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SOCIETY REPORT

Society of abdominal radiology gastrointestinal bleeding disease-focused panel consensus recommendations for CTA technical parameters in the evaluation of acute overt gastrointestinal bleeding

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Abstract

Purpose To formulate consensus recommendations for CT angiography technical parameters used to evaluate overt gastrointestinal (GI) bleeding.

Methods An electronic questionnaire consisting of 17 questions was sent to a panel of 16 radiologists with expertise on the imaging of GI bleeding from the Society of Abdominal Radiology GI Bleeding disease-focused panel to obtain consensus agreement on issues related to CTA technical parameters for imaging overt GI bleeding. A multi-round Delphi method of voting was performed to obtain consensus which was defined as ≥ 80% agreement.

Results Consensus agreement was reached in 15/17 (89%) of the questions including the technique for the administration of IV contrast, the number of phases, scan timing, and image reconstruction.

Conclusions A panel of experts on the imaging of GI bleeding from the Society of Abdominal Radiology was able to reach consensus on the majority of technical parameters used for CTA of overt GI bleeding. These recommendations should improve the quality of patient care by adopting these minimal technical requirements for optimal exam performance and lead to less variation in the performance of these exams which will facilitate collecting and comparing published data from different centers. These recommendations will need revisions as additional scientific data become available.

Keywords Gastrointestinal hemorrhage · Computed tomography angiography · Colon · Intestine · Small

Introduction

CT angiography (CTA) has been shown to have excellent sensitivity and specificity for detecting and localizing overt gastrointestinal (GI) bleeding [1]. In recent years, awareness of the value of CTA for identification of the bleeding site, potential cause of the bleeding, and ease to obtain a study broadened utilization in clinical practice. However, across different practices anecdotally, we have become aware of wide variability in CTA technique in clinical practice. Furthermore, a number of CTA protocols have been described in literature [1–14] adding further confusion to the topic (Table 1). Dual-energy and spectral imaging CT technology has become available and offers potential advantages for GI bleeding studies; however, there are limited data demonstrating how this technology should be best used.

The purpose of this project was to formulate consensus recommendations from experts on the imaging of GI bleeding in the Society of Abdominal Radiology (SAR) GI bleeding disease-focused panel (DFP) for CTA technical parameters used to evaluate overt GI bleeding.

Materials and methods

This study was performed using a multi-step process which has previously been used for the development of imaging recommendations by radiology working groups [15, 16].

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Table 1 Summary of published CTA technical parameters for imaging of overt GI bleeding

Author	Year	Unenhanced acquisition	Volume of contrast (mL)	Iodine concentration (mgI/mL)	Injection rate (mL/s)	Method to determine scan delay	Timing of 1st phase (s)	Timing of 2nd phase (s)	Oral contrast
Ernst	2001	Yes	160	300	4	Fixed delay	30	120	None
Tew	2003	Yes	75–100	370	3–4	Fixed delay	30–40	None	None
Yamaguchi	2003	No	100	300	2	Fixed delay	30	300	None
Sabharwal	2005	Yes	100	270	3	Bolus triggering	120 HU threshold	120 s after arterial phase	None
Zink	2008	Yes	100	300	4	Test bolus	Peakx2 + 35–40 s	None	None
Lee	2008	Yes	100	370	4.5	Bolus triggering	150 HU threshold (20–30 s)	70	None
Foley	2009	Yes	100	370	4	Bolus triggering	Not provided	90	None
Palma	2010	Yes	120	400	4	Fixed delay	30	60	None
Al-Saeed	2011	Yes	120	300	4	Bolus triggering	15	65	1000 mL oral water
Marti	2012	Yes	100–125	350	4	Bolus triggering	150 HU threshold	70	None
Ren	2015	No	0.7 mL/kg	Not provided	4	Bolus triggering	100 HU threshold	None	None
Nagata	2015	Not provided	90	300	Not provided	Not provided	Not provided	Not provided	None

Step 1: Formation of panel of experts and creation of data collection sheet

The Society of Abdominal Radiology has formed several disease-focused panels which represent working groups of society members with expertise in a specific disease process. In early 2018, the SAR formed a new GI bleeding DFP consisting of experts in the field of overt and occult gastrointestinal bleeding.

The SAR GI Bleeding DFP membership includes 16 radiologists (14 diagnostic radiologists, 1 vascular and interventional radiologist, and 1 radiologist who does both diagnostic and vascular/interventional radiology) and 2 gastroenterologists from 12 academic institutions in the United States ($n = 10$), Asia ($n = 1$), and South America ($n = 1$).

One of the radiologists (data manager; MLG), created a data collection spreadsheet to capture information on the parameters used for CTA. Questions were asked regarding the use of oral and IV contrast, the number and timing of scanning phases, image reconstruction techniques, the use of dual-energy technology and billing. Online Resource 1 summarizes the questions asked in the questionnaire.

Step 2: Data collection on site-specific CTA protocols

A data collection sheet questionnaire was sent electronically to all radiologists. One radiologist at each site reported the CTA parameters used at their institution to the data manager.

Step 3: Review of published CTA techniques

Articles included in the most recent meta-analysis assessing CTA for overt lower GI bleeding [1–14] were reviewed by separate radiologists ($n = 11$) and the CTA parameters from these studies were reported to the data manager.

A lead reference librarian using Ovid MEDLINE(R), Epub Ahead of Print, In-Process & Other Non-Indexed Citations and Daily, Ovid EMBASE, and Scopus performed a literature search for CTA and GI bleeding including the years from 2010 to 2018 using the following search criteria:

1. computed Tomography Angiography/,
2. phlebography/or angiography/or angiography, digital subtraction/or cineangiography/or magnetic resonance angiography/or radionuclide angiography/,

3. tomography, x-ray computed/or colonography, computed tomographic/or four-dimensional computed tomography/or positron emission tomography computed tomography/or single-photon emission computed tomography computed tomography/or tomography, spiral computed/,
4. 2 and 3,
5. ((ct adj3 (angiogra* or enterogra*)) or cta).mp. [mp = title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms],
6. 1 or 4 or 5,
7. exp Gastrointestinal Hemorrhage/,
8. ((gastrointestin* or gi) adj3 (bleed* or hemorrhag* or haemorrhag*)).mp. [mp = title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms],
9. 6 and (7 or 8),
10. limit 9 to (english language and year = "2010–2018").

These articles were divided by chronological order and assigned to the different radiologists ($n = 16$) in the DFP for review. The reviews performed by the individual radiologists were sent to the DFP chair (JLF) who identified articles tagged as technique-related. Articles which addressed various technical parameters scientifically [17–20] were sent to all of the DFP members for review.

Step 4: Review of site-specific protocol and published literature

The data manager summarized the results showing the various parameters from all sites and the published literature. These summary data were reviewed and discussed by the DFP members during two conference calls in May and July of 2018.

Step 5: Development of topics for consensus agreement

After the panel discussions, the co-chairs of the DFP (JLF, JAS) and project chair (MLG) developed 17 questions on specific issues for consensus agreement. The questions and answer stems were discussed and developed by these three radiologists.

Step 6: Multi-round Delphi method

The 17 questions (Online Resource 2) were sent to each radiologist in an electronic format for voting using a multi-round Delphi method. Radiologists were asked to only answer questions regarding dual-energy options if they were performing dual-energy CTA in their practice. After each round of voting, the results were shared with the panel members and there was a discussion on the topics where consensus was not reached. Three rounds of voting were performed. Voting was only repeated for questions without consensus on each subsequent round. One question was reworded after panel discussion in round 3 to facilitate consensus. Consensus was considered to be present if there was greater than or equal to 80% agreement.

Results

Consensus agreement was reached in 15/17 (89%) of the questions.

Oral and IV contrast

There was consensus that no oral contrast (93% agreement achieved in Round 1) should be administered. A high concentration of intravenous iodinated contrast of 350–375 mg I/mL (87% agreement achieved in Round 1) should be administered at a rapid rate of 4–5 mL/s (93% agreement achieved in Round 1). The minimal amount of contrast that should be administered to an average-sized individual in the United States did not reach consensus in Round 3. Sixty percent of responders recommended 100 mL for the minimal amount while 20% recommended 120 mL.

Phases and scan timing

There was consensus that unenhanced images should be obtained on all cases when single-energy CT was used (100% agreement achieved in Round 1). There was consensus that the unenhanced images could be performed at a lower radiation dose (80% agreement achieved in Round 1). If using dual-energy technology a virtual non-contrast/non-enhanced (VNC/VNE) reconstruction was felt to be an adequate replacement for conventional unenhanced images (100% agreement achieved in Round 2).

There was consensus that 2 phases should be acquired following the administration of the IV contrast (100% agreement achieved in Round 1). The first phase should be timed using a bolus-tracking technique with a region of interest in the aorta (93% agreement in Round 1) during the late arterial phase. There was consensus that the late arterial phase should be 10 s after the bolus trigger (80% agreement

achieved in Round 2), while 20% recommended scanning to begin as soon as possible after the enhancement threshold is reached. There was consensus that the second phase should be acquired during a 70 to 90 s window after the initiation of the contrast bolus injection (100% agreement achieved in Round 3).

Image reconstruction

There was consensus that the maximum reconstruction thickness should be 1 to 3 mm (93% agreement achieved in Round 1) and that multi-planar reconstructed images should be generated on all cases and all series (100% agreement achieved in Round 1). There was not a consensus whether maximum intensity projection (MIP) and volume rendered (VR) should be performed routinely.

Dual-energy options

Five of the 12 sites were using dual-energy CTA techniques. As mentioned above, there was consensus that a VNC/VNE was an acceptable replacement for convention unenhanced images. Consensus could not be reached regarding which phase or the number of phases which should be acquired using dual energy. The majority (67% agreement achieved in Round 3) recommended optional acquisition of dual energy on both phases. There was consensus that the amount of IV contrast could be reduced when using a dual-energy technique (100% agreement achieved in Round 1) and should be individualized dependent on patient weight and kV utilized (86% agreement achieved in Round 1).

There was consensus in Round 1 that all image reconstruction techniques presented for voting should be generated and sent to the reading station for review including VNC/VNE (100%), low monoenergetic keV (86%), and iodine maps or overlays (100%).

Discussion

There is wide variability in the CTA techniques used for the evaluation of overt lower GI bleeding both within the SAR GI Bleeding DFP and the published literature. However, the panel of experts included on this project were able to reach consensus for the vast majority of topics.

There was consensus that oral contrast should not be administered. Giving oral contrast will delay scanning of the patient and in this period, the bleeding could cease. Patients who are admitted, undergoing work up and are hemodynamically stable potentially could receive neutral enteric contrast to optimize evaluation for small bowel pathology; however, some have suggested that this fluid potentially could dilute subtle areas of bleeding. Positive enteric contrast should not be administered as its high attenuation will obscure intraluminal vascular extravasation.

Among centers participating in this survey, an intravenous contrast agent with a high concentration of iodine was routinely used in CTA to improve vascular opacification. In theory, this higher concentration should also allow better visual detection of subtle areas of extravasation and allow the creation of optimal quality CTA three-dimensional (3D) reconstructions of the abdominal vasculature to help with conventional angiography planning. More rapid injection should also improve vascular opacification. The DFP could not reach consensus on the minimum amount of contrast that should be administered to an average-sized individual; however, the majority felt that 100 mL was adequate.

All DFP sites acquired unenhanced images and there was unanimous consensus to maintain this practice. Unenhanced images are helpful to identify pre-existing high attenuation ingested material within the bowel that might mimic extravasated contrast, hemorrhage, or sentinel clot. The identification of these high attenuation foci is helpful at preventing false-positive interpretations.

When evaluating for overt GI bleeding, two phases should be performed following IV contrast. The first should be obtained during a late arterial phase which provides some additional time for the contrast to extravasate from the vessels into the bowel lumen. Bolus tracking was preferred over a standard delay to optimize the timing as many of these patients are older or might be hemodynamically compromised or have underlying cardiac disease, and may have a prolonged contrast transit time. The DFP had more difficulty agreeing on the timing of the second phase. Several different scan delays are used in clinical practice and in literature including a portal venous phase (60-70 s.), a late venous phase (90 s.), delayed phase (120 s.), and vascular equilibrium (3-5 min). The DFP reached consensus that a 70–90 s window should be used after the initiation of contrast. This window instead of a fixed time allows some variation and adjustment for those patients with a compromised cardiac output.

The opinion of the panel was that high-resolution images with a maximum slice thickness of 1–3 mm are necessary to detect subtle areas of bleeding and associated lesions. Multi-planar reconstructions are recommended to enhance detection of pathology as some abnormalities may be more apparent in one projection. Maximum intensity projection (MIP) images may also be helpful to improve conspicuity of abnormalities; however, there was no consensus that these or volume-rendered images are always necessary.

Dual energy is a relatively new technology and is not widely used for CTA in the evaluation of overt lower GI bleeding. This may be in part that there are limited dual-energy CT scanners located in or near the emergency department. Only five of the DFP sites have experience

using dual-energy CTA for this indication with variations in protocols and varied experience. Dual energy has several potential advantages. Virtual non-contrast images can be reconstructed with little or no additional radiation that are exactly matched anatomically with the contrast-enhanced dataset. Monoenergetic low keV images can be reconstructed, which increase iodine conspicuity and may allow improved detection of subtle enhancement and extravasation. Iodine maps or overlays can also be generated and help demonstrate areas of iodine accumulation improving differentiation from ingested material. Because this technology is in its infancy and due to the limited clinical experience, consensus was not reached regarding the number of phases or which phases should be acquired with dual-energy technique. However, the majority believed the best recommendation was performing dual-energy technology on a single phase with the additional phase being single-energy CT and dual-energy optional. There was consensus that VNC, monoenergetic low keV, and iodine maps should all be routinely reconstructed. The recommendation of the panel was that the amount of IV contrast administered could be reduced if using dual energy, and that the dosage should be determined by the patient weight and kV utilized as both affect image quality.

There are several limitations to this consensus statement. There is a paucity of high-quality scientific data to support the DFP recommendations. In addition, only 12 sites are represented in the recommendations, all tertiary academic medical centers. If more sites had been included the results may have been different. The DFP also had limited experience with dual-energy technique which did not allow consensus on most dual-energy issues.

In conclusion, a panel of experts on the imaging of GI bleeding from the Society of Abdominal Radiology was able to reach consensus on the majority of technical parameters and issues for CTA of overt GI bleeding. These recommendations should improve the quality of patient care by adopting these minimal technical requirements for optimal exam performance and lead to less variation in performance of these exams which will facilitate collecting and comparing published data from different centers. These recommendations will need revisions as additional scientific data become available.

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