NEUROIMAGING:
CT Studies

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CT Head

One of the most commons studies ordered from the emergency department, the CT head is as bread-and-butter to the radiologist as the chest radiograph. The most important processes to detect or exclude are major territory infarct and intracranial hemorrhage. Major blind spots in evaluation of the CT head include subtle hemorrhage layering in dependent portions of the CSF space as well as thin subdural collections over the convexities. Missed findings also include soft tissue lesions in the scalp/neck and venous infarcts, especially if in the more peripheral venous sinuses. An organized approach follows.

1. **Look at the indication, history, and priors.**

2. **Assess adequacy, technique, and limitations.**
    a. Use MPRs to re-orient the patient anatomy to standard planes as needed.

3. **Always look at the localizer (scout) views first for incidentals outside your field of view, and to prime you to major boney findings.**

4. **Start with the axials. Correlate with other projections as necessary.**

5. **Examine the extracranial soft tissues.**
    a. This is a major blind spot. Scalp findings may help prime you to detect more subtle but concerning findings at the underlying bone/brain in the setting of trauma.
        i. Look for scalp hematomas/soft tissue defects/skin nodules.
        ii. Check specifically at the parotid glands, external auditory canal, and any imaged tissues of the face.
    b. Check the posterior nasopharynx. Look for masses.
        i. Assess the fossae of Rosenmuller, tonsils, retropharyngeal lymph node spaces
        ii. If you see the base of tongue or mouth, check there as well.
    c. Check the orbits, especially for inflammatory change, mass lesion, and enlargement/thrombosis of the superior ophthalmic vein.
        i. Assess each globe for proptosis, shape/integrity, internal lesion. Assess each lens for position/presence/surgical change.
        ii. Check the extra-ocular muscles for enlargement or adjacent mass lesion.
        iii. Assess the integrity of the intraconal and extraconal fat.
        iv. Specifically check the superior ophthalmic veins for enlargement or occlusion (if contrast enhanced study)

v. Look for integrity of the optic struts, preservation of the fat planes within the superior and inferior orbital fissures.
vi. Misses at orbit are common.

d. In the setting of head in neck neoplasia/infection, it is important to check posterior to the orbits, for preservation of the fat in the pterygopalatine fossa, as well as the peri-antral fat planes.

6. Examine the bones, look for fractures, aggressive lesions.

a. Check the cranium. Use 3D-recons if available, especially for pediatric patients.
b. Look at the mastoid air cells and paranasal sinuses. Note any fluid or soft tissue.
c. Check the temporal bones, boney external/middle/inner ear. Look at the ossicular chain as well as contents of the otic capsule: semicircular canals and cochlea.
d. Examine the skull base.
    i. Get a look at all the foramina for the cranial nerves, the carotid canal, jugular bulb, foramen magnum. Look at the clivus. Skull base and clival lesions are easy to miss.
    ii. Check any imaged facial bones: the naso-orbito-ethmoidal (NOE) complex, zygomaticomaxillary complex, pterygoid plates (Le fort patterns), TMJs, mandible/teeth (if visible), cranio-cervical junction, atlantoaxial junction.
e. When looking for traumatic injury, use lung windows for air, i.e. pneumocephalus.

7. Examine the CSF spaces.

a. You're mostly looking for intracranial hemorrhage or mass lesion.
b. Look for extra-axial blood (SDH/EDH), check convexities over each lobe, the surfaces of the falx and tentorium. Be very careful adjacent to the temporal lobes and at the apex – also use the coronals for these.
    i. Scroll slowly, and insist on obtaining of thin slices. These findings may be very subtle.
    ii. Double check to make sure that you saw all the sulci. If they are not visible, this could indicate subacute SDH or brain edema.
    iii. Subtle increase in size or prominence of the extra-axial CSF space could reflect the more common diffuse volume loss, though could also reflect very subtle chronic subdurals, hygromas, or effusions. Look for subtle attenuation difference from CSF, mass effect on the gyri, or change from a prior.
c. Look specifically for subtle SAH.

i. There are 4 areas where SAH can easily missed. Check these first: the posterior temporal horns of lateral ventricles, dependent Sylvian fissures, sulci at the apex, interpeduncular cistern. 2 additional regions you may want to add to your checklist are within the cerebellar folia and dependent regions near the foramen magnum.

d. Check for intraventricular blood/mass: Check the lateral ventricles, 3rd and 4th ventricles.
   i. Look at the basal cisterns. Check the suprasellar, ambient, and quadrigeminal cisterns, CPA, IAC, pre-pontine, and cisterna magna.

e. Assess ventricular size.
   i. Are the ventricles asymmetric or large out of proportion to the sulci? Look at each of the lateral ventricles, the third, and forth ventricles.
   ii. Note change from priors, or associated periventricular hypodensity that could clue you into ventricular enlargement that is due to more than cerebral atrophy.
   iii. The temporal horns of the lateral ventricles are a sensitive area to detect early/subtle hydrocephalus. Width of the third ventricle can also be used as a sensitive marker.

8. Assess the brain parenchyma for intra-parenchymal blood/mass lesion.

a. Look at the frontal, temporal, parietal, occipital lobes. Check the cerebellum and brain stem.
b. Assess the basal ganglia.
c. Also look at the forceps major/minor, corpus callosum/cingulate gyrus for blood/mass.
d. Be particularly wary for contusions at the peripheral and inferior-most portions of the frontal, temporal, and occipital lobes.

9. Look for mass effect/herniation.

a. Look for deviation of the septum pellucidum from midline.
b. Are the ventricles or basal cisterns effaced anywhere? Especially the suprasellar cistern for uncal herniation, CSF space around the midbrain for trans-tentorial herniation, and foramen magnum for tonsillar herniation.

10. Look specifically for signs of ischemic stroke.

a. Check for each of the signs of large arterial territory infarct.
   i. Look for a hyperdense vessel at the MCA, ACA, PCA and basilar artery. Even smaller vessels may be seen to be hyperdense (M2-M3, A2-A3, PICA/SCA) with thrombus, though these may be too subtle to detect without localizing neurologic history.

1. When you assess the vessels, remember the common areas of aneurysm formation, and be ready to detect any incidental large aneurysm.

ii. Check for obscuration of basal ganglia, loss of insular cortical ribbon, loss of G-W differentiation of the overlying cortex. Thick sections will make loss of the G-W differentiation more conspicuous. Loss of cortical grey-white differentiation in the occipital lobes may be more conspicuous on the coronal and sagittal projections.

iii. Look for sulcal effacement and abnormal attenuation differences between the supra- and infra tentorial compartments.

iv. Common blind spots include the posterior fossa, brainstem, and thalamus. In addition to using the axials, checking these on the sagittals may provide greater sensitivity.

b. Look for central venous sinus thrombosis.

i. Look to see if there are hyperdense superior sagittal/transverse/sigmoid sinuses (HU>70). Check the jugular bulb for hyperdensity.

ii. Check for a hyperdense cavernous sinus, bulging cavernous sinus, and enlarged/asymmetrical ophthalmic vein. The venous sinuses are a common blindspot.

iii. Look for cortical venous infarcts, which may appear as linear hyperdensity over the convexity.

c. Look for watershed/global ischemia. Check for diffuse edema, loss of cerebral/cerebellar and deep gray grey-white differentiation. The fronto-parietal junction is often involved with watershed infarcts.

d. Look for lacunar infarcts. Check for focal hypodensities in basal ganglia, internal capsule, pons, and subcortical/periventricular white matter.

11. Consider briefly double checking for serious pathology as this point.

a. Prior to moving on to the other reconstructions, I often to an additional quick review of the cortex (especially the GW-junction), convexities, and CSF spaces for subtle mass lesions.

b. Typically, my first pass at these areas is in search of hyperdense lesions such as acute blood. On a quick double check, I'm looking for subtle distortion and other attenuation differences.

12. Examine the coronal reconstructions.

a. Do a second look for blood/mass. Check along convexities, especially at the apex, temporal convexities, falx, and tentorium, which are better seen.

b. Check for uncal and transtentorial hernia, which are also easier to see on the coronals.

c. Check the orbits. Assess the periorbital soft tissues, look for retro-orbital mass/collection.
d. Paranasal sinuses. Certain things are seen better here. Check for polyps/retention cysts, mass, opacification, dehiscence. Check for abnormal air cells (agger nasi, concha bullosa, Haller, Onodi)
e. With facial trauma, also check the facial bones in coronal. Similarly assess for NOE, ZMC, le Fort, and mandibular fractures.

13. Examine the reconstructions

a. Start at the midline sagittal view, which best evaluates the sella, hypothalamus/infundibulum, clivus, cerebellar tonsils/foramen magnum, and pineal region.
b. Check the sella for mass lesion or empty sella. Check the hypothalamus/infundibulum for mass lesion.
c. Check the clivus for boney destruction, adjacent mass lesion.
d. Look at the pineal. Check to see if calcification is appropriate to age, and if there is mass lesion.
e. Check the position of the cerebellar tonsils: Herniated? Low lying?
f. Check the remaining bones. Some boney findings are best seen on the sagittals. Onodi cells at the sphenoid, dental pathology (if the face is included), and any suboccipital surgical changes are best seen this way.

14. Perform any last checks and proofread.

An Abbreviated Checklist for the CT Head

1. **History, indication, priors**

2. **Adequacy, technique, limitations**

3. **Localizer images**

4. **Extracranial soft tissues**
    a. Scalp, parotids, face
    b. Posterior nasopharynx
    c. Orbits
    d. Peri-antral, PPF fat planes

5. **Bones**
    a. Calvarium, skull base
    b. Paranasal sinuses, mastoid air cells
    c. Inner/middle ear
    d. Facial bones if seen (NOE, ZMC, Le fort, mandible, teeth)
    e. Craniocervical junction

6. **CSF spaces**
    a. 4 subtle areas + 2 additional
    b. Ventricles, basal cisterns
    c. Effacement, mass effect, hernia, hydrocephalus

7. **Parenchyma**
    a. GWJ + WM of each lobe
    b. Deep grey, central WM, cingulate
    c. Cerebellum, brain stem

8. **Ischemia patterns**
    a. Major territory: hyperdense vessel, GW-differentiation, sulcal effacement
    b. Sinus thrombosis/venous
    c. Watershed/global
    d. Lacunar