PICTORIAL REVIEW

"NORMAL LOOKING ABNORMAL BRAIN: A REVIEW OF ABNORMALITIES IN BLINDSPOTS OF CT BRAIN"

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ABSTRACT

Brain imaging techniques provide the ability to non-invasively map the structure and function of the brain. Though CT is the earliest, fastest and convenient first line modality to evaluate the abnormality within the normal looking brain. There are certain blind spots where pathological findings are commonly missed along with the subtle radiological findings which are commonly misinterpreted by the radiologist, especially the one with the limited experience. **METHOD:** Aim of our study is to determine such blindspot areas and enlist the cases encountered at Shifa International Hospital which were most commonly missed / misinterpreted by retrospectively reviewing 1200 consecutive CT brain over a period of one year from June 2018 to june 2019. **RESULTS:** Out of these, 150 CTs showed nearly missed /misinterpreted findings which are further characterized into; traumatic (fractures, subdural and subarachnoid hemorrhage) 61/150 scans (40.7%); ischemic (hyperacute infarcts) 44/150 scans (29.3%); vascular (aneurysms and dural sinus thrombosis) 30/150 scans (20.7%); neoplastic (meningioma, glomus tumor, CP angle schwannoma) 14 /150 scans (9.3%) and miscellaneous including infections 1/150 scans (less than 1%). **CONCLUSION:** Knowledge of anatomical features of these blind spots and use of appropriate window width and level settings while evaluating CT images are important for avoiding false negative results in a normal looking brain. Also systematic review of the blind spots using comprehensive check list is key to avoid such errors.

Keywords: Blindspot, CT, window width, trauma, vascular.

Introduction

Brain imaging techniques provide the ability to non-invasively map the structure and function of the brain. Though CT is the earliest, fastest and convenient first line modality to evaluate the abnormality within the normal looking brain.[1] It is estimated that approximately 1 in 14 patients presenting to emergency department undergo CT scan head, for quick establishment or exclusion of life-threatening conditions. There are certain blind spots where pathological findings are commonly missed along with the subtle radiological findings which are commonly misinterpreted by the radiologist, specially the one with the limited experience.[1,2] These areas or blind spots include the cortical sulci, dural venous sinuses, orbits, clivus, Meckel cave, brainstem, skull base, parapharyngeal soft tissues, basal cisterns and craniovertebral junctions. Therefore establishment of a schematic search pattern that minimizes such errors and aids in timely recognition of these intracranial pathologies is of great importance to reduce patient's mortality and morbidity.[3] Also utilizing multiplanar reconstruction (MPR) while reviewing a scan at workstation in combination with different window width and level settings helps in reducing the rate of missed findings at these blind spots of CT brain.[3]

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These missed findings or errors encountered in radiology are broadly classified as perceptive errors (failure to recognize pathology on scan) or cognitive errors (finding recognized but misinterpreted or wrongly attributed) errors.[3,4] Also it is observed that radiologist undergoing training and junior radiologists are more prone to make these errors.[3,5] It is reported in literature that the minor and major discrepancy rates between radiology residents and trained radiologists is approximately 2.6% and 1.7%, respectively.[6,7] These false negative interpretations are attributed to a variety of causes starting from incomplete clinical data being provided, suboptimal imaging protocols, failure to review prior imaging studies, inappropriate window width and level settings, failure to utilize MPR for viewing scans in different anatomical planes or lack of effort to continue the search for subsequent abnormality following identification of a pathology.[3,4,7]

The purpose of this article is to discuss and illustrate these blind spots within the CT head to minimize interpretation error. Further utilizing different window width and level settings and MPR with respect to CT may help in evaluating these blind spots.

Material and Methods

The study was approved by our institutional review board and ethics committee (IRB and EC). We retrospectively reviewed 1200 CT brain performed from emergency department of Shifa international hospital, Islamabad (SIH) over a period of one year from June 2018 to june 2019. Inclusion criteria was adult patient more than 18 years of age and availability of stat report in radiology information system (RIS). Those patients having history of prior craniotomies or follow up cases were excluded from sample. Stat reports of these 1200 CT brains by radiology residents and formal reports by radiology consultants were retrieved from radiology information system (RIS) and both were compared for missed / misinterpreted findings.

These findings were then computed on SPSS v 21 and displayed as frequency percentages.

Results

Out of these, 150 CTs showed nearly missed /misinterpreted findings. These are further characterized into traumatic (fractures, subdural and subarachnoid hemorrhage) 61/150 scans (40.7%); ischemic (hyperacute infarcts) 44/150 scans (29.3%); vascular (aneurysms and dural sinus thrombosis) 30/150 scans (20.7%); neoplastic (meningioma, glomus tumor, CP angle schwannoma) 14 /150 scans (9.3%) and miscellaneous including infections 1/150 scans (less than 1%).

Discussion

In this article we will illustrate these nearly missed/ misinterpreted findings and reinforce different methodologies described in literature to minimize such events.

Trauma:

One of the major indications for performing CT brain is trauma locally as well as worldwide to assess acute intracranial hemorrhages or osseous fractures. A study performed in 2013 reported 300,110 head trauma cases with fatality rate of 13% (148,691 cases).[8] Intracranial hemorrhages particularly subdural hematoma most commonly occurs in association head trauma to head, specifically in cases of falls, road traffic accidents and assaults.[9] Sub dural hemorrhage occurs as bridging cortical veins undergo tearing and stretching when entering the dural sinuses, while crossing the subdural space. Hence, appears as combination of cerebrospinal fluid (CSF) and blood in the subdural space. The characteristic appearance on CT scan include crescentic hyper-dense collection along cerebral hemisphere tracking along inner table of skull.[10] The subdural hematomas have varying CT appearance depending upon duration of hemorrhage representing evolution of hemorrhage in different stages, thus appears more hypodense beyond the acute phase. Subdural hemorrhage of different phases may be masked on evaluating a CT brain on standard brain windows as the hemorrhage and adjacent structures including cerebral cortex and calvarium may appear in a similar grayscale value. Hence reviewing a CT scan in different window width and level settings is crucial to detect these findings.[10] Another important cause of trauma related morbidity and mortality is attributed to craniofacial fractures.[11] Non contrast CT scan headis the imaging modality of choice in such cases as thin section acquisitions with bone algorithms confidently allows detection of even subtle, hair-line and nondisplaced cranio-facial fractures. The detection of these subtle craniofacial fractures is enhanced by using multi-planar reconstruction (MPR) and three-dimensional image reconstruction allowing to review a scan in multiple planes i.e coronal and sagittal planes.[11] Additional fractures involving orbit floor or roof which are directed slightly oblique to the plane of image acquisition may be missed on standard axial images as they are a potential blind spot. Thus viewing these on MPR images and three dimensional reconstructed images is valuable.[12] Also to aid detection of cranio-facial fractures, secondary findings must be vigilantly looked for in the adjacent structures. These secondary findings may include soft tissue swelling, fluid or hemorrhage in paranasal sinuses/mastoids or associated intracranial hemorrhages in the setting of trauma.

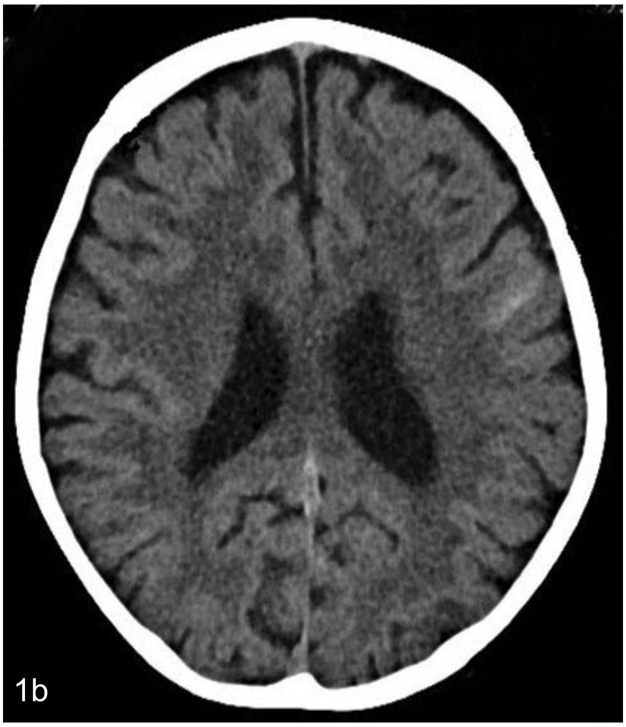
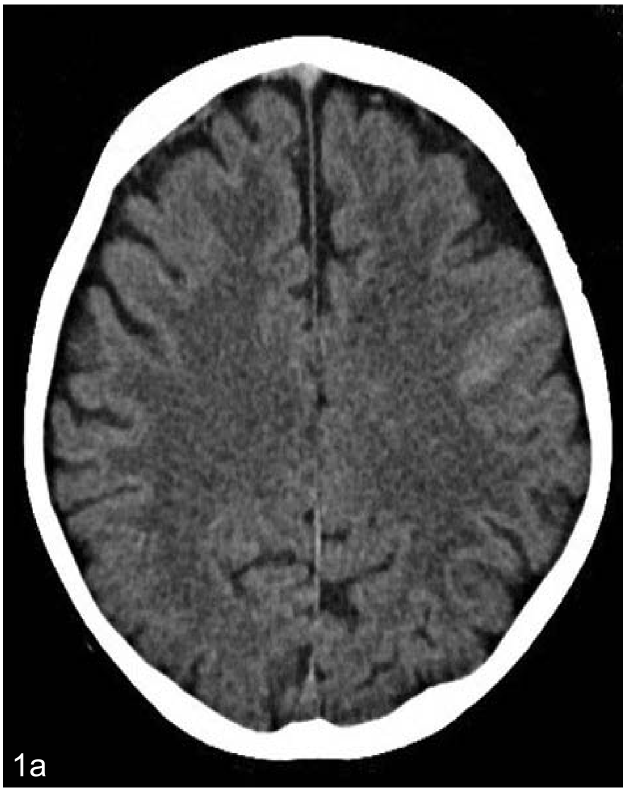


Figure 1(a,b): Showing trace linear hyperdensity in the sulci of left frontal region representing subarachnoid hemorrhage that was a missed finding. Can be avoided using appropriate windowing.



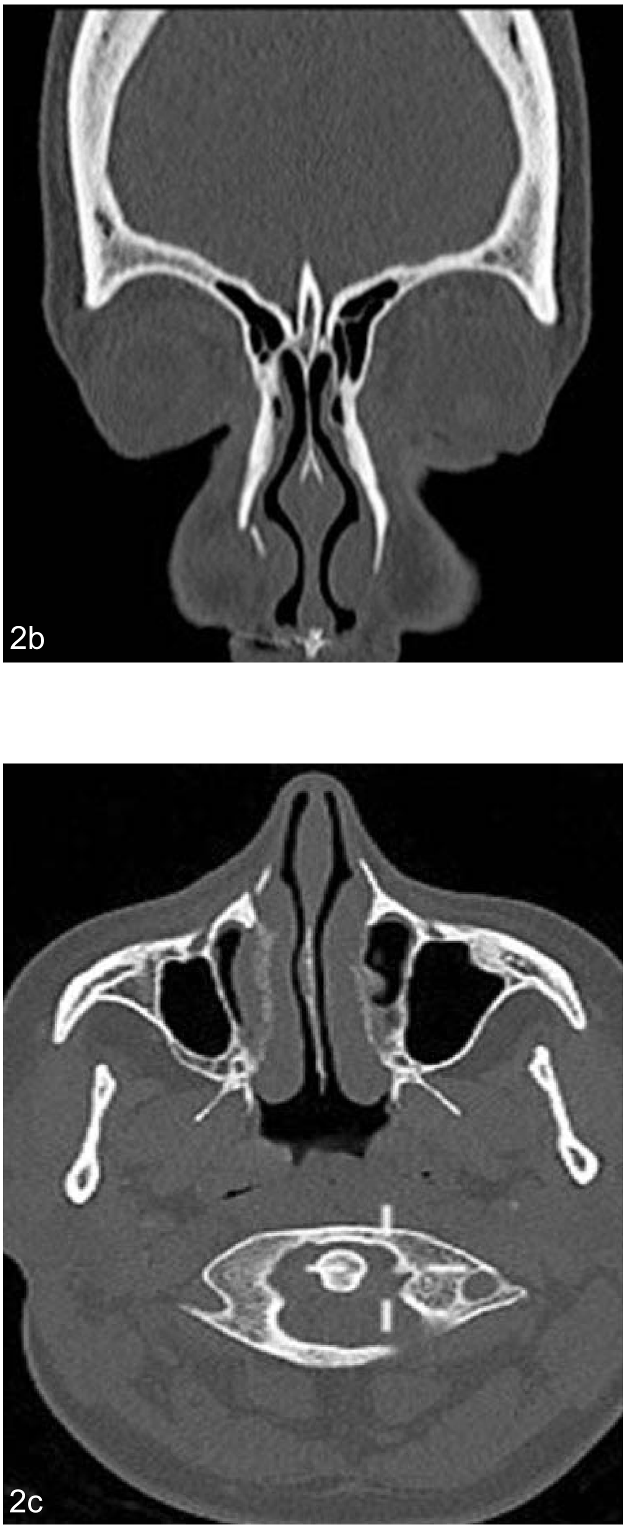


Figure 2: Images represent missed finding of right nasal bone fracture. **2a:** Reveals secondary finding of soft tissue swelling associated with fracture. **2b:** Shows using MPR and viewing scan in sagittal planes helps detection of these fractures easily. **2c:** Shows viewing scan in bone window algorithm also aids in minimizing errors.

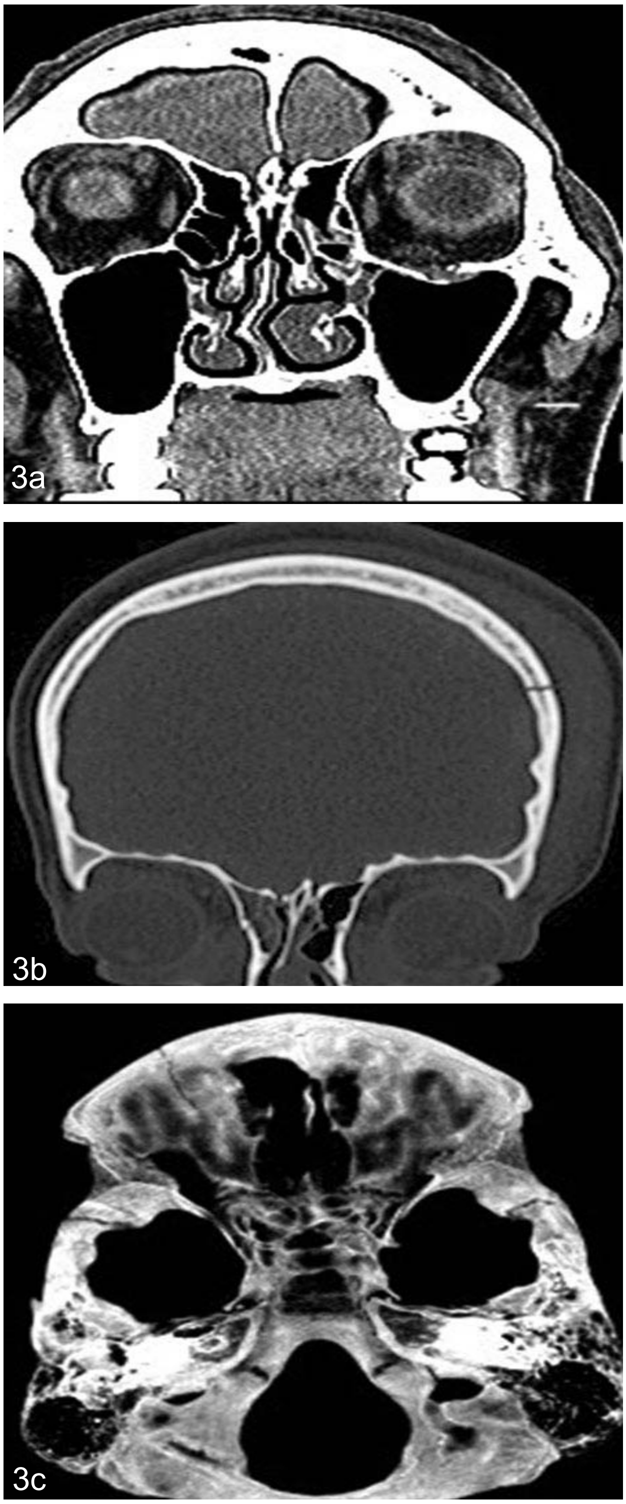


Figure 3: represent easily missed craniofacial fractures involving orbits. **3a:** Coronal CT shows left orbit floor fracture which was overlooked when scan was reviewed on axial images only. **3b:** Coronal CT head in bone window algorithm shoes left parietal bone fracture, however subtle hairline fracture of right orbit roof was missed which becomes evident using MPR mip images as seen in **3c**.

Stroke:

CT head is often first line modality for patients presenting to emergency department with focal neurological deficits. Apart from diagnosing stroke; CT is often employed to exclude any accompanying pathology which may include intracranial hemorrhage, intracranial neoplasms, infections (encephalitis and abscess). Moreover, CT brain plays a crucial role in selecting patients for thrombolytic therapy by excluding hemorrhagic conversion of acute infarcts which is the contraindication for administration of thrombolytic therapy. The signs of brain ischemia on CT are evident usually at about 6 hours after the onset, early signs being subtle and include hyper dense Middle cerebral artery, loss of grey - white matter differentiation with parenchymal hypo-density, blurring of basal ganglia outlines or focal brain swelling.[13]

A highly specific however insensitive sign of stroke on non-contrast CT include a clot in middle cerebral artery (MCA) appearing as hyperdense vessel sign. It may be seen in upto 35 - 50% of MCA occlusions confirmed on angiography. Studies also suggest presence of hyperdense MCA sign suggest poor clinical outcome and increased patient's morbidity.[14] This presence of hyperdense vessel can be applied to other arteries of brain as well if there is suspicion of ischemia. CT brain may also show other subtle signs of ischemia including blurring of basal ganglia outlines, insular ribbon sign and loss of grey white matter differentiation.

Similarly, if window level for the given CT scan is too wide or too narrow, essential information from brain images may be masked resulting in another diagnostic pitfall.[4] For the purpose of explanation, window width represents a range of CT numbers from black to white that an image contains. While window level is referred to midpoint of the range of CT numbers displayed. Therefore, windowing allows the reviewer to alter the image contrast by adjusting the range of CT numbers and hence improving the detection of pathology in area of interest by enhancing difference between different tissue densities. Application of this concept while reviewing CT brain demands using 'stroke window' (approximately 40 width: 40 level) for better detection of ischemia.[15] Hence CT brain should be meticulously reviewed using different window width and level settings to minimize overlooking these subtle signs of ischemia.

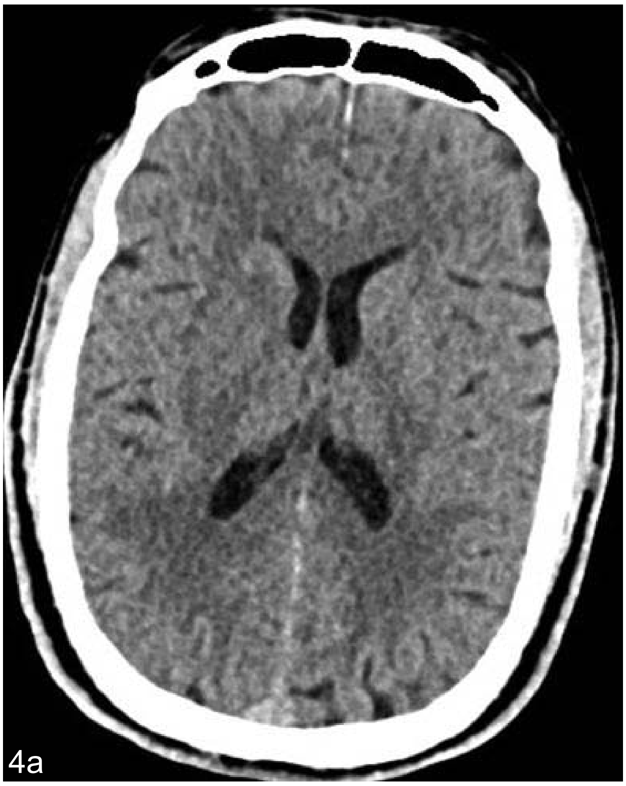


Figure 4a: shows subtle hypodensity involving right basal ganglia representing evolving infarct which was overlooked. **4b:** This becomes more evident by using ‘’Stroke window’’. **4c:** Shows hyperdense right MCA sign.

Vascular:

Dural venous sinuses and cortical veins are one of the most common blind spots in a non-contrast CT brain, as these can be evaluated on the basis of their morphology and attenuation, hence are more easily overlooked in a non-tailored non contrast CT brain routinely performed in ER.[4] The presence of increased attenuation within these venous structures compared to surrounding blood vessels hints towards abnormality involving these venous channels which may include thrombosis or related to hematocrit levels. Also, the presence of dilated or prominent hyper-attenuating vessels adjacent to dural venous sinuses strongly suggest presence of underlying dural arteriovenous fistulas. Post IV contrast CT venography (CTV) or MR venography (MRV) are the appropriate modalities for evaluating dural sinuses and their associated pathologies including thrombosis or arterio-venous fistulas. Certain typical signs are described of dural sinus thrombosis (DST) on these modalities, a triangular filling defect in the superior sagittal sinus on axial CTV images represents an ‘’Empty Delta Sign’’ or non-enhancing sinus on MRV suggest DST.[16]

The potential complications due to DST often encountered are venous infarcts or intra-axial hemorrhages / hematomas that are usually bilateral, sparing the cortex and do not conform to any specific arterial territory. Therefore, in the presence of any auxiliary sign even in a non-tailored study, one must raise the concern of abnormality involving DST.[4] Also, the detection of these pathologies may be enhanced by using specific window width and level setting labelled as ‘’Subdural window’’ (Level: 70-100 HU; window:

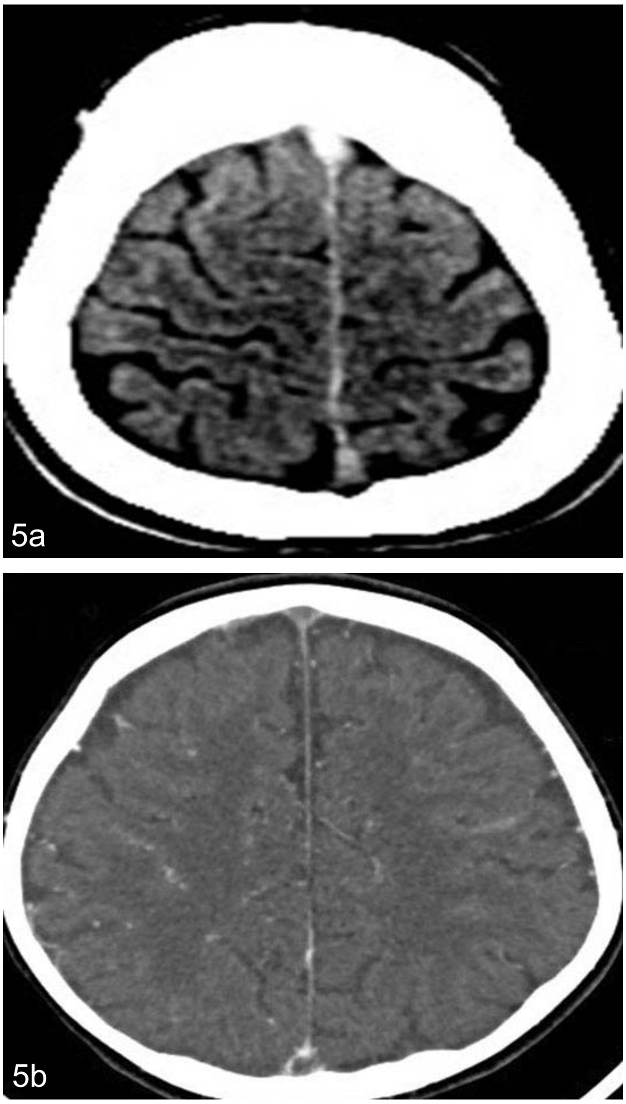


Figure 5a: Showing hyperdense dural sinuses on a non contrast CT head. **5b:** Showing Empty delta sign on post contrast CT head representing DST.

150-300 HU).[17] Regarding other vascular pathologies, diagnosing AVMs or AVFs on a non-contrast CT head is often challenging. However, a concern should be raised if abnormal brain parenchymal hyper-density or hemorrhage is noted in atypical location or atypical age of presentation.[18]

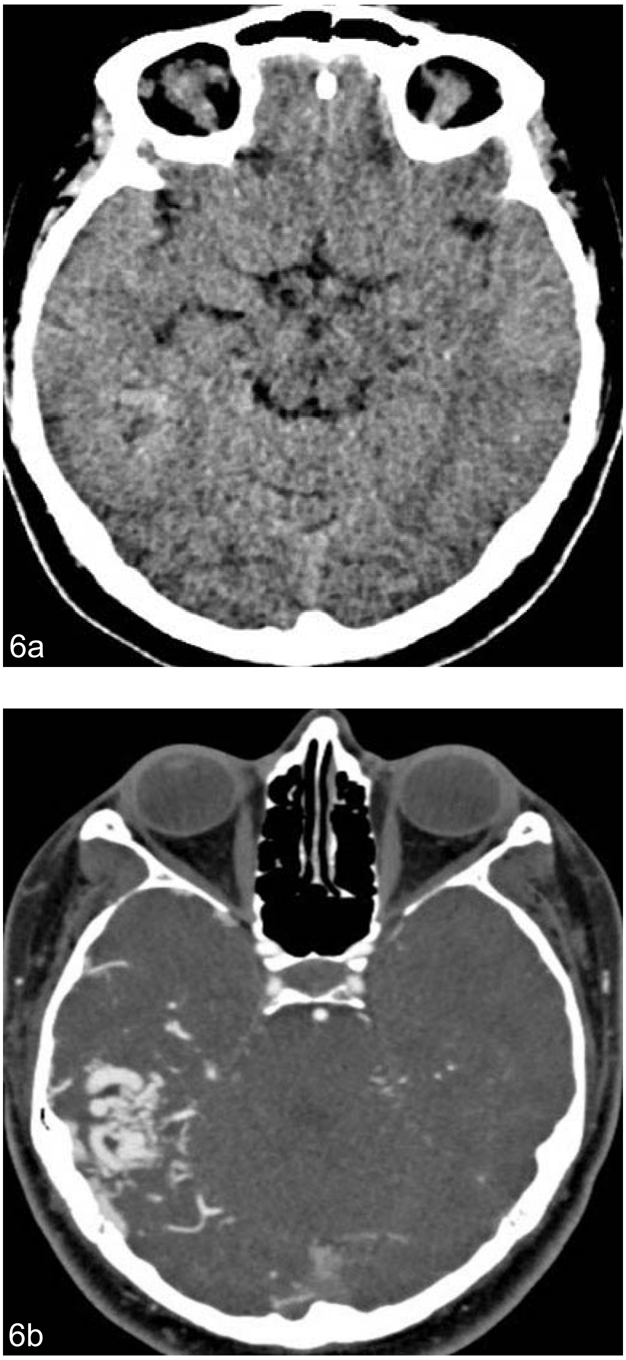
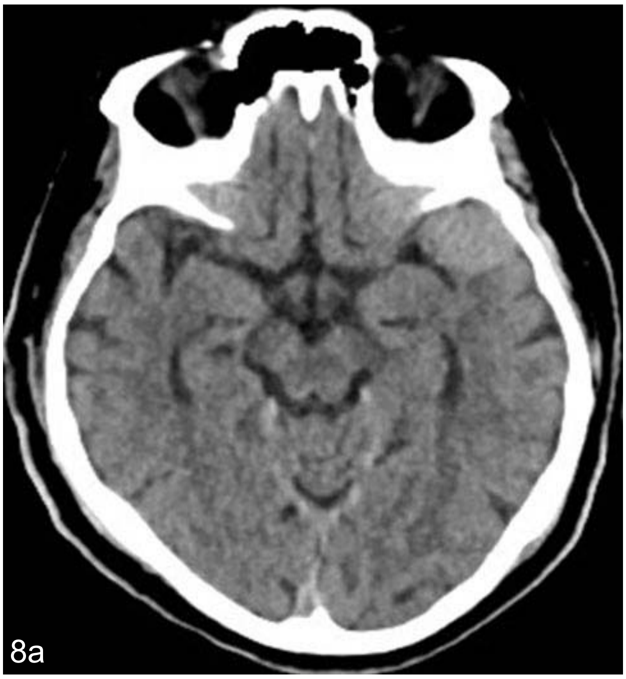


Figure 6a: Showing subtle hyperdensity in right temporal lobe on non contrast CT head. **6b:** Postcontrast CT shows AVM corresponding to hyperdense area in right temporal lobe.

Neoplastic and Miscellaneous:

The neoplastic and miscellaneous condition like infections are often missed on the images through posterior fossa and the level of skull base. The skull base has complex anatomy with various structures and foramina. This skull base should be examined particularly using coronal and sagittal images and different windows especially the bone window settings for identifying subtle erosions related to skull base tumors.[19] The most common tumor in the aforementioned blind spot areas are Schwannomas (up to 85%). Meningioma being the second most common.[20,21] Expansion of skull base foramina must be looked for in cases of Schwannomas which tend to be slow growing. Contrarily erosions at skull base must be searched for in cases of aggressive neoplasms like glomus tumors etc. Careful evaluation of CP angle cisterns for asymmetry, soft tissue fullness or internal auditory canal expansion / erosion is the key to avoid missing such pathologies.[22]

Figure 7: CT image shows left CP angle tumor / small schwannoma with asymmetric soft tissue in left CP angle.



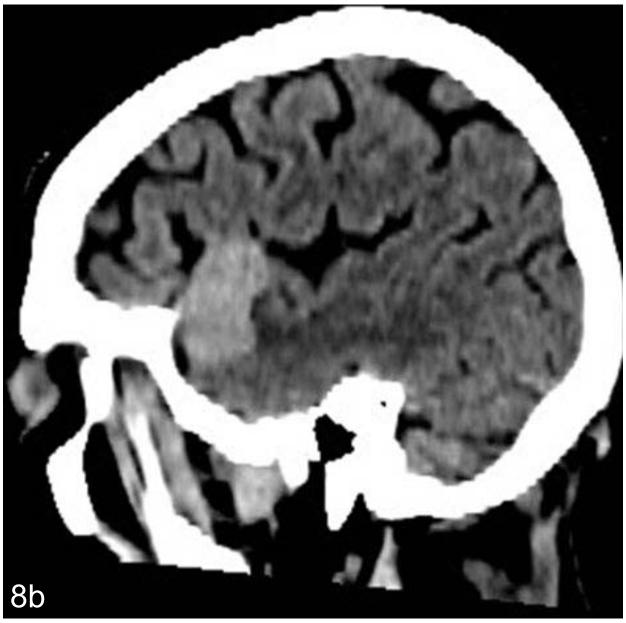


Figure 8a: Showing subtle hyperdense area in left temporal region, which is easily visible as a mass / meningioma on MRP sagittal images as shown in **8b**.

It is of utmost importance that infective or inflammatory processes must not be overlooked particularly at the skull base as they can rapidly spread intracranial and may cause cavernous sinus thrombosis with dire consequences for the patient.[22,23]

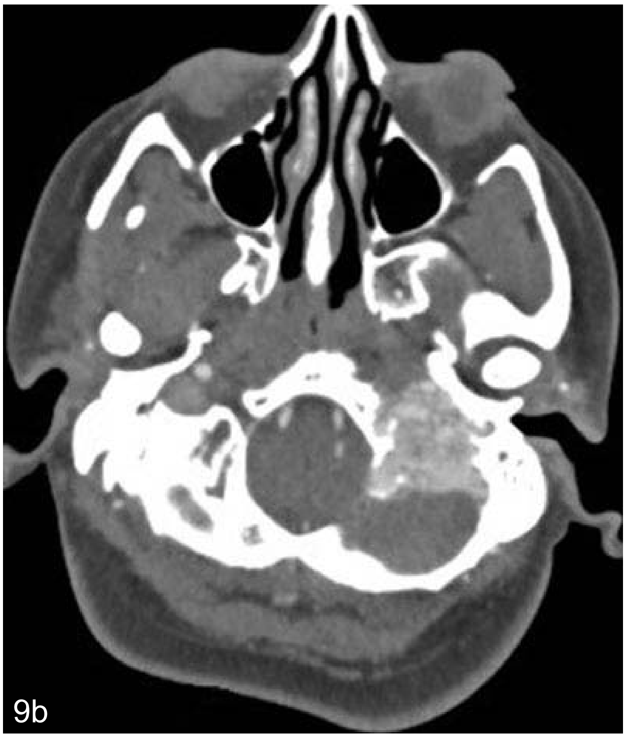


Figure 9a: Bone window CT head shows subtle erosions involving mastoids and CP angle on left. This turned out to be a glomus tumor on post contrast imaging as shown in **9b**.

Conclusion

This study contains selected cases which are presented as example of life threatening pathologies overlooked on non-contrast CT brain. Reviewing a scan in coronal and sagittal views using MPR and different window width and level settings may help to address the issues faced during evaluation of a CT head. Also, timely diagnosis of these pathologies may improve patient's clinical outcome as knowing these easily missed pathologies and all the blind spots of CT head marks a first step in reducing the errors related to interpretation. Knowledge of anatomical features of these blind spots and use of appropriate window width and level settings while evaluating CT images are important for avoiding false negative results in a normal looking brain. Also systematically reviewing the blind spots using comprehensive check list is key to avoid such errors.

Conflict of Interest: None

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