



Original Article

## Neurosurgical emergencies during pregnancy – Management dilemmas

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### ABSTRACT

**Background:** Neurosurgical emergencies in the obstetric setting pose considerable challenges. Decision-making involves deliberations on the gestational age, critical nature of the illness, timing of surgery, maternal positioning during neurosurgery, anesthesiologic strategies, monitoring of the pregnancy during surgery, and the mode of delivery. The present study discusses the management and ethical dilemmas encountered during the management of six obstetric patients with neurosurgical emergencies.

**Methods:** A retrospective review of all neurosurgical operations performed between January 2016 and December 2022 were included in the study.

**Results:** This study includes a series of six pregnant women who presented with neurosurgical emergencies, secondary to freshly diagnosed pathologies in the period 2016–2022. The mean maternal age was 31.33 years. Four of the six patients were in the third semester and two were in the second trimester. The underlying etiologies were as follows: spontaneous intracerebral hypertensive hemorrhage (1), obstructive hydrocephalus due to shunt malfunction (1), brain tumor (02), and compressive spinal cord myelopathy due to tumors (02). Three patients who were near term underwent lower cesarean section followed by emergency neurosurgical procedure in the same sitting. Two second trimester patients continued their pregnancy after the emergency neurosurgical operation. In one patient, in whom a brain tumor was diagnosed near term, underwent neurosurgery 1 week after successful cesarean section. All the six mothers and fetus recovered well, except two patients who have persisting residual deficits.

**Conclusion:** Treatment of neurosurgical emergencies during pregnancy needs to be customized depending on the clinical condition of the pregnant woman, prognosis of the disease, gestational age and the status of the pregnancy. With careful planning, timely intervention, consultative decision making and it is possible to achieve the ultimate goal – which is to protect and safeguard the mother and preserve and deliver a viable fetus.

**Keywords:** Brain tumor, Fetus, Intracerebral hemorrhage, Neurosurgery, Obstetrics, Pregnancy

### INTRODUCTION

Pregnant women who require emergency neurosurgical intervention pose major challenges in decision-making and treatment planning.<sup>[25,27,36,38]</sup> Decision-making involves deliberations on the gestational age, critical nature of the illness, timing of surgery, termination of pregnancy, maternal positioning during surgery, anesthesiologic strategies, and monitoring of the pregnancy during surgery and the mode of delivery. Ethical dimension involves the debate about maternal versus fetal rights and prioritizing between mother and baby raise unique ethical challenges as

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well.<sup>[1,38]</sup> We describe six patients who underwent successful neurosurgical management during pregnancy and describe the challenges involved.

## MATERIALS AND METHODS

A retrospective review of all pregnant patients who underwent neurosurgical operation during their pregnancy were included in the study. The study period was between January 2016 and December 2022. Patient demographics, obstetric history, neurosurgical intervention and timing of surgery were reviewed from case records. Outcome was assessed on discharge and on follow up in the out patient clinic.

## RESULTS

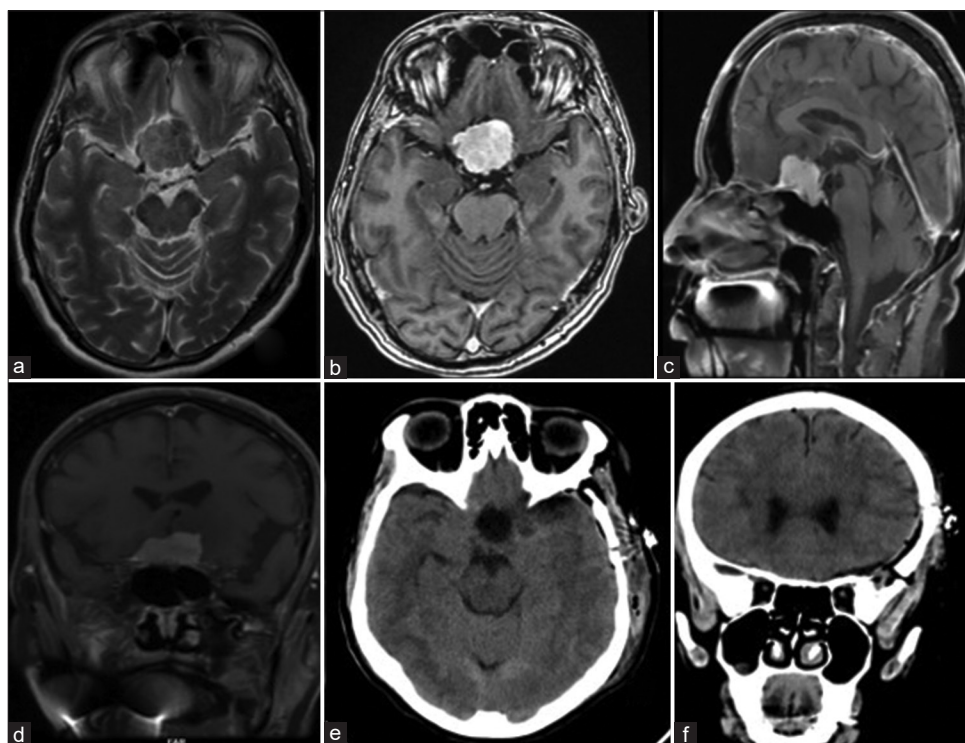
### Case 1

A 25-year-old female homemaker (G<sub>2</sub>P<sub>2</sub>L<sub>1</sub>) with 28 weeks of amenorrhea presented with acute onset painless progressive loss of vision in both eyes. On admission, she had no perception of light in her left eye and could barely perceive hand movements in the temporal field in her right eye. An urgent magnetic resonance imaging (MRI) revealed a suprasellar lesion characteristic of a meningioma

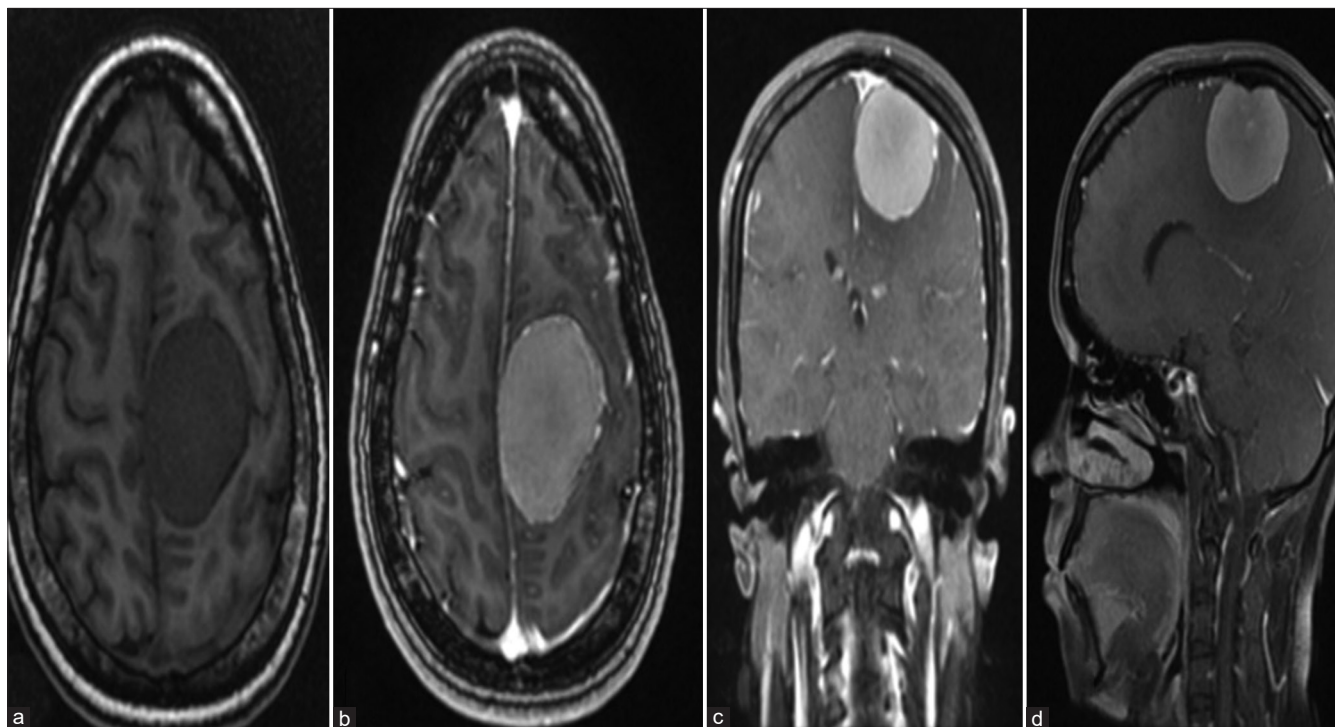
[Figures 1a-d]. Continuation of pregnancy carried a potential risk of blindness in both eyes and craniotomy under general anesthesia carries a risk of spontaneous abortion. After considerable deliberations and an informed consent, she underwent emergency craniotomy and gross total excision of the lesion [Figures 1e and f]. Her vision improved following surgery. Pregnancy continued and she developed a healthy baby 6 weeks later through caesarean section.

### Case 2

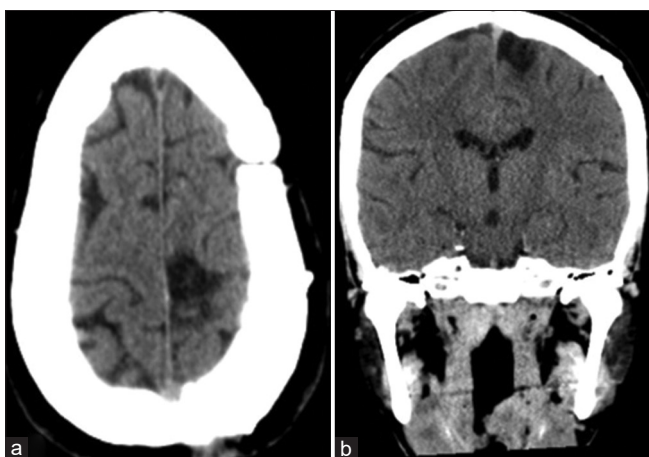
A 35-year-old home maker, (G<sub>3</sub> P<sub>1</sub> L<sub>1</sub> Ab<sub>1</sub>) presented with one episode of generalized seizure in her 30<sup>th</sup> week of gestation. On admission, she was neurologically stable and had no deficits. Imaging done revealed a broad based parasagittal mass measuring 5.1 × 4.1 × 3.5 cm with hyperostosis of the adjacent left parietal bone suggestive of a left mid third parasagittal meningioma [Figure 2]. She was initiated on antiseizure medication. As she was clinically stable craniotomy was deferred until completion of pregnancy. She underwent a caesarean section at term following premature rupture of membranes, hypothyroidism, and flexed breech position of the fetus. Nearly 1 month after the delivery, she underwent craniotomy and excision of the tumor following which she had an uneventful postoperative recovery [Figure 3].



**Figure 1:** Magnetic resonance imaging images flair (a), T1 contrast (b), Sagittal T1 (c), and Coronal contrast (d) showing an enhancing suprasellar mass with chiasmal compression. Postoperative axial computerized tomography (CT) scan plain (e) and coronal CT plain (f) showing total excision of the tumor.



**Figure 2:** Magnetic resonance imaging axial T1 plain (a), contrast (b), contrast coronal (c), and Sagittal contrast (d) images showing a large contrast enhancing mass lesion in the left middle third parasagittal region suggestive of a meningioma.



**Figure 3:** Postoperative computerized tomography scan axial plain images (a and b) showing total resection of the lesion with a gliotic tumor bed.

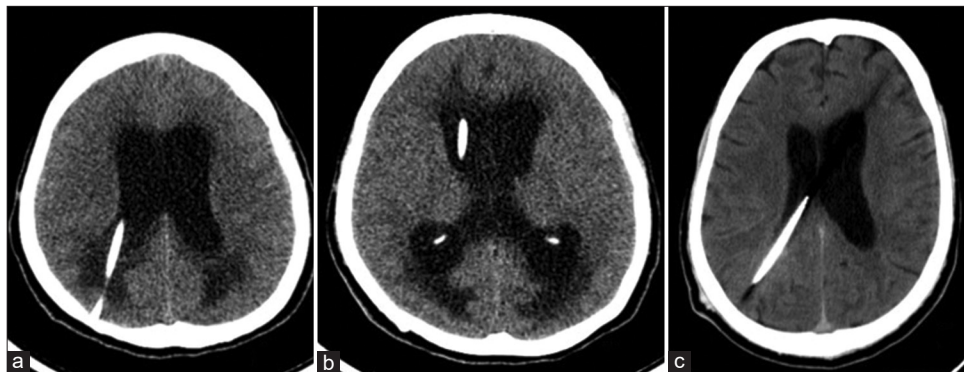
### Case 3

A 26-year-old female (G<sub>1</sub> P<sub>1</sub> L<sub>1</sub>) presented to the neurosurgery department with pain abdomen for 2 days and on and off headache for 3 days at 32+ weeks of gestation. A known diabetic, she had undergone ventriculoperitoneal shunt in childhood for obstructive hydrocephalus due to aqueduct stenosis. As her headache continued to worsen, raised intracranial pressure due to shunt malfunction was suspected which was confirmed on imaging [Figures 4a and b].

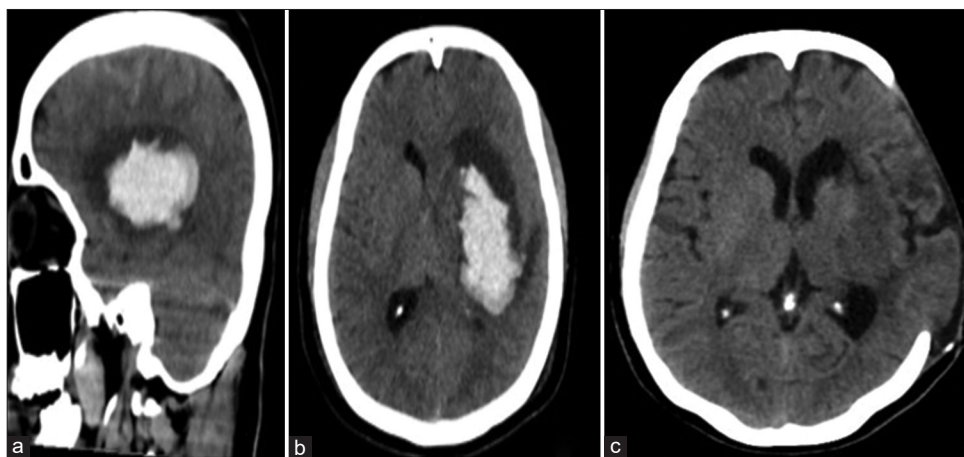
Emergency cesarean section followed by endoscopic third ventriculostomy (ETV) was done in the same sitting. Postoperatively, her ventricle size reduced and she had an uneventful recovery and continue to remain so 6 years later [Figure 4c].

### Case 4

A 36-year old female homemaker (G<sub>2</sub> P<sub>1</sub> L<sub>1</sub>) presented to the emergency in her 29<sup>th</sup> week of gestation with features of accelerated hypertension and impending eclampsia. An emergency lower section cesarean section was done to deliver a preterm baby who was immediately shifted and nursed in the neonatal intensive care unit. Post caesarean section, she developed sudden severe headache, slurring of speech, and right-sided weakness of upper and lower limb and a drop in sensorium. Urgent computerized tomography (CT) scan revealed a large left basal ganglionic hematoma measuring 6.2 × 3.4 × 4.3 with peri-focal edema causing mass effects in the form of compression of ipsilateral lateral ventricle, mild midline shifts [Figures 5a and b]. She immediately underwent a decompressive craniectomy and evacuation of the hematoma followed by autologous cranioplasty 6 weeks later [Figure 5c]. On follow-up 6 months after the surgery, she had fixed deficits in the form of the right hemiparesis and expressive dysphasia but was independent for activities of daily living. The baby recovered well and has attained normal milestones.



**Figure 4:** Computerized tomography (CT) scan axial plain images (a and b) showing ventricular dilatation with periventricular Seepage suggestive of hydrocephalus. Shunt tip can be seen in position in the lateral ventricle. Post endoscopic third ventriculostomy CT scan (c) showing reduction in ventricle size and appearance of sulci and gyri.



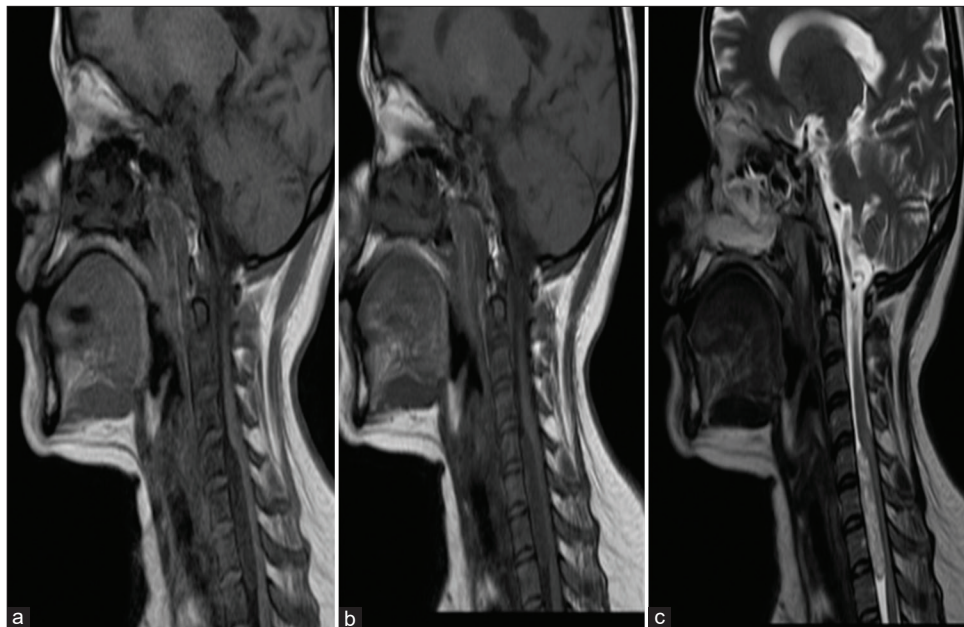
**Figure 5:** Computerized tomography scan images plain sagittal (a), axial (b), and coronal (c) showing a large hyperdense Lesion in the left basal ganglionic region suggestive of spontaneous intracerebral hemorrhage. Axial image (c) showing the postoperative scan following decompressive craniectomy and evacuation of the hematoma.

#### Case 5

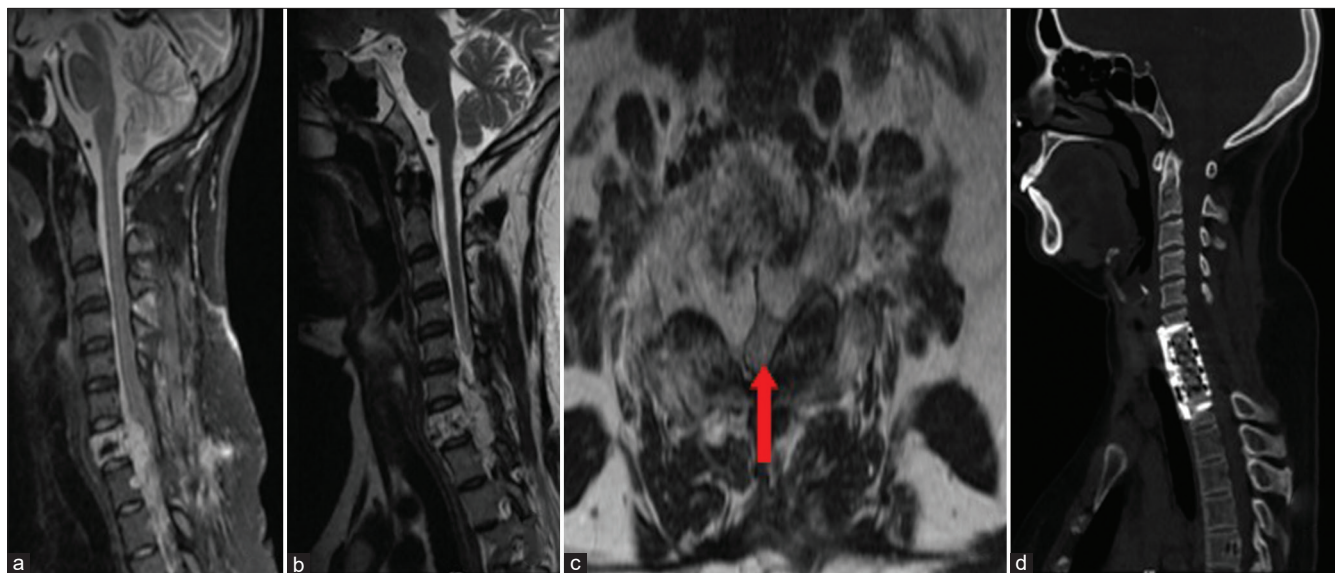
A 33-year-old homemaker (P2L2) presented at 34 + 1 weeks of pregnancy with acute onset, rapidly progressive ascending weakness starting from both lower limbs. On admission, she had Grade 0 power in bilateral lower limbs and Grade 3 power in bilateral upper limbs. She had a sensory level at D1 and had to be catheterized for bladder retention. She also gave history of lower cervical neck pain which had worsened during pregnancy. An urgent MRI of spine revealed a well-defined altered signal intensity intradural extramedullary lesion in the spinal canal from C7 to D1 level, significantly compressing the spinal cord [Figure 6]. She underwent emergency cesarean section followed by laminectomy and excision of an intradural extramedullary schwannoma. At 3-month follow-up, her upper limbs power had become near normal but lower limbs continued to be spastic with Grade 0 power. The baby recovered well and remained normal.

#### Case 6

A 33-years-old lady (G2Ab1) presented with progressive weakness of both lower limbs at 5 months of gestation. On admission, she was bedbound with spastic Grade 2–3 power in bilateral lower limbs. MRI revealed a C7 vertebral hemangioma with circumferential cord compression [Figures 7a-c]. The ideal surgical approach is a radical decompression and a 360° fusion of the spine which would involve intraoperative fluoroscopy. Considering her age, precious nature of pregnancy, a two staged approach was planned. As a first step to provide cord decompression and facilitate neurological recovery, she underwent three level laminectomy in lateral position. Pregnancy thereafter continued and she delivered a term baby through cesarean section 4 months after the first surgery. Following the delivery, she was reinvestigated and underwent anterior corpectomy and fusion to decompress the cord anteriorly also



**Figure 6:** Magnetic resonance imaging sagittal images T1 (a), Fat suppressed T1 (b), and T2 (c) showing an intradural extramedullary well delineated lesion in the lower cervicothoracic region Extending from (C5 to D10 suggestive of a schwannoma). The spinal cord is seen pushed posteriorly.



**Figure 7:** Magnetic resonance imaging images Sagittal T2 (a and b) showing an extradural lesion involving the C7 vertebral body. The cord is seen pushed posteriorly. Axial images (c) show the cord compressed circumferentially anterior by the tumor and posteriorly against the lamina and posterior elements. Red arrow indicates Compressed Spinal Cord (d) Showing postoperative computerized tomography scan following corpectomy with a cage *in situ*.

[Figure 7d]. Her power thereafter improved and at 3 months following the surgery, she is ambulant with support.

## DISCUSSION

Pregnant women who require emergency neurosurgical intervention pose major challenges in therapeutic

decision-making and treatment planning. Pregnancy is associated with multiple physiological changes which include increased cardiac output, increased intracranial and intra-abdominal pressure, hypercoagulability, and hormonal changes. These changes can promote growth of an existing tumor, induce bleeding in an existing vascular malformation or tumor, or result in a hemorrhagic stroke

in a predisposed patient. Such neurosurgical emergencies during pregnancy can result in significant rates of maternal death, fetal loss, miscarriage, and disability in pregnant women.<sup>[3,8,12,13,19,31,39]</sup> Laviv *et al.* have reported that, overall, nonobstetric surgeries carry an increased relative risk of 2.1 for neonatal death and 2.0 for infant death, between 1 month and 1 year following surgery.<sup>[25]</sup>

### Common neurosurgical emergencies during pregnancy

Common neurosurgical emergencies during pregnancy include cereberovenous thrombosis with hemorrhagic transformation, intracranial hemorrhage, hydrocephalus, intracranial and spinal tumors, and head trauma. The incidence of brain tumors in pregnant women ranges between 3.6/million and 3/100,000 while that of vascular lesions in pregnant women is 0.01–0.05%.<sup>[3,12,13,31]</sup>

Meningiomas tend to have an increased growth rate during pregnancy and are perhaps the most common of all brain tumors which become symptomatic during pregnancy. They occur with a frequency of 1–4.5/100,000 and are usually detected during the second and third trimesters.<sup>[15,18]</sup> The exact mechanism for meningiomas becoming symptomatic during pregnancy remains unknown. The possible mechanisms postulated include the role of progesterone, increase in local blood flow, increase in edema and intratumoural bleeds.<sup>[11,17,27,29,33]</sup> Surprisingly, the contrary has also been reported where pregnancy-related meningiomas can shrink during pregnancy.<sup>[21]</sup> The first reported case of pregnancy associated visual loss due to a tuberculum sella meningioma was by Cushing and Eisenhardt.<sup>[9]</sup> Since then nearly 22 cases of tuberculum sella meningioma during pregnancy have been reported.<sup>[11,15,28]</sup> Deterioration in vision is a predominant symptom in pregnant ladies with suprasellar meningiomas and is probably related to the combination of pregnancy associated tumor growth and pituitary gland volumetric expansion.<sup>[10,28]</sup> The first patient in our series had a similar presentation which improved following successful decompression of the tumor.

Vertebral hemangioma is one of the most common benign tumors of the spine seen in approximately 10% of the population.<sup>[7,16,22]</sup> Vertebral hemangiomas are usually incidental and only <1% cause neurologic symptoms by compressing the spinal cord or nerve root.<sup>[16]</sup> Pregnancy is a risk factor for worsening of symptoms and commonly happens during the third trimester and in the upper thoracic vertebrae.<sup>[16]</sup> In the third trimester, the gravid uterus compresses the inferior vena cava and this increase in intra-abdominal pressure causes redistribution and increased blood volume into the vertebral venous plexus, resulting in the expansion and growth of vertebral hemangiomas.<sup>[16]</sup> Treatment options for symptomatic hemangiomas include radiation therapy, embolization, vertebroplasty, and

surgery.<sup>[16]</sup> Surgery is the first choice during pregnancy as all other modalities involve radiation to the mother and fetus. Laminectomy with or without stabilization is the preferred option.<sup>[16]</sup> Hemangiomas are highly vascular tumor and intraoperative blood loss may be profound. Anterior approach through anterior corpectomy should be carefully considered during pregnancy.<sup>[7]</sup> We therefore adopted a two staged approach – initial laminectomy and decompression followed by corpectomy with stabilization after the pregnancy was terminated.

The incidence of pregnancy-related intracerebral hemorrhage (ICH) is around 12.2/100,000 deliveries and is responsible for up to 7.1% of all maternal mortality.<sup>[5,24,35,36]</sup> Risk of brain hemorrhage among pregnant women is highest nearing term and the relative risk of bleed can vary from 2.5 (95% CI 1.0–6.4) in the third trimester to 28.3 (95% CI 13.0–61.4) in the postpartum period.<sup>[6,23]</sup> Preeclampsia and eclampsia are the most common causes for pregnancy-associated ICH and account for nearly 14–50% of cases.<sup>[32,34,36]</sup> The second common cause is related to vascular malformations (37%) and the other common risk factors include advanced maternal age, hypertension, coagulopathy, tobacco abuse,<sup>[6,36]</sup> a syndrome of hemolysis, elevated liver enzymes, and low platelet count may represent a severe form of preeclampsia in which there is a risk for developing spontaneous ICH due to an acquired coagulopathy.<sup>[30,36]</sup> Among vascular malformations arteriovenous malformations are the most frequent cause of hemorrhage (25.8%) followed by aneurysms (16.5%) and moyamoya disease (10.3%).<sup>[36]</sup> Hemorrhages secondary to vascular malformations are more frequent in the second trimester but the timing is controversial. Aneurysmal subarachnoid hemorrhage during pregnancy is rare but likely to be more fatal. The bleed in our patient was probably a combination of multiple factors-pre eclampsia, high maternal age, and coagulopathy.

In pregnant women with hydrocephalus, increase of total body water, cardiac output, and central venous pressure, and decrease in plasma osmotic pressure might contribute to development and sudden worsening of symptoms.<sup>[33,41]</sup> Increase in intrabdominal pressure and fetal compression can also result in shunt blockage as happened in our patient.

### Management - General principle

There are no established guidelines regarding treating pregnant women with neurosurgical emergencies. The treatment plan needs to be customized based on her neurological condition, gestational age, tumor size, and likely pathology. The challenge is in successfully treating the mother's neurological problem without adversely injuring the growing fetus.<sup>[8,29]</sup> In general, if the patient does not have significant/impending risk to life or deficit, a decision to postpone surgery into the postpartum period is reasonable.<sup>[37]</sup>

If surgery is mandatory and clearly indicated, it needs to be performed irrespective of the timeline of pregnancy. The first concern is the mother's health and safety and a pregnant woman should not be denied surgery regardless of the gestational age.<sup>[26,28,37,39]</sup> If indicated nonurgent surgery should be performed during the second trimester when preterm contractions and spontaneous abortion are least likely (ACoG). If the fetus is in the first or early second trimester, the expecting mother might be treated as if she is not pregnant.<sup>[3,4,25,32,38]</sup>

### Timing of surgery

Timing of the surgical intervention is of critical importance as a delay in performing the surgery to safeguard pregnancy may result in irreversible neurological deficits to the mother.<sup>[25,39]</sup> Second trimester is generally considered the safest period for general anesthesia. During second trimester, major organogenesis would have been initiated and risks of teratogenic effects of anesthetics are lesser.<sup>[8,21,37]</sup> First trimester surgery carries a high risk of birth defects and spontaneous abortion (up to 10.5%) and should be reserved for severely symptomatic patients.<sup>[8,20,21,37]</sup> Third trimester surgery carries higher risks for both mother and fetus related to the large fetal size and hyperdynamic circulation. During the third trimester, it is preferable to perform urgent delivery of the fetus before neurosurgery with special precaution to safeguard prematurity.<sup>[29]</sup> In general, among babies born at gestation weeks 24–25 only 50% survive, compared to 50–70% survival rates for weeks 26–27 and approximately 90% survival rates for babies born at 27 weeks.<sup>[25]</sup> This should be an important consideration in decision-making.

Case 2 in our series, the patient was diagnosed with a brain tumor late in her pregnancy following an episode of seizure. As seizure was her only symptom and she was neurologically well preserved, it was decided to initiate her on antiseizure medications and craniotomy was performed after completion of normal delivery. This approach, however, they may not be applied in more aggressive or malignant tumors. Case 1 in our series had a suprasellar tumor which suddenly increased in size and caused optic nerve compression with sudden decrease in vision. The pregnancy was in its second trimester. As preserving the mother's vision gained priority over the fetus, craniotomy under general anesthesia was performed explaining the risk for spontaneous termination. A similar situation was encountered in Case 6 for whom we proceeded in two stages. The mother was losing power in her limbs and her precious pregnancy was in early second trimester and the fetus was not viable. Ideal surgical approach involved intraoperative fluoroscopy and positioning in prone position. As a first stage procedure, laminectomy was done in a lateral position to decompress the spinal cord without using any form of intraoperative radiography. Pregnancy was allowed

to continue and once the baby was delivered at term complete removal of the tumor and stabilization was done as a second stage procedure.

When the fetus is in the third trimester of gestation and the mother's neurological illness is critical, an emergency cesarean section should be considered.<sup>[9]</sup> We adopted this strategy for Case 3, Case 4, and 5. In Case 3 of our series, the mother was in her third trimester and had refractory raised intracranial pressure secondary to hydrocephalus. The growing fetus had probably caused blockage of an indwelling ventriculoperitoneal shunt. As the fetus was near term and viable, cesarean section was performed before ETV protecting both the mother and fetus. In Case 4, the mother had a life threatening intracerebral bleed. Although she was only 29 weeks of gestation, pregnancy was terminated and craniotomy was performed to drain the clots. Similarly, in Case 5, the mother became quadriplegic due to a high cervical cord compression by a cervical schwannoma. Further delay in surgery would have resulted in fatal respiratory depression. As the pregnancy was near term and the fetus viable, emergency cesarean section was performed in the supine position followed immediately by a laminectomy in prone position with satisfactory outcome.

### Anesthetic considerations

Anesthetic procedures carry a risk towards the fetus and involve unique challenges.<sup>[6]</sup> Administration of drugs needs to be carefully decided, keeping in mind the risk of fetal transfer of the drug across placenta. Use of mannitol needs to be guarded as it crosses the placenta and can cause a hyperosmotic state in the fetus, leading to dehydration.<sup>[19,21]</sup> Anti-seizure medications have teratogenic complications and levetiracetam is considered to be the safest option currently. Safe anesthetic agents include barbiturates, propofol, intravenous anesthesia, and local anesthetics.<sup>[37,40]</sup> Cranial procedures can only be performed under general anesthesia but few cases of spinal surgery can be attempted under spinal anesthesia. Fetal heart rate and maternal uterine contraction monitoring are recommended for pregnant women undergoing intracranial surgery in the second trimester, in accordance with the American College of Obstetricians and Gynecologists.<sup>[20,26]</sup>

### Positioning

Positioning the patient for surgery is another concern especially in spinal surgeries.<sup>[12]</sup> Spinal surgeries are usually done in the prone position which is particularly difficult in the third trimester and can result in aortocaval compression. Left lateral decubitus position is an alternative but compromises the surgical exposure. If prone position is mandatory, it can still be attempted with special paddings to

avoid any abdominal pressure. In Case 6, as the surgery was carried out in the second trimester, we used the left lateral position and in Case 2 as the surgery followed termination of pregnancy, we adopted a prone position. Many skull base approaches are now being approached endoscopically through the nose avoiding a major craniotomy. This is of special benefit in pregnant women as. Endoscopic and other minimally invasive approaches provide several potential advantages, including less tissue manipulation, avoidance of brain retraction, and often a shorter hospital stay.<sup>[2]</sup>

### Imaging

Diagnostic imaging becomes a challenge during pregnancy. CT scan, the modality of choice for neurosurgical emergencies, carries a risk of radiation exposure to the fetus especially in the first and second trimester. The threshold level for teratogenic risk has been estimated to be >0.05 Gy with the highest risk in the first trimester.<sup>[12]</sup> CT is more rapid, more readily available, and is more sensitive for detecting acute blood. The shielded fetal radiation exposure from a maternal noncontrast head CT is estimated to be less than 0.005 mGy, with the generally considered threshold for development of fetal malformations from radiation exposure is 100 mGy.<sup>[3]</sup> MRI, thus, is the preferred imaging modality of choice for cranial and spinal neurosurgical emergencies. Gadolinium-based contrast agents are typically not used during pregnancy because of uncertainty regarding effects on the fetus.<sup>[14]</sup> Spinal surgery may however require intraoperative radiation exposure and spinal surgery requiring intraoperative fluoroscopy is best avoided in the first trimester and early second trimester. If the surgery is mandatory and cannot be avoided, preoperative termination of pregnancy needs to be considered.<sup>[13]</sup>

To summarize, the primary concern in such situations of neurosurgical emergencies complicating pregnancy is the mother and three different options can be adopted.<sup>[12]</sup> The first option is to go proceed as you would for a person with no pregnancy. This option carries a risk to the fetus which needs continuous monitoring (Case 1, 6). However, if surgery involves radiation, termination of pregnancy followed by urgent treatment of the expectant mother is preferred especially in patients near term with a viable fetus (Case 3, 4, 5). The third option is to wait until normal delivery and then proceed with treatment of the neurological illness. This strategy can be adopted when the mother is near term and a few days' delay in treatment is unlikely to have any adverse consequences (Case 2).

### CONCLUSION

Neurosurgical emergencies during pregnancy pose considerable ethical and management dilemmas. Along with the underlying ethology, multiple other factors such as gestational period, nature, and severity of the underlying

pathology need to be considered before arriving at a decision. With careful planning, timely intervention, consultative decision-making and it is possible to achieve the ultimate goal – which is to protect and safeguard the mother and preserve and deliver a viable fetus.

### Declaration of patient consent

Patients' consent not required as patients' identities were not disclosed or compromised.

### Financial support and sponsorship

Nil.

### Conflicts of interest

There are no conflicts of interest.

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