Preface

This book is designed for the medical practitioner who is not specializing in diagnostic radiology. It is organized by the clinical presentations of your patients and the medical imaging procedures you are likely to use while diagnosing or evaluating those clinical problems. We believe this patient-oriented approach provides a uniquely practical and useful radiology reference for the student and practicing medical provider.

Edward C. Weber has been a private practice radiologist for more than 30 years and has also been teaching radiology to first and second year medical students at the Indiana University School of Medicine in Fort Wayne (IUSM-FW) for about twenty years. He guided the orientation of this book and provided almost all of the radiologic and clinical information. This was done while practicing full time – thus, most of this book was written on weekends!

Joel Vilensky is an anatomist who has been teaching at IUSM-FW also for more than 30 years. His role was primarily to ensure that all of the textual and graphic material presented in this book could be completely understood by students who have taken a course in medical anatomy and who have had some basic clinical experience.

Alysa Fog is a practicing PA specializing in orthopedics. She ensured that the material was ideally presented for students and beginning medical professionals. AF also contributed much of the organization and clinical material for chapter 2.

Because this book will teach you how to use radiology as a clinical tool, the chapters are arranged by clinical presentation, generally with separate *Modalities* and *Interpretation* sections for each group of conditions. For each clinical problem we present the most appropriate imaging procedures for evaluation and diagnosis of your patients.

Unique to this radiology text, we indicate when it is *unlikely* that a radiologic study will change the diagnosis or treatment of your patient. In other words, we say when history, physical and/or laboratory studies should be sufficient to diagnose your patient. We also emphasize instances when more costly radiologic procedures, such as MRI, are likely to be no more useful to diagnosis than less expensive procedures such as radiography. This information can be found under the heading of *Cost-Effective Medicine.*

We have included special sections that contain information particularly relevant to children and the elderly.

We also cover radiology-related *Patient Communication* issues you will face, such as explaining the results of radiology procedures that your patients have had.

Each clinical chapter includes an example case that illustrates the use of imaging in one or more of the clinical situations described in the chapter. Each chapter also has a table showing clinical information that should accompany a radiology order for specific conditions. At the conclusion of each chapter there are five to ten review questions.

We provide a glossary in which we not only define bolded terms found throughout the book, but also indicate the imaging modalities to which the terms apply.

We have carefully selected radiologic images to accompany the text that illustrate the characteristic appearance of the described pathological conditions. Within the images, we use red arrows to indicate pathology and blue to indicate normal anatomy.

The concluding chapter in this book discusses issues that influence how your use of medical imaging affects the patient care you provide.

In all aspects of this text we have striven to offer images and information of the highest quality possible, to present the information in the most pedagogically effective way possible, and to render a resource that all medical providers will find invaluable as they seek to provide the best patient care possible.

— *Edward C. Weber*
Joel A. Vilensky
Alysa M. Fog

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4 EYES, EARS, NOSE AND THROAT

CASE STUDY A 65–year-old female with no significant medical history other than mild hypertension presents with complaint of progressive headache during the last month. She has no allergies or any symptoms or signs of sinus disease. There is no nuchal rigidity. Although she denies other symptoms, her husband reports that her speech is mildly changed, with slight slurring of speech that is new for her. You order MRI with contrast enhancement.

FUNDAMENTALS OF BRAIN IMAGING

Radiography of the skull has little or noo value because it does not directly visualize intracranial contents. For example, a skull fracture can be seen on radiographs but that finding poorly correlates with the degree of intracranial injury.

The ability to directly visualize the central nervous system with CT and MRI in adults, and with ultrasound in infants, has revolutionized the triage of neurologic patients between medical and surgical conditions. The speed of CT imaging and its sensitivity to detection of hemorrhage has great advantages in the setting of an acute emergency. The soft tissue contrast of MRI provides much more information than CT about the brain in subacute and chronic neurologic conditions.

Neuroradiology also includes diseases of the spinal cord, which in this text is covered in Spine Imaging (Chapter 3), and overlaps with EENT imaging (Chapter 5).

TRAUMA

The fundamental clinical issues in closed head trauma include level of consciousness and if there was a history of loss of consciousness after trauma because these details of clinical history are part of well established and widely used clinical criteria for deciding if imaging is indicated after head trauma. . For example, patients who suffer an epidural hematoma often have a "lucid interval" after an immediate post-trauma loss of consciousness, but that lucid interval should not distract from the essential historical point of loss of consciousness that suggests that a serious intracranial injury may have occurred.

Modalities

When imaging is indicated for closed head trauma based on clinical criteria such as the Glasgow Coma Scale, non-contrast (unenhanced) CT is the appropriate imaging procedure.

COST EFFECTIVE MEDICINE

There is low diagnostic yield from CT when patients have had minor head injury and high Glasgow Coma scores.

Closed head trauma is often associated with cervical spine trauma. In this case, both the cervical spine and head can be immediately studied with CT. In some cases, especially when there is a neurologic deficit not completely explained by the findings on CT, additional examination with MRI is needed. When there is clinical concern that traumatic carotid or vertebral artery dissection has occurred, MR angiography (MRA) , or CT angiography (CTA) may be necessary.

When you suspect skull base injury, perhaps along with injuries to the craniocervical junction, thin section helical CT

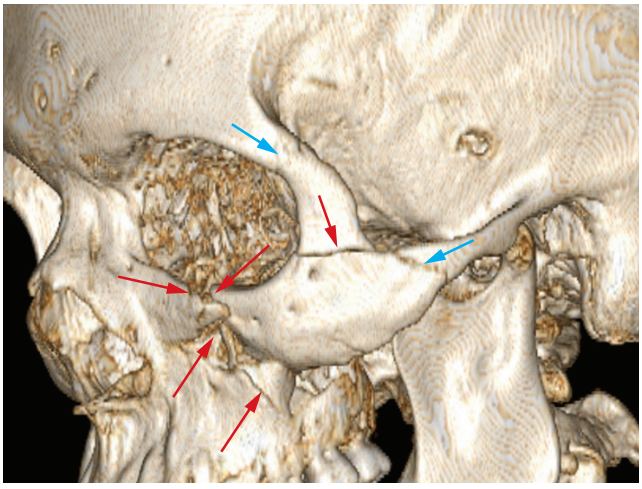


FIGURE 4-1 Axial CT image with brain window setting showing an epidural hematoma (arrows). Images using bone window setting (not shown) revealed a skull fracture.

scanning with multiplanar reconstructions should be done, rather than the routine protocol for head CT that consists of axial 5 mm slice thickness, which do not provide the imaging dataset needed for viewing complex skeletal structures in multiple planes.

Interpretation

CT images are viewed with a bone window setting (see Chapter 1) to inspect for skull fracture, as well as window settings ideal for the supratentorial brain and the posterior fossa. Very precise windowing may be needed during interpretation to ideally display intracranial blood (dense on CT) just deep to the also radiographically very dense skull.

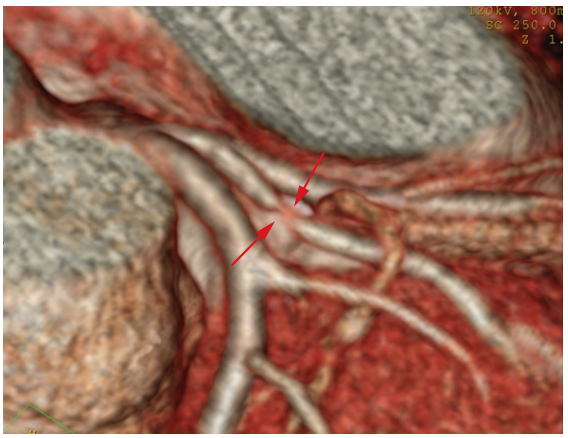


FIGURE 4-2 Axial CT demonstrating an acute subdural hematoma (arrows). Deep to the hematoma there is severe cerebral edema with positive mass effect.

The classic appearance of an acute epidural hematoma is a biconvex or lentiform high density fluid between the depressed brain surface and the skull, most often deep to a fracture that crosses the groove for the middle meningeal artery, as shown in Figure 4-1.

An acute subdural hematoma has a broader extent of the high density blood than an epidural hematoma and often has a concave inner margin rather than the biconcave shape of an epidural hematoma, as demonstrated in Figure 4-2.

When the otoscopic exam of a trauma patient shows blood in the external auditory canal and/or behind the tympanic membrane, thin section temporal bone CT will show not only the opacification of the middle ear with blood, but also a temporal bone fracture, for example.

A cephalhematoma (Figure 4-4), a sequel of childbirth trauma, is a subperiosteal hematoma of the outer surface of the skull that does not have neurologic significance. As the hematoma matures and calcifies it produces a hard lump or "knot" that is often quite persistent, causing alarm in parents that may lead to imaging that has little diagnostic value.

In older patients with cerebral cortical atrophy, bridging veins associated with the dura become more susceptible to shearing injuries and episodes of slow subdural bleeding with relatively minor trauma. The slow development of these subdural fluid collections is often associated with a delayed clinical presentation, unlike the clinical presentation of an acute post-traumatic subdural hematoma. The most common complaint for a chronic subdural hematoma is headache, often with the patient unable to recall an episode of trauma. See Figure 4-16.

ACUTE NON-TRAUMA NEUROLOGIC EMERGENCY (Stroke and Subarachnoid Hemorrhage)

A stroke is defined as a cerebrovascular event (or "accident" - CVA) that results in a neurologic deficit that persists for more than 24 hours. An acute cerebrovascular event with neurologic deficit that resolves within 24 hours is called a transient ischemic attack (TIA). Strokes are divided into ischemic strokes (with no intracranial bleeding) and hemorrhagic strokes. Acute subarachnoid hemorrhage (SAH) is a separate category from strokes because it has a different clinical presentation. Stroke and SAH are common medical emergencies for which successful treatment is critically time-dependent and requires immediate and appropriate medical imaging.

It is critically important that those stroke patients with intracerebral hemorrhage be identified (by imaging) because the thrombolytic treatments used for ischemic stroke increase bleeding, perhaps fatally, if used on a patient with a hemorrhagic stroke.

The characteristic history for a patient with an acute SAH (usually caused by a ruptured aneurysm) is the acute or hyperacute onset of "the worst headache of my life," often as-

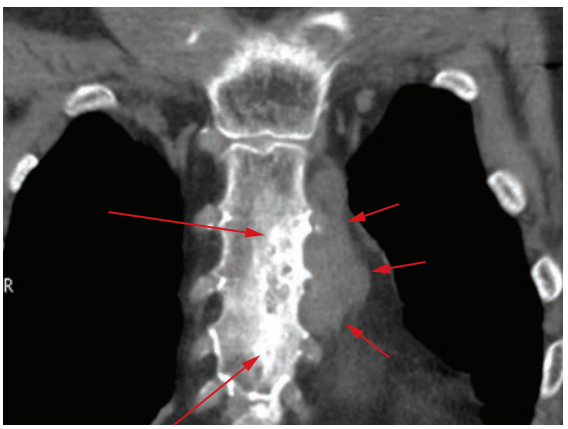


FIGURE 4-3 Thin section axial CT that shows a fine nondisplaced fracture of the petrous portion of the temporal bone (arrows) with hematoma (star) in the external auditory canal.

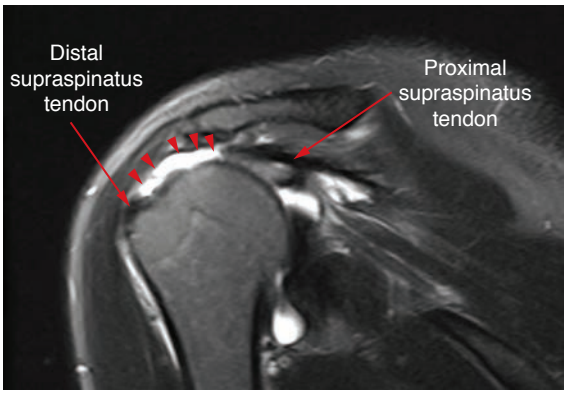


FIGURE 4-4 Axial CT of an infant with a cephalhematoma with a densely calcified rim (arrow). Note the fontanelle (star).

sociated with decreased level of consciousness, photophobia and other visual problems, and neck stiffness. Symptoms of acute ischemic stroke include dizziness, slurred speech, ataxia, double vision, unilateral motor deficits, unilateral paresthesias, paralysis, and decreased cognition.

Modalities

Although acute hemorrhage can be detected with MRI, it is more common to perform an urgent CT scan to differentiate ischemic from hemorrhagic stroke because unenhanced CT is a readily accessible and rapid procedure for imaging stroke victims during the time-critical hyperacute phase, the very few hours of *the therapeutic window*, in which cerebral damage can be minimized by the use of thrombolytic treatment. When no hemorrhage is found on CT, intravenous thrombolytic therapy can be administered even while further imaging is done. CTA and a CT brain perfusion study may be done to identify an obstructed artery and assess the territory of the brain deprived of blood flow.

COST EFFECTIVE MEDICINE

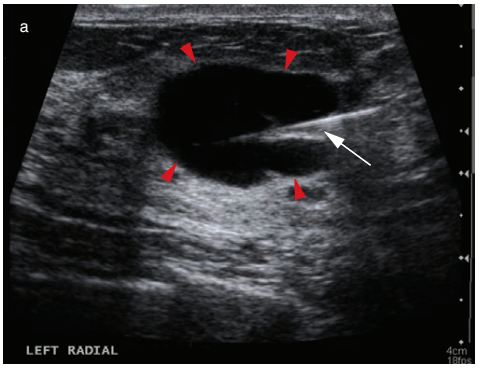
As an alternate to CTA and CT brain perfusion, many patients with stroke undergo multimodality evaluation with both CT and MRI. Although it may seem costly for a patient to undergo multiple expensive procedures, quality care sometimes requires an aggressive approach in order to minimize complications and achieve the best possible outcome.

In the patient with (nonhemorrhagic) ischemic stroke, the **diffusion weighted MRI sequence** (DWI), can detect an ischemic stroke as early as 30 minutes after an arterial occlusion, prior to any other positive imaging finding on CT or other MRI sequences. Almost immediately after the onset of stroke, there is increased intracellular water content within ischemic brain parenchyma. Those water molecules now in the intracellular compartment are less free to move than interstitial water molecules, and it is this *restricted diffusion* that is demonstrated with DWI. During the acute and subacute phases, DWI has an extremely high sensitivity and a high specificity (few false positives). MRA and MR brain perfusion studies are used in stroke patients as well.

Perfusion studies, whether CT or MRI, are used in ischemic stroke to map the extent of infarcted brain tissue and borderline ischemic tissue, *the ischemic* penumbra, which is at risk for infarction.

Stroke protocols for imaging vary among institutions, but have in common the goal of a rapid assessment of stroke when brain parenchyma is at risk of infarction, adhering to the principle that "time is brain."

Causes of intracerebral hemorrhage include tumors, hypertension, amyloid angiopathy, and vascular malformations.



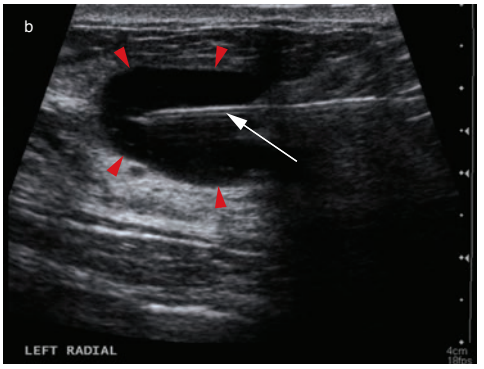


FIGURE 4-5 Axial CT demonstrating an acute intracerebral hemorrhage (star).

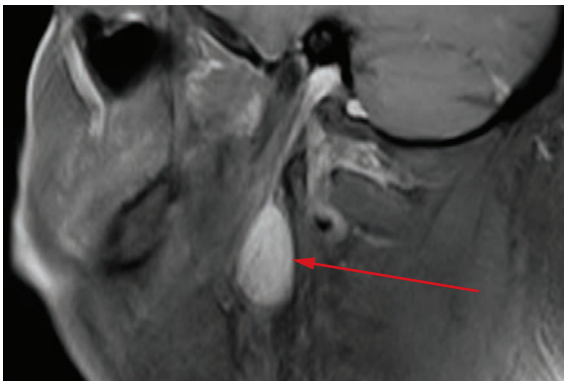


FIGURE 4-6 Axial T2 MRI of the brain with uncal herniation (solid star) impinging on the pons (arrow). There is a large area of vasogenic edema (open star) in the temporal lobe.

Additionally, thromboembolic (ischemic) strokes may cause infarction that is not initially hemorrhagic, but later hemorrhages as infarcted parenchyma breaks down. For these patients, MRI is needed for complete evaluation, even when a diagnosis has been initially established with CT.

SAH is usually caused by rupture of an aneurysm of the circle of Willis. When an SAH is found on CT or MRI, an immediate CTA or MRA can be performed to identify the bleeding vessel. (In patients with a family history of intracranial aneurysm, MRA is recommended for noninvasive screening for asymptomatic intracranial aneurysms.)

In the appropriate setting where aggressive intervention is available, invasive catheter angiography may be used in hemorrhagic stroke and SAH to stop bleeding. In ischemic stroke this intervention can be used for lysis and the physical removal of intraluminal thrombus from an obstructed vessel.

Unfortunately, not every patient who suffers a stroke seeks immediate medical attention. Subacute ischemic strokes/cerebral infarctions, and subacute intracranial hemorrhage are much better seen on MRI than CT.

Interpretation

Acute intracerebral hemorrhage is seen as a hyperintensity on CT within brain parenchyma, as shown in Figure 4-5, which is associated with **positive mass effect** that describes how the space occupied by a hematoma (or tumor, focal brain edema, abscess, cyst, etc.) displaces adjacent tissue. Within the confines of the skull, positive mass effect is a more critical issue than in other parts of the body. As a neurologic emergency, the complication of positive mass effect of an intracranial lesion (e.g., uncal herniation, subfalcine herniation) can be more immediately significant than the lesion itself (Figure 4-6).

SAH, which is associated with a high mortality rate, is seen on unenhanced CT as localized or diffuse increased CT density within the subarachnoid space in sulci, fissures, or basal cisterns. An example of an acute SAH is shown in Figure 4-7.

The imaging appearance of any intracerebral hemorrhage or hematoma varies over time due to the changes in characteristics of blood products over time on both CT and MR. In MRI, T1 and T2 signal intensity varies as a hematoma ages. You may likely see the phrase, *magnetic susceptibility* in MRI reports that refers to the paramagnetic effect of the iron content in hemoglobin on an MR image, specifically in **gradient echo sequences**. Hemosiderin within macrophages that linger at the site of even a very old hemorrhage can be detected on these sequences. For example, the MRI of a patient seen for an acutely bleeding arteriovenous malformations (AVM) may not only have a new hematoma, but also a focus of magnetic susceptibility at the site of an old hemorrhage from another AVM (they are often multiple), as shown in Figure 4-8.

Another example of the imaging of blood changing over time is that immediately after SAH, CT has extremely high sensitivity, but in the absence of continued bleeding, blood in the subarachnoid space becomes diluted with CSF, so there is progressive decrease in CT sensitivity in the hours and days after a hemorrhage. Therefore, CT can become significantly less sensitive for detecting SAH in the subacute phase than it is acutely.

When a patient has suffered a TIA, imaging, is focused on finding an underlying cause, for example an ulcerated plaque in the carotid artery that may be responsible for microemboli to the intracranial circulation. Similarly, when a patient presents with amaurosis fugax, a search is made for a cause of microemboli to the ophthalmic artery.

The CT findings of acute cerebral infarction in unenhanced CT may be very subtle, especially within the first few

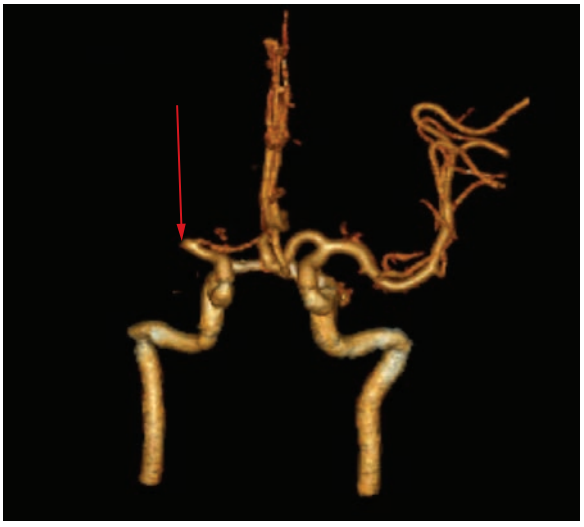


FIGURE 4-7 Axial CT that shows hemorrhage (arrows) in the subarachnoid space.

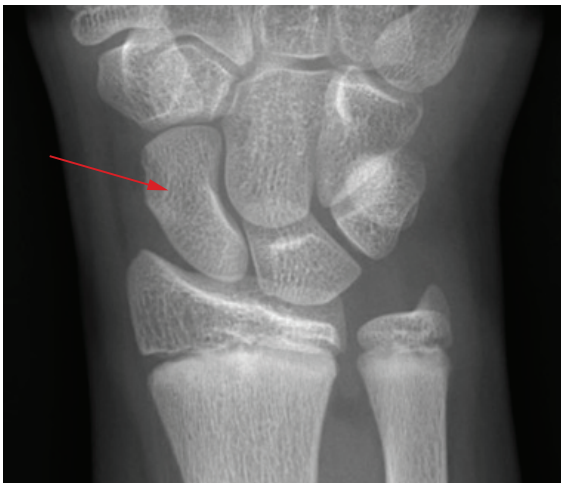


FIGURE 4-86 Axial MRI, gradient echo sequence image on a patient with multiple AVMs. The focus of magnetic susceptibility (arrow) is at the site of an old hemorrhage. The acute hemorrhage (not shown) was at a different location.

hours after ictus. A finding that suggests cerebral infarction is a decrease ("blurring") of the visible difference between gray and white matter, such as the **insular ribbon sign** in which the insular cortex is no longer visible as slightly hyperdense to the underlying subcortical white matter, and *obscuration* of the normal CT visibility of the basal ganglia (Figure 4-9). Another significant CT finding that you may see in radiology reports of CT done on stroke patients is the presence of the **hyperdense vessel** sign in which a thrombosed artery (most commonly the proximal middle cerebral artery [MCA]) is visible because intraluminal thrombus is denser than blood, as shown in Figure 4-10. Large cerebral infarctions, usually in the distribution of the MCA, can cause cerebral edema of the infarcted tissue that can be appreciated as effacement of sulci and narrowing of the Sylvian fissure. These findings are usually seen in the more extensive and severe cerebral infarctions. Acute cytotoxic edema may result in conspicuous decrease in density of affected parenchyma.

When acute ischemic stroke is diagnosed after unenhanced CT or MRI, treatment commonly involves the use of intravenous tissue plasminogen activator (tPA). However, advanced imaging procedures such as CT or MR perfusion studies, CTA, or MRA, may rapidly be done in many hospital settings when more aggressive treatment such as intra-arterial tPA, or transcatheter clot retrieval are being considered. As an example, Figure 4-11 is a volume rendered display from a CTA on an acute stroke patient, in which the right MCA is occluded.

Mild strokes often present to the practitioner in the subacute phase (days to several weeks), when CT may have a low sensitivity. In MRI, the DWI sequence is nearly 100% sensitive in detecting early subacute cerebral infarction, as shown in Figure 4-12.

HEADACHE

Although most headaches are idiopathic, headache may be a presenting symptom of serious pathology, such as brain tumor or abscess. Clinical judgment is essential in the very difficult task of separating the typical headaches likely to have very low diagnostic yield with imaging from those headaches that might be associated with serious pathology.

When headache is frontal, clinical evaluation may suggest that sinusitis is present (see Chapter 5). Some headaches, such as migraine and cluster headaches have characteristic clinical histories.

The following Modalities section applies to patients with generalized headache; a separate Modalities section is presented for unilateral headache.

Modalities

Unenhanced CT may be useful when there is a limited goal for imaging of ruling out large lesions or hydrocephalus. For chronic clinical problems, CT without and with contrast enhancement is better than unenhanced CT alone, but is not as sensitive or specific as unenhanced MRI of the brain. The most thorough and accurate examination can be expected from MRI without and with contrast enhancement. Unenhanced MRI has a very low false negative rate and is usually sufficient to rule out significant pathology. But when pathology becomes evident on unenhanced images, further refinement of imaging diagnosis with contrast-enhanced image sequences may be critical. It can be very efficient to order "brain MRI, contrast enhancement if needed" as shown in Table 4-1.

When brain imaging is ordered for an oncology patient for suspected intracranial metastases, it should always be done without and with contrast enhancement. Remember that for older and diabetic patients and those with known renal insufficiency, serum creatinine level and creatinine clearance should be obtained prior to MRI if the use of a gadolinium-based contrast agent might be needed.

Chronic Headache

There is a very low yield in neuroimaging on patients who have a history of headaches for many months or years. Chronic migraine patients do, however, have positive MR findings that reflect the micro-ischemic effects of the vasospasm that occurs with this disorder. Although MRI may have a low yield for detecting pathology that changes clinical management in these patients, a negative imaging study can have psychosocial value in providing needed reassurance to the patient.

Although most imaging studies that are done for chronic

TABLE 4-1 Sample Neuroradiology Requisition Information

Modality	Clinical Data/History
MRI brain, with contrast if needed MRI brain without/with Gd, attn. pituitary CT head w/o (pacemaker pt.) Dementia - R/O hydrocephalus	Progressive h/a, confusion, no focal findings hyperprolactinemia
MRI brain, wo/w contrast	h/a, weakness left side, stage 4 breast ca
Intracranial MRA	Intermittent h/a; fam hx intracranial aneurysm
MRI brain and orbits wo/w Gd	Visual disturbance, bilat arm and leg paresthesias - R/O optic neuritis, MS

headache show no significant pathology or result in change in clinical management, there can be an association between the chronic headache found with pseudotumor cerebri and the finding on MRI of an empty sella .

Recent Onset or Change in Character of Headache

Unlike chronic headache with no new neurologic problems, imaging is often appropriate, even mandatory, when headache in the adult is new, progressive, different than previous "routine" headache, and associated with neurologic complaints.

With Other Neurologic Symptoms and Signs

With major intracranial pathology, such as hydrocephalus, tumor, or abscess, the patient may present with a combination of complaints e.g., nausea, visual problems, slurred speech, behavioral changes, and ataxia or dizziness but also a new onset, change in the pattern of, or progression of headache. Additionally, seizure in an adult with no prior history of seizure, and no history of brain trauma that could have caused an epileptogenic lesion, is a very clear sign that the associated headache is not benign.

Elderly patients with chronic subdural hematomas may present with chronic headache, often with slowly progressive neurologic dysfunction such as difficulty with speech, memory, and ambulation.

INTERPRETATION

In children, adolescents, and younger adults, hydrocephalus is likely to be secondary to a tumor causing an obstructive (noncommunicating) hydrocephalus, such as a mass in the fourth ventricle, as shown in Figure 4-13 or an extraventricular mass impinging on the cerebral aqueduct (of Sylvius). A third ventricle lesion may cause dilatation of the lateral ventricles; the fourth ventricle is normal in these cases. See Box 4-1 for specific information regarding hydrocephalus in the pediatric and geriatric patient. This condition is discussed later in this chapter under Movement Disorders.

Box 4-1 Hydrocephalus

- **Pediatric**
  Hydrocephalus in infants is typically manifest as an enlarged head, usually detected during neonatal exams.
- **Geriatric**
  In elderly patients, hydrocephalus is more commonly a normal pressure hydrocephalus (NPH), and symptoms other than headache predominate.

A common, usually benign intracranial tumor, the meningioma, is characteristically a sharply marginated, homogeneously enhancing dural-based mass. A finding that is highly associated with the origin of this lesion from the dura, not the underlying brain, is that of a "dural tail," as shown in Figure 4-14.

Although these are usually benign histologically, the pressure they exert upon adjacent intracranial structures (mass effect) can lead to a wide variety of symptoms, including headache.

Intracerebral abscesses and malignant brain tumors are typically contrast-enhancing masses. Depending upon the histologic type, these may be centrally cystic or necrotic and have varied degrees of edema in adjacent brain tissue. When brain edema is caused by pathology such as trauma, infection, or tumor, there is increased water content in the interstitial space (unlike the intracellular edema that is found in an ischemic stroke), and is described as vasogenic edema. It is shown in MRI as decreased T1 signal and increased T2 signal. The vasogenic edema surrounding a brain lesion may also have significant positive mass effect that may be more profound than the mass itself. The vasogenic edema that is adjacent to tumor may obscure its margins and therefore gadolinium enhanced images are needed to provide precise delineation of its margins, an important issue for treatment (Figure 4-15).

As stated above, acute subdural hematomas are usually conspicuously dense in CT, whereas subacute subdural hematomas may be isodense to brain on CT, and may therefore be difficult to perceive.

In the elderly patient, as subdural hematomas evolve from subacute to chronic, the resorption of blood products in the hematoma may be so complete that the subdural fluid is low density on CT and easily seen. These are sometimes referred to as a subdural *hygroma*, common in the elderly who may develop a subdural fluid collection slowly after relatively minor trauma. A chronic subdural hematoma (hygroma) is shown in Figure 4-16.

CASE UPDAT The radiologist interpreting the MRI on your 65-year-old female patient with dysarthria calls you with the unformild-to-moderate vasogenictunate finding (that you suspected) of a left posterior frontal lobe enhancing mass (probable glioma). There is edema. You arrange for the patient an immediate consultation with a neurosurgeon. She is prescribed steroids to reduce the vasogenic edema and arrangements are made for surgery the following week.

With Signs of Meningeal Irritation

When nuchal rigidity suggests meningeal irritation, and is associated with extremely severe headache and decreased cognition, imaging is immediately done to rule out intracranial hemorrhage. However, when signs of meningeal disease are associated with fever and slow onset of headache, clinical concern may be directed towards meningitis. In this situation, a lumbar puncture (*spinal tap*), becomes an important diagnostic procedure, but must be done after a CT scan. The CT scan is used to rule out the presence of major intracranial pathology that may result in brain herniation through the foramen magnum when fluid is removed from the spinal canal during lumbar puncture. During the course of meningitis, additional imaging may be needed to identify intracranial meningeal inflammation, development of intracranial abscess, or the development of communicating hydrocephalus, which may be a complication of meningeal disease.

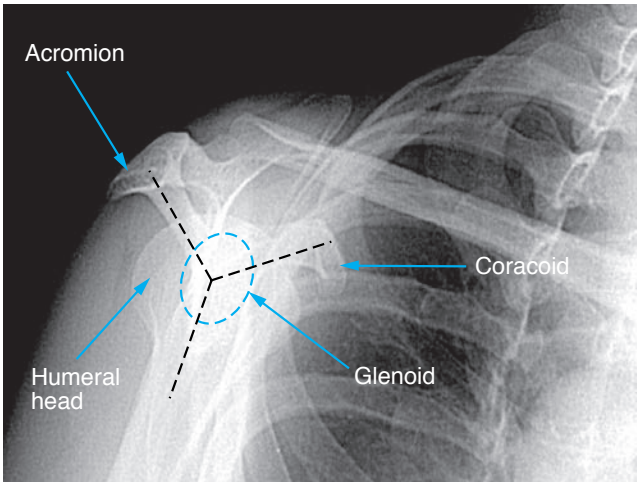


FIGURE 4-9 Axial MRI, gradient echo sequence image on a patient with multiple AVMs. The focus of magnetic susceptibility (arrow) is at the site of an old hemorrhage. The acute hemorrhage (not shown) was at a different location.

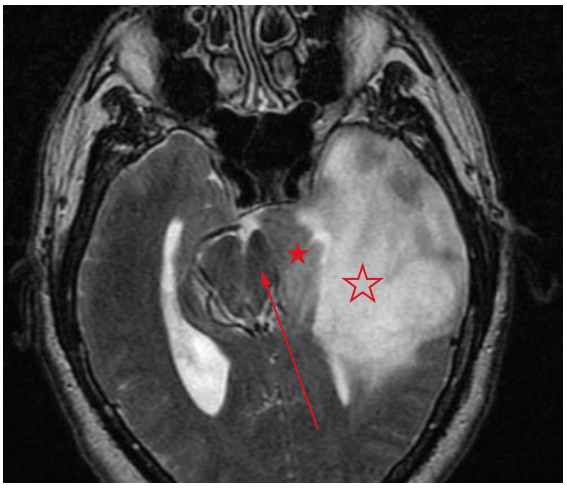


FIGURE 4-10 Axial MRI, gradient echo sequence image on a patient with multiple AVMs. The focus of magnetic susceptibility (arrow) is at the site of an old hemorrhage. The acute hemorrhage (not shown) was at a different location.

INTERPRETATION

For the complete intracranial evaluation of leptomeningeal disease, MRI done without and with contrast can directly visualize thickened and inflamed meninges, as shown by the red arrow in Figure 4-17.

In the Pregnant Patient

Headaches are common in pregnancy, mostly tension and migraine, but when there is a new onset of headache or very severe headache, the clinician should be alert to the possibility of serious neurologic conditions. The hormonal changes in pregnancy may cause rapid growth in a pre-existing intracranial lesion, such as meningioma or pituitary adenoma. Because pregnancy is a hypercoagulable state, intracranial vascular events such as intracranial venous thrombosis and pituitary apoplexy sometimes occur in the pregnant patient. Immediate and appropriate imaging is needed for prompt diagnosis and specific treatment of these conditions.

When the clinical presentation in the pregnant patient suggests acute intracranial hemorrhage such as with a ruptured intracranial aneurysm, unenhanced CT is indicated. The tight **collimation** (restricting and shaping by shielding) of the X-ray beam in a CT scan of the head and the simple application of a lead drape assures that the fetus will not be exposed to a significant dose of radiation.

Pituitary apoplexy usually develops over days, not hours as in a more typical intracranial hemorrhage, and, because of

mass effect on the optic chiasm, frequently is associated with visual disturbances. Unenhanced MRI provides a more comprehensive exam than CT, and enhanced MRI is usually not needed for this diagnosis. As noted above, there is a relative contraindication to the use of gadolinium-based contrast agents for MRI in pregnant patients because these agents pass through the placenta into fetal circulation.

INTERPRETATION

Using special flow-sensitive MR pulse sequences in which blood flow determines signal intensity, an unenhanced MR venogram (MRV) can be done when there is clinical suspicion of intracranial venous thrombosis (Fig. 4-18)

Pituitary apoplexy results in an enlarged pituitary that often has mixed signal characteristics of venous hemorrhage and thrombosis on MRI, as shown in Figure 4-19.

Unilateral Headache

Most unilateral headaches fall within the clinical patterns of those chronic headaches, such as migraine and cluster headaches, for which imaging is not generally needed. Temporal arteritis (giant cell arteritis) is most definitively diagnosed by temporal artery biopsy, although imaging is sometimes used during the work-up, and can be helpful. Acute unilateral headache with pain radiation and neurologic signs and symptoms that suggest arterial dissection, requires urgent imaging.

MODALITIES

Imaging is often not needed for evaluation of temporal arteritis. When clinical management may be altered by imaging, the superficial temporal artery can be evaluated with ultrasonography but this modality is less sensitive in detecting mild vascular changes than CTA, MRA, or invasive catheter angiography. Because non-invasive vascular imaging techniques have progressively improved, there is declining use of invasive catheter angiography for such a vascular diagnosis.

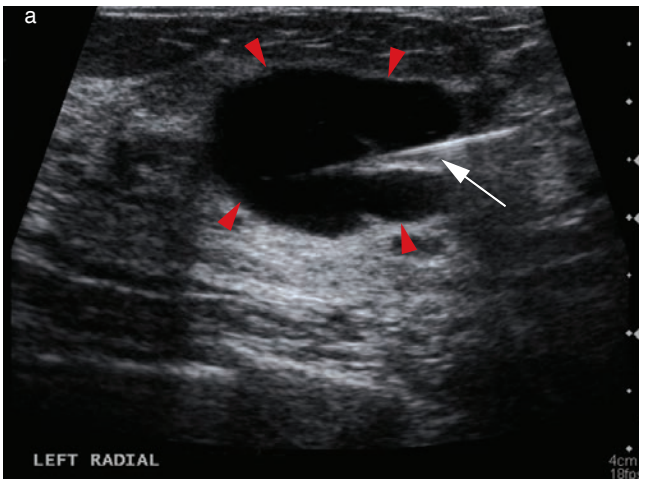


FIGURE 4-11 Axial MRI, gradient echo sequence image on a patient with multiple AVMs. The focus of magnetic susceptibility (arrow) is at the site of an old hemorrhage. The acute hemorrhage (not shown) was at a different location.

For imaging of suspected carotid or vertebral artery dissection, CTA or MRA is done, usually along with unenhanced brain CT to rule out hemorrhage, or along with brain MRI without and with contrast enhancement. When noninvasive imaging is not definitive and/or when trans-catheter intervention is planned, then invasive catheter angiography is appropriate in these cases.

INTERPRETATION

In temporal arteritis ultrasonography and high resolution MRI demonstrate evidence of arterial wall edema. In ultrasonography, the edema surrounding the artery results in a hypoechoic halo around the vessel.

Carotid or vertebral artery dissections are revealed by the presence of a dark line within the vessel that is the elevated flap of intima, as shown in the CTA presented in Figure 4-20.

DEMENTIA

Just as dementia is the loss of cognitive abilities beyond that expected of normal aging, the imaging findings in dementia may be significantly different quantitatively and qualitatively from the common (and expected) imaging changes of the aging brain. The diagnosis of dementias, including Alzheimer's disease (AD), is primarily clinical. Imaging is ancillary in the diagnostic work-up of dementia; however, it has been shown to increase diagnostic accuracy.

Vascular dementias are very common, either from small vessel disease causing white matter changes or multi-infarct dementia.

Modalities

MRI is the procedure of choice for identifying the white matter changes and cortical atrophy associated with dementia and the hydrocephalus associated with dementia in NPH. For these goals, unenhanced MRI is usually sufficient, with relatively little increased diagnostic yield from contrast-enhanced MR sequences; therefore, contrast-enhanced MRI is considered optional. In patients who cannot undergo MRI, unenhanced CT can reveal severe degrees of cerebral cortical atrophy and hydrocephalus. There is now also growing use of PET scanning in the diagnosis of dementia, because the information gained from PET scanning can be applied to newer specific treatment options.

Beyond routine MRI, advanced volumetric analysis of the hippocampus from MRI data is used in evaluation of AD. Emerging imaging techniques for evaluating patients with dementia include functional MRI, and SPECT scanning.

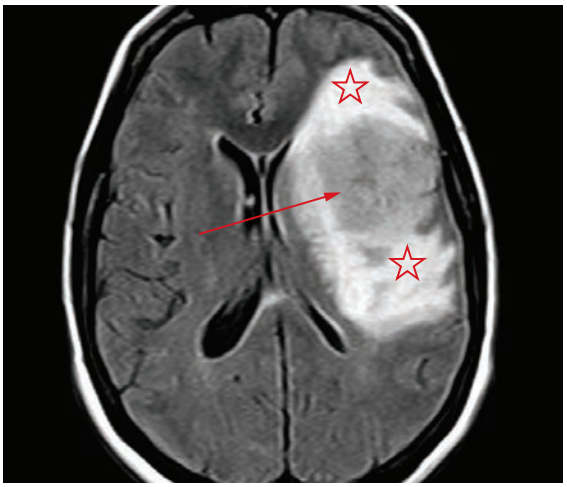


FIGURE 4-12 Axial MRI, gradient echo sequence image on a patient with multiple AVMs.

Interpretation

The normal aging brain commonly shows white matter changes that are progressive. The most common of these findings are so widely seen that they have been given the dismissive moniker of the "UBO," the unidentied bright object. These small foci of high T2 signal are commonly multiple, and widely distributed in the major white matter tracts of both cerebral hemisphere, as shown in Figure 4-30.
UBOs should not be misinterpreted as evidence of specific disease in patients older than 65.

More advanced and confluent white matter hyperintensity is often the result of widespread microangiopathic (small vessel) white matter changes, as shown in Figure 4-31.

Multi-infarct dementia is evident on imaging by the finding of multiple foci of gliosis and cystic encephalomalacia at the sites of numerous cerebral infarctions, as seen in Figure 4-32.

In addition to UBO's and more extensive white hyperintensity of chronic ischemic white matter changes, diffuse cerebral cortical atrophy is often seen in the aging brain. When there is disproportionate hippocampal cortical atrophy, a diagnosis of AD is considered. (Figure 4-33)

Dementias that are difficult to differentiate from AD are the frontotemporal dementias, of which Pick's disease is best known. The imaging findings reflect the desciption of these disorders by showing disproportionate cortical atrophy in the frontal and temporal lobes (Figure 4-34).

CASE CONCLUSION Your 65- year-old female patient who was given steroids for the vasogenic edema around her brain tumor had been feeling better, but the weekend before her planned surgery experienced an explosive onset of headache, labeled "the worst headache of her life." She is rushed to the Emergency Department where an immediate unenhanced CT is performed and revealing an intracerebral hemorrhage in the left frontal lobe, a positive mass effect, and signs of uncal herniation. She undergoes urgent neurosurgery to evacuate the hematoma and to biopsy the mass that pathology revealed to be a glioblastoma multiforme.
She has done well since surgery and is now enrolled in a clinical trial of new treatment for this usually fatal cancer.

Patient Communication **Box 4-1**

In many cases of testicular cancer, the imaging characteristics of the mass can provide a realistic measure of optimism to offer your patient. Although you must be careful to not offer a false promise, when a testicular mass is found that has imaging characteristics highly consistent with a pure seminoma, it is realistic for the patient to be very hopeful that surgery will reveal early disease with no metastases, in which case the long-term survival in this cancer is at least 95%.

Chapter Review

Chapter Review Questions

1. Which of the following associations is not correct?
   A. Epidural hematoma – skull fracture across groove for middle meningeal artery
   B. Chronic subdural hematoma – shearing of dural bridging veins
   C. Cephalhematoma – immediate CT and MRI needed
   D. Otoscopic exam showing blood behind tympanic membrane in a trauma patient – thin section CT temporal bone
   E. Head trauma - unenhanced CT
2. DWI MRI sequences are most important for the diagnosis of:
   A. chronic subdural hematoma
   B. acute ischemic stroke
   C. hemosiderin
   D. pituitary apoplexy
   E. empty sella syndrome
3. The contrast enhanced coronal T1 image shown above is important:
   A. to determine if this is a tumor which is malignant
   B. to definitively differentiate tumor from abscess
   C. to define margins of the tumor for treatment planning
   D. to determine if there is mass effect
   E. to determine if there is bleeding
4. Which of the following is TRUE pertaining to the appearance of blood in neuroimaging?
   A. Acute and chronic hematomas have the same density on CT images
   B. Acute and chronic hematomas have the same intensity on MR images
   C. On CT, an acute hematoma appears less dense than a chronic hematoma
   D. Magnetic susceptibility is associated with residual hemosiderin from an old hemorrhage on MR
   E. MRI is not useful in cases of intracranial hemorrhage.
5. Your diagnosis based on the above MRI image is?
   A. Hydrocephalus
   B. Epidural hematoma
   C. Subdural hematoma
   D. SAH
   E. Meningitis
6. T2 hyperintensity is consistently associated with:
   A. Parkinson's disease
   B. White matter diseases
   C. Alzheimer's disease
   D. Fronto-temporal dementia
   E. Pituitary apoplexy
7. Your diagnosis based on the above image is:
   A. ischemic stroke in the territory of the right MCA
   B. hemorrhagic stroke in the territory of the right of the ICA
   C. empty sella syndrome
   D. sigmoid sinus venous thrombosis
   E. SAH
8. Which of the following is incorrect pertaining to the images of patients with seizures?
   A. Children younger than 6 with febrile seizures need immediate imaging
   B. Adult seizure patients can usually be satisfactorily evaluated with unenhanced MRI
   C. Seizure activity is often associated with mesial temporal sclerosis
   D. Seizure activity may be associated with MRI showing increased T2 signal in the hippocampus
9. UBOs are:
   A. diagnostic for MS
   B. diagnostic for AD
   C. associated with venous thrombosis in pregnancy
   D. associated with empty sella syndrome
   E. normally found in the aging brain
10. Neuroimaging should routinely be ordered for patients with all of the following except:
    A. progressive headache
    B. chronic headache
    C. headache with focal neurologic signs
    D. _An acute severe headache that is described as the worst headache of their life.