The postoperative cranium, normal findings and complications

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Purpose

The neurosurgical cranial procedures are relatively frequent in the daily practice and a wide range of neurosurgical techniques has been developed to treat patients with intracranial disorders.

Imaging is important in the routine postoperative follow-up of these patients. The radiologist must know how to recognize postoperative complications and differentiate them from expected normal findings (Figure 1) because an early and accurate diagnosis is fundamental for proper postoperative care. Interpretation of postoperative images requires knowledge of the normal cranial anatomy, the surgical technique employed (burr holes, craniotomy, craniectomy or cranioplasty) and also the underlying pathology and the clinical status of the patient. Clinical, surgical and radiologic correlation is essential.

In the early postoperative period, computed tomography (CT) is the main imaging modality used to evaluate potential complications because it is fast, accessible in most hospitals, compatible with monitoring equipment and implanted devices and relatively inexpensive.

CT is useful to evaluate complications such as hemorrhage, brain edema, tension neumocephalus, brain herniation and infection (contrast-enhanced CT). However, magnetic resonance imaging (MRI) is more sensitive than CT in detecting intracranial infection and ischemia.

Both CT and MRI are susceptible to artifacts from metallic implants, which reduce the sensibility of the exploration and make the images more difficult to interpret.

The purpose of this work is to describe the different complications in the neurosurgical procedures performed in our hospital, and their frequency, according to the surgical indication and the type of procedure (urgent or programmed).
Fig. 1: Normal postoperative findings. (1) Subdural pneumocephalus in patient 1 day after resection of a left temporal meningioma. Axial CT shows a low attenuation pneumocephalus (arrow) in the right frontal subdural space. (2) Small hemorrhage in surgical bed and laminar subdural hematoma in 40-years-old woman with family cavernomatosis disease, who presented a right parietal cavernoma.

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Methods and Materials

We retrospectively reviewed all the neurosurgical procedures performed at our center from January 2011 to April 2012, following-up our patients until December 2012.

From an overall of 610 neurosurgical cranial procedures we included 411, only those in which the technique was burr holes, craniectomy, craniotomy or cranioplasty, and excluding all the ventricular shunt placement procedures.

Postoperative control was carried out with CT, MRI and cerebral angiography, evaluating both expected imaging findings and complications.

With this 411 procedures we created a database in which we included the personal data, surgery indication (tumor, vascular disease, trauma or others), date and type or surgery (urgent or programmed), appearance of complications, and type and date of complications if any.

The complications were classified as tension neumocephalus, infection (soft tissue infection, bone flap infection, empyemas or brain abscesses), hemorrhages (intraparenchymal, intraventricular, and subdural or epidural hematomas), hydrocephalus, infarction and others, and we calculated the frequency of each one.

We also calculated the rate of complications in all of the 411 neurosurgical procedures, according to the surgery indication and the type of surgery. We finally used the chi-square test ("\( \chi^2 \) test") to prove if the differences between the different samples were statistically significant from the average.
Results

From a total of 411 neurosurgical cranial procedures, 90/411 (22%) presented one or more postoperative complications (Table 1).

We found 18/90 (20%) extracranial herniations, which is a typical complication of the craniectomy (Figure 2). The brain and vessels extrude through a skull defect, and if the defect is too small, this can result in compression of cortical veins and lead to venous infarction and contusion of the brain at the craniectomy margins. In our 46 patients who underwent decompressive craniectomy, extracranial herniation occurred in 18 (39%).

There were 16/90 (18%) hygromas: subdural or subgaleal fluid collections that usually appear within days of surgery and resorb over a period of weeks to months. They generally behave in a benign fashion; only 2/16 (12%) of them caused a brain tamponade, which is a rare but potentially life-threatening complication caused by a pressurized subgaleal fluid collection. The diagnosis includes the imaging findings in the context of neurologic deterioration of the patient and neurologic improvement after drainage of the fluid collection (Figure 3).

15/90 (17%) complications were some type of hemorrhage (Table 2): 5/15 (33%) subdural hematoma, 4/15 (27%) subgaleal hematoma, 4/15 (27%) intraparenchymatous hemorrhage (Figure 4 y 5) and 2/15 (13%) others hemorrhages (intraventricular hemorrhage). One of the intraparenchymal hemorrhage is actually a remote cerebellar hemorrhage (Figure 6), it is thought that this complication results from cerebro-spinal fluid (CSF) volume depletion leading to sagging of the cerebellum, with consequent occlusion of the superior bridging veins of the posterior fossa and hemorrhagic infarction.

There were 14 (16%) infarctions (12 arterial (Figure 7) and 2 venous (Figure 8)). The 2 venous infarctions were due to venous thrombosis in surgery for metastasis and meningioma resection.

The rate of infection was 12/90 of the 411 procedures (13%) (Table 3): 4/12 (34%) were subdural empyemas (Figure 9), fluid collections overlying the cerebral convexity or alongside the falk cerebri, with attenuation slightly higher than that of CSF. They often produce mass effect, edema in the underlying brain and diffuse enhancement of the adjacent cortex. There were 3/12 (25%) soft tissue or subgaleal infections, which usually begin at the line of the skin closure, so the role of imaging is to identify deep extension. 3/12 (25%) were CSF infections, with ventriculitis or meningitis. 1/12 (8%) were intraparenchymal abscesses, fluid collections with whose margins appear thickened and enhanced after contrast administration. Finally, there was 1/12 (8%) bone
flap infection in the context of a cranioplasty (Figure 10), with abnormal texture and multiple lytic areas in the bone flap.

Finally, there were 10/90 (11%) hidrocephalus and 4/90 (4%) tension neumocephalus, 1 of them in the context of a posterior fossa surgery (Figure 11) and the other 3 after a supratentorial procedure, all of them in tumor resections. The tension pneumocephalus is a rare but potentially life-threatening complication that occurs when subdural air collections compress the brain. Axial CT shows low attenuation collections with mass effect, and sometimes we can see the "Mount Fuji" sign, in which which bilateral tension pneumocephalus cause compression and separation of the frontal lobes from the falx cerebri. Similar findings may be seen at imaging in asymptomatic patients, so the diagnosis should be made only if clinical deterioration accompanies these imaging findings.

Special cases were classified as others:

- 2 cases of pseudomeningocele (Figure 12), it is an abnormal collection of CSF that communicates with the CSF space around the brain. In contrast to meningocele, in which the fluid is surrounded and confined by dura mater, in a pseudomeningocele, the fluid has no surrounding membrane, but it is contained in a cavity within the soft tissues.

- 2 pseudoaneurysms (or false aneurysms): This is a hematoma that forms as the result of a leaking hole in an artery, contained by the surrounding tissues. We found one of them in transssphenoidal resection of pituitary macroadenoma (Figure 13).

- 2 venous thrombosis, associed to the 2 venous infarcts before mentioned.

- 1 one-month-delayed-intraparenchymal-hemorrhage in a metastasis resection (Figure 14).

The rate of complications attending to the surgery indication was 38/203 (18%) in patients who had a tumor, 20/55 (36%) in patients who suffered a trauma and 22/90 (24%) in patients with vascular disease. The other group is formed by 63 patients most of which were cranioplasties to repair a surgical skull defect, from which we found 10 complications (16%) (Table 4). Only the trauma sample presented a stadistically significant difference in the Chi square test (p < 0,05).

133 interventions were urgent, most of them trauma emergencies, and 43/133 presented postoperative complicacions while only 47/278 (17%) programmed interventions presented complications, being these differences statistically significant in the Chi square test (p < 0,001) (Table 4).
Table 1: Postoperative complications.
Fig. 2: Frontoparietal extracranial herniation after decompressive craniotomy for evacuation of acute subdural hematoma in 35-years-old man with traffic injuries. Axial CT also shows acute subdural and subgaleal hematoma.
**Fig. 3:** External brain tamponade in a 59-year-old woman 3 months after decompressive craniectomy for an empyema as complication of a meningioma exeresis. Coronal CT shows a large, low-attenuation, subgaleal fluid collection compressing the frontal lobes at the craniectomy site.

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Table 2: Hemorrhages.
Fig. 4: (1) Posterior fossa intraparenchymal hematoma which extends to basal cisterns, ventricular system, tentorium and falx cerebri in a 71-years-old man after resection of cerebellar metastasis of lung tumor. The patient presented reduced level of consciousness before dying. (2) RM shows the occipital metastases before the surgery.

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Fig. 5: (1) Intraparenchymal hematoma in surgical bed with intraventricular hemorrhage (arrowhead), and brainstem hematoma (arrow) in 78-years-old woman who presented right midriasis after an urgent surgery because of a posterior fossa meningioma with important mass effect. (2) Axial CT shows the meningioma before the surgery.

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Fig. 6: Remote cerebellar hemorrhage in a 77-years-old man who presented aphasia after a left temporal craniotomy for resection of a meningioma. Axial CT shows curvilinear streaks (arrow) of subacute hemorrhage in the sulci of the left cerebellar hemisphere.

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Fig. 7: Arterial infarct in aneurysm clipping. (1) Subacute hippocampal infarct in 66-years-old man 2 days after a surgery for clipping a left middle cerebral artery (MCA) aneurysm. Axial CT shows small hypodense area next to hippocampus suggestive of subacute infarct (arrow). We can also recognize metallic implant artifact used in the surgery (arrowhead). (2) Subacute infarct in 53-years-old woman 3 days after a surgery for clipping right middle cerebral artery (MCA). Axial CT shows right frontal cortico-subcortical hypodense area with mass effect above cerebral parenchymal and ventricular system. (3) Middle cerebral artery (MCA) aneurysm before the surgery.

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Fig. 8: Venous infarct because of superior sagittal sinus thrombosis in a 74-years-old man 5 days before of a surgery for resection of metastases of esophageal tumor. (1) Filling defect in superior sagittal sinus (arrow). (2) Fluid-attenuated inversion recovery (FLAIR) images shows left occipital hyperintense area (arrow). (3) These area is hyperintense (hemorrhage = H) and hypointense (infarct = I) in T1-weighted MR images. (4) Diffusion-weighted images shows restricted diffusion (arrow), so it is a acute/subacute infarct.
Table 3: Infections.

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**Fig. 9:** Burr hole in 71-years-old man for evacuation of a right hemispheric chronic subdural hematoma. One week later the RM shows subdural hematoma with septa, reblooding signs and contrast enhancement (arrow). These findings are suggestive of hematoma’s sobreinfection.

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**Fig. 10:** Subdural empyema and bone flap infection in a 52-years-old man after revision surgery to secure a loose bone flap from a pre-existing craniectomy for evacuation of a subdural hematoma. (1) Axial CT 1 week after the surgery shows normal postoperative changes before a left hemispheric cranioplasty. (2) Axial CT 5 months after the surgery shows abnormal texture and multiple lytic areas of the bone flap. (3) The patient also presented a subdural fluid collection with contrast enhancement and engorgement of the adjacent cortical vessels, suggestive of subdural empyema (arrow).
Fig. 11: Tension pneumocephalus in a 78-year-old man who presented a reduced level of consciousness after posterior fossa surgery for a trigeminal neuralgia. Axial CT shows bilateral pneumocephalus with mass effect on the frontal lobes and displacement of the frontal lobes from the falx cerebri.

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Fig. 12: Occipital pseudomeningocele in 33-years-old woman 1 week after a craniotomy for resection of arteriovenous malformation (AVM). (1) Axial CT shows occipital hypodense fluid collection communicated with an extraaxial collection of cerebro-spinal fluid (CSF) (arrow). (2) The pseudomeningocele extends through the cervical muscles to C3.
Fig. 13: Iatrogenic pseudoaneurysm. (1) Pseudoaneurysm in A2 segment of left anterior cerebral artery in a 70 year-old-man one day after a transnasal resection. (2) The pseudoaneurysm was embolized with coils by angiography.

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Fig. 14: One month delayed hemorrhage in a 48-years-old man who presented headache and reduced level of conciousness after resection of a glioblastoma. (1) Axial CT 2 days after the surgery with normal postoperative findings. (2) Axial one month after the surgery shows CT shows acute intraparenchymal hemorrhage in the surgical bed (arrowhead) and subdural hematoma (arrow).

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Table 4: Postoperative complications according to the surgery indication and the type of surgery.

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Conclusion

It is important for the radiologist to be familiar with the normal CT and MRI findings after each type of neurosurgical intervention, as well as to recognize postoperative complications to prevent a delay in the diagnosis and treatment, and thus a poor outcome.

A good correlation between the patient’s clinical status and imaging findings is also essential.

Postoperative complications in our hospital are more frequent among patients in patients who suffered a cranial trauma and those who underwent urgent neurosurgical cranial procedures.
References


