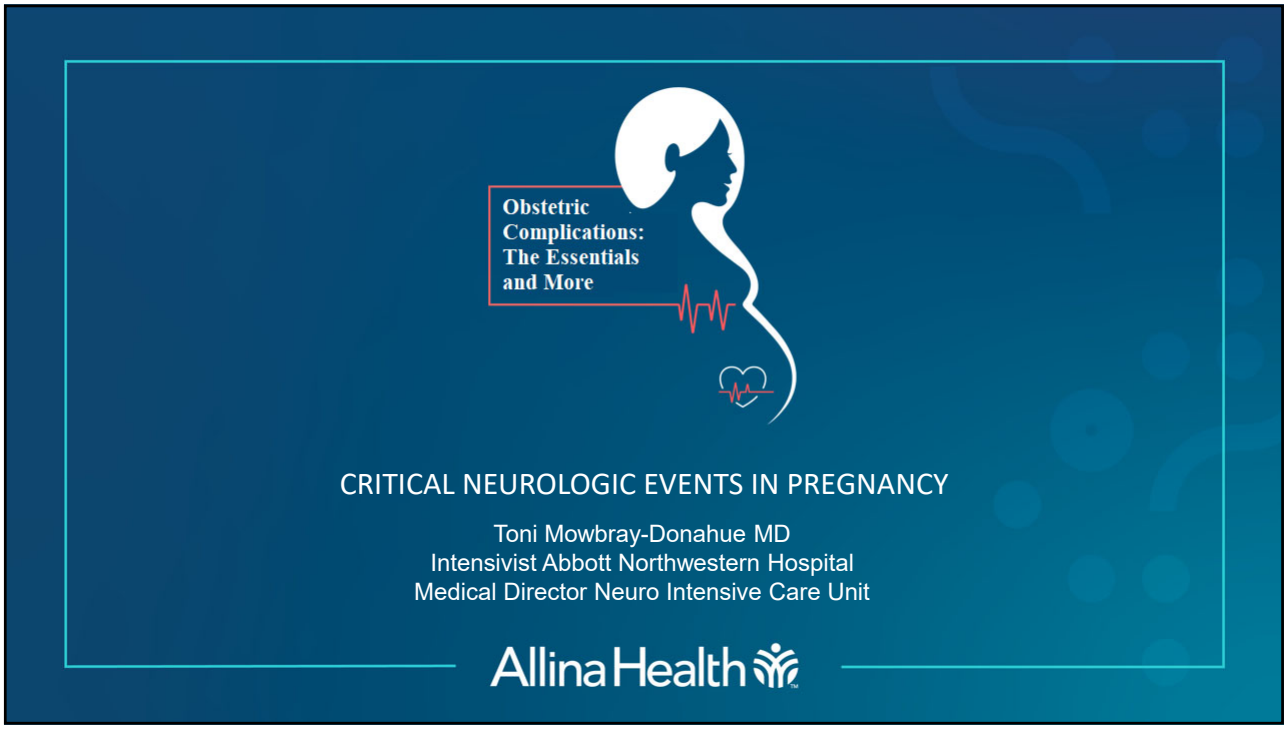

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WHY ARE PREGNANT PATIENTS WITH NEUROLOGIC EMERGENCIES SO CHALLENGING?

- 45% increased plasma volume
- 40% decrease in systemic vascular resistance
- mean arterial pressure (MAP) decreased by 10–15 mmHg
- increase in heart rate by 10–20 beats per min (bpm)
- increased cardiac output
- anemia
- hypervolemic hyponatremia
- central hyperventilation, $PaCO_2$ 28 mmHg
- dyspnea on exertion
- peripheral edema
- hypercoagulability

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EMERGENCY MEDICINE/CRITICAL CARE ASSESSMENT:

This patient has mixed cardiogenic/vasodilatory shock with respiratory failure: Likely due to something sinister?

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OBSTETRIC ASSESSMENT

Healthy Pregnant Woman

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ADDITIONAL CHALLENGES

- Diagnostic evaluations and management decisions each need to be carefully considered for pregnant patients given potential effects on the fetus.
- Not withholding therapies that reduce disease-related morbidity and mortality.
- Pregnant patients present with common symptoms like headache and have subtle neurological changes making diagnosis difficult.
- Very few treatments are based on high-quality data given the complexity of performing high quality trials on pregnant women

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ADDITIONAL CHALLENGES

- Observational data and clinical expert opinion often guide treatments
- Neurologic disease, aside from pre-eclampsia and eclampsia, typically do not warrant early delivery in the absence of fetal distress.
- The post partum period is also an altered physiologic state and vigilance for acute neurologic disorders related to pregnancy during the first 6 weeks after delivery is warranted.

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The Team

- Obstetrics/Maternal Fetal Medicine
- Emergency Medicine
- Critical Care Medicine
- Neurosurgery
- Neurology
- Neuro Interventional Radiology
- Anesthesia

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3 categories of Neurologic Critical Events

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Coincidental development of an acute primary neurological emergency

- Cerebrovascular disease (CVD)
- Pregnancy-associated acute ischemic stroke (PAS)
- Ruptured vascular malformation
- Aneurysmal subarachnoid hemorrhage (aSAH)
- Cerebral venous sinus thrombosis (CVST)
- Reversible vasoconstriction syndrome (RCVS)
- Pregnancy-associated intracerebral hemorrhage (pICH)
- Post-maternal cardiac arrest (CA) care
- Somatic fetal support in mothers declared dead by neurologic criteria
- Symptomatic status epilepticus
- Traumatic brain injury

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Exacerbation of pre-existing neurological disease

- Multiple sclerosis
- Myasthenia gravis
- Epilepsy
- Hormone sensitive intracranial neoplasms

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NEUROLOGICAL COMPLICATION OF PREGNANCY

- Sheehan's syndrome
- Hypertensive disorders of pregnancy
- Pre-eclampsia (PE)/eclampsia
- Posterior reversible encephalopathy syndrome (PRES)
- Hemolysis, elevated liver enzymes, low platelets (HELLP)

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Case #1

35-year-old female (nullipara)who was 24 weeks pregnant presented to the emergency department with a history of sudden onset headache with loss of consciousness, nausea and vomiting.

Patient straining to lift something with sudden onset severe headache.

She was witnessed to sit down then became briefly unconscious. On presentation to emergency department, she has ongoing severe occipital headache and nausea with vomiting.

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PHYSICAL EXAM:

HR 110 BP 160/94 Temp 37 RR 24
Somnolent, complains of ongoing headache, nausea, and photophobia
HEENT: PERRLA, EOMI
Resp: CTAB, diminished at bases
CVS: Mild tachycardia, RRR
Abdomen: Gravid, non-tender
Ext: Trace edema bilateral LE
Neuro: Non-focal, MAEs, follows commands intermittently
Psych: Alert with stimulation

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DIFFERENTIAL

- Pregnancy-associated acute ischemic stroke (PAS)
- Ruptured vascular malformation
- Aneurysmal subarachnoid hemorrhage (aSAH)
- Cerebral venous sinus thrombosis (CVST)
- Reversible vasoconstriction syndrome (RCVS)
- Pregnancy-associated intracerebral hemorrhage (pICH)

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CEREBROVASCULAR DISEASE (CVD)

- Occurs rarely in pregnancy, but pregnancy-induced hypercoagulable state and hypertensive diseases of pregnancy are risk factors.
- The incidences of CVD types in descending order during pregnancy and puerperium are:
  1. PAS (34/100,000)
  2. pICH (12.2/100,000)
  3. CVST (12/100,000 – highest during puerperium)
  4. aSAH (10-58/100,000)

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PREGNANCY ASSOCIATED ISCHEMIC STROKE (PAS)

- Pregnancy Associated Ischemic Stroke (PAS) accounts for 15% of maternal mortality.
- Highest risk: third trimester, immediate postpartum period, African American ethnicity, age over 35, and presence of autoimmune disease, immune thrombocytopenia purpura (ITP), and other thrombotic microangiopathies of pregnancy
- Cesarean delivery is associated with increased likelihood of postpartum stroke, a causal relationship has not been established.

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REVERSIBLE VASOCONSTRICTION SYNDROME(RCVS)

- RCVS is associated with a range of conditions:
  1. Postpartum
  2. Use of immunosuppressive drugs
  3. Vasoactive substances (such as phenylpropanolamine, serotonin reuptake inhibitors or cocaine), as well as endogenous vasoactive substances, catecholamine-secreting tumors and cranio-cervical arterial dissection.

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RCVS

- Characterized by thunderclap headache (reaching peak intensity within <1 min).
- Headache often has a posterior onset and can be accompanied by nausea, vomiting, confusion, photophobia, phonophobia and visual changes.
- Generalized tonic–clonic seizures and focal deficits have been reported as well.
- Daily recurrence of episodes of sudden-onset, high-intensity headache with a duration of several weeks after the first episode is almost pathognomonic.

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CRITERIA FOR DIAGNOSIS OF RCVS

- Segmental cerebral artery vasoconstriction seen on the Magnetic Resonance Angiography (MRA)
- No evidence of subarachnoid hemorrhage
- Normal CSF analysis
- Severe headache with/without neurological findings
- Reversibility of angiographic abnormalities within 12 weeks

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OUR PATIENT

- Cerebrovascular disease (CVD)
- ~~Pregnancy-associated acute ischemic stroke (PAS)~~
- Ruptured vascular malformation
- Aneurysmal subarachnoid hemorrhage (aSAH)
- Cerebral venous sinus thrombosis (CVST)
- ~~Reversible vasoconstriction syndrome (RCVS)~~
- Pregnancy-associated intracerebral hemorrhage (pICH)

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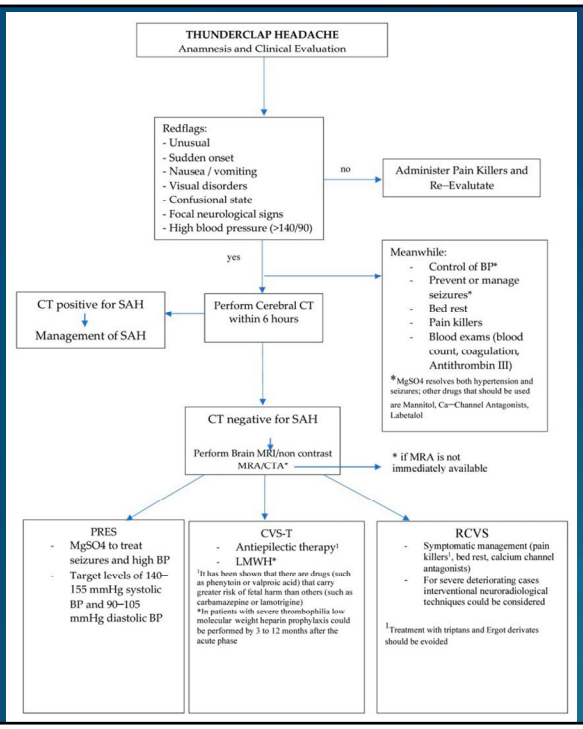

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Red Flags and Immediate Actions

- Unusual
- Sudden onset
- Nausea/vomiting
- Visual Changes
- Confusion
- Focal Neurologic changes
- Hypertension

- Control Blood Pressure
- Prevent/manage seizures
- Bed rest
- Analgesia
- Labs

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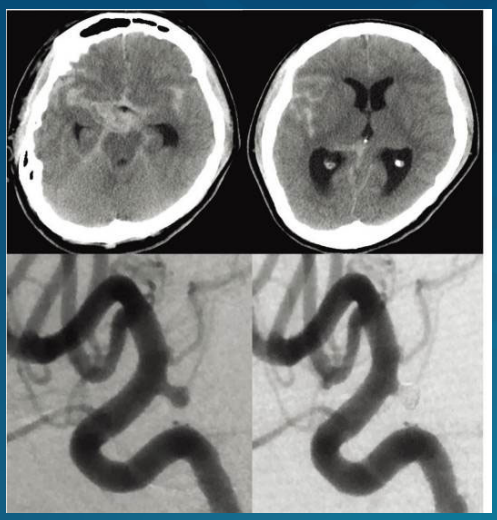
CT and Cerebral Angiogram

- SAH on the right side with the basal cistern and mild hydrocephalus.
- Digital subtraction angiography (DSA) of the right internal carotid artery through right brachial artery puncture demonstrated an aneurysm measuring 2.2 × 2.7 mm at the right IC-PC bifurcation. DSA through right brachial artery puncture performed.
- SAH was evaluated as Hunt & Hess grade II.
- Coil embolization was performed.



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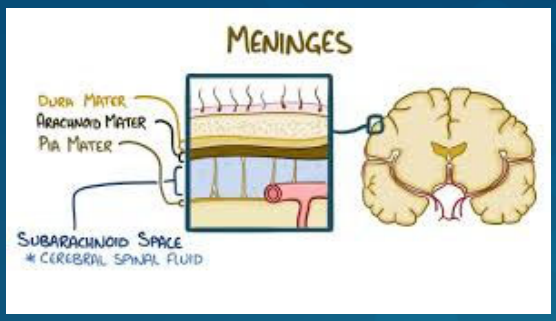
Subarachnoid Hemorrhage (SAH)

1. Patient received IV labetalol and IV nicardipine for BP control, goal SBP<140
2. Serum sodium 130, NS at 100ml/hr and sodium values followed.
3. Neuro exam per protocol
4. Nimodipine 60mg q 4hr
5. Trans cranial doppler surveillance for vasospasm
6. No complications for patient or her baby
7. Follow up cerebral angiogram was stable



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Radiation

- The influence of radiation exposure on the fetus depends on the radiation dose and timing.
- Prior to week 8 of pregnancy, the radiation sensitivity for fetal anomalies is high, with a threshold of ≤500 mGy.
- Radiation sensitivity of the fetal central nervous system is the highest between weeks 8 and 15 of pregnancy
- The International Commission on Radiological Protection (ICRP) recommends a threshold limit of 100 mGy. A previous study examined the abdominal exposure dose under fluoroscopy/imaging conditions and showed approximately 0.5 mGy, which corresponds to 0.01% of the maximum cephalic radiation dose and is below the reference value ≤100 mGy.

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FURTHER FETAL PROTECTION

- Hemostatic devices requiring fluoroscopy should not be used.
- Trans-brachial approach
- The area below the diaphragm should not be irradiated
- Use of a protector on the patient's back
- Reduction of frequency of DSA and pulse rate

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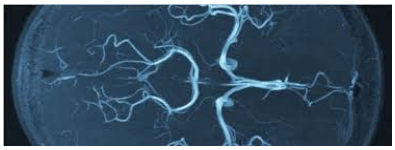
CONTRAST MEDIUM



- Safety of iodine contrast medium in the fetus has not been established and its use should be avoided if possible.
- Food and Drug Administration (FDA) classified contrast medium as Category B (no evidence regarding risks in humans) according to the fetal drug risk classification criteria.
- I did not find any reported disorders including teratogenicity, related to endovascular treatment for ruptured aneurysms in pregnant women.

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General Anesthesia

- General anesthesia is considered safest after the second trimester of pregnancy.
- A previous study reported no teratogenicity even in patients who had general anesthesia before week 16 of pregnancy.

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OTHER MEDS

- Clopidogrel

A systematic review of antiplatelet therapy in pregnant women including 7 different antiplatelet agents with clopidogrel being the most common. In 42 patients, 14 women received antiplatelet therapy in the first trimester. 14 women had regional anesthesia (12 while taking clopidogrel), all without complication. Two women developed bleeding post caesarean section. There were no recorded neonatal delivery complications. Two neonates had congenital anomalies not felt to be related to maternal antiplatelet use.

- Levetiracetam

Studies demonstrate that levels decrease by 40 to 62 percent during the second and third trimesters. A prospective study of 18 pregnancies in women on levetiracetam revealed that the increased clearance is maximal in the first trimester, reaching 1.7 times baseline, and that seizure worsening occurs when the individual's serum concentration decreases to 65 percent or less of the non-pregnant baseline concentration.

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Blood Pressure Goals in Pregnancy

- In pregnancy, severe hypertension is defined as > or = 160/110 mmHg and is considered an obstetric emergency requiring immediate inpatient care. Initial goal should be to lower BP < 160/110 mmHg.
- BP goals of pregnancy should be followed including when considering permissive or therapeutic hypertension

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CONTROL OF HYPERTENSION IN PREGNANCY STUDY (CHIPS)

International multicenter randomized controlled trial, found that independent of pre-eclampsia (PE), pressures above this threshold were associated with:

- Increased maternal length of stay >10 days
- Pregnancy loss or high level of neonatal care for >48 h
- Increased risk of preterm birth at both <34-week and < 37-week gestation
- Low birth weight (<10th percentile)
- Low maternal platelets and elevate maternal liver enzymes (HELLP).

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HYPERTENSION

- Untreated BP of 140/90 mmHg or higher increased the incidence of severe hypertension (relative risk 1.8; 95% CI, 1.34–2.28).
- Once BP < 160/110 mmHg is achieved and neurological indication for hypertension has resolved, careful titration of medication should be made to achieve the goal of <140/90 mmHg.
- Close monitoring of the blood pressure is needed to avoid episodes of hypotension and low placental perfusion. Continuous fetal monitoring is required to identify early signs of fetal distress

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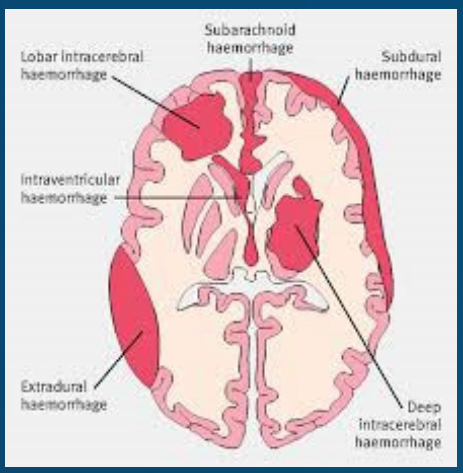
Intracerebral Hemorrhage



- Associated with an in-hospital maternal mortality rate of nearly 20%
- 50% of pICH occurs in the puerperal period
- 40% are reported close to delivery
- Blood pressure control, reversal of coagulopathy, and management of mass effect are treatment priorities.

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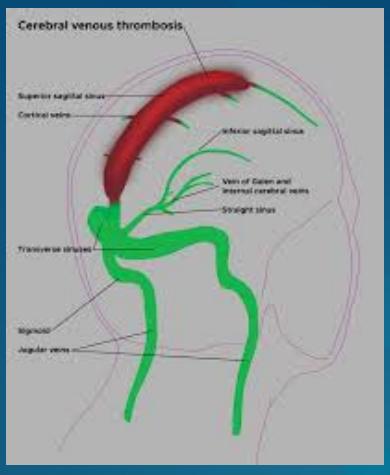
Cerebral **Venous** Sinus thrombosis

- Estimated to affect 0.012% of deliveries during the puerperal period.
- Risk is increased by infection, instrumented delivery, cesarean section, increasing maternal age, hyperemesis gravidarum hemodynamic fluctuations, and hyperhomocysteinemia.
- Anticoagulation remains the mainstay of treatment, no role for DOACs



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CASE #2

- 24 yo female with history of seizure disorder previously well controlled on levetiracetam, G2P1 32 weeks 4 days presents via EMS after 2 witnessed seizures at home. Patient was in her usual state of health and has had no complications with her pregnancy. She was witnessed by family to have GTC seizure lasting approximately 2-3 minutes. Following the seizure patient was somnolent an unresponsive. Patient transported via EMS.

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ON ARRIVAL TO EMERGENCY DEPARTMENT

Head CT normal, no hemorrhage or acute pathology.

- Vitals: Temp 36.7, HR 120, BP 130/56, RR 24, O2 Sat 98% 2L NC
- General: Alert, denies pain, nausea or SOB, somnolent
- HEENT: PERRL, EOMI
- Resp: CTAB, diminished at bases
- CVS: RRR, flow murmur (stable from previous exam)
- Abdomen: Gravid, non-tender
- Ext: 1+ edema b/l LE
- Skin: Warm, no rashes
- Neuro: CN II-XII intact, no motor or sensory loss
- Psych: Alert, does not remember events but knows she had a seizure

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