CT Diagnosis of Acute Bleeding

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SHORT ABSTRACT

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Acute bleeding is one of the more common disease states in the emergency department and elsewhere. Theoretically, the imaging modalities that can be employed in the assessment of acute bleeding, whether from trauma, gastrointestinal sources, or other origin include:

CT (computed tomography): It is fast and widely available, and it can provide detailed images of the whole body. CT angiography can demonstrate active bleeding sites and assess vascular and/or parenchymal origin. In trauma cases, CT enables practitioners to evaluate multiple body regions quickly and accurately. However, ionizing radiation may be limited in differentiating old blood from fresh hemorrhage, and intravenous contrast administration may to be avoided in patients with limited renal function.

Ultrasound: Quick and bedside (like in the case of FAST – focused assessment sonography in trauma), it can detect free fluid in abdominal or thoracic cavities without ionizing radiation, but it is largely operator-dependent and highly limited in assessing deep structures or in patients with excess gas or obesity.

Nuclear Medicine Studies (e.g., tagged red blood cell scans): Although not applied any more in most clinical settings, it may be indicated in selected patients to detect slow bleeding, especially with suspicion of intermittent gastrointestinal bleeding, but it takes longer than CT, provides limited anatomical details, and uses ionizing radiation.

MRI (magnetic resonance imaging): Provides high-resolution images and can differentiate between old and new hemorrhage without ionizing radiation. MRI is not commonly used for this indication in clinical practice. The examination time of MRI is much longer than CT, and MRI might not be suitable for unstable patients and cannot be performed in patients with certain medical devices or in patients with claustrophobia.

Angiography (digital subtraction angiography – DSA): It is the gold standard for the detection of bleeding and allows for therapeutic action like embolization. Some interventional radiologist prefer CT-based vascular mapping before angiography. Angiography is invasive, requires specialized facilities and dedicated staff, and harbors a low risk of complications.

CT is obviously the preferred first-line modality in many emergency situations due to its availability and short examination time. Computed tomography (CT) is used to diagnose various types of internal bleeding, and different phases of contrast enhancement can contribute to this diagnostic process. The three main phases used, especially in the context of abdominal and pelvic bleeding, include:

1. Non-contrast phase (or plain/unenhanced CT): Useful for identifying high-density materials as calcifications or blood.
2. Arterial Phase (or Early Phase):
   * This phase captures images shortly after the intravenous administration of contrast, typically around 25–35 seconds for abdominal imaging.

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   * The arterial phase is valuable for identifying active arterial bleeding. A 'contrast blush' or extravasation during this phase may indicate active hemorrhage.
   * This phase is also useful for detection of certain hypervascular tumors that are predominantly fed by arterial blood supply.
   * The arterial phase displays the vascular anatomy, at times useful for planning of interventional procedures.
3. Venous or Portal Venous Phase:
   * Typically captured around 60–70 seconds after intravenous contrast administration for abdominal imaging.
   * This phase provides optimal visualization of the portal vein and other venous structures.
   * Useful for the assessment of the liver, spleen, and other organs, as well as for identifying pathologies as tumors or certain types of hemorrhage. In acute bleeding, the (arterial) blush typically enlarges in the venous phase, or 'moves' in the GI tract.
4. Delayed Phase (captured several minutes after contrast administration): May be indicated in selected patients. However, in the context of acute bleeding, the unenhanced, arterial, and venous phases are usually diagnostic.

Spectral CT (or dual-energy CT) has been an emerging and exciting development. It offers the ability to obtain images at two different energy levels, thus enabling differentiation of materials based on their energy-dependent attenuation characteristics. Iodine maps, in the context of spectral CT, refer to images that specifically depict the distribution and concentration of iodine (from intravenous contrast administration) within the scanned volume. This is based on the distinct attenuation properties of iodine at the two different energy levels used in spectral CT. Spectral CT with iodine maps can be beneficial in the context of GI bleeding:

1. Visualization of Active Bleeding: The high-resolution iodine map can clearly show the extravasation of contrast from the bleeding vessel, and contributes to the detection active bleeding site.
2. Improved Differentiation: Spectral CT allows for better differentiation between blood and other substances/materials in the gastrointestinal tract, in particular in the presence of intraluminal contrast or food residues'.
3. Virtual Non-Contrast (VNC) Images: Using spectral data, virtual non-contrast images can be generated that can be useful in cases where unenhanced images were not obtained.
4. Reduced Beam Hardening Artifacts: Beam hardening, a common artifact in standard CT, is often reduced in spectral CT, which can be particularly helpful in areas like the pelvis where such artifacts can obscure findings.
5. Characterization of Lesions: The ability to differentiate materials can be useful in more appropriate characterizing of lesions, such as distinguishing between hemorrhagic and non-hemorrhagic lesions.
6. Fewer Phases Needed: Since the iodine concentration can be displayed, and virtual non-contrast images can be calculated, there might be cases where fewer scan phases are needed, contributing to the decrease of the radiation dose.

In the context of acute GI bleeding, spectral CT with iodine mapping can be a powerful tool to rapidly identify and localize the bleeding site, especially when other modalities (like endoscopy) might be inconclusive, not feasible, or not immediately available. However, the actual application would depend on the specific clinical scenario and the available resources at the healthcare institution.

When looking at the images for diagnostic reading, thin-sliced MIP (maximum intensity projections) offer a definite advantage over routine axial images. Indeed, in routine axial images, small vessels, or tiny foci of contrast extravasation can sometimes be overlooked, especially if they are in close proximity to other high attenuation structures. MIP images, by projecting the brightest intensities, can provide a clearer 'road map' of the vascular anatomy and any associated pathologies. The culprit vessel can be detected much easier and provides a reliable roadmap for the interventional radiologist.

An ideal examination report should answer to the following five questions:

1. The presence/absence of bleeding
2. The assessment of active bleeding (extravasation)
3. The exact anatomical bleeding site, and the likelihood of compartmental syndrome.
4. Estimation of the amount of blood loss (volume of the hemorrhage)
5. Indication of the culprit vessel and providing a representative roadmap if possible.

In conclusion, CT is the workhorse in the diagnosis of acute bleeding and requires adherence to a strict scan protocol and interpretation to provide crucial information for the clinician, the surgeon and interventional radiologist.

COMPETING INTERESTS

The author has no competing interests to declare.

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