Imaging Diagnosis of Nontraumatic Neurologic Emergencies

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Wendy R. K. Smoker, MD, University of Iowa Hospitals and Clinics, Iowa City, Iowa, USA, addressed an array of emergency situations, including orbital pathologies affecting vision, neck infections that may affect the airway, odontogenic infections, and intracranial complications of acute sinusitis.

Traumatic vision loss can be caused by open globe injuries, lens dislocation, retinal detachment, or orbital fractures. Other emergency orbital conditions include acute orbital infection, pseudotumor, subperiosteal orbital hematoma, and carotid-cavernous fistula (Table 1).

Several types of throat and neck conditions can threaten the airway (Table 2). Dr Smoker emphasized the importance of butterfly imaging for these conditions. In patients with amalgams causing artifacts in areas of interest, it is important to get angle or butterfly images to see behind the amalgams.

Frontal or ethmoid and sphenoid sinusitis infections have the potential for intracranial complications, but direct extension from the maxillary sinus to critical structures is rare. Acute sphenoid sinusitis can be complicated by epidural abscess in the middle cranial fossa and extend into the masticator space. Superior ophthalmic vein thrombosis or cavernous sinus thrombosis can be seen in sphenoid sinus disease. Acute frontal sinusitis can be complicated with Pott puffy tumor or intracerebral abscess.

Patrick Turski, MD, University of Wisconsin, Madison, Wisconsin, USA, discussed the differential diagnosis of intracranial hemorrhage, its appearance on computed tomography (CT) and magnetic resonance imaging (MRI), and its complications. Spontaneous primary intracranial hemorrhage is caused by hypertension (36%) or amyloid angiopathy, whereas secondary intracranial hemorrhage can be due to aneurysm (36%), arteriovenous malformation (AVM), and other (17%), including hemorrhagic transformation of ischemic infarction, venous thrombosis, hemorrhagic neoplasms, and vasculitis. Table 3 summarizes the imaging evaluation of intracranial hemorrhage.

Hypertension leads to arteriolar degeneration, resulting in lacunar infarcts caused by arteriolar sclerosis or Charcot-Bouchard aneurysms caused by arteriolar dilatation. A focal area of enhancement >1.5 mm indicates a Charcot-Bouchard aneurysm. The most common location of hypertensive hemorrhage is the putamen and external capsule (60%), followed by the thalamus (20%), pons (10%), cerebellum (5%), and subcortical white matter (5%). A poor prognosis is associated with age >80 years, hemorrhage volume >30 cc, and posterior fossa or intraventricular extension. CT of a hematoma over time shows increasing attenuation due to clot retraction, cells, and platelets (50 to 60 HU), followed by a 1.5-HU/d decrease in attenuation due to increased hydration. Rim enhancement appears in 1 week and persists for 8 to 12 weeks.

Cerebral amyloid angiopathy (CAA) accounts for about 20% of spontaneous hemorrhages in the elderly. It is associated with amyloid deposition in the vessel walls and surrounding tissues. Patients aged >55 years with lobar, cortical, or subcortical microhemorrhages meet the Boston criteria for probable CAA.

In a study of aneurysm growth and rupture, 18% of all aneurysms grew during the follow-up of 2.4 years [Villablanca JP et al. *Radiology*. 2013]. There was a 12-fold increase in rupture for growing aneurysms of all sizes. Other risk factors were smoking and aneurysm size >5 mm at presentation.

Vascular malformations that can lead to hemorrhage include pial AVM, dural arteriovenous fistula, cavernoma, and developmental venous anomaly. Ischemic infarction can undergo hemorrhagic transformation. The risk is increased following therapy, with increased permeability of the infarct core. Venous thrombosis can occur in a variety of conditions, including Crohn disease, transverse sinus–vein of Labbe thrombosis, and cerebritis. Vasculitis can be primary or secondary due to autoimmune diseases, drug use, or other causes.

In conclusion, CT and CT angiography are the primary tools for diagnosing nontraumatic central nervous system hemorrhage. MRI with susceptibility-weighted imaging is used for amyloid angiopathy. Imaging studies should be used to determine the location, look for evidence of active bleeding, identify underlying lesions, and determine the size of hematomas and mass effect.

According to E. Turgut Tali, MD, Gazi University School of Medicine, Ankara, Turkey, nontraumatic spine emergency (NTSE) should be considered in patients with spontaneous limb weakness, paresthesia, progressive inability to ambulate, cauda equina syndrome, or rapid onset of a severe neurologic syndrome. The NTSE incidence rate varies from 11 to 70 per million in different countries and may

Table 1. Acute Orbital Conditions Causing Vision Loss

Orbital Conditions	Features
Orbital infection	
Preseptal cellulitis	Usually children aged < 5 y
	Periorbital induration, erythema, tenderness
	Preseptal, upper eyelid edema
	Postseptal space clear, proptosis, stranding of retrolobular fat
	Antibiotics
Postseptal infection	Includes subperiosteal phlegmon or abscess, cellulitis, orbital abscess
	Proptosis, chemosis, ophthalmoplegia, decreased vision
	Frank abscess between periorbita and bone
	Inferior lateral displacement of orbital structures
	Limitation of extraocular muscles
	Intravenous antibiotics
Orbital pseudotumor	Nonspecific, idiopathic inflammatory condition
	Rapidly developing, unilateral, painful ophthalmoplegia, proptosis, chemosis
	Rapid, lasting response to steroid therapy
Subperiosteal orbital hematoma	Rare complication of trauma; leukemia or blood dyscrasia
	Most common in children and young adults
	Painful unilateral proptosis
	Most common in orbital roof
	Can be continuous with extradural hematoma
Carotid-cavernous fistula	Abnormal communication between cavernous segment of internal carotid artery and cavernous sinus
	Chemosis, proptosis, exophthalmos, and bruit
	Danger signs: intracranial hemorrhage or cortical venous shunting; rapid vision loss

Table 2. Throat and Neck Emergencies That Threaten the Airway

Orbital Conditions	Features
Peritonsillar abscess	May extend into the PPS, MS, or SMS
	Unilateral bulging tonsil
	Treated with incision and drainage, antibiotics, later tonsillectomy
	Imaging needed if trismus or progression
Retropharyngeal abscess	Potentially life-threatening
	ICA spasm common
	Imaging to evaluate abscess
	Antibiotics
Epiglottitis and epiglottic abscess	Airway compromise
	Swollen, thickened epiglottis
	Perform tracheostomy or intubation
	Imaging to evaluate abscess
	Antibiotics, steroids
Odontogenic infections	Can spread to MS, PPS, SLS, SMS
	Imaging to evaluate infection and abscesses
	SMS abscess–can have fat edema, stranding
	Incision and drainage of abscesses, antibiotics
Ludwig angina	Usually odontogenic (90%)
	SLS and SMS, often bilateral
	Gangrene or phlegmon; cellulitis, not abscess; no pus
	Staphylococcus or *Streptococcus* species
	Spreads contiguously
Necrotizing fasciitis	Asymmetric fascial thickening, gas along fascial planes
	Can be odontogenic
	Usually not well-defined abscess
	Rapid progression
	Airway compromise can be early complication
Lemierre syndrome	Septic thrombosis of IJV typically following oropharyngeal infection, usually tonsillitis
	Fusobacterium necrophorum
	Neck tenderness
	May have respiratory distress due to septic pulmonary emboli
	High mortality
	Evaluate with neck, chest imaging

ICA, internal carotid artery; IJV, internal jugular vein; MS, masticator space; PPS, parapharyngeal space; SLS, sublingual space; SMS, submandibular space.

result from a variety of causes [van den Berg MEL et al. *Neuroepidemiology*. 2010]. Clinical findings and symptoms are often nonspecific. The most common causes are tumors, inflammation, and infections. Types of NTSE conditions include congenital disorders, degenerative diseases, inflammation, neoplasms, tumor-like lesions, vascular disorders, hematologic diseases, and metabolic diseases.

The pathophysiology of myelopathy involves both static factors causing compression and dynamic factors resulting in repetitive spinal cord injury. A history and physical examination often localize the abnormality to the spine. Prompt imaging of the spine, spinal cord, and roots is necessary to evaluate the abnormality. MRI is the modality of choice, with the addition of fat-suppressed and contrast-enhanced sequences. Digital subtraction angiography is useful for evaluating vascular emergencies.

Conventional MRI sequences cannot reliably differentiate between benign compressions and those secondary to myelomatous infiltration. Diffusion-weighted imaging may be useful in such cases. Early imaging diagnosis

Table 3. Imaging Evaluation of Intracranial Hemorrhage

Type of Hemorrhage	Imaging Evaluation
Hypertensive Charcot-Bouchard Hypertensive hematoma	> 1.5-mm enhancement CTA important for identifying spot sign About 30% of patients have spot sign, of whom about 75% will have hematoma expansion [Wada R et al. *Stroke.* 2007] CT and MRI for monitoring hematoma evolution over time Edema halo on CT or MRI
Cerebral amyloid angiopathy	Lobar hemorrhage on MRI T2*-weighted microhemorrhages in subcortical white matter High-signal intensity on diffusion-weighted imaging Reduced signal intensity on ADC map Inflammatory cerebral amyloid angiopathy characterized by white matter edema, inflamed amyloid-filled vessels Leptomeningeal amyloid angiopathy: siderosis due to recurrent small SAH visible on T2* and SWI SWI more sensitive than T2* for detecting microhemorrhages [Haacke EM et al. *AJNR Am J Neuroradiol.* 2007]
Aneurysmal SAH	Evaluated with CT, CTA, CTP T2 flair (sensitive but not specific) Phase-contrast MRA cardiac gated to evaluate flow characteristics Graded with the Fisher grading scale based on CT findings and Hunt and Hess grading scale
Arteriovenous malformation	Evidence of hemosiderin on MRI (prior hemorrhage) Evaluate for aneurysms, deep venous drainage, venous outflow obstruction (risk factors for hemorrhage)
Dural arteriovenous fistula	Evaluate for enlarged dural arteries, occluded dural sinus, venous hypertension Types: fistula within sinus wall with antegrade drainage ± cortical vein reflux; direct cortical drainage, no venous ectasia (40% hemorrhage); venous ectasia (60% hemorrhage) [Gandhi D et al. *AJNR Am J Neuroradiol.* 2012]
Cavernoma	"Popcorn" bright center, dark rim Blood products, calcification Single or multiple lesions 10% to 33% associated with a developmental venous anomaly
Developmental venous anomaly	MRI: T1+ contrast, SWI/SWAN, T2*, CBV, FMT Medusa-head appearance Associated cavernoma Venous thrombosis Perfusion: prolonged mean transit time and increased CBV Up to 30% have hypodense foci on SWI [Takasugi M et al. *AJNR Am J Neuroradiol.* 2013]
Ischemic infarction-hemorrhagic transformation	Dense middle cerebral artery Hemorrhagic transformation risk factors: microhemorrhages, very low CBV, very low ADC, increased permeability
Vasculitis	MRA beading or string of sausage Not excluded by normal MRI or MRA Digital subtraction angiography or leptomeningeal biopsy may be required

ADC, apparent diffusion coefficient; CBV, cerebral blood volume; CT, computed tomography; CTA, computed tomography angiography; CTP, computed tomography perfusion; FMT, fluorescent molecular tomography; MRI, magnetic resonance imaging; MRA, magnetic resonance angiography; SAH, subarachnoid hemorrhage; SWAN, susceptibility-weighted angiography; SWI, susceptibility-weighted imaging; T2*, T2 star.

of spondylitis, discitis, and epidural infection facilitates prompt treatment. Spinal cord injury caused by rheumatoid arthritis is characterized by transverse atlantal ligament laxity and atlantoaxial subluxation, vertical subluxation, odontoid erosion, and pannus around the odontoid.

Spinal cord involvement in multiple sclerosis typically occurs in the dorsolateral regions of the cervical cord. Neuromyelitis optica is characterized by lesions extending contiguously over ≥3 vertebral segments. Acute transverse myelitis affects >2 vertebral segments and involves smooth cord expansion in the central cord location. In Guillain-Barré syndrome, imaging shows a normal conus/slight prominence of root size, avid enhancement of the pial surface of the distal core, and cauda equina demyelination. Mass effect of vasogenic edema, slight cord swelling, and variable enhancement are seen in acute disseminated encephalomyelitis.

Schwannoma is the most common intradural extramedullary mass. Imaging shows cord displacement, meniscus sign, and marked enhancement. Ependymomas occur in the central canal, most commonly in the cervical, thoracal, and filar regions. In patients with intracranial hypotension due to cerebrospinal fluid (CSF) leakage, radionuclide and CT cisternography can localize the CSF leak. Magnetic resonance cisternomyelography with intrathecal gadolinium has 90% sensitivity for CSF leakage [Algin O et al. *Neuroradiol.* 2011].

Nontraumatic causes of spine injury should be considered when a patient presents with acute spine symptoms. The primary diagnostic challenge is to identify a treatable abnormality.