Suez Canal University Medical Journal Vol. 27 (9), 2024
Pages 8-21

Role of Multi-Slice CT in Diagnosis and Evaluation of Patients with Small Bowel Obstruction.

[1]Kareem Mohamed El-Ashry, [1]Doaa Mostafa Mohamad Mostafa, [2]Ayman Mohamed Gomaa, [1] Tarek Hamed El-kammash

[1] *Diagnostic Radiology Department, Faculty of Medicine, Suez Canal University, Egypt.*

[2] *Surgical Oncology Department, Faculty of Medicine, Suez Canal University, Egypt*

Abstract

Background: **For identifying the occurrence, the reason, and the location of intestinal blockage, multi-slice computed tomography (MSCT) scans are extremely sensitive and precise.** ***Aim*****: To evaluate MSCT diagnostic efficacy in cases of small bowel obstruction, which lowers the disease's morbidity and death rates.** ***Patients and methods:*** **A cross-sectional analytical investigation was conducted at the CT unit-Radiology department of the Faculty of Medicine at Suez Canal University hospital in Ismailia, Egypt, on 34 patients who had reported to the emergency room with symptoms suggesting small bowel obstruction, during a period time from April 2022 to May 2023. Full history taking, radiological investigation, multi-slice computed tomography examination and classification of obstruction were done for all patients under study.** ***Results:*** **According to CT scans, 46.9%, 25%, and 28.1% of the patients in our research had total, high-grade, and low-grade small intestinal blockage. The X-ray had an 82.3% sensitivity and 100% specificity in identifying minor intestinal obstructions. While CT had a 94.1% sensitivity, 100% specificity, and 100% accuracy in detecting minor bowel obstructions.** ***Conclusions:*** **Using a comprehensive approach, multi-slice CT not only aids in accurately diagnosing intestinal obstruction but also has an impact on patient outcome. With confidence, this study has determined the function of MSCT in identifying small bowel obstruction reasons and modifying treatment regimens.**

Keywords**:** Computed tomography, Diagnostic performance, Emergency room, Multi-slice CT, Small bowel obstruction

Introduction

A surgical emergency known as small bowel obstruction occurs when the transit of intestinal contents is impeded by a mechanical blockage of the small intestine[(1).] It falls into one of two categories: total obstruction or partial (incomplete). Constipation, distension, vomiting, and stomach discomfort are common signs of small bowl obstruction. Still, not every one of these symptoms will manifest, particularly in the elderly[(2)]. Effective treatment for small bowel obstruction (SBO),

**Corresponding Author: doaa.mostafa@med.suez.edu.eg*

a frequent clinical condition, depends on a prompt and precise diagnosis[2-4]. Even with improvements in imaging technology and our knowledge of small intestinal pathophysiology, small bowel obstruction is still frequently misdiagnosed or discovered too late, leading to a high rate of morbidity and death. A thorough strategy that incorporates patient history, clinical findings, and triage exams such plain abdominal radiography will assist the doctor in creating a customized treatment plan[5, 6]. Even though a physical examination can identify small intestinal blockage, more testing is frequently necessary for surgical evaluation and treatment[6]. Small intestinal obstruction was previously diagnosed mostly by physical examination; however, with the development of computed tomography (CT), the characterization and accuracy of this disease have improved significantly. A common additional imaging modality is radiography[7]. Conventional plain radiography studies can be utilized to confirm the diagnostic and extent of small-bowel blockage imaging, but not the cause of the obstruction. Determining the source of blockage is the goal of further imaging modalities[8]. The sensitivity of plain radiography is low, thus while it can be used as a first screening for clear air-fluid levels and free intra-abdominal air, it cannot be dependent upon to rule out small intestinal blockage[9]. In cases of suspected small bowel obstruction, however, it has been demonstrated that adding ultrasonography after clinical diagnosis increases the specificity[10]. Because the entrapment of air in tiny bowel blockage inhibits the ultrasound's ability to transmit, ultrasonography has limited utility and should only be used by healthcare professionals.[11-13] When it comes to small intestinal obstruction diagnosis, magnetic resonance imaging appears to be limited. Though there are currently no clear standards for employing MRI in routine clinical practice, the technology offers equal sensitivity and specificity to CT-scan[12, 14]. When a CT scan is not available or cannot be performed, magnetic resonance imaging can be helpful. But compared to a CT scan, it is less accurate in diagnosing small intestinal obstruction due to its accessibility, expense, and lower spatial and temporal resolution[14, 15, 16]. Evaluation of the small bowel has advanced significantly with the development of Multi-Slice Computed Tomography (MSCT) from traditional CT. From the volume data, the volume rendering (VR), Maximum intensity projection (MIP), or multi-planar reconstruction (MPR) images can be recreated using the 3-dimensional imaging approach[17]. The use of CT in the assessment of patients with small bowel obstruction is widely accepted, and numerous studies have shown that CT is a useful tool for diagnosing small bowel obstruction, determining its cause and transition point, and most importantly for detecting ischemia, which necessitates immediate surgical intervention[18]. On the other hand, CT results for these points show inconsistent diagnostic performance. For instance, there was a range in the specificity values from 57% to 100% and the sensitivity of CT for the diagnosis of small intestinal obstruction from 50% to 100%[17]. Additionally, a prospective investigation revealed a weak sensitivity of 15% for ischemia, despite other studies reporting that CT had good sensitivity and specificity for ischemia of small intestinal

obstruction. A recent study of 108 cases also revealed no association between CT results and surgical intervention, despite multiple studies demonstrating that CT might predict surgical intervention for patients with small intestinal obstruction[17, 18]. The inability of clinical presentation, physical examination findings, and laboratory tests to accurately diagnose small bowel obstruction presents a challenge for clinical management; however, since then, significant advancements in imaging technology, including CT, have transformed the approach to management[19]. Because the literature that is currently available is inconsistent, we conducted a cross-sectional study to analyze and appraise CT's diagnostic efficacy for small bowl obstruction. Therefore, the aim of this study was to evaluate multi-slice computed tomography (MSCT) diagnostic efficacy in cases of small bowel obstruction, which lowers the disease's morbidity and death rates.

Patients & methods:

Study design:

A cross-sectional analytical investigation was conducted at the CT unit-Radiology department of the Faculty of Medicine at Suez Canal University hospital in Ismailia, Egypt, on 34 patients who had reported to the emergency room with symptoms suggesting small bowel obstruction, during a period time from April 2022 to May 2023.

Ethical approval:

The individual was informed of the study's objectives in detail and was then asked to sign an informed consent form. The consent form was prepared in accordance with the guidelines provided by the Egyptian Ministry of Health's Quality and Improvement System and the Helsinki Declaration. The study plan was approved by the Suez Canal University's local ethical scientific council in Ismailia, Egypt (IRB ID: RPNC-1).

Patients who were over the age of eighteen, those who had small bowel blockages and were experiencing one or more of the following symptoms: constipation, acute abdominal, vomiting, nausea, and difficulty passing stool were enrolled in the study.

Exclusion criteria: Patients who have undergone intestinal surgery in the past, those who are hemodynamically unstable, those who have severe cardiac disease that causes orthopnea, pregnant women, those who are sensitive to the contrast medium, and those who have not received regular dialysis on account of chronic renal failure or impairment.

All patients of this study were subjected to full history taking including name, age, sex… etc.

Radiological investigation as follow:

CT scan:

At the Suez Canal University hospital in Ismailia, Egypt, the imaging scan was performed in the CT unit of the Diagnostic Radiology department of the Faculty of Medicine. With the Toshiba CT Scanner (Alexion Model TSX – 034A), produced in Japan in 2014.

Classification of obstruction:

When delayed scans taken between three and twenty-four hours later show no contrast medium passing through the ob-

struction, this is regarded as a complete obstruction. When enough contrast material passes through the blockage's site, it is thought to be a low-grade partial small bowel obstruction[20]. When there is considerable stasis and a delay in the contrast medium's passage, diluted oral contrast material occurs in the enlarged proximal gut and minimal contrast material appears in the compressed distal loops, this condition is characterized as high-grade partial small intestinal obstruction. There is a 50% caliber difference between the distal collapsed intestine and the proximal dilated bowel in a high-grade obstruction[20].

Multi-slice computed tomography examination:

In this investigation, patients were examined using a Toshiba CT Scanner (Alexion Model TSX – 034A), a 16-channel multislice CT scanner in the diagnostic radiology department of Suez Canal University Hospital, Ismailia. The patients had been fasting for at least six hours before the evaluation. An intravenous line with a big bore (18 G) was inserted into the antecubital fossa. Some patients received water or an oral contrast agent that had been diluted. Within 120 minutes, this was administered orally in a continuous, regular way (150 ml every 20 minutes); the final 100 ml was placed on a table. Depending on the patient's tolerance, different amounts of fluid were consumed. Each patient is given 1000 ml (7.5 ml of oral contrast medium plus 992.5 ml of water). A rectal enema using diluted positive contrast (gastrografin) was performed on a few patients right before the examination. Depending on the patient's age and tolerance level, a different volume of enema infusion is administered. An automatic injector delivered 50 ml of nonionic contrast medium (iopromide) at a rate of 3 ml/s. Slice collimation of 2.5 mm, pitch of 1-2.5, matrix of 512 x 512, 200–350 mA, and 120–140 kV were used for all imaging. Referring physicians assisted in the interpretation of the findings, which were read on the CT machine's Vitrina workstation.

Data Management and Statistical Analysis

The gathered data was statistically analyzed using a Statistical Package for the Social Sciences statistics application for Windows (SPSS, version 26, IBM, Armonk, NY, USA). The distribution of the data was examined for normalcy using the Shapiro-Wilk test. Every test was carried out with a 95% confidence level. A P (probability) value less than 0.05 is regarded as statistically significant. SPSS Chart Builder and Microsoft Excel for Windows 2019 were used to create the charts[21].

Results

A study population flowchart can be seen in Figure 1. At Suez Canal University Hospital, 45 patients had characteristics that suggested they might have a minor intestinal obstruction. Thirteen patients were deemed unsuitable for inclusion in the trial, while four patients could not fulfill the necessary requirements for participation (Figure 1). The patients' ages ranged from 23 to 73 years old, with a mean age of 48.8 ±13.2. The majority of patients (53%) were over 50 years old; 41.2% were between 30 and 50 years old; 5.8% were under 30 years old; 70.6% of patients were female; and 29.4% were male (Table 1).

Furthermore, 82.4% of patients had an X-ray showing blockage (dilated bowel loop/multiple air fluid level), whereas all

patients reported stomach discomfort, 61.8% vomiting, 64.7% distension, 58.8% constipation, 67.6%, 70.6%, and 52.9% tachycardia, tenderness, and guarding, respectively. (Table 2).

Table 1. Age and gender distribution among the studied patients.

	Patients (n=34)
Age/year	
Mean±SD	48.8 ± 13.2
Range	23-73
Age group	
<30 years	2 (5.8%)
30-50 years	14 (41.2%)
>50 years	18 (53%)
Gender	
Male	10 (29.4%)
Female	24 (70.6%)

Table 2. Clinical data and X ray finding of the studied patients.

Patients (n=34)		%
Abdominal pain		
Yes	34	100%
No	0	0%
Vomiting		
Yes	21	61.8%
No	13	38.2%
Distension		
Yes	22	64.7%
No	12	35.3%
Constipation		
Yes	20	58.8%
No	14	42.2%
Tachycardia		
Yes	23	67.6%
No	11	32.4%
Tenderness		
Yes	24	70.6%
No	10	29.4%
Guarding		
Yes	18	52.9%
No	16	47.1%
Obstruction by X ray (dilated bowel loop/multiple air fluid level)		
Yes	28	82.4%
No	6	17.6%

According to Table 3, all patients had obstruction by perioperative finding, and 94.1% of patients had obstruction by CT. Additionally, CT revealed that, respectively, 46.9%, 25%, and 28.1% of patients had total, high-grade, and low-grade small intestinal blockage. 35.3%, 35.3%, and 29.4% of the patients in the study had complete, high-grade, and low-grade small intestinal blockage, according to the perioperative data (Figure 2).

Moreover, a different final diagnosis of small bowel obstruction was made. Based on the results of the operation, we listed the causes of obstruction, which included Crohn's disease (5.9%), small bowel tumor (8.8%), adhesive bands (14.7%), radiation enteritis (8.8%), intussusception (14.7%), mesenteric ischemia (8.8%), obstructive hernia (23.5%), small bowel tumor (8.8%), small bowel volvulus (3%) and gallstone ileus (3%), (Figure 3).

Table 3. CT and Perioperative finding of the studied patients.

	Patients (n=34)	%
Obstruction by CT		
Yes	32	94.1%
No	2	5.9%
Obstruction by Perioperative finding		
Yes	34	100%
No	0	0%

In addition, the X-ray had a sensitivity and specificity of 82.3% and 100%, respectively, to detect small intestinal obstruction, while the CT had a sensitivity, specificity, and accuracy of 94.1% and 100%, respectively (Table 4).

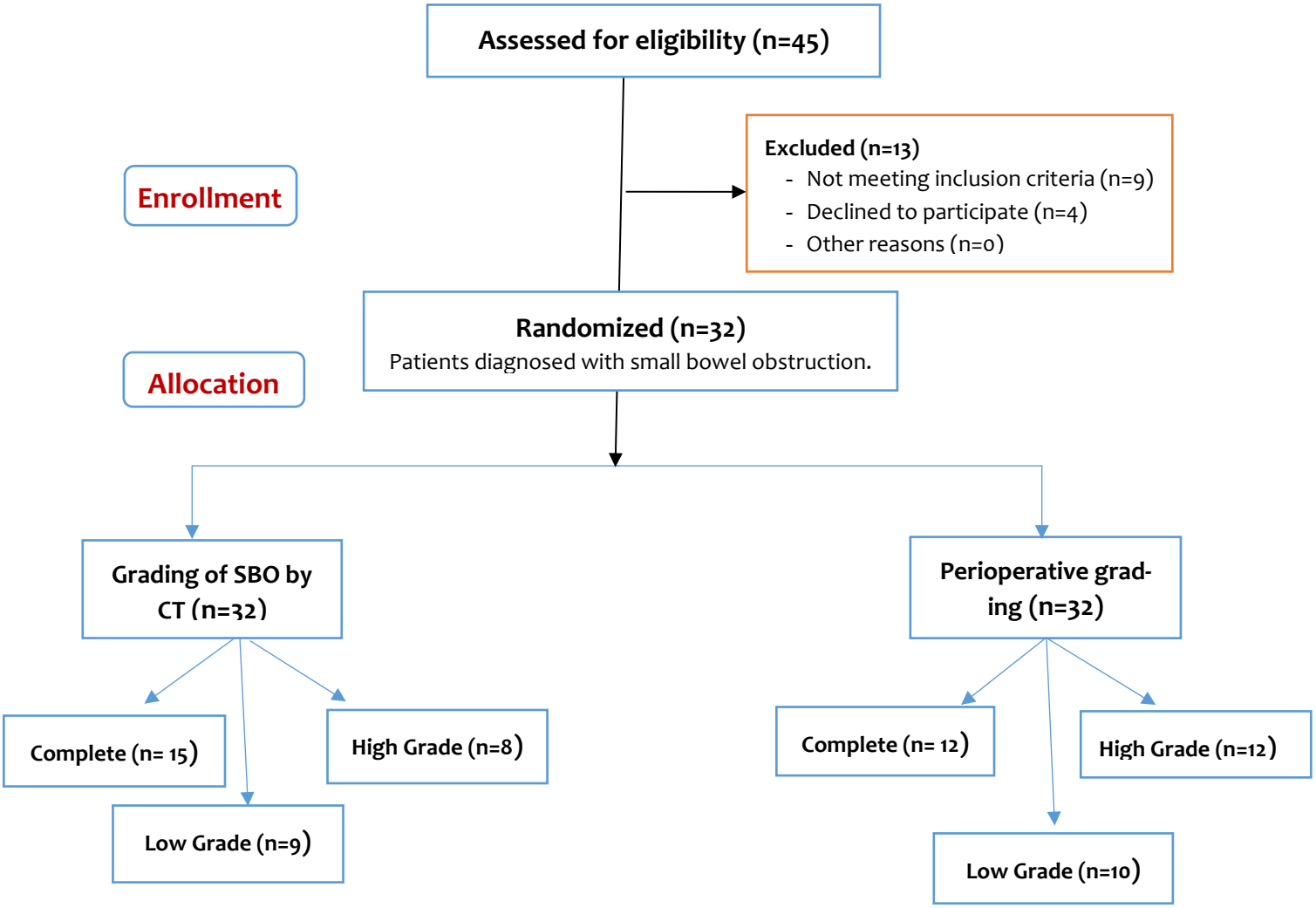


Figure 1. Flowchart of the studied patients with small bowel obstruction.

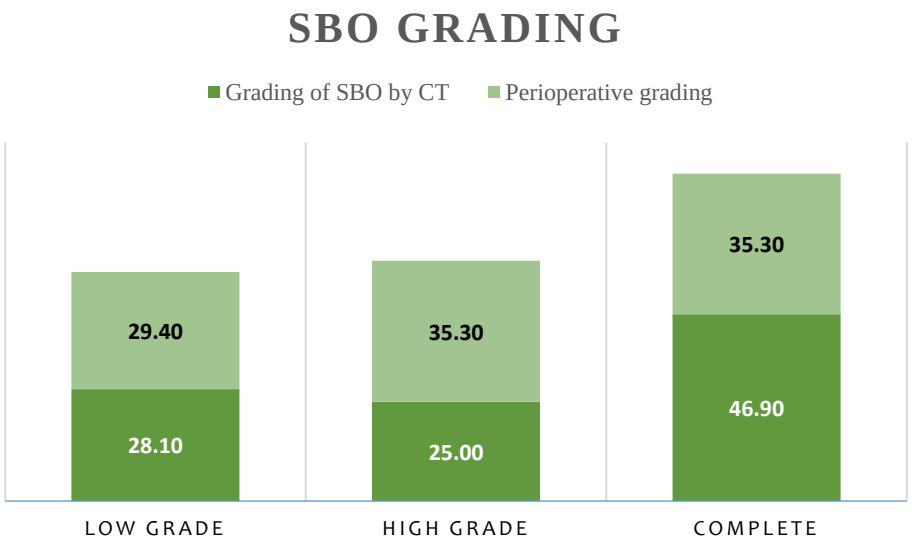


Figure 2. Grading of small bowel obstruction by CT and perioperative finding of the patients.

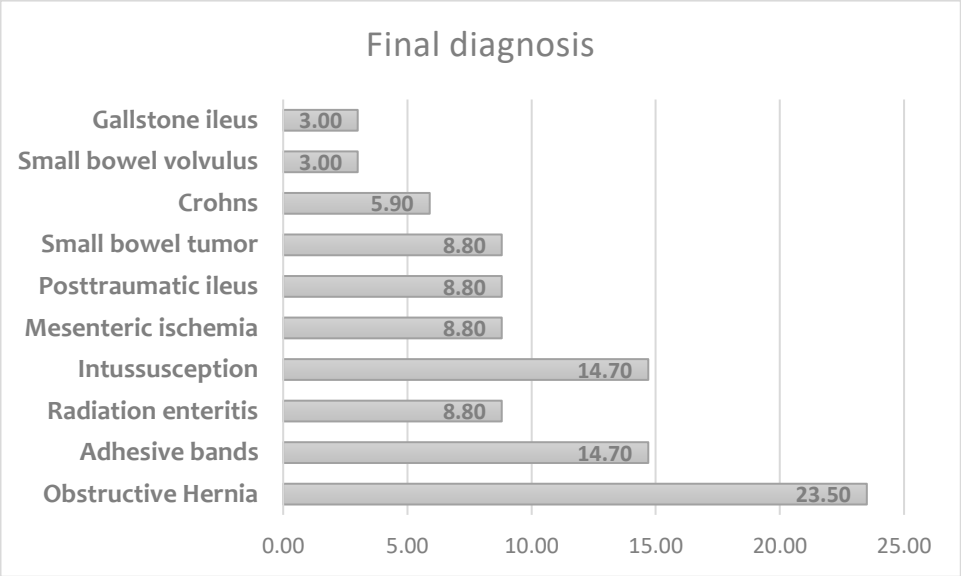
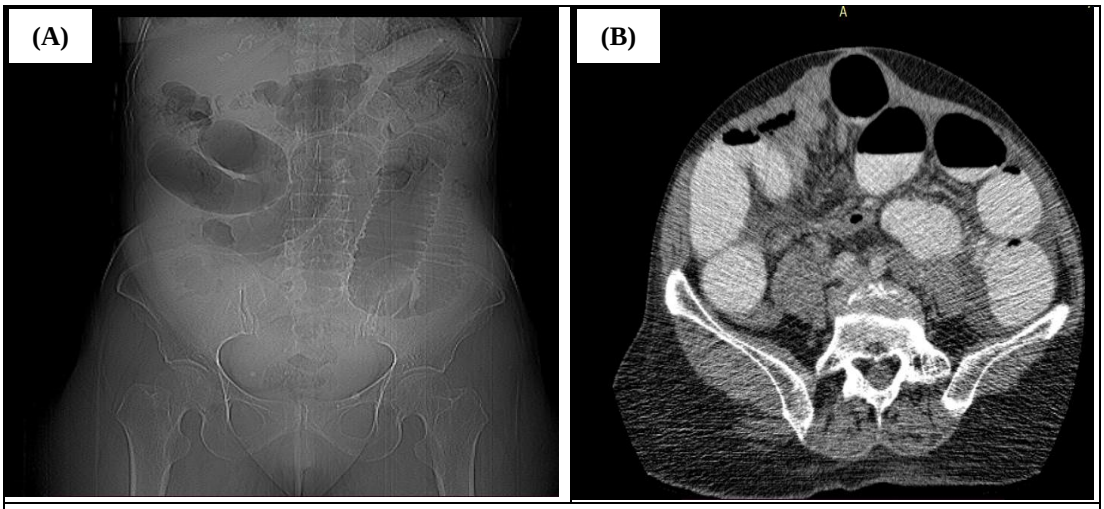
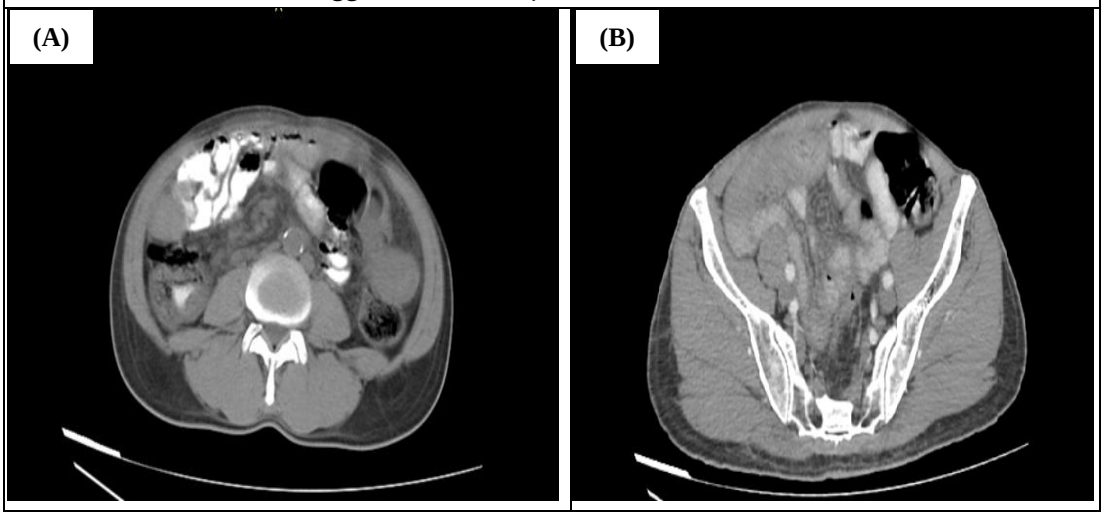


Figure 3. Final diagnosis of the studied patients.

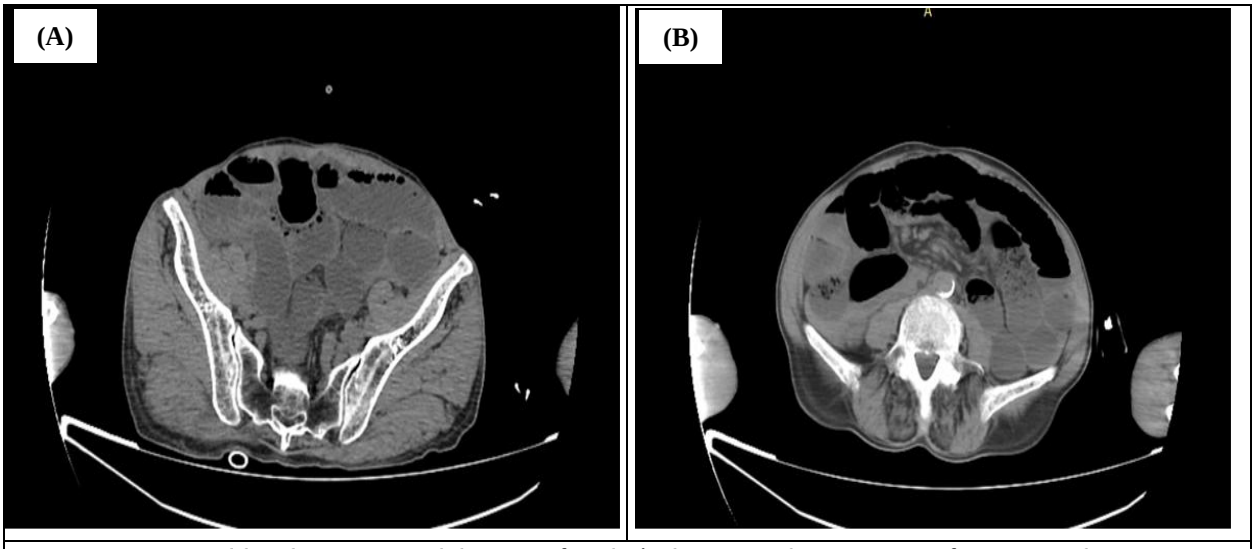
Table 4. Diagnostic power of X ray and CT to detect small bowel obstruction.			
X ray	**Number**	**Parameters**	**Value**
True positive	28	Sensitivity	82.3%
False positive	0	Specificity	100%
True negative	0	Prevalence	100%
False negative	6	Positive predictive value	100%
CT			
True positive	32	Sensitivity	94.1%
False positive	0	Specificity	100%
True negative	0	Prevalence	100%
False negative	2	Positive predictive value	100%



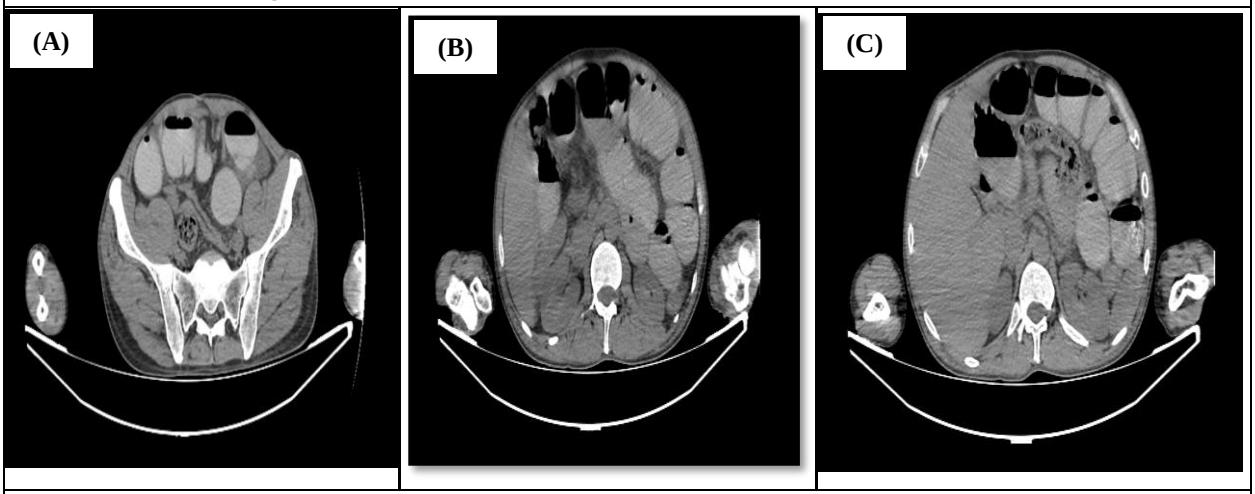
Cas 1. A 71-year-old female patient with symptoms of nausea and vomiting. (A) X ray showing multiple dilated gas filled loops of small bowel throughout the abdomen. The valvulae connivences are illustrated indicated it is small bowel. (B) CT Axial image shows proximal bowel dilatation and distal ileal collapse. transitional zone is seen at the level of ileum (the arrow) mostly due to adhesive band. Oral contrast is seen passing through the transitional zone at the level of ileum suggestive of incomplete obstruction.



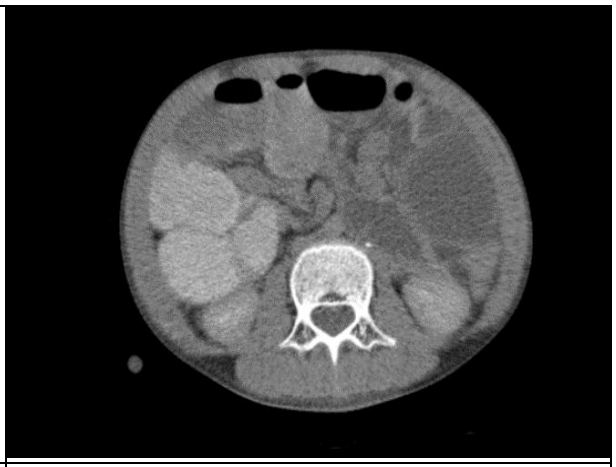
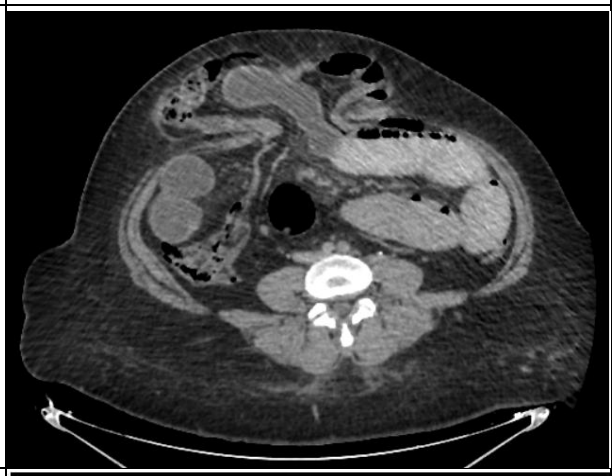
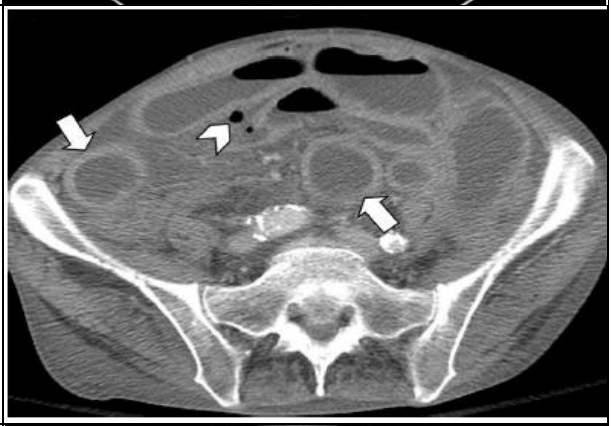
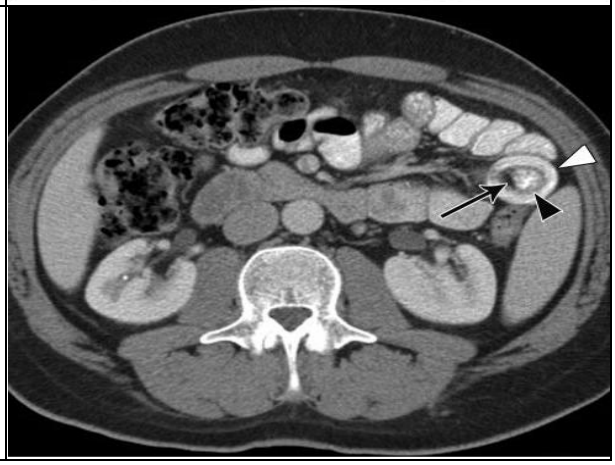
Case 2. A 25-year-old male patient. CT image obtained after repeated hospital admissions with abdominal bloating and vomiting for more than one year. (A) Axial CT abdomen shows in a gas bubbles mixed with particulate matter (small bowel feces sign). (B) Arrow shows the long segment intussusception noted at the jejunum causing subacute obstruction, the intussusception shows a segment of mildly thick-walled slightly enhancing intussusception.



Case 3. A 38-year-old male patient with history of Crohn's disease with symptoms of nausea and vomiting. CT demonstrates (SBO) multiple dilated bowels are seen. (A) Axial CT scan through lower abdomen of small-bowel obstruction secondary to Crohn's disease shows multiple fluid-filled loops of small bowel (arrows) and CT equivalent of string-of-pearls sign. (B) Axial CT scan through lower abdomen shows partially solid material intermixed with air within distal small bowel (arrows), similar in appearance to feces in colon "small-bowel feces" sign.



Case 4. A 63-year-old female patient with symptoms of constipation and abdominal pain for 5 days. With history of abdominal surgery. CT images show multiple dilated bowels due to adhesions. (A) Axial CT scan through lower abdomen shows collapsed distal loop (arrow). (B) CT scan obtained inferior to (a) showing transitional zone (arrow). (C) CT scan obtained inferior to (a, b) shows narrowing of involved loop of bowel and showing "small-bowel feces" sign (arrows).

Case 5. A 50-year-old male patient images presented with cramping abdominal pain, distention, and constipation, with nausea and vomiting. (A) Axial CT scan of the abdomen shows whirl sign (arrow) signifying volvulus. Volvulus can result of loop of bowel rotated around its mesentery. If loop sits in axial plane, it well appears as U or C shape.	
Case 6. A 50-year-old female patient with symptoms of acute sharp abdominal pain. With history of irreducible umbilical hernia. CT images show multiple dilated bowels due to obstructive hernia. (A) Axial CT scan of the abdomen demonstrating acute small bowel obstruction secondary to an incarcerated umbilical hernia. There is a small bowel dilatation proximally and collapsed distally. (Arrows).	
Case 7. A 65-year-old male with history of abdominal liposarcoma, after a whole abdominal radiation therapy. Presented with diarrhea, nausea, and vomiting. (A) Axial CT scan of the abdomen shows marked small bowel wall thickening (the arrows) the transmural enhancement suggests early ischemia. There is small volume pneumoperitoneum (arrowheads) suggestive of focal bowel necrosis.	
Case 8. A 55-year-old male patient with recurrent left lower quadrant pain and constipation. CT scan shows the multilayered appearance of a small bowel intussusception. (A) Axial CT scan of the abdomen demonstrating the intussusception (black arrowhead), with complex of mesenteric fat and blood vessels (arrow), is surrounded by the thick wall (white arrowhead).	

Discussion

Around 80% of cases of intestinal obstruction (IO) are found to have small bowel obstruction[7]. There is a need to identify patients whose small bowel obstruction (SBO) can resolve spontaneously so that unnecessary surgical interventions are avoided[7]. This study aimed to evaluate to evaluate multi-slice computed tomography (MSCT) diagnostic efficacy in cases of small bowel obstruction, which lowers the disease's morbidity and death rates. The average age of the patients, according to our study, was 48.8 ± 13.2, with a range of 23 to 73 years. Furthermore, there were 29.4% male patients and 70.6% female patients. We concurred with Iqbal et al.'s[22] findings about the diagnostic accuracy of curved Multiplanar reformat of multidetector CT scan in identifying the transition zone in patients suffering from intestinal obstruction. The patients included twenty-eight male and thirty-two female individuals ranging in age from fifteen to eighty years. The effectiveness of computed tomography (CT) imaging in identifying the existence, degree, and cause of intestinal blockage was also assessed by Khatri and Khatri[23]. The study participants had a mean age of 51.62±17.46 years, with 46% being male and 54% being female. On the other hand, Elsayed et al.[24] talked about the value of multidetector computed tomography (CT) in assessing intestinal blockage and its underlying causes. Of the 20 patients in this study, 4 (20%) were women and 16 (20%) were men. With a range of 1 month to 85 years, the mean age was 38.95 years.

Most patients in our study (53.3%) were over 50 years old, 41.2% had ages between 30 and 50, and 5.8% had ages under 30. Furthermore, Khatri and Khatri[23] demonstrated that most of the study population (56.0%) belonged to the 41–60-year age group, with 24% of patients falling into the >60-year age group and 20% falling into the 21–40-year age group. According to Elsayed et al.[24] there were 5/20 patients under the age of 18 (25%), 4/20 between the ages of 18 and 45 (20%), and 11/20 above the age of 45 (55%). Intestinal blockage is more common in those over 45 years of age. Raja et al.[25] discovered 26% in the 51–60 age range, 23% in the 41–50 age range, and 22% in the >60 age range. The age group under 20 years old had a minimum of 2% of participants. Based on X-ray findings, our study revealed that 82.4% of patients experienced obstruction (dilated bowel loop/multiple air fluid level). Maglinte et al.'s[9] study examined the accuracy of plain film radiography in determining the degree of small-bowel blockage. 56% (20/36) of low-grade obstacles were accurately identified on plain films when they were classified as low- or high-grade partial small-bowel blockages. 86% (24/28) of high-grade blockages were appropriately detected by plain film radiography. All false-negative plain film interpretations were related to low-grade small-bowel obstruction caused by adhesions; patients with false-negative high-grade small-bowel obstruction were explained by severe generalized ileus. The overall accuracy of plain film radiography in identifying small-bowel obstructions of different severity was comparable. The first imaging modality to be used on individuals suspected of having small-bowel obstructions should still be plain film radiography. By CT, 94.1% of the participants in our research had blockage. Adhesion bands (18%) by CT was the most common cause of obstruction, according to Raja et al.[23] who also found that dilated gut loops (17%), gut perforation (8%), intussusceptions (8%), tumors (7%), mesenteric infarction (5%), sigmoid volvulus (5%), internal hernia (4%), external hernia (3%), pancreatitis (3%), sigmoiditis (3%), intra-peritoneal abscess (3%), radiation enteritis (3%), appendicitis (2%), post-traumatic ileus (2%), Jejunal hematoma (2%), cecal volvulus (1%), extra-peritoneal hematoma (1%), gall stone ileus (1%), carcinomatosis (1%), fecal im-

paction (1%), and unknown cause (2%). Similar to those mentioned by Horton et al.[26] are our diagnostic standards for colonic cancer, which are as follows: A distinct soft-tissue tumor that narrows the intestinal lumen is usually visible on CT scans of patients with colorectal cancer. Furthermore, a notable proportion of colorectal malignancies present with localized thickening of the colonic wall and luminal constriction; this appearance highlights the significance of appropriate colonic opacification and distention. The lumen may be constricted due to asymmetric nodular wall thickening that is a common appearance of rectal and sigmoid malignancies. According to our study, the percentage of patients with complete, high-grade, and low-grade small intestinal obstruction by CT was 46.9%, 25%, and 28.1%, respectively. Perioperative data from the patients under study showed that, respectively, 35.3%, 35.3%, and 29.4% of patients had complete, high-grade, and low-grade small intestinal blockage. According to the results of the operation, the following causes of obstruction were identified: small bowel tumors (8.8%), Crohn's disease (5.9%), adhesive bands (14.7%), radiation enteritis (8.8%), intussusception (14.7%), mesenteric ischemia (8.8%), obstructive hernias (23.5%), small bowel volvulus (3%) and gallstone ileus (3%). According to surgical results, Iqbal et al.[22] also identified the following causes of obstruction: adhesions (43.2%), hernias (18.1%), tumors (4.5%), tuberculosis (9%), foreign bodies (4.5%), and ischemia in (40.9%) on CT scans. The X-ray's sensitivity and specificity for identifying small intestinal obstruction in our investigation were 82.3% and 100%, respectively. Moreover, CT had a 94.1% sensitivity and 100% specificity in identifying minor bowel obstructions. A systemic review was done by Mallo et al [27] and yielded similar results. Our investigation demonstrated that the most therapeutically valuable data from CT was related to individuals in whom it was challenging to distinguish between ileus and bowel obstruction, intestinal obstruction was identified, and conservative treatment was considered. Precise CT results were useful in directing the course of the patient's care (surgical versus conservative). which concurred with Khatri and Khatri[23] who concluded that imaging characteristics aid in patient stratification for conservative or surgical care. Since classic clinical indications of vascular compromise, such as acidosis, fever, leukocytosis, and tachycardia, are frequently incorrect in forecasting the need for operational intervention, imaging is frequently a crucial component aiding in the decision-making process. Therefore, it is crucial for radiologists to recognize imaging characteristics that point to a high risk of bowel vascular compromise to aid improve treatment before intestinal ischemia and ultimately necrosis arise. According to Iqbal et al [22], the curved Multiplanar reformat of a multidetector CT scan is a highly effective diagnostic tool that is essential for identifying and describing the area of transition in patients who have intestinal blockage as well as for appropriate therapy. Ultimately, this study demonstrated how CT has completely changed how patients with minor intestinal blockage are evaluated. CT is readily available in many hospitals around the clock, making the test quick, easy, and diagnostic. Before surgery, a precise assessment of the obstruction's etiology, location, and degree is made, and strangulation is visualized. We think that additional CT evaluations of patients with suspected blockage will ultimately save more lives and money, even though they are more expensive. Therefore, as a first step towards a diagnosis, we recommend that any patient with suspected small intestinal blockage undergo an initial CT study.

Limitations of the Study

Due to variations in patient numbers and examination methods, it was difficult to compare our findings with those of some other research, which meant that our study had cer-

tain limitations such as our study was a single center study with small sample size of our patients.

Conclusion

When it comes to identifying small intestinal blockage, its location, and its etiology, multislice CT scans are incredibly sensitive and specific. Small intestinal obstruction can be diagnosed with multislice CT with a sensitivity and specificity of 94.1% and 100%, respectively. Using a complete approach while using Multislice CT not only improves patient outcome but also aids in accurately diagnosing intestinal blockage. With confidence, this study has determined the function of MSCT in small intestinal obstruction diagnosis and treatment plan modification.

References:

1. Hernandez MC, Haddad NN, Cullinane DC, Yeh DD, Wydo S, Inaba K, et al. The American Association for the Surgery of Trauma Severity Grade is valid and generalizable in adhesive small bowel obstruction. J Trauma Acute Care Surg 2018; 84(2): 372–8.
2. Dehlawi A. Surgical Management of Small Bowel Obstruction In Adults. Journal of Pharmaceutical Negative Results. 2023 Jun 30:372-81.
3. Gharib A, Carpenter CR. Small Bowel Obstruction. Evidence-Based Emergency Care: Diagnostic Testing and Clinical Decision Rules. 2023 Apr 14:439-46.
4. Fakhry SM, Duane TM, Garland JM, Dunne JR, Kurek SJ, Hunt DL, Plurad DS, Shillinglaw WC, Carrick MM, Lieser MJ, Wyse RJ. Survey of Diagnostic and Management Practices in Small Bowel Obstruction: Individual and Generational Variation Despite Practice Guidelines. The American Surgeon. 2023 Feb 28:00031348231160851
5. Silva, Ana Catarina et al. "Small Bowel Obstruction: What to Look For". Radiographics, vol 29, no. 2, 2009, pp. 423-439. Radiological Society of North America (RSNA).
6. Cirocchi R, Abraha I, Farinella E, Montedori A, Sciannameo F. Laparoscopic versus open surgery in small bowel obstruction. Cochrane Database Syst Rev. 2010;2010(2):CD007511-CD007511.
7. Tamburrini S, Lugarà M, Iaselli F, Saturnino PP, Liguori C, Carbone R, Vecchione D, Abete R, Tammaro P, Marano I. Diagnostic Accuracy of Ultrasound in the Diagnosis of Small Bowel Obstruction. Diagnostics (Basel) 2019; 9(3).
8. Khan, Ali Nawaz. Small-Bowel Obstruction Imaging and Diagnosis: Practice Essentials, Radiography, Computed Tomography. 2021.
9. Maglinte Dean DT, Heitkamp Darel E, Howard Thomas J, Kelvin Frederick M, Lappas John C. Current concepts in imaging of small bowel obstruction. Radiol Clin N Am 2003; 41: 263–83.
10. Van Oudheusden, Thijs R. "Challenges in Diagnosing Adhesive Small Bowel Obstruction". World Journal of Gastroenterology, vol 19, no. 43, 2013, p. 7489. Baishideng Publishing Group Inc.
11. Markogiannakis H, Messaris E, Dardamanis D, Pararas N, Tzertzemelis D, Giannopoulos P, Larentzakis A, Lagoudianakis E, Manouras A, Bramis I. Acute mechanical bowel obstruction: clinical presentation, etiology, management and outcome. World journal of gastroenterology: WJG. 2007 Jan 1;13(3):432.
12. Bonouvrie DS, van Beek HC, Taverne SB, Janssen L, van der Linden TN, van Dielen FM, Greve JW, Leclercq WK. Pregnant Women After Bariatric Surgery: Diagnostic Accuracy of Magnetic Resonance Imaging for Small Bowel Obstruction. Obesity Surgery. 2022 Feb 1:1-1.
13. Minordi LM, Larosa L, Barbaro B, Angelino A, Broglia D, Cipri C, Scaldaferri F, Manfredi R, Natale L. How the radiologist must reason for a correct diagnosis in patients with small bowel mural thickening studied by CT or MRI: a pictorial review. Current Problems in Diagnostic Radiology. 2023 Mar 28.

14. Tong, Jia Wei Valerie et al. "Adhesive Small Bowel Obstruction – An Update". Acute Medicine &Amp; Surgery, vol 7, no. 1, 2020. Wiley.
15. Beek K, de Jonge CS, van Rijn K, de Voogd FA, Buskens CJ, D'Haens G, Gecse KB, Stoker J. P355 Motility in small bowel strictures in Crohn's Disease measured with cine-MRI. Journal of Crohn's and Colitis. 2023 Feb 1;17(Supplement_1):i491-2.
16. Katwal S, Katuwal S, Bhandari S. A case report of metronidazole-induced encephalopathy in a bowel obstruction patient with MRI findings. SAGE Open Medical Case Reports. 2023 Aug; 11:2050313X231193385.
17. Marshall S, Nielsen A, Andruczak R. Bezoar following gastrectomy Digest Dis & Sc 2005; 13: 579-583
18. Li I, Zhengyan H, et al. Diagnostic utility of CT for small bowel obstruction: systematic review and meta-analysis. PloS One 2019; 14(12): e0226740.
19. Dollinger, M et al. "Role of Clinical and CT findings in the identification of adult small-bowel intussusception requiring surgical intervention". BJS Open, vol 5, no. 5, 2021. Oxford University Press (OUP).
20. Tucker ON, Escalante-Tattersfield T, Szomstein S, Rosenthal RJ. The ABC System: a simplified classification system for small bowel obstruction after laparoscopic Roux-en-Y gastric bypass. Obesity surgery. 2007 Dec; 17:1549-54.
21. Quist MC, Bonvechio KI, Allen MS. Statistical analysis and data management. Standard methods for sampling North American freshwater fishes. American Fisheries Society, Bethesda, Maryland. 2009:171-94.
22. Iqbal A, Shahzad S, Gul P, Kumar B. To Determine the Diagnostic Accuracy of Curved Multiplanar Reformat of Multidetector CT Scan in Visualizing Zone of Transition in Patients with Intestinal Obstruction. J Liaquat Uni Med Health Sci 2017; 16(01): 37-40.
23. Khatri JN and Khatri R. Role of CT scan in evaluation and management of intestinal obstruction. Indian Journal of Basic and Applied Medical Research 2018; 7(2): 189-193.
24. Elsayed EEM, Habib RM and Soltan BSH. Role of multidetector computed tomography in the diagnosis of intestinal obstruction. Menoufia Medical Journal 2019; 31: 1456-1462.
25. Raja WM, Rather ZM, Majid NA, Islam MN, Toktosunovich YI. Role of multi-slice computed tomography in evaluation and management of intestinal obstruction. Int Surg J 2019; 6: 2663-9
26. Horton KM, Abrams RA, Fishman EK. Spiral CT of colon cancer: imaging features and role in management. Radiographics 2000; 20: 419–430.
27. Mallo RD, Salem R, Lalani T. Computed tomography diagnosis of ischemia and complete obstruction in small bowel obstruction: a systematic review. J Gastrointestinal Surg 2005; 9: 690-4.