Hypotension and the abdominal CT

Poster No.: R-0066
Congress: 2017 ASM
Type: Educational Exhibit
Authors: F. Delaney¹, I. Bickle², A. Dixon³, C. Hacking¹, H. Knipe³; ¹QLD/AU, ²Bandar Seri Begawan/BN, ³VIC/AU
Keywords: Abdomen, Trauma, CT, CT-Angiography, Contrast agent-intravenous, Contrast agent-oral, Embolisation, Haemorrhage, Ischaemia / Infarction
DOI: 10.1594/ranzcr2017/R-0066

Any information contained in this pdf file is automatically generated from digital material submitted to EPOS by third parties in the form of scientific presentations. References to any names, marks, products, or services of third parties or hypertext links to third-party sites or information are provided solely as a convenience to you and do not in any way constitute or imply ECR's endorsement, sponsorship or recommendation of the third party, information, product or service. ECR is not responsible for the content of these pages and does not make any representations regarding the content or accuracy of material in this file.

As per copyright regulations, any unauthorised use of the material or parts thereof as well as commercial reproduction or multiple distribution by any traditional or electronically based reproduction/publication method is strictly prohibited.

You agree to defend, indemnify, and hold ECR harmless from and against any and all claims, damages, costs, and expenses, including attorneys' fees, arising from or related to your use of these pages.

Please note: Links to movies, ppt slideshows and any other multimedia files are not available in the pdf version of presentations.
www.myESR.org
Learning objectives

• To explore the evolving role of abdominal computed tomography (CT) in the evaluation of hypotensive patients
• To recognize the features of hypotension on abdominal CT, and understand how their correlation with clinical hypoperfusion can predict severity and guide management
• To classify and describe important causes with sample case illustrations
Background

Hypotension is defined as a systolic blood pressure of less than 90 mmHg or mean arterial pressure less than 65 mmHg, and constitutes shock when there is associated evidence of tissue hypoperfusion. It can be due to inadequate cardiac output or peripheral circulatory failure or both. When considering abdominal CT in hypotensive patients, hypovolaemia from haemorrhage or third-spacing is the most common pathology identified, but others such as sepsis from an intra-abdominal source may also be important.

Evolving use of abdominal CT in hypotensive patients

Hypotensive patients have previously been considered too unstable for CT, progressing instead directly to definitive treatment. Patient resuscitation has evolved however, and improvements in facility designs and imaging techniques have greatly reduced transportation distances and image acquisition times [1]. Modern interventional radiological techniques can provide better outcomes than unguided open surgery and require the level of anatomic and diagnostic detail provided by CT for planning [1-4]. Thus, the use of abdominal CT in hypotensive patients with a range of acute abdominal and systemic disorders is increasing and evolving [5].

Classification of important causes

- **Trauma**: Abdominal CT use in hypotensive patients following trauma is primarily in cases of blunt abdominal trauma where there is growing evidence of its feasibility and importance, in contrast to traditional Advanced Trauma Life Support guidance that hypotensive trauma patients are unsafe for advanced imaging [1-4]. In addition to providing accurate diagnosis of solid organ injury and localising the source of any haemorrhage, bleeding can be further assessed using the enhanced contrast feature, and surgical or interventional radiological treatments can be planned [6]. In penetrating trauma, abdominal CT is often used in the haemodynamically stable patient managed conservatively [7]

- **Non-traumatic solid organ**: Haemorrhage may occur spontaneously from a range of intra-abdominal solid organs resulting in hypotension. This is often due to underlying cystic or neoplastic lesions, and most commonly involves the liver or kidneys [8, 9]

- **Gastrointestinal**: In lower gastrointestinal haemorrhage (distal to ligament of Trietz), CT angiography can be an effective, non-invasive method for bleeding site identification and subsequent treatment planning in certain cases. With
active bleeding at a rate of at least 0.35ml/min, the source of bleeding can be localised in approximately 90% of patients [10, 11]. It is much less useful in slow or intermittent bleeding. Other pathologies of the gastrointestinal tract such as bowel perforation or ischaemia may also be important abdominal causes of hypotension diagnosed on CT

- **Vascular:** Abdominal aortic aneurysm rupture is the most important abdominal vascular disorder resulting in hypotension, and specific CT features have been described. Suitability for endovascular treatment can also be assessed [4, 12]. CT is the critical investigation in another vascular disorder of the abdomen, segmental arterial mediolysis [13]

- **Systemic:** Sepsis from an intra-abdominal source may lead to septic shock with abdominal CT used in diagnosis and to guide treatment e.g. abscess drainage

- **Abdominal wall:** Haemorrhage from the abdominal wall can be primary or secondary and is especially seen in coagulopathic patients [14]
Abdominal CT hypotension complex

In hypotensive patients the abdominal CT may demonstrate several classic signs, collectively known as the CT hypotension complex, which are primarily due to sympathetic nervous system activation as a protective physiological reaction [5, 15-20]. The generic findings may be divided into visceral and vascular groups as illustrated below. Cases 1-3 highlight some examples of these (Fig.1, Fig.2, Fig.3).

**Visceral**
- Small intestinal wall thickening (Fig.1)
- Increased small intestinal mucosal enhancement (Fig.1, Fig.11)
- Striated nephrogram (Fig.2, Fig.3)
- Abnormal hepatic/splenic enhancement (Fig.3, Fig.8)
- Peri-pancreatic fluid
- Intense renal/adrenal enhancement (Fig.8, Fig.9)
- Gallbladder mucosal enhancement (Fig.10)
- Abnormal pancreatic enhancement (Fig.11)

**Vascular**
- Inferior vena cava (IVC) flattening (slit sign) (Fig.3, Fig.4)
- Halo sign surrounding intrahepatic IVC
- Reduced aortic calibre (Fig.4)
- Abnormal mesenteric enhancement

**Cause-specific findings**

In addition to the generic findings of the CT hypotension complex, abdominal CT can provide more specific information for both diagnosis and treatment planning depending on underlying cause, as described using sample cases below:

**Trauma:** Case 4 demonstrates hepatic, splenic, and duodenal injury in blunt abdominal trauma in combination with generic signs of hypotension (Fig.4). These are among the most commonly damaged organs. The spleen is the organ most frequently injured, with Case 5 showing a splenic injury of the highest grade in association with renal injury (Fig.5).
Non-traumatic solid organ: Case 6 is an example of spontaneous solid organ haemorrhage from the liver associated with an underlying neoplastic lesion, likely hepatocellular carcinoma (Fig.6). Similarly, Case 7 shows haemorrhage from a renal angiomyolipoma (Fig.7).

Gastrointestinal: Case 8 illustrates both the role of multi-phase CT in the assessment of gastrointestinal bleeding and the potential treatment with catheter angiography (Fig.8). Bowel ischaemia in association with multiple indicators of hypotension is seen in Case 9 (Fig.9).

Vascular: An example of abdominal aortic aneurysm rupture is shown in Case 10 (fig.10). The location of the aneurysm and its relationship to the branches of the abdominal aorta can be determined.

Systemic: In Cases 11 and 12 sepsis from an intra-abdominal source (pyelonephritis and uterine infection following prolonged foetal death) has led to organ hypoperfusion represented by CT hypotension complex signs (Fig.11, Fig.12). Interestingly in cases of septic shock vascular manifestations of hypotension (small calibre aorta and slit-like IVC) are not seen as blood volume is normal.

Abdominal Wall: Case 13 demonstrates abdominal wall haemorrhage with active contrast extravasation indicative of ongoing blood loss (Fig.13).

Value in overall clinical management

In addition to diagnosis and specific treatment planning, abdominal CT may also be important in guiding clinical patient care. Patterns of the CT hypotension signs discussed here have recently been shown to correlate with clinical severity of injury, metabolic abnormalities, fluid requirements and mortality [21-23]. Understanding of this relationship will continue to expand as increased numbers of hypotensive patients undergo abdominal CT. It demonstrates the important role radiologists can perform in helping to determine clinical severity of shock early and the potential for these CT findings to be incorporated into clinical treatment algorithms.
Fig. 1: Selected contrast-enhanced CT images of a 45 year old male who presented after high-energy blunt trauma demonstrating shock bowel with small bowel mucosal thickening and mucosal hyperenhancement (white arrows).

© Case courtesy of Dr Dayu Gai, Radiopaedia.org, rID: 30856

Fig. 2: Selected contrast-enhanced CT images of a 65 year old male who presented with shock requiring inotropes demonstrating bilateral striated nephrograms.
Fig. 3: Selected contrast-enhanced CT images of a 70 year old male who presented post cardiac arrest demonstrating multiple features of CT hypotension complex: slit-like IVC (red arrow), striated nephograms (white arrow), differential hepatic enhancement (orange arrow), along with portal venous gas (blue arrow).

Fig. 4: Selected axial contrast-enhanced CT images of a 27 year old female who presented with shock after a motor vehicle collision demonstrating hepatic (white arrow)
and splenic (red arrow) lacerations with adjacent haemoperitoneum, duodenal injury (orange arrow) and signs of CT hypotension with slit-like IVC (blue arrow) and narrow calibre aorta (yellow arrow).

© Case courtesy of RMH Core Conditions, Radiopaedia.org, rID: 33574

**Fig. 5:** Selected multiphase CT images of a 33 year old male who presented after falling from a motorbike demonstrating a splenic injury with contrast extravasation on arterial (red arrow) and portal venous phase (blue arrow).

© Case courtesy of Dr Ian Bickle, Radiopaedia.org, rID: 25533
Fig. 6: Selected non-contrast CT images of a 57 year old male who presented with abdominal pain and shock demonstrating a large hepatocellular carcinoma (red arrows) and a large volume of haemoperitoneum (yellow arrows) with evidence of acute haemorrhage (blue arrow).

© Case courtesy of Dr Ian Bickle, Radiopaedia.org, rID: 45568
Fig. 7: Single contrast-enhanced axial CT image in a 70 year old female who presented with left flank pain and shock demonstrates a large left renal angiomyolipoma (red arrow) with a large left retroperitoneal haemorrhage (orange arrow).

© Case courtesy of Dr Rishikesan Ramaesh, Radiopaedia.org, rID: 33008
Fig. 8: Selected contrast-enhanced CT axial images (upper panels) of a 54 year old female who presented with anaemia demonstrating contrast extravasation in the jejunal on arterial phase (red arrow) with pooling on delayed phase (yellow arrow). Active bleeding subsequently confirmed on DSA (lower panels) with contrast extravasation from a jejunal artery (blue arrow) successfully embolised.

© Case courtesy of Dr Ian Bickle, Radiopaedia.org, rID: 44763
Fig. 9: Selected contrast-enhanced CT images of a 75 year old male who presented with acute abdominal pain demonstrating signs of ischaemic gut with pneumatosis intestinalis (blue arrows) from a thrombosed superior mesenteric artery (red arrow) and signs of CT hypotension including striated nephrogram (yellow arrow), adrenal hyperenhancement (orange arrow), and hepatic and splenic hypoenhancement.

© Case courtesy of Dr Henry Knipe, Radiopaedia.org, rID: 28176
Fig. 10: Selected axial contrast enhanced axial CT image of a 92 year old male who presented with back pain and hypotension demonstrating a large rupture abdominal aortic aneurysm (red arrow) and a large left retroperitoneal haemorrhage (orange arrow).

© Case courtesy of Dr Ian Bickle, Radiopaedia.org, rID: 48187
Fig. 11: Selected portal venous phase CT images of a 35 year old female who presented in septic shock demonstrating signs of CT hypotension: adrenal hyperenhancement (red arrows), gallbladder wall oedema (orange arrow), small bowel mucosal hyperenhancement (yellow arrow) with delayed splenic enhancement and heterogeneous hepatic enhancement. The underlying cause was pyelonephritis (blue arrow).

© Case courtesy of Dr Jeremy Lim, Radiopaedia.org, rID: 48788
Fig. 12: Selected contrast-enhanced CT images of a 35 year old female who presented in septic shock demonstrates features of endometritis (red arrow) with signs of hypotension being small bowel mucosal hyperenhancement (orange arrow) and splenic hypoenhancement (green arrow). Note that in septic shock the IVC (yellow arrow) and aortic (blue arrow) calibre are preserved as the blood volume is normal.

© Case courtesy of Dr Chris O'Donnell, Radiopaedia.org, rID: 41863
Fig. 13: Single axial contrast-enhanced CT of a 50 year old female who presented with acute left abdominal pain demonstrates a large left rectus sheath haematoma with contrast extravasation (red arrow) indicating active bleeding.

© Case courtesy of Dr Ian Bickle, Radiopaedia.org, rID: 33434
Conclusion

CT imaging is increasingly prevalent in patients presenting with hypotension due to a variety of acute causes. Abdominal CT can provide the level of detail necessary for accurate diagnosis, allow planning of potential interventional radiological treatment or surgery and help to predict clinical illness severity. This makes knowledge of the abdominal CT in hypotension increasingly valuable and important in radiology practice.
Personal information

Francis Delaney MBBS

Email: francisdelaney721@gmail.com
References:


