Primary Brain Lesion Resection Complications: An Overview and Malignant Brain Swelling After Resection of Superior Sagittal Sinus Meningioma

VINAYAK NARAYAN, VIJAY AGARWAL, MICHAEL J. LINK, ANIL NANDA

HIGHLIGHTS
- The overall incidence of complications associated with primary brain tumor resection worldwide ranges from 20% to 35%.
- These complications can be broadly divided into neurologic, regional, and systemic complications.
- The surgery of superior sagittal sinus meningioma carries high risk of complications.
- Due to the advancements in neuroimaging, neuroanesthesia, and surgical adjunct precision in modern times, gross total resection of a primary brain tumor can be performed without significant complications.
- The careful selection of patients, a proper surgical plan, meticulous operative technique, anticipation of a complication, and the precautions to avoid the same are the main keys to a good surgical outcome.

Introduction
The surgical management of brain tumors has taken a paradigm shift over the last century from the Cushing era of cytodestruction surgery to the present golden period of advanced tumor surgery. Neurosurgical adjuncts such as cortical mapping, frameless stereotaxy, and intraoperative magnetic resonance imaging (MRI) play a huge role in the safe resection of primary brain tumors with absent or minimal complications. The objectives of brain tumor resection are the establishment of exact histopathologic diagnosis, neurologic recovery, and prolongation of patient survival. The overall incidence of complications associated with primary brain tumor resection worldwide ranges from 20% to 35%. This chapter throws light on a variety of complications associated with resection of primary brain lesions, its classification, diagnostic methods, and management strategies.

The definition of complication in primary brain tumor surgery is mostly subjective. Most surgical series define the adverse events as complications without giving due regard to whether they are expected. Apart from the surgeon’s knowledge and skill, there are various factors directly or indirectly involved in the incidence of a complication. The patient’s age, physical/neurologic status, previous treatment, tumor size and location, extent of resection, availability of monitoring/operative navigational devices, and histopathologic characteristics are a few of them. The neurosurgeon should have good acumen on all tumor-related complications because it helps in better counseling of the patient and family, both before and after surgery.

Classification of Neurosurgical Complications
A neurosurgical complication is not a single entity. It encompasses a spectrum of surgical complications as well as medical complications that may happen in the perioperative period (Table 20.1). Sawaya et al. provide a rational framework for categorizing complications associated with brain tumor surgery. In this classification pattern, the neurosurgery-related complications are broadly organized into neurologic, regional, and systemic complications. Neurologic complications are adverse events that directly impair motor, sensory, language, or visual functions (e.g., hematoma, vascular injury, edema), whereas regional complications are related either to the wound (e.g., infection, pseudomeningocele) or to the brain (e.g., seizures, hydrocephalus), but they are not associated with any...
neurologic deficits. Systemic complications include more generalized medical conditions (e.g., thromboembolism, pneumonia). Neurologic complications are the most common cause of postoperative mortality. These three complications can be further subclassified into major and minor complications based on the severity, duration of deficit, and need of reexploration surgery.

**Complications and Strategy for Their Avoidance**

### Neurologic Complications

The incidence of a new neurologic deficit (minor or major) after craniotomy for intrinsic tumor ranges from 10% to 25% in many surgical series.\(^1\)\(^-\)\(^4\) Several predictors of adverse neurologic outcome have been described in previous surgical series: age older than 60 years, Karnofsky Performance Scale (KPS) score less than 60, deep tumor location, and tumor in proximity to eloquent brain areas.\(^1\)\(^-\)\(^3\)\(^,\)\(^5\) The surgical strategy must be ideally planned based on these factors.

The main causes for neurologic complications are direct brain parenchymal injury, brain edema, vascular injury, and hematoma. The wrong localization of the tumor in relation to the adjacent eloquent brain areas is the main reason for inadvertent brain injury. Brain edema is also a notorious cause of neurosurgical morbidity. The predisposing factors for postoperative brain edema include excessive brain retraction and subtotal resection of the tumors, commonly high-grade gliomas. The incidence rate of vascular injury associated with brain retraction and subtotal resection of the tumors, commonly high-grade gliomas.\(^3\)\(^-\)\(^4\)\(^,\)\(^5\) The gross total resection of a malignant glioma is associated with reduced postoperative edema/hematoma (wounded glioma syndrome) and the resulting morbidity compared with its partial-resection counterparts.\(^1\)\(^,\)\(^3\)\(^,\)\(^9\) The risk of vascular injury while performing surgery can be reduced by the strong anatomic suspicion of the location of vascular structures, early identification of arteries and veins, judicious sacrifice of draining veins, careful and intermittent retraction, surgery along the subpial plane, and careful use of an ultrasonic aspirator. Most of the operative site hematomas can be avoided by careful preoperative preparation, meticulous operative technique, and vigilant postoperative care.

### Systemic Complications

The incidence of medical complications ranges from 5% to 10% of patients undergoing craniotomy and removal of primary brain tumor.\(^3\) The spectrum of medical complications includes deep venous thrombosis, pulmonary embolism, myocardial infarction, infection, gastrointestinal hemorrhage, and electrolyte disturbances, of which the most frequent is deep venous thrombosis.\(^3\)\(^,\)\(^5\)\(^,\)\(^13\) The predisposing factors are elderly population, poor KPS score, preexisting medical conditions, prolonged surgery, and bed rest.

Several perioperative mechanical and pharmacologic prophylactic measures can reduce the risk of thromboembolic events. The use of elastic stockings and compression boots and the administration of minidose heparin (5000 units subcutaneously twice a day) or by proper positioning of the patient, hyperventilation, high-dose corticosteroids, diuretics, and intermittent retractor placement. Frameless stereotaxy also helps in determining the optimal surgical trajectory and reduces the need for prolonged retraction and consequent cerebral edema.\(^7\) The gross total resection of a malignant glioma is associated with reduced postoperative edema/hematoma (wounded glioma syndrome) and the resulting morbidity compared with its partial-resection counterparts.\(^1\)\(^,\)\(^3\)\(^,\)\(^9\) The risk of vascular injury while performing surgery can be reduced by the strong anatomic suspicion of the location of vascular structures, early identification of arteries and veins, judicious sacrifice of draining veins, careful and intermittent retraction, surgery along the subpial plane, and careful use of an ultrasonic aspirator. Most of the operative site hematomas can be avoided by careful preoperative preparation, meticulous operative technique, and vigilant postoperative care.

### Regional Complications

Regional complications are events associated with the surgical site (e.g., infection, pseudomeningocele) or the brain (e.g., seizures, hydrocephalus, pneumocephalus) without any neurologic deficits.\(^3\) A complication occurs in 1% to 5% of patients undergoing craniotomy for removal of intrinsic brain tumors.\(^1\)\(^-\)\(^2\)\(^-\)\(^4\) Redo surgery and radiotherapy are two plausible factors that can lead to wound infection.\(^5\)\(^-\)\(^8\) The tumor proximity to the motor cortex and a history of preoperative epilepsy are the strongest predictors for seizures.\(^6\) Local factors such as degree of cortical injury, prolonged retraction while performing the operation, and postoperative edema/hematoma can be avoided by careful preoperative preparation, meticulous operative technique, and vigilant postoperative care.

### Summary of the Complications Associated With Primary Brain Tumor Surgery

<table>
<thead>
<tr>
<th>Neurologic</th>
<th>Regional</th>
<th>Systemic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor deficit</td>
<td>Hydrocephalus</td>
<td>Pulmonary embolism</td>
</tr>
<tr>
<td>Sensory deficit</td>
<td>Seizure</td>
<td>Deep vein thrombosis</td>
</tr>
<tr>
<td>Aphasia/dysphasia</td>
<td>Pneumocephalus</td>
<td>Pneumonia</td>
</tr>
<tr>
<td>Visual field deficit</td>
<td>Wound infection</td>
<td>Urinary infection</td>
</tr>
<tr>
<td>Meningitis</td>
<td>Brain abscess</td>
<td>Sepsis</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Neurologic Complications</th>
<th>Regional Complications</th>
<th>Systemic Complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive deficits</td>
<td>Hydrocephalus</td>
<td>Pulmonary embolism</td>
</tr>
<tr>
<td>Gastrointestinal bleed</td>
<td>Pneumocephalus</td>
<td>Deep vein thrombosis</td>
</tr>
<tr>
<td>Olfactory deficit</td>
<td>Urinary infection</td>
<td>Pneumonia</td>
</tr>
<tr>
<td>Visual field deficit</td>
<td>Sepsis</td>
<td>Myocardial infarction</td>
</tr>
<tr>
<td>Hearing deficit</td>
<td>Gastrointestinal bleed</td>
<td>Hematoma</td>
</tr>
<tr>
<td>Somatosensory deficit</td>
<td>Electrolyte disturbances</td>
<td>Pneumonia</td>
</tr>
</tbody>
</table>

**Abbreviations:**
- KPS: Karnofsky Performance Scale
- MRI: Magnetic Resonance Imaging
- CT: Computed Tomography

**Table 20.1 Summary of the Complications Associated With Primary Brain Tumor Surgery**

low-molecular-weight heparin after craniotomies are some of them.\textsuperscript{16–20} The neurosurgeon should keep a vigilant eye in the postoperative period to avoid or minimize the aforementioned complications to a great extent.

Next is an example of primary brain tumor; superior sagittal sinus (SSS) meningioma and the complications associated with its resection are discussed.

**Neurosurgical Complications After Resection of Superior Sagittal Sinus Meningioma**

The treatment of meningiomas that invade the intracranial venous system remains a significant and controversial challenge for neurosurgeons.\textsuperscript{21} Specifically, damage to the major dural venous sinuses, the deep cerebral veins, and the vein of Labbé, among others, can lead to major complications such as seizures, hemorrhage, sinus occlusion, corticovenous thrombosis, and regional or diffuse brain swelling.\textsuperscript{22,23} These complications can lead to significant morbidity and mortality. Meningiomas in the parasagittal region comprise 21% to 31% of all intracranial meningiomas.\textsuperscript{21,22} Invasion of the SSS is common with these lesions and increases the risk of subtotal resection and thus recurrence. Meningiomas along the SSS range from 14.8% to 33.9% in the anterior third, from 44.8% to 70.4% in the middle third, and from 9.2% to 29.6% in the posterior third of the sinus.\textsuperscript{22} Those lesions involving the posterior two-thirds of the SSS pose a substantially increased risk, whereas the previous literature has supported the sacrifice of the anterior one-third, with minimal consequence.

There is a current lack of large published series of parasagittal meningiomas that invade the SSS. Due to this, there are no accepted guidelines for the management of these lesions or their complications, and treatment paradigms vary significantly between institutions.

**Anatomic Insights**

**Venous Anatomy**

The intracranial venous system can be divided into a superficial and a deep system (Fig. 20.1). The superficial system is comprised of the sagittal sinuses and cortical veins. The deep system drains the deep gray structures via the internal cerebral veins, basal veins of Rosenthal, vein of Galen, and the straight sinus. The SSS, the lateral sinuses (including the transverse and sigmoid sinus), and the cavernous sinus are the most frequently thrombosed dural sinuses, followed by the straight sinus and vein of Galen.\textsuperscript{24} Studies have shown a permanent morbidity range of 6% to 20% from cerebral venous thrombosis, although prognosis is thought to be better than for arterial stroke.\textsuperscript{25,26} Detailed evaluation of the venous sinuses and information on patency are best obtained via a venous MR angiogram, CT venography, or a digital subtraction angiography with late venous phases.

**Dural Sinuses**

Superficial veins of both hemispheres drain via the SSS, which starts at the foramen cecum and runs posteriorly toward the internal occipital protuberance, at which point it joins the straight and lateral sinuses to form the torcular Herophili. The SSS increases in size from anterior to posterior and ranges in width from 4.3 to
The Superficial Veins of the Brain

The superficial veins can be classified into three categories: (1) midline afferents to the SSS, (2) inferior cerebral afferents to the transverse sinus, or (3) superficial sylvian afferents to the cavernous sinus. Midline afferents are primarily encountered when using interhemispheric approaches. Sacrifice of the midline central group of veins within 2 cm posterior to the coronal suture carries a significant risk. Other small-caliber midline veins can be taken with minimal risk. The vein of Trolard, or the superior anastomotic vein, is the primary connecting midline afferent and usually enters into the SSS in the postcentral region. Inferior cerebral veins are cortical bridging veins that primarily channel into the basal sinuses or the deep venous system. Small-caliber veins in this system can usually be sacrificed with minimal consequence if they do not contribute significantly to the Labbé system. The vein of Labbé, or inferior anastomotic vein, connects the superficial sylvian vein and the transverse sinus. Injury to the vein of Labbé, particularly in the dominant hemisphere, can cause an infarct in the posterior hemisphere with severe, permanent neurologic deficit. The superficial sylvian vein is formed from the connection of the temporosylvian veins and enters into the cavernous sinus.

Important superficial veins include:

- Superior cerebral veins: drain the superior surface; empty into the SSS
- Superficial middle cerebral vein: drains the lateral surface of each hemisphere; empties into the cavernous or sphenopalatine sinuses
- Inferior cerebral veins: drain the inferior aspect of each cerebral hemisphere; empty into the cavernous and transverse sinuses.
- Superior anastomotic vein (vein of Trolard): connects the superficial middle cerebral vein and the SSS
- Inferior anastomotic vein (vein of Labbé): connects the superficial middle cerebral vein and the transverse sinus

The Deep Veins of the Brain

The deep veins of the brain drain into the confluence of the Galen complex, which, in turn, drains into the straight sinus. In addition to the paired internal cerebral veins, the Galen system also receives the paired basilar veins of Rosenthal (which begins at the anterior perforated substance by the union of the anterior cerebral vein, the middle cerebral vein, and the striate vein); the veins from the corpus callosum, the cerebellum, and the occipital cortex; and the vermicular precentral vein. The deep veins are often encountered when operating in the lateral ventricle, third ventricle, and pineal region. The great cerebral vein of Galen is approximately 1 to 2 cm long and passes posterosuperiorly behind the splenium of the corpus callosum in the quadrigeminal cistern. Injury or occlusion of the vein of Galen can have catastrophic consequences. There have been case reports of ligation of the vein of Galen without significant clinical sequelae, but this is likely due to the development of collateral circulation and to the significant anatomic variation of the vein of Galen and its tributaries.28-29

Surgical Resection of SSS Meningiomas

Meningiomas invading the SSS remain a challenging lesion for neurosurgeons. They can be difficult to resect completely and carry significant risk of morbidity, including intraoperative and postoperative hemorrhage, sinus occlusion, and corticovenous thrombosis.22 Although subtotal resection is associated with a high rate of recurrence, absolute care must be taken to preserve the collateral channels at all steps of the surgery.30-32

Venous invasion by the meningioma can range from invasion of the outer surface of the venous wall to complete invasion and occlusion of the sinus. The first detailed classification scheme was proposed by Merrem and Krause et al. and then later modified by Bonnal and Brotoch et al.33 A simplified version was proposed by Sindou and Hallacq in 1998.23 This classification included the categorization described later.

With the advent of microsurgical techniques, intracranial dural venous sinus reconstruction became possible. In 1971, Kapp et al. used an autogenous great saphenous vein and shunt device to reconstruct the SSS.32 This was followed by Marks et al. in 1986 and Sakaki et al. in 1987.30,34 Reconstructive materials have included autologous great saphenous vein, neck superficial veins, Dacron, and silicone tubing.35-37 Sindou and Hallacq reported a series of 47 meningiomas: 41 of the sagittal sinus, 4 of the transverse sinus, and 2 torcular.23 A gross total resection was achieved in all cases. Thirty-nine patients were reported as having good outcomes and resumed their previous activities, whereas five patients had permanent neurologic deficit due to central venous infarction (all in the middle one-third of the sagittal sinus). Three patients died from brain swelling; all three involved meningiomas totally occluding the sinus, and in all three patients resection was achieved without sinus reconstruction. Nine patches, six Gore-Tex bypasses, and nine autologous vein bypasses were employed. The authors recommended the following: excision of the outer layer of sinus wall and coagulation of dural attachment in Type 1, removal of intraluminal fragment and repair of dural defect with a patch in Type 2, resection of sinus wall and repair by patch graft in Type 3, repair by patch or bypass with saphenous or external jugular vein graft in Type 4, and removal of involved portion of sinus and restoration by venous bypass in Types 5 and 6.

Mathiesen et al. supported the practice of sagittal sinus repair or reconstruction after resection by invasive meningiomas when attempting a macroscopic radical removal.38 They proposed a direct primary repair when resecting just an invaded edge; closure with a patch graft of dural, falcine, or pericranial tissue when resecting...
one to two invaded walls; and using an interposition venous graft when resecting three sinus walls. In this prospective study of 100 patients, the authors had good to excellent outcomes in 94 patients but found that microscopic radical resection was difficult to achieve. Gamma Knife radiosurgery was used as an adjunct in patients with tumors of low proliferative index, and the authors felt that tumor control was better when Gamma Knife radiosurgery was used as a primary treatment strategy than when it was employed only after tumor progression.

Over time, however, extensive reconstruction of the SSS after meningioma resection has played a diminishing role. In 2014, Mantovani et al. reported on the management of meningiomas invading the major dural venous sinuses. The authors reported on 38 patients who underwent operations for meningioma resection: 26 patients with lesions in the SSS, 5 with lesions in the torcular Herophili, 5 with lesions in the transverse sinus, and 2 with lesions in the sigmoid sinus. Twenty-seven patients had World Health Organization (WHO) Grade I meningiomas, and 11 had WHO Grade II meningiomas. In 50% of cases (13 patients), the sinus was completely occluded. A gross total resection was achieved in 86.9% of patients. Sinus reconstruction was performed in 21 cases: 13 by direct suture and 8 using a patch. Postoperatively, the sinus was found to be patent in 52.4% of patients and narrowed in 33.3% of patients. Correspondingly, an occlusion rate of 14.3% was found. No deaths were reported, and one major postoperative complication occurred. Further diminishing the role of sinus reconstruction, DiMeco et al. reported on their surgical experience in 108 cases of meningiomas invading the SSS. Thirty patients with meningiomas completely occluding the SSS had complete resection of the involved portion of sinus, and Simpson Grade I or II resection was achieved in 100 patients. Two perioperative deaths were noted. Serious complications included brain swelling in 9 patients (8.3%) and postoperative hematoma in 2 patients (1.8%). At a mean follow-up of 79.5 months, tumor recurrence was noted in 15 patients (13.9%). The authors concluded that if extreme care is taken to preserve cortical veins, good results are achieved without reconstruction of the sinus.

Surgical management of meningiomas of the SSS remains controversial. Resection should be offered to those with symptoms or with lesions that exhibit growth. Close examination of preoperative imaging for extent of SSS invasion is essential to guide the surgeon’s goals of care. After exposure or injury of the sagittal sinus during meningioma surgery, the patient is at risk for intraoperative excessive blood loss or air embolism. In most cases, injury is controllable with packing by Surgicel, Gelfoam, and microsurgical patties. Care should be taken with injectable thrombotic agents to avoid inadvertent occlusion. If there is planned resection of a portion of the SSS during surgery, a preoperative formal angiogram may be very helpful in evaluating the collateral venous anatomy to avoid inadvertently interrupting critical pathways.

Complications of Venous Injury

The risk of postoperative seizures after craniotomy is a well-recognized phenomenon. They are generally classified into three categories based on time interval: immediately postoperatively, occurring within 24 hours; early seizures, within 1 week; and late seizures, 1 week or more after the craniotomy. Immediate postoperative seizures occur in approximately 4.3% of craniotomy patients. Patients with supratentorial meningiomas or supratentorial low-grade gliomas are at a much higher risk than patients with lesions in various other intracranial locations. Generalized tonic-clonic seizures are the most common postoperative seizure noted in the neurologic intensive care unit, but a high index of suspicion must be maintained because some patients will present with neurologic deterioration and decreased level of consciousness rather than with convulsions.

Literature regarding the benefit of prophylactic treatment with antiepileptics in brain tumor patients is inconsistent. Furthermore, the exact choice of antiepileptic agent remains controversial. Phenytoin, phenobarbital, carbamazepine, valproic acid, zonisamide, and levetiracetam have all been used for the prevention of early postoperative seizures with varying results. However, inadequate dosing is common, and caregivers must be vigilant about maintaining appropriate levels. Seizures manifesting from a reversible primary source such as cerebral edema, intracranial hemorrhage, meningitis, or infection should be addressed by aggressively reversing the source.

### SURGICAL REWIND

#### My Worst Case

This is the case of 52-year-old woman who was referred for treatment of petroclival and SSS meningiomas invading into and occluding the SSS at the level of the coronal suture (Fig. 20.2). She was asymptomatic until approximately 1 year prior, when she noted the onset of right face tingling and the onset of headache centered over the right orbit. She did not note face pain, weakness, or numbness. She also noted a distant history of right-sided hearing loss. Approximately 4 months before presentation she developed diplopia with a right lateral gaze palsy. She subsequently underwent Gamma Knife radiosurgery to treat her right cavernous sinus Meckel’s cave meningioma (marginal dose of 14 Gy and a maximum dose of 28 Gy to a volume of 9.1 cm³) (Fig. 20.3). After Gamma Knife treatment her diplopia resolved, and she had no new symptoms. A cerebral angiogram confirmed that the SSS was completely occluded at the site of the tumor, with collateral venous circulation around the tumor.

Approximately 3 months after Gamma Knife therapy, she underwent a bifrontal craniotomy for complete resection of her meningioma involving the anterior one-third of the SSS and overlying bone. At the time of craniotomy, extensive venous bleeding was noted arising from collateral veins and the SSS at the posterior margin of the tumor. This was controlled with Gelfoam soaked in thrombin, bipolar coagulation, and 5-0 monofilament suture. There were no other adverse events during tumor resection, and she did not require blood transfusion. Immediately upon awakening from anesthesia, she was noted to have difficulty speaking. A CT scan showed a small intraparenchymal hematoma in the medial left frontal lobe beneath the tumor resection. The patient was taken to the neurosurgery intensive care unit for postoperative monitoring. She continued to follow commands but had a complete motor aphasia. She had some difficulty with following commands with the tongue and mouth.

On postoperative day 2, she suffered a generalized seizure. She was taken to the CT scanner for a repeat scan, which revealed some new circumferential hemorrhage around the previous hematoma as well as increased edema around the hematoma with minimal left-to-right shift (Fig. 20.4). The patient recovered and was able to move three of her four extremities purposefully and without motor deficit. Her left lower extremity

Continued
was weak. It was intended to reload the patient with phenytoin; however, it was written as a per oral order, and she did not receive it because she was not deemed safe for oral intake.

Four hours after her seizure, she suffered a respiratory arrest felt possibly secondary to another seizure. She was apneic with desaturation, and she was intubated. She also required resuscitation for hypotension during this episode. Once hemodynamically stable, she was taken to the CT scanner, which showed increased size of her hematoma and diffuse cerebral edema. An intracranial pressure monitor was placed in the left frontal area with readings in the range of 110 to 120 mm Hg. She was taken to the operating room for a left frontal lobectomy and decompressive hemicraniectomy. Gross herniation was noted. She was taken back to the intensive care unit and subsequently progressed to clinical brain death.

In the case presented here, even though the anterior one-third of the SSS was completely occluded by the tumor, both frontal lobes were draining via cortical collaterals and then entering the SSS at the posterior margin of the tumor. These veins were injured during the craniotomy and subsequently sacrificed to control the bleeding. In retrospect, performing a small craniectomy with a diamond burr over this area would have been much safer than elevating a large bone flap that put these veins at risk.

The immediate frontal lobe dysfunction also should have been an indication that there was a vascular problem and that the patient would be at risk of increased intracranial pressure. Finally, after her initial generalized seizure, anticonvulsant therapy should have been aggressively pursued. Likely, after the initial seizure she hypoventilated, which increased her PCO₂ and cerebral blood flow with aggravation of already elevated ICP from insufficient venous drainage of the frontal lobes.
Due to advancements in neuroimaging, neuroanesthesia, and surgical adjunct precision in modern times, gross total resection of a primary brain tumor can be performed without significant complications. The careful selection of patients, a proper surgical plan, meticulous operative technique, anticipation of a complication and the precautions to avoid the same are the main keys to a better outcome.

Venous injury during resection of SSS meningiomas can have severe consequences. It is imperative to closely examine preoperative imaging for patency of the sagittal sinus and orientation of collateral flow. Due to the high recurrence rate, aggressive surgical resection is warranted, but the collateral flow must be vigilantly maintained. If resection of the SSS is undertaken, the anterior one-third is felt to pose the least risk of new neurologic morbidity. After injury or resection of a portion of the SSS, close observation must be maintained for the onset of seizures or brain edema. Early intervention is critical in the event of complications arising from dural venous compromise.

References

Cranial Complications


