BRIGHAM AND
WOMEN'S HOSPITAL

Pregnancy and Stroke

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Disclosures

I have no financial relationships with the developers of any of the products discussed.

NINDS
- SPOTRIAS
- NeuSTART
- IRIS (and Takeda Pharmaceuticals)
- ATACH II
- POINT
- StrokeNET
- DEFUSE-3
- ARCADIA

Covidien
- SWIFT PRIME

Topics

I. *Importance of stroke in pregnancy*
II. *Pathophysiology of stroke in pregnancy*
III. *Cerebral venous thrombosis*
IV. *Acute ischemic stroke*
V. *Subarachnoid hemorrhage*
VI. *PRES and RCVS*

Morbidity of Stroke in Pregnancy and the Puerperium

Healthcare Cost and Utilization Project of the Agency for Healthcare Research and Quality N = 9 million discharges 2000-2001

- **Stroke Rate** **34 per 100,000**
- **Mortality Rate** **1.4 per 100,000 = 4.1 %**

Disability estimates

- **Long-term disability in ~2/3 survivors, greater in women**
- **Depression in 11-68%**
- **Major depression in 10-27%**

James AA Obstet Gynecol Survey 2006;61:4-5.
Bousser M-G Circulation 1999;99:463

Leading Causes of Death in Adolescents and Young Adults

Cause of Death	*Rate per 10^5 Age 15-24*	*Rate per 10^5 Age 25-34*
Accident	6.0	37.5
Homocide	0.8	13.0
Suicide	10.0	12.4
Cancer	4.1	9.0
Heart disease	2.7	8.1
Diabetes mellitus	0.5	1.5
Cardiovascular disease	0.5	1.4

Summary of Risks

Non-pregnancy women of childbearing age

- The annual risk of stroke in non-pregnant women ages 15-44 is low ($10/10^5$). However, the risk may be rising (Ban $25/10^5$). (up to age 49)

Pregnancy-associated

- 42% of strokes in women 15-44 y/o are associated with pregnancy.

All Strokes

- Considering ALL STROKES (ICH + AIS): There is a small increase in ALL STROKES during pregnancy driven by hemorrhagic stroke.
- There is a marked increase in ALL STROKES during the early postpartum period.

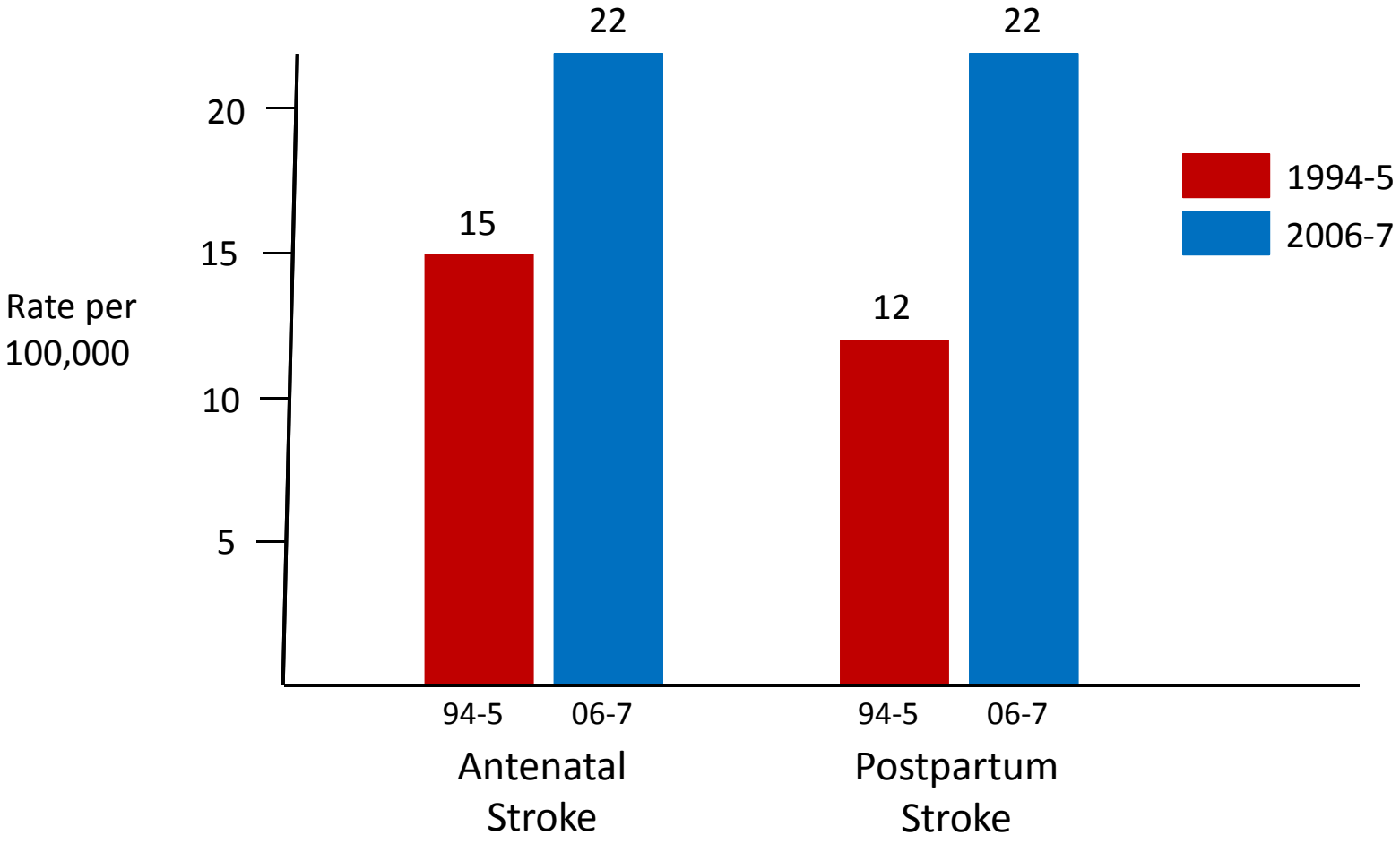
During pregnancy

- There is no increase in the risk of ISCHEMIC STROKES during pregnancy. (Ban found slight decrease.)
- There is an increase in the risk of HEMORRHAGIC STROKES during pregnancy (Kittner 2.5-fold, Ban increased SAH)

During the early postpartum period

- There is an increased risk of ISCHEMIC STROKES in the early postpartum period (up to 6 weeks). (Kittner 8.7-fold)
- There is an increased risk of HEMORRHAGIC STROKES in the early postpartum period (up to 6 weeks). (Kittner 28.5-fold, Ban increased ICH and SAH)

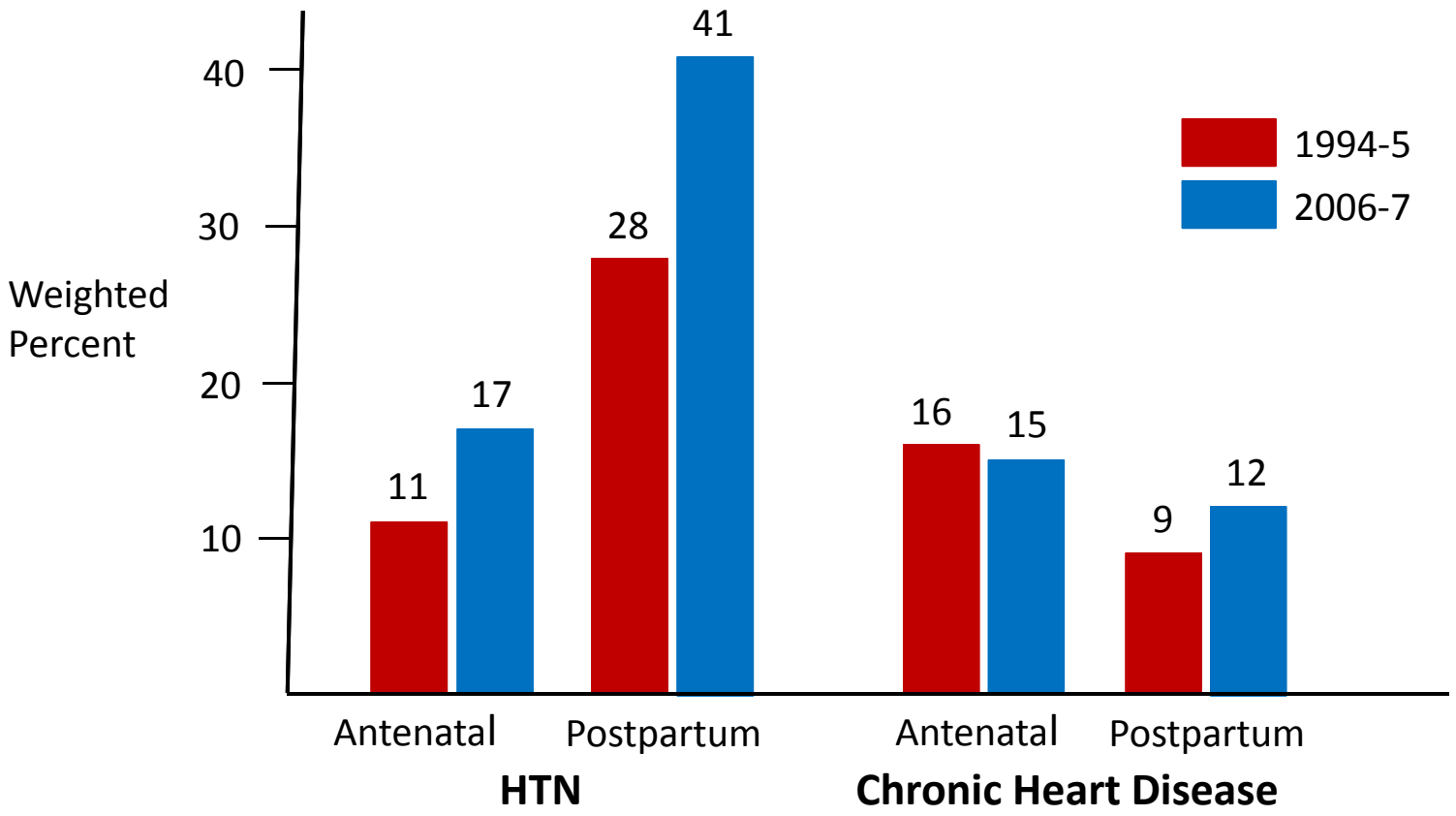
Rate of Stroke in Pregnancy and the Puerperium
Is It Increasing?



Healthcare Cost and Utilization Project of the Agency for Healthcare Research and Quality

Stroke 2011;42:2564

Increase in Rate of Stroke Follows Increases in Rates of HTN and Chronic Heart Disease



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Relative Risk of Stroke in Pregnancy and the Puerperium

Stroke Type	*Relative Risk of Stroke during Pregnancy*	*Relative Risk of Stroke during the Puerperium (6 wk)*
Cerebral infarction	**0.7**	**8.7**
Cerebral hemorrhage	**2.5**	**28.5**

Kittner N Engl J Med 1996;335:768-74.

Major References: Epidemiology

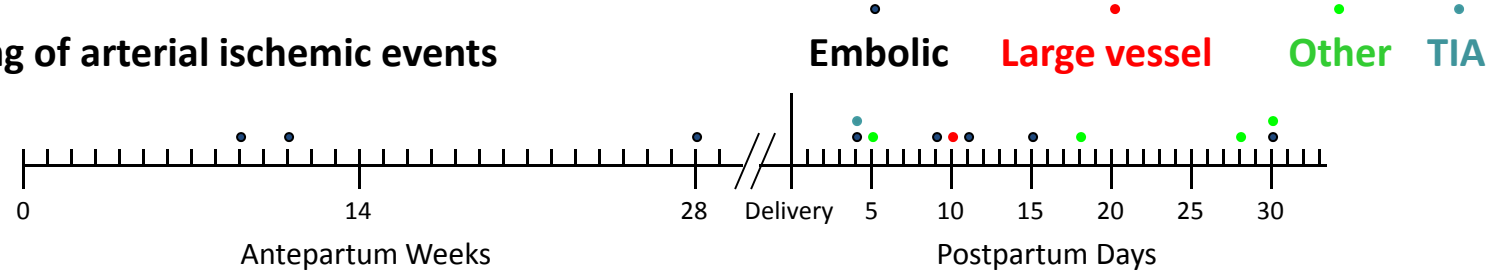
Sharshar T, et al. Incidence and causes of strokes associated with pregnancy and puerperium: A study in public hospitals of Ile de France. Stroke 1995;26(6):930-6.

Kittner SJ, et al. Pregnancy and the risk of stroke. N Engl J Med 1996;335(11):768-74.

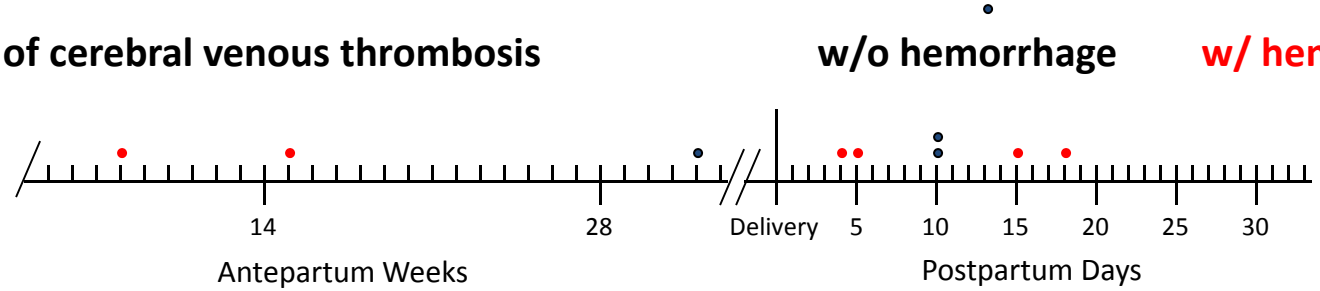
Ban L, et al. Incidence of first stroke in pregnant and nonpregnant women of childbearing age: A population-based cohort study from England. J Am Heart Assoc 2017;6(4):e004601.

Timing of Events

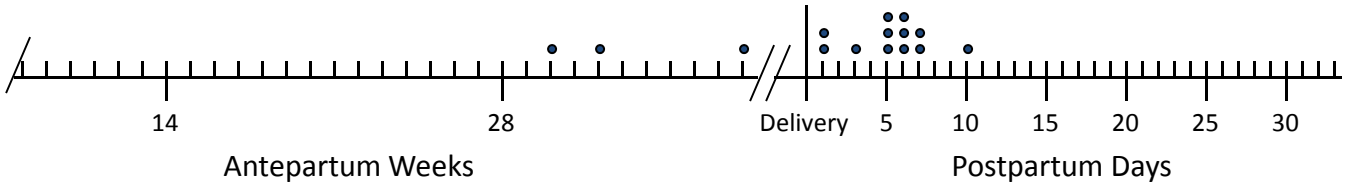
Timing of arterial ischemic events



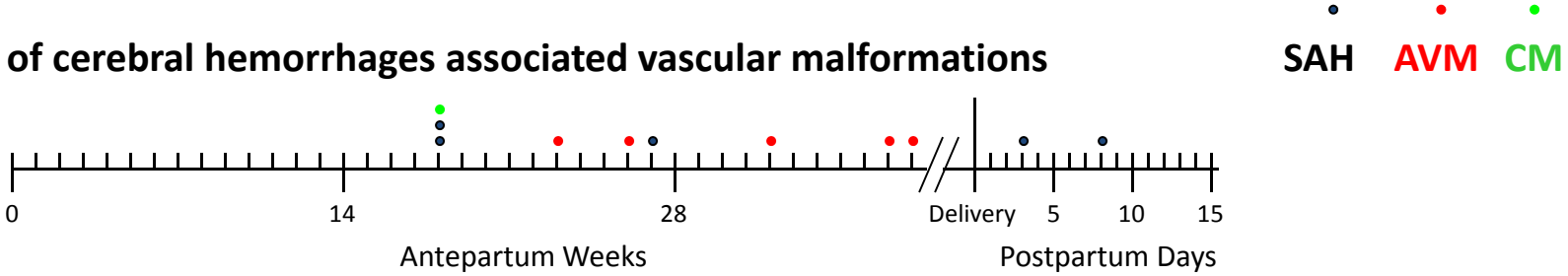
Timing of cerebral venous thrombosis



Timing of cerebral hemorrhages associated with preeclampsia/eclampsia



Timing of cerebral hemorrhages associated vascular malformations



Feske Stroke 2009;40(4):e183

Changes in Coagulability during Pregnancy

- **Physical changes**
  - **Compression of the IVC**
  - **Compression of the aorta**
  - **Compression of uterine arteries and veins**
  - **Decreased venous compliance**

- **Increases in procoagulant factors**
  - **Increase in factors I, VII, VIII, IX, X, XII, and XIII**
  - **No change in factors II, V, XI**

- **Decreases in coagulation inhibitors**
  - **Decreased AT III**
  - **Decreased protein S**
  - **Functional protein C resistance**

- **Thrombin generation and fibrinolysis**
  - **Increased thrombin generation**
  - **Increased fibrinogen and fibrinolysis**
  - **Platelet consumption**

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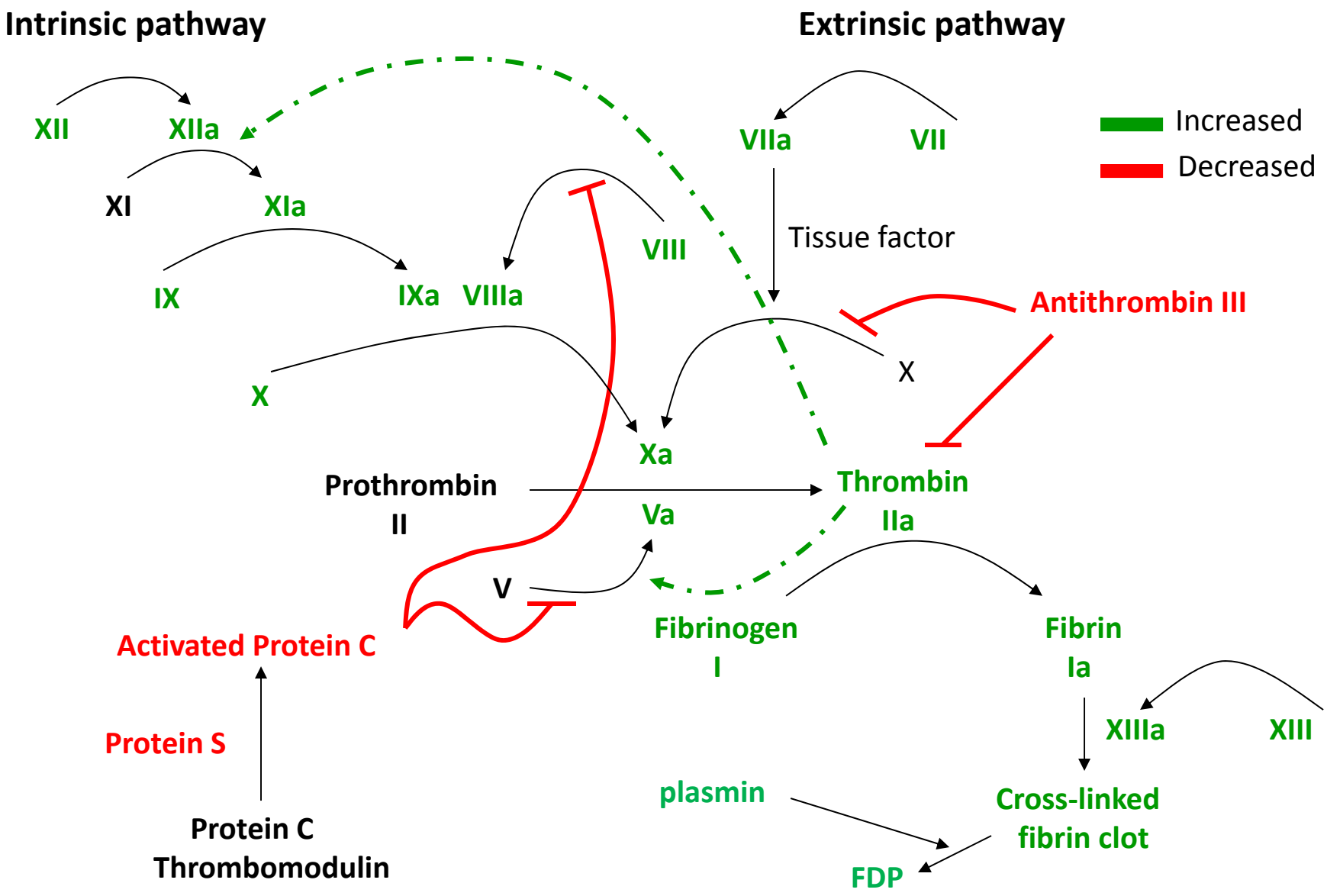


Acute Hemorrhage is a Thrombophilic State!

- Thrombosis and hemorrhage are well-known complications of trauma

- Increased high molecular weight fibrinogen after delivery as part of the acute phase reaction

- The mild "DIC" state:
  - Increased thrombin generation
  - Increased fibrinolysis
    - increased FDP
    - increased D-dimer
    - Fibrinogen consumption
  - Platelet consumption

Adker G et al. Thromb Res 2000;97(6):405-10

Postpartum Thrombophilia

1,687,930 Californian women hospitalizations for delivery from Jan 2005 to June 2010

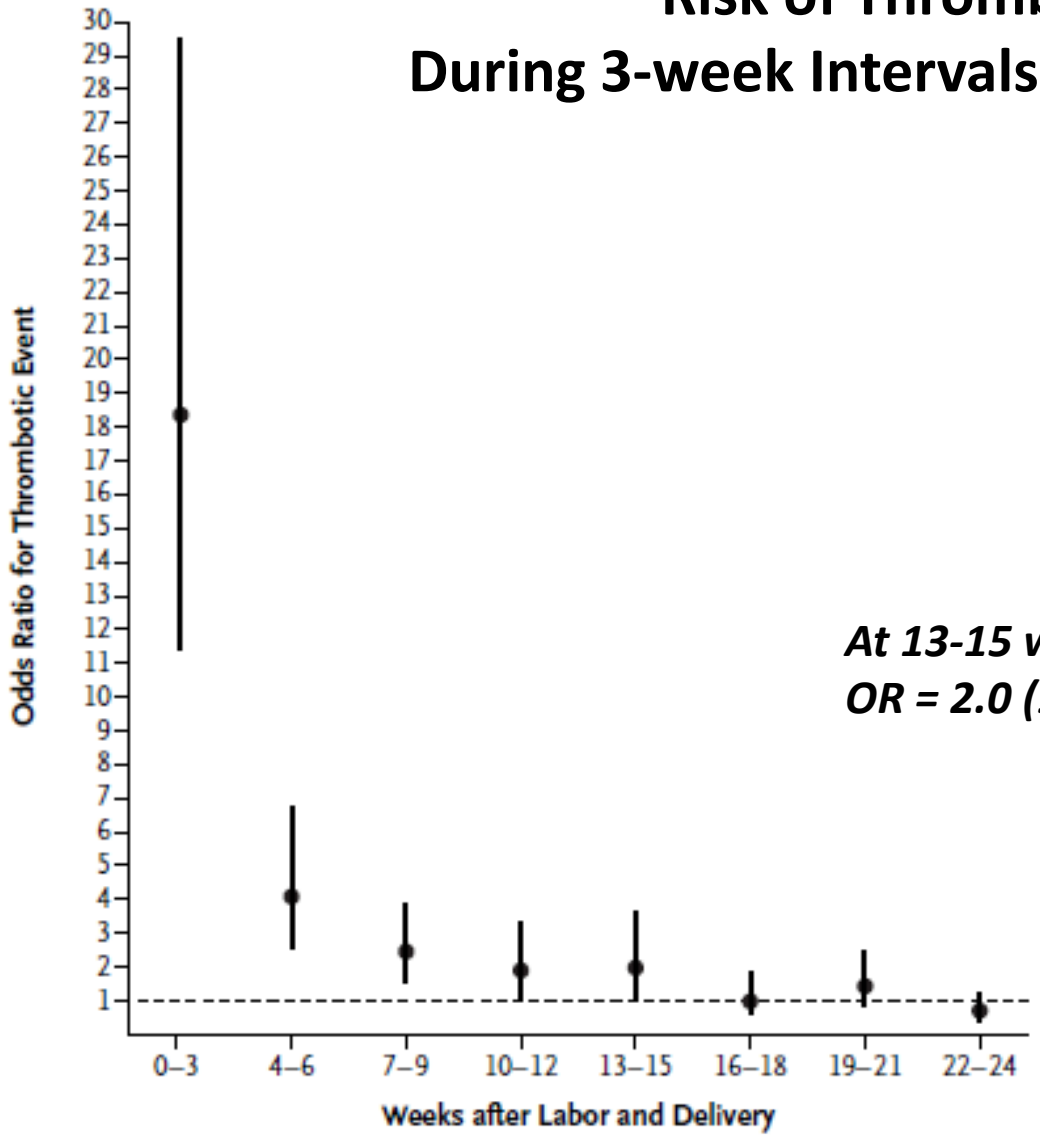
Thrombotic events: Stroke, MI, VTE

Risk factors

- **Older**
- **White or African American v Hispanic or Asian**
- **No private insurance**
- **Other risk factors for thrombosis**
  - **Age > 35 yr**
  - **Eclampsia**
  - **Primary hypercoagulable state**
  - **Smoking**
  - **Cesarean delivery**

Kamel NEJM 2014;370:1307

Risk of Thrombosis
During 3-week Intervals after Delivery



At 13-15 weeks
OR = 2.0 (95% CI, 1.1-3.6)

Kamel NEJM 2014;370:1307

Risk of Stroke Based on Time After Delivery

Time after Delivery	*Case Period*	*Crossover Period*	*Absolute Risk Difference*	*Odds Ratio (95% CI)*
	Rate per 100,000 deliveries			
Weeks 0-6	**7.1**	**0.8**	**6.2**	**8.5 (4.9 - 14.8)**
Weeks 7-12	**0.9**	**0.5**	**0.4**	**1.7 (0.7 - 3.8)**
Weeks 13-18	**0.5**	**0.5**	**0**	**1.0 (0.4 – 2.5)**
Weeks 19-24	**0.9**	**0.9**	**0.1**	**1.1 (0.5- 2.2)**

Kamel NEJM 2014;370:1307

Risk of Thrombotic Event Based on Time After Delivery

Odds Ratios

Time after Delivery	*Stroke*	*MI*	*VTE*	*Composite*	*All*
		Odds Ratio			
Weeks 0-6	**8.5**	**13.0**	**12.1**	**10.8**	**22.8**
Weeks 7-12	**1.7**	**4.0**	**2.2**	**2.2**	**2.1**
Weeks 13-18	**1.0**	**1.0**	**1.6**	**1.4**	**1.0**
Weeks 19-24	**1.1**	**2.5**	**0.9**	**1.0**	**0.9**

Clear increase in risk for at least 12 weeks; though small after 6 weeks…

Kamel NEJM 2014;370:1307

Risk of Thrombotic Event Based on Time After Delivery

Absolute Risk

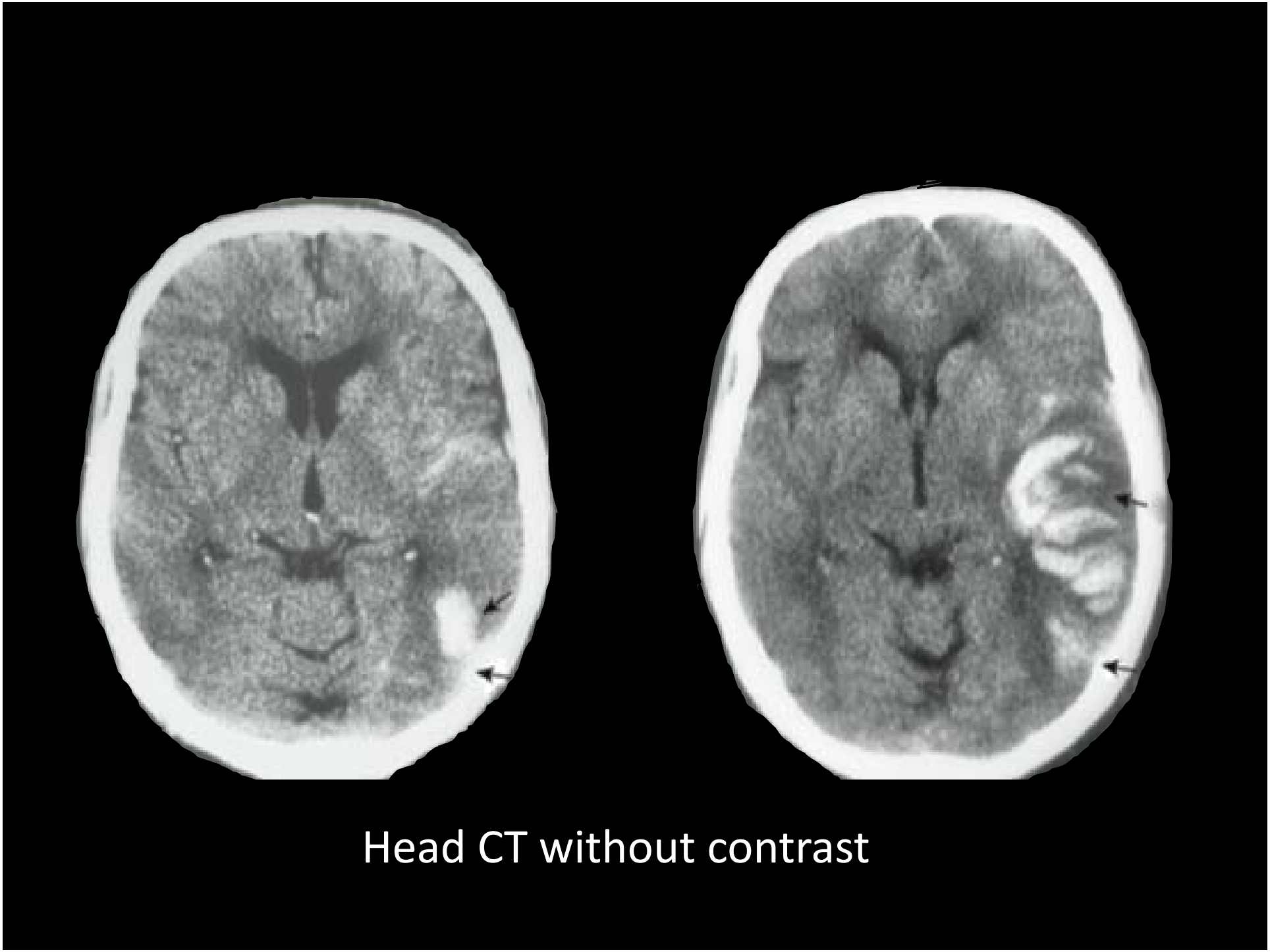
Time after Delivery	***Stroke***	***MI***	***VTE***	***Composite***	***All***
	Absolute Risk Difference				
Weeks 0-6	**6.2**	0.7	**15.2**	**22.1**	**127.6**
Weeks 7-12	0.4	0.4	**2.3**	**3.0**	**6.1**
Weeks 13-18	0	0	0.9	0.9	0.2
Weeks 19-24	0.1	0.2	-0.3	-0.1	-0.9

Clinical importance: VTE > Stroke > MI

Kamel NEJM 2014;370:1307

Case

A 34-year-old woman began having headaches **several days after delivery** of her first child. The **pregnancy and delivery had been normal**, and the baby was healthy. Her **headaches** were diffuse, worse at night. Four days after onset, her husband witnessed a **grand mal seizure**. She had no history of prior seizures. On initial examination her pulse was 80 and regular, **BP 115/70**; she was **aphasic and had mild right hemiparesis**.



Head CT without contrast

Causes of Hemorrhagic Stroke in Pregnancy
Percent of All Hemorrhages

	Preeclampsia Eclampsia	*Unknown*	*AVM*	*Aneurysm*	*Other*	*Cavernous Malformation*
Feske 2009	*42*	*11*	*14*	*14*	*17*	*3*
Liang 2006	*24*	*24*	*19*	*10*	*24*	*--*
Jeng 2004	*32*	*--*	*23*	*14*	*--*	*--*
Jaigobin 2000	*--*	*23*	*38*	*23*	*15*	*--*
Kittner 1996	*15*	*31*	*23*	*--*	*31*	*--*
Sharshar 1995	*44*	*19*	*13*	*13*	*--*	*13*

Causes of Hemorrhagic Stroke in Pregnancy
Percent of All Hemorrhages

	Preeclampsia Eclampsia	Unknown	AVM	Aneurysm	CVT	Cavernous Malformation
Feske 2009	42	11	14	14	17	3
Liang 2006	24	24	19	10	24	--
Jeng 2004	32	--	23	14	--	--
Jaigobin 2000	--	23	38	23	15	--
Kittner 1996	15	31	23	--	31	--
Sharshar 1995	44	19	13	13	--	13

Goals of Neuroimaging in Pregnancy

1. ***Provide standard of care imaging able to answer important diagnostic questions.***
2. ***Minimize risks to the fetus.***
3. ***Use radiation doses as low as reasonably achievable for potential stochastic effects.***
4. ***Use doses below exposure thresholds for deterministic effects.***

- ***Stochastic effects – May occur after any dose of radiation; higher doses increase risk.***
  - ***Mutagenesis***
  - ***Childhood malignancy***

- ***Deterministic effects – Predictably occur above specific exposure thresholds.***
  - ***Cataract formation***
  - ***Infertility***

Considerations in Neuroimaging in Pregnancy

1. *Radiation dose and rate absorbed*
    1. *E.g. Estimate 6% increase in risk of childhood cancer per 100 rad.*
    2. *Fetal exposure to indirect radiation from CT is to be < 0.01 rad.*
    3. *Fetal exposure to direct radiation from pelvic CT may reach 3 rad.*
2. *Fetal gestational age*
    1. *0-4 weeks – Increase risk of miscarriage with doses > 10 rad.*
    2. *5-10 weeks – Fetal malformation, growth retardation, and death possible with doses > 5 -10 rad.*
    3. *6 weeks – birth – Mental retardation with doses > 5-10 rad.*
        1. *Very low risk after 15 weeks*
3. *Urgency of diagnostic need*

For potential stroke in pregnancy:

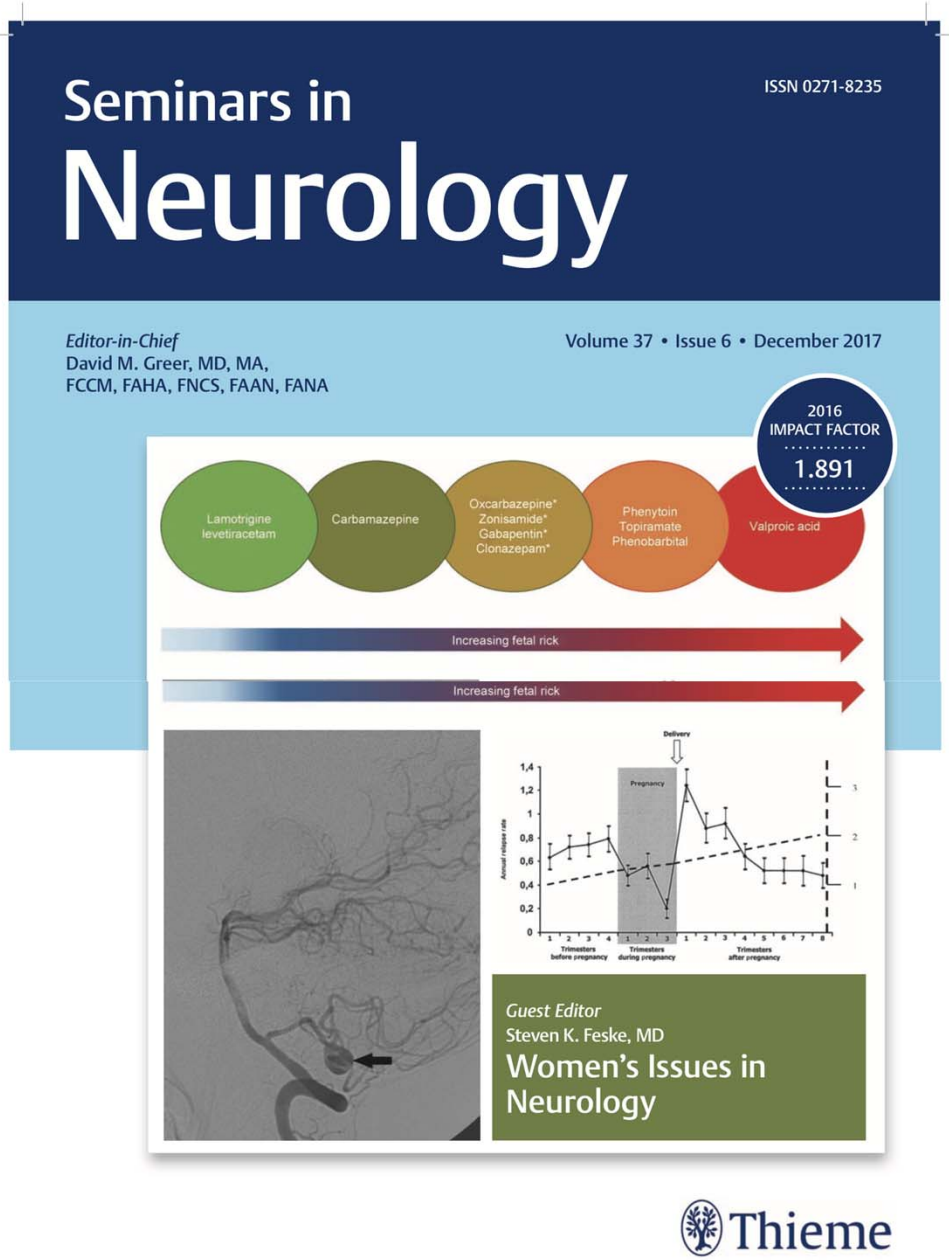
- ***Degree of urgency is high.***
- ***Exposure is indirect and doses are low.***
- ***Events occur late in pregnancy when fetal risks are minimal.***

Further Considerations in Neuroimaging in Pregnancy

1. *MRI*
2. *Iodinated Contrast Agents*
3. *Gadolinium*

Further Considerations in Neuroimaging in Pregnancy

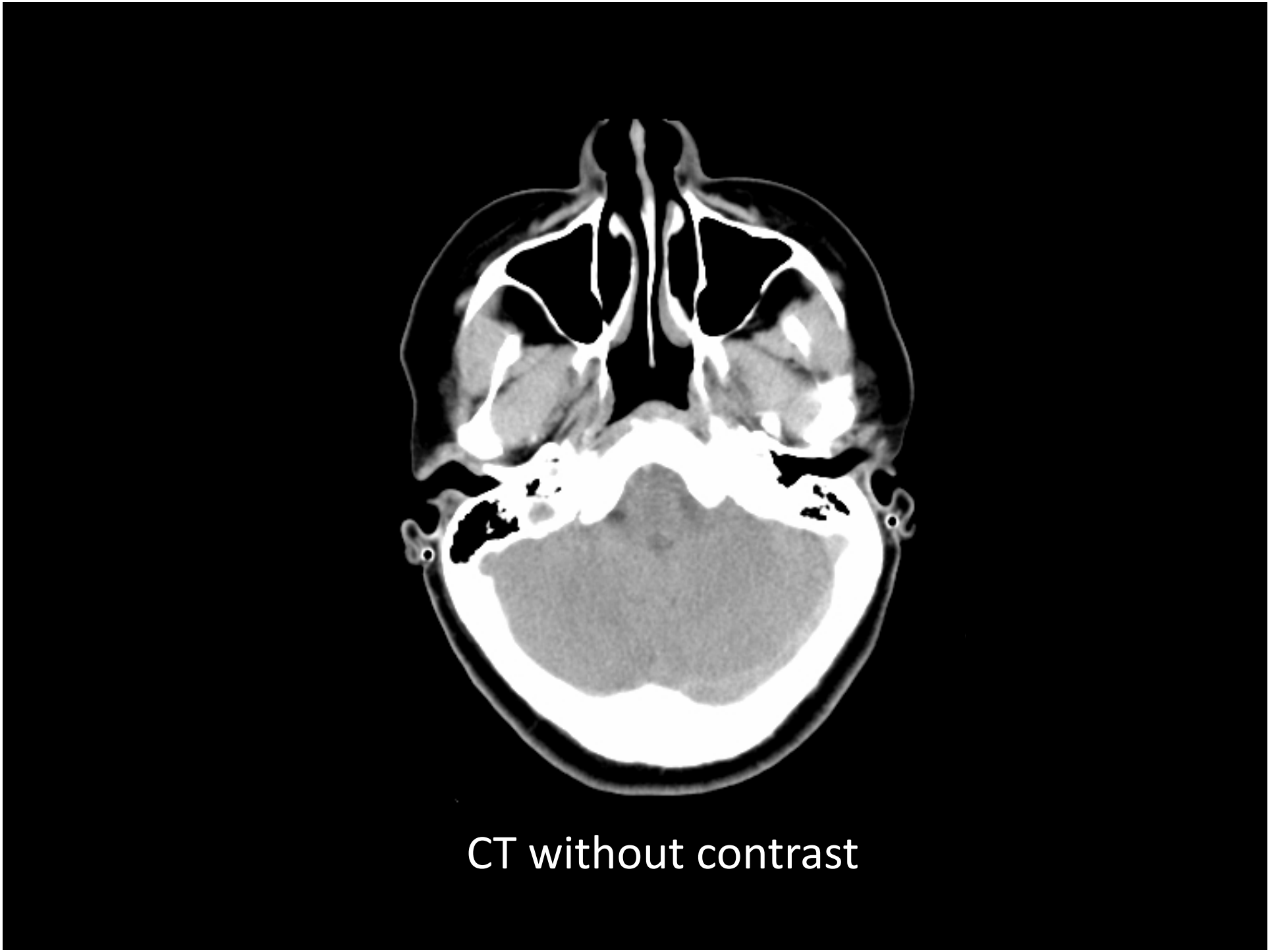
1. *MRI is felt to be safe.*
    1. *No conclusive evidence of fetal harm from exposure up to 3 T.*
    2. *Theoretical concerns*
        1. *Noise exposure*
        2. *Strong magnetic fields*
        3. *Increase in body temperature*
2. *Iodinated contrast agents should be avoided, except when no alternative.*
    1. *Theoretical concerns*
        1. *Neonatal hypothyroidism*
        2. *Renal injury*
3. *Gadolinium should be avoided.*
    1. *Theoretical concerns*
        1. *Miscarriage*
        2. *Developmental abnormalities*



Chansakul T, Young GS. Neuroimaging in pregnant women. Semin Neurol 2017;37(6):712-23.

Sells CM, Feske SK. Stroke in pregnancy. Semin Neurol 2017;37(6):669-78.

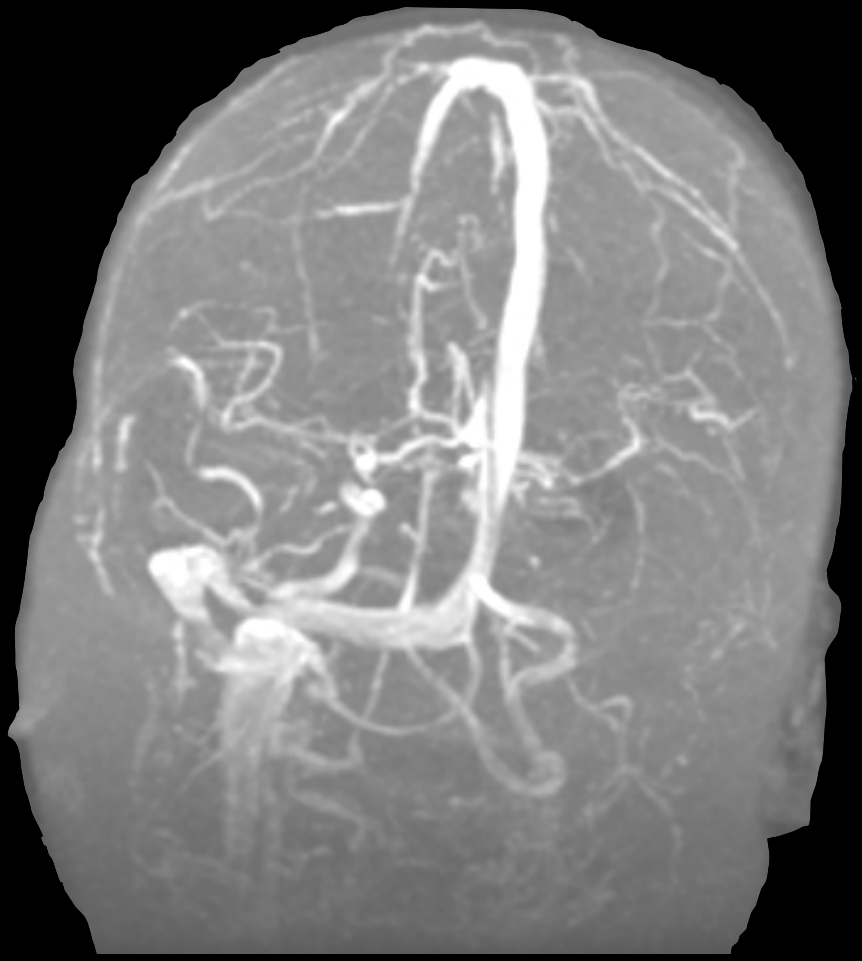
Can A, Du R. Neurosurgical issues in pregnancy. Semin Neurol 2017;37(6):689-93.



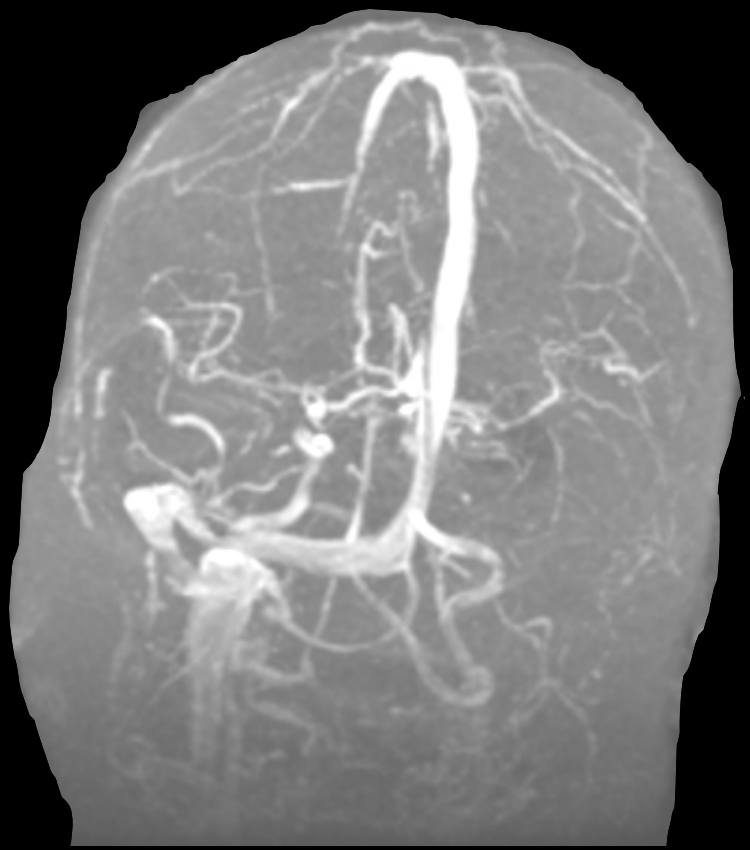
CT without contrast

Empty Delta Sign

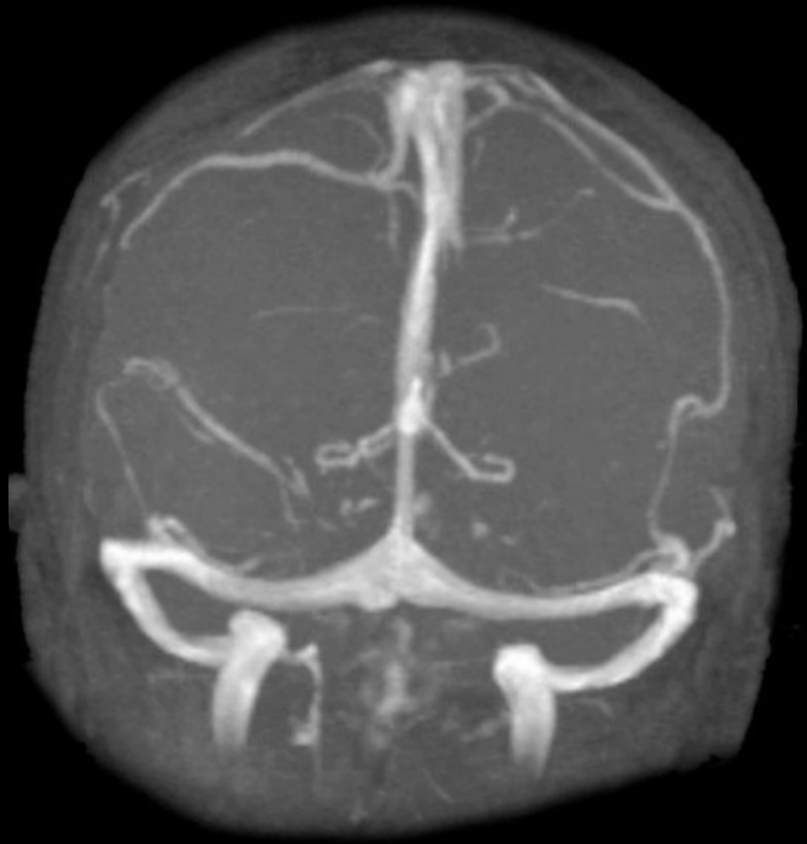
CT with contrast



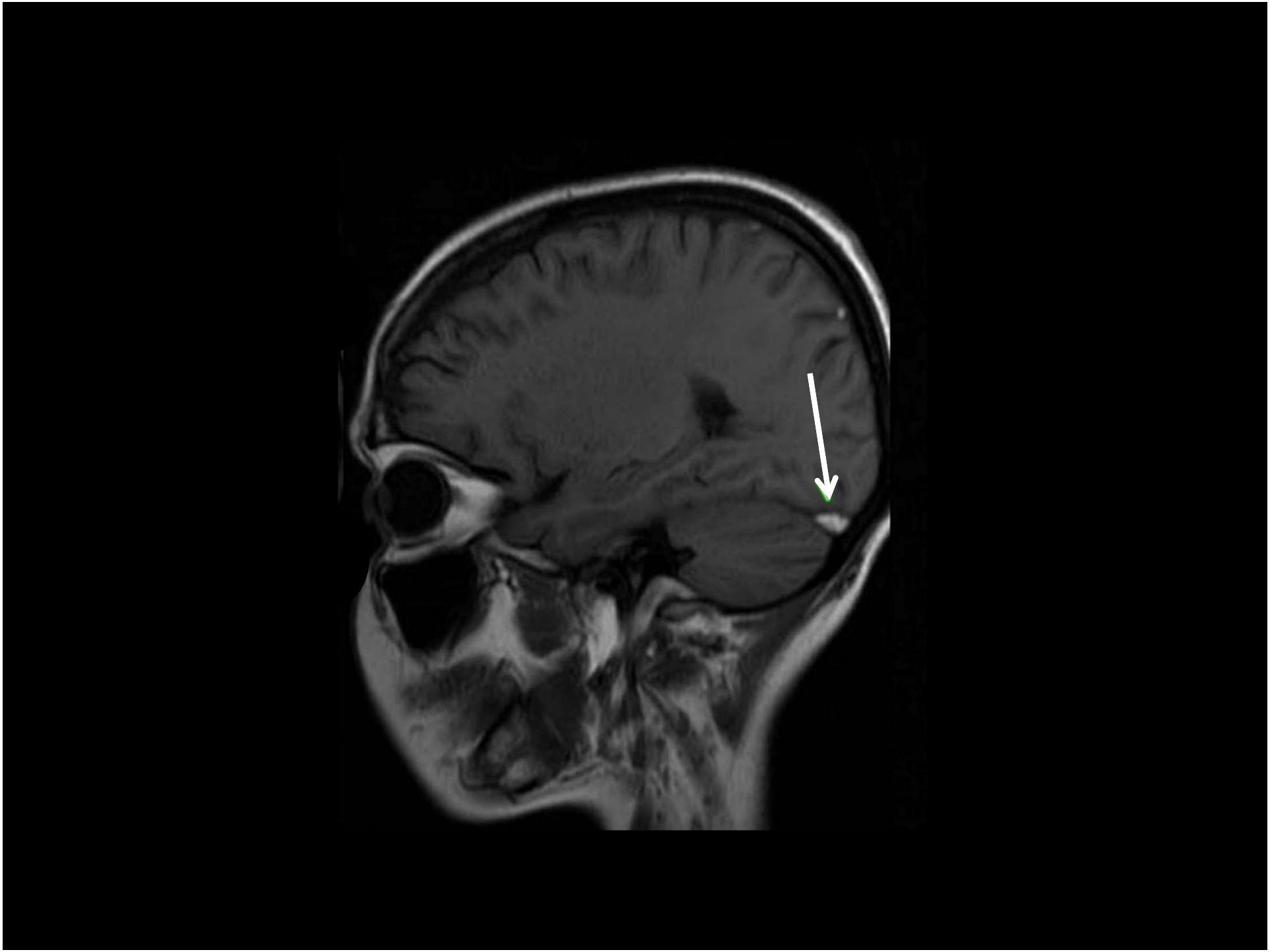
MR Venogram

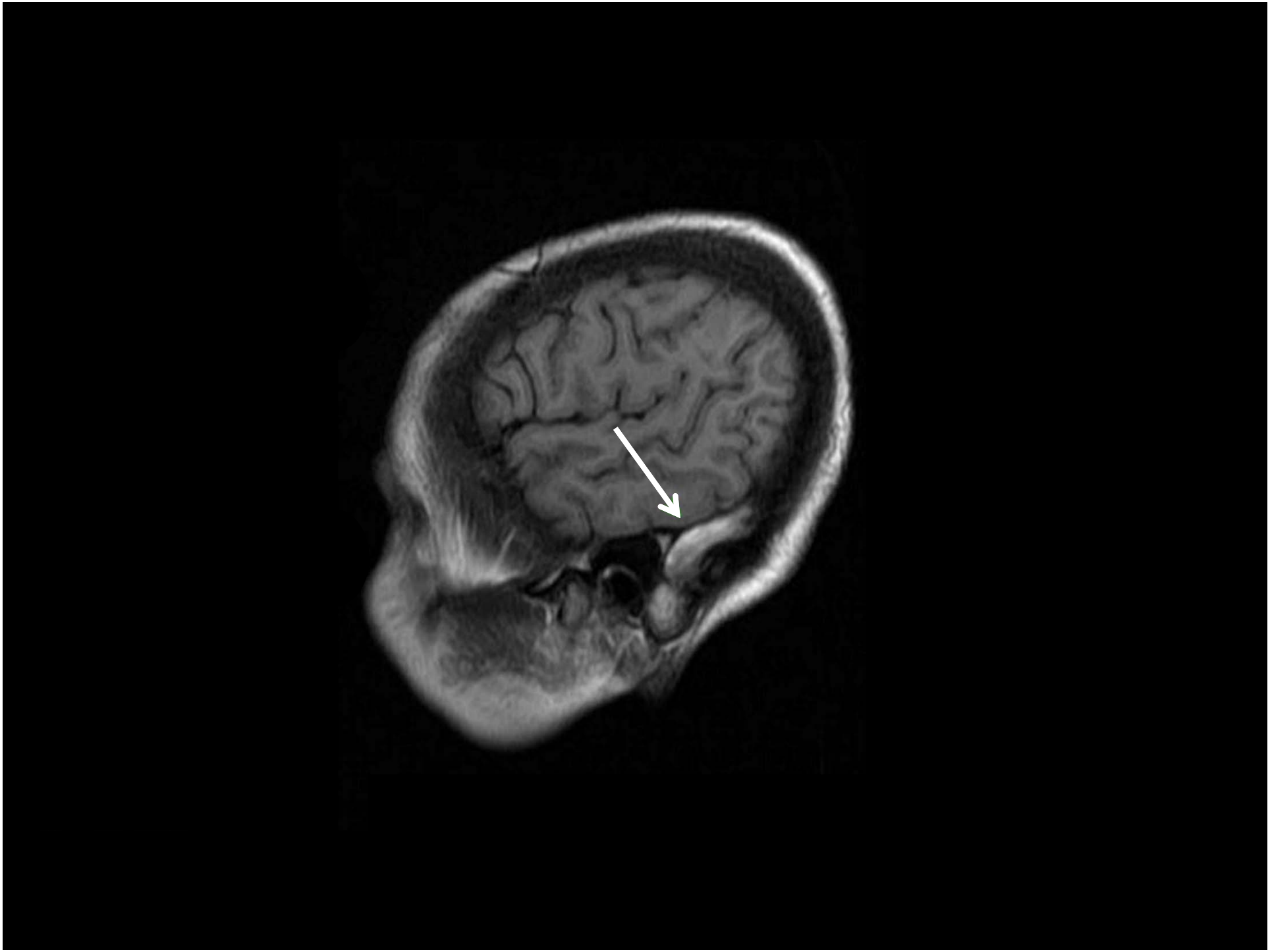


Left Transverse Sinus Thrombosis



Normal MR Venogram





How should we treat her?

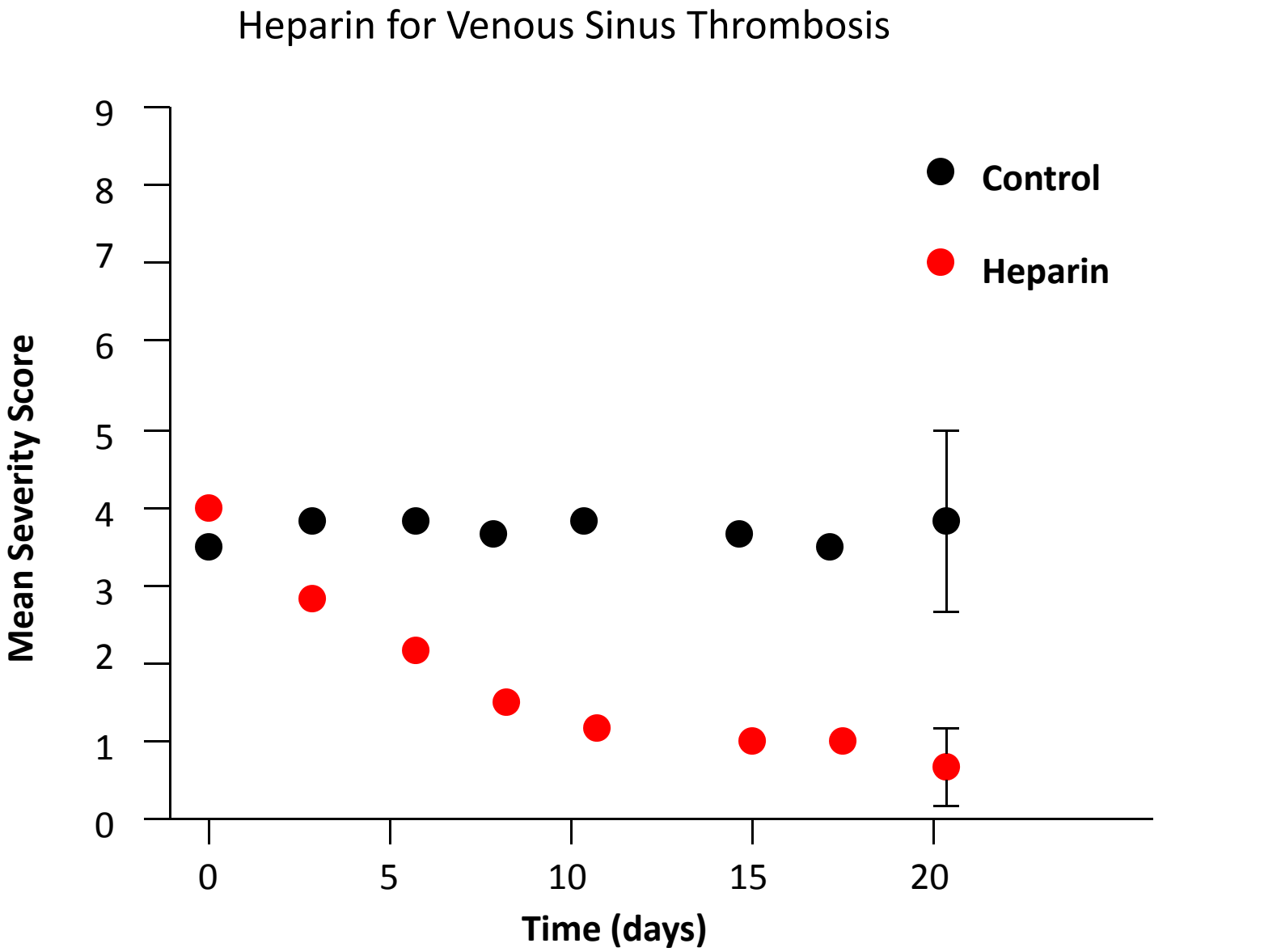
Treatment of CVT

1. Einhäupl KM et al. Heparin treatment in sinus venous thrombosis. Lancet 1991;338:597-600.

2. de Bruijn SF et al. Randomized, placebo-controlled trial of anticoagulation treatment with low-molecular-weight heparin for cerebral sinus thrombosis. Stroke 1999;30:484-8.

3. Stam J, et al. Anticoagulation for cerebral sinus thrombosis. Cochrane Database Syst Rev 2002;(4):CD002005.

4. Ferro JM, et al for the ISCVT Investigators. Prognosis of cerebral vein and dural sinus thrombosis: Results of the International Study on Cerebral Vein and Dural Sinus Thrombosis (ISCVT) Stroke 2004;35:664-70.



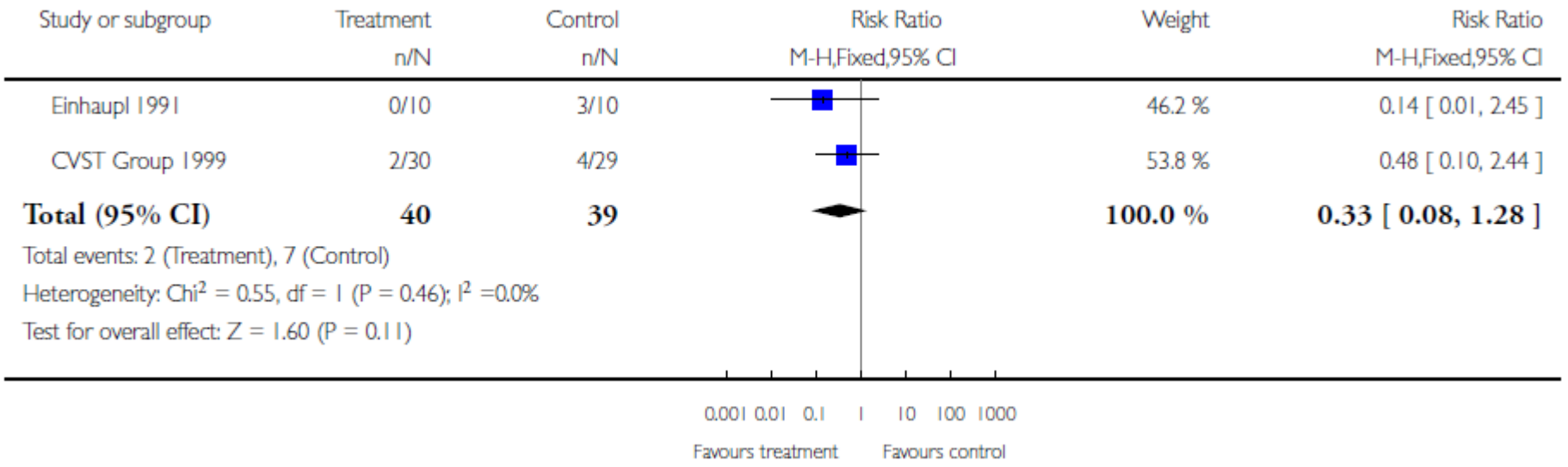
Einhäupl Lancet 1991;338:597

Heparin for Venous Sinus Thrombosis
3-month Outcomes

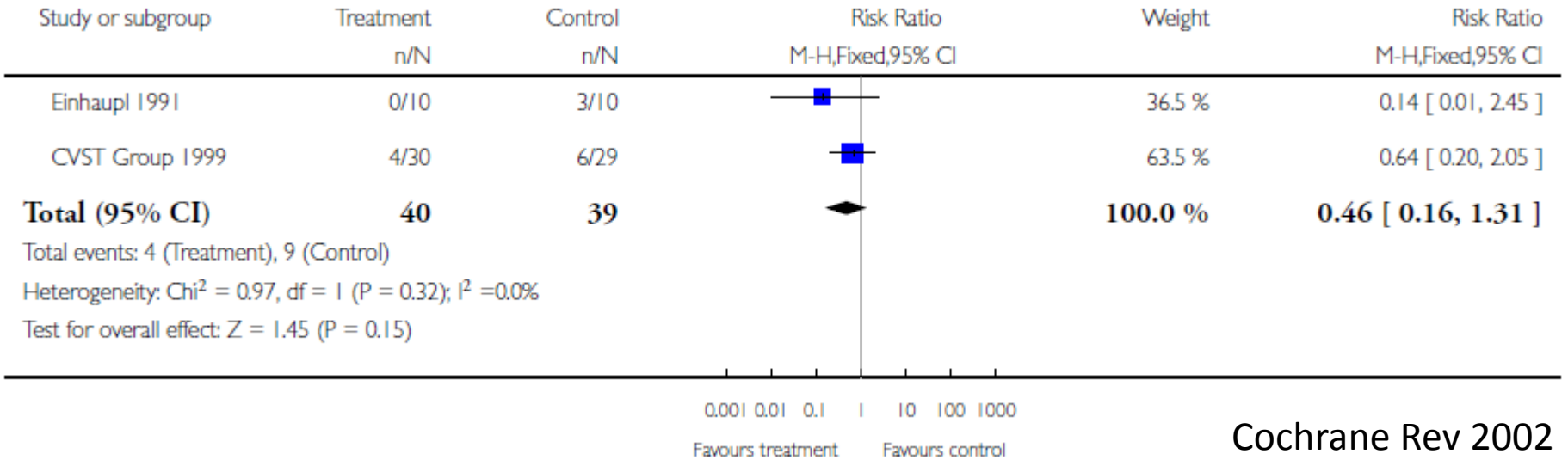
Outcome	*Control (N=10)*	*Heparin (N=10)*
Complete recovery	**1**	**8**
Slight neurologic deficit	**6**	**2**
Death	**3**	**0**

Einhäupl Lancet 1991;338:597

Overall Benefit or Harm of Heparin, Outcome: Death



Overall Benefit or Harm of Heparin, Outcome: Death and Dependency



Cochrane Rev 2002

AHA/ASA Guidelines 2011

6. For patients with CVT, ***initial anticoagulation with UFH or LMWH in full anticoagulant doses is reasonable, followed by warfarin, regardless of the presence of ICH*** *(Class IIa; Level B)*

8. In patients with CVT and increased ICP it is reasonable to initiate treatment with acetazolamide (Class IIa; Level C)

9. Endovascular intervention may be considered if deterioration occurs despite intensive anticoagulation treatment (Class IIb; Level C)

10. In patients with neurological deterioration due to severe mass effect or ICH causing intractable intracranial hypertension, decompressive hemicraniectomy may be considered (Class IIb; Level C)

Saposnik G et al. Stroke 2011;42:1158

Case

28-year-old RH woman 30-weeks pregnant without prior complications

- **10:00 AM last seen well**
- **10:50 AM found on ground by her husband, eyes open, mute, weak on R**
- **Brought to a local hospital**
  - **Alert without gaze deviation**
  - **Dense motor aphasia, mute**
  - **Dense right hemiplegia**
  - **No signs of trauma**
  - **Normal CBC, platelets, INR, PTT**
  - **Head CT normal (or subtle change of acute stroke; no hemorrhage)**
  - **MRI early acute stroke left basal ganglia**

Case

PMH

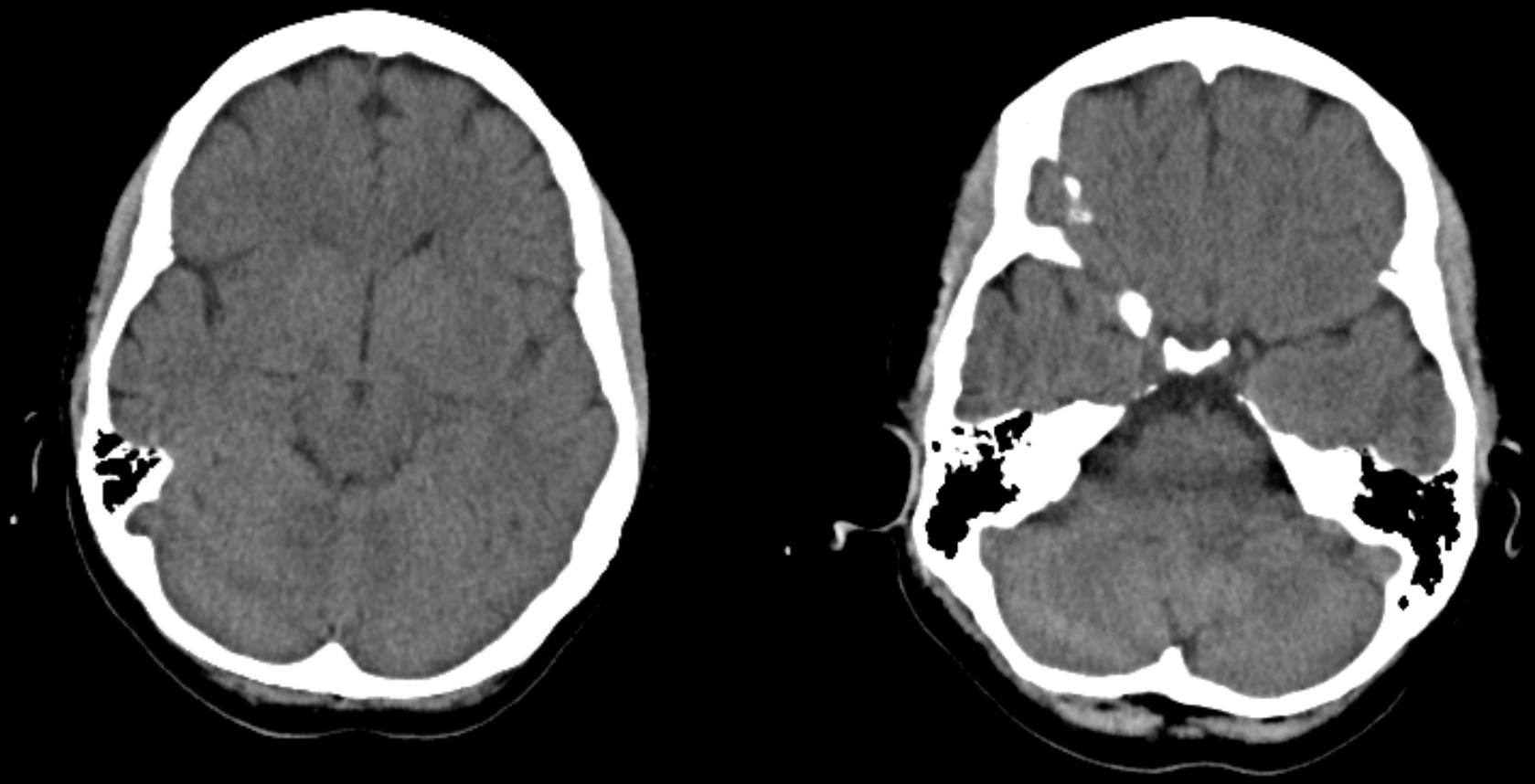
- **G2 P1**
- **G1 2009; stat C-section at term for concerning fetal heart tracing**
- **G2 current @ 30 weeks;**
  - **Rh^- received Rhogam at 28 weeks**
  - **Observed briefly for preterm contractions at 28 weeks**
- **No miscarriages**
- **No pre-eclampsia-eclampsia**
- **No prior abnormal thrombosis**
- **No trauma**
- **Nonsmoker; no alcohol or drug abuse**

FH

- **2 maternal uncles and one aunt with DVT/PE; ?FVIII excess**
- **No family history of arterial dissection, aneurysm, or AVM**
- **Father estranged and history unknown**

11:50 AM
1 hr 50 mim

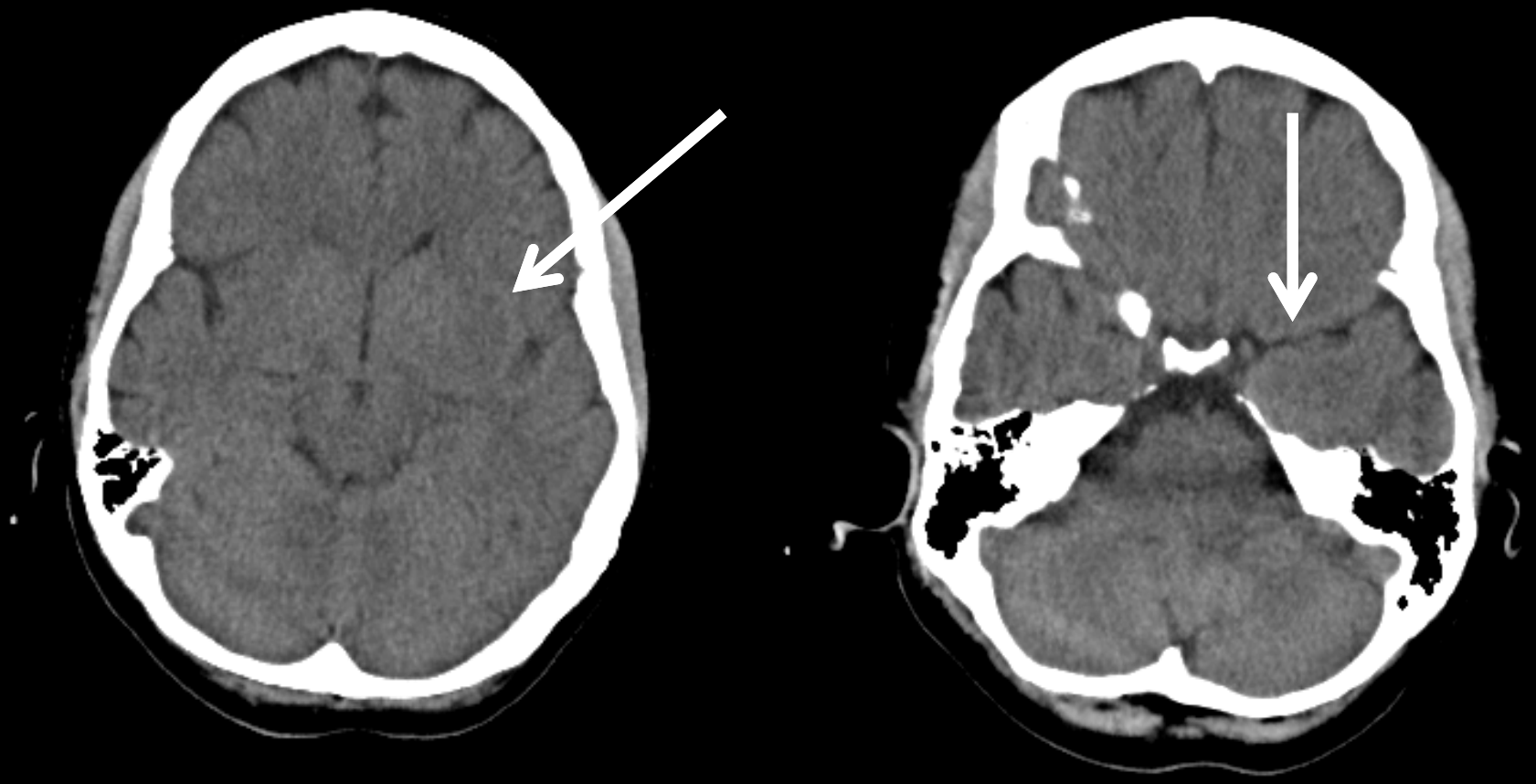
On Arrival at Local Hospital



CT without contrast

11:50 AM
1 hr 50 min

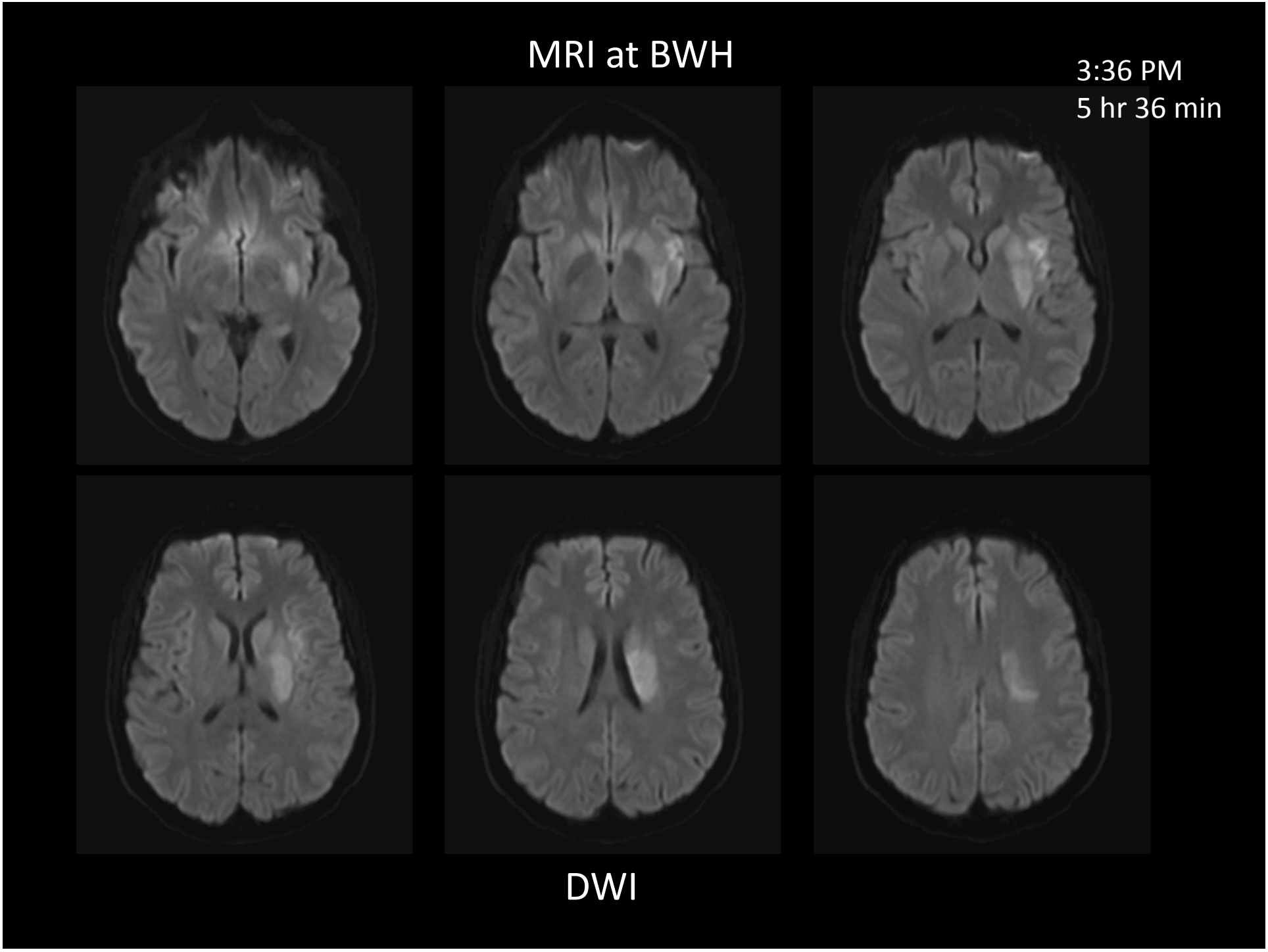
On Arrival at Local Hospital



CT without contrast

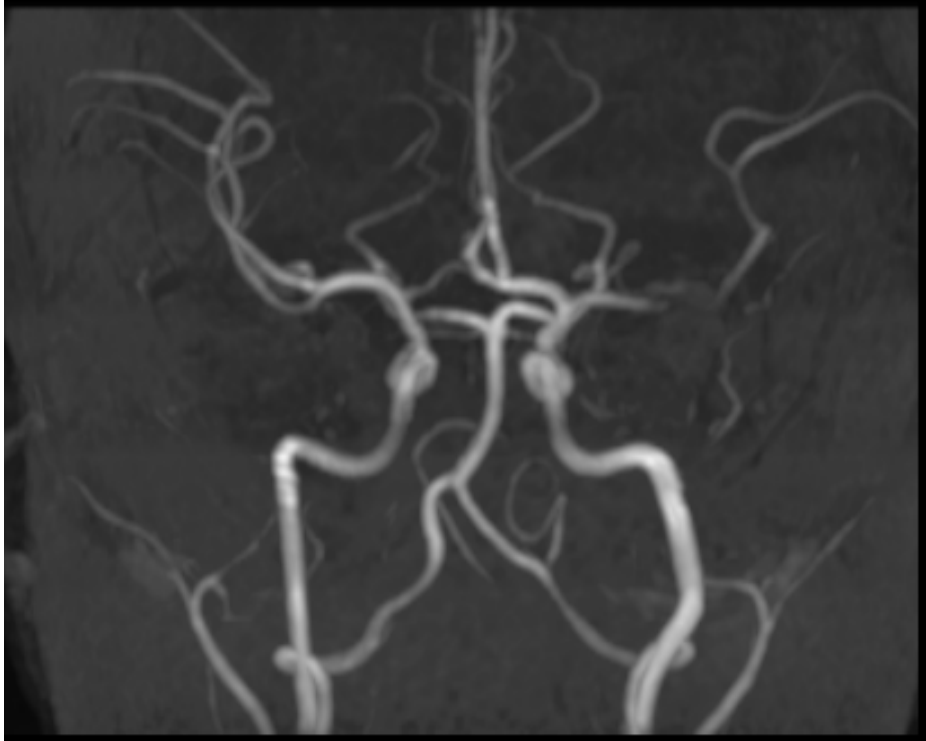
What would you do now?

What additional imaging studies would you get?


MRI at BWH
3:36 PM
5 hr 36 min
DWI

MRA at BWH

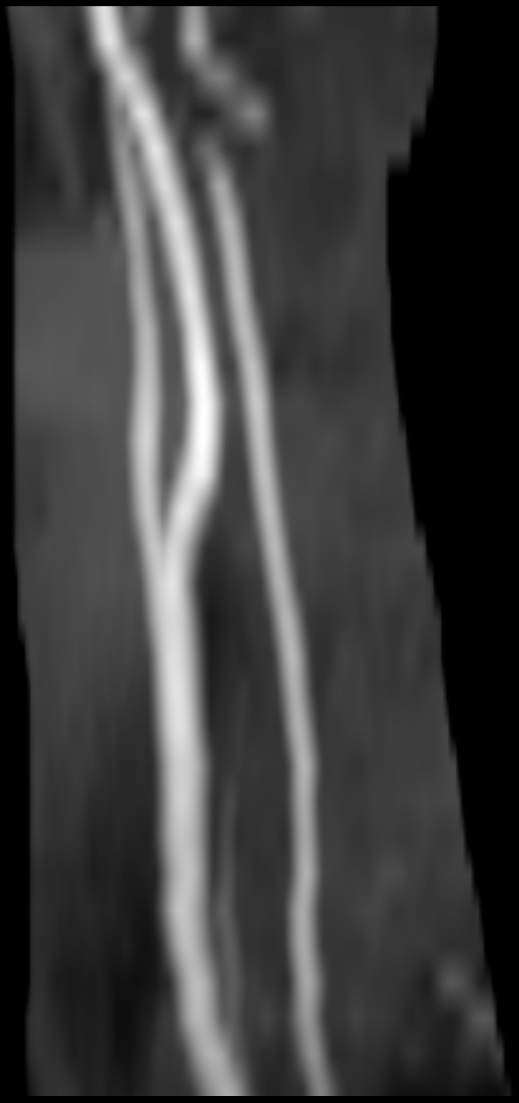
3:36 PM
5 hr 36 min



Left M1 occlusion

Cervical MRA at BWH

3:36 PM
5 hr 36 min



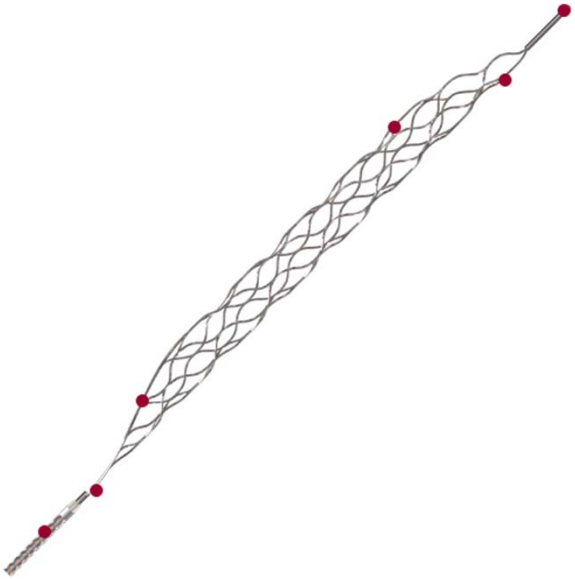
Open left ICA without evidence of dissection

Mechanisms of Ischemic Stroke in Pregnancy

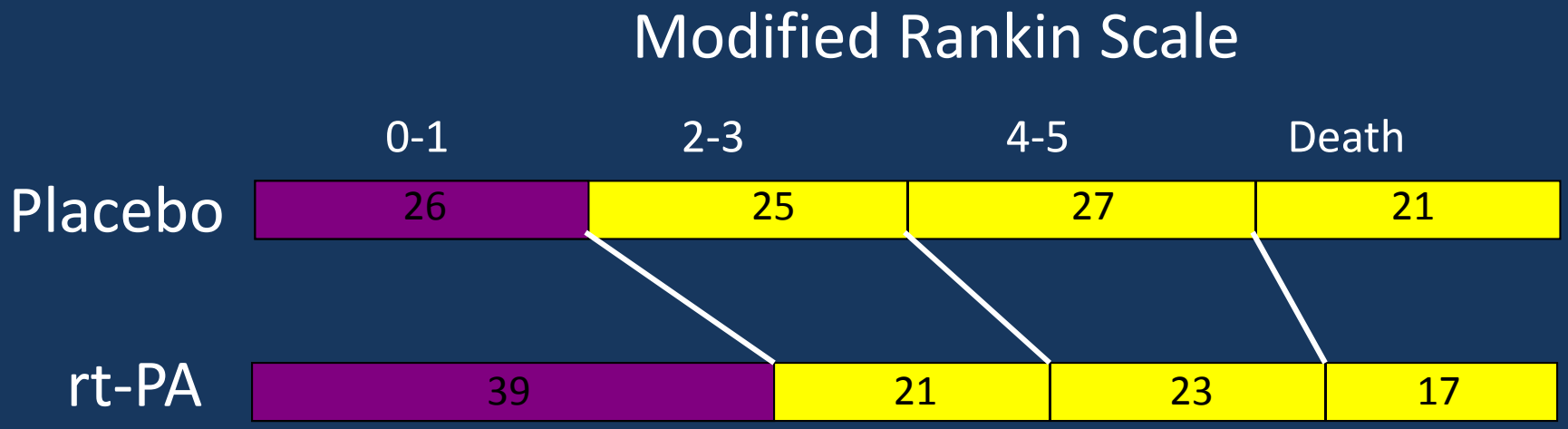
Author/Year	*% Cardio-embolism*	*% PEE*	*% Peripartum Angiopathy*	*% CVT*	*% Unknown*	*% Other*
Awada 1995 Saudi Arabia	33	11	--	--	44	11
Sharshar 1995 Ile de France	--	47	7	--	27	20
Kittner 1996 Md/Wash DC	--	25	13	6	38	19
Witlin 1997 Memphis	--	--	--	64	--	--
Jiagobin 2000 Toronto	20	20	--	40	20	15
Jeng 2004 Taiwan	44	--	--	22	22	--
Liang 2006 Taiwan	36	18	--	27	--	--
Feske 2009 Boston	35	26	--	39	--	22

How should we treat her?

Treatment of Acute Ischemic Stroke



NINDS Study of IV rt-PA for Acute Ischemic Stroke Outcome



ARR = 13 %

NNT = 8

NNH = 20 (sICH 6 v 0.6 %)

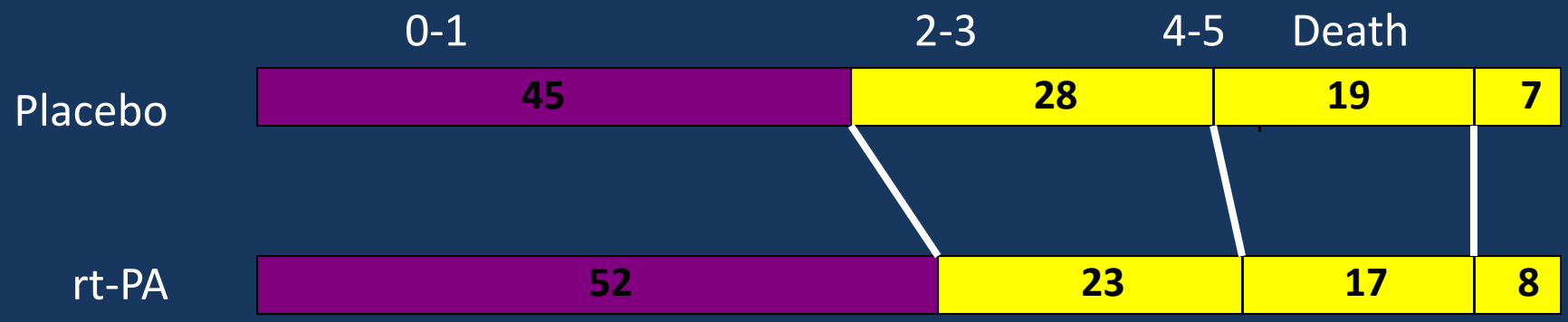
(Harm as sICH)

The NINDS Stroke Study Group NEJM 1995;333:1581

IV tPA in 3-4.5 hr Window

ECASS III Results: Primary Endpoint

Modified Rankin Scale at 90 days



ARR = 7 %

NNT = 14

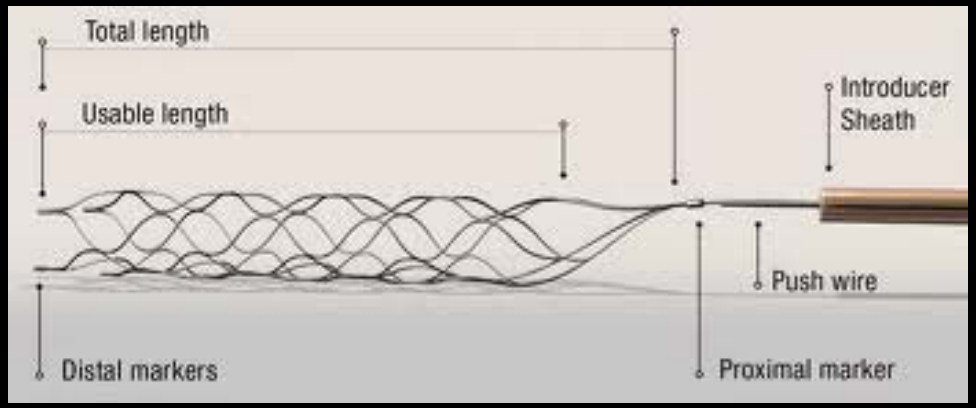
NNH = 45 (sICH 2.4 v 0.2 %)

OR = 1.34

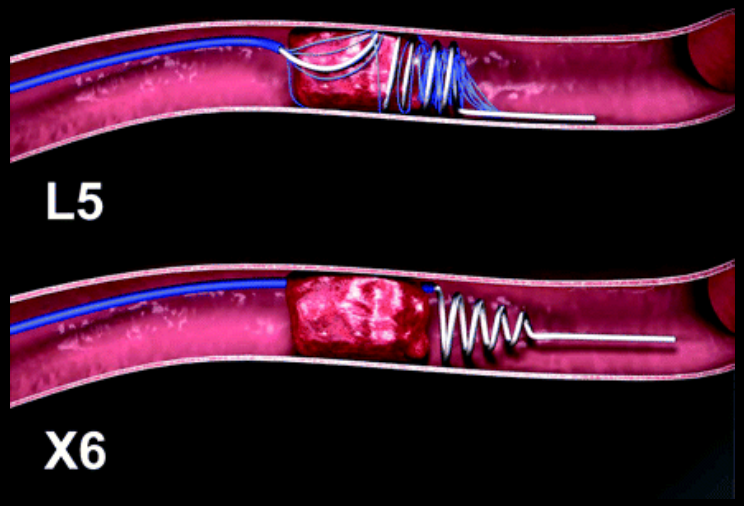
P-value = 0.04

ECASS III NEJM 2008;359:1317

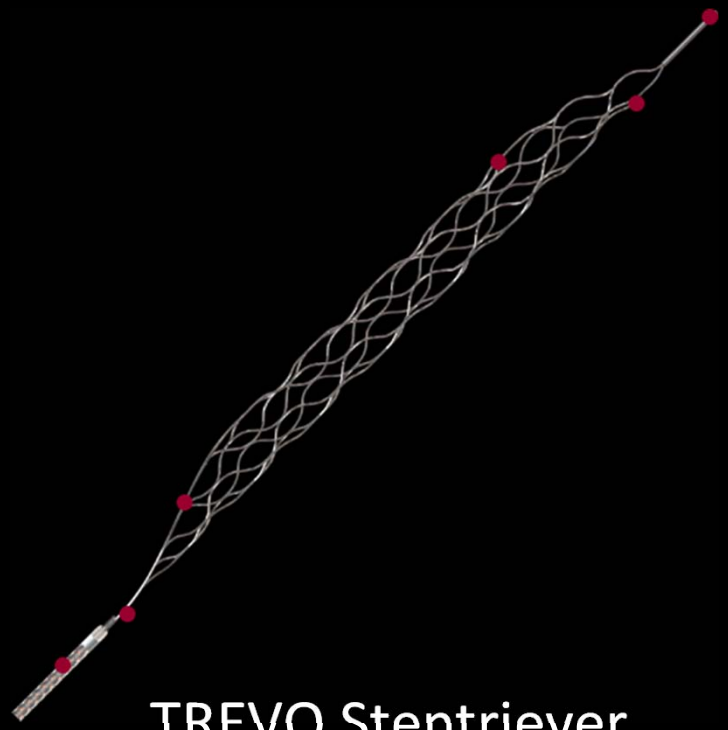
Mechanical Clot Retrieval Devices



SOLITAIRE Flow Restoration



MERCI devices

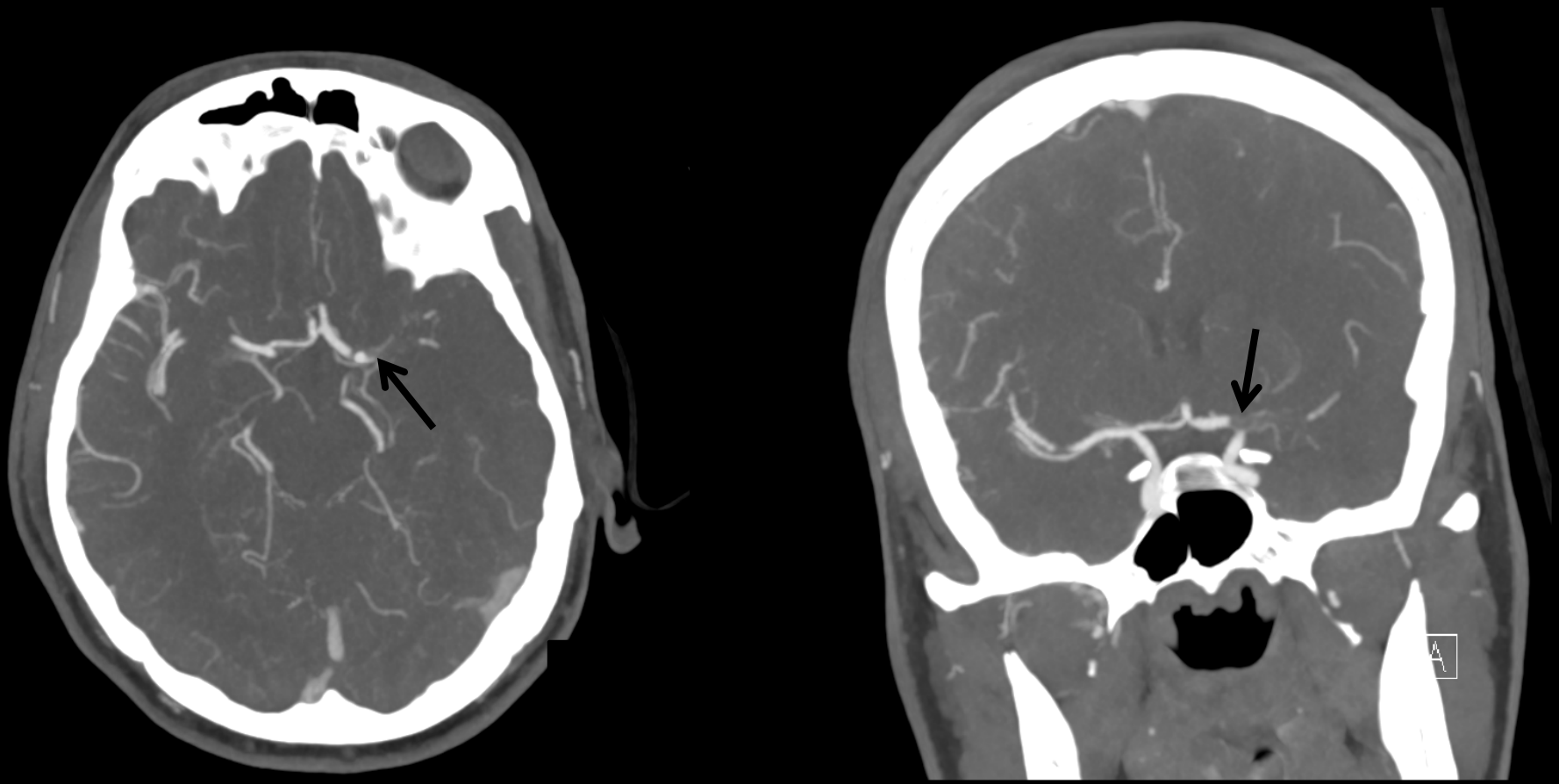


TREVO Stentriever

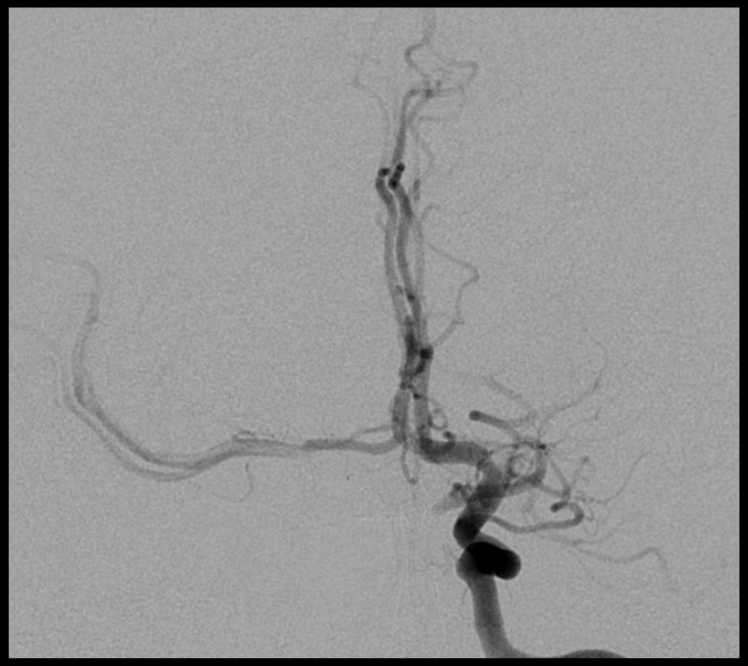
Dense Left MCA Sign

CT without contrast

Occlusion of the Terminal LICA



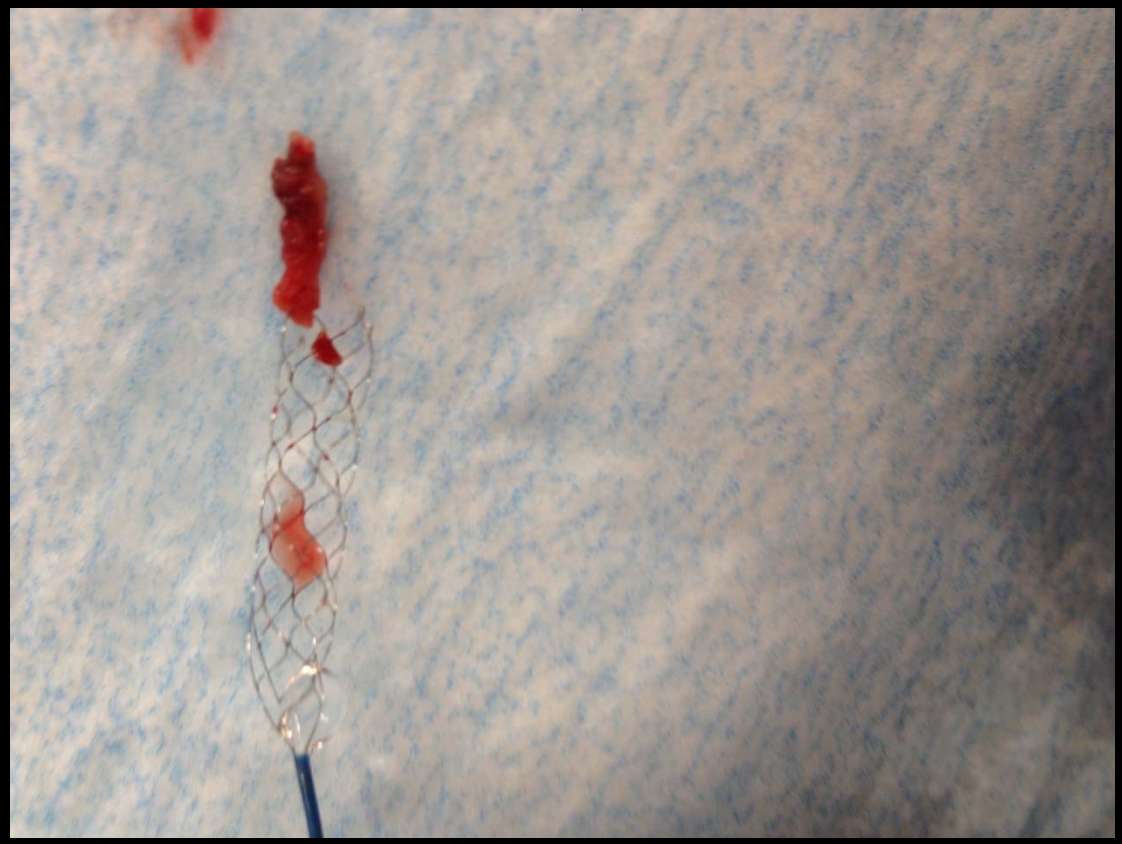
CTA



Before clot extraction

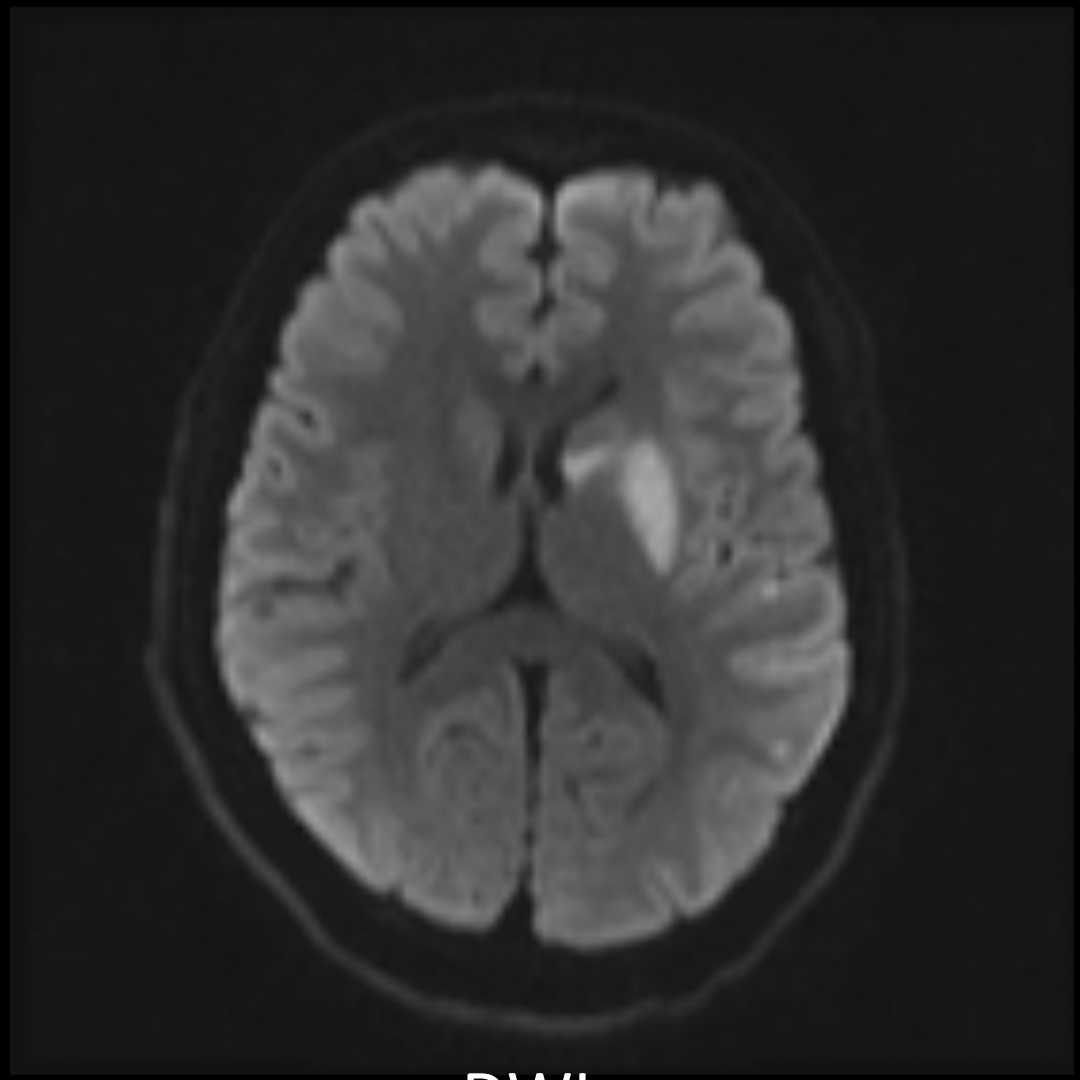
After clot extraction

Angiogram



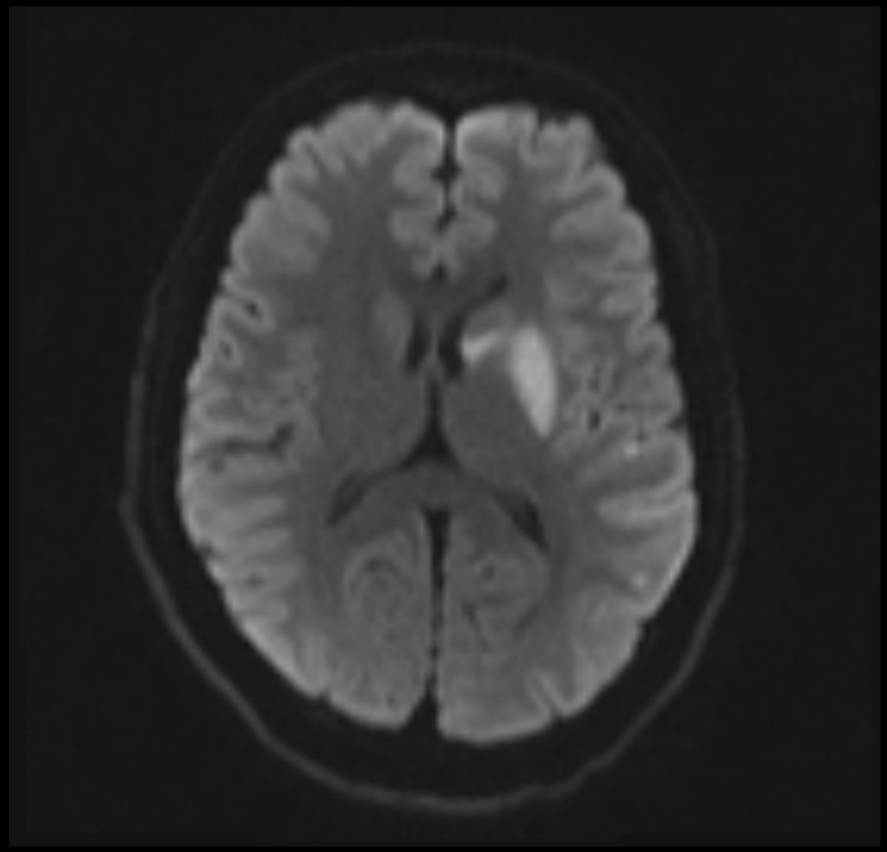
Stent Retriever with Extracted Clot

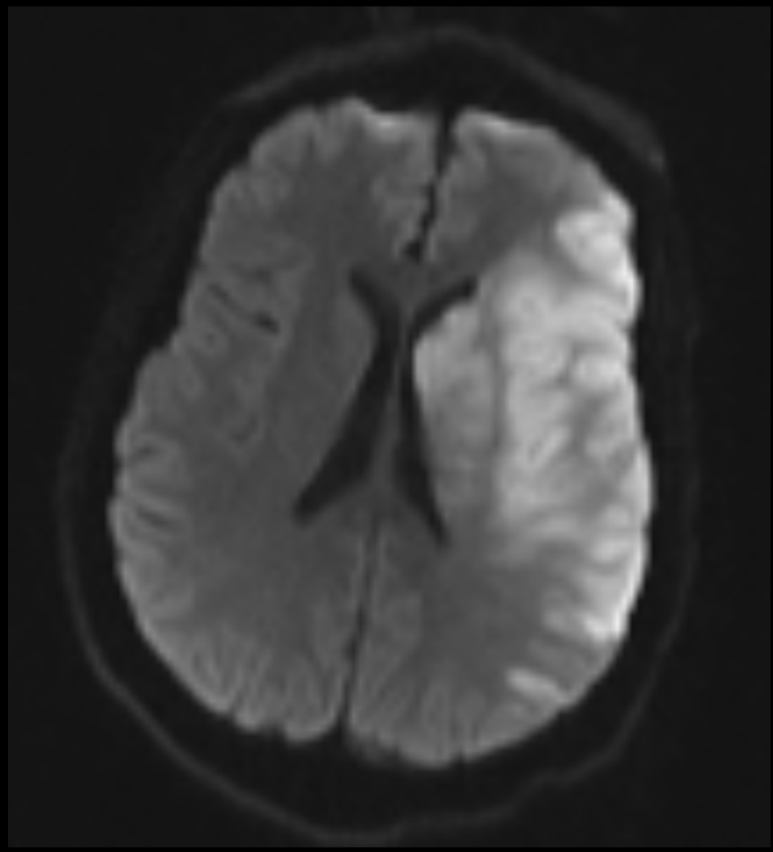
Final Stroke



DWI

Final Stroke

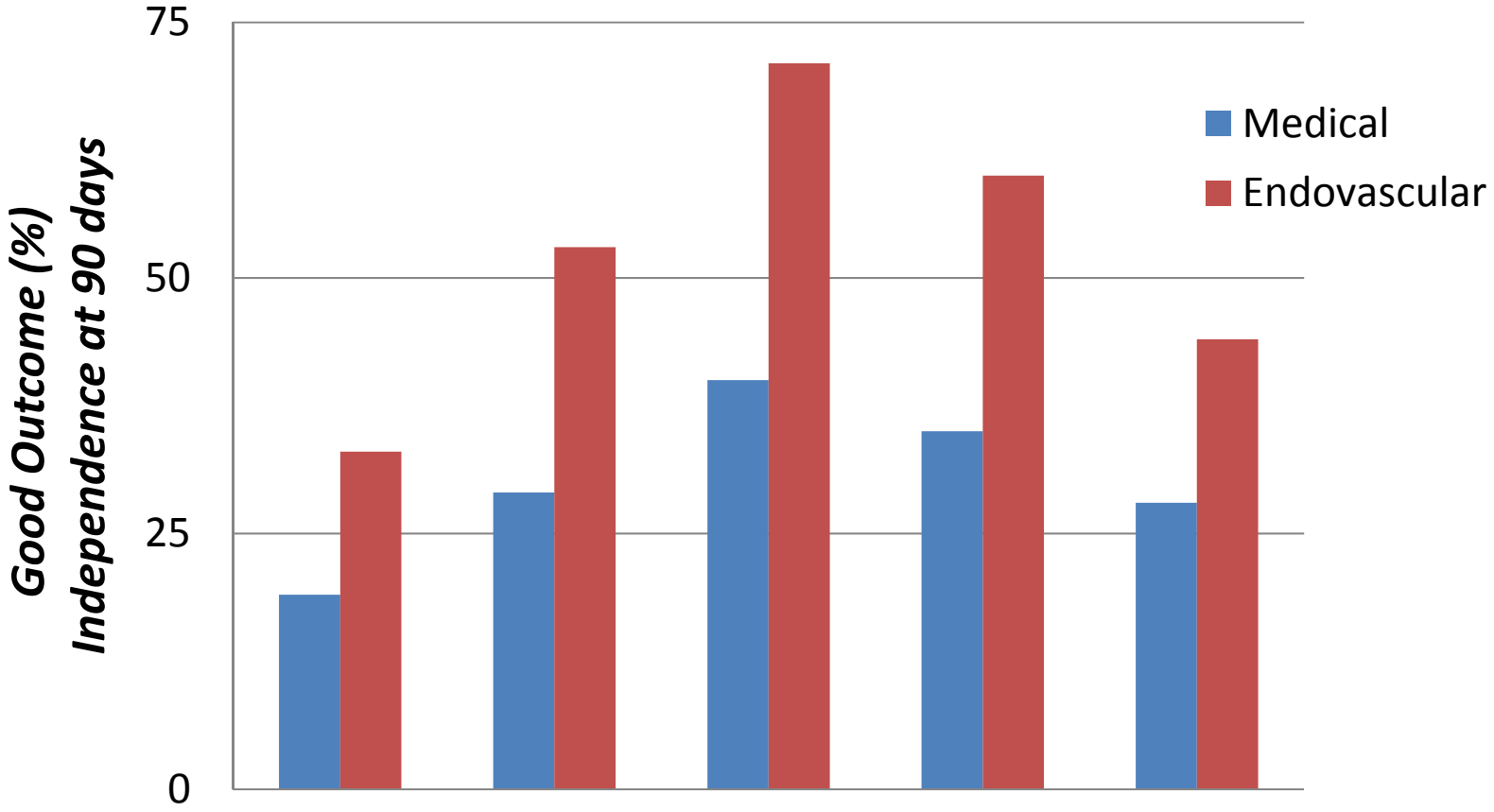




This…

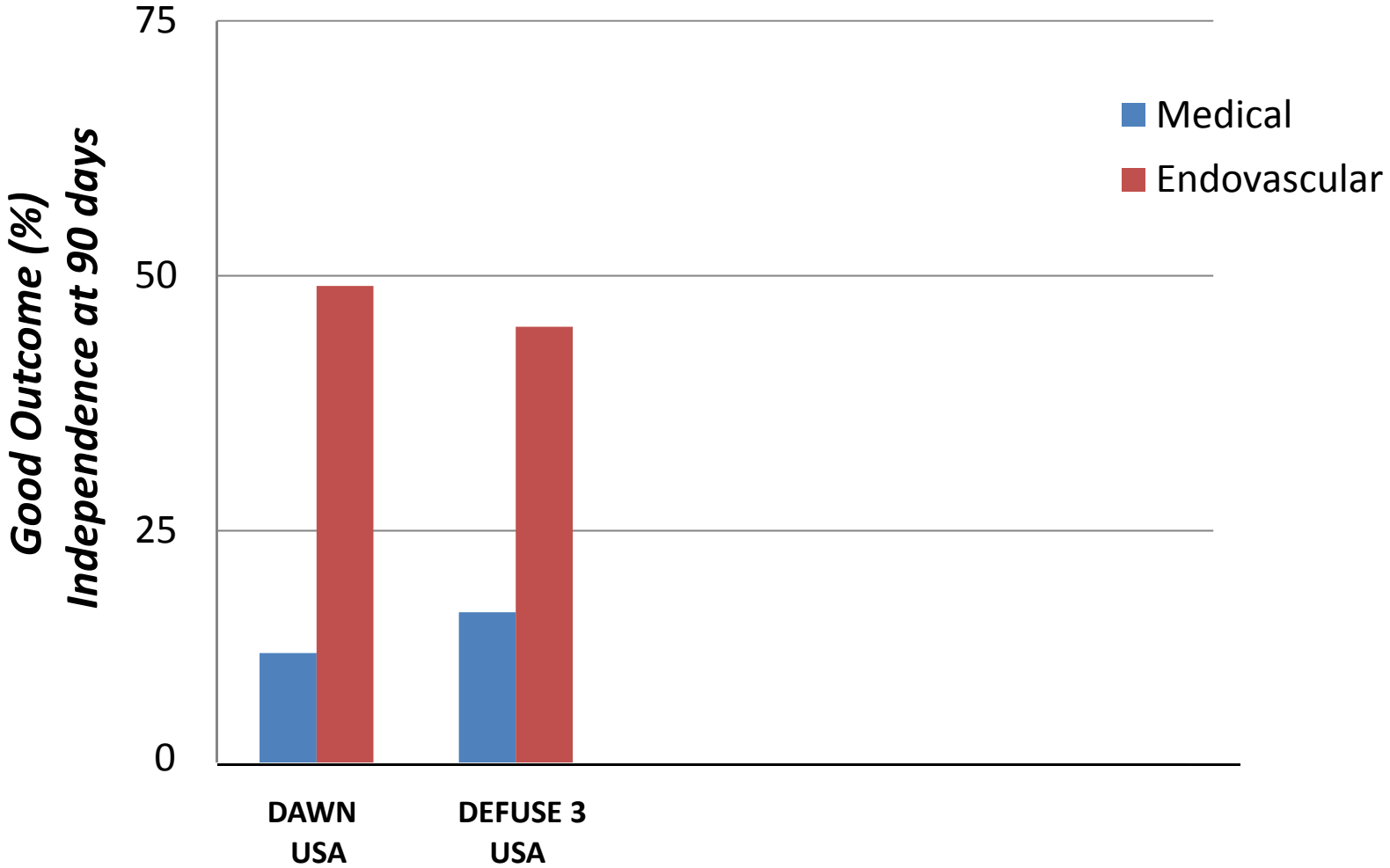
Not This!

Randomized Clinical Trials of Endovascular Therapy for Acute Ischemic Stroke 2015



	MR CLEAN Netherlands	ESCAPE Canada	EXTEND-IA Australia	SWIFT PRIME USA	REVASCAT Spain	THRACE France	PISTE UK
Endovascular	33	53	71	60	44		
Medical	19	29	40	35	28		

Randomized Clinical Trials of Endovascular Therapy for Acute Ischemic Stroke in Late Window 2018



	DAWN USA	DEFUSE 3 USA
Endovascular	49	45
Medical	13	17
NNT	3	4

tPA use in Pregnancy

Study/Year Wk	*Gestation*	*Indication No.treated*	*Outcome Mother*	*Outcome Fetus*
Baudo 1990	35	PE 1	No cx	No cx
Flossdorf 1990	31	PE 1	No cx	No cx
Azzano 1995	16	Valve 1	Severe bleeding rethrombosis	Fetal death after
Schumacher 1996	21	MI 1	No cx	No cx
Fleyfe 1997	28	Valve 1	No cx	No cx
Total		5	1 bleeding	1 death

From Ahearn Arch Intern Med 2002;162:1221

IV tPA Use for Stroke in Pregnancy

Study/Year	*Maternal/Gestational Age*	*Outcome* *Maternal*	*Fetal*
Dapprich 2002	-- / 12 wk	minor ICH	No Cx
Weise 2006	33 yr / 13 wk	No Cx	No Cx
Leonhardt 2006	26 yr / 23 wk	No Cx	No Cx
Murugappan 2006	37 yr / 12 wk	minor uterine hematoma	MTP*
Murugappan 2006	31 yr / 4 wk	No Cx	MTP*
Murugappan 2006	29 yr / 6 wk	died**	died
Yamaguchi 2010	36 yr / 18 wk	No Cx	No Cx
Hori 2013	35 yr / 4 mos	no Cx	No Cx
Tassi 2013	28 yr / 16 wk	no Cx	No Cx
Ritter 2014	32 yr / 36 wk	no Cx	No Cx

*MTP = medical termination of pregnancy

** died from arterial dissection complicating angioplasty

Dapprich Cerebrovasc Dis 2002;13:290
Wiese Stroke 2006;37:2168
Leonhardt J Throm Thrombolys 2006;21:271
Murugappan Neurology 2006;66:768
Yamaguchi Rinsho Shinkeigaku 2010;50:315
Hori Rinsho Shinkeigaku 2013;53:212
Tassi Am J Emerg Med 2013;31:448
Ritter J Neurol 2014;261:632

IA tPA Use for Stroke in Pregnancy

Study/Year	*Maternal/Gestational Age*	*Outcome*	
		Maternal	*Fetal*
Elfort 2002	28 / 1wk (after IVF)	minor ICH	No Cx
Johnson 2005	39 yr / 37 wk	No Cx	No Cx
Murugappan 2006	43 yr / 37 wk	No Cx	No Cx
Murugappan 2006	28 yr / 6 wk	buttock hematoma	No Cx
Murugappan 2006	25 yr / 1st trimester	minor ICH	Miscarriage*
Li 2012	24 yr / 11 wk	No Cx	No Cx

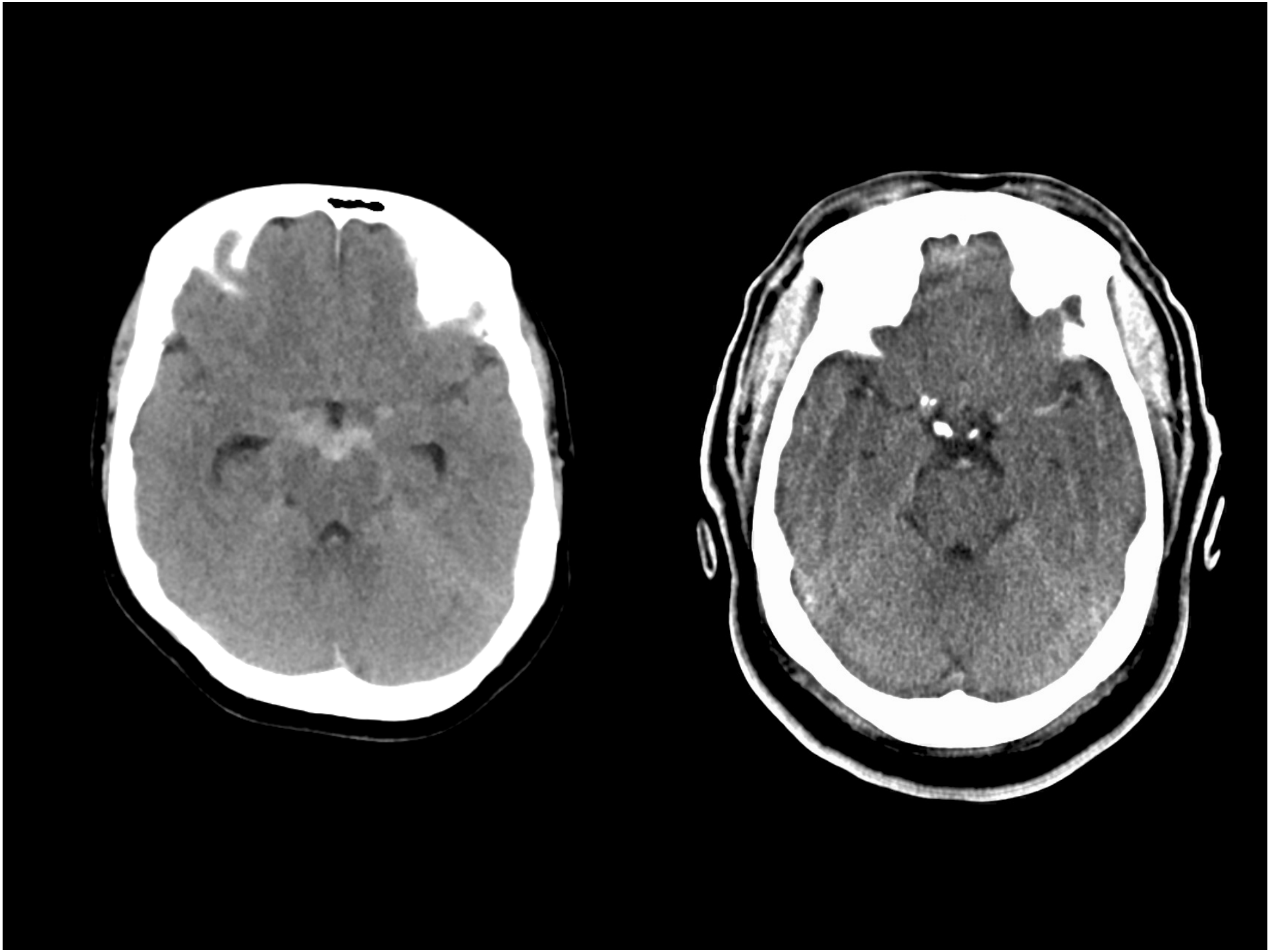
* Mother had bacterial endocarditis

Elfort Neurology 2002;59:1270
Johnson Stroke 2005;36:e53
Murugappan Neurology 2006;66:768
Li Neurologist 2012;18:44

Case

A 37-year-old woman 27 weeks pregnant developed a **sudden, severe headache** and nausea and vomiting and **neck stiffness**.

On initial examination her pulse was 100 and regular, BP 145/70; she was initially alert and then slightly drowsy. Otherwise mental state and the rest of the neurologic examination were normal.



Conventional Angiogram

L Vertebral Injection AP

Conventional Angiogram

3D Reconstruction

Conventional Angiogram

Before

After Coiling

L Vertebral Injection AP

Importance of Hemorrhagic Stroke in Pregnancy

Absolute risk	**0.006**
Relative risk	**28.5**
Mortality	**5-12%**

Mechanisms of Hemorrhagic Stroke in Pregnancy

Author/Year	*% AVM*	*% Aneurysm*	*% CM*	*% PEE*	*% Unknown*	*% Other*
Sharshar 1995 Ile de France N = 16	13	13	13	44	19	--
Kittner 1996 Md/Wash DC N = 13	23	--	--	15	31	31
Witlin 1997 Memphis N = 6	50		--	--	50	--
Jiagobin 2000 Toronto N = 13	38	23	--	--	23	15
Jeng 2004 Taiwan N = 22	23	14	--	32	--	--
Liang 2006 Taiwan N = 21	19	10	--	24	24	24
Feske 2009* Boston N = 30	17	17	3	50	13	--

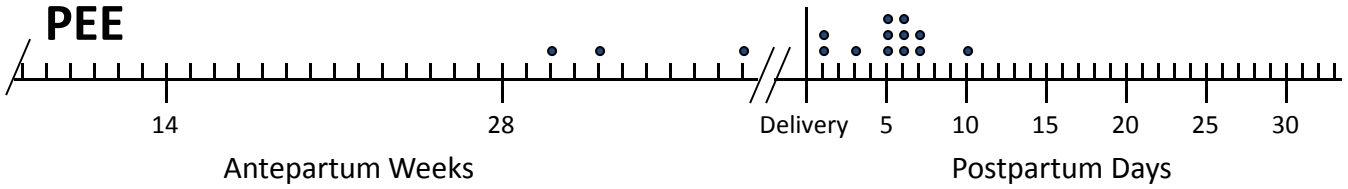
* 6 CVT not included

Mechanisms of Hemorrhagic Stroke in Pregnancy

Author/Year	*% AVM*	*% Aneurysm*	*% CM*	*% PEE*	*% Unknown*	*% Other*
Sharshar 1995 Ile de France N = 16	13	13	13	44	19	--
Kittner 1996 Md/Wash DC N = 13	23	--	--	15	31	31
Witlin 1997 Memphis N = 6	50		--	--	50	--
Jiagobin 2000 Toronto N = 13	38	23	--	--	23	15
Jeng 2004 Taiwan N = 22	23	14	--	32	--	--
Liang 2006 Taiwan N = 21	19	10	--	24	24	24
Feske 2009* Boston N = 30	17	17	3	50	13	--

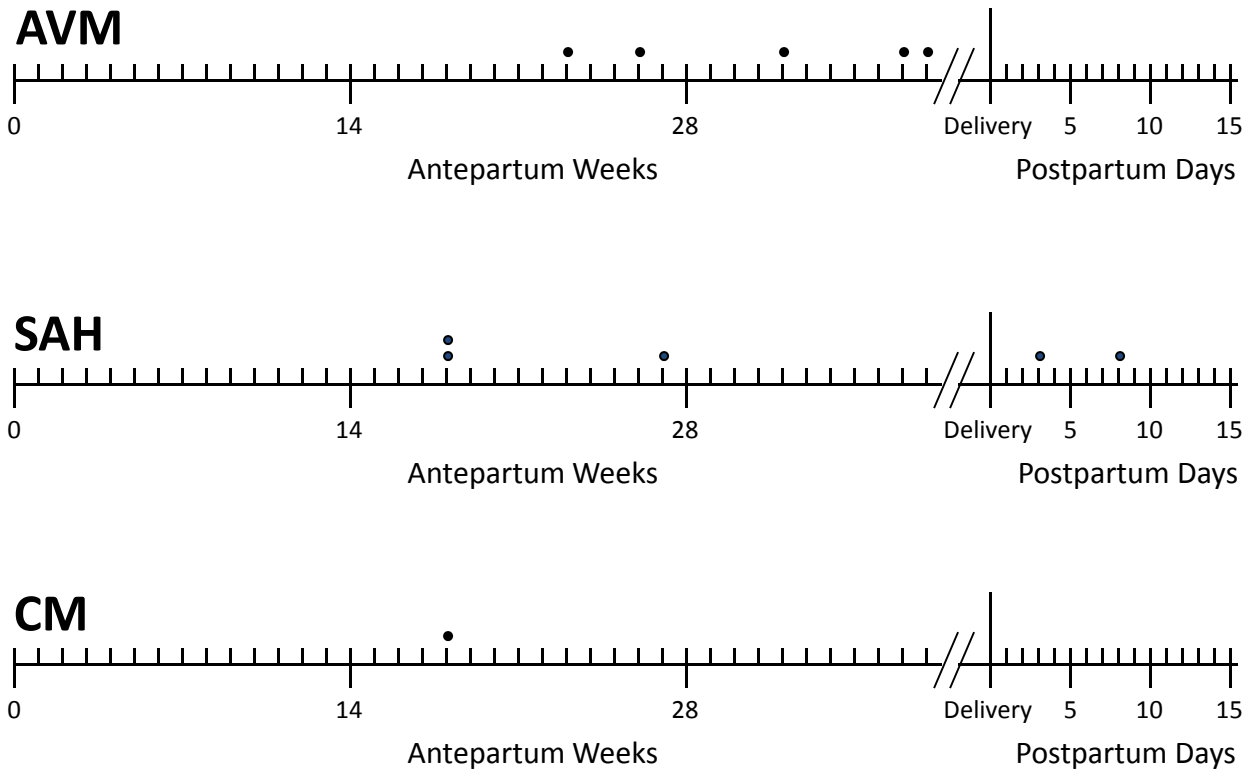
* 6 CVT not included

Timing of cerebral hemorrhages associated with preeclampsia/eclampsia



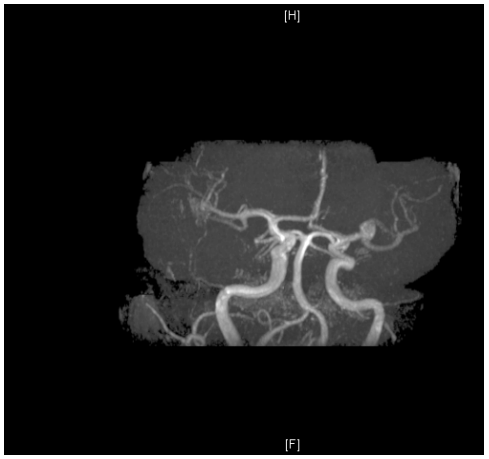
Feske 2009

Timing of cerebral hemorrhages associated with vascular malformations



Feske 2009

Treatment of aneurysms



Risks

- **Increasing risk of recurrent hemorrhage with progression of pregnancy; peaks at 30-34 weeks**

- **High risk of recurrent hemorrhage if an initial bleeding aneurysm goes unsecured: 33-50%**

- **High maternal and fetal mortality; great benefit of surgery**

Overall:	**mother 35%;**	**fetus 17%**
With no surgery:	**mother 63%;**	**fetus 27%**
With surgery:	**mother 11%;**	**fetus 5%**

Recommendations

- **Secure aneurysm as soon as possible after rupture by open or endovascular surgery.**

- **If cannot, because urgent obstetrical issues prevent it, then proceed to C-section and then secure aneurysm.**

Dias Neurosurgery 1990;27:855

Treatment of AVMs

Risks

- Some authors have found increased risk of AVM hemorrhage during pregnancy, others have not.
- Analysis of risk of rupture per day shows many-fold increase of risk on day of delivery.
- Risk is greatly increased after hemorrhage during pregnancy; to about 26% (vs 6% risk if hemorrhage before pregnancy).

Recommendations

- If known AVM, address before pregnancy.
- If AVM found during pregnancy without hemorrhage, "controlled delivery" with plan to treat AVM after delivery.
- If AVM bleeds during pregnancy, treat definitively based on neurosurgical principles (based on grading of AVM).

Ogilvy Stroke 2001;32:1458

Case

A 36-year-old woman complained of **headaches** and was found to have **new HTN 10 days after delivery** of twins by C-section. Initial head CT and MRI were normal. Headaches persisted, and she had a **grand mal seizure** and developed **aphasia and right hemiparesis**.

Singhal AB NEJM 2009;360:1126

Singhal AB NEJM 2009;360:1126

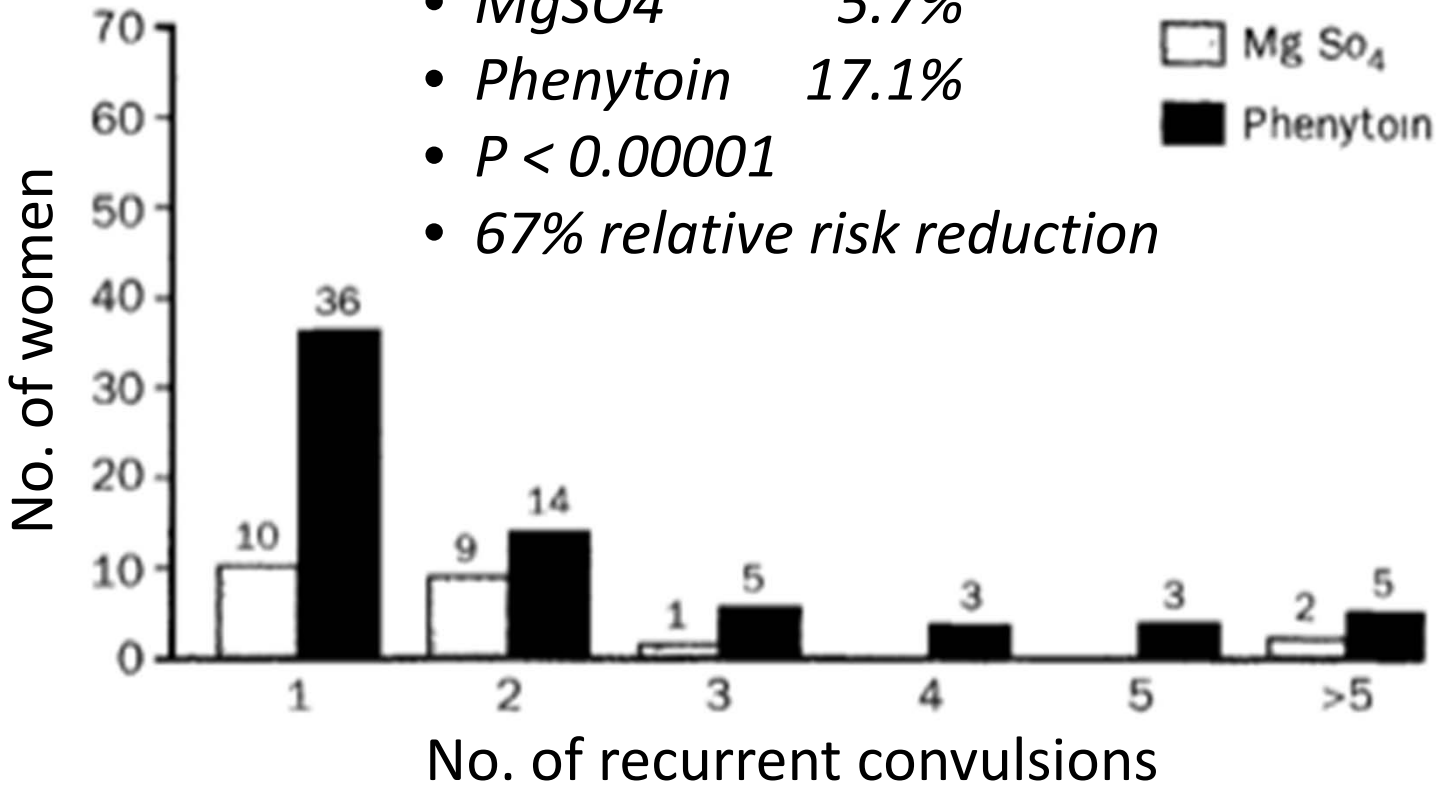
What is the diagnosis?

How should we treat her?

MgSO4 versus Phenytoin for Eclampsia

Recurrent convulsions

- *MgSO4 5.7%*
- *Phenytoin 17.1%*
- *P < 0.00001*
- *67% relative risk reduction*



Eclampsia Trial Collaborative Group Lancet 1995;345:1455