ORİJİNAL ARAŞTIRMA ORIGINAL RESEARCH

DOI: 10.5336/medsci.2018-63298

Multiplanar Imaging Evaluation of Specific Signs in Identifying "Closed Loop Small Bowel Obstruction" with Multidetector Computed Tomography

Çok Düzlemli Reformasyon Görüntüleme Özelliği Kullanılarak Kapalı Ans Tipi Bağırsak Obstrüksiyonunu Tanımlayan Özel Bulguların Çok Kesitli Bilgisayarlı Tomografi ile Değerlendirilmesi

Kemal Murat HABERAL[a],
Koray HEKİMOĞLU[a]
Mahir KIRNAP[b]

Departments of
[a]Radiology,
[b]General Surgery
Başkent University Faculty of Medicine,
Ankara, TURKEY

Received: 15 Oct 2018
Received in revised form: 05 Jul 2019
Accepted: 10 Sep 2019
Available online: 16 Sep 2019

Correspondence:
Kemal Murat HABERAL
Başkent University Faculty of Medicine,
Department of Radiology, Ankara,
TURKEY/TÜRKİYE
kmhbjk@hotmail.com

ABSTRACT Objective: Closed-loop obstruction (CLO) is a relatively uncommon clinical entity. Ischemic changes are commonly associated with this type of obstruction. Early diagnosis becomes very critical to choose the pathway to manage the patients, surgical or medical and can be also lifesaving. The aim of this study was to determine the diagnostic impact of multiplanar evaluation of specific signs in identifying CLO with multidetector computed tomography (MDCT). **Material and Methods**: Between June 2012 and December 2017, a retrospective search has been done from medical records of hospital information system for the words "closed-loop, small bowel obstruction" on CT reports for adult patients (>18 years of age) undergoing MDCT imaging. One hundred and six patients, who meet the criteria, were included in the study. Multidetector computed tomography exams were performed with 16 slices scanner. Images were then evaluated by multiplanar reformatting on the workstation in terms of specific findings of CLO. The results were correlated with the surgical diagnosis. The sensitivity, the specifity and the accuracy of multiplanar MDCT evaluation were calculated. **Results:** We have diagnosed sixty-two patients with CLO with specific signs. All of the cases had dilated U/C shaped bowel loops. Forty patients had the beak sign, twenty-five had mesenteric congestion sign, ten had radial distribution, and four of them had the whirl sign. Sixteen patients had MDCT signs of strangulation including intestinal pneumatosis, thickening of the bowel wall, mesenteric congestion, engorgement of mesenteric vessels, increased haziness and blurring of the mesenteric structures. Twelve patients were excluded from the study due to missing surgical data. Fifty of the 62 patients underwent surgery in our hospital. There was no statistically significant difference between ischemia at the surgery and correct diagnosis of CLO at MDCT (p=0.88). The mean sensitivity, specificity, and accuracy for the detection of CLO were found to be 94%, 90%, and 95% respectively. **Conclusion:** Multidetector computed tomography with the capability of multi planar imaging is a valuable modality for demonstrating the specific signs of CLO.

Keywords: Intestinal obstruction; mesenteric vascular occlusion; adhesions; multidetector computed tomography

ÖZET Amaç: Kapalı ans tipi barsak obstrüksiyonu (KATO) nadir görülen bir durumdur. İskemik değişiklikler sıklıkla bu tip barsak tıkanıklığına eşlik etmektedir. Erken tanı hayat kurtarıcı olmasının yanında hastaların cerrahi veya medikal yolla tedavi seçimini yönlendirmede önemlidir. Bu çalışmanın amacı, KATO'nun çok kesitli bilgisayarlı tomografi (ÇKBT) ile tanımlanmasında özel işaretlerin çok düzlemli reformasyon görüntüleme özelliği kullanılarak değerlendirilmesinin tanısal etkisini belirlemekti. **Gereç ve Yöntemler:** Haziran 2012 ile Aralık 2017 arasında, ÇKBT görüntülemesi yapılan erişkin hastalarda (yaş >18) BT raporlarında "kapalı ans, ince barsak obstrüksiyonu" kelimeleri için hastane bilgi sisteminin tıbbi kayıtlardan geriye dönük bir araştırma yapıldı. Kriterlere uyan 106 hasta çalışmaya dahil edildi. Çok kesitli bilgisayarlı tomografi 16 detektörlü BT cihazı ile gerçekleştirildi. Görüntüler daha sonra KATO'nun spesifik bulguları açısından iş istasyonunda multiplanar reformasyon görüntüler oluşturularak değerlendirildi. Sonuçlar kesin tanı ile korele edildi. ÇKBT'nin duyarlılığı, özgüllüğü ve doğruluğu hesaplandı. **Bulgular:** Kapalı ans tipi barsak obstrüksiyonu olan 62 hasta spesifik bulgularla teşhis edildi. Olguların tümünde U/C şeklinde dilate barsak ansları izlendi. Kırk hastada gaga işareti, yirmi beş hastada mezenterik tıkanıklık işareti, on hastada radyal dağılım, dört hastada burgu işareti vardı. On altı hastada intestinal pnömatozis, barsak duvar kalınlaşması, mezenterik damarların tıkanması, mezenterik heterojenite gibi strangülasyon bulguları saptandı. On iki hasta ameliyat raporlarına ulaşılamadığından çalışmadan çıkarıldı. Altmış iki hastanın 50'si hastanemizde ameliyat edildi. Ameliyatta iskemi ile ÇKBT'de KATO'nun doğru tanısı arasında istatistiksel olarak anlamlı bir fark saptanmadı. Kapalı ans tipi barsak obstrüksiyonu için, KATO saptanmada duyarlılık, özgüllük ve doğruluk sırasıyla %94, %90 ve %95 olarak hesaplandı. **Sonuç:** Çok düzlemli reformasyon görüntülerinin yeterliliğine sahip ÇKBT, KATO'nun spesifik belirtilerini göstermek için değerli bir yöntemdir.

Anahtar Kelimeler: İntestinal obstrüksiyon; mezenterik damar tıkanıklığı; adezyon; çok kesitli bigisayarlı tomografi

Closed-loop obstruction (CLO) is an infrequent clinical problem and a type of small-bowel obstruction. The frequency of CLO is not so high, with an average of approximately 10%.[1,2] The hallmark of the problem is the obstruction of a bowel segment at two points proximally and distally along its course with involving its blood supply. Closed-loop obstruction is generally under conditions such as postoperative brids, congenital bands, internal hernias, and malrotation.[2] It can produce a small bowel volvulus that makes the entity dynamic, which may untwine spontaneously or need an instant laparotomy. So, early diagnosis of this disease remains crucial as CLO is commonly associated with mesenteric vascular impairment. The mortality of CLO could reach as high as 35% by the time especially after 36 hours of obstruction.[2]

Closed-loop obstruction is presented with sudden onset severe abdominal pain without relaxing periods. Multidetector computed tomography (MDCT) has very high accuracy for the diagnosis of CLO and has been shown to be valuable in demonstrating the site and the cause of the obstruction.[3] Multi-detector computed tomography could define CLO and strangulation with specific signs on multiplanar images. Most important findings of CLO in MDCT are isolated U or C shaped dilated small bowel loops, the whirl sign with the spiral appearance of the mesentery, beak sign as a sudden caliber decrease at the obstruction point, and also the radial distribution of mesenteric vessels converging towards the obstruction point. By the way, poor or no contrast enhancement of bowel loops, mesenteric, haziness, the presence of interloop fluid and intestinal pneumatosis are very definitive signs for CLO.[3] Multidetector computed tomography with multiplanar reformatting at a workstation provides overall evaluating of all diagnostic signs on multiplanar images. The aim of this study was to evaluate of these pathologic signs with MDCT in patients with CLO.

MATERIAL AND METHODS

This retrospective study was approved by the institutional review board of the university with a waiver of informed consent. A retrospective search has been done from medical records of hospital information system for the words "closed-loop, small bowel obstruction" on CT reports for adult patients (>18 years of age) undergoing MDCT imaging between June 2012 and December 2017. One hundred six patients consisted of 62 men and 44 women aged 30-81 years (mean age, 53 years) were found from the records to represent the study population. All MDCT images 106 of patients were reviewed on the workstation by using multiplanar evaluation.

MDCT TECHNIQUE

MDCT examinations were routinely performed on a 16-detector row CT (Siemens Somatom Sensation, Siemens AG., Munich, Germany) employs a 16x1.25 detector configuration and reconstruction of 3-mm-thin axial slices with no overlap. Three-dimensional reformatted MPR images at Workstation have been created from axial thin images for all patients. The parameters for MDCT were 120 kVp, 400 mA, and 16x3mm detector configuration. Unless contraindicated, patients are given oral contrast solution before 2 hours of scanning. Oral contrast was withheld if the patients could not tolerate drinking. Multidetector computed tomography imaging is performed after intravenous injection of 150 ml non-ionic contrast agent (iopamidol 300 mg I/ml) injected at a rate of 2-3 ml/s with scan delay of 60 seconds from the injection. Image acquisition was performed during the portal venous phase. The scanning performed from the diaphragmatic dome to the symphysis pubis.

IMAGE ANALYSIS

The images were interpreted manually and continuously on multiplanar plans at the workstation by two over ten-year abdominal radiology experienced radiologists independently. The readers were aware that the patients were scanned for intestinal obstruction pre-diagnosis but were blinded to clinical management and the final diagnosis. Diagnosis of CLO was made with classic MDCT signs (C- or U- shaped dilated small bowel loops, beak sign, bowel wall thickening, interloop fluid,decreased bowel wall enhancement, whirl sign, etc.) as defined previously by Balthazar et al.[1]

The surgically detected reason of CLO was the reference standard for the research which recorded in surgical reports. A term of "closed loop" in the operation reports was accepted as the gold standard for CLO diagnosis.

STATISTICAL ANALYSIS

The data collected from patients after surgical correlation was used for determining sensitivity, specificity, positive (PPV) and negative (NPV) predictive values for each reviewer. Differences in sensitivity and specificity by reviewer experience were evaluated with logistic regression test. Confidence interval was also calculated with standard errors based on reviewers results. Inter-reader agreement for detecting CLO was evaluated using Pearson correlation (r). In this method; variables close to 1 indicates high agreement while close to 0 indicates "no agreement." The correlation between MDCT signs of CLO with multiplanar evaluation and presence of CLO intraoperatively was assessed using the χ^2 test of association.

RESULTS

We have diagnosed sixty-two patients with CLO with specific signs. All of the cases had dilated U/C shaped bowel loops (Figure 1). Forty patients had the beak sign (Figure 2), twenty-five had mesenteric congestion sign, ten had radial distribution (Figure 3), and four of them had the whirl sign (Fig-

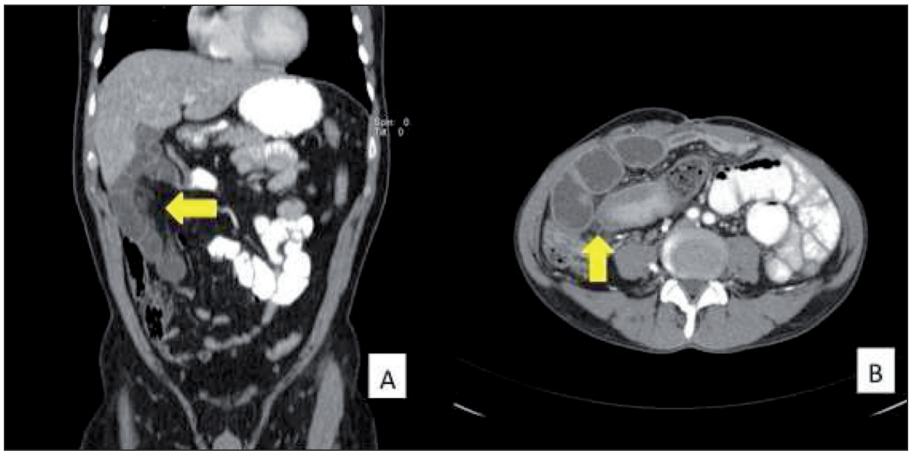

FIGURE 1: Axial and coronal computed tomography images of 2 different patients with intravenous and oral contrast material demonstrating U/C shaped dilated bowell loops (arrows).

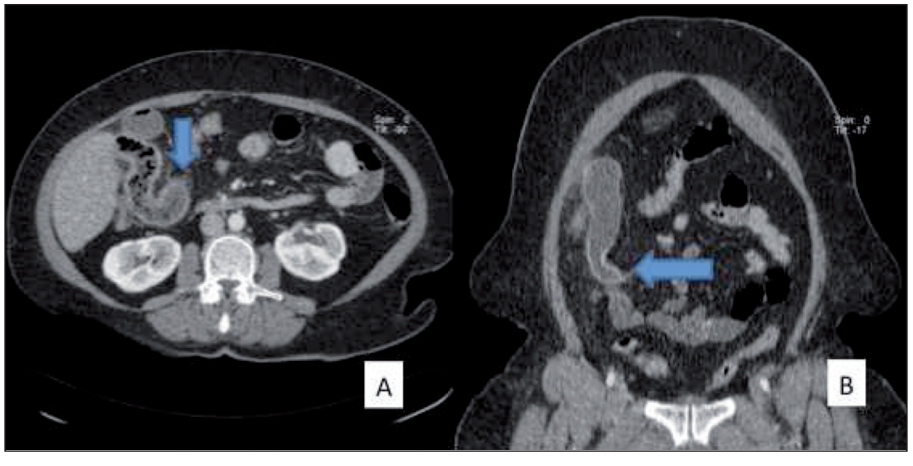

FIGURE 2: Axial and coronal computed tomography images of 2 different patients with intravenous contrast material demonstrating 'beak sign' at the point of obstruction (arrows) and dilated bowel loops proximal to the point.

FIGURE 3: Axial computed tomography image demonstrating radial layout of the vessels converging towards obstruction point.

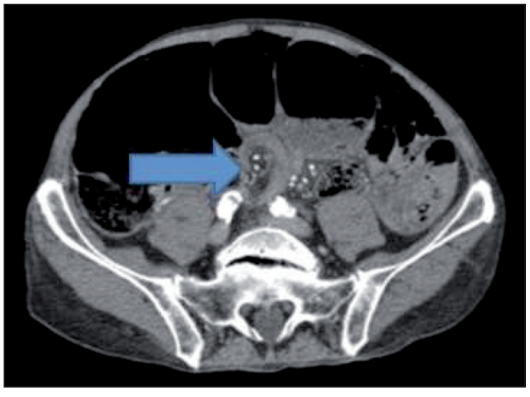

FIGURE 4: Axial computed tomography image with intravenous contrast material demonstrating flat intestinal loops encircle vessels.

ure 4). Sixteen patients had MDCT signs of strangulation including intestinal pneumatosis, thickening of the bowel wall, mesenteric congestion, engorgement of mesenteric vessels, increased haziness and blurring of the mesenteric structures. Twelve patients were excluded from the study due to missing sugical data. Fifty of the 62 patients underwent surgery in our hosptal. There was no statistically significant difference between ischemia at the surgery and correct diagnosis of CLO at MDCT ($p > 0.05$). The causes of CLO varied, and the postoperative "brids-adhesions" were the most common causes of CLO (Table 1). Volvulus was identified in five patients during surgery. Three patients had an external or an internal hernia which demonstrated on coronal and sagittal multiplanar imaging. There was also Crohn disease with inflammation of bowel walls in three patients. Thus, in one patient compression of a mass was the cause of CLO.

The mean sensitivity, specificity, PPV, NPV for reviewers were categorized in evaluating CLO in the group of surgically confirmed fifty patients. The mean sensitivity, specificity, and accuracy for the detection of CLO were found to be 94%, 90%, and 95% respectively. There was an excellent correlation between the presence of MDCT signs of the CLO and the surgical presence of CLO (Table 2). Kappa value of agreement between reviewers for evaluating CLO signs was 0.90 (excellent). The MDCT signs, those had the strongest correlation with CLO, were dilated U/C shaped bowel loops, beak sign, and mesenteric congestion sign (r=0.98, 0.80, and 0.72 respectively, Table 3).

TABLE 1: Causes of closed-loop bowel obstructions.

Cause	Number of Patients (percentage)	Prior surgery
Adhesions-Brids	38 (76%)	32
Volvulus (strangulation)	5(10%)	2
External-Internal hernia	3(6%)	2
Inflammation-Crohn disease	3(6%)	0
Mass effect	1(2%)	0

TABLE 2: Reviewer correlation with MDCT signs of CLO and reporting ratios of reviewers.

Signs	Reviewer 1	Reviewer 2
Dilated U/C loops	0.98	0.98
Beak Sign	0.80	0.74
Mesenteric Congestion	0.72	0.72
Radial Distribution	0.50	0.40
Whirl Sign	0.24	0.20

TABLE 3: The percentage of spesific CLO signs in patients that CLO is surgically proved.

Spesific CLO Signs	Number of Patients,50	Percentage
U/C shaped bowel loops	50	%100
Beak Sign	32	%64
Mesenteric Congestion	20	%40
Radial Distribution	8	%16
Whirl Sign	3	%6

DISCUSSION

Small bowel obstruction (SBO) is a common clinical entity that accounts for approximately 20% of surgical approaches and 4% of overall emergency department visits.[4] By the way, CLO entity is a relatively rare subtype of SBO for overall evaluation. It exhibits the obstruction of a small bowel segment/segments which bordered two separate points along its length. Despite this, the other segments of small bowel exhibit a shape within normal limits. CLO typically occurs as a result of a single trigger lesion. This type is obstruction is associated with an over risk for acute vascular impairment. In cases of strangulation, it could need urgent laparotomy which depending on the time of onset.[5] The beginning process of CLO, the obstructed segment of bowel cannot decompress into upstream other loops, by the time obstruction process leads to ischemia, and intestinal necrosis.[6] Patients with CLO carry a high risk for bowel ischemia and necrosis during the obstruction course, such as 35% after onset 36 h of CLO.[2,7] In this rapid process, early diagnosis of this potential surgical emergency is crucial for preventing the complications. Without a doubt, primary clinical assessment is very important for patients with suspected intestinal obstruction.

Over the last decade, computed tomography has become an essential modality in evaluating patients with a possible bowel obstruction.[3]

Today, MDCT has been widely used to define SBO and its complications. Generally, routine diagnosis of SBO and CLO is performed with MDCT of the abdomen and pelvis combined scanning.

The reasons for CLO may be varied patient to patient radiologically.

The radiologic signs of CLO in CT have been discussed in previous studies.[1-3] Dilated U/C shaped bowel loops, bowel wall thickening, whirl sign, radial distribution of mesenteric vessels, intestinal pneumatosis, increased haziness, and finally ischemic changes in the bowel wall are the most common signs of CLO.

Balthazar et al. first described several specific signs of CT at CLO.[1,7] U- or C-shape dilated bowel loops, beak sign at the point of obstruction, converging mesenteric vessels toward the obstruction (whirl sign) were concluded in literature as specific CT signs of CLO. However, the importance of accurately diagnosing CLO with specific multiplanar MDCT signs cannot be overstated clearly until today.

As known U or C shaped dilated loops are identified in many CT studies concerning SBO.[1-5] We also concluded that U- or C-shaped dilated bowel loops are the most common and valuable marker for SBO and CLO in MDCT. This sign is described on axial image firstly in the literature.[8-10] Thus, sagittal and coronal reconstructed images also and more clearly demonstrate the specific signs for CLO. Dilated loops should be over >2.5 cm diameter and generally located one or two adjacent regions of the abdomen in CLO.

Especially coronal and modified coronal (oblique) reformatted images were very helpful for determining the start and ending points of CLO in patients of study. The beak-sign is another very important sign in MDCT for the diagnosis of CLO. This sign appears as a fusiform tapering of the closed-loop segment as a triangular segment in CT. The apex of the triangle pointed to the obstruction point. We detected this sign in mean of %77 of suspected CLO patients in this research. In a series of 120 patients with CLO, Scaglione et al. noted that the beak sign was found at %25 of patients with SBO with spiral CT imaging.[3-6] We thought that the difference between the percentages results from multiplanar MDCT imaging's detecting the beak sign more clearly. We found mesenteric congestion and radial distribution of vessels signs as important diagnostic markers of CLO in the multiplanar evaluation of MDCT. The radial distribution sign refers to mesenteric vessels just as spokes of a wheel emanating from a central point converging toward the point of obstruction. This sign is also important in predicting necrosis of intestine. The mean reporting ratio for mesenteric congestion and radial distribution of vessels were %72 and %45 respectively. These valuable diagnostic signs were not clearly evaluated in literature for CLO until today.

The whirl sign occurred when affected bowel loops rotate greater than 90 degrees around the obstruction point and encircled mesenteric vessels. We found whirl sign in %22 as an early specific sign of CLO. Balthazar et al. have declared that this is an early valuable sign for the diagnosis of CLO. However, Gollub et al. also evaluated whirl sign in a large group study and concluded that the whirl sign is quite limited as a diagnostic sign for SBO.[1,11] However, this research was primarily focused on intestinal volvulus, and all specific CT signs of SBO with multiplanar images were not clearly evaluated.

Various studies were reported in literature about the reasons of SBO and CLO. Adhesions-brids were found to be the most common cause for CLO in this research. In 76% patients in the study, these causes were surgically confirmed. This result was similar to other studies about SBO.[5,12,13] An ample amount of research in literature have concluded that the brids are the most common cause for CLO.[1,5,14] Strangulation/volvulus most commonly associated with brids or herniated bowel segments. This situation referred the cause of CLO almost 10% of patients in the literature.[1,7] In this study strangulation was defined as the cause of CLO after surgery in five of fifty patients, at same ratio as in the literature. In patients with strangulation, bowel ischemia and infarction may result in increased mortality due to an obstruction to the venous flow of the affected loops. Bowel ischemia may be suggested when occurring some markers including circumferential bowel wall thickening,whirl sign, pneumatosis intestinalis on the bowel wall, or lack of wall enhancement with contrast media. At that time, haziness of mesenteric fat near the lesion is a supplementary finding for ischemia in CLO.[15] For optimal evaluation of bowel wall enhancing; generally, oral contrast administration is not recommended in the scanning of patients with SBO and CLO.

CONCLUSION

The diagnosis of CLO is considered to be an alert for surgical emergency. Multidetector computed tomography with multiplanar imaging is the crucial method for demonstrating the specific signs and precise diagnosis of CLO.

Ethics Committee Approval

Başkent University Medicine and Health Sciences Research Board, 26/06/2018/ KA18/203.

Source of Finance

During this study, no financial or spiritual support was received neither from any pharmaceutical company that has a direct connection with the research subject, nor from a company that provides or produces medical instruments and materials which may negatively affect the evaluation process of this study.

Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

Idea/Concept: Design: *Kemal Murat Haberal, Koray Hekimoğlu;* ***Control/Supervision:*** *Koray Hekimoğlu;* ***Data Collection and/or Processing:*** *Kemal Murat Haberal, Koray Hekimoğlu;* ***Analysis and/or Interpretation:*** *Koray Hekimoğlu;* ***Literature Review:*** *Koray Hekimoğlu;* ***Writing the Article:*** *Koray Hekimoğlu;* ***Critical Review:*** *Koray Hekimoğlu;* ***References and Fundings:*** *Kemal Murat Haberal.*

REFERENCES

1. Balthazar EJ, Birnbaum BA, Megibow AJ, Gordon RB, Whelan CA, Hulnick DH. Closed-loop and strangulating intestinal obstruction: CT signs. Radiology. 1992;185(3):769-75. [Crossref] [PubMed]
2. Elsayes KM, Menias CO, Smullen TL, Platt JF. Closed-loop small-bowel obstruction: diagnostic patterns by multidetector computed tomography. J Comput Assist Tomogr. 2007;31(5):697-701. [Crossref] [PubMed]
3. Makar RA, Bashir MR, Haystead CM, Iseman C, Mayes N, Hebert S, et al. Diagnostic performance of MDCT in identifying closed loop small bowel obstruction. Abdom Radiol (NY). 2016;41(7):1253-60. [Crossref] [PubMed]
4. Desser TS, Gross M. Multidetector row computed tomography of small bowel obstruction. Semin Ultrasound CT MR. 2008;29(5):308-21. [Crossref] [PubMed]
5. Scaglione M, Romano S, Pinto F, Flagiello F, Farina R, Acampora C, et al. Helical CT diagnosis of small bowel obstruction in the acute clinical setting. Eur J Radiol. 2004;50(1):15-22. [Crossref] [PubMed]
6. Birnbaum BA, Maglinte DDT. Small bowel obstruction. In: Herlinger H, Maglinte DDT, Birnbaum BA, eds. Clinical Imaging of the Small Intestine. 2nd ed. New York, NY: Springer-Verlag; 2001. p.467-506.
7. Balthazar EJ, Liebeskind ME, Macari M. Intestinal ischemia in patients in whom small bowel obstruction is suspected: evaluation of accuracy, limitations, and clinical implications of CT in diagnosis. Radiology. 1997;205(2):519-22. [Crossref] [PubMed]
8. Sinha R, Verma R. Multidetector-row computed tomography in bowel obstruction. Part 1. Small bowel obstruction. Clin Radiol. 2005;60(10):1058-67. [Crossref] [PubMed]
9. Obuz F, Terzi C, Sökmen S, Yilmaz E, Yildiz D, Füzün M. The efficacy of helical CT in the diagnosis of small bowel obstruction. Eur J Radiol. 2003;48(3):299-304. [Crossref] [PubMed]
10. Mak SY, Roach SC, Sukumar SA. Small bowel obstruction: computed tomography features and pitfalls. Curr Probl Diagn Radiol. 2006;35(2):65-74. [Crossref] [PubMed]
11. Gollub MJ, Yoon S, Smith LM, Moskowitz CS. Does the CT whirl sign really predict small bowel volvulus?: experience in an oncologic population. J Comput Assist Tomogr. 2006;30(1):25-32. [Crossref] [PubMed]
12. Maglinte DD, Herlinger H, Nolan DJ. Radiologic features of closed-loop obstruction: analysis of 25 confirmed cases. Radiology. 1991;179(2):383-7. [Crossref] [PubMed]
13. Serifoğlu I, Oz II, Tosun A, Demir MK. The role of computed tomography signs in diagnosis of patients with small bowel obstruction. Acta Medica Alanya. 2018;2(2):85-90. [Crossref]
14. Manchanda SD, Prasad A, Sachdev N, De P, Abbas SZ, Baruah BP. Multidetector computed tomography (MDCT) evaluation of small bowel obstruction: pictorial review. Trop Gastroenterol. 2010;31(4):249-59. [PubMed]
15. Mallo RD, Salem L, Lalani T, Flum DR. Compute tomography diagnosis of ischemia and complete obstruction in small bowel obstruction: a systematic review. J Gastrointest Surg. 2005;9(5):690-4. [Crossref] [PubMed]