



eBook for Undergraduate Education in Radiology

| **CHAPTER:** Emergency Radiology



Preface

Undergraduate teaching of radiology in Europe is provided according to national schemes and may vary considerably from one academic institution to another. Sometimes, the field of radiology is considered as a “cross-cutting discipline” or taught within the context of other clinical disciplines, e.g., internal medicine or surgery.

This e-book has been created in order to serve medical students and academic teachers throughout Europe to understand and teach radiology as a whole coherent discipline, respectively. Its contents are based on the *Undergraduate Level of the ESR European Training Curriculum for Radiology* and summarize the so-called **core elements** that may be considered as the basics that every medical student should be familiar with. Although specific radiologic diagnostic skills for image interpretation cannot be acquired by all students and rather belong to the learning objectives of the *Postgraduate Levels of the ESR Training Curricula*, the present e-book also contains some **further insights** related to modern imaging in the form of examples of key pathologies, as seen by the different imaging modalities. These are intended to give the interested undergraduate student an understanding of modern radiology, reflecting its multidisciplinary character as an organ-based specialty.

We would like to extend our special thanks to the authors and members of the ESR Education Committee who have contributed to this eBook, to Carlo Catalano, Andrea Laghi and András Palkó who initiated this project, and to the ESR Office, in particular Bettina Leimberger and Danijel Lepir, for all their support in realising this project.

We hope that this e-book may fulfil its purpose as a useful tool for undergraduate academic radiology teaching.

Minerva Becker

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Based on the ESR Curriculum for Undergraduate Radiological Education

Chapter: **Emergency Radiology**

Authors

Katharina Mueller-Peltzer¹

Dinesh Varma²

Affiliation

¹ Department of Diagnostic and Interventional Radiology, Medical Center – University of Freiburg, Faculty of Medicine, University of Freiburg, 79106 Freiburg, Germany

² Department of Radiology, Alfred Health, Adjunct Professor, Department of Surgery, Monash University, Melbourne 3004, Victoria, Australia

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Principles of Emergency Radiology

It takes the effort of several people of different professions to transport, examine, conduct diagnostics and treat a patient in an emergency setting. The radiology staff is part of this team and engages in the communication and the decision-making process.

The exchange of information between the various disciplines involved is important to initiate the right diagnostic steps and to choose the appropriate therapy. The radiologist must select an appropriate imaging protocol while ensuring to limit the radiation exposure based on ALARA principles (As Low As Reasonably Achievable)¹.

A focused primary assessment of the scans in an emergency setting followed by the immediate communication of life-threatening imaging findings is crucial.

This chapter will explain the role of various imaging modalities in common emergencies and how to systematically approach and identify critical and important imaging findings expediently that need urgent treatment.

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Diagnostic Imaging Techniques



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Choosing the appropriate imaging technique is crucial in making the correct diagnosis.

The following factors need to be considered in an emergency setting:

- what are the most relevant differential diagnoses and can I rule them out using the chosen modality
- what imaging modality is available
- is the patient stable enough for the examination
- can the patient hold still, is sedation an option
- is there an imaging modality with or without less radiation exposure and comparable sensitivity available

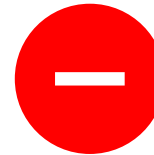
In general, the imaging modalities used in an emergency department are ultrasound, X-ray, Computed tomography (CT) and Magnetic resonance imaging. Of course, technical equipment of the emergency department may vary depending on institution size, location and type of cases treated.



Diagnostic Imaging Techniques: Ultrasound



- Widely available
- Low costs
- Fast
- Safe
- Enables bedside imaging
- Allows visualisation of blood flow
- Helps to safely place tubes and catheters
- No radiation exposure
- Can reduce the use of CT ²



- Operator dependant
- Visualisation can be limited due to meteorism or obesity
- Low reproducibility²

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See also the e-book chapter "Ultrasound".



Diagnostic Imaging Techniques: Ultrasound



Typical indications for ultrasound in the emergency room:

Acute cholecystitis, acute appendicitis, ovarian/testicular torsion, vascular pathologies (stenosis, occlusion, aneurysm, venous thrombosis), urinary stasis, free fluid, bleeding (FAST and E-FAST³, see below for more details), intestinal obstruction, infectious foci in lung parenchyma or abdomen

FAST and E-FAST

- FAST = focused assessment with sonography for trauma
- E-FAST = extended FAST, additionally assessing for thoracic injuries
- FAST/E-FAST assumes that all clinically significant injuries are associated with haemorrhage in the pleural, pericardial or peritoneal space or with pneumothorax
- FAST includes four basic sonographic views to exclude free fluid:
 - pericardial, perihepatic, perisplenic, pelvic
- E-FAST additionally includes the examination of the thorax anteriorly to assess for pneumothorax and the pleural recesses for haemothorax
- FAST/E-FAST is an important component of trauma algorithms for the initial evaluation of trauma patients

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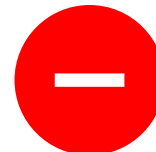
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Diagnostic Imaging Techniques: X Ray Imaging



- Widely available
- Low costs
- Fast
- Can be used to control the positioning of tubes and catheters⁴
- Can be used bedside

- Radiation exposure
- Patient must hold still
- Limited sensitivity and specificity compared to CT⁴

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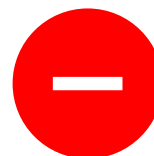
See also the e book chapter "Conventional X-ray Imaging".



Diagnostic Imaging Techniques: Computed Tomography (CT)



- Allows the evaluation of multiple organ systems with 1 scan
- Enables visualisation of pathologies in situations when ultrasound and X-ray are of limited help
- Contrast medium allows the evaluation of pathologies of vascular structures, parenchyma and soft tissue⁵



- Radiation exposure
- Patient positioning, planning, performing and reading the scan takes time
- Higher costs compared to ultrasound and X-ray
- Potential allergic reactions to contrast medium⁵

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See also e-book chapter "Computed Tomography".



Diagnostic Imaging Techniques: Computed Tomography (CT)



CT imaging is widely used in emergency settings. In some cases, only one or two body regions will be scanned, in other cases, for example in polytraumatized patients, a whole-body CT scan will be performed.



Prior to performing a CT scan, we need to ensure that the additional information we expect from the CT scan outweighs the disadvantage of dose exposure and potential risks related to contrast medium administration.

Furthermore, we need to ensure that no other imaging modality, for example ultrasound or MRI are more appropriate compared to CT. However, in polytrauma the benefits of CT scan outweigh any risk of radiation or contrast agents⁶.

Once a CT scan is determined to be the appropriate imaging modality, the following principles need to be considered:

- ✓ Discuss the likely and differential diagnoses with the referring doctors
- ✓ Consider any potential limitations regarding the scan, for example: can the patient hold their breath, can they hold still and are there any contraindications to contrast medium administration
- ✓ Apply the most appropriate CT protocol
- ✓ Limit the scan to the body region of interest

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Diagnostic Imaging Techniques: Computed Tomography (CT)



Choosing the appropriate CT protocol

non-contrast enhanced scans for:



- intracranial haemorrhage
- elevated intracranial pressure
- pulmonary infections
- fractures
- sinusitis
- hollow organ perforation
- Renal colic
- Spinal, pelvic and complex skeletal trauma

contrast enhanced scans for:



- vascular pathologies (dissection, stenosis, aneurysms, bleeding, pulmonary embolism)
- abdominal infections
- soft tissue infections (for example abscess or empyema)
- penetrating or blunt trauma
- polytrauma patients
- bowel obstruction

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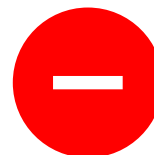
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Diagnostic Imaging Techniques: Magnetic Resonance Imaging (MRI)



- Excellent visualisation of the central nervous system (brain, spinal cord)
- Excellent visualisation of soft tissue (abdominal parenchymal organs, muscles, fat tissue)
- Excellent visualisation of bone involvement in soft tissue infections
- No radiation exposure^{7, 8}



- Limited availability in emergency departments
- long examination duration
- Higher costs compared to ultrasound, X-ray and CT
- Potential allergic reactions to contrast medium
- Contraindicated in patients with certain medical implants or metallic foreign bodies^{7, 8}

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Head and Neck Emergencies: Stroke



If a patient is admitted to the hospital due to symptoms of a stroke, imaging is used to:

- differentiate between ischemic and haemorrhagic stroke, localize the pathology, look for signs of increased intracranial pressure,
- if ischemic: look for infarct demarcation, arterial occlusion and collaterals, penumbra and core of the ischemic area
- if haemorrhagic: look for a potential source of bleeding
- If a stroke is suspected CT and MRI imaging are appropriate imaging modalities.



See also the e-book chapter "Central Nervous System"

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Head and Neck Emergencies: Stroke



How to approach the scan

- **First step** is always to rule out cerebral haemorrhage and to clearly communicate the detection or exclusion of a haemorrhage to the treating physicians. This is important because intracranial haemorrhage is a contraindication for intravenous lysis therapy.
If there are no other contraindications for lysis therapy (for example uncontrolled blood pressure despite intravenous application of antihypertensive medication or a major operation in the current patient history), lysis therapy will be started as quickly as possible.
- **Second step** is to look for hypoattenuating areas of brain parenchyma and for a hyperdense artery sign in CT or for signal alterations on MRI.



Remember:



Time is brain



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Head and Neck Emergencies: Stroke



Detecting hypoattenuating areas in a brain CT can be challenging, these tips might help:

- The symptoms tell you where to look first:
patient can't move the left leg and arm → look on the right hemisphere)
- Lean back in your chair and reduce the image magnification for a good overview
- Choose a narrow window to enhance contrast, this "stroke window" is often saved as a pre-set on the keyboard, see fig. 1 to compare brain window and stroke window⁹

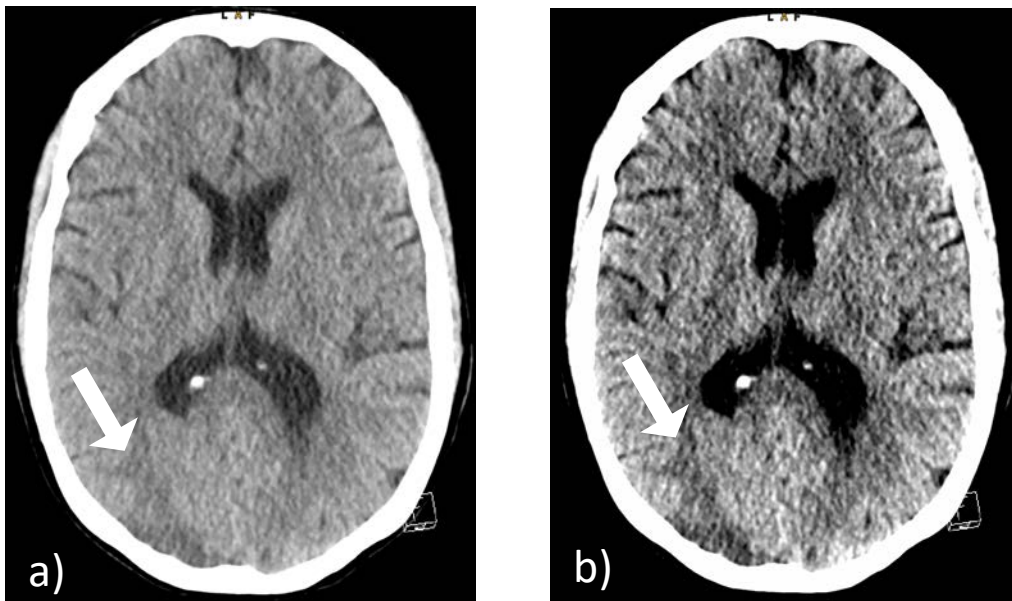


Fig. 1. Axial image of a head CT scan of a patient with symptoms of a stroke.

a) Brain window pre-set. Right occipital infarct (white arrow).

b) Same patient with narrow window settings ("stroke window"). The infarct is better delineated (white arrow).

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Head and Neck Emergencies: Subarachnoid Haemorrhage



- The most common causes of subarachnoid haemorrhage are trauma (→ see next slides) and aneurysm rupture
- Depending on the location of an aneurysm the haemorrhage can not only result in subarachnoid but also in intraventricular haemorrhage, see fig. 2 a) & b)
- Saccular aneurysms are most frequently localised in the anterior or posterior communicating artery (35%, respectively), middle cerebral artery (20%) or basilar artery (5%), see fig. 2 b)
- Therapeutic options are endovascular (coils and/or stents, see fig. 2 c)) or neurosurgical (clipping) occlusion of the aneurysm

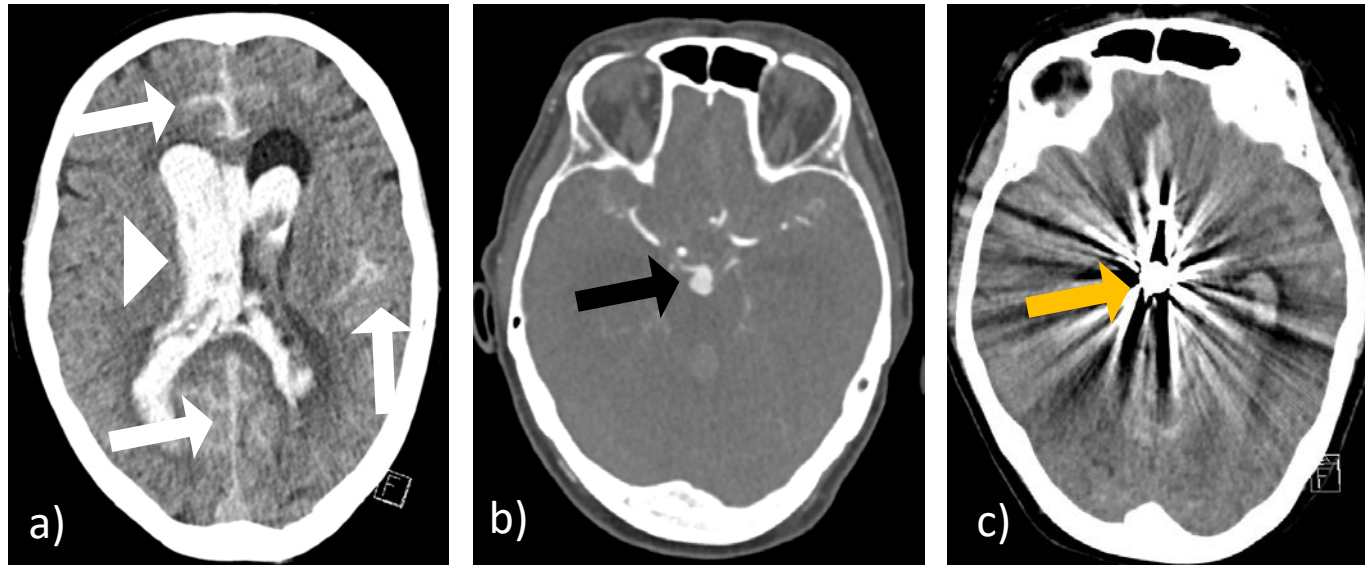


Fig. 2. Axial images of CT brain of the same patient.

- a) Subarachnoid (white arrows) and intraventricular haemorrhage (white arrowhead).
- b) CT angiography visualizing a large aneurysm of the basilar artery (black arrow).
- c) Control CT four days after endovascular therapy using coils. Note the extensive artefacts caused by the coils in the aneurysmal sac (orange arrow).

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Head and Neck Emergencies: Trauma

If a patient is admitted to the hospital due to suspected traumatic brain injury, imaging is used to identify:

- location, size and type of intracranial haemorrhage
- signs of increased intracranial pressure
- fractures
- signs of open traumatic head injury → foreign bodies, intracranial gas bubbles

How to approach the scan

Finding small intracranial haemorrhages can be challenging, these tips might help:

- Look for a subgalea hematoma first, this is the site of the coup, check for intracranial haemorrhage here.
- Then look at the opposite site of the skull, this is the contra-coup site, check for haemorrhage here, fig. 3.



Fig. 3. Domestic fall. The patient has hit his left forehead sustaining a small right frontal subgalea hematoma. (asterisk). This is the site of the coup. On the opposite side is a small contra-coup occipital subarachnoid haemorrhage (white arrow).



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Head and Neck Emergencies: Trauma

How to approach the scan

Distinguishing between the different types of intracranial haemorrhage can be tricky, these tips might help:

- Check the coronal reconstruction, subdural hematoma will be formed like a sickle, fig. 4
- An epidural hematoma will have lenticular shape in the axial and the coronal reconstruction, fig. 5. These are commonly associated with skull fracture so look carefully for a fracture
- Subarachnoid haemorrhage will be linear and follow the sulci, fig. 6
- Traumatic intraparenchymal haemorrhage can be round or oval and often shows a hypoattenuating ring, a perifocal edema, fig. 7
- In many cases you will find more than one type of intracranial haemorrhage¹⁰

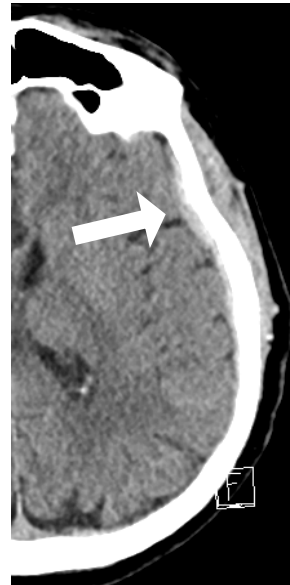


Fig. 4.
Thin subdural hematoma on the left side, marked by a white arrow.

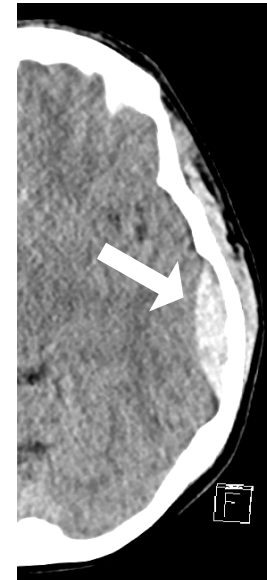


Fig. 5. Epidural hematoma on the left side (white arrow). There was a fracture adjacent to the hematoma (Not shown on the image).



Fig. 6.
Small subarachnoid haemorrhage frontal left (white arrow).

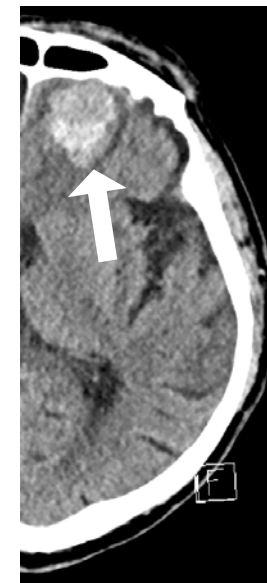


Fig. 7.
Intra-parenchymal haemorrhage left frontal lobe with a perifocal edema (white arrow).



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Head and Neck Emergencies: Infectious Disease



- Common infections in the head and neck region are sinusitis, odontogenic infection, tonsillitis, peritonsillar or laryngeal abscess
- Due to the close anatomical position of the different structures in the head and neck region infectious diseases in this area can cause life-threatening conditions
 - spread of the infection to the mediastinum, spine, or intracranial compartments
 - airway obstruction
 - vascular complications (thrombosis, haemorrhage)

How to approach the scan

- Look for:
 - hypoattenuating muscles (edema)
 - fat stranding (soft tissue edema)
 - fluid collections with hyperattenuating ring (abscess)
 - enlarged lymph nodes

Fig. 8. Young male patient with fever, unable to open his mouth, and dysphagia. Post contrast CT neck at the level of oropharynx. Large right tonsillar abscess (white arrow).



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Chest Emergencies: Acute Chest Pain

- is one of the most common complaints in the emergency department, so have your differential diagnoses at hand, most common DD's are listed in table 1.
- chest pain can be caused by acute life-threatening and harmless diseases, therefore it is important to exclude diagnoses with the highest short-term mortality risk first: acute coronary syndrome, pulmonary embolism and acute aortic syndrome.
- Symptoms, medical history, physical examination, ECG and laboratory results help to confirm or eliminate acute life-threatening disease¹¹

Cardiac causes	Respiratory causes	Other causes
Acute coronary syndrome	Pulmonary embolism	Musculoskeletal
Aortic dissection	Pneumonia	Gastro-oesophageal reflux disease
Pericarditis	Pneumothorax	Anxiety/panic attack
Myocarditis	Pleurisy	...

Table 1. Most common causes of acute chest pain¹².

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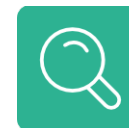
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Chest Emergencies: Pulmonary Embolism



- Clinical signs and symptoms are nonspecific, it may be asymptomatic or discovered incidentally
- Common symptoms: dyspnoea, chest pain, presyncope or syncope or haemoptysis
- Assessment of clinical pre-test probability: The Wells score and PERC rule are the most validated tools that assist in clinical decision making and are important to limit overuse of imaging¹¹



- CT pulmonary angiography (CTPA) is the method of choice:
- Readily available in most centres, excellent accuracy, may provide alternative diagnosis, short acquisition time



- Radiation exposure, exposure to iodine contrast (limited use in iodine allergy and hyperthyroidism, tendency to overuse because of easy accessibility)^{11, 13}
- V/Q scanning, especially in the presence of a normal chest X-ray, is a more reliable test in pregnancy than in the non-pregnant population as they are generally younger and have fewer comorbidities

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Chest Emergencies: Pulmonary Embolism



How to approach the scan

- Check the main pulmonary arteries first to find central thromboembolism, fig. 9
- Then follow the lobar, segmental and then the subsegmental arteries in each lobe for thromboembolism, fig. 11
- Check if the right ventricle has a larger diameter than the left → sign for right ventricle pressure overload, fig. 10
- Check for other pathologies (pneumonia, pleural or pericardial effusion, pulmonary edema etc.)

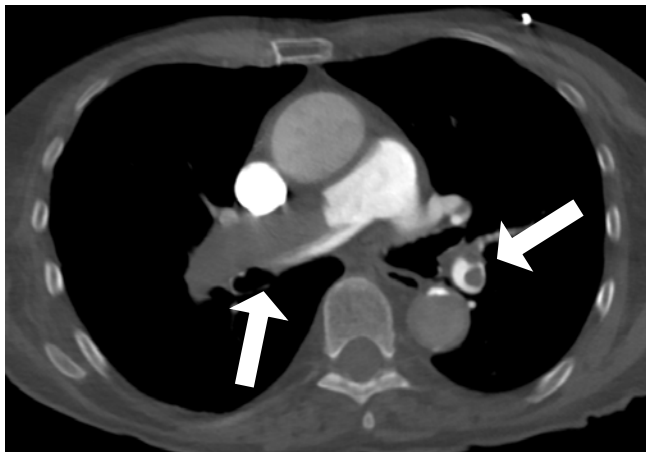


Fig. 9. Transverse images of a CT pulmonary angiography scan. Extensive pulmonary embolism in the right main pulmonary artery and the left upper lobe artery (white arrows).

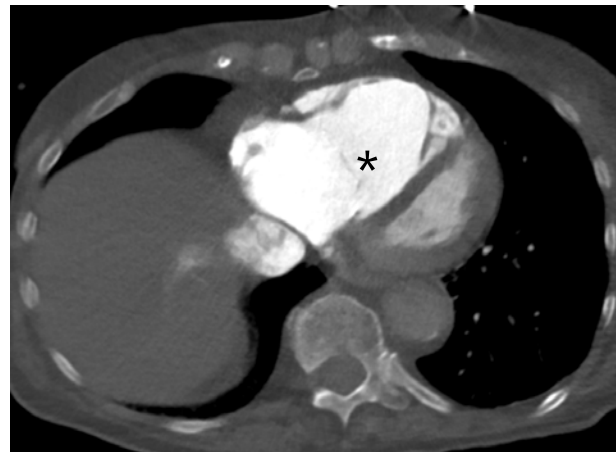


Fig. 10. Same patient as in fig. 9. The right ventricle (black asterisk) is enlarged with mild leftward deviation of the interventricular septum, demonstrating right ventricle pressure overload caused by extensive pulmonary embolism.

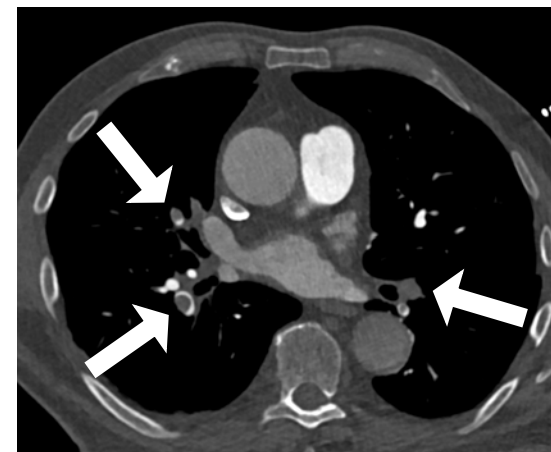


Fig. 11. CT pulmonary angiography with bilateral segmental pulmonary embolism (white arrows)

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Chest Emergencies: Acute Aortic Syndrome



- Acute aortic syndrome includes the following pathologies: aortic dissection, intramural haematoma and penetrating atherosclerotic ulcer (PAU)
- Risk factors: hypertension, genetic disorders (Marfan and Turner syndrome), inflammatory vasculitis, infective arteritis, iatrogenic factors (cardiac valve or aortic surgery), pregnancy

- CT-Imaging:

- It is important to perform a non-enhanced and a contrast enhanced scan. The non-enhanced scan helps to visualize a hyperdense, thickened aortic wall in case of an intramural haematoma¹¹, fig. 12.
- We perform the CT using ECG gating to avoid moving artefacts in the ascending aorta caused by the beating heart, compare fig. 13 a) and b).



Fig. 12. Non-contrast enhanced, ECG gated CT thorax. Hyperdense intramural hematoma of the ascending aorta, marked by a white arrow.

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Chest Emergencies: Acute Aortic Syndrome

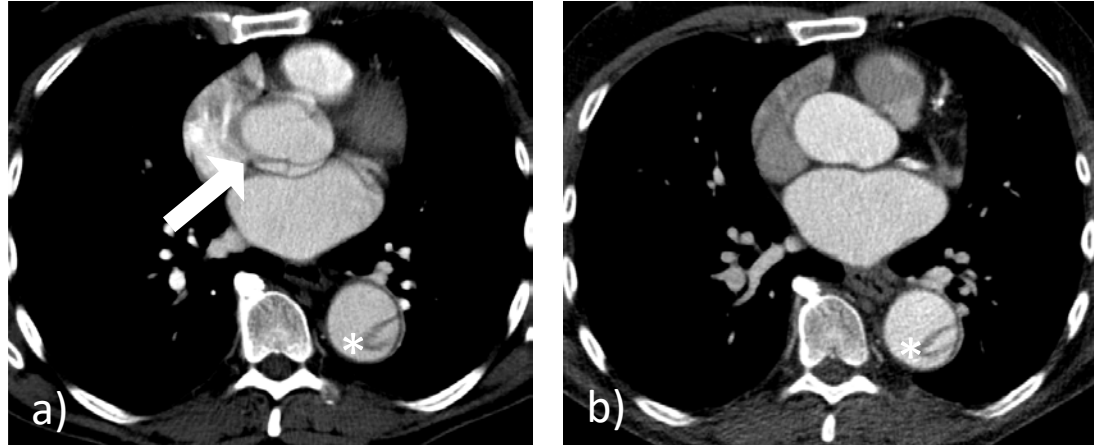
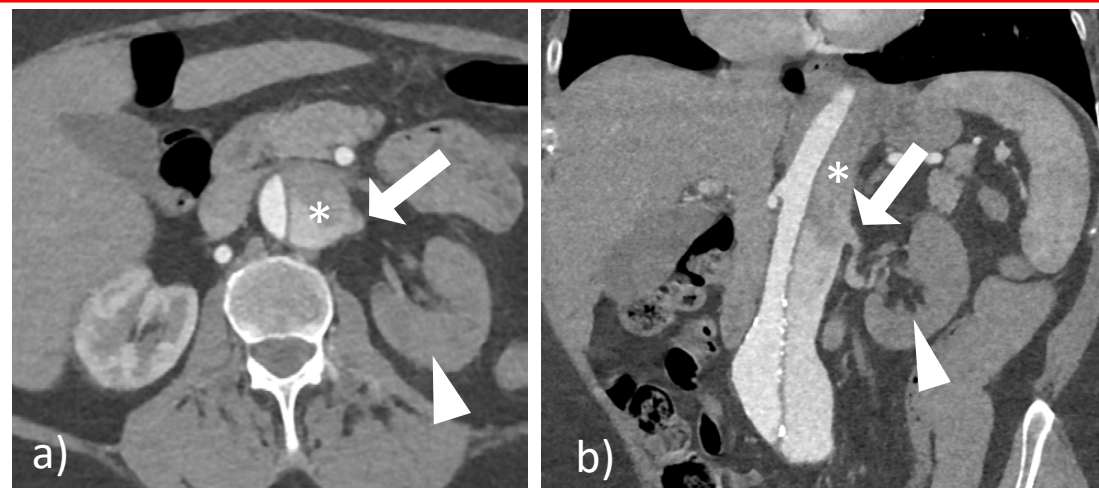


Fig. 13.
a) Non ECG gated CT scan of the thoracic aorta. The white arrow marks artefacts in the ascending aorta. Note the dissection in the descending aorta (asterisk).
b) Same patient as in figure 13 a) ECG gated CT scan eliminates the artefact in the ascending aorta.

- Life-threatening complications of aortic dissections include organ ischemia (abdominal, see fig. 14, limb, myocardial, brain), aortic rupture and pericardial tamponade¹¹

Fig. 14. Transverse a) and coronal b) image of CT angiography of a patient with Stanford A dissection. The left renal artery (white arrow) originates from the false lumen (asterisks) and thus the perfusion of the left kidney (white arrowhead) is significantly reduced. While the right renal artery arises from the true lumen and the right kidney enhances regularly.



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Chest Emergencies: Acute Aortic Syndrome



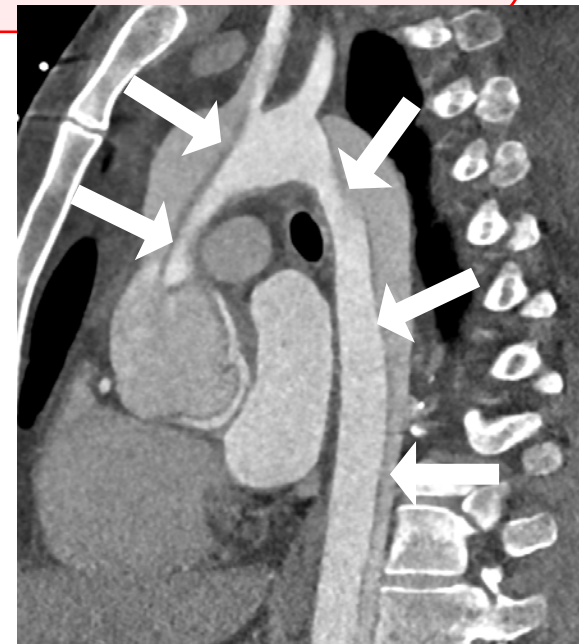
How to approach the scan

- First check the non-contrast scan for a crescent hyperdense area (= intramural haematoma), it can be subtle, fig. 12
- Then check the contrast enhanced scan for a hypodense line (= intimomedial flap) within the aortic lumen. Aortic dissection is classified as Stanford A (involving the ascending aorta, fig. 15) or Stanford B (distal to the left subclavian artery)
- The intimomedial flap separates the aortic lumen in 2 parts: true lumen (= normal lumen) and false lumen (= pathologic lumen within the wall)

Check if you can trace the intimomedial flap to

- the coronary arteries → this can cause myocardial ischemia
- to the supracoronary arteries → this can cause a stroke
- to the abdominal aorta and the visceral branch vessels → this can cause abdominal organ ischemia¹¹, fig. 14

Fig. 15. Contrast enhanced CT thorax in arterial phase, sagittal image. Stanford A aortic dissection extending from aortic valve to the descending aorta. The intimomedial flap is marked by white arrows.



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Chest Emergencies: Pneumothorax



- Imaging modality of choice in case of suspected pneumothorax is an X-Ray.
- Severely injured patients will get a CT scan to simultaneously check for injuries of the vessels, mediastinum, lung parenchyma, bones and pleural space
- Pathophysiology: gas collection within the pleural space
- A tension pneumothorax occurs if intrapleural gas accumulates progressively, the mediastinal shift compromises the blood flow to the heart. A tension pneumothorax is an emergency clinical condition → immediate recognition, communication and therapy are very important¹¹

How to approach the scan

- Check if you can see fine vessels in the periphery of both lungs
- Check if you can detect a very fine hyperattenuating line = visceral pleura
- Check if you see a radiolucent area peripheral to the pleural line
- Check if the mediastinum is moved to the other side and if the diaphragm is flattened → tension pneumothorax ¹¹, figure 16.

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Chest Emergencies: Pneumothorax

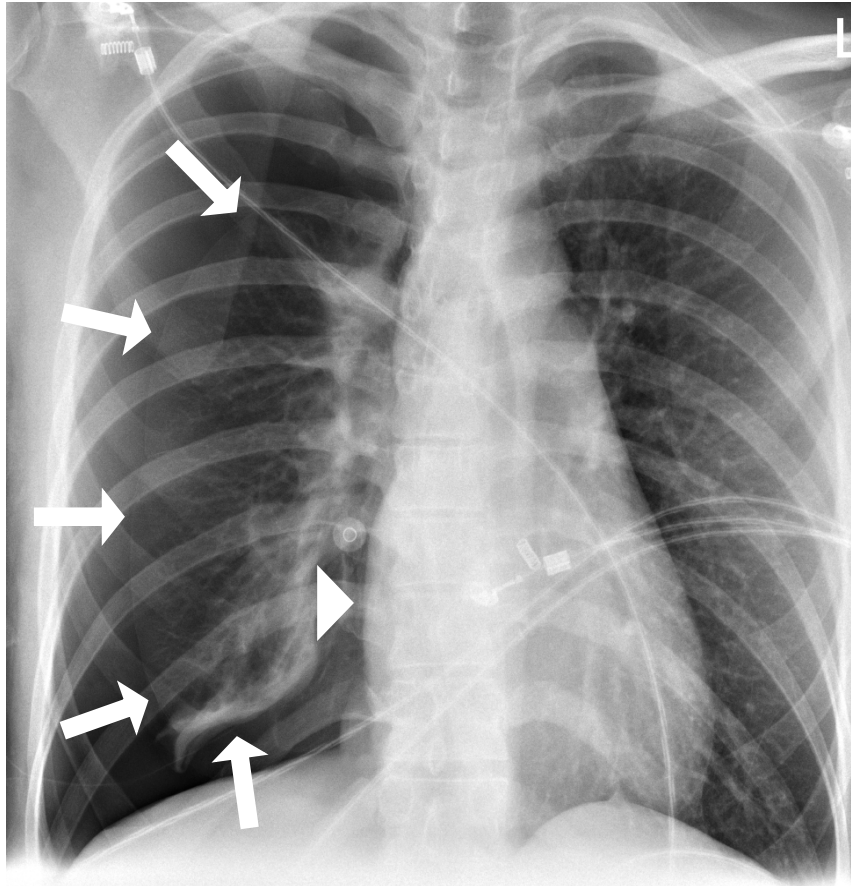


Fig. 16. Tension pneumothorax. White arrows mark the visceral pleural edge on the right side. Note that the right heart contour is pushed to the contralateral side (white arrowhead) and the right side of the diaphragm is pushed downward and flattened.

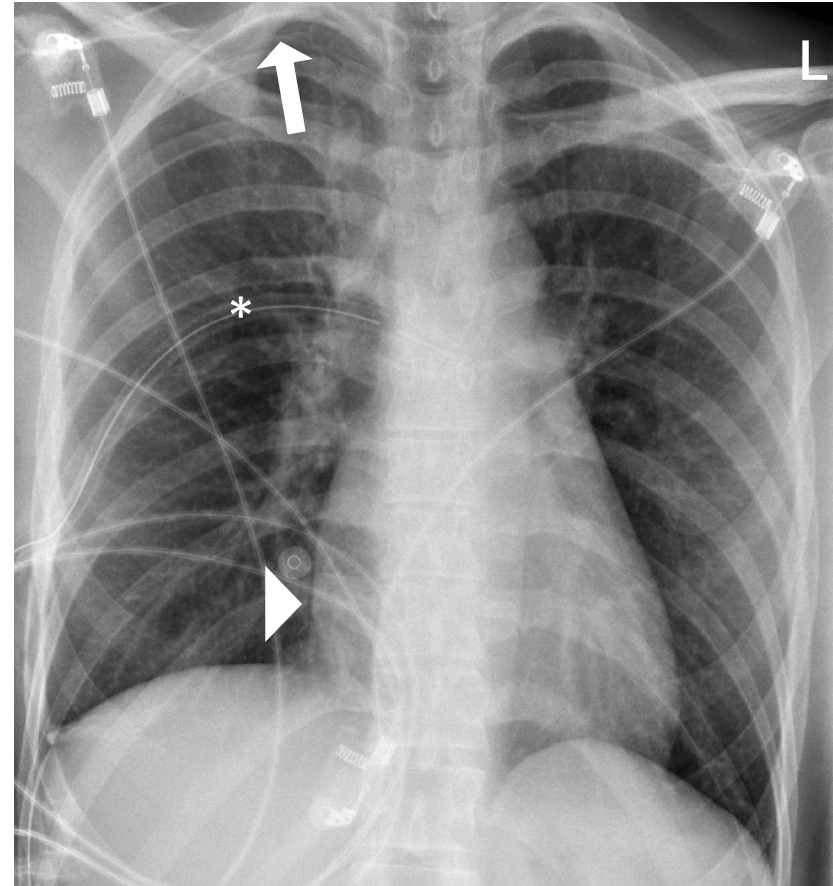


Fig. 17. Same patient as in fig. 16, after placement of a chest drain (white asterisk) the mediastinum (white arrowhead) and right diaphragm contour and position are now normal. A small residual pneumothorax is marked by a white arrow.

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Chest Emergencies: Pneumonia



- Common symptoms are fever, cough, purulent expectoration, and deep chest pain
- Community-acquired pneumonia (CAP) can be classified into lobar pneumonia, bronchopneumonia and interstitial pneumonia, imaging features are listed in table 2¹¹

Lobar pneumonia	Bronchopneumonia	Interstitial pneumonia
Infection of alveoli	Bronchial mucosal inflammation	Infection of pulmonary interstitium
Limited to one segment or lobe	Spreads through the airway into alveoli	frequently peribronchial lobular tissue involved

Table 2. Characteristic imaging features of CAP¹¹.

How to approach the scan

- Check for patchy, reticular or homogeneous changes in the lung parenchyma
- Then check the pattern: one side or both sides involved? More than one lobe involved?
- Check for parapneumonic effusion

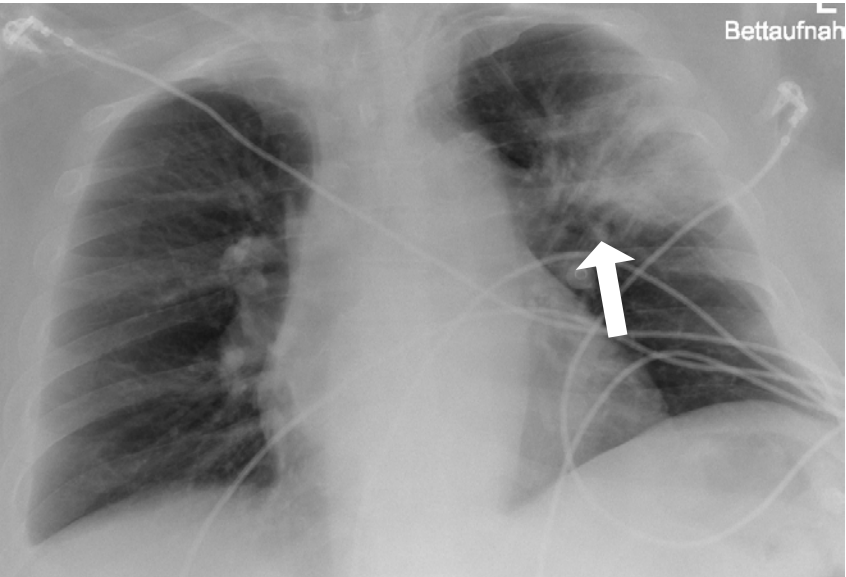


Fig. 18. Chest X-ray of a patient presenting with a fever and cough. Lobar pneumonia on the left upper lobe (white arrow).

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Chest Emergencies: Airway and Lung Trauma



- Trauma to the thorax can be blunt (for example fall from a height or a car accident) or penetrating (for example knife stabbing)
- We look for bleeding in the lung parenchyma, which can be patchy or homogenously consolidated, for pneumothorax, emphysema of the soft tissues or the mediastinum, haemothorax and active bleeding¹¹

How to approach the scan

Check for

- air in the pleural space → pneumothorax
- air in the soft tissue → emphysema
- fluid in the pleural space, if the fluid has increased density → haemothorax, fig. 19
- ground glass opacities and consolidation in the parenchyma → bleeding¹⁰, fig. 20



Fig. 19. Haemothorax with clotted blood (asterisk) on the right side in a patient who fell down the stairs.

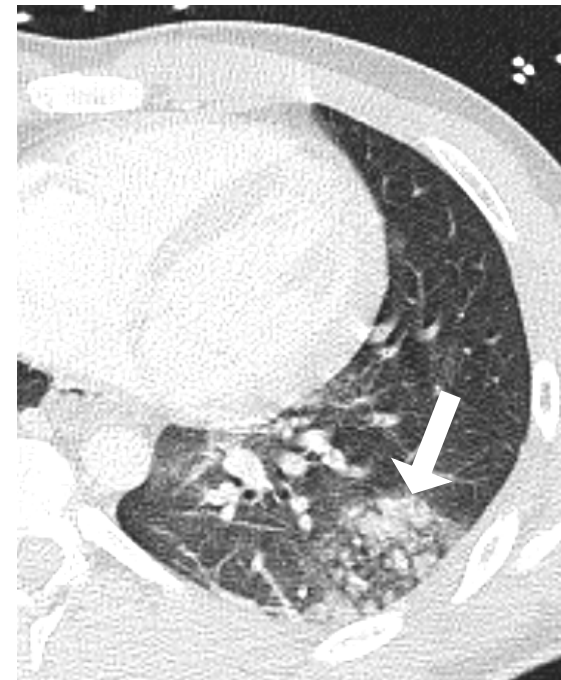


Fig. 20. Pulmonary haemorrhage in the left lower lobe (white arrow) in a young patient who had a motorbike accident.

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Chest Emergencies: Oesophageal Trauma



- Oesophageal injuries are uncommon, but you should consider a potential oesophageal injury in case of penetrating wounds to the lower neck or mediastinum, following cervicothoracic instrumentation, following forceful retching/vomiting (Boerhaave syndrome) or in case of blunt thoracic trauma
- The patient's history is very important. A patient with deep chest pain might not report vomiting or a medical procedure such as a gastroscopy
- Oesophageal injury can result in mediastinitis and abscess formation, hence important to diagnose and treat early¹¹

How to approach the scan

Check for

- air in the mediastinum
→ be aware that the air could originate from the airways as well
- Check if the oesophageal wall is oedematous
- Check for fluid in the mediastinal fat surrounding the oesophagus¹⁰



Fig. 21. Pneumomediastinum (black arrow) in a patient who presented with deep chest pain 24 hrs post gastroscopy.

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Abdominal Emergencies: Acute Abdomen

- Is a frequent reason for consultation in the emergency department
- Various conditions can cause an acute abdomen and it is important to know the potential differential diagnoses
- Fig. 22 and table 3 demonstrate the most common differential diagnoses in relation to the pain localisation.

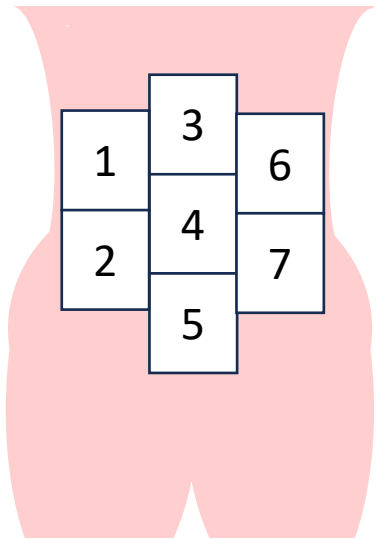


Fig. 22. Schematic drawing of localisations of the differential diagnoses discussed in table 3.

1	<ul style="list-style-type: none">• Cholecystitis, choledocholithiasis, cholangitis• Hepatitis, liver abscess, pancreatitis• Pyelonephritis• Basal pneumonia, myocardial infarction
2	<ul style="list-style-type: none">• Appendicitis, bowel obstruction, inflammatory bowel disease, infectious enteritis, hernia• Adnexitis, ectopic pregnancy, gonadal torsion• Kidney stones
3	<ul style="list-style-type: none">• Appendicitis (early stage), gastritis, duodenal ulcer, oesophagitis• Pancreatitis

4	<ul style="list-style-type: none">• Appendicitis (early stage), gastroenteritis, enterocolitis, bowel obstruction
5	<ul style="list-style-type: none">• Bladder infection, acute bladder retention• Gonadal torsion
6	<ul style="list-style-type: none">• Pancreatitis• Gastritis• Pyelonephritis• Basal pneumonia, myocardial infarction
7	<ul style="list-style-type: none">• Acute diverticulitis• Adnexitis, ectopic pregnancy, gonadal torsion• Kidney stones

Table 3. Common differential diagnoses of an acute abdomen

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Abdominal Emergencies: -itis



- If the patient's history, clinical examination and the laboratory results indicate an abdominal inflammation there are many differential diagnoses to be considered, the location of the pain gives important information, see fig.22 and table 3
- In an acute setting a CT abdomen in portal venous phase is the imaging protocol of choice
- Important CT findings are such as free fluid, stranding of the abdominal fat tissue, wall thickening of bowel/ bladder/ gallbladder, will lead you to the organ inflamed, fig. 23.



Fig. 23. Patient presented with severe lower right abdominal pain, fever and elevated inflammation parameters.

CT abdomen in portal-venous phase confirms acute appendicitis - enlarged and oedematous appendix (white arrow) with surrounding fat stranding (asterisk) and a small amount of adjacent free fluid (white arrowhead).

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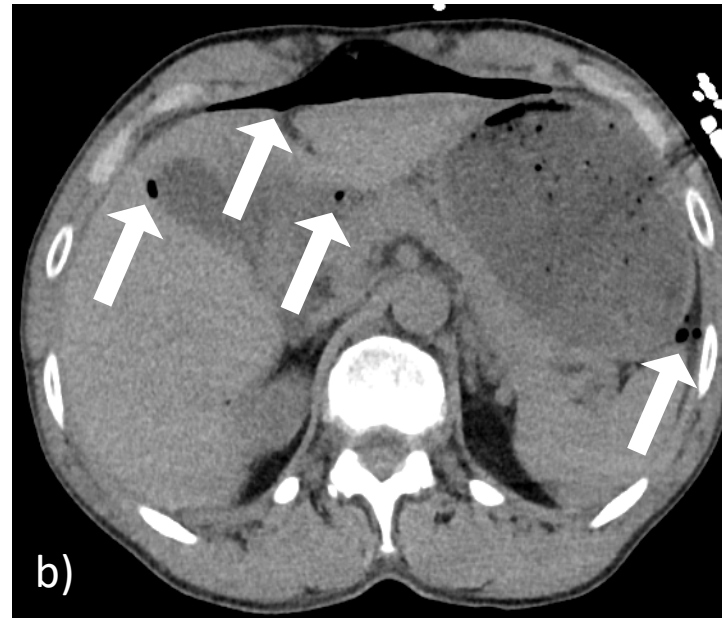
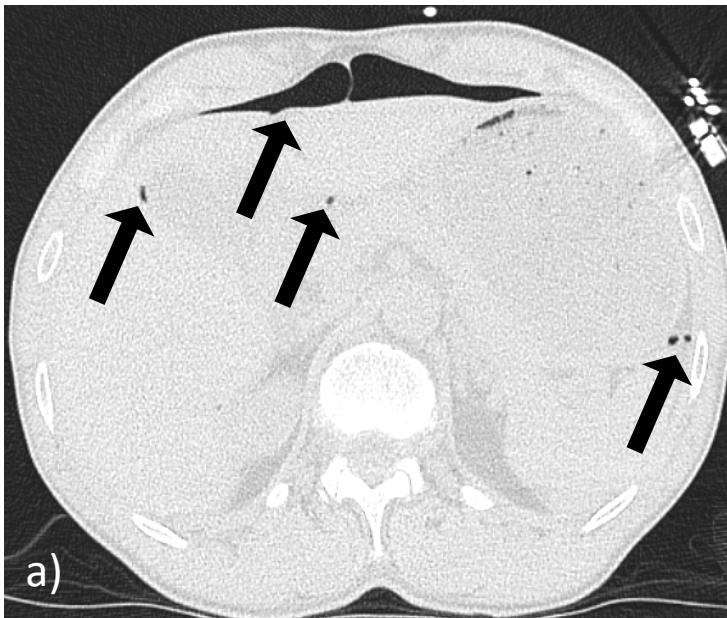


Abdominal Emergencies: Hollow Organ Perforation



- Ulcer, inflammation, ischemia, tumour or gastro-intestinal instrumentation can result in perforation
- The patient's history can assist in identifying an aetiology
- Free abdominal gas is normal in the first days after abdominal surgery
- X-ray of the abdomen can be performed in an erect or in a lateral decubitus position, but small amounts of free abdominal gas can be missed using X-ray
- Using CT very small amounts of free gas as well as the origin of the free gas can be detected, fig. 24 a) and b)

Fig. 24. The patient presented with acute epigastric pain and guarding on examination. A CT scan of abdomen in lung window (a) and soft tissue window (b) shows large amount of free intra-peritoneal gas (black and white arrows). At surgery a perforated gastric ulcer was found.



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Abdominal Emergencies: Bowel Obstruction



- Common causes in the small bowel are adhesions or hernia and in the large bowel malignancy or volvulus. Inflammatory/anastomotic strictures can be seen in small and large bowel obstruction
- Imaging is important to differentiate it from an adynamic ileus and to find the location of the mechanical obstruction, fig. 26

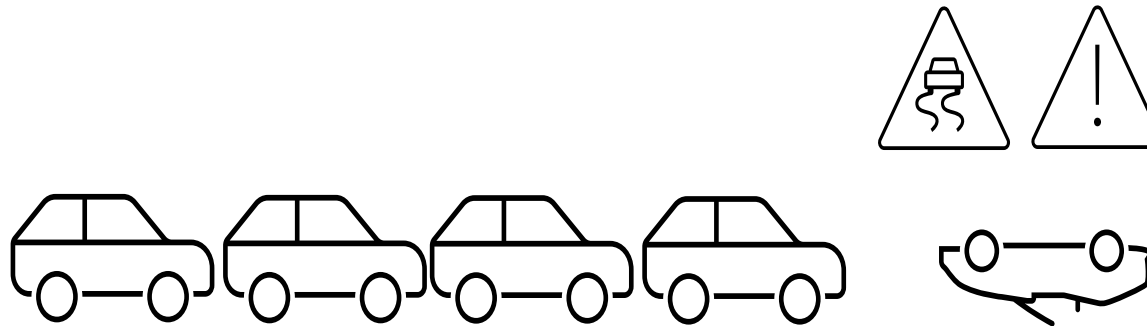


Fig. 25. Schematic drawing of a traffic jam. Beyond the accident the road is empty.

How to approach the scan

- Think of it as a traffic jam: the roads are crowded up to the point where the accident happened and beyond the accident the road is empty = the bowel will be dilated and filled up to the point of the obstruction and collapsed beyond that.
- To find the obstruction you must follow the dilated bowel from oral to aboral

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Abdominal Emergencies: Bowel Obstruction



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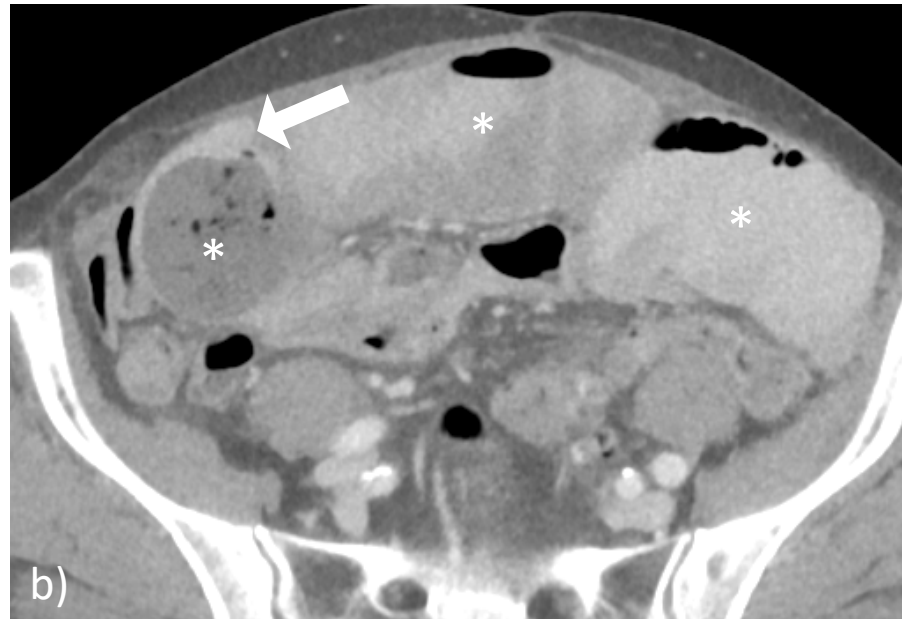


Fig. 26. The patient had a history of hemicolectomy for ascending colon carcinoma. CT scan of abdomen a) transverse and b) coronal images show dilated bowel loops (asterisks) and a transition point (white arrow) with collapsed loops distally. Diagnosis of bowel obstruction caused by an adhesion was confirmed during operation.



Abdominal Emergencies: Bowel Ischaemia

- It can be caused by arterial embolism (e.g. caused by atrial fibrillation), arterial thrombosis (caused by arteriosclerosis), venous thrombosis (e.g. hypercoagulation disorders) or nonocclusive (e.g. use of vasoactive agents)
- Symptoms are often nonspecific with diffuse or periumbilical, constant, severe pain
- Begins with reversible mucosal ischaemia → irreversible ischaemia → bowel necrosis causing pneumatosis, perforation, peritonitis, and possibly death
- CT-imaging is important to look for patency of the arteries (arterial phase), patency of the veins and ischaemic bowel wall changes (venous phase)¹⁴

How to approach the scan

Check if

- the celiac trunk, superior and inferior mesenteric artery are patent
- the mesenteric veins and the portal veins are patent
- the bowel walls are enhancing with contrast media (see fig. 27a)) or not (wall look grey fig. 27b)). Non-enhancing bowel wall looks similar to the fluid inside the bowel loops

Tip: The coronal view gives a better overview of the small and large bowel and makes comparing the contrast enhancement easier

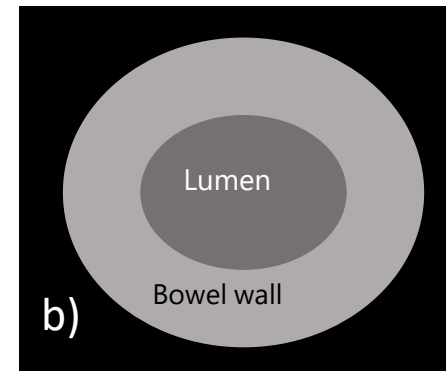
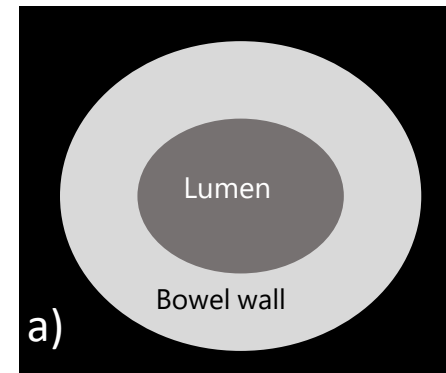


Fig. 27 a) Schematic drawing of a normal bowel wall enhancement. b) Schematic drawing of a non-enhancing bowel wall in ischaemic bowel.

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Abdominal Emergencies: Bowel Ischaemia



Fig. 28. CT abdomen in portal venous phase, coronal view, demonstrating normal contrast enhancement and calibre of bowel loops.



Fig. 29. Different patient. CT abdomen in portal venous phase, coronal view. Ischaemic bowel loops (asterisks) lack adequate contrast enhancement and are dilated due to ileus. White arrows mark extraluminal gas caused by focal perforation of ischaemic bowel loops.



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Abdominal Emergencies: Bleeding



- Can occur anywhere in the body: pleural or peritoneal cavity, intramuscular, subcutaneous, intraparenchymal
- Can be caused by trauma, blood thinner, operations/interventions, tumours, inflammation, vascular anomalies, coagulopathy in sepsis, congenital coagulopathies
- For unstable patients CT is the imaging modality of choice; the bleeding protocol includes a non-contrast scan to highlight any pre-existing hyperdense material (calcifications, clips, blood clots etc.), an arterial phase to demonstrate vascular anatomy and contrast extravasation and a venous phase to visualize the increasing contrast extravasation¹⁵

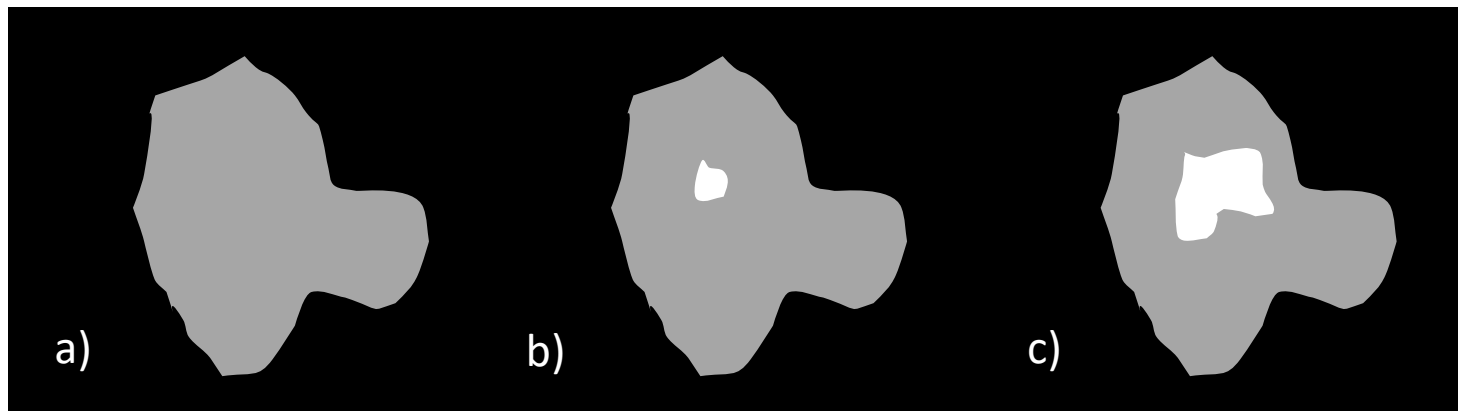


Fig. 30. Schematic drawing of a haemorrhage in
a) a non-contrast scan,
b) a scan in arterial phase with arterial extravasation within the haemorrhage and
c) in a scan in venous phase showing increasing extravasation within the haemorrhage.

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Abdominal Emergencies: Bleeding



How to approach the scan

- Look for hyperdense blood clots, asymmetry in the soft tissue, fat stranding or blood-filled bowel loops (in case of gastrointestinal bleeding) in the non-contrast scan, see fig. 31 a)
- When you find a haematoma look for contrast extravasation (white arrow), which is visualized as hyperdense spots/areas within the haematoma that can't be found in the non-contrast scan, see fig. 31 b), then check if the extravasation becomes larger in size in the venous phase (white arrowhead), see fig. 31 c)

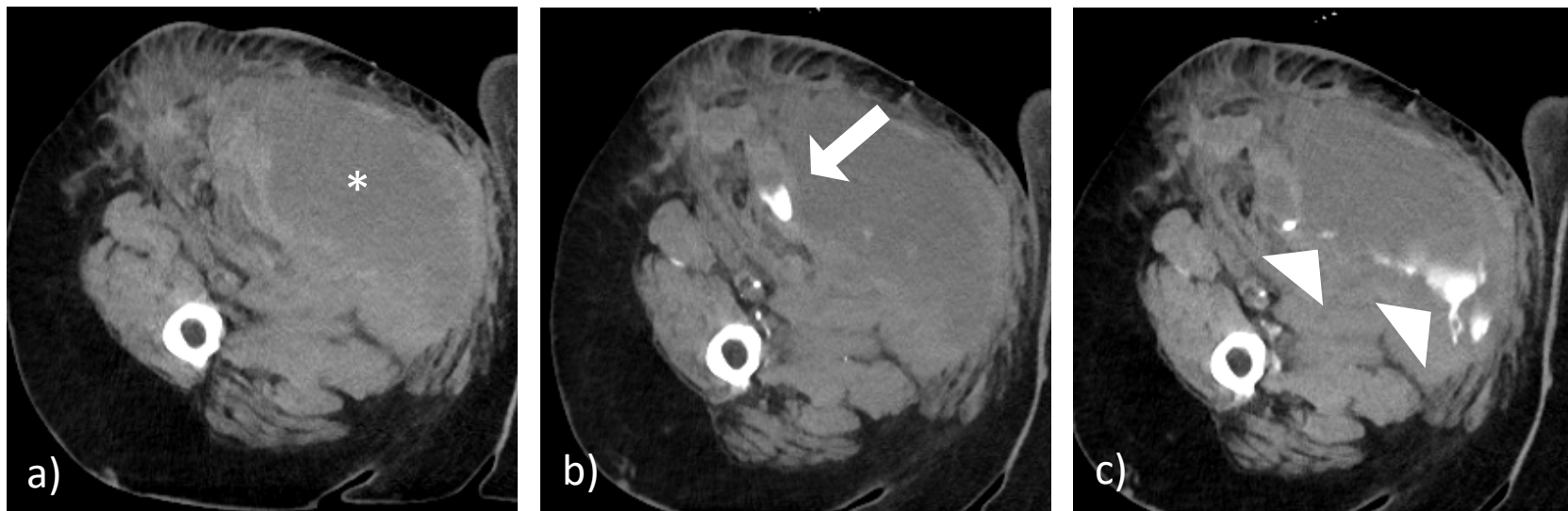


Fig. 31. Triphasic CT scan of the right proximal thigh with non-enhanced a), arterial phase b) and venous phase scan c). The patient had a massive swelling in the right groin and upper thigh after cardiac intervention. The asterisk marks the haematoma, the white arrow marks the contrast extravasation in the arterial phase and the white arrowheads marks the enlarging contrast extravasation.

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Musculoskeletal Emergencies: Spinal Trauma



- 2 important components:
 - vertebral body fractures can be detected using x-ray, CT and MRI
 - spinal cord, ligamentous and intervertebral disc injuries are detected using MRI
- Most often caused by motor vehicle accidents or fall from a great height
- The patho-mechanism can assist in predicting the injuries: we differentiate between compression (fig. 32a), distraction fig. 32b) and translation (fig. 32c) injuries.
- Spinal cord injury is more likely to occur in distraction and translation injuries
- The patients are often seriously injured

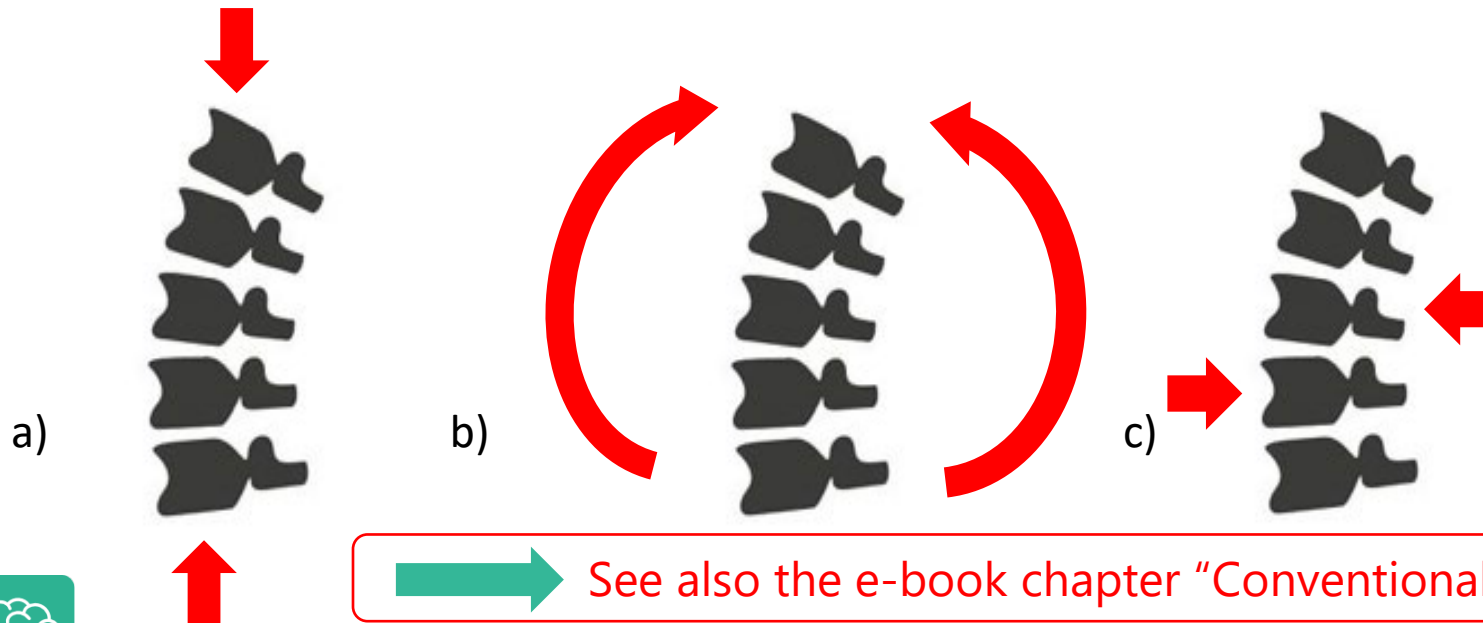


Fig. 32. Schematic drawing of the three main mechanisms of spinal trauma: a) compression, b) distraction and c) translation. The red arrows mark the direction of the force.



See also the e-book chapter "Conventional X-ray Imaging".

[Link to the poster of the AO Spine thoracolumbar injury classification system](#)

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Musculoskeletal Emergencies: Spinal Trauma



How to approach the scan

Look for

- dislocation or displacement within the vertebral column
- an asymmetric ventral or dorsal gap between the osseous structures
- fracture lines, dorsal fragments and reduction in height of the vertebral bodies

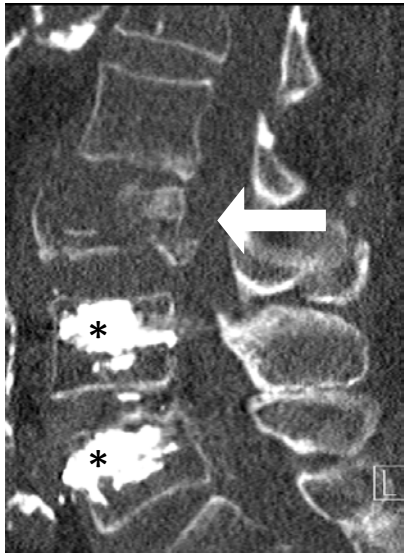


Fig. 33. Sagittal image of a CT scan of an 85-year-old patient who fell on the left hip. Burst compression fracture of L3 (L3: A4 AO spine) is marked by a white arrow. Note previous vertebroplasty of L4 and L5 (asterisks).



Fig. 34. Sagittal image of a CT scan of an 80-year-old patient who fell down the stairs. A distraction fracture of Th7/8 (Th7/8: B3, Th8: A2 AO spine) is marked by a white arrow. Note the widening (asterisks) ventrally and dorsally caused by the distraction.



In distraction and translation injuries the structures linking the vertebral bodies (ligaments, intervertebral discs) and the vertebral bodies are damaged.

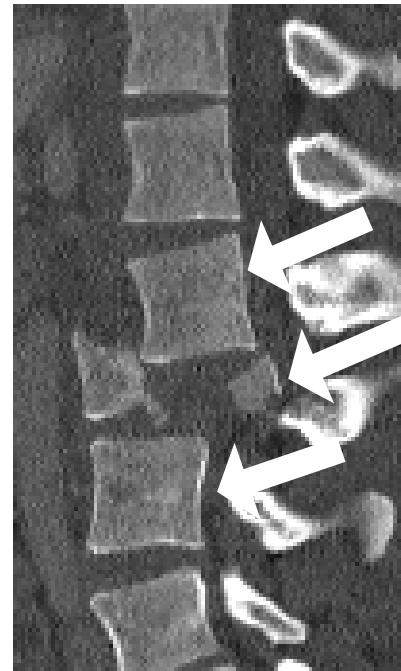


Fig. 34. Sagittal image of a CT scan of a translation injury of L2-4 (L2-4: C AO spine) (white arrows) in a patient involved in a motorbike accident. Note the burst fracture of L3 and the disruption of the posterior vertebral line.

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Musculoskeletal Emergencies: Pelvic Trauma



- The pelvis is a complex ringlike structure composed by bones and ligamentous structures, the interosseous sacroiliac ligaments are the strongest, while the symphysis is the weakest link in the pelvic ring
- In young patients, pelvic fractures result from high energy trauma, such as motor vehicle accidents or falls from a height and can be associated with injuries of arteries, veins, the bladder or nerves
- In elderly patients, non-displaced pelvic fractures can also result from low-energy trauma or falls¹⁶

How to approach the scan

- First, search for fractures in the anterior and posterior pelvic ring and for widening of the pubic symphysis and the sacroiliac joint
- Second, look for pelvic and surrounding soft tissue haematomas

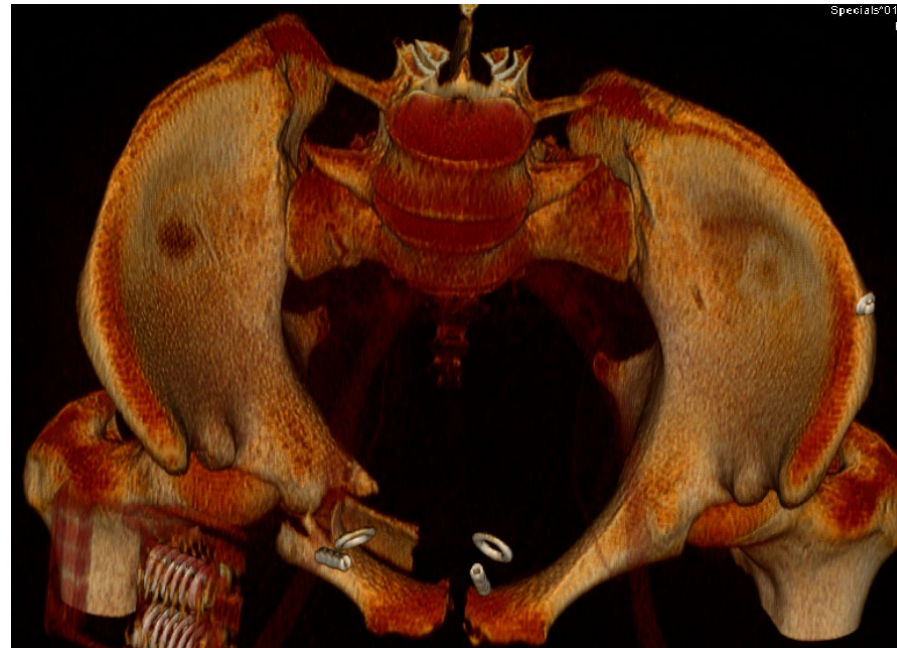


Fig. 36. 3-D reconstruction of a CT scan of a complex, unstable pelvic ring fracture (anterior and posterior ring is injured). The patient was hit by a truck.

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Musculoskeletal Emergencies: Spondylodiscitis



- Most of the patients present with back pain, only a few have a fever
- > 50 % are caused by Staphylococcus aureus
- Caused by
 - hematogenous spread secondary to bacteraemia (commonly caused by endocarditis or intravenous drug use),
 - extension from an adjacent abscess (oropharyngeal infection or sacral decubitus ulcers) or
 - direct inoculation after spinal surgery or penetrating trauma
- Most frequent presentation: single level involvement commonly in the lumbar spine
- MRI is the imaging modality of choice; sensitivity and specificity are higher compared to CT

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Musculoskeletal Emergencies: Spondylodiscitis



How to approach the scan

- Look for a high signal on T2 sequences and for enhancement on T1 post contrast in the disc space, adjacent endplates and paravertebral soft tissue¹⁷, fig. 37

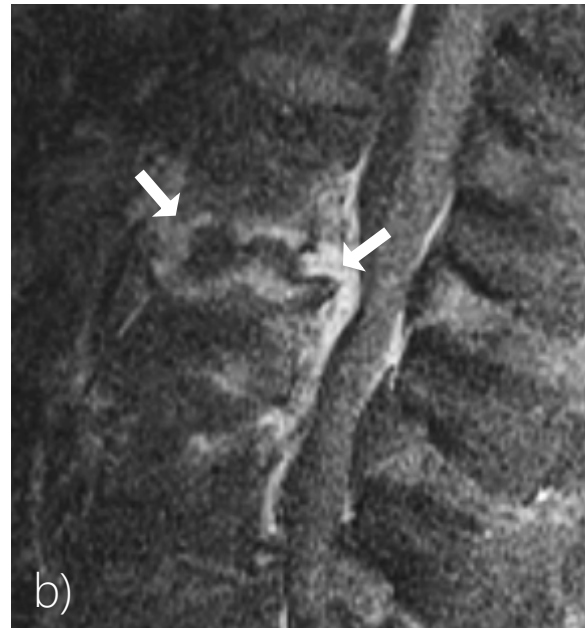
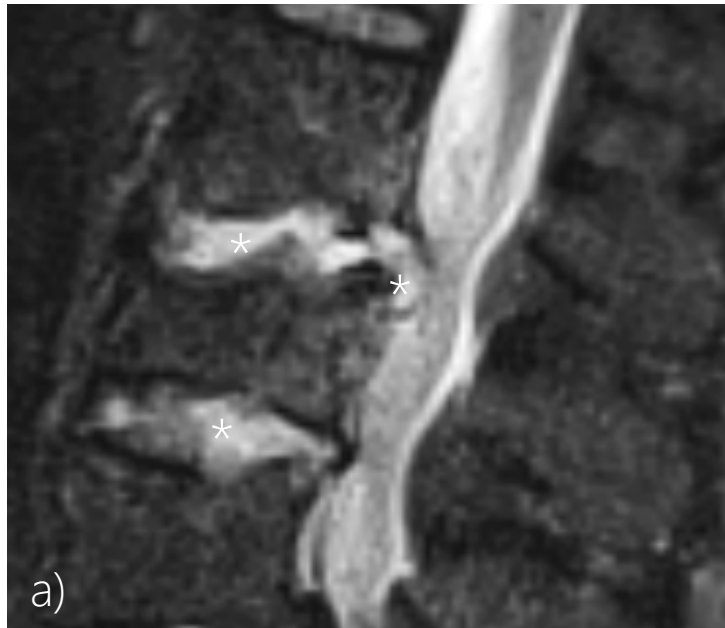


Fig. 37. MRI scan of a patient with history of intravenous drug use and back pain, diagnosed with spondylodiscitis L1-L3.

- a) Sagittal T2 sequence with fat suppression. Asterisks marks fluid signal in the disc and epidural space.
- b) Sagittal T1 sequence post contrast with fat suppression. White arrows marks contrast enhancement in the discs, the endplates and epidural space.

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Polytrauma



- = major trauma
- The definition of “polytrauma/major trauma” has changed over time and different definitions exist in the literature. It can be defined based on the Abbreviated Injury Score (AIS) or the Injury Severity Score (ISS). The most pragmatic definition is the following: combination of injuries in different body regions of which at least one or the combination of different injuries is potentially life-threatening¹⁸
- Polytraumatized patients are evaluated in an interdisciplinary team in the shock room
- The extent of imaging depends on the mechanism of injury and the suspected injuries and can include:
 - E-FAST – checking for free fluid and pneumothorax
 - polytrauma CT scan – checking for injuries of head, neck, thorax and abdomen
 - X-ray – checking for injuries of the extremities
- When reporting on a polytrauma scan it is important to diagnose first what kills first: e.g. large intracranial haemorrhage, signs of increased intracranial pressure, spine injury, hemopericardium, injury of large vessels, large pneumothorax, haemothorax, hemoperitoneum, extensive injury to parenchymal abdominal organs, active bleeding, mispositioning of foreign material^{19, 20}

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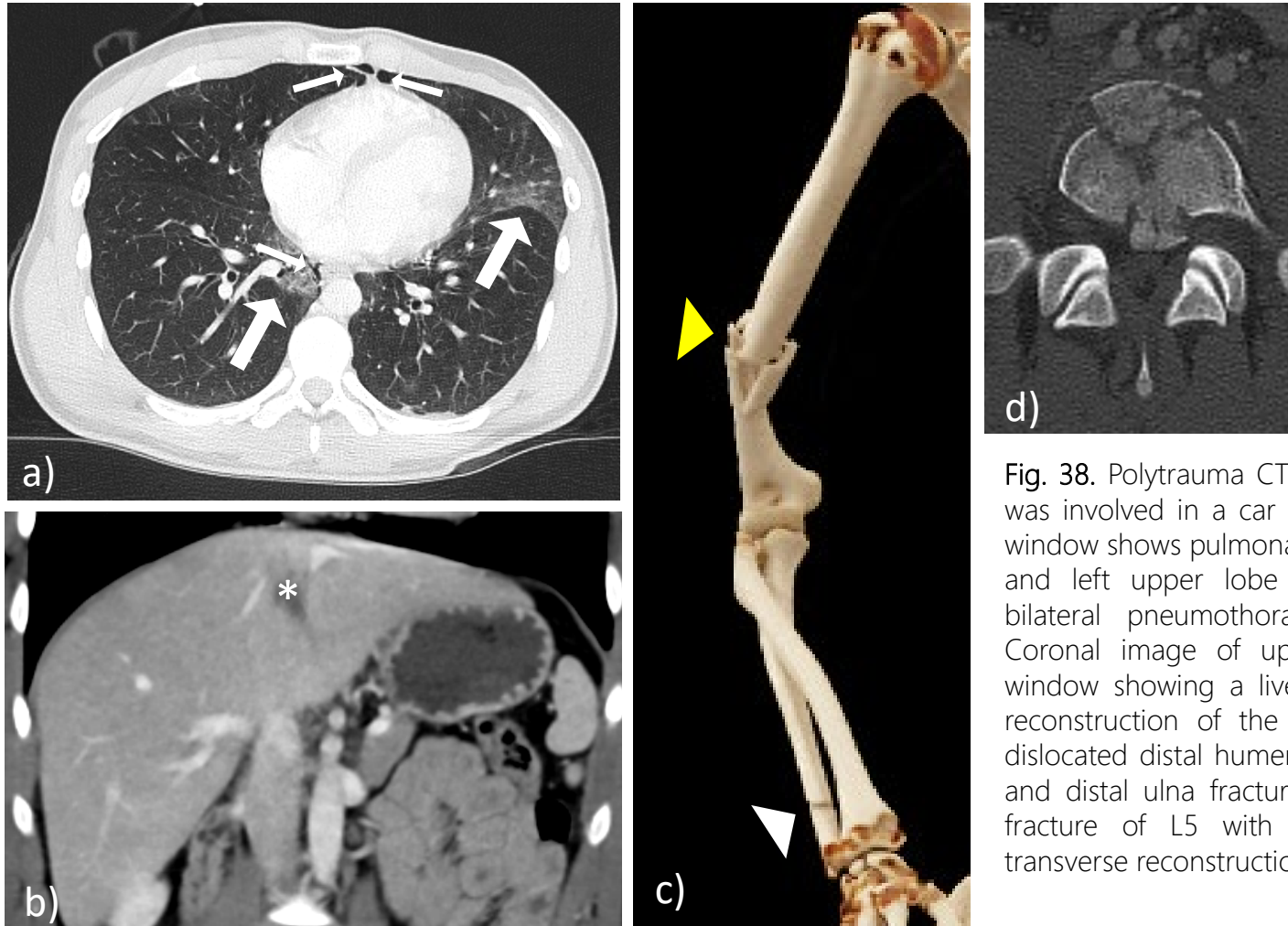


Fig. 38. Polytrauma CT scan of a young patient who was involved in a car accident. a) CT chest on lung window shows pulmonary contusion in the right lower and left upper lobe (white arrows) and a small bilateral pneumothorax (small white arrows). b) Coronal image of upper abdomen in soft tissue window showing a liver laceration (asterisk). c) 3-D reconstruction of the right upper limb showing a dislocated distal humeral fracture (yellow arrowhead) and distal ulna fracture (white arrowhead). d) Burst fracture of L5 with retropulsed fragment on a transverse reconstruction in bone window.

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- A detailed patient history, clinical examination and laboratory results are very important in considering which imaging modality is necessary to confirm or exclude the suspected diagnosis.
- Do you need intravenous contrast? Do you need one phase or a multiphasic scan?
- Check for contraindications to intravenous contrast in CT and any absolute contraindications for MRI.
- It is important to communicate critical findings immediately that require urgent treatment and intervention.
- **First look:** look for life-threatening pathologies.
- **Second look:** look for other pathologies and incidental findings.

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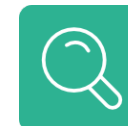
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1 - What is a possible respiratory cause for acute chest pain?

- Pericarditis
- Pleurisy
- Acute coronary syndrome
- Myocarditis





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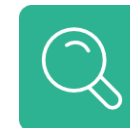
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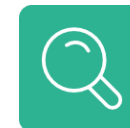
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2 - What is ultrasound used for in an emergency setting? (Multiple answers might be correct)

- In a patient with abdominal pain and elevated inflammatory parameters to exclude cholecystitis
- To exclude free fluid in a polytraumatized patient
- To look for deep vein thrombosis in a young female patient with dyspnoea and shortness of breath
- To look for urinary stasis in a patient with colicky abdominal pain





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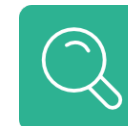
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→ see slide 10 for further information





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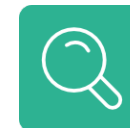
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3 – A patient fell and hit his head against a rock. What is the diagnosis?

- Subdural haematoma
- Epidural haematoma with skull fracture
- intraparenchymal haemorrhage
- Subarachnoid haemorrhage





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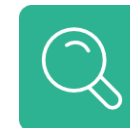
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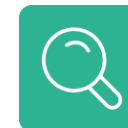
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4 - A 78-year-old male patient is brought to the emergency department. He has a severe abdominal pain, is pale and sweaty and on examination shows abdominal guarding. His blood pressure is 80/50 mmHG. His wife reported to the paramedics that he has a known abdominal aortic aneurysm. Which answer is correct?

- A ruptured abdominal aortic aneurysm is a likely diagnosis. The patient should undergo MRI imaging to visualize the aortic diameter.
- A ruptured abdominal aortic aneurysm is a likely diagnosis. Ultrasound can be used to measure the abdominal aortic diameter and to look for free fluid, while he is undergoing resuscitation.
- A ruptured abdominal aortic aneurysm is a likely diagnosis. A monophasic CT scan in portal venous phase is the protocol of choice to look for an active bleeding.
- A ruptured abdominal aortic aneurysm is not a likely diagnosis in this case.





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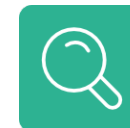
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- A ruptured abdominal aortic aneurysm is a likely diagnosis. The patient should undergo MRI imaging to visualize the aortic diameter.
- ✓ A ruptured abdominal aortic aneurysm is a likely diagnosis. An initial ultrasound in the emergency room can be used to measure the abdominal aortic diameter and to look for free fluid, while he is undergoing resuscitation.
- A ruptured abdominal aortic aneurysm is a likely diagnosis. A monophasic CT scan in portal venous phase is the protocol of choice to look for an active bleeding.
- A ruptured abdominal aortic aneurysm is not a likely diagnosis in this case.





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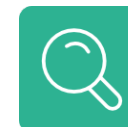
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5 - In a CT scan of a polytrauma patient we want to look for acute life-threatening injuries first. What kind of injury would classify as potentially life-threatening and needs your attention in the initial review of the images? (Multiple answers might be correct)

- Displaced rib fracture with consecutive haemothorax in a patient who was found unconsciousness on the street.
- Displaced distal radial fracture in a bicycle accident.
- Abdominal periaortic haematoma in a car accident.
- Subcutaneous haematoma of the right flank in a patient who fell from a ladder.





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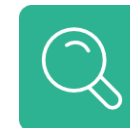
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- Displaced distal radial fracture in a bicycle accident.
- ✓ Abdominal periaortic haematoma in a car accident.
- Subcutaneous haematoma of the right flank in a patient who fell from a ladder.

→ See slide 43 for further information





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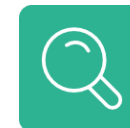
► Test Your Knowledge

Test Your Knowledge



6 - Which statement regarding a stroke is correct? (Multiple Answers might be correct)

- Stroke imaging can be performed using MRI.
- A non-enhanced CT scan is not necessary if a CT scan with arterial contrast is performed.
- The clinical symptoms of a stroke can be caused by an intracranial haemorrhage.
- A CT angiography of the arteries supplying the brain is used to look for arterial vessel occlusions.





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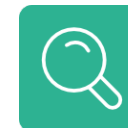
Test Your Knowledge



6 - Which statement regarding a stroke is correct? (Multiple Answers might be correct)

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- A non-enhanced CT scan is not necessary if a CT scan with arterial contrast is performed.
- ✓ The clinical symptoms of a stroke can be caused by an intracranial haemorrhage.
- ✓ A CT angiography of the arteries supplying the brain is used to look for arterial vessel occlusions.

→ See slides 16 and 17 for further information.





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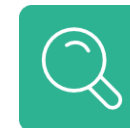
► **Test Your Knowledge**

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7 – Which statement regarding spondylodiscitis is correct.

- All patients are febrile.
- Back pain is an uncommon symptom.
- Can be caused by haematogenous spread.
- Staphylococcus aureus is an uncommon pathogen to cause spondylodiscitis.





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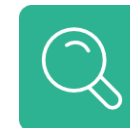
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- Back pain is an uncommon symptom.
- ✓ Can be caused by haematogenous spread.
- Staphylococcus aureus is an uncommon pathogen to cause spondylodiscitis.

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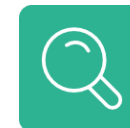
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8 - Which is not a common indication for an unenhanced CT scan?

- Intracranial haemorrhage
- Sinusitis
- Active abdominal bleeding
- Spinal fracture





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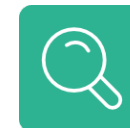
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8 - Which is not a common indication for an unenhanced CT scan?

- Intracranial haemorrhage
- Sinusitis
- ✓ Active abdominal bleeding
- Spinal fracture
- Renal colic

→ See slide 14 for further information.





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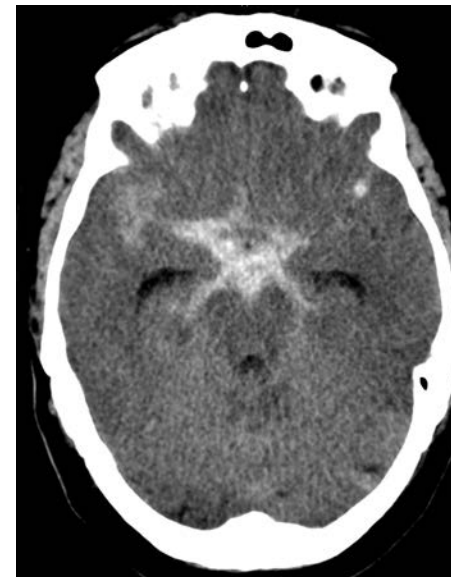
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Test Your Knowledge



9 - A patient with sudden onset of a severe headache was admitted to the emergency room. What is the most likely diagnosis in the non-enhanced CT scan of the head shown here?

- Tumour-related haemorrhage
- Subarachnoid haemorrhage caused by the rupture of an arterial aneurysm
- Epidural haematoma caused by a traumatic injury
- Intraparenchymal haemorrhage caused by hypertension





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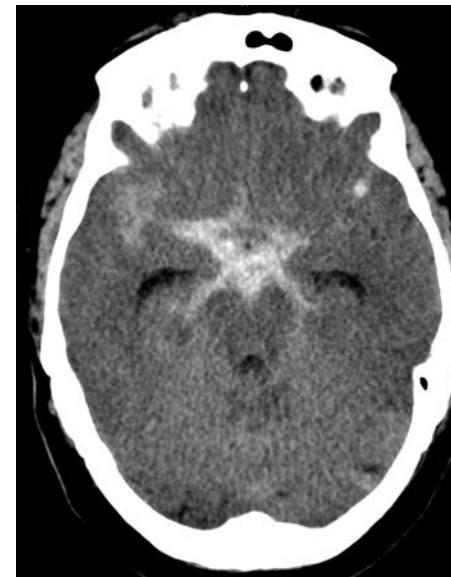
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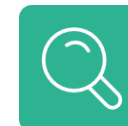


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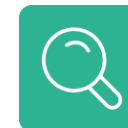
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10 - What is an advantage of CT imaging?

- Higher costs compared to ultrasound and X-ray
- Radiation exposure
- Potential allergic reactions to contrast medium
- Contrast medium allows the evaluation of pathologies of vascular structures, parenchyma and soft tissue





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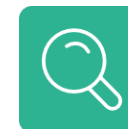
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10 - What is an advantage of CT imaging?

- Higher costs compared to ultrasound and X-ray
- Radiation exposure
- Potential allergic reactions to contrast medium
- ✓ Contrast medium allows the evaluation of pathologies of vascular structures, parenchyma and soft tissue

→ See slide 12 for further information





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