TRAUMA: THE ROLE OF DIAGNOSTIC IMAGING

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Trauma is a common reason for presentation to the emergency department, and a common cause of mortality in dogs and cats. Examples include blunt trauma (e.g. road traffic accidents), penetrating trauma (e.g. bite wounds) or falling from a height. With the increasing availability of ultrasonography, computed tomography and MRI, the management of trauma patients has changed, as these techniques allow a better selection of the patients in which surgery will be necessary and also improve the selection of types of surgery and surgical approaches, thereby minimizing surgical time and potential complications.

RADIOGRAPHY

Thoracic radiographs are typically obtained in the trauma patient and are recommended even in seemingly stable patients to look for early and subtle signs of traumatic injuries such as hemorrhagic effusion, pneumothorax, and pulmonary contusions which may warrant a closer observation of the patient. Thoracic (and abdominal) radiographs are also very useful for the diagnosis of traumatic diaphragmatic hernias. Presence of significant pleural effusion may challenge the radiographic recognition of diaphragmatic hernias, and the use of contrast studies such as GI barium study or iodinated peritoneography could be useful in such cases. Of course, radiography is also important in the evaluation of skeletal injuries such as fractures and luxations. Articular ligamentous injuries may remain undetected on radiographs obtained in neutral positions and may necessitate stress radiographs under heavy sedation or anesthesia for diagnosis. Radiography has limited usefulness for the diagnosis of skull and brain injury. Skull fractures as well as spinal fractures/subluxations may be overlooked on radiographs. In the spinal trauma patient, radiography has only a moderate sensitivity for fractures (72%) and subluxations (77.5%) and has a low negative predictive value for the presence of vertebral canal narrowing (58%) and fracture fragments within the vertebral canal (51%).

ULTRASOUND

The ultrasound examination techniques known as A-FAST and T-FAST (Abdominal and Thoracic Focused Assessment with Sonography for Trauma, Triage, and Tracking) constitute abbreviated ultrasound examinations that focus on identifying the presence of fluid within the peritoneal, pleural, and pericardial spaces. Examination findings are used to direct immediate patient stabilization efforts and serial studies can be used to monitor hospitalized patients. In the emergency setting, focused ultrasound examinations are increasingly being used as an extension of the physical examination. In the trauma patient, A-FAST examination can be used to rapidly identify free fluid or major traumatic injuries such as large hematomas. It utilizes four acoustic “windows”: the diaphragmatic-hepatic window, the spleno-renal window, the cysto-colic window and the hepatorenal window. In the trauma patient, the T-FAST examination allows rapid assessment of both hemithoraces for pleural space disease (presence of free gas or hemorrhagic effusion) and pericardial effusion, as well as assessment of the peripheral pulmonary parenchyma for signs of contusions/hemorrhage. Once the patient is stabilized, complete evaluation of the lungs can be performed by obtaining three-view thoracic radiographs. More thorough ultrasound examination may be useful to look for subtler traumatic injuries such as liver/splenic or renal hematomas, forming ill-defined heterogeneous mass lesions often bulging or disrupting the capsule of these organs. Bladder rupture may be diagnosed with ultrasound using agitated saline injected via a urethral catheter; the hyperechoic bubbles are seen in real time freely diffusing into the abdominal fluid around the bladder during injection. Other changes such as trauma-induced pancreatitis may also be assessed with ultrasound.
COMPUTED TOMOGRAPHY
There is general agreement that computed tomography (CT) is the modality of choice to evaluate patients with acute head trauma, especially in moderate and severe cases, as it is quick and highly accurate in the diagnosis of conditions which may impact clinical management such as fractures, intracranial hemorrhage, brain swelling and brain herniation. Intracranial hemorrhage is easily recognized at CT due to the hyperattenuating nature of hematoma compared to brain parenchyma on unenhanced CT images. For spinal traumatic injury, CT is excellent as rapid imaging with excellent bone detail of the entire spine can be obtained. Patients suspected to have vertebral instability may be scanned while strapped on a rigid plank to minimize motion and worsening of neurological damage. The use of multiplanar reformatting and volumetric reconstructions facilitates the recognition of minimally displaced skeletal injuries.

CT is also useful for the evaluation of patients with traumatic pelvic injuries as the assessment of multiple pelvic fractures with radiography may be challenging due to the complex anatomy and superimpositions. CT could also be useful in the management of patients with acute abdominal hemorrhage to try and identify the source of bleeding. In gun injuries, CT is very useful to get a quick global assessment of the extent of injuries and determine the path of the ballistic projectile.

MAGNETIC RESONANCE IMAGING
Head trauma can lead to traumatic brain injury (TBI), defined as an injury to the intracranial structures following physical trauma to the head. Not all patients presented with head trauma will undergo advanced imaging of the head/brain. However, advanced cranial imaging should be considered in patients who fail to respond to aggressive medical management, patients who deteriorate after an initial response to medical therapy, and/or patients with focal or asymmetric neurologic signs. In the acute head trauma patient, MRI is indicated when CT fails to explain the neurologic findings and is also the preferred imaging modality for subacute and chronic traumatic brain injury. In people, MRI and CT have similar sensitivity in the detection of acute epidural and subdural hematomas but MRI is superior in the detection of non-hemorrhagic lesions, brainstem injuries and subarachnoid hemorrhage. The by-products of progressive degradation of hemoglobin in hemorrhagic lesions cause changes in MRI signal on T1W and T2W images, the intensity of which depends on the degradation stage. T2*W Gradient Echo images are useful to demonstrate the susceptibility artifacts associated with the magnetic properties of some by-products of hemoglobin degradation.

Depending on the location, intracranial hemorrhage can be categorized as:

- Epidural: Well-defined biconvex (lenticular) extra-axial mass of variable signal intensity dependent on age of hematoma; the lesion may cross dural folds such as falx cerebri and osseous tentorium cerebelli but usually does not cross suture lines where the dura is tightly adhered to the underlying calvarium.
- Subdural: Peripheral crescent-shaped collection of hemorrhage of variable signal intensity, which is often very extensive; the lesion may cross suture lines but its limited by the falx and tentorium which are dural extensions that extend between cerebral hemispheres and cerebrum/cerebellum, respectively, and block subdural hemorrhage from crossing.
- Subarachnoid: In acute cases, there may be no abnormal findings on conventional T1W and T2W images, as acute hemorrhage is isointense to CSF. However, hyperintense signal will be noted in the subarachnoid space on T2-FLAIR images; in subacute or chronic cases, hemoglobin degradation by-products may be visible on conventional Spin Echo sequences dependent on stage of degradation, but appear iso-, mixed or hypointense to CSF on T2-FLAIR. Susceptibility artifacts (signal voids) will be noted on T2*W images.
- Ventricular: Ventricular hemorrhage can cause a gravity-dependent fluid-precipitate level in the ventricular lumen.
- Intra-axial: Intraparenchymal mass of variable size and intensity with perilesional T2W and T2-FLAIR hyperintensity consistent with edema.

Brain contusions may also be recognized with MRI. They are a common sequela to head trauma and consist of heterogeneous regions of hemorrhage, edema and necrosis, often located in the superficial gray matter. Ill-defined intra-axial lesions close to the brain surface are seen, with variable signal intensity dependent upon the relative amounts of edema and hemorrhage.

Other changes that can be seen in patients with head trauma include mass effect with or without...
herniation, concurrent skull fractures (disruption of the normal MRI signal void of the cortex of the calvarium), and signal change of overlying soft tissues (e.g. muscles). Diffuse cerebral swelling and pneumocephalus may also be seen in patients with head trauma.

Negative prognostic MRI findings reported in dogs with head trauma include the severity of midline shift, the extent of intraparenchymal lesions, and the presence of brain herniation, skull fractures and/or injuries affecting the caudal fossa or both the rostral and caudal fossa.

There is little documentation about the utility of MRI in the evaluation of spinal trauma in dogs and cats, but it is a valuable tool, especially to evaluate the soft tissue components and secondary spinal cord injury. In people, like CT, MRI is more sensitive than plain radiographs in the identification and classification of vertebral traumatic injuries. Vertebral fractures may be recognized on MRI due to the focal interruption of the normal hypointense vertebral cortex, together with changes in contour and changes in signal intensity of the vertebral body due to hemorrhage and edema. T1W and Proton Density images are particularly useful for this specific assessment. Variable degrees of relative displacement of the fractured fragments may be identified. The fracture line itself may appear as a hypointense line on T2W or T2*W images due to the focal hemorrhage along the margins of the fracture. Minimally or non-displaced fractures can be spotted on MRI as focal, somewhat linear areas of T2W hyperintense signal due to bone marrow edema. Vertebral subluxation or luxation can be spotted on MR images in various planes, depending on the location of the injury and direction of the subluxation/luxation. Combined assessment of multiplanar images, especially in the sagittal and dorsal plane, is recommended to better evaluate for subtle intervertebral subluxation, paying particular attention to the alignment and congruence of the articular process joints and adjacent vertebral bodies. Injuries to the supporting soft tissue structures of the spine are best identified on T2W images, preferably with Fat Saturation. These ligamentous structures normally appear as thin hypointense bands on all pulse sequences. MRI is also extremely valuable in the diagnosis of disc extrusion secondary to trauma, which is relatively common in dogs, even in the absence of concurrent vertebral fracture and/or subluxation/luxation. In most cases, traumatic disc extrusion is non-compressive and spinal cord trauma is due to contusion or intramedullary disc herniation, as typically seen with acute non-compressive hydrated nucleus pulposus. Pre-existing degenerative intervertebral disc disease may be a predisposing factor for spinal cord compression after traumatic extrusion.

Last, MRI is useful to identify paravertebral, intraspinal extradural or intramedullary hemorrhage that can happen secondary to traumatic spinal injuries in dogs and cats. T2*W Gradient Echo pulse sequences have been reported to be useful in identification of extradural or intramedullary hemorrhagic changes in dogs. Signal voids due to susceptibility artifacts associated with hemoglobin by-products are typically seen. Epidural space hemorrhage (hematomas) can also cause focal epidural masses that are of variable signal depending on the age of the lesion, and rarely contrast-enhance. Variable degrees of spinal cord compression may be present secondary to these epidural lesions. Intramedullary hemorrhagic changes are also associated with susceptibility artifacts causing low-signal foci on T2*W and, potentially, T2W images. They are typically associated with a more severe neurologic grade at presentation and poorer prognosis.

REFERENCES


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