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. [(1)]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 infectionand hemorrhage are common to all neurosurgical procedureshowever recognizing life-threatening complications such as tensionpneumocephalus and paradoxical herniation, which requires urgentintervention, is important for a better clinical outcome. Computedtomography is fast, cost effective, and easily accessible for first-line imaging.[(1)]

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 intraor extracerebral hematoma, cerebral edema and infarction.[(2)]

Imaging studies in our institute are done routinely for the postoperative cranial surgeries, even in the absence of clinical indication or postoperativecomplications; thus, raising suspicion about the role and efficacy of routine postoperative imaging. [(3)]

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-

252Patients from all the age groups including both men and women who had undergone neurocranial surgeries at our institutewere 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 duringthe initial 72 hours or as was indicated by neurological status of the patient.Patients were scanned using128 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).

Findings		Number	Percentage
Normal post operative findings	Scalp swelling	131	51.98
	Dural thickening	27	10.71
	Extradural collection	68	26.98
	Subdural pneumocephalus	70	27.78
	Subarachnoid pneumocephalus	30	11.9
Complications	Tension pneumocephalus	3	0.012
	Extra dural hemorrhage	6	0.024
	Intraparenchymal hemorrhage	15	0.06
	Hygroma	4	0.016
	External brain tamponade	2	0.008
	Sinking skin flap	15	0.04
	Cerebral edema	4	0.016
	Paradoxical brain herniation	3	0.012
	Cerebral infraction	6	0.024
	Soft tissue infection	5	0.02

Sociodemographic characteristics of study population

Study variable		Frequency	Percentage
Gender	Male	144	57.57
	Female	108	42.43
Age group(in years)	0-20	9	3.5
	21-40	153	60.72
	41-60	86	34.12
	>60	4	1.5

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 inthe 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)]

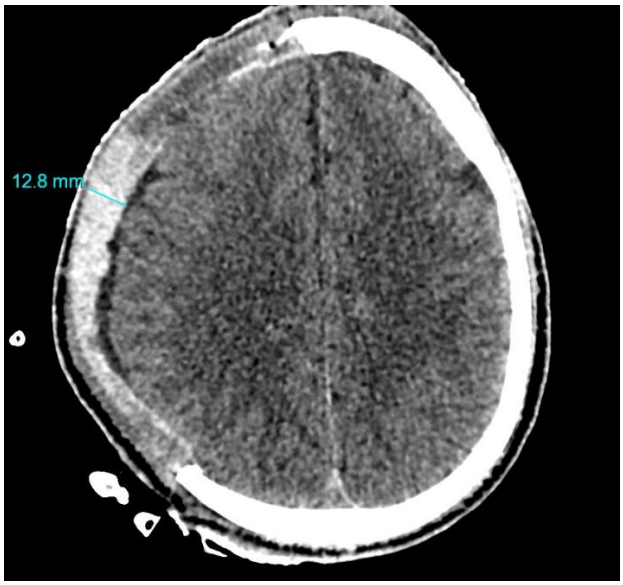

Fig: In a patient with post craniectomy status, subgaleal swelling in right frontoparietal region admixed with hemorrhagic contents.

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.

Fig:Right frontal cranioplasty status. Underlying extradural collection containing tiny air foci and adjacent dural thickening and calcification.

Fig: Extradural hematoma in left frontal region in a patient of left frontoparietal cranioplasty.

Dural thickening-

After craniotomy, neovascular granulation tissue is formed between the margins of the bone flap and the calvaria which may enhance upto 1year 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.

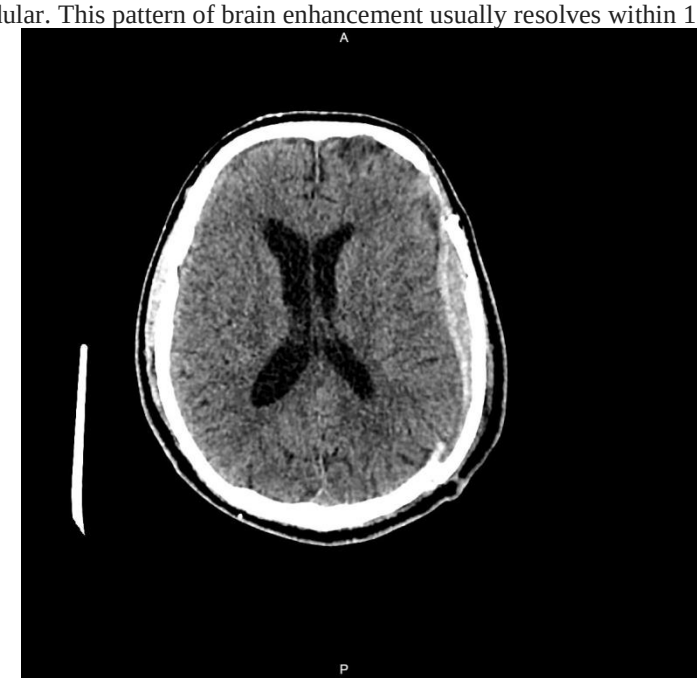

Fig: Reactive dural thickening in left frontoparietal cranioplasty associated with epidural hemorrhage.

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.

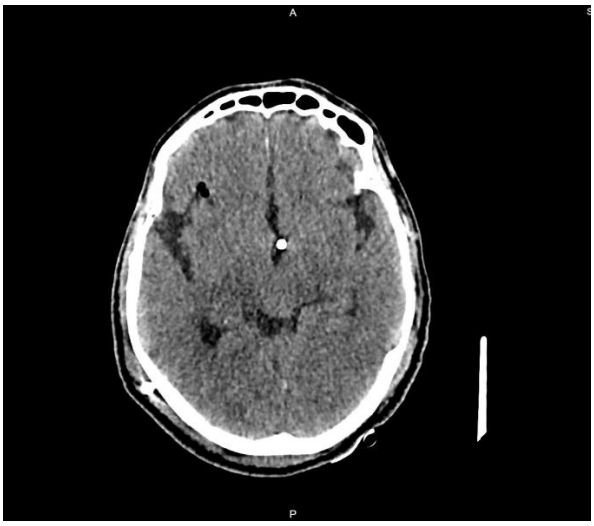

Fig :Subarachnoid pneumocephalus in right MCA cistern in right frontal region.

Fig: Post left frontoparietal burr hole status with subdural pneumocephalus over left frontal convexity.

Common postoperative complications specific to neurosurgery

Hemorrhage:
The risk of ICH increases with hypertension,coagulopathy, poor surgical haemostasis, chronic alcohol intakeand use of mannitol. Most commonly it occurs within the first 4 hours following surgery.

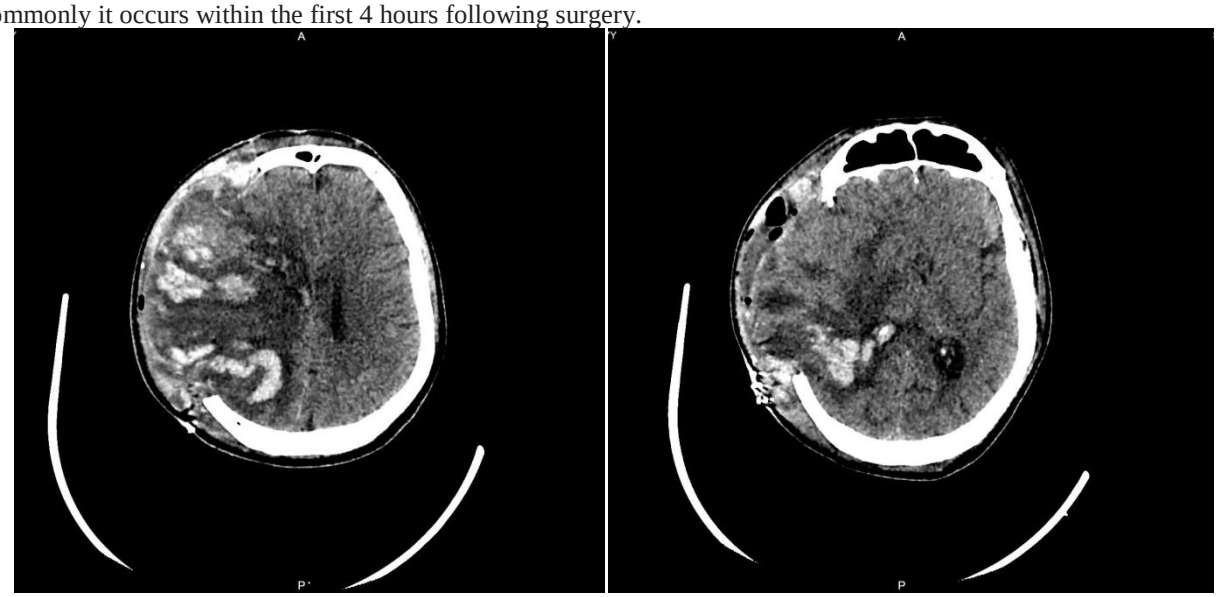

Fig:Right fronto-temporo-parietal craniotomy status with bulging of underlying neuroparenchyma. Post operative changes with significant patchy areas of parenchymal bleed and surrounding edema in underlying right frontoparietal region with midline shift towards left.Intraventricular extension of bleed 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 bemarked and factors leading to its development include prolongedbrain retraction, repeat surgery and a long duration of surgery(>6 hours). Hyperperfusion (e.g. following arteriovenous malformation occlusion) states also accelerate the development ofcerebral 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 ofneurosurgery, especially when considering carotid artery surgeryand endovascular intervention. Endarterectomy, surgical aneurysm clipping, and endovascular embolization of AVMs andaneurysms are associated with more frequent postoperativestrokes than other neurosurgical procedures. Venous infarcts may occur during craniotomy and can sometimes beassociatedwith ICH that results from disruption of cortical draining veins ordural 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

of the interhemispheric space.Pneumocephalus may occur commonly after intracranial surgery particularly posterior fossa craniotomy,transphenoidal surgery and chronic subdural haematoma evacuation. Small amounts of intracranial air are well tolerated andtypically only manifest with headache. However, if the patienthas co-existing hydrocephalus and undergoes surgery in a sittingposition, there is an increased risk of trapping a large amount ofintracranial air causing altered mental status, coma and seizures(tension pneumocephalus)

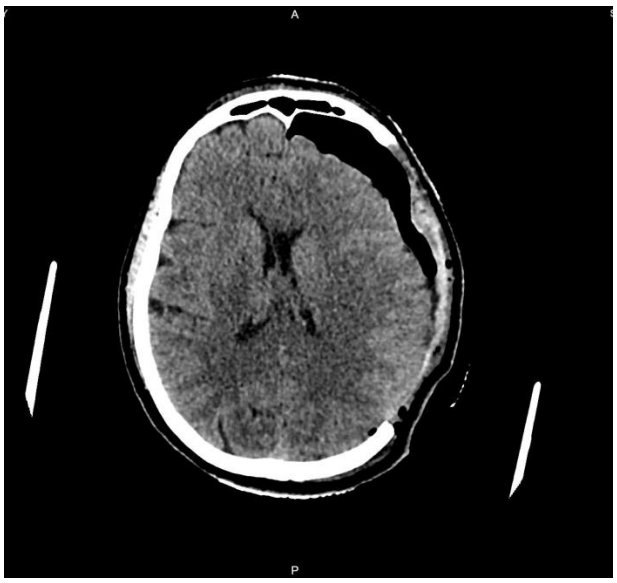

Fig:Subdural pneumocephalus in left frontal region with mild midline shift.

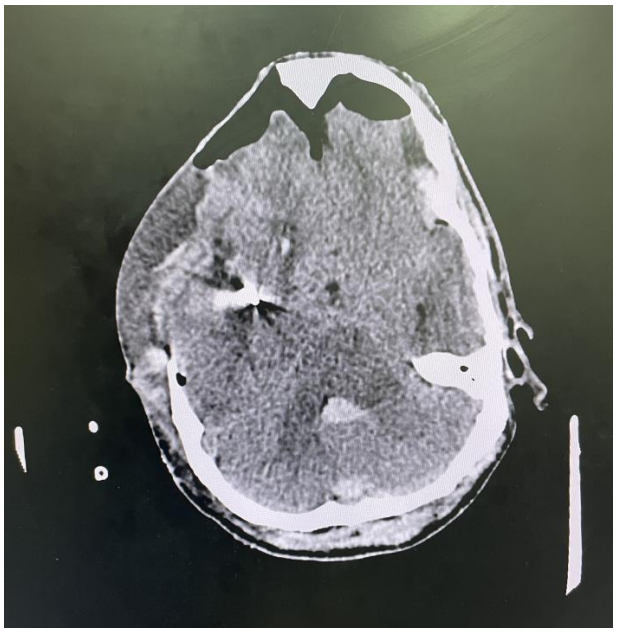

Fig: subdural tension pneumocephalus over bilateral frontal convexities with subdural hypodense collection in right frontotemporal region.

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. [(9)]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.

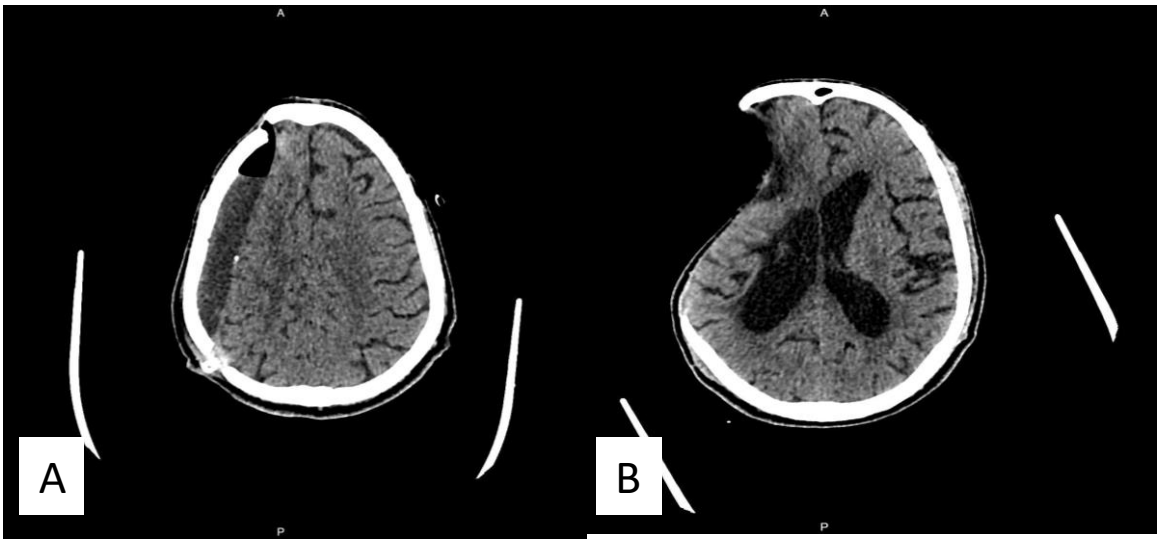

Image A shows interval cranioplasty with extra-axial collection containing air-fluid level in underlying right frontoparietal region. Image B shows right fronto-parietal craniectomy status with sinking of the overlying flap.

Paradoxical herniation:

Paradoxical herniation is an uncommon complication of decompressive craniectomy which is also known asmesodiencephalic herniation syndrome. Patients with a large craniectomy defect who then undergo CSF drainage (eg, 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 aresubfalcine 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.[9]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.

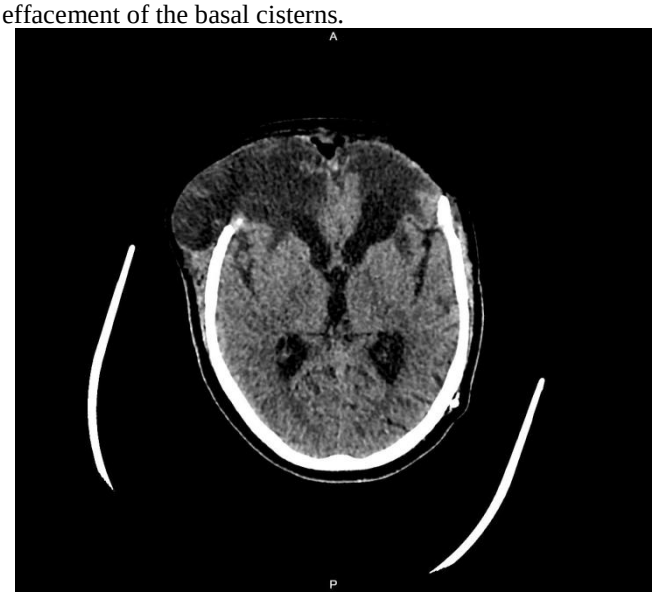

Fig: Bilateral frontal craniectomy status with bulging of CSF filled sac and neuroparenchyma on right post operative site.

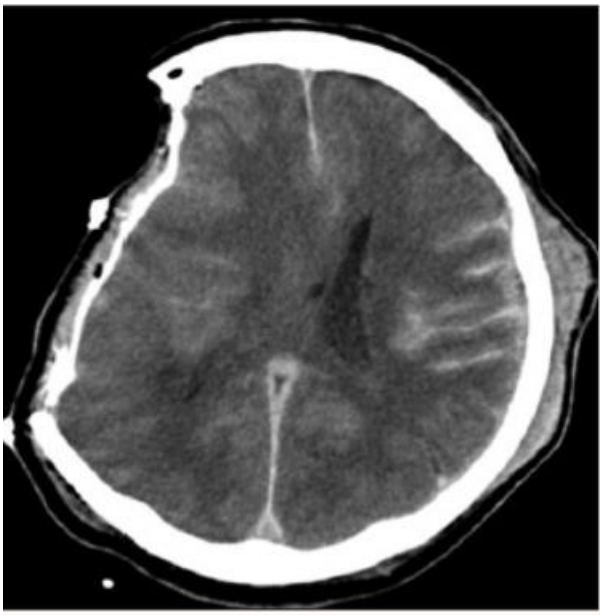

Fig: Right frontoparietal craniotomy status with sinking flap and subsequent paradoxical subfalcine herniation away from the site of craniotomy. Subarachnoid hemorrhage is seen in the left parietal sulcal spaces.

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.

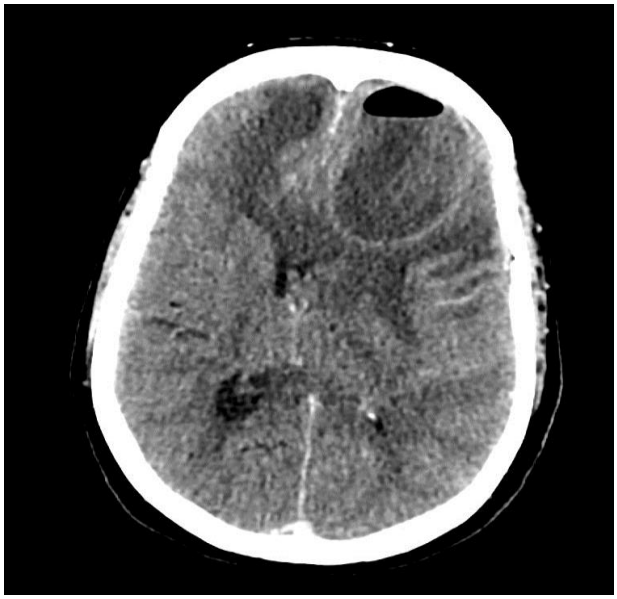

Fig: In a trans sphenoidal resection of high grade pituitary neoplasm, post operative NCCT head scan shows fairly well defined thick hyperdense walled lesion in left frontal lobe with non-dependent air foci with perilesional hypodense edema suggest intraparenchymal abscess.

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 changeswhich 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 statuswhen interpreting the post-op images. Interpretation of post-op cranium images requires knowledge of the normal anatomy, types of craniosurgery, and differentiating normal post-op changes from complications. Reporting a complication, especially a life threatening one, always should be done with clinical correlation. [10]

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