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Accuracy of CT angiography in the diagnosis of acute gastrointestinal bleeding: systematic review and meta-analysis

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Abstract
Objective To assess the diagnostic accuracy of computed tomography (CT) angiography in the evaluation of patients with an episode of acute gastrointestinal haemorrhage.
Methods Systematic review and meta-analysis to estimate pooled accuracy indices. A bivariate random effects model was adjusted to obtain a summary receiver-operating characteristic (sROC) curve and the corresponding area under the curve (AUC).
Results Twenty-two studies were included and provided data on 672 patients (range of age 5–74) with a mean age of 65 years. The overall sensitivity of CT angiography for detecting active acute GI haemorrhage was 85.2 % (95 % CI 75.5 % to 91.5 %). The overall specificity of CT angiography was 92.1 % (95 % CI 76.7 % to 97.7 %). The likelihood ratios for positive and negative test results were 10.8 (95 % CI 3.4 to 34.4) and 0.16 (95 % CI 0.1 to 0.27) respectively, with an AUC of 0.935 (95 % CI 0.693 to 0.989). The sources of heterogeneity explored had no significant impact on diagnostic performance.
Conclusions CT shows high diagnostic accuracy and is an excellent diagnostic tool for detection and localising of intestinal bleeding sites. It is highly available, provides fast detection and localisation of the bleeding site, and is minimally invasive.
Key Points
- *CT angiography is increasingly used for investigating severe gastrointestinal bleeding.*
- *This systematic review and meta-analysis updates previous ones.*
- *In patients with massive gastrointestinal bleeding, CT angiography/MDCT detects bleeding accurately.*
- *CT angiography is useful in locating the bleeding site and determining appropriate treatment.*

Keywords Gastrointestinal haemorrhage · CT angiography · Sensitivity and specificity · Systematic review · Meta-analysis

Abbreviations

CT	Computed tomography
MDCT	Multi-detector computed tomography
GI	Gastrointestinal
SROC	Summary receiver-operating characteristic
AUC	Area under the curve
Sen	Sensitivity
Spe	Specificity
LR	Likelihood ratio
DOR	Diagnostic odds ratio
ESS	Effective sample size
CI	Confidence interval

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Introduction

Acute gastrointestinal bleeding is a medical emergency situation and remains a major cause of morbidity and mortality despite significant advances in diagnosis and treatment [1]. Mortality figures range between 8 and 16 % in the normal population, but reach up to 40 % in elderly patients and those with comorbidities [2, 3].

According to the anatomical site, bleeding is defined as either upper gastrointestinal bleeding (from the mouth to the ligament of Treitz) or lower gastrointestinal bleeding (from the angle of Treitz to the anus). Lower gastrointestinal bleeding represents 20 % of all intestinal bleeding and its annual incidence is estimated at 20/100,000 inhabitants [4]. Median gastrointestinal bleeding has recently been introduced as a new concept (reaching from the ampulla of Vater to the terminal ileum) [2, 5, 6].

Many diagnostic and treatment tools have been used for the study of this entity. So far, the endoscopic techniques (upper and lower) are considered to be a good choice for both diagnostic and treatment purposes. Colonoscopy can locate the cause of bleeding in up to 70 %, but has some disadvantages as it requires patient preparation. For this reason it cannot be performed immediately. Also technical difficulties sometimes occur in severe bleeding and it cannot assess the small intestine. Furthermore, up to 15–20 % of cases of bleeding treated with endoscopic procedures recur within 72 h [2, 3, 6].

Digital subtraction arteriography allows both diagnosis and treatment of gastrointestinal bleeding. It detects bleeding rates of 0.5 ml/min with a sensitivity of 63–90 % in upper gastrointestinal bleeding and 40–86 % in lower gastrointestinal bleeding with a specificity approaching 100 %. Its disadvantages are that it is an invasive technique because of the use of radiation and iodinated contrast material, which has contraindications [7–9].

As for nuclear medicine tests, scintigraphy with technetium-99-labelled red blood cells is a slower technique, but can detect bleeding in any location with bleeding rates as low as 0.2–0.4 ml/min. Therefore, it is useful for intermittent bleeding and for mild intestinal bleeding. Its usefulness in severe acute bleeding is debatable and its availability in the clinical setting is limited [4, 7].

Emergency surgery is another treatment option in certain clinical settings, in which patients are mainly unstable or have severe relapses. It should be done under the best conditions though, with a prior diagnosis and mapping of the source of bleeding, since the mortality for blind surgery is high (25–57 %) [10].

Multidetector computed tomography (MDCT) is a promising first-line diagnostic technique for evaluating the presence and location of intestinal bleeding. It is already widely available, rapid and minimally invasive because of the use of radiation and iodinated contrast, with wide anatomical coverage, and it does not need preparation. It can detect active bleeding greater than or equal to 0.3 ml/min and helps to choose between surgical treatment, selective embolisation, arteriography and colonoscopy [2, 6–8, 11].

The objective of this review is to expand upon prior reviews of CT to systematically assess the diagnostic accuracy of CT angiography to evaluate patients with suspected acute gastrointestinal bleeding.

Materials and methods

Literature review

We searched MEDLINE, EMBASE and WoS for relevant citations. The search was completed in December 2011 and covered published literature since January 1990. The terms in the search were “gastrointestinal haemorrhage” OR “gastrointestinal bleeding” AND “CT angiography” OR “X-ray computed” OR “MDCT”.

The reference lists of known previous reviews and of all of the primary studies included were examined to identify cited articles not found by the electronic searches. There were no restrictions regarding publication language. No other methodological filters were applied, as recommended [12].

Selection of studies

Titles and abstracts identified by the electronic search were analysed by two independent reviewers (A.V. and V.G.), and full text versions of all citations that were likely to meet the selection criteria were obtained. Disagreements were resolved by consensus or after discussion with a third reviewer (J.Z.). Between-reviewer agreement was assessed by the kappa coefficient. Studies were selected for the review if they included at least five patients with suspected acute gastrointestinal bleeding diagnosed by CT angiography and were confirmed with a valid reference standard: endoscopy (gastroscopy, colonoscopy or capsule endoscopy), surgery, nuclear medicine or clinical follow-up.

We have only included original articles and we did not consider reviews, abstracts, isolated cases, commentaries, editorials or letters. In cases of suspected duplicate publication, the most recent and complete version was selected. We also excluded studies analysing non-acute bleeding patients according to chronic or occult bleeding.

Data extraction and methodological quality assessment

Data were extracted independently by two reviewers (AV and VG) onto a specifically designed data extraction form

with information regarding study design, participant recruitment, blinding procedure, data collection, test details, QUADAS score, test accuracy results (TP, FP, FN and TN) and scope of study. Additionally, the following variables were extracted for the population of each study: age, sex, type of gastrointestinal bleeding (upper, lower or both), severe or not severe, study design (prospective or retrospective), type of CT used, CT positivity criteria and reference standard tests used.

This extraction form was piloted on a small number of studies before the final collection of information. We assessed the quality of the studies included against the Quality Assessment of Diagnostic Studies (QUADAS) criteria. This included evaluation of study design components including population, test, reference standard, patient outcome and study design [13].

Statistical analysis

We estimated sensitivity/specificity (Sen/Spe), positive and negative likelihood ratios (LR+/LR−) and diagnostic odds ratio (DOR) for individual studies along with their 95 % confidence intervals (CIs) and displayed in forest plots to explore for heterogeneity. A bivariate random effect model [14] was adjusted to obtain a summary receiver-operating characteristic (SROC) curve and the corresponding area under the curve (AUC) including those studies in which it was possible to extract information on all four cells of the 2×2 table. The bivariate model captures the correlation between sensitivity and specificity, which is, in most cases, the consequence of an implicit threshold for the positivity of a test. This threshold makes the sensitivity of the test become inversely correlated to the specificity. The bivariate model simultaneously combines both accuracy indexes modelling their conjoint distribution. The results of these models can be presented with curves (SROC curves) in the ROC space (1-specificity as x-axis and sensitivity as y-axis) or summary points on the curve with confidence ellipses around them. Summary estimates of sensitivity and specificity with their 95 % CIs were obtained from the fitted SROC curve. Heterogeneity among studies was quantified with the variance of the logit of accuracy indices as estimated by the bivariate model. Characteristics of both the study design and CT devices were analysed as sources of heterogeneity. Specifically, we were interested in comparing accuracy indices of studies with prospective vs. retrospective designs, CT ≥16 slice vs. <16 slice and whether the studies included clinical observation as part of the reference standard or not.

Publication bias was assessed using funnel plots, representing a single measure of diagnostic accuracy [i.e. diagnostic odds ratio (DOR), which is computed as the ratio of the odds of positivity in disease relative to the odds of positivity in non-disease] versus the inverse of the square root of the effective sample size (ESS). In the absence of bias the plot should show an inverted symmetrical funnel shape. The degree of asymmetry was statistically evaluated by a regression of the logarithm of DOR against 1/ESS^(1/2), weighted by ESS [15].

For the analyses, we used the Meta-DiSc programme version 1.4 [16] to produce the forest plots and the METANDI macro in State version 11 [17] to estimate the bivariate model and to obtain the pooled diagnostic accuracy index and their 95 % CIs.

Results

Literature search and selection of studies

The electronics search retrieved a total of 3,783 unique titles. After scrutinising titles and abstracts, 3,713 were rejected for different reasons. The flow chart illustrating the application of inclusion and exclusion criteria is shown in Fig. 1. Agreement between reviewers in this selection process was almost perfect (kappa=0.93).

Seventy papers were selected for full text reading. A second selection was made by the same two reviewers independently. After this second step, 48 of the 70 articles were removed for different reasons (Fig. 1), and finally 22 studies were selected for inclusion in the review. Agreement between reviewers in the later selection process was almost perfect (kappa=0.82).

These 22 studies provided data on 672 patients (range 5–74) with a mean age of 65 years (range 53 to 76.8 years). The severity of intestinal bleeding data was variable; some reported massive urgent gastrointestinal bleeding (14 studies, 63.6 %) but in 36.4 % the data were not clear. Ten studies (45.5 %) were related to lower gastrointestinal bleeding, and the remaining 12 studies concerned both upper and lower gastrointestinal bleeding. None of the studies exclusively addressed upper gastrointestinal bleeding (Table 1).

CT features, protocols and reference standard

Only the two oldest studies [33, 34] used a single-detector CT in the diagnosis of intestinal bleeding, while 86.4 % of articles used an MDCT (2 to 64 slices); half of them used 16- or 64-slice MDCT.

The CT technical protocols varied among studies; all but one study did not use oral contrast medium. In 63.3 % of the studies baseline CT without intravenous contrast medium was performed in order to detect pre-existing high-density images, which could make the further evaluation of the CT difficult. All of the studies acquired an arterial phase intravenous iodinated contrast medium at high flow (4 cm^3/s on

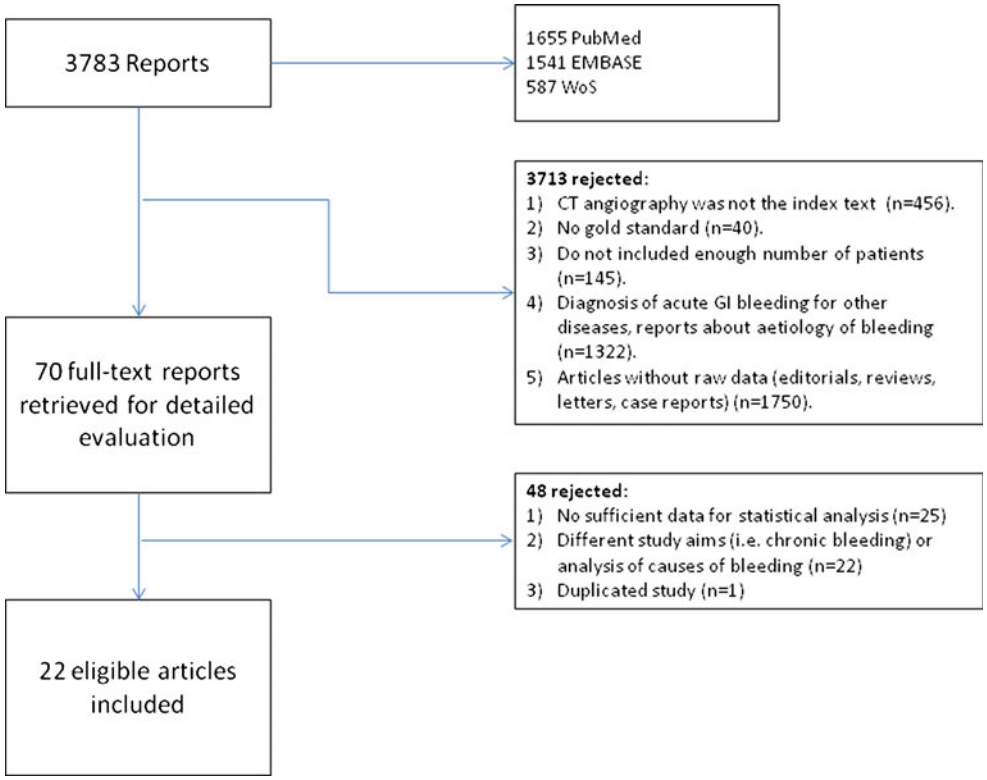

Fig. 1 Study selection flow chart

average) with high iodine concentrations. Most (68.2 %) of the studies included a portal phase (70–80 s at the onset of contrast medium injection). Only three studies (13.6 %) included a 5-min delayed phase.

As for the criteria of test positivity, 90.9 % (20 studies) considered active bleeding demonstrated by CT when there was extravasation of contrast medium during the arterial phase. Six studies [4, 18, 24, 26, 29, 34] (31.8 %) reported positive results when increased extravasations of contrast medium were present in the venous phase. Some studies reported other information such as haematoma in basal study and identification of malformations or tumours.

The reference standard varied widely between studies; however endoscopic examinations (upper endoscopy in 54.5 %, colonoscopy in 72.7 % and capsule endoscopy in 13.6 %) were used most widely.

In 16 studies (72.7 %) angiography (either digital subtraction or conventional) was used as the reference test. In 18 studies (81.81 %) surgery was performed, either alone or in combination. Nuclear medicine was used as the reference test in only six of the studies included in the review [1, 4, 20, 22, 24, 25] (Table 1).

Study quality

The methodological quality of the included studies is shown in Fig. 2. In summary, the methodological quality of the articles was variable. According to the QUADAS, 19 studies (86.4 %) described the selection criteria clearly enough. Only 50 % of studies followed a prospective design. In 20 articles (90.9 %) the results of the CT angiography were reported without knowledge of the results of the reference test. Only in three studies (13.6 %) [2, 4, 26] were the results of the reference test evaluated without knowledge of the CT angiography results, and this aspect could not be determined in 5 studies [1, 3, 18, 19, 25]. In five studies (22.7 %) the interpretation of the results was double-blinded [1, 4, 22, 28, 32]. The patients received the same reference standard regardless of the index test result in only six studies [1, 18, 23, 28, 32, 34].

Descriptions of the results for the CT angiography and the gold standard test were scarce or non-existent in most of the articles reviewed. In all of the 22 studies (100 %) the CT angiography acquisition was described in sufficient detail to allow its reproducibility, but only in 9 studies (40.9 %) [1, 4, 18–20, 23, 28, 31, 33] was the reference standard described with sufficient detail to permit its reproducibility.

Accuracy estimates

We excluded two studies from the meta-analysis as there were no patients without GI bleeding [27, 32]. These studies provided a partial 2×2 diagnostic table where it was not possible to estimate specificity. This precluded inclusion of the studies in the analysis to fit the SROC model.

Table 1 Study characteristics and results

Author/year	Reference number	Patients included	Mean age	Male/ female	Study design	Consecutive recruitment	Blinding	Type of AGIB	No. slice of CT	TP	FP	FN	TN	Criteria for positive CT	Reference standard
Martí et al. (2012)	[2]	47	68	27/20	Prosp.	Yes	Yes	Lower	64	19	1	0	27	Extrav; HL	C/A/S
Al-Saeed et al. (2011)	[3]	27	56	8/19	Prosp.	NA	Yes	Lower	64	19	0	3	5	Extrav; HL	C/S
Kim et al. (2011)	[18]	46	61	29/17	Retrosp.	Yes	Yes	Mixed	64	26	3	6	11	Extrav; I.Extrav	G/C/A
Palma et al. (2010)	[19]	34	71	22/12	Retrosp.	Yes	Yes	Lower	4	30	0	2	2	Extrav	E/S
Kennedy et al. (2010)	[20]	74	63	37/37	Retrosp.	NA	Yes	Mixed	64	21	1	5	59	Extrav.	G/C/NM/A/S/O
Foley et al. (2010)	[21]	20	76.8	14/6	Retrosp.	Yes	Yes	Lower	16	8	1	2	9	Extrav	E/A/S/O
Hara et al. (2009)	[22]	48	69	22/26	Retrosp.	NA	Yes	Mixed	16/64	7	3	14	24	NA	G/C/A/NM/S/O
Heiss et al. (2009)	[23]	6	53	2/4	Prosp.	NA	Yes	Mixed	16	4	2	0	0	Extrav	A/S
Frattaroli et al. (2009)	[5]	29	97	17/12	Prosp.	NA	Yes	Mixed	16	20	8	0	1	Extrav	G/C/A/S
Lee et al. (2009)	[24]	14	71.8	8/6	Retrosp.	NA	Yes	Lower	64/16	7	5	2	1	Extrav; I.Extrav	G/C/CE/A/NM/S
Zink et al. (2008)	[4]	55	73.8	32/23	Prosp.	NA	Yes	Lower	8/64	9	1	11	20	I.Extrav	A/NM
Lee et al. (2008)	[25]	49	ND	ND	Prosp.	Yes	NA	Mixed	4/16	32	1	12	4	NA	E/A/NM
Jaeckle et al. (2008)	[26]	36	60	22/14	Retrosp.	Yes	Yes	Mixed	16/40	24	0	2	10	Extrav; I.Extrav	G/A/S
Scheffel et al. (2007)	[27]	18	57	16/2	Retrosp.	Yes	No	Mixed	4/16/64	15	0	3	0	Extrav	E/A/S
Yoon et al. (2006)	[1]	26	66	17/9	Prosp.	Yes	Yes	Mixed	4	20	1	2	3	Extrav	G/C/A/NM/S/O
Sabharwal et al. (2006)	[28]	7	68	2/5	Prosp.	NA	Yes	Lower	4	5	0	0	2	Extrav	G/C/A
Ko et al. (2005)	[29]	58	28–89	41/17	Retrosp.	NA	Yes	Mixed	4	20	0	18	20	Extrav; I.Extrav	E/S/O
Miller et al. (2004)	[30]	18	69	9/9	Prosp.	NA	Yes	Mixed	2	14	0	2	2	Extrav	G/C/S
Tew et al. (2004)	[31]	13	ND	ND	Retrosp.	Yes	Yes	Lower	4	7	0	0	6	Extrav	A/S/O
Yamaguchi et al. (2003)	[32]	5	62	4/1	Retrosp.	Yes	Yes	Lower	ND	4	0	1	0	Extrav	E
Ernst et al. (2003)	[33]	24	59	15/4	Prosp.	Yes	Yes	Lower	1	15	0	4	5	Extrav; other	C/CE/S/O
Ettorre et al. (1997)	[34]	18	ND	ND	Prosp.	Yes	Yes	Mixed	1	13	0	3	2	Extrav; I.Extrav	C/A/S

AGIB acute gastrointestinal bleeding; *TP* true positive; *FP* false positive; *FN* false negative; *TN* true negative; *ND* no data; *Extrav* extravasation; *I.Extrav* increased extravasation; *HL* hyperdensity lumen; *E* endoscopy; *G* gastroscopy; *C* colonoscopy; *CE* capsule enteroscopy; *A* arteriography; *S* surgery; *NM* nuclear medicine; *O* observation (clinical follow-up)

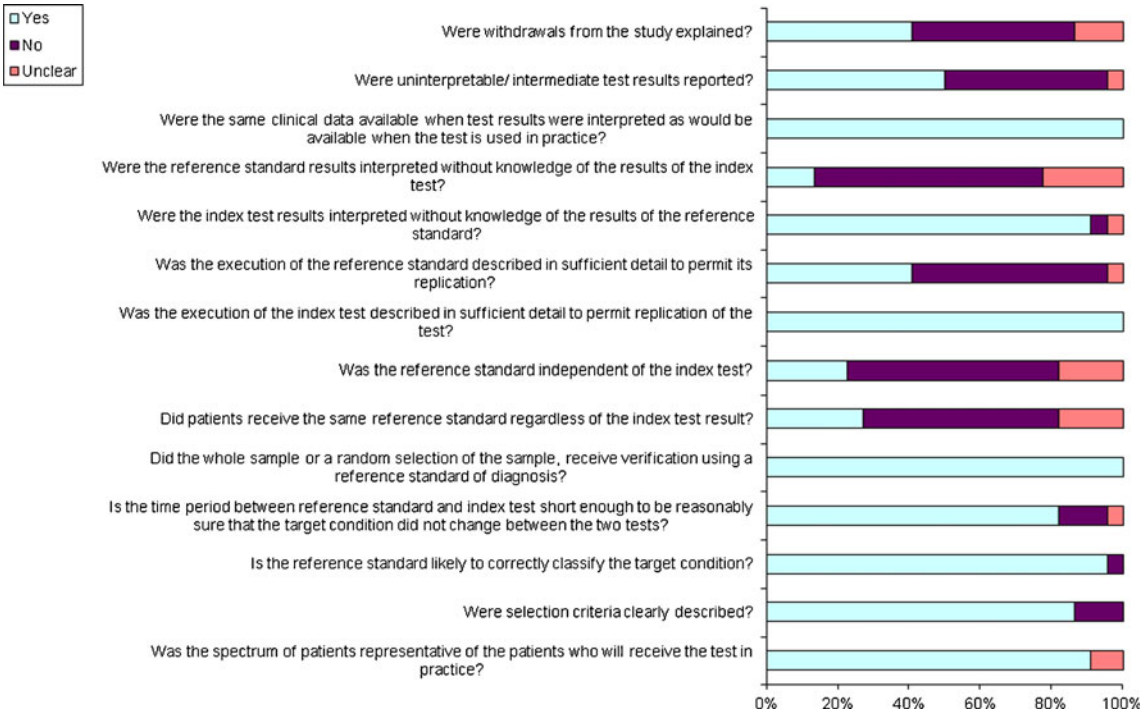

Fig. 2 Quality assessment of diagnostic accuracy studies (QUADAS) scores

Sensitivities and specificities vary widely between individual studies, ranging between 33.3 % and 100 % and 0 % and 100 % for sensitivity and specificity respectively. The overall sensitivity of CT angiography for detecting active acute gastrointestinal haemorrhage was 85.2 % (95 % CI 75.5 % to 91.5 %). The overall specificity of CT angiography was 92.1 % (95 % CI 76.7 % to 97.7 %). The variance of the logit of specificity was four times the variance of the logit of sensitivity (2.49 vs. 0.62). The likelihood ratios for positive and negative test results were 10.8 (95 % CI 3.4 to 34.4) and 0.16 (95 % CI 0.1 to 0.27) respectively.

Individual study accuracy estimate measures are graphically depicted as forest plots in Fig. 3. The area under the SROC curve is as high as 0.935 (95 % CI 0.693 to 0.989) and the curve is plotted in Fig. 4.

Sources of heterogeneity

We assessed the impact on the results of excluding those studies in which fewer than ten patients had been recruited, which hardly modified the overall results (data not shown). We found no differences in accuracy estimates when subgroups of studies of the following characteristics were compared: CT slice ≥16, clinical follow-up of patients included as part of the reference standard and prospective versus retrospective study design (Table 2).

No publication bias was detected (P=0.17). Figure 5 shows the corresponding funnel plot. As a sensitivity analysis, we assess the impact on the results of excluding those studies who had recruited less than ten patients. These exclusions hardly modified the overall results (data not shown).

Discussion

Gastrointestinal bleeding is a medical emergency with high morbidity and mortality rates and requires immediate action to reach the right diagnosis, localise the bleeding site and establish the cause in order to quickly initiate appropriate treatment.

To date, agreed-upon protocols consider endoscopy to be the first-line diagnostic technique. However, this technique is not always available at all emergency departments and requires special patient preparation, thus delaying time to diagnosis. In recent years, MDCT has been incorporated as a new tool in the diagnosis of gastrointestinal bleeding as it is accessible and available in the emergency department, is very quick, requires no special patient preparation, has a wide spatial and temporal resolution, and allows assessment of the entire gastrointestinal tract and other organs, and it shows high diagnostic accuracy.

In our meta-analysis we found that CT showed high sensitivity (85.2 %) and high specificity 92.1 %. Our results confirm those obtained in previous systematic reviews. Chua [7] in 2008 showed a sensitivity and specificity of 0.86 and 0.95 (n=129) respectively. In 2010 Wu et al. [11] showed sensitivity and specificity of 0.89 and 0.85 (n=198) respectively.

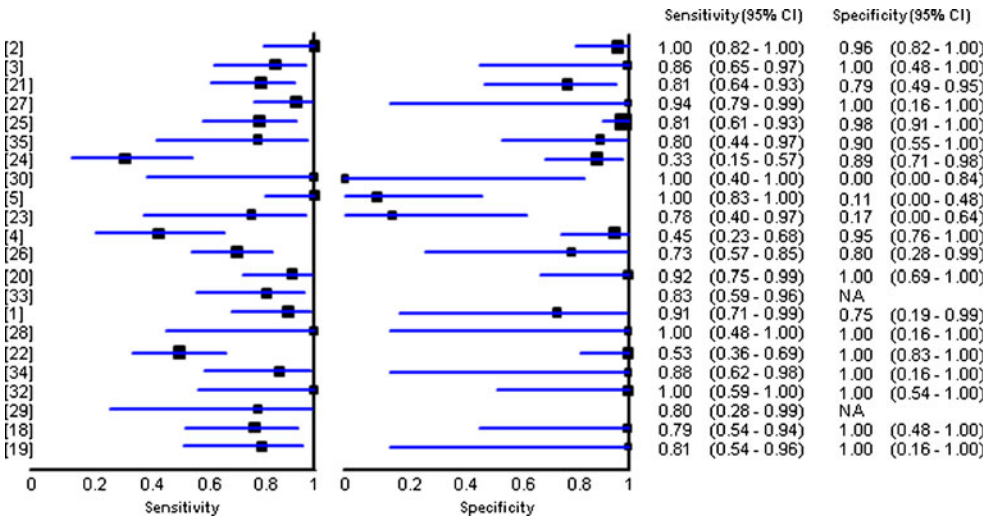

Fig. 3 Forest plot of sensitivity and specificity of CT angiography in the diagnosis of gastrointestinal bleeding (*NA*: data not available)

We have included the most up-to-date evidence on the role of spiral CT and MDCT for the detection of gastrointestinal bleeding in the review, including to our knowledge the highest number of studies (n=22) and the highest number of patients (n=686) to date. We found substantial between-study heterogeneity and varying accuracy estimates among the individual studies. Unfortunately, we were not able to identify any source of heterogeneity that could explain the variation of results in individual studies. The clinical status of patients recruited varied widely from study to study. The severity of gastrointestinal bleeding is an important factor in determining a test's diagnostic accuracy.

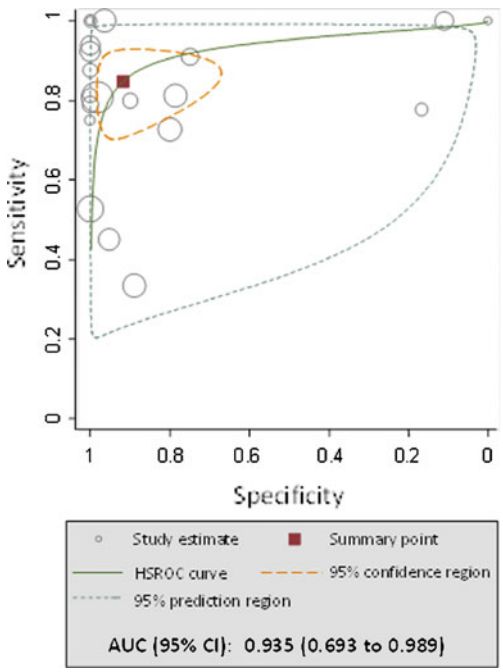

Fig. 4 Summary receiver-operating characteristic (sROC) curve for CT angiography in the diagnosis of gastrointestinal bleeding

CT angiography results largely depend on the severity of bleeding, being more accurate with a higher severity of bleeding. This is a typical example of the spectrum of disease bias. We selected a similar spectrum of the disease by including studies with acute massive and serious gastrointestinal bleeding. Although this characteristic was not clearly stated in some studies, we are confident that we excluded those studies specifically declaring minor and/or chronic bleeding from the review. In our review, studies have more frequently recruited patients with gastrointestinal bleeding than patients without bleeding, making our estimates of specificity less precise than estimates of sensitivity.

Our results showed that the sensitivity of CT angiography is higher when there is a high rate of bleeding or when active bleeding is present. In this situation of severe active bleeding, CT is able to detect as bleeding of as little as 0.3 ml/min.

Because gastrointestinal bleeding is intermittent, CT angiography can detect active signs of bleeding that could turn out to be undetectable when other techniques such as colonoscopy or angiography are performed. Miller et al. [35] describe five bleeding episodes detected by CT that could not be further confirmed by colonoscopy.

Technical details of the screening protocols vary, although all of them coincide in that the arterial phase is the most sensitive for the detection of active bleeding.

We have also found substantial differences between studies regarding the definition of the investigational reference standard. The presence of verification bias cannot be excluded, particularly in those studies using clinical follow-up as the only reference standard. Studies using more sensitive confirmatory techniques exhibit lower sensitivities than those studies that have employed less sensitive techniques. For example, in Ko et al.'s study [29], most patients with positive CT examination had confirmation by high sensitivity reference standard techniques (such as surgery or endoscopy). This may explain why the sensitivity of CT in this study was one of the lowest.

Table 2 Analysis of sources of heterogeneity

Covariates	Estimate	(95 % CI)	*P* value
Type of design			
Relative sensitivity (prospective vs. retrospective)	1.09	(0.93–1.29)	0.30
Relative specificity (prospective vs. retrospective)	0.95	(0.79–1.15)	0.61
CT slices			
Relative sensitivity (≥16 vs. <16)	0.96	(0.81–1.13)	0.60
Relative specificity (≥16 vs. <16)	0.88	(0.70–1.05)	0.14
Reference standard includes clinical follow-up			
Relative sensitivity (yes *vs.* no)	0.97	(0.82–1.16)	0.74
Relative specificity (yes *vs.* no)	1.19	(0.95–1.48)	0.13

Several studies included in our meta-analysis have shown that CT can diagnose bleeding episodes that were not visualised with angiography [28, 35]. In the study by Sabharwal et al. [28] CT was able to identify the site of bleeding in three patients in whom angiography was negative, and colonoscopy performed in an emergency situation could only demonstrate the bleeding without identifying the source.

As well as the better diagnostic accuracy, CT is minimally invasive with respect to angiography (which is not without side effects) and helps to locate the bleeding site and its cause quickly. If the result of CT angiography is positive for extravasations, it can be used to guide further explorations and to plan treatment. CT is also useful in bleeds located in anatomical regions inaccessible to endoscopy such as the small bowel.

As for the limitations of CT angiography, these include the radiation exposure, the risk of allergic reactions to contrast medium, and the problems in patients with severe renal impairment or hyperthyroid crisis. Another less important disadvantage is the presence of metal artefacts in the bowel, which can interfere with the interpretation of the examination. This limitation may be overcome if a baseline CT examination without intravenous contrast medium is performed. However, the major disadvantage of CT compared with other techniques, such as colonoscopy or angiography, is that CT is just a diagnostic technique lacking any therapeutic utility.

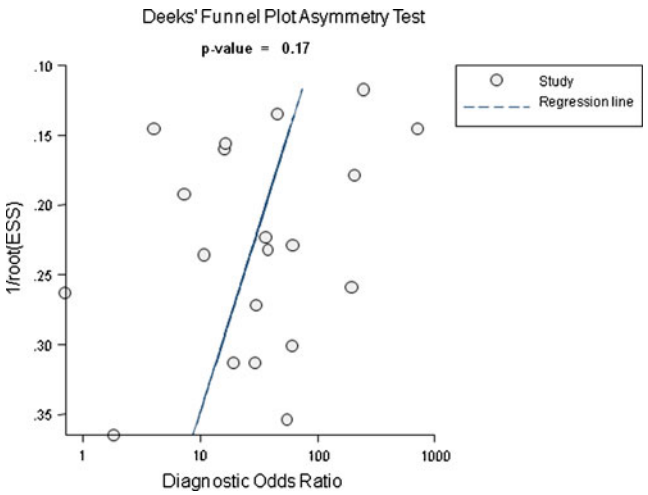

Fig. 5 Funnel plots to assess publication bias

Our meta-analysis included the largest number of studies (n=22) compared with previous reviews and also has a large number of patients (n=686). It includes articles in all languages in seeking to minimise the publication bias. The most up-to-date articles are included, and those with moderate or severe acute gastrointestinal bleeding were selected.

We appraised the methodological quality of the studies with the QUADAS tool, finding that the overall study quality is only moderate. It is worth noting that most of the studies were run following current clinical practice; thus they used reference standards not totally independently of index test (CT) results. This is an important flaw that surely has had an impact on the accuracy estimates we obtained. It is acknowledged that studies with poor methodological standards tend to overestimate diagnostic performance [30]. Furthermore, studies with methodological flaws often show poor quality of reporting and vice versa. Although editors and investigators are aware of the existence of specific guidelines (i.e. the STARD statement), for better reporting of diagnostic accuracy studies [36], the quality of reporting is still low, and this has an adverse impact on the quality of the answers that can be provided by evidence synthesis studies like this.

In conclusion, our synthesis of the most recent evidence compiled to date, which is highly consistent with previous meta-analysis, qualifies CT as an accurate diagnostic tool for the detection and localisation of the site and the aetiology of intestinal bleeding. This asseveration is weighed down because of the moderate methodological quality of the primary studies included in the review. CT diagnostic performance, along with its high availability in the clinical setting, and its properties of fast detection and accurate localisation of the bleeding site and minimal invasiveness make CT a valuable and useful tool for the diagnosis of gastrointestinal bleeding.

However, the actual value of the recent technological developments of MDCT should be evaluated with well-designed prospective trials assessing the cost-effectiveness of a diagnostic workup algorithm including CT angiography.

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