What the Radiologist provides in the diagnosis of Spontaneous Intracranial Hemorrhage (SICH).

Specialty Area: Neuroradiology, Medical Physics: Research Interest - Hemorrhagic Stroke

Speaker: Patrick Turski, M.D.

University of Wisconsin –Madison

The imaging evaluation of spontaneous intracranial hemorrhage (SICH) employs three modalities, computed tomography (CT), magnetic resonance imaging (MRI) and digital subtraction catheter angiography (DSA). The modalities are complementary with specific roles and clinical applications. The primary modality to detect SICH remains CT which is fast, widely available and can be obtained even in uncooperative patients. The initial non contrast CT of the head can be supplemented by performing CT angiography, CT perfusion and post contrast CT images to assess for contrast enhancement or extravasation. Magnetic Resonance Imaging (MRI) of SICH is frequently obtained in the subacute setting to identify underlying pathology. MRI is also supplemented by MRA and MR perfusion to further characterize the hemorrhage and surrounding tissues. Digital Subtraction Angiography (DSA) requires invasive arterial catheterization but has the advantage of very high spatial and temporal resolution. The access to the arterial system during the DSA exam also provides a potential pathway for endovascular treatment of lesions such as intracranial aneurysms.

When a spontaneous intracranial hemorrhage is identified by CT, the radiologist tries to determine if it is a primary hemorrhage (hypertension and amyloid angiopathy) or a secondary hemorrhage (aneurysm, vascular malformation, hemorrhagic transformation of an infarct, venous thrombosis, hemorrhagic neoplasm).

Imaging of Primary SICH: Intracranial hemorrhage due to chronic hypertension is the most common cause of spontaneous intracranial hemorrhage and accounts for approximately 36% of all hemorrhages. It is causes by degeneration of the arterioles leading to the development of micro aneurysms (Charcot Bouchard aneurysms). The aneurysms form at the termination points of penetrating arteries and thus the locations of hypertension hemorrhage corresponds to the distribution of the perforating arteries. In addition to non contrast CT, CTA adds additional information by excluding an underlying aneurysms or vascular malformation. In approximately 30% of patients CTA also identifies the bleeding site (spot sign). More than half of the patients with a spot sign will have expansion of the hematoma leading to a worse prognosis.

In patients over the age of 60 primary SICH may also occur due to cerebral amyloid angiopathy. The deposition of beta amyloid in small and medium size vessels leads to vessel fragility vessel rupture can produce micro or macro hemorrhages. MRI Susceptibility Weighted Imaging (SWI) is a key component of the evaluation of these patients. The presence of greater than 5 micro hemorrhages in the cortical or subcortical regions with or without lobar hemorrhage supports the diagnosis of amyloid angiopathy.

Imaging of Secondary SICH: Subarachnoid hemorrhage (SAH) due to a ruptured intracranial aneurysm accounts for approximately 36% of all intracranial hemorrhages. The initial evaluation encompasses CT, CTA and in selected patients CT perfusion. The distribution of the SAH aids in the identification of the culprit aneurysm. CT is also valuable for the detection of hydrocephalus and follow up CTA / CT perfusion studies can assist in the detection of vasospasm. Although fluid attenuated inversion recovery MRI (FLAIR) has a high sensitivity for the detection of SAH, the finding of high signal intensity in the subarachnoid space is non-specific and can be seen with other processes that increase CSF protein. MRA plays a major role in the screening of patients for aneurysms, the follow up of patients treated by coil embolization of the aneurysm, detection of wall enhancement and assessing the underlying hemodynamics using 4D Flow MRI.

Although CT and CTA are effective for the detection of hemorrhage related to vascular malformations MRI and MRA offers several advantages. MRI is superior to CT in defining the location of the vascular malformation, the presence of hemorrhage of various ages, enhancement of the aneurysm wall and the detection of associated edema and gliosis. The typical MRA protocol includes 3D TOF and time resolved contrast enhanced MRA. There is a growing interest in using 4D Flow MRI to display flow characteristics of the vascular malformation. When cavernous malformations and developmental venous anomalies are encountered SWI is particularly helpful in identifying blood breakdown products (hemosiderin) from previous hemorrhages and displaying the venous anatomy based on signal loss due to deoxyhemoglobin.

MR diffusion weighted imaging is highly sensitive and is widely used for the detection of cerebral infarction. MR perfusion imaging is used to identify the penumbra, a hypo perfused region surrounding the infarct. Infarcted tissue results in alterations in the blood brain barrier and permeability increases within the core of the infarct. Hemorrhagic transformation of an infarct may occur when perfusion is reestablished to the territory of the infarct either spontaneously or after thrombolysis. Reperfusion hemorrhages have been reported to occur more frequently within regions of increased permeability.

Venous thrombosis may lead to venous hypertension, reduced perfusion and venous infarction. The MRI characteristics of the parenchymal hemorrhage and well as the intravascular thrombus will depend on the age of the hemorrhage or thrombus. MR venography using TOF, contrast enhance MRA or phase contrast MRA is essential for complete delineation of the intracranial venous system.

One of the major advantages of MRI is the high sensitivity for the detection of primary and metastatic intracranial neoplasms. Tumors with high vascularity may present as intracranial hemorrhage. In this instance MRI is invaluable for the detection of a neoplastic process underlying the hemorrhage. Occasionally, the hemorrhage may obscure the neoplasm, follow up MR exams may be required to identify the underlying mass.

Challenges for future MR research related to SICH should focus on topics such as: techniques to assess arteriolar degeneration in patients with hypertension or amyloid angiopathy, improved vessel and aneurysm wall imaging, faster 4D Flow MRI processing to identify high risk aneurysms, fast whole brain 4D CE MRA to improve characterization of vascular malformations, methods to identify SAH that equal or exceed CT in all regions of the brain and quantitative methods to measure perfusion and permeability in acute stroke.

Suggested Reading.

Khosravani, H., Mayer, S. A., Demchuk, A., Jahromi, B. S., Gladstone, D. J., Flaherty, M., … Aviv, R. I. (2013). Emergency Noninvasive Angiography for Acute Intracerebral Hemorrhage. *American Journal of Neuroradiology*, *34*(8), 1481–1487. doi:10.3174/ajnr.A3296

Broderick, J. P., Connolly S., … Zuccarello M. (2010). Guidelines for the Management of Spontaneous Intracerebral Hemorrhage : A Guideline for Healthcare Professionals From American Stroke Association Stroke/ American Heart Association. *Stroke*, *41*(4) 2108-2129. doi:10.1161/STR.0b013e3181ec611b

Fischbein, N. J., & Wijman, C. A. C. (2010). Nontraumatic Intracranial Hemorrhage. *Neuroimaging Clinics of North America*, *20*(4), 469–492. doi:10.1016/j.nic.2010.07.003