Evaluation of CT Signs in Diagnosis of Acute Mesenteric Ischemia: A Systematic Review

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Purpose

Acute mesenteric ischemia (AMI) is a life-threatening condition with mortality rate range between 59% and 93%, timely diagnosis and prompt effective treatment can improve the clinical outcome[1]. AMI can be divided into two groups: primary AMI for a vascular origin and secondary AMI with bowel obstruction. However, their early detection and clinical diagnosis are often problematic[2, 3]. Guidelines published by the AGA concluded that computed tomography (CT) is of limited use with neither high sensitivity nor high specificity in diagnosis of AMI using known CT signs[1], but a systematic review made by Jan Menke[4] concluded that contrast enhanced multi-slice CT (MSCT) allows the diagnosis of AMI with high sensitivity and specificity, recently. It may be a strong evidence for clinician to choose the contrast enhanced MSCT as the first-line imaging method in patient with clinical suspicious AMI, but the CT criteria of AMI was blurry and different among its enrolled studies. To responsible hospital radiologist, it is important to assess the abnormal CT presence and accurately diagnose AMI with these CT findings. While, not all CT signs simultaneously perform in one patient of AMI[5], the weight and positive assessment of CT signs in diagnosis of AMI did not come to an agreement and its CT diagnostic criteria were not consistent[6-15]. Therefore, being familiar with the accuracy of each CT sign in diagnosis of AMI is necessary to radiologist in everyday practice. Furthermore, some CT performance of AMI indicate the degree of ischemia[16], which is helpful to the management.

The purpose of our review was to summarize the published evidence of the accuracy of each CT sign about bowel wall, mesentery and vascular abnormality in diagnosis of AMI.
Methods and Materials

Search strategy:

We searched PubMed search engine, Embase, CNKI and Cochrane electronic database from January 1996 to November 2012, kept "mesenteric vascular occlusion" "mesenteric ischemia," "intestinal obstruction and ischemia," "tomography, X-ray computed," and related terms such as "intestinal infarction," "intestinal ischemia," "strangulating obstruction" and each CT sign as keywords. Reference list of selected research papers were also searched. Although no language restrictions were applied in the search protocol, full text review and final data analysis only permitted Chinese and English articles.

Study selection:

Two reviewers selected the items by reading the title and abstract independently with consensus for divarication, then reviewed the full text which met the title and abstract, concentrating on the inclusion criteria: (1) the research design must be diagnostic test consist of diseased group and control group on human, (2) patients were clinically suspected of having AMI, small bowel obstruction, or an acute or subacute abdomen of unknown origin and were consecutively enrolled, (3) single detector CT only allowed for assessment of bowel wall, mesenteriy and ascites, multidetector CT with contrast enhancement was persisted for assessment of mesenteric or portal vascular abnormality except vein gas, (4) the reference standard was surgery or clinical outcome, and (5) at least one CT sign was evaluated by sufficient data reported to construct 2×2 contingency tables. The researches were assessment of chronic mesenteric ischemia or not met any one of the inclusion criteria was excluded.

Quality assessment of the studies:

The methodologic quality and potential sources of bias of the individual study were assessed with 14 standard items from the Quality Assessment of Diagnostic Accuracy Studies (QUADAS). Each question was answered by yes, no or unclear.

Data extraction and synthesis:

To evaluate sensitivity and specificity of each CT sign in the diagnosis of AMI, the same two reviewers extracted the data from each enrolled primary studies to fill into the 2×2 contingency table by CT signs respectively, which consists of true-positive, false-positive, false-negative, true-negative. The mortality reported about each CT sign in studies was also recorded.
The 2×2 count data for each CT sign were imported into Meta-DiSC (version 1.4), Diagnostic Threshold was analyzed firstly, the p value of less than 0.1 was considered to indicate a statistically difference; Q-test was applied to identify the heterogeneity among the studies for each CT sign, if p>0.1, the fix effect model was applied to summarized the pooled sensitivities and specificities of the studies by a forest plot; if p<0.1, $I^2$ was calculated to access the degree of heterogeneity, the heterogeneity was accepted by $I^2<$50%, then the random effect model was applied; while the $I^2$#50%, it suggests that the sensitivities and specificities should not be summarized. Besides, we attempted to analyze data for CT signs reported in 4 or more studies.
Results

3.1 Studies identified and characteristics

Initial search identified 3314 articles, 33 of them met the title and abstract were considered for inclusion. After we looked over the full text of the 33 articles, 20 of them were excluded for the following reasons: (1) not provided sufficient data of CT signs (n=12); (2) different study aims (i.e. clinical outcome with each CT sign) (n=7) and (3) duplicated study written by different language (n=1). QUADAS was applied to the remaining 13 articles, 3 of them were informed low quality, because of unclear depiction of the protocol of CT scanning[3], imaging interpretation[17] and the intervening time between the index test and reference standard conducted[18]. Finally, 10 studies were eligible for our systematic review. They were all high quality with 12 or 13 items filled in the QUADAS checklist Fig 1

Fig. 1: Bar graph of study quality assessment with QUADAS checklist

References: radiology department, west china hospital - Cheng du/CN

Five studies depicted unclear about whether the clinical data was available when imaging interpreted, all studies could not ensure the reference standard performance blinded to the results of CT. The characteristics of the 10 studies were given in Table 1-2. 5 studies were about AMI secondary to intestinal obstruction, one of them was prospective, other four were retrospective. 5 studies were about primary AMI, three of them were prospective, other two were retrospective. Only one set of data was acquisition from the
study by Shannon P Sheedy et al. [10] because of a shorter intervening time less than 24 hours.

3.2 Heterogeneity and accuracy of CT signs

The CT performance of AMI included 15 CT signs to our knowledge, but each study only contained some of them. 14 of them were included in our study, except hyperattenuation of bowel wall which was not evaluated due to none of ten studies reported adequate data.

Meta-analysis were not applied on hyperattenuating ascites and free intraperitoneal air due to that only 3 and 2 studies reported sufficient data of them. We analyzed the diagnostic threshold and heterogeneity of each remaining CT sign among studies, The ascites show marked threshold effect (p=0.032). Q-test was applied on remain CT signs. Reduce enhancement of bowel wall, target sign, mesenteric vein thrombosis, portomesenteric gas, pneumatosis intestinalis and solid organ infarction showed homogeneity among studies (p>0.1), the results of bivariate fix-effects model showed that they had high pooled specificity of 98.8%(95%CI 97.4%-99.6%), 91.6%(95%CI 87.6%-94.7%), 98.1%(95%CI 95.9%-99.3%), 100%(95%CI 98.6%-100%), 99.3%(95%CI 97.4%-99.9%) and 96.3%(95%CI 93.3%-98.2%) respectively, however their pooled sensitivity were 43.9%(95%CI 38.2%-49.7%), 36.4%(95%CI 23.5%-37.9%), 23%(95%CI 17.4%-29.5%), 14%(95%CI 8.8%-20.8%), 28.3%(95%CI 21.5%-36%) and 21.4%(95%CI 15.3%-28.6%) respectively for diagnosis of AMI. Their forest plots were showed in Fig. 2-7

Fig. 2: pooled sensitivity and specificity of reduce enhancement of bowel wall

References: radiology department, west china hospital - Chegn du/CN

Fig. 3: pooled sensitivity and specificity of target sign

References: radiology department, west china hospital - Chegn du/CN
Fig. 4: pooled sensitivity and specificity of mesenteric vein thrombosis

*References:* radiology department, west china hospital - Chegn du/CN

Fig. 5: pooled sensitivity and specificity of portomesenteric gas

*References:* radiology department, west china hospital - Chegn du/CN

Fig. 6: pooled sensitivity and specificity of pneumatosis intestinalis

*References:* radiology department, west china hospital - Chegn du/CN

Fig. 7: pooled sensitivity and specificity of solid organ infarction

*References:* radiology department, west china hospital - Chegn du/CN

Bowel wall thickening, mesenteric haziness or fluid, mesenteric engorgement, ascites, SMA occlusion and luminal dilation had unacceptable heterogeneity (p<0.1, I²>50%), so their sensitivities and specificities did not be summarized, but their sensitivity and specificity of each study were also showed as forest plot in Fig 8-13.
Fig. 8: sensitivity and specificity of bowel wall thickening  

References: radiology department, west china hospital - Chegn du/CN

Fig. 9: sensitivity and specificity of mesenteric haziness  

References: radiology department, west china hospital - Chegn du/CN

Fig. 10: sensitivity and specificity of mesenteric engorgement  

References: radiology department, west china hospital - Chegn du/CN

Fig. 11: sensitivity and specificity of ascites  

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Three out of enrolled ten studies reported the mortality details[6, 9, 12]. In AMI group, 19 out of 23 patients (82.6%) died with mesenteric arterial occlusion, 13 out of 18 patients (72.2%) died with solid organ infarction, 19 out of 28 patients (67.8%) died with pneunatosis intestinalis and 6 out of 15 patients (40%) died with SMV/PV occlusion summarized from these three studies; 10 out of 18 patients (55.5%) died with reduce enhancement of bowel wall and 7 out of 11 patients (63.6%) died with free intraperitoneal air summarized from two studies.
Fig. 1: Bar graph of study quality assessment with QUADAS checklist

Fig. 2: pooled sensitivity and specificity of reduce enhancement of bowel wall
Fig. 3: pooled sensitivity and specificity of target sign

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Fig. 4: pooled sensitivity and specificity of mesenteric vein thrombosis

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Fig. 5: pooled sensitivity and specificity of portomesenteric gas

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Fig. 6: pooled sensitivity and specificity of pneumatosis intestinalis

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Fig. 7: pooled sensitivity and specificity of solid organ infarction

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**Fig. 8:** sensitivity and specificity of bowel wall thickening

**Fig. 9:** sensitivity and specificity of mesenteric haziness

**Fig. 10:** sensitivity and specificity of mesenteric engorgement
Fig. 11: sensitivity and specificity of ascites
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Fig. 12: sensitivity and specificity of SMA occlusion
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Fig. 13: sensitivity and specificity of bowel dilation
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**Table 1:** The characteristics of the 10 studies (1).

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| Kim et al., 2004 | retrospective | secondary AMI | Final clinical diagnosis | Consecutive 71 | 51<sup>(10)</sup> to 90<sup>(11)</sup> | 136 (64±70) | Single row helical CT: Intervascular contrast 8-10mm ST10.5pitch. | Three readers: | Independently Prospective reading |
| Kidpatrick et al., 2003 | prospective | Primary AMI | AMI suspected | Consecutive 21<sup>(10)</sup> | 39<sup>(10)</sup> to 78<sup>(11)</sup> | 62 (26±35) | 4 row MDCCT: Negative oral contrast; Intervascular contrast AP: 1.25mm collimation, FPP: 5mm collimation; | Two readers: | Independently Prospective reading |
| Zelman et al., 2005 | prospective | secondary AMI | High grade obstruction suspected | Consecutive 81<sup>(10)</sup> | 60<sup>(10)</sup> to 84<sup>(11)</sup> | 14K (10±20) | Two patients underwent further examinations after 6 months | Two readers: | Consensus: Prospective reading |
| Ha et al., 1997 | retrospective | secondary AMI | Surgery confirmed obstruction | Consecutive 44<sup>(10)</sup> | 40<sup>(10)</sup> to 64<sup>(10)</sup> | 34 (41±40) | Single row CT: 5-7mm ST10.5pitch. | Two readers: | Independently Prospective reading |
| Toccal et al., 1996 | prospective | Primary AMI | AMI and non-enhancement but AMI was suspected | Consecutive 28<sup>(10)</sup> | 28<sup>(10)</sup> to 53<sup>(10)</sup> | 63 (36±24) | Single row CT: 5-7mm ST10.5pitch. | Two readers: | Independently Prospective reading |

**Table 2:** The characteristics of the 10 studies (2).

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Conclusion

Reduce enhancement of bowel wall, mesenteric vein thrombosis, portomesenteric gas, pneumatosis intestinalis and solid organ infarction suggest definitely diagnosis of AMI and indicate worse clinical outcome. Target sign also reveals high specificity in diagnosis of AMI. Although other CT signs may support the diagnosis, more quantitative threshold or qualitative criteria need to be established to identify them.
References


