CT Hypoperfusion Complex

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Agenda

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What is CT Hypoperfusion Complex?

• Constellation of **vascular** and **visceral** CT signs seen in cases of hypovolemic shock

• Hypovolemic shock is an **infrequently encountered entity** on CT scans of victims of severe trauma

• **However, early abdominal and pelvic CT scans** may alert the radiologist to the presence of hypovolemic shock.
## Components of CT Hypoperfusion Complex

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Vascular Manifestations
Flattening of IVC

- Occurs as a result of **reduced venous return** secondary to systemic hypotension
- Radiological definition:
  - **AP diameter <9 mm**
  - Measured at **3 levels**:
    - Intrahepatic IVC
    - At the level of renal arteries
    - 2cm below the level of renal arteries
Companion Patient #1: Normal IVC on CT
Companion Patient #2: Narrowed IVC on CT

Tarrant, et al...The British Journal of Radiology, 81 (2008), 252–257
Halo Sign

- Circumferential zone of **low attenuation (<20 HU)** around a collapsed intrahepatic IVC
- Probably represents **extracellular fluid**
- Most frequently located at a level corresponding to the **superior segments of the liver**, below the confluence of hepatic veins

**NOT SPECIFIC** for CT hypoperfusion complex:
- Also reported in patients with **biliary cirrhosis, hepatitis, and tumors blocking lymphatic drainage**
Collapsed IVC seen with a zone of low attenuation surrounding it → Halo Sign

Companion Patient #2: Halo Sign on CT

Tarrant, et al...The British Journal of Radiology, 81 (2008), 252–257
Small calibre aorta

• **Frequent finding** in hypovolemic shock

• Defined as a calibre **<13 mm at a level 2cm both above and below the origin of the renal artery**

• **Not a specific sign of hypotension**, but when associated with decreased caliber of other intra-abdominal vessels, may be considered to be evidence of hypotension.
Companion Pt #1: **Normal caliber aorta on CT**

Companion Pt #2: **Narrowed aorta on CT (Purple Arrow)**
Visceral Manifestations
Splenic Hypoperfusion

• Arterial flow to the spleen lacks autoregulatory mechanisms
• Thus, it is highly sensitive to sympathetic stimulation → vasoconstriction in the situation of hypoperfusion
• Low attenuation values for the spleen can be attributed to hypotension if obvious splenic artery and splenic injury are excluded first
Companion Pt #1: Normally perfused spleen

Companion Pt #2: Hypoperfused spleen (Purple Arrow)
Increased adrenal gland enhancement

- Defined as **attenuation values equal or greater than those of IVC**
- Usually **symmetrical**
- May be due to a protective sympathetic response to preserve these vital organs
Companion Pt #1: Normal adrenal gland attenuation on CT

Companion Pt #2: Abnormal enhancement of adrenal gland on CT (Purple Arrow)
Intense renal parenchymal enhancement

- A fall in systolic pressure causes intense efferent glomerular arteriolar vasoconstriction $\rightarrow$ tubular stasis $\rightarrow$ increased resorption of salt and water
- Hence, a prolonged, abnormally intense nephrogram is seen
- However, scan timing must be carefully chosen to confirm delayed rather than normal parenchymal enhancement.
Companion Pt #1: **Normal kidney enhancement on CT**

Companion Pt #2: **Increased enhancement of kidneys in hypotension on CT (Purple Arrow)**
Shock bowel

• Refers to the appearance of the bowel due to hypoperfusion

• The **most frequent** findings of shock bowel are:
  • **Increased small bowel mucosal enhancement** (HU > psoas muscle)
  • **Mural thickening >3mm**

• Contrast agent replacing the depleted intravascular volume, along with increased bowel wall permeability due to ischemia lead to the typical CT findings

• A point to look out for:
  • Mucosal enhancement and mural thickening **in the presence of free fluid** are indicators of perforation and peritonitis **NOT** shock bowel
Note the normal bowel wall thickness, and indistinct normal bowel wall mucosa.
Companion Pt #2: **Increased bowel wall thickness on CT**

Companion Pt #2: **Increased small bowel mucosal enhancement on CT**

Tarrant, et al...The British Journal of Radiology, 81 (2008), 252–257
Non-specific visceral findings

**Abnormal liver enhancement**
Can be easily mistaken for **fatty liver**, as in both cases, the liver enhancement is closer to the HU of the spleen and fat in abdominal wall.

**Peri-pancreatic edema and hyperenhancement**
Is very commonly seen in cases of **pancreatitis**, so can be easily confused.

**Gallbladder mucosal enhancement**
Let’s now see a real patient’s findings:
History and Physical Examination

• Patient name: EW
• 48 year, male
• S/P Motor vehicle crash vs. pole at 70 mph
• Emergency medical service found the patient conscious, complaining of chest pain, with no major external injuries.

• PR: 98/min, regular, weakly felt
• BP: 112/76 mmHg
Chest findings

1. Traumatic aortic pseudoaneurysm with mediastinal hematoma
2. Multiple bilateral rib fractures with large pneumothoraces
3. Left lung contusions
4. Possible mild hemothorax
5. Extensive subcutaneous emphysema
6. Properly placed endotracheal tube
7. Properly placed B/L chest tubes.
Importance of Abdominal CT in this case

• With the patient’s hemodynamic status relatively normal, and the traumatic aortic injury already detected, the emergency physicians may be tempted to refer the patient for surgical treatment
  • But as a routine, an abdominal CT is ordered

• The keen radiologist will have kept in mind that abdominal injuries are very common in motor vehicle accidents.

• So the abdominal CT is done, and after careful review, the following are the key images:
Our Patient: Narrowed IVC on CT
Our Patient: Halo Sign on CT
Our Patient: **Hyperenhancing Kidneys on CT**
Our Patient: Pancreatic hyperenhancement on CT
Our Patient: Hyperenhancement of adrenal gland on CT
Abdominal CT findings

1. Small caliber of inferior vena cava
2. Hyperenhancement of pancreas
3. Right adrenal laceration with extravasation of fluid (blood)
4. Left adrenal hyperenhancement
5. Hyperenhancement of kidneys bilaterally

• All these findings point to CT Hypoperfusion Complex
• But....
Differential Diagnoses
For the findings of CT hypoperfusion complex

• The two conditions whose CT findings most closely mimic CT-HC are:
  
  • Traumatic bowel injury
  • Bowel ischemia due to vascular occlusion
Differential Diagnoses
For the findings of CT hypoperfusion complex

Traumatic bowel injury
CT-HC vs. Traumatic Bowel Injury

• It is not likely to be mistaken for CT hypoperfusion complex

• Bowel trauma will usually appear as a focal instead of diffuse abnormality on CT

• Bowel trauma may cause wall thickening

• But, the submucosa will contain high attenuation blood, rather than the near-water attenuation edema in CT-HC

• Intense mucosal enhancement is not present in bowel trauma

• Bowel trauma is usually associated with pneumoperitoneum and gas in the mesentery or bowel wall
Differential Diagnoses
For the findings of CT hypoperfusion complex

Bowel ischemia due to vascular occlusion
CT-HC vs. Bowel ischemia due to vascular occlusion

• May **also result in bowel wall thickening**

• **Arterial occlusion**
  • Will **not show** diffuse mucosal enhancement or submucosal edema

• **Venous occlusion**
  • May show both

• Differentiating features are **collapsed IVC, pancreatic and renal hyperenhancement**
Our Patient’s Outcome

• The patient who presented to the OR who underwent abdominal CT was diagnosed as having an adrenal gland injury.

• Upon exploratory laparotomy, blood was found in the abdominal cavity, which was found to be seeping from a damaged adrenal artery.

• The vascular defect was corrected surgically and the patient went on to make a full recovery!
Conclusion

• In most cases of motor vehicle accidents and other trauma, the injuries to the viscera will be obvious

• But, these diffuse features of CT Hypoperfusion Complex may alert the radiologist to the presence of hypovolemia

• Benefits of identifying CT Hypoperfusion Complex:
  • Simultaneously identifies hypovolemia and rules out visceral injuries
  • Helps to guide the physician to a medical line of treatment, rather than an unnecessary surgical intervention
I would like to thank the following individuals for their guidance and help with this presentation:

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• Dr. Gillian Lieberman
References


2. Broder, Joshua S. Diagnostic Imaging for the Emergency Physician

Thank you!