Utility of CT head in depicting postoperative neurological complications

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Abstract- Complications like postoperative infection and hemorrhage are common to all neurosurgical procedures however recognizing life-threatening complications such as tension pneumocephalus and paradoxical herniation, which requires urgent intervention, is important for a better clinical outcome. Computed tomography is fast, cost effective, and easily accessible for first-line imaging. CT is being utilized as the primary diagnostic examination in the postoperative period for evaluation of complications such as intra or extracerebral hematoma, cerebral edema and infarction. An awareness of the complications that may occur after neurosurgery is necessary to prevent a delay in diagnosis and treatment with an associated poorer outcome. The most important role of radiologists is to recognize the less common, but life threatening, post-op complications such as tension pneumocephalus, external brain tamponade and paradoxical herniation. Early and accurate diagnosis is essential for improving the outcome. As some findings may be seen in asymptomatic patients (pseudo complications), one should always consider the patient’s clinical status when interpreting the post-op images.

Keywords: Post-operative, Tension pneumocephalus, Sinking flap syndrome, Paradoxical herniation.

INTRODUCTION
Imaging plays an essential role in the patient management following elective as well as emergency cranial surgery. A variety of neurosurgical techniques have been developed to treat patients with intracranial pathologies such as hemorrhage, infection, and tumor. Imaging plays an important role in the routine postoperative follow-up of these patients, as well as in identifying complications, which often manifest with relatively nonspecific symptoms. For better interpretation of postoperative images requires knowledge of the normal cranial anatomy and the surgical technique employed, such as burr holes, craniotomy, craniectomy, and cranioplasty. To identify abnormal postoperative appearances, it is necessary to be familiar with the normal postoperative appearance after these procedures. Complications like postoperative infection and hemorrhage are common to all neurosurgical procedures however recognizing life-threatening complications such as tension pneumocephalus and paradoxical herniation, which requires urgent intervention, is important for a better clinical outcome. Computed tomography is fast, cost effective, and easily accessible for first-line imaging. Due to the relative non-invasive nature of the study, CT is being utilized as the primary diagnostic examination in the postoperative period for evaluation of complications such as intra or extracerebral hematoma, cerebral edema and infarction. Imaging studies in our institute are done routinely for the postoperative cranial surgeries, even in the absence of clinical indication or postoperative complications; thus, raising suspicion about the role and efficacy of routine postoperative imaging.

In our study, we discuss the normal postoperative imaging appearances of neurosurgery and to describe the appearances of the complications associated with the cranial surgeries and its role in patient care and outcome.

Objectives-
1) To describe the normal postoperative changes due to cranial surgeries
2) To describe the radiological appearances of common complications of cranial surgery

Materials and Methods-
This was a record based descriptive cross sectional study conducted in the Department of Radio diagnosis, GMC & Superspeciality hospital, Nagpur, India over a period of 12 months from April 2022 to May 2023.

Inclusion criteria-
252 Patients from all the age groups including both men and women who had undergone neurocranial surgeries at our institute were included.

Exclusion criteria-
1. The patients who had undergone VP shunt were excluded.
2. Patients with incomplete data were excluded.

All patients underwent head CT during the initial 72 hours or as was indicated by neurological status of the patient. Patients were scanned using 128 slice Toshiba CT scanner.
Results -
1. Of 252 cases examined, we had 131(51.98%) cases of significant scalp swelling, 68(26.98%) cases of extra-dural fluid collection, 27(10.71%) cases of dural thickening, 70(27.78%) cases of subdural pneumocephalus, 30(11.9%) cases of subarachnoid pneumocephalus.
2. Complications observed are tension pneumocephalus (3), extra dural hemorrhage (6), intraparenchymal hemorrhage (15), hygroma (4), external brain tamponade (2), sinking skin flap (10), cerebral edema (4), soft tissue infection (5), cerebral infarction (6) and paradoxical brain herniation (3).

<table>
<thead>
<tr>
<th>Findings</th>
<th>Number</th>
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<tr>
<td>Scalp swelling</td>
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<tr>
<td>Dural thickening</td>
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<td>Subarachnoid pneumocephalus</td>
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<td>Extra dural hemorrhage</td>
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<td>Intraparenchymal hemorrhage</td>
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<tr>
<td>Paradoxical brain herniation</td>
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<td>Soft tissue infection</td>
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Sociodemographic characteristics of study population

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DISCUSSION

Postoperative patient management following elective cranial surgery varies substantially between different neurosurgical institutions. The common objective in this crucial period is to avoid or detect any early postoperative complications such as intracranial bleeding, ischemia, or brain swelling. High resolution and thin slice CT technology has gained popularity due to their high diagnostic performance in the management of brain trauma, tumors and other cranial pathologies during initial presentation and during the follow-up. (4)

The early post-operative period in patients who are operated upon for intra-cranial lesions due to trauma is the most crucial period in terms of recovery potential as well as the development of delayed traumatic lesions. (5)
Routine postoperative CT scans following tumor resection potentially provides useful information regarding a gross assessment of the extent of tumor resection; detection of any bleeding, edema, pneumocephalus and ischemia. (6)

Normal cranial anatomy appearances of post neurosurgery patients.

Subgaleal swelling- Scalp swelling in the early postoperative period is common, which is a mixture of edematous fluid, hemorrhage, cerebrospinal fluid and air in varying amounts. (7)
Extra-axial fluid collection:
Small extra-axial fluid collections deep to the bone flap are seen in the vast majority of patients and contain varying amounts of blood, CSF, and air. These collections show attenuation depending on its contents. At postoperative imaging, sometimes it can be difficult to determine the exact location of these fluid collections, but more often they are extradural than subdural.
Dural thickening-
After craniotomy, neovascular granulation tissue is formed between the margins of the bone flap and the calvaria which may enhance upto 1 year after surgery. It almost always occurs in the dura mater that is deep to the flap, and is more widespread. The dura mater enhances in a smooth linear pattern as early as 9 hours after surgery, and enhancement can last even after many years postsurgery. When surgery includes resection of brain tissue, the surgical margins may begin to enhance within 17 hours. They initially appear as thin linear areas of enhancement that increase with time; by the 6th postoperative day they are present in all patients and are thicker and nodular. This pattern of brain enhancement usually resolves within 1 month after surgery.

Subdural and subarachnoid pneumocephalus- Intracranial air in some amount is unavoidable after craniotomy, and is a certain finding at early postoperative imaging. Pneumocephalus can occur in any of the intracranial compartments but more commonly it occurs in the subdural space over the frontal lobe.
Common postoperative complications specific to neurosurgery

Hemorrhage:
The risk of ICH increases with hypertension, coagulopathy, poor surgical haemostasis, chronic alcohol intake and use of mannitol. Most commonly it occurs within the first 4 hours following surgery.
Right fronto-temporo-parietal craniotomy status with bulging of underlying neuroparenchyma. Post operative changes with significant patchy areas of parenchymal bleed and surrounding edema in underlying right frontoparietal region with midline shift towards left. Intraventricular extension of bleed is also noted. Subgaleal collection having mixed attenuation and contains a mixture of blood, oedematous fluid and air.

Oedema:
Cerebral oedema following tumour resection can be marked and factors leading to its development include prolonged brain retraction, repeat surgery and a long duration of surgery (>6 hours). Hyperperfusion (e.g., following arteriovenous malformation occlusion) states also accelerate the development of cerebral oedema. (8)

Fig: Suboccipital craniotomy status. Post operative changes with patchy hemorrhages, small air foci and surrounding edema in cerebellum. Extra-axial air in prepontine cistern.

Stroke:
Thromboembolic (ischemic) stroke is a complication of neurosurgery, especially when considering carotid artery surgery and endovascular intervention. Endarterectomy, surgical aneurysm clipping, and endovascular embolization of AVMs and aneurysms are associated with more frequent postoperative strokes than other neurosurgical procedures. Venous infarcts may occur during craniotomy and can sometimes be associated with ICH that results from disruption of cortical draining veins or dural sinuses.

Fig: Post right frontal cranioplasty status. Patient develops left upper limb paresis after surgery. Ct images shows ill defined cortical and subcortical hypodensity in right high frontal region suggesting non hemorrhagic stroke.

Tension pneumocephalus:
CT findings of spontaneous non-surgical tension pneumocephalus include the “peaking” sign, in which subdural air collections compress the frontal lobes, and the “Mount Fuji” sign, in which compression and separation of the frontal lobes result in widening.
Pneumocephalus may occur commonly after intracranial surgery particularly posterior fossa craniotomy, transphenoidal surgery and chronic subdural hematoma evacuation. Small amounts of intracranial air are well tolerated and typically only manifest with headache. However, if the patient has co-existing hydrocephalus and undergoes surgery in a sitting position, there is an increased risk of trapping a large amount of intracranial air causing altered mental status, coma and seizures (tension pneumocephalus).

**Fig:** Subdural pneumocephalus in left frontal region with mild midline shift.

**Fig:** Subdural tension pneumocephalus over bilateral frontal convexities with subdural hypodense collection in right frontotemporal region.

**Sinking flap syndrome:**
In the intermediate postoperative periods, patients who undergo craniectomy may experience sinking flap syndrome. Symptoms usually are intermittent headaches, seizures, dizziness, undue fatiguability, mood changes, and, often, a sunken appearance of the skin flap. The pathophysiology of this condition is thought to result from exposure of the intracranial contents to atmospheric pressure, which alters CSF hydrodynamics, deforms the brain, and reduces cerebral perfusion. Some patients with symptomatic sunken skin flaps may show clinical improvement after the cranial defect is repaired with cranioplasty. CT and MR imaging show a depressed skin flap at the craniectomy site and concave deformity of the adjacent brain.
Paradoxical herniation: Paradoxical herniation is an uncommon complication of decompressive craniectomy which is also known as mesodiencephalic herniation syndrome. Patients with a large craniectomy defect who then undergo CSF drainage (e.g., lumbar puncture, external ventricular drainage, ventriculoperitoneal shunting) have a resultant decrease in CSF pressure, which leads to a reduction in intracranial pressure and vulnerability of the cranial contents to atmospheric pressure. Predominant finding in this type of complications are subfalcine and transtentorial herniation away from the craniectomy defect and results in mesodiencephalic dysfunction. Symptoms include a depressed level of consciousness, autonomic instability, signs of brainstem release, and focal neurologic deficits. Paradoxical herniation is a neurosurgical emergency. Urgent intervention is necessary to increase intracranial pressure, stop any CSF leakage, and restore the continuity of the calvaria. Treatment options include placing the patient in the Trendelenburg position, clamping ventricular shunts or drains, administering intravenous fluid, and performing early cranioplasty. Lumbar epidural blood patch has been effectively and quickly placed to reverse symptoms of paradoxical herniation. At imaging, a sunken skin flap is seen with herniation of the brain away from the craniectomy defect, which results in midline shift, compression of the midbrain, and effacement of the basal cisterns.
Fig: Right frontoparietal craniotomy status with sinking flap and subsequent paradoxical subfalcine herniation away from the site of craniotomy. Subarachnoid hemorrhage is seen in the left parietal sulcal spaces.

**Soft tissue infection:**
Postoperative neurosurgical infections most often manifest as meningitis, extradural abscess, subdural empyema, or brain abscess. Infections usually begin at the line of the skin closure. Cellulitis typically involves the skin and superficial fascia and spares the subgaleal tissues. Infection is readily diagnosed clinically; therefore, the role of imaging is to identify deep extension into the bone flap, extra-axial spaces, meninges, or brain. Another complication associated with intracranial infection is dural venous sinus thrombosis.

Fig: In a trans sphenoidal resection of high grade pituitary neoplasm, post operative NCCT head scan shows fairly well defined thick hyperdense walled lesion in left frontal lobe with non-dependent air foci with perilesional hypodense edema suggest intraparenchymal abscess.

**CONCLUSION:**
Radiological imaging is fast, accessible and cost effective. It is essential to consider the patient's clinical status when interpreting imaging findings. An awareness of the complications that may occur after each of these procedures is necessary to prevent a delay in diagnosis and treatment with an associated poorer outcome. Most of the changes are expected (normal) post-op changes which do not adversely affect the patient outcome. Scalp swelling, simple pneumocephalus, small size hemorrhages or edema in surgical site, extradural or subdural fluid collections and dural or surgicalsite dural thickenings in early post-op period are examples of normal post-op changes. Some complications are seen only in special procedures (such as plunging of burr holes or extracranial herniation, trephine syndrome, or external brain tamponade in craniectomy) and others are common for all procedures. Skull fractures, infection (extradural abscess, subdural empyema, bone flap infection), hemorrhage (subdural, extradural, parenchymal hematoma) and pneumocephalus are common complications of all neurosurgical procedures. The most important role of radiologists is to recognize the less common, but life threatening, post-op complications such as tension pneumocephalus, external brain
tamponade and paradoxical herniation. Early and accurate diagnosis is essential for improving the outcome. Since some findings may be seen in asymptomatic patients (pseudocomplications), one should always consider the patient’s clinical status when interpreting the post-op images. Interpretation of post-op cranium images requires knowledge of the normal anatomy, types of craniotomies, and differentiating normal post-op changes from complications. Reporting a complication, especially a life threatening one, always should be done with clinical correlation.\textsuperscript{(10)}

REFERENCES: