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Diagnostic Imaging

Radiography, ct and mri in the management of dogs and cats with head trauma
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Thorax: General considerations
Injury of the thoracic and abdominal is common in dogs and cats. They rarely occur as isolated injuries; patients are often in shock, may have combinations of thoracic and abdominal trauma, and other significant injuries such as fractures of the vertebral column with associated neurological disease. Therefore, assessing and supporting all vital organs is always the first step in managing these patients and imaging never is the first step in the management of any trauma patient. Assessing the A-(airway), B- (breathing), C- (cardiovascular) status and neurologic status of the animal is followed by treatment of life-threatening conditions. The minimal data base also requires taking blood for assessing packed cell volume, total protein, blood glucose, activated clotting time.

One also has to consider that thoracic injuries as documented by radiographs, blood gases, or ECGs may not be clinically relevant at this time, and correlation between radiographic findings and outcome is poor (Sigrist N., al. 2004), whereas the trauma score at presentation is significantly associated with outcome. In other words, the fate of many traumatized animals is determined by the ability of the clinician to recognize clinical signs rather than imaging. Nevertheless, when initial stabilization is obtained, imaging often is indicated and may give important information concerning further management of a patient. Since radiographic equipment is present in most small animal practices and clinics, and radiography is a fast and simple procedure giving excellent anatomical overview without requiring any special skills, it is still a basic procedure in working up patients with thoracic and/or abdominal injury (Morgan JP., and Wolvekamp P. 2004). Whether the radiographs are focused on one of the 2 body regions or is performed including both regions in the same examination has to be determined on the case.

Technical aspects
Primum nil nocere (Scribonius Largus, medico of the emperor Tiberius Claudius Nero Caesar Drusus) is the first and most important axiom.

Thorax: One of the common signs of dogs and cats with thoracic trauma is dyspnea and manipulation of the animal may aggravate the clinical signs. Therefore, the first radiograph is always taken in the position with the least stress for the animal. In our practice this is usually the ventral recumbency, and this first dorsoventral radiograph is assessed before other projections are made. In many cases no other projections are needed for treatment planning. If clinically indicated and possible, projections in right or left lateral recumbency, or horizontal beam radiographs are taken.
Traumatized animals often have increased respiration rate that may result in movement and a reduction in the radiographic quality. Short exposure times therefore are important. This can be achieved by the use of a combination of fast rare-earth-type intensifying screens with appropriate film, the highest possible kVp and mA.

However, since radiography as a planimetric method has many limitations, other imaging modalities such as Ultrasonography (US), Computed tomography (CT), or magnetic resonance imaging (MRI) play an important role in the work-up of trauma patients and may complement or replace special radiographic procedures. A recent study revealed that Ultrasound can be a fast and accurate method to assess pneumothorax and other thoracic injury in traumatized dogs. In this study, patients were sonographically evaluated using a standardized 4-point thoracic FAST (focused assessment with sonography for trauma) protocol, before thoracic radiography and thoracocentesis was performed. Results showed an overall sensitivity of 78.1%, specificity of 93.4%, and 90% accuracy of TFAST relative to radiographs. The median time for the procedure was only 3 minutes.

What to look for

Chest wall injuries

- Trauma often leads to pain and a low tidal volume-high respiratory rate respiratory pattern ("splinting"). This may be seen on a radiograph as unilaterally decreased rib spaces on dorsoventral radiographs leading to asymmetry of the thorax with a straight thoracic wall on the affected side.

- Subcutaneous emphysema is common with injuries perforating the skin of neck and thorax, also in pharyngeal, laryngeal, tracheal and esophageal perforation or rupture. In perforating chest wall injuries the emphysema may be associated with pneumothorax.

- Soft tissue swelling of the thoracic wall may be a sign of blunt trauma with hemorrhage, muscle trauma, rarely also associated with rupture of the abdominal wall. Abnormally wide spacing of ribs may be a sign for rupture of intercostals musculature.

- Single fractures of ribs and multiple fractures of individual ribs usually do not cause respiratory failure. Severely displaced fragments may lead to lung laceration and may require surgery. Flail chest is present when multiple ribs in a row are fractured or when over 2 segmental fractures (2 fractures in 1 rib) are present. Flail chest is associated with paradoxical movement of the flail segment and a risk factor for respiratory failure. Bite wounds are often causes of flail chest.

- Fractures of any other bone including thoracic limbs, spine and sternum may be present and are helpful in establishing the diagnosis in cases with unclear history. In patients with neurological disease watch for fractures and deviation of the axis of the spine. Concurrent sternal fracture/luxation may be an additional finding in severe trauma.

In pneumothorax, the vertical beam left lateral recumbent and the expiratory horizontal beam ventrodorsal views are reported to be the most effective radiographic views for the detection of pneumothorax. In lateral recumbency with
vertical x-ray beam orientation, a commonly reported sign is separation of the heart ("elevation") from the sternum. Separation of the visceral and parietal pleural surfaces on the horizontal beam ventrodorsal view is reportedly the best indication of small amounts of air in the pleural spaces. (Kern, 1994). Pneumothorax may be present with or without other abnormalities. In the dog, pneumothorax usually is bilateral.

**Pneumomediastinum** may be the result of a disruption of the lung parenchyma, intra- or extrathoracic tracheal rupture, or bronchial rupture. The most frequent and reliable radiographic sign is delineation of both the inner and outer aspects of the tracheal wall, identification of the azygos vein and the presence of mediastinal air pockets (1986). Delineation of the aorta, other mediastinal vessels and the esophagus are also common signs. Pneumothorax secondary to pneumomediastinum is common, the opposite does usually not occur. Depending of cause, severity and duration, a pneumomediastinum may be associated with subcutaneous emphysema extending in the neck, and/or the retroperitoneum. Pneumopericardium is rare and may be associated with trauma.

**Pleural and mediastinal effusion** (Hemothorax) is common in dogs and cats with blunt trauma. It may be associated with injury to blood vessels, diffuse bleeding from an injured chest wall or lung, rupture of the thoracic duct. However, it is a non-specific sign and may have causes unrelated to the trauma. Since severe effusion effaces the border of the heart and the diaphragm it may mask other injuries such as diaphragmatic rupture and pulmonary contusion. Ultrasound examination is helpful in these patients and it is recommended to tap the fluid before taking radiographs.

**Diaphragmatic rupture** is common in trauma to the thorax and abdomen. Indicative findings are loss of the diaphragmatic contour, abnormal position of the diaphragm, masking of the cardiac silhouette, and lack or abnormal position of abdominal organs. Identification of the stomach or tubular GI structure in the thorax makes the diagnosis easy. Accumulation of free pleural fluid may obliterate underlying pathology. CT, but also US examination in cases with suspected diaphragmatic rupture is helpful. Radiographic contrast procedures are neither indicated nor helpful.

**Airway obstruction** may be occur anywhere in the respiratory system; therefore, meticulous clinical examination to localize the problem is most important. In addition to laryngeal collapse or paralysis, airway obstruction is often secondary to severe head and neck trauma, or to regurgitation/vomiting of recently ingested food. Radiography (inspiratory, expiratory, fluoroscopy) may be helpful in localizing the problem, and to differentiate between the types of obstruction. Complete tracheal rupture may be seen on chest radiography and may be a cause of obstruction.

**Lung contusion/laceration** is the most common injury after thoracic trauma. Damage to the lung causes hemorrhage and edema into the interstitium, alveoli, and small airways, and may be seen as ill defined often patchy and confluent areas of increased opacities. Traumatic bulla and bleb formation may be seen as well circumscribed lesions. Depending on the amount of bleeding and time after injury, their radio-opacity is variable. Horizontal beam radiographs reveal fluid gas interfaces. Lung injury is often leading to pneumothorax and pneumomediastinum.

**Abdomen: General considerations and technical aspects**

In dogs and cats with abdominal trauma, Ultrasonography plays an important role. However, since pain and uptight abdomen are common features of trauma patients,
Ultrasonography may not be easy to perform, and may cause further discomfort and stress for the patient. Therefore, and because not all relevant structure are easily accessible (e.g. the lower urinary tract), radiography is still the primary imaging modality in assessing the posttraumatic abdomen. This is even more important, because many patients with abdominal injury also have fractures/dislocations of the spine, pelvis, or other bones and a radiographic examination may be a very valuable screening procedure addressing these structures.

Abdominal radiographs are usually taken in left or right lateral, and in dorsal recumbency. They should include the diaphragm, the spine, and the pelvis. Occasionally horizontal beam radiographs may be helpful, e.g. for assessing the abdomen for the presence of free gas. Whereas contrast procedures of the gastrointestinal tract are not indicated in trauma patients, urethrography, urethrocystography, or excretory urography are fast and accurate procedures in assessing the integrity of the urinary tract. In order to avoid adverse reactions it is recommended to use non-ionic Iodine based contrast media with low osmolality (table1). Of course, if clinically indicated and available, CT is a very sensitive imaging modality to assess the posttraumatic abdomen.

What to look for

The same principles as described for the thorax apply also for the abdomen. Trauma often leads to fractures and dislocation of skeletal structures including spine, pelvis, caudal ribs, or femurs, to soft tissue swelling, rupture of the abdominal wall (including diaphragm) with or without herniation of abdominal structures, and/or penetration of the abdominal wall. Radiography is helpful in assessing the integrity of the abdominal wall; discontinuation and or thickening and loss of discrimination of fascial planes, and dislocation/herniation of abdominal structures may be radiographic signs. Avulsed bone fragments, e.g. from the pecten ossis pubis with ventral herniation of the bladder or GI structure may also be present. More than the 2 standard projections and sometimes (e.g. dislocation of bladder or even kidney) contrast studies may be helpful.

Free abdominal gas may be of different origin and it is important to differentiate between intra- and retroperitoneal free gas. Intraperitoneal free gas may be caused by perforating abdominal wall (including diaphragmatic) injuries, or rupture of the gastrointestinal tube from the stomach to the descending colon except the rectum. Pneumoretroperitoneum may be caused by dissection of gas from pneumomediastinum, or perforating rectal or perineal injuries. If free intraperitoneal gas is suspected, a left lateral recumbent ventrodorsal horizontal beam radiograph may be helpful. With the animal in lateral recumbency, sonographic examination of the highest point (last ribs) of the abdomen without applying pressure (!) is also a very sensitive method.

Free abdominal fluid may be located in the peritoneal cavity and can be seen as increased radiographic opacity, and decreased abdominal detail with effacement of serosal margins of abdominal organs and structures. Depending on the amount and type of fluid, it may have a homogenous, patchy, or stripy appearance. The most common causes are rupture of liver and spleen; diffuse bleeding from other vessels, and rupture of the urinary bladder. Retroperitoneal fluid is commonly seen after rupture of blood vessels, kidney, ureters, or the bladder neck. Depending on the amount of fluid, loss of detail (e.g. kidney border effacement) or mass effect with
ventral displacement of GI structures may be seen; rupture of bladder neck and urethra may lead to loss of detail and fluid accumulation in the pelvic canal. Trauma induced rupture of the GIT is relatively rare and leads to inhomogeneous appearance and gas. Peritonitis with signs of functional ileus and corrugated bowel walls may be seen as well. However, since hemorrhage, urine, bile and other types of fluid may have a similar radiographic appearance; abdominocentesis is recommended for fluid analysis. Suspicion of GIT rupture usually is not an indication of a contrast study. In these cases, ultrasound and abdominocentesis are the diagnostic procedures of choice. In contrast, excretory urography is a fast and safe procedure to assess kidneys and ureters, and urethra-cystography is indicated if lower urinary tract rupture is suspected.

**INTRODUCTION**

Imaging procedures are an important part in the diagnostic workup of patients with suspected or confirmed head trauma. Since different imaging modalities are available, the choice of the best modality and technique in order to obtain the necessary information is an important step. Radiographic examinations of the traumatized head in human medicine have been almost completely replaced by computed tomography (CT), or magnetic resonance imaging (MRI). However, in veterinary medicine, conventional radiography is still an important imaging modality, especially in the assessment of the viscerocranium. Historically, the limited availability of CT or MRI, high costs, and the necessity for general anesthesia restricted the use of time consuming procedures especially MRI, and if general anesthesia was contraindicated. However, in recent times, after the introduction of fast helical CT units in veterinary medicine, CT studies can often be performed in a few seconds on the sedated or no-sedated dog or cat, and all the necessary views can be produced without loss of significant information. Compared to conventional (planimetric) radiographs, CT and MRI can provide better assessment of individual structures with significantly higher contrast of bone and soft tissues.

Radiographic diagnostics on the skull, because of its complex anatomical structure, is one of the most difficult regions to image. A multitude of various positioning techniques, projections, and the variations of skull shapes between cat and dog and the many dog breeds make thorough radiographic examinations challenging. The standard radiographic views of the head are a lateral and a ventro-dorsal or dorso-ventral projection. Special projections and oblique views are often necessary to visualize individual structures since the standard projections are often non-conclusive. Special projections may include open mouth oblique views of the mandible and maxilla, intraoral projections, oblique projections of the temporomandibular joint, the tympanic bullae and middle ear structures, or the atlanto-axial joint along the dens axis. Frontal (rostro-caudal) projections using different angles may also be necessary to assess the frontal sinus, foramen magnum, the tympanic bulla, or the dens axis. It is very time consuming and expensive to acquire these different projections and the results have limited sensitivity. Therefore, veterinary centers with access to CT or MRI often switch to CT or MRI for imaging the viscerocranium (e.g. nasal cavity).

Fractures and dislocations of facial bones and fracture/luxation of the temporomandibular joints are common, and they are often visible on radiographs allowing planning of the necessary conservative or surgical therapy. The presence of a cranial fracture on a radiograph also may indicate injury to the underlying soft tissue structures such as the brain. However, since fractures of the neurocranium are often not or only minimally displaced, located at the base of the skull, and...
superimposed by other structures, they are commonly undetected on radiographs. Therefore, and because the brain, meninges, and cranial nerves cannot be assessed on radiographs, CT and MRI have quickly become the imaging modalities of choice in cases with suspected trauma of the neurocranium in veterinary imaging.

Computed Tomography (CT)
A CT unit consists of a control console, a patient table and gantry with rotating X-ray tube and a bank of detectors. Similar to radiography, CT is based on the absorption of the X-ray beam by tissue which is measured as an attenuation coefficient and expressed in Hounsfield units (HU). The HU's are translated into gray scale and together with windowing; they result in very high contrast resolution of soft tissues. By producing slices of the body superimposition of structures is eliminated, and CT produces images with excellent spatial resolution.

Positioning of the patient depends on the body part to be scanned and clinical indications. In trauma patients with the head as region of interest, sternal position is preferred, and it is helpful to place the animal as straight and symmetrical as possible. In an emergency situation and with a critical patient the animal has to be monitored closely without neglecting the radiation protection principles for the people involved. Working with a helical multidetector CT, a small field of view, a large matrix and low slice thickness using continuous image acquisition (helical mode) will allow short acquisition times and high resolution images. This will allow multiplanar (sagittal, dorsal or diagonal) reconstructions of the acquired transverse plane images without losing significant resolution or clinically important information.

CT images that should later be analyzed in a "bone" window should be calculated using a bone-reconstruction algorithm (filter, kernel), which will give high-definition images and detailed bone contours. This method enables the detection of even the finest fissure lines. Increased resolution decreases the signal to noise ratio decreasing also the soft-tissue contrast of the CT images. Very thin slices also have disadvantages in assessing the soft tissues of the skull, especially the brain. This disadvantage can be compensated using higher kvp and ma (X-ray tube!) during acquisition or to acquire the images with thicker slices that are reformatted later in a post-processing operation into thinner slices, a feature offered by many current CT-units. Images that are viewed from a soft tissue window should primarily be calculated with a soft tissue algorithm. Simply changing window width and window levels usually leads to suboptimal image quality.

One also has to bear in mind to adapt the CT protocols between a Chihuahua puppy, or an adult great dane. Pre- and post contrast studies should be done for soft tissue examinations and the native images have to be compared with the postcontrast images. Three dimensional reconstructions (volume rendering, surface shaded display (SSD), maximum intensity projection (MIP)) sometimes help the clinician to better understand the findings and may facilitate the planning for surgery. They are very helpful for communication of the pathological findings to the pet owners.

Magnetic Resonance Imaging (MRI)
MRI is based on the physical principle of magnetic resonance phenomenon - without ionizing radiation. By selecting appropriate sequence parameters different proton content and biochemical binding can be measured and is used for image formation. These different sequences produce variable image contrast for individual tissues and produce detailed information of these tissues. Compared to CT, spatial resolution is lower, but the contrast resolution of MRI is superior compared to - making MRI the image modality of choice for most neurological problems. In contrast, CT is the modality of choice for dense osseous structures and their anomalies. Since gas and bone are both of low signal intensity (black) on MRI (e.g. wall of the tympanic bulla)
ct is the method of choice to assess such interfaces. the advantage of having different sequences that can be acquired in all desired planes using mri has the disadvantage of being very time consuming compared to (helical multislice) ct. in a given case, it is therefore important to carefully choose the appropriate imaging modality to address the clinical problem in an optimal fashion.

for examination of the head, mr images should be acquired in the three standard planes (transverse, sagittal, dorsal) and using different sequences. the dorsal and transverse planes allow direct comparison of symmetrical structures and considerably facilitate the analysis. evaluation of midline structures, ventricles, hemispheres of the forebrain or the cerebellum, or cranial nerves is easier if symmetrical positioning is achieved. relative position of the tectum and cerebellum with regard to the tentorium cerebelli and foramen magnum is best done using sagittal plane images. however, it is not necessary to acquire each sequence in all the planes; this would be very time consuming working with low field scanners that are widely used in veterinary medicine. acquisition of high resolution gradient echo sequences allows multiplanar reconstruction and shortens the total examination time.

the basic sequences are the t1- and t2-weighted spin- or turbo-(fast)spin echo sequences (se, tse, fse) with the t1-w sequence producing good anatomical information, and the t2-w sequence being sensitive for high proton (fluid) content and therefore sensitive for most pathologies. for examination of soft tissue and bone structures of the viscerocranium, fat suppression sequences such as stir (short ti inversion recovery), spectral fat saturation or fat-water separation are recommended since with the fat suppression, bone or muscle pathologies and any pathology surrounded by fat (retrobulbar region) are highlighted. flair (fluid attenuated inversion recovery) sequences make it possible to differentiate between “high water” lesions (e.g. edema, tumor, inflammation, hemorrhage, but also gliosis) within the brain parenchyma and cerebrospinal fluid (csf) -filled areas. compared to t2-w sequences they have a higher sensitivity for brain lesions, and they also improve conspicuity for periventricular lesions (edema). they are also helpful to differentiate csf from fluid accumulations with high protein content (e.g. blood or exudates). gradient echo sequences (gre, fe) such as the t2* sequence are very sensitive for susceptibility artifacts caused by the iron in hemoglobin or blood degradation products and are recommended if intracranial bleeding is suspected. gradient echo sequences are also helpful to assess bone structures. intravenous injection of a paramagnetic contrast agent (most of them are gadolinium based) further helps to differentiate between different types of lesions since degree and pattern of contrast uptake varies between different disease processes. they are t1 based (se, fse, gre), and always done after and in addition to the precontrast sequences.

3-d sequences with high in plane resolution and isotropic voxels allow multiplanar reconstruction of additional planes in the post-processing without prolonging the scan-time. gradient echo sequences with high resolution and good bone contrast for the detection of minimal dislocated fractures therefore should be included in the examination protocol of trauma patients. a protocol that is valid for all mr units and indications cannot be given. body region, e.g. brain versus nose or middle ear requires different protocols and the field strength of an mri unit also has to be considered.

**Pathologies**

Trauma to the maxilla, mandible, or the temporomandibular joint are almost never indications for emergency imaging procedures, and unlike in human medicine, reconstructive surgery is also rarely an indication for advanced imaging in dogs or
cats with trauma to the head. Imaging in such patients usually is done for fracture and dislocation assessment including temporomandibular joint luxation, and to allow the surgeon to choose the most appropriate therapy to re-establish function of these structures.

However, as soon as involvement of the neurocranium including the brain and the cranial nerves is suspected, advanced imaging may be indicated for establishing a precise diagnosis, prognosis, and to offer guidance for the clinician in choosing the best possible therapy for an individual patient. In other patients, the cause of the history in a comatose patient or an animal in status epilepticus may be unknown and it may be crucial in such patient to know the underlying disease process. Besides trauma, the list of differential diagnosis is long and includes tumor, granulomatous and infectious diseases, hemorrhage, infarcts, or increased intracranial pressure of any other cause.

At this point, it is important to remember that by far not all dogs or cats with craniocerebral injury require CT or MRI of the skull. As in any trauma patient, assessing the A-(airway), B- (breathing), C- (cardiovascular) status and neurologic status of the animal is followed by treatment of life-threatening conditions are the first and most important actions to be taken. The next step is to consider if and what way an individual patient may profit from imaging. The main indications are injuries requiring a surgical therapy. They include penetrating injuries such as bite wounds where debridement and removal of foreign material may be necessary, displaced open or closed skull (impression type) fractures for pressure release and removing the bone fragments, and suspected life threatening intracranial bleeding. Intracranial bleeding may be intra-axial (intracerebral) or extraaxial (epidural, subdural, subarachnoidal). In contrast to humans, epidural hematomas, and life threatening subdural hematomas requiring trepanation or other surgical therapy, are rare in the dog and cat, since they do not have the bridging veins leading to rupture and bleeding. They may be differentiated by their shape: a convex border most likely indicates a subdural, a convex border an epidural hematoma. Injury to the brain parenchyma may lead to intracerebral hemorrhage caused by vascular injury and contusions, and may involve the ventricles as well. Gradient echo sequences (T2*) a very sensitive for such lesions.

CT has traditionally been the method of choice in acute hemorrhage. While this has changed in human medicine it still is an excellent option in the dog and cat. In addition to the very short examination time, at least if helical CT is used, CT is also the most sensitive method in assessing skull fractures (displaced or non-displaced). Acute hematomas are hyperattenuating space occupying lesions (60-100HU), often surrounded by a hypodense (edema) rim. Older literature suggested that acute intracerebral hemorrhage (<24hours) may be missed on MRI because detectable amounts of paramagnetic deoxyhemoglobin have not yet been accumulated. However, if susceptibility-weighted MRI sequences such as T2* sequences are used, the sensitivity of MRI also in hyperacute hemorrhage is similar to CT, at least if high field scanners are used. The T2 shortening effect caused by the magnetic susceptibility effects is enhanced on higher-field-strength MR units.

In more chronic cases, MRI has been shown to be the more sensitive method, since x-ray attenuation in CT will be similar to brain tissue. If active bleeding is suspected, postcontrast studies may be helpful. In chronic hematomas, contrast uptake is variable and may have a rim-like appearance. The appearance of intracranial hemorrhage on MRI primarily depends on the age of the hematoma and on the imaging sequence or parameters (eg, T1-w, T2-w sequences, table 1). Other parameters influencing the characteristics of the signal are the site of the
hemorrhage, the local partial pressure of oxygen in the tissues (venous or arterial origin), the local pH, the patient's hematocrit, and many other factors including local glucose concentration, hemoglobin concentration, or the patient's body temperature.

Other findings on CT or MRI may be related to increased intracranial pressure. Signs of increased cranial pressure on MRI may be edema of brain tissue, transtentorial displacement of brain tissue or herniation through the foramen magnum, signs for obstruction of CSF-flow, flattening of the sulci, and maybe space occupying lesions. A sign that has not investigated in dogs or cats that could be useful is the distention of the optic nerve sheath diameter, since elevated intracranial pressure is transmitted through the cerebrospinal fluid surrounding the optic nerve. A possibly life threatening condition is tension pneumocephalus. It is a rare finding consisting of accumulation of air in the ventricular system that may occur after trauma, or after transfrontal craniotomy.

### Table 1

<table>
<thead>
<tr>
<th>Phase</th>
<th>Time</th>
<th>Hemoglobin Location</th>
<th>SI in T1-W</th>
<th>SI in T1-W</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hyperacute</td>
<td>&lt;24 h</td>
<td>Oxymyoglobin intracellular</td>
<td>Hyperintense or hypointense</td>
<td>Hyperintense</td>
</tr>
<tr>
<td>Acute</td>
<td>1-3 d</td>
<td>Deoxymyoglobin intracellular</td>
<td>Hypointense</td>
<td>Hypointense +</td>
</tr>
<tr>
<td>Early subacute</td>
<td>&gt;3 d</td>
<td>Methemoglobin intracellular</td>
<td>Hyperintense*</td>
<td>Hypointense +</td>
</tr>
<tr>
<td>Late subacute</td>
<td>&gt;7 d</td>
<td>Methemoglobin extracellular</td>
<td>Hyperintense*</td>
<td>Hyperintense</td>
</tr>
<tr>
<td>Chronic</td>
<td>&gt;14 d</td>
<td>Ferritin and hemosiderin extracellular</td>
<td>Hypointense</td>
<td>Hypointense</td>
</tr>
</tbody>
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### REFERENCES


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