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Masterthesis

Extracranial-intracranial cerebral bypass for aneurysmal rupture in post-partum woman: a case report and review of the literature

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Abstract

Background: **We report the first case of extracranial-intracranial (EC-IC) cerebral bypass in a postpartum woman with a ruptured cerebral aneurysm unsuitable for endovascular treatment. We also review literature on aneurysmal subarachnoid hemorrhage (aSAH) in pregnancy, including delivery timing, treatment strategies, bypass techniques, and anesthetic management.**
Case Report: **A 33-year-old woman at 35 weeks of pregnancy presented with seizures and coma (GCS 3/15). She was intubated and transferred to hospital. CT revealed a Fisher IV subarachnoid hemorrhage due to a ruptured 21 mm left Sylvian aneurysm, with cerebral herniation.**
An emergency C-section was performed, followed by external ventricular drainage. The cerebral aneurysm was not suitable for endovascular treatment. She underwent a temporo-sylvian artery bypass, allowing for aneurysm clipping. Unless intensive reanimation supports implemented, progressive multi-organ failure included refractory lactic acidosis, renal failure and liver dysfunction. Family opted for comfort measures after consensus.
Discussion: **Managing ruptured cerebral aneurysms in pregnancy requires a multidisciplinary approach due to maternal-fetal considerations. We review the epidemiology of pregnancy-related aneurysms and discuss adherence to current treatment guidelines. Endovascular and surgical options are compared, with emphasis on delivery timing and intervention choice. In this case report, bypass techniques are discussed, highlighting the role of direct revascularization when aneurysms are unclippable or uncoilable. Anesthetic management is also addressed, given its critical impact on outcomes.**
Conclusion: **Ruptured cerebral aneurysms in pregnant women are rare and complex. In select cases, cerebral bypass followed by clipping may be a viable option when endovascular treatment is not possible. Larger studies are needed to assess the safety and efficacy of these approaches.**

Keywords: **Case Report, Cerebral Revascularization, Subarachnoid Hemorrhage, Intracranial Aneurysm, Pregnancy.**

Introduction

We present the first reported case of extracranial-intracranial (EC-IC) in a post-partum woman suffering from a ruptured aneurysm non-treatable by endovascular way. We explored a narrative review of the literature on guidelines about aneurysmal subarachnoid hemorrhage (aSAH) in pregnant patient, recommended timing of delivery, options of treatment (endovascular vs surgical treatment), cerebral bypass techniques and perioperative anesthetic management of aSAH.

Clinical data were collected retrospectively from the patient's medical records. The patient's widower provided informed consent for the publication of this case report, and all data were

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anonymized to ensure confidentiality. A narrative review of the literature was conducted using PubMed database focusing on aSAH during pregnancy using the terms "subarachnoid hemorrhage," "pregnancy," "intracranial aneurysm," "case report" and "cerebral revascularization". Studies were selected based on relevance to the presented case.

Case report

A 33-year-old and 35-week pregnant (G2P1) caucasian woman presented at the emergency room (ER) of a hospital with sudden acute headaches, nausea, vomiting and aphasia in a context of intense emotional stress because of the hospitalization of her child (see figure 1). During the night, she presented seizures and loss of consciousness at home. The emergency rapid response unit (ERRU) was sent to her home. At arrival of the ERRU, two successive seizures, hypoxia, systolic blood pressure of 100 mmHg and anisocoria were observed. The Glasgow Coma Scale dropped to 3/15. Rapid sequence induction and tracheal intubation were performed to secure the airway. Systolic blood pressure after tracheal intubation was 120 mmHg, seizures stopped and anisocoria resolved. The patient was sedated with propofol 1% continuous IV. In the resuscitation room (RR) a multidisciplinary approach was taken with the obstetrical, neonatal, radiological and neurosurgical team for further decisions. In the ABCD approach, AB were optimal, C was characterized with bradycardia and D with miosis, reactive pupils and swallowing reflex. Fetal monitoring was normal. Cerebral computed tomography (CT) studies revealed subarachnoid hemorrhage Fischer IV due to a left Sylvian aneurysm rupture (21mm = diameter) causing quadriventricular hemorrhage, transtentorial engagement and engagement of the cerebellar tonsils in the Foramen Magnum. The original Fisher grading scale was applied. Fisher grade IV corresponds to diffuse or thick subarachnoid blood with intraventricular hemorrhage or parenchymal extension, indicating high risk of vasospasm.

Continuous fetal heart rate monitoring was performed upon admission and remained reassuring until delivery. Emergency C-section was done in the operating room (OR) before the external ventricular derivation (EVD) procedure for intracranial pressure (ICP) monitoring. Before EVD, ICP was 62 mmHg and cerebral perfusion pressure (CPP) estimated at 30 mmHg. After EVD, ICP decreased transiently to 25 mmHg, then rose again.

The newborn required initial respiratory support and was admitted to the neonatal intensive care unit (NICU) but progressed well over the following days.

Endovascular treatment by the interventional radiologists for vascular exclusion of the aneurysm wasn't successful due to the size and form of the aneurysm. Osmotherapy with Mannitol and NaCl 20% along with controlled hypothermia were used to control ICP. Transcranial Doppler in ICU demonstrated persistent good flow in the middle cerebral artery, with a low pulsatility index (PI) and an end-diastolic velocity (EDV) between 40 and 60 cm/s. Calcium antagonist was then started at the admission to prevent secondary arterial vasospasm. Continuous IV sedation in ICU was midazolam 6 mg/h, sufentanil 7 mcg/h and ketamine 4 mg/h.

The patient developed secondary stress cardiomyopathy with apical ballooning (Tako-Tsubo), confirmed by echocardiography and Pulse Contour Cardiac Output (PICCO) technology providing measurements to assess cardiac function and fluid status. Dobutamine was used to overcome myocardial dysfunction. High doses of vasoactive drugs were needed because of drug-induced vasoplegia and unstable hemodynamics. Norepinephrine was titrated up to 1.9 µg/kg/min and Dobutamine up to 11.9 µg/kg/min. Based on the arteriography performed on admission, there was no endovascular option other than embolization of the aneurysm, which would likely sacrifice both branches of the sylvian bifurcation and result in ischemia of the left convexity. According to the age of the patient and after multidisciplinary discussions between intensive care unit doctors, interventional radiologist and neurosurgeons, an emergency cerebral bypass surgery and surgical clipping of the aneurysm were indicated as rescue procedure. The EC-IC bypass was decided immediately after failure of endovascular treatment and refractory ICP despite maximal medical management. No ongoing bleeding was noted. At last, a new EVD was placed in the other side and ICP decreased at 8 mmHg at the end of the surgery.

VA-ECMO was initiated within 12 hours post-clipping due to refractory cardiogenic shock, with partial hemodynamic stabilization. Diagnosis was based on echocardiography and PICCO technology. Hemodynamic monitoring showed low cardiac index (CI < 2.0 L/min/m²) and elevated filling pressures. The VA ECMO was femoro-femoral and configuration was arterial cannula 17 Fr and venous 21 Fr with artial improvement of lactate and mean arterial pressure noted.

Unless intensive reanimation supports implemented, progressive multi-organ failure included refractory lactic acidosis, renal failure and liver dysfunction. Family opted for comfort measures after consensus.

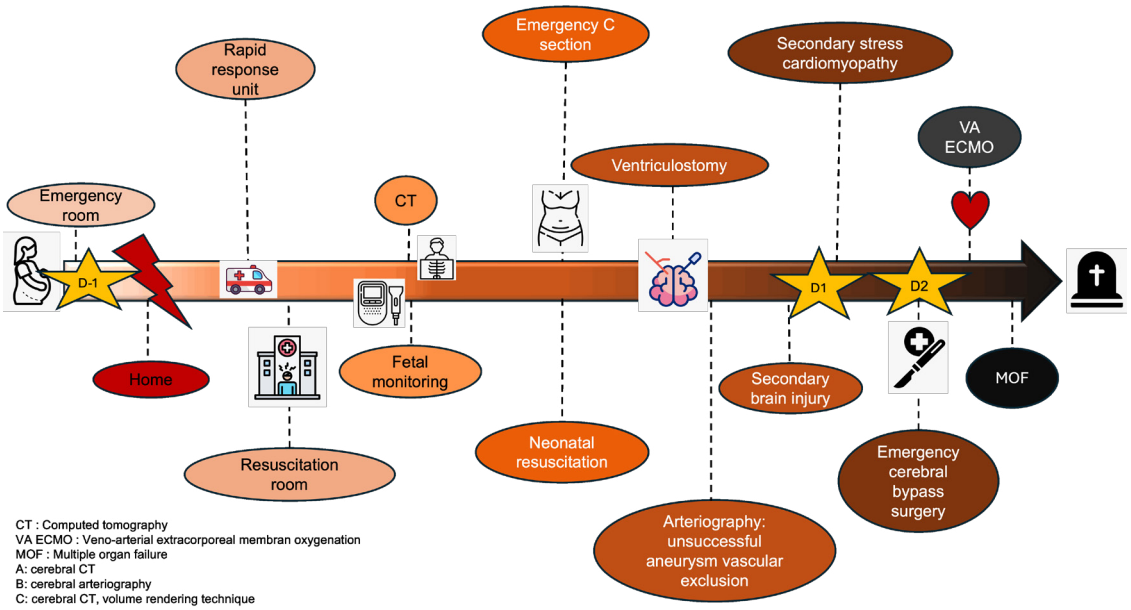


Fig. 1 — This figure shows the timeline of events. We underlign that, after emergency C-section and external ventricular derivation, interventional radiology was unsuccessful for aneurysm exclusion. Two days after hospital admission, extracranial-intracranial cerebral bypass and aneurysm clipping were performed. Despite intensive care support, patient developed multiple organ failure leading to her death.

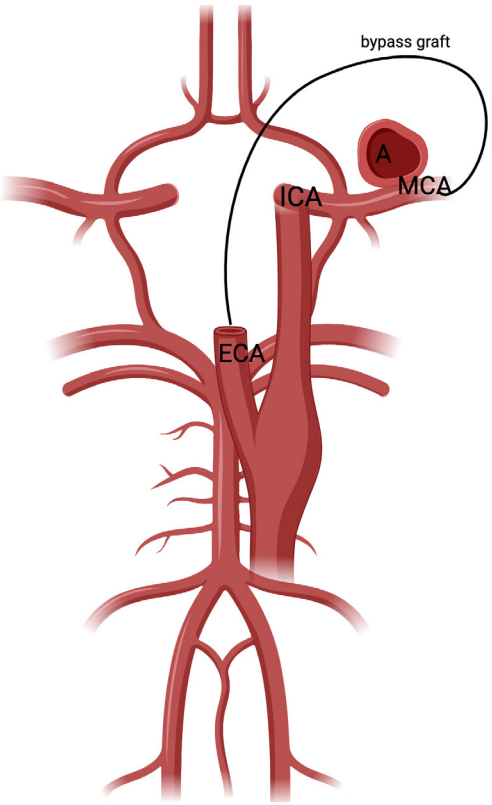


Fig. 2 — Temporal-Sylvian artery bypass and clipping of the left Sylvian aneurysm.
ICA : internal carotid artery; ECA : external carotid artery; MCA : middle cerebral artery; A : aneurysm.
Created in BioRender. Reynkens, A. (2025) https://BioRender.com/iqs94ua

The patient's radiological images can be found in the supplementary documents:
Cerebral CT (Appendix A)
Cerebral CT Volume Rendering Technique (Appendix B)
Cerebral Angiography (Appendix C).

Discussion

Management of aSAH is challenging. This special case-report describes aSAH in a pregnant woman without history of congenital disorders or hypertension. The aSAH was treated by surgical clipping and EC-IC cerebral revascularization. The aneurysm was not treatable by endovascular procedure. This situation is due to the type, size and location of the aneurysm. Complex aneurysms afford highly individualized treatment strategies. However, there is a lack of specific guidelines for managing these patients.

Therefore, we will discuss the best management of aSAH in pregnant women and additionally focusing on anesthetic management during an EC-IC cerebral bypass, through a narrative review of the literature on the following specific points:

- Epidemiology
- Delivery
- Blood pressure management
- Hydrocephalus and CSF diversion
- Vasospasm management
- Aneurysmal management (endovascular vs surgical treatment)
- Cerebral bypass techniques
- Anesthetic management during EC-IC cerebral bypass
- Management of secondary brain insult

We will not discuss aSAH in non-pregnant woman or non-aneurysmal SAH to limit the discussion.

Epidemiology

A recent systematic review on intracranial aneurysms in pregnant patients reported fetal and maternal mortality rates of 17% and 35% respectively for aSAH[1]. It estimated that 1.8% of pregnant women have unruptured aneurysms, and among those, the risks of rupture during pregnancy and delivery were 1.4% and 0.05%, respectively[2]. The data of Robba et al. highlighted an increased risk of aneurysm rupture during pregnancy, particularly in the third trimester and postpartum period (≥24 hours). ASAH in pregnant patient occurred at 31,5 weeks of pregnancy[3]. Risk factors for the development and rupture of an aneurysm include advanced age, female sex, hypertension, smoking, and excessive alcohol consumption.

The size and location of the aneurysm influence the risk of rupture. Aneurysms smaller than 7 mm located in the anterior circulation have a five-year rupture rate of less than 1%, while those larger than 25 mm, especially in the posterior circulation, have a higher rupture rate, reaching up to 10%[4]. It has to be noted that majority of aneurysms in pregnant woman are located in anterior region of the brain (68%)[5]. In our case, the aneurysm was located in the Sylvian segment of the left middle cerebral artery. The size of the aneurysm was 21 mm. The only risk factor of our patient was female sex. Pre-eclampsia was not explored or diagnosed in our patient. Given the context of potentially severe arterial hypertension, as well as possible kidney and liver dysfunction, this diagnosis should have been considered.

Delivery

Our patient suffered from a subarachnoid hemorrhage Fischer IV due to a left Sylvian aneurysm rupture (diameter = 21mm) causing quadriventricular hemorrhage and herniation in the foramen Magnum. C-section was performed to manage and treat intracranial hypertension (IH). According to a prospective observational study[6], pregnancy, labor and postpartum period do not increase the risk of aSAH, and there is no need to advise against pregnancy or vaginal delivery in women at risk of subarachnoid hemorrhage. Vaginal delivery is not contraindicated after securing the aneurysm if possible. However, C-section is preferable in certain circumstances, such as a short interval between delivery and aneurysm treatment, a life-threatening condition for the mother, incomplete occlusion of the aneurysm, or a high risk of intracranial bleeding[3]. A multidisciplinary discussion involving a neurosurgeon, intensivist, obstetrician, neonatologist, and anaesthesiologist is essential. Maternal and fetal status should be considered, with maternal prioritization being the primary focus. Vaginal delivery may be possible for small, stable aneurysms. While some studies 2 show no increased global risk, others 3 suggest elevated rupture risk during the third trimester and early postpartum. This contradiction may reflect methodological variability. Endovascular treatment is preferably performed after delivery to avoid fetal risks associated with radiation exposure, anticoagulation/antiplatelet therapy, incomplete aneurysm exclusion, or post-procedure rupture. Emergency C-section in the context of fetal distress may be challenging due to a hostile environment, with limited monitoring and equipment available. In cases of aSAH, management could be divided into three stages based on weeks of pregnancy 3. Before 24 weeks of gestation, treatment is conducted without considering the pregnancy, and if the aneurysm is secured, the pregnancy can continue to term. According to a recent systematic review of the literature, most patients under 24 weeks of pregnancy do not undergo immediate delivery 5. Between 24 and 34 weeks, a multidisciplinary decision is made, considering both maternal and fetal status. Authors showed 61% of immediate delivery between 24 and 34 weeks and 90% of them underwent emergency C-section 5. Other authors suggest an emergency C-section after 34 weeks particularly for patients with poor and declining clinical exam 3. This apparent contradiction reflects evolving expert consensus: vaginal delivery is not contraindicated after aneurysm securing, but in the acute phase, C-section is often favored to prevent BP surges or stress-related aneurysm rebleeding.

In our case, the C-section was performed under general anesthesia due to maternal unconsciousness. This decision was taken due to signs of transtentorial and cerebellar tonsil herniation seen on CT, reflecting life-threatening raised intracranial pressure.

The child was delivered in good condition and transferred to NICU for further care.

Blood pressure management

In clinical practice, high blood pressure (BP) is often managed until the ruptured aneurysm is secured. The impact of early BP control on the risk of rebleeding remains unclear. While addressing severe high BP upon presentation is reasonable, there is currently insufficient evidence

to recommend a specific BP target. What we know is that sudden and drastic reduction in BP should be avoided. Big fluctuations in BP have been linked to poorer outcomes in aSAH. Excessive BP reduction may impair cerebral perfusion, increasing the risk of ischemia, particularly in cases with intracranial hypertension (IH)[7]. According to recent guidelines on aSAH[8], a gradual BP reduction is recommended in patients with severe hypertension (systolic BP >180–200 mmHg), ensuring that low BP (mean arterial pressure <65 mmHg) is strictly avoided. Neurological status should be closely monitored during BP management. There is also a higher rebleeding risk with systolic BP >160 mmHg[7]. BP management should be individualized, considering factors such as initial BP at presentation, brain swelling, hydrocephalus, prior hypertension, and renal function. Future studies are needed to determine the optimal BP management strategy between patient presentation and aneurysm treatment. Key considerations include whether BP targets should be based on systolic BP thresholds, mean arterial pressure, or the degree of BP reduction to minimize variability. Fetal monitoring also represents a key consideration when managing arterial and cerebral perfusion pressures in pregnant patients. In cases of aSAH or other severe neurological conditions during pregnancy, maintaining adequate maternal CPP is essential. However, interventions aimed at optimizing maternal hemodynamics—such as increasing mean arterial pressure or administering vasopressors—may impact uteroplacental blood flow and, consequently, fetal oxygenation. As such, continuous fetal heart rate monitoring serves as a valuable real-time tool to assess fetal well-being. It can help guide therapeutic decisions and ensure that maternal hemodynamic targets are balanced with fetal needs.

This strategy is particularly important in pregnancies beyond 24 weeks, where fetal viability becomes a critical factor, and early delivery may be considered in the event of maternal clinical deterioration.

In our patient, invasive BP monitoring was used and a systolic BP of 110 mmHg and minimal CPP of 60 mmHg was targeted on the request of the neurosurgeon. During EVD placement, the Initial ICP was measured at 62 mmHg, indicating that CPP was approximately 30 mmHg during several hours before the surgery. The target ICP was set <20 mmHg, and MAP was maintained around 90 mmHg to ensure a CPP ≥60 mmHg. Before EVD, ICP was 62 mmHg and CPP estimated at 30 mmHg. After EVD, ICP decreased transiently to 25 mmHg, then rose again.

Hydrocephalus and cerebrospinal fluid (CSF) diversion

Patients with aSAH face a significant risk of developing symptomatic acute or chronic hydrocephalus. The incidence of acute hydrocephalus in the early phase of aSAH varies between 15% and 87%8. In case of acute symptomatic hydrocephalus, cerebrospinal fluid (CSF) diversion either through an EVD or lumbar drainage is recommended to stabilize neurological function[8]. EVD placement seems to be safe in pregnant patients[5]. Research suggests that lumbar CSF drainage following aSAH can lower the occurrence of delayed cerebral ischemia (DCI) and contribute to better early clinical outcomes[9]. However, evidence remains weak regarding the optimal strategy for managing continuous versus intermittent CSF drainage, as well as determining the appropriate daily drainage volume via EVD or lumbar drainage in acute hydrocephalus cases. In Beighley's review, only 2 patients had an EVD[5]. One of them was 38-year-old G3P2 presented at 36 gestational weeks with a diffuse bilateral subarachnoid hemorrhage with fourth ventricle bleeding and hydrocephalus. EVD with clipping of the aneurysm on the left posterior communicating artery were done immediately after the C-section. Mother and newborn were discharged from hospital in a good health status except Broca's aphasia in the mother[10]. The other case was a 37-year-old G7P4 woman presenting at 34 weeks of pregnancy with a Fisher IV SAH. Emergency C-section was done before the EVD placement. The patient died on day-4 after the operation[11].

Our patient presented with a Fisher IV SAH due to a ruptured 21 mm left Sylvian aneurysm, 33-year-old and 35-week pregnant G2P1 patient. Clinical examination and CT showed signs of severe IH. Our neurosurgical team therefore decided to place an EVD. Our patient died due to MOF 4 days after the cerebral bypass surgery.

Vasospasm management

For patients who survive the initial rupture of an aneurysm, DCI remains a significant concern. Cerebral vasospasm (CVS), visible on angiographic imaging, is a key factor contributing to DCI and is strongly associated with increased morbidity and mortality[8]. CVS is estimated to 16,7% taking in account the underreporting of negative cases[5], which is like CVS rate in non-pregnant patients (approximately 30%)[3]. The reported 16.7% incidence likely underestimates the

true prevalence due to underreporting or missed diagnosis in less severe or non-imaged cases.

Historically, undiagnosed or inadequately treated CVS was a leading cause of death following aSAH. However, DCI is now recognized as a multifactorial process involving blood-brain barrier disruption, microthrombosis, cortical spreading depolarization, ischemia, and impaired cerebral autoregulation[8]. Management strategies include a pharmacological approach such as Nimodipine, a dihydropyridine calcium channel blocker that supports neurological recovery following aSAH. Administration of 60 mg orally every four hours started immediately on admission and for 21 days in non-pregnant patients has shown a reduced risk of DCI and enhance functional outcomes[8]. However, some reports of aSAH in pregnancy claim the potential teratogenicity of nimodipine and other calcium channel blocker, explaining why they avoid it[5]. While animal data suggested teratogenic potential, human data remain limited[8]. In post-delivery cases, the risk becomes negligible. No clear safer pharmacologic alternative is currently validated. Magnesium sulfate has been hypothesized to reduce vasospasm but lacks strong evidence[8].

Endovascular interventions such as angioplasty in severe CVS cases also provide a mechanical method to restore cerebral perfusion, but they carry a risk of vessel rupture.

It is worth noting that transcranial doppler has limited sensitivity and is operator-dependent but remains useful for bedside serial monitoring of flow velocities.

Transcranial Doppler was performed on our patient in ICU demonstrating persistent good flow in the middle cerebral artery, with a low pulsatility index (PI) and an end-diastolic velocity (EDV) between 40 and 60 cm/s. Nimodipine was administered enterally through a nasogastric tube (NGT) due to coma. Although a 21-day course is standard, nimodipine was administered for 48 hours until clinical deterioration and withdrawal of care. True full duration was not reached.

Aneurysmal management: Interventional radiology or surgical treatment

Intracranial aneurysms (IAs) in pregnant patients can be managed through surgical intervention (clipping, with or without bypass) or endovascular techniques (coiling, stenting, or flow-diversion). The choice of treatment depends on multiple factors, including aneurysm status (ruptured vs. unruptured), gestational age, aneurysm morphology, comorbidities, and available expertise[12].

Ruptured Aneurysms

In cases of ruptured aneurysm—such as in our patient—urgent exclusion of the aneurysm is required to prevent rebleeding and further neurological deterioration. Both surgical clipping and endovascular coiling are acceptable approaches.

Recent reviews suggest that surgical or endovascular management of ruptured aneurysms in pregnant patients is associated with higher maternal survival (85.7%) compared to conservative management (58.3%)[5]. Moreover, maternal mortality appears similar between clipping and coiling (14.8% vs. 13.3%)[5].

However, endovascular treatment involving stents or flow-diverters often requires dual antiplatelet therapy (DAPT), which increases the risk of postpartum hemorrhage and placental abruption[14]. To mitigate this, 50% of ruptured aSAH patients were treated by clipping versus 27.8% by coiling[5]. In many cases beyond 24 weeks of pregnancy, cesarean delivery prior to endovascular intervention was performed to avoid DAPT-related risks[5].

In our case, endovascular treatment was attempted but failed due to aneurysm anatomy. There was no endovascular option other than embolization of the aneurysm, which would likely sacrifice both branches of the sylvian bifurcation and result in ischemia of the left convexity. Therefore, surgical clipping and a direct EC-IC bypass were performed. To our knowledge, only two prior case reports describe clipping after emergency C-section and EVD, but none included bypass[10,11].

Unruptured Aneurysms

For unruptured aneurysms, treatment strategy is more individualized. Treatment timing depends on aneurysm size, location, and patient symptoms. Surgical or endovascular intervention is often postponed until after delivery unless high-risk features (size >7 mm, posterior location, growth, or symptomatic aneurysm) warrant earlier exclusion. Endovascular approaches are generally favored for their minimally invasive nature and shorter recovery time, especially in older or medically fragile patients. However, surgical management, including bypass, remains appropriate in selected younger patients with complex aneurysms not amenable to coiling[5,8].

Evolving Guidelines and Uncertainty

The literature on aneurysm management in pregnancy remains limited, especially in young and pregnant populations, making strong recommendations difficult. While meta-analyses of small retrospective series suggest similar outcomes

between flow-diversion and clipping[8], a recent nationwide U.S. database (2016–2018) showed no significant mortality difference between coil, clip, or conservative treatment[15]. However, these findings must be interpreted with caution for several reasons: Selection bias is highly probable in large administrative datasets. Patients selected for conservative management are often those with better initial neurologic status, smaller aneurysms, or earlier gestational age, which may inherently reduce the mortality risk compared to those requiring urgent intervention. The study did not account for aneurysm morphology, hemodynamic instability, or fetal outcomes, all of which are crucial in clinical decision-making.

Therefore, management decisions should be based on a multidisciplinary and individualized assessment, balancing maternal safety, fetal viability, and aneurysm-specific risks.

Our patient's cerebral bypass

Bypass procedures can be classified into direct, indirect and combined techniques[16]. A direct bypass involves microsurgical anastomosis between a donor artery and an intracranial recipient artery, providing immediate blood flow to the brain. Depending on the donor artery used, direct bypasses are further divided into extra-to-intracranial (EC-IC) and intra-to-intracranial (IC-IC) types. The anastomosis can be performed with or without graft interposition, depending on whether a vascular graft (arterial or venous) is used. Our patient presented an intracranial giant aneurysm and flow-preservation bypass surgery was the only treatment available as it could not be managed with endovascular techniques or selective clip reconstruction. The treatment of this giant aneurysm involved sacrificing the artery carrying the aneurysm and/or its efferent branches. However, the primary objective of aneurysm treatment is both the exclusion of the aneurysm and the preservation of adequate blood supply to the brain. As a result, a bypass procedure is essential to compensate for the blood flow loss due to the sacrificed artery. In flow-preservation bypass surgery, a critical factor is ensuring that the bypass provides sufficient flow to match that of the occluded artery. The procedure performed for our patient was a direct EC-IC bypass, as it ensured the immediate restoration of blood flow to the affected brain region.

Peroperative anesthetic management of a cerebral bypass

There is limited research on the optimal intraoperative anesthetic management of patients undergoing surgery for ruptured aneurysms[8]. For patients under general anesthesia, a balanced anesthetic approach using a combination of agents to ensure hypnosis, analgesia, and amnesia while minimizing patient movement is commonly employed. Continuous infusions of sedative and analgesic agents help maintain a steady anesthetic depth. Intraoperative priorities include maintaining cardiovascular stability, optimizing ventilation, and strictly avoiding any patient movement during critical stages such as aneurysm exposure, clip application, or coil deployment[8]. During aneurysm clipping for patients with aSAH, hyperosmotic agents such as mannitol and hypertonic saline are commonly used to lower intracranial pressure, improve cerebral perfusion, and promote brain relaxation. This is crucial in the presence of cerebral edema to optimize surgical exposure and reduce the risk of ischemia. Unlike routine surgeries, careful fluid management is required to avoid hypovolemia and hypotension. Hypertonic saline is preferred for its limited diuretic effect and capacity to increase blood pressure, while mannitol, though effective, carries risks due to its potent diuretic action[8]. A recent meta-analysis suggested that hypertonic saline was associated with more beneficial outcomes than mannitol in patients undergoing craniotomy[17]. The use of these agents aims to create optimal conditions for safe aneurysm manipulation and cerebral protection during the procedure. Optimal cerebral perfusion and hemodynamic control is critical in the perioperative period. Hypotension may lead to ischemia and hypertension may induce bleeding. The general recommendation is to maintain normotension and keep the blood pressure within 10% to 20% of the preoperative established baseline blood pressure for all patients[18]. Rapid cardiac pacing can also be used intraoperatively to induce hypotension during clip placement in selected aneurysms[18].

Ventilation should aim to maintain normal carbon dioxide and oxygen levels (normocarbia and normoxia). Research indicates that intraoperative hypocapnia (PaCO2 30–35 mm Hg) is associated with slower recovery of consciousness and more postoperative neurological deficits compared to patients maintained with PaCO2 between 40– 50 mm Hg[18]. Furthermore, hypercapnia may lead to uneven blood flow.

Management of secondary insults in pregnant women

Neuroanesthesia in pregnant women presents unique challenges, particularly when managing conditions like acute IH. A recent review article focused on specific considerations of acute IH management during pregnancy and described the prevention of secondary brain insults of systemic origin[19].

Specific critical care support and optimal treatment of medical complications are fundamental for the improvement of aSAH pregnant patients[8].

To prevent secondary brain insults, a multimodal strategy is essential. Interventions include osmotherapy (Mannitol 0.25 g/kg every 4–6 hours, NaCl 20% 100 mL every 6 hours), deep sedation, and neuromuscular blockade to control intracranial hypertension and optimize cerebral perfusion.

SAH is often associated with a massive surge of catecholamines, leading to systemic complications such as Tako-Tsubo cardiomyopathy, arrhythmias, hypertension or vasoplegia. This surge is due to the intense sympathetic activation from brain injury and can mimic acute coronary syndrome. Tako-Tsubo syndrome (stress-induced cardiomyopathy) has been increasingly recognized in SAH patients and should be considered in cases of sudden hemodynamic collapse, ECG changes or elevated troponins, echocardiographic findings of apical ballooning with no coronary obstruction. The management includes inotropic support and mechanical circulatory support in refractory cases[20].

Worse outcomes are observed in cases with medical complications such as cardiac arrest in 4% of aSAH cases. Among them, 25% of survivors have good outcomes[8]. There is no conclusive and sufficient data regarding the optimal management and treatment of these cardiac complications[8].

During the acute phase of aSAH, significant respiratory issues such as respiratory failure requiring mechanical ventilation and acute respiratory distress syndrome (ARDS) can arise and negatively influence outcomes. ARDS has been independently linked to poorer prognosis in SAH patients. Management strategies typically involve a bundled approach, including lung-protective ventilation with low tidal volumes, moderate levels of positive end-expiratory pressure, early initiation of enteral nutrition, standardized antibiotic protocols for hospital-acquired pneumonia, and a structured process for extubation[8].

According to a recent randomized controlled trial (RCT), liberal transfusion strategy did not result in a lower risk of an unfavorable neurologic outcome at 12 months than a restrictive strategy in patients with aSAH and anemia[21].

Hyponatremia is a common clinical issue in aSAH, with or without polyuria or natriuresis, although its link to DCI and poor outcomes has been inconsistent in studies[22, 23]. Severe hyponatremia and uncontrolled natriuresis can cause significant intravascular volume depletion, leading to neurological and systemic complications.

Some RCTs have shown that fludrocortisone can help limit sodium loss, urine output, and the need for fluid replacement during acute aSAH, but it did not consistently prevent DCI or improve outcomes[24,25]. Other treatments like high-dose hydrocortisone showed similar benefits on sodium balance but were associated with higher rates of complications such as hyperglycemia, hypokalemia, gastrointestinal bleeding, and heart failure[8].

Conclusion and take-home message

We reported the case of a pregnant woman with aSAH treated by EC-IC cerebral revascularization and surgical clipping of the aneurysm.

The treatment strategy depends on aneurysm status (ruptured vs unruptured).

Although robust guidelines are limited due to the rarity of aSAH during pregnancy, key evidence-based elements include early aneurysm exclusion, cautious BP control, use of nimodipine post-delivery and individualized timing of delivery.

Multidisciplinary coordination is crucial, balancing maternal neurological status with fetal viability, and considering surgical, endovascular or hybrid approaches.

Recommendations may differ based on weeks of pregnancy:

- <24 weeks—treat mother, maintain pregnancy
- 24–34 weeks—consider early delivery if necessary
- >34 weeks—delivery often prioritized

In case of acute symptomatic hydrocephalus, EVD is recommended and seems to be safe in pregnant woman.

Some reports of aSAH in pregnancy claim the potential teratogenicity of nimodipine, in the prevention of CVS, but this issue is in part resolved when the baby is extracted.

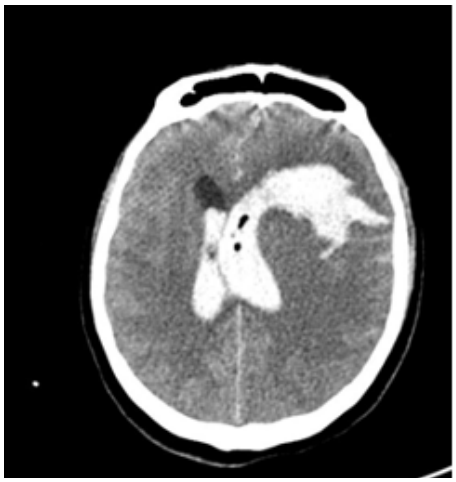
Surgical or endovascular management of aSAH pregnant woman is necessary compared to conservative treatment but it seems that there is no difference in maternal mortality comparing surgical clipping and endovascular coil in these conditions.

In case of large aneurysm involving critical artery, a direct EC-IC cerebral bypass is essential to compensate for the blood flow loss due to the sacrificed artery before the surgical clipping of the aneurysm.

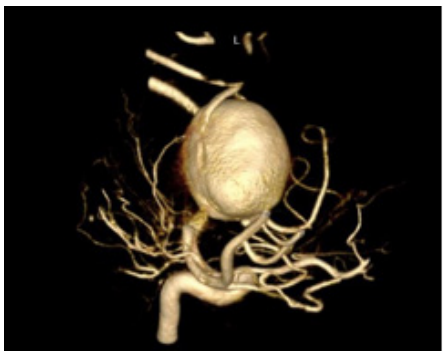
Key anesthetic objectives include maintaining adequate cerebral perfusion, hemodynamic stability, relaxed brain for surgical exposure and cerebral protection.

Acknowledgements and conflicts of interest: We thank the husband of the patient who gave us his consent to report her case. We have no conflicts of interest to declare. Grammarly was used exclusively for refining English phrasing and syntax corrections. BioRender was used to create figure 2.

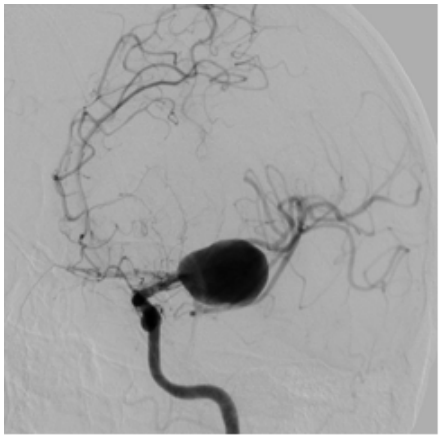
Appendices



Cerebral CT (Appendix A)



Cerebral CT Volume Rendering Technique (Appendix B)



Cerebral Angiography (Appendix C)

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