified	0	32

[Table/Fig-10]: MDCT with surgical correlation in intestinal and extra-intestinal complications.

Diagnostic accuracy of MDCT: Comparing the CT findings and pre-operative findings, sensitivity, specificity, positive predictive value, negative predictive value of CT in determining the level of obstruction/transition zone was 97.44%, 100%, 100%, 50% with an accuracy rate of 97.5%. Similarly, MDCT showed a sensitivity, specificity, positive predictive value, negative predictive value of 92.31%, 100%, 100%, 25% in identifying

the cause of obstruction an accuracy rate of 92.5%. MDCT has got a very high sensitivity of 100% in identifying the intestinal and extra-intestinal complications with a specificity of 94.12%, positive predictive value of 75%, and negative predictive value of 100% and accuracy of 95% [Table/Fig-11].



	Level	Cause	Complications
Sensitivity	97.44%	92.31%	100%
Specificity	100%	100%	94.12%
PPV	100%	100%	75%
NPV	50%	25%	100%
Accuracy	97.50%	92.50%	95%

[Table/Fig-11]: Diagnostic accuracy of MDCT.
PPV: Positive predictive value; NPV: Negative predictive value

DISCUSSION

The MDCT plays an important role in the imaging of patients presenting with acute symptoms like abdominal pain, vomiting, abdominal distension and constipation suggestive of intestinal obstruction, which helps in confirming the diagnosis, finding out the cause of obstruction, and detecting and predicting the complications like bowel ischaemia, bowel wall necrosis, perforation and secondary peritonitis [7].

The normal calibre of the small bowel, large bowel and caecum is less than 3 cm, 6 cm and 9 cm, respectively. Whenever small bowel calibre is greater than 3 cm and large bowel calibre is greater than 6 cm, these bowel loops are considered dilated. The diagnosis is more certain when a transition point is detected [13]. In the appropriate clinical setting, the absence of a transition point on CT helps to make a diagnosis of a dynamic ileus, which is caused by a lack of enteric propulsion. Causes for ileus include drugs with anticholinergic action, post-trauma, early postoperative period and metabolic disturbances like hypokalemia and hyponatremia [14,15].

Because of the presence of air and retained fluid within the dilated bowel loops which gives an inherent negative contrast, there is no need for oral contrast for CT studies [7]. Intravenous contrast is required to look for bowel viability. A viable bowel wall shows homogeneous enhancement with contrast while a non viable bowel does not enhance [16].

The study conducted by Mohi JK et al., showed that CT had a sensitivity of 90% and specificity of 100% in the diagnosis of intestinal obstruction [8]. Megibow AJ et al., showed that CT had a sensitivity of 94% and specificity of 96% [17]. In this current study, CT showed an overall sensitivity of 97.44% and specificity of 100% in identifying the transition point. The statistics of this study conforms with the above-mentioned studies.

The outcome variables of the present study have been compared with previous similar studies in [Table/Fig-12] [8-11,18,19]. In the present study, group of 40 patients with intestinal obstruction, it was found that males were affected more than females with a gender ratio of 1.66:1. This is as per the study conducted by Singh A et al., and Saini DK et al., where the number of males outnumbered females [9,10]. On analysing the age distribution in the present study, patients aged 45-60 years were affected the most (40%). However, studies conducted by Singh A et al., and Saini DK et al., have stated that patients <45 years were more commonly affected [9,10]. In another study done by Sekhon G et al., patients <20 years were the most common age group affected [11].

Small bowel obstruction was much more common than large bowel obstruction. In the present study, small bowel obstruction was seen in 75% of patients as opposed to large bowel obstruction in 25% of patients. This was similar to the study done by Sultan A et al., where small bowel obstruction was present in 80% of cases and large bowel obstruction in 20% of cases [20]. The “string of beads” sign and “small bowel faeces” sign are important radiological signs associated with small bowel obstruction [Table/Fig-13] [21]. Small pockets of gas trapped between the valvulae conniventes give the appearance of a string of beads. The small bowel faeces sign is a result of prolonged stasis of small bowel contents mingled with gas bubbles that mimic faeces.

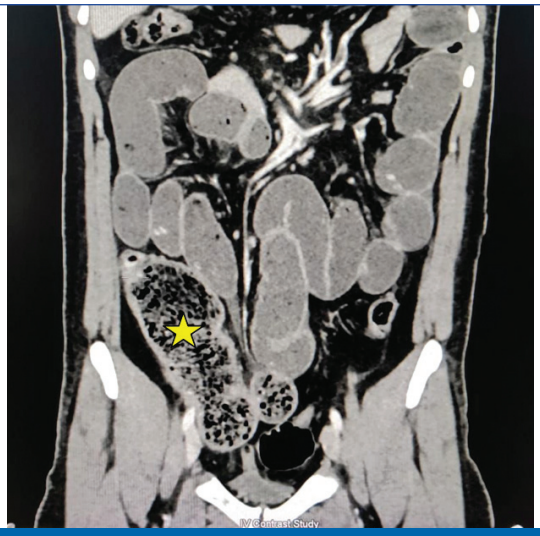
Adhesions were the most common cause in concordance with many other previous studies [9-11]. However, studies done by Mohi JK et al., Sindhwani G et al., and Elsayed EE et al., showed malignancy to be the most common cause [8,18,19]. This variability in the cause for obstruction may be influenced by the ethnicity, geographical location and dietary habits of the study population [22]. If neoplasms are found out to be the cause of intestinal obstruction, accurate staging of the malignancies can be done by CT. Added to this, visualisation and evaluation of extraluminal pathology makes CECT the investigation of choice. Late presentations of intestinal obstruction complicated with intestinal perforation and peritonitis can also be easily detected on CT [23].

Nasogastric tube decompression with supportive care is the most commonly followed conservative approach in the management of patients with uncomplicated intestinal obstruction. Surgical intervention is needed for patients with evidence of complications like vascular compromise and failure to resolve with a conservative approach.

Thus, imaging using CT is an important factor in the decision-making process in predicting the need for surgical intervention. It is very important to identify imaging features that suggest bowel vascular compromise at the earliest which helps in optimising the management, thus preventing impending complications like bowel ischaemia, necrosis, perforation and peritonitis [7]. The presence or absence of strangulation is a piece of vital information that CT can

Variables studied	Mohi J.K et al [8]	Singh A et al [9]	Saini DK et al [10]	Sekhon G et al [11]	Sindhwani G et al [18]	Elsayed EE et al [19]	Current study
Common age group	41-50 yrs	31-40 yrs	31-45 yrs	<20 yrs	41-50 yrs	>45 yrs	46-60 yrs
Gender	Males (63.3%)	Males (60%)	Males (67%)	Males (67.5%)	Females (60%)	Males (80%)	Males (62%)
Small bowel obstruction	74%	75%	-	95%	47.5%	55%	75%
Large bowel obstruction	26%	25%	-	5%	35%	45%	25%
Transition zone	Proximal small bowel	Ileum (52.5%)	-	Ileum (67.5%)	-	-	Ileum (55%)
Commonest cause of obstruction	Malignancy (41.46%)	Adhesions (32.5%)	Adhesions (24.13%)	Adhesions (32.5%)	Malignant mass (42.1%)	CA colon (50%)	Adhesions (35%)
Complications	-	10%	7.5%	12.5%	15%	-	20%

[Table/Fig-12]: Comparison of current study with other studies [8-11,18-19].



[Table/Fig-13]: Coronal Contrast-Enhanced CT (CECT) image showing small bowel faeces sign (yellow star) in a patient with small bowel obstruction due to benign partial stricture at ileum.

provide the surgeon in cases of intestinal obstruction [13]. Bowel wall thickening, ascites, pneumatosis intestinalis and portal/mesenteric venous gas are the important signs and prognostic indicators that have been associated with intestinal ischaemia. Ischemic thickened bowel wall has a trilaminar appearance, known as the "target" sign. "Target sign" appearance is because of hyperenhancement of the mucosal layer, hypodense submucosal oedema and reduced enhancement of outer wall [24].

For patients with a high risk of contrast-induced nephropathy, several studies [25-27] have focused on the diagnostic value of unenhanced CT for small bowel obstruction, which might be safer for these patients [28]. Submucosal haemorrhage, which is also a sign of bowel ischaemia is seen as increased attenuation of bowel wall on non contrast scans. Atri M et al., reported that unenhanced CT had accuracy similar to an enhanced CT for diagnosis of mechanical small bowel obstruction [25]. For ischaemia, a retrospective study showed that hyperattenuating bowel-wall on unenhanced images had 100% specificity and 56% sensitivity [26]. Furthermore, a recent study found that the addition of unenhanced CT to CECT could improve the sensitivity and diagnostic confidence for the diagnosis of ischaemia [26]. Due to the lack of evidence, the effect of unenhanced CT for ischaemia should be studied in the future. However, enhanced CT might be more powerful in the diagnosis of ischaemia, aetiology and predicting surgical intervention [29,30].

Limitation(s)

The present study had a small sample size that included only 40 patients.

CONCLUSION(S)

The MDCT has good diagnostic accuracy for the diagnosis of intestinal obstruction. The results of this study like previous similar studies showed that CT should be the choice for the diagnosis of intestinal obstruction, determining its aetiology, transition point and for prediction of bowel ischaemia. Thereby, radiologists can guide surgeons in the management and assist pre-operative planning of a patient presenting with intestinal obstruction.

Disclosure: All surgical photographs have been reproduced with permission from the Department of General Surgery, Krishna Rajendra Hospital, Mysore and after concealing patient identity.

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PARTICULARS OF CONTRIBUTORS:
1. Associate Professor, Department of Radiodiagnosis, Mysore Medical College and Research Institute, Mysore, Karnataka, India.
2. Junior Resident, Department of Radiodiagnosis, Mysore Medical College and Research Institute, Mysore, Karnataka, India.
3. Professor, Department of Radiodiagnosis, Mysore Medical College and Research Institute, Mysore, Karnataka, India.
4. Junior Resident, Department of Radiodiagnosis, Mysore Medical College and Research Institute, Mysore, Karnataka, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
B Sriviruthi,
616, Kurinji Street, 6th Main Road, Gomathipuram, Madurai-625020, Tamil Nadu, India.
E-mail: sriviruthi1@gmail.com

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