TCD Case Studies – Interventions and Follow-ups

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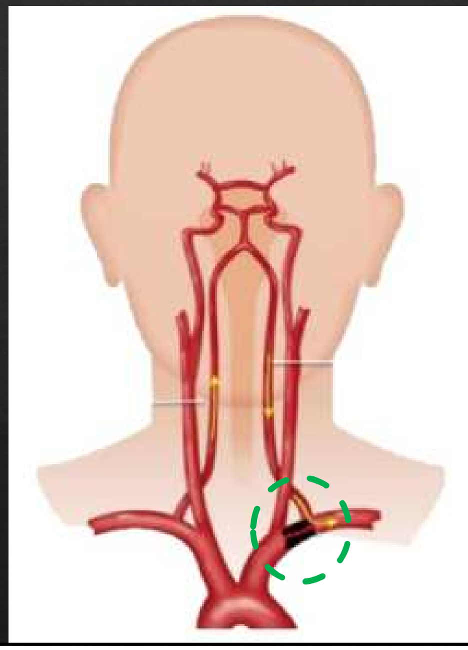
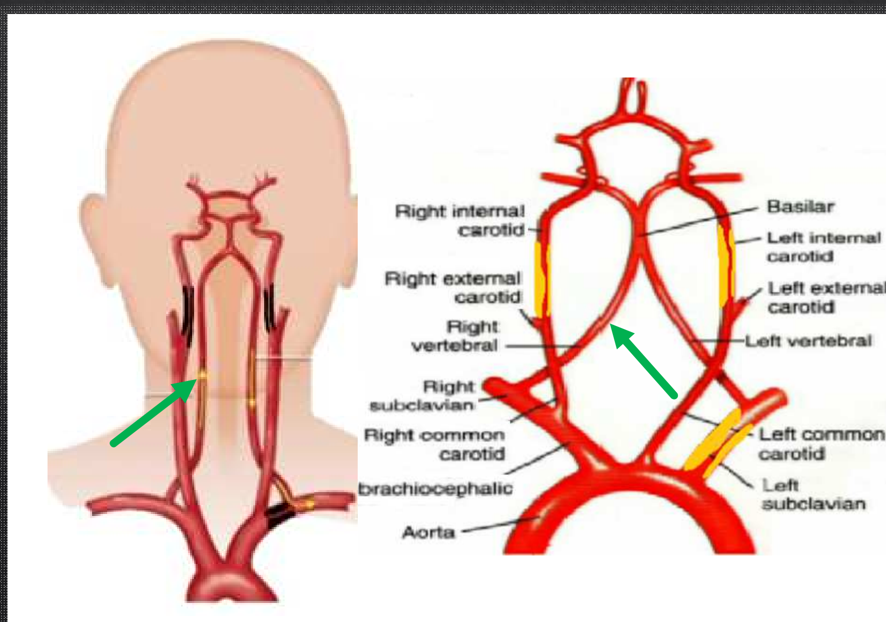
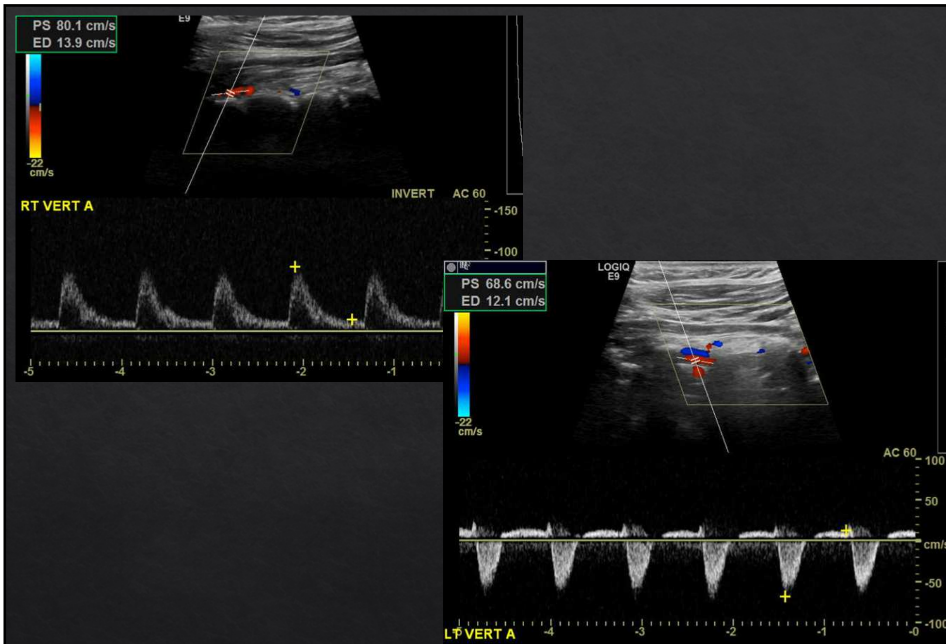
Disclosures

- NONE

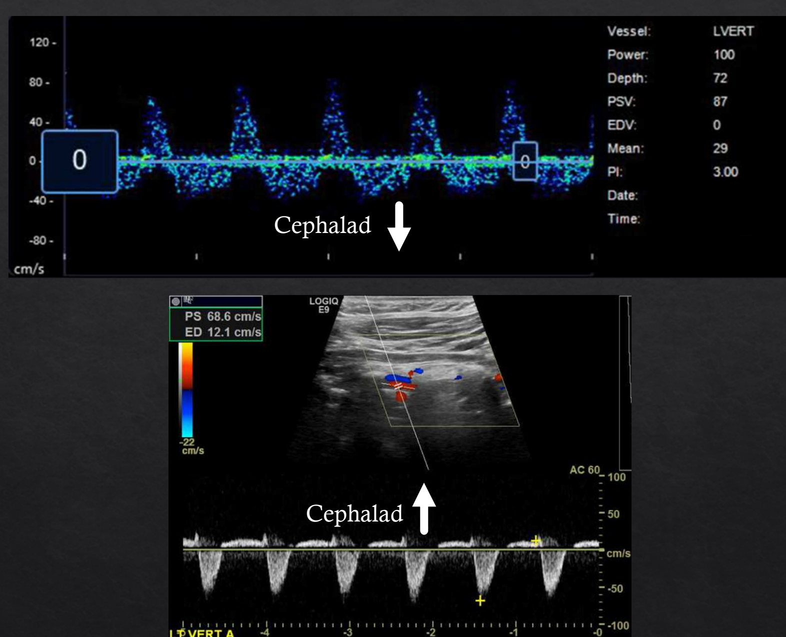
Subclavian Steal





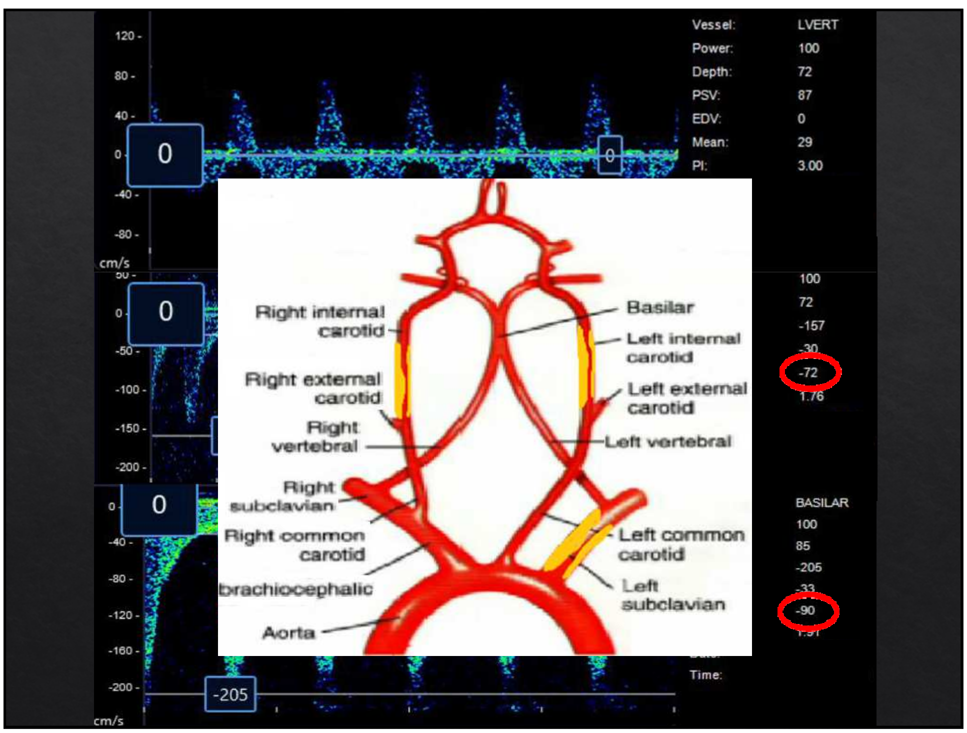


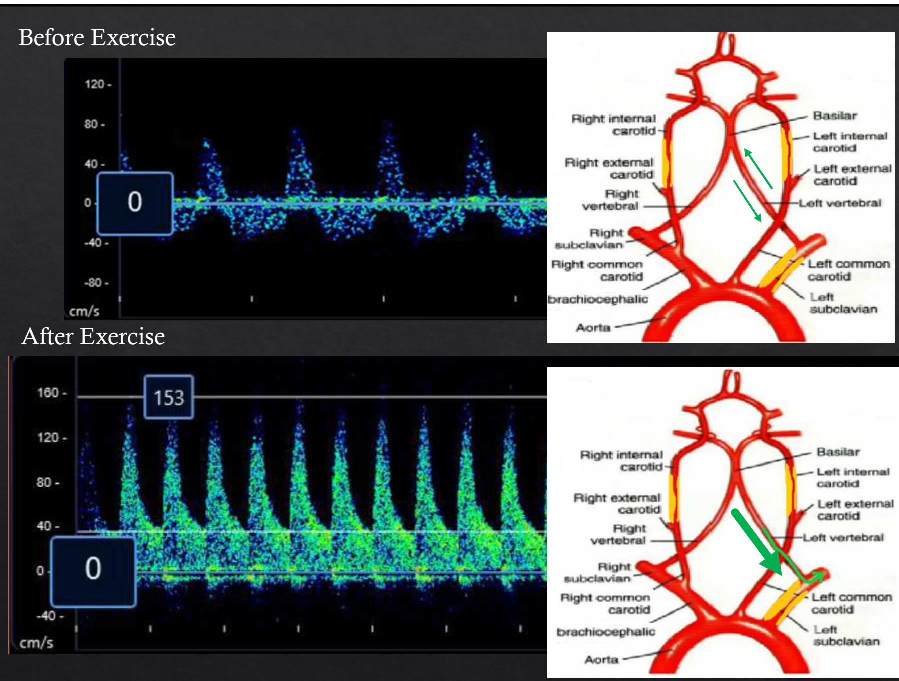
Vertebral artery Doppler waveform changes indicating subclavian steal physiology. Kliewer MA, Hertzberg BS, Kim DH, Bowie JD, Courneya DL, Carroll BA AJR Am J Roentgenol. 2000;174(3):815.



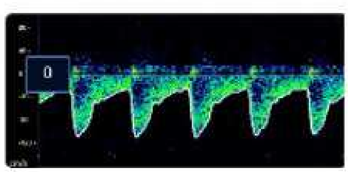
Dynamic Subclavian Steal Assessment

- Dopplers Pre and Post Exercise of ipsilateral arm, or
- Pre and Post reactive hyperemia using BP cuff
  - Above systolic pressure for 3-5 minutes
  - Rapid deflation and observation of changes in vertebral flow
  - May cause transient symptoms

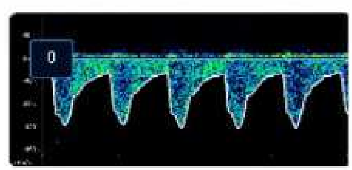


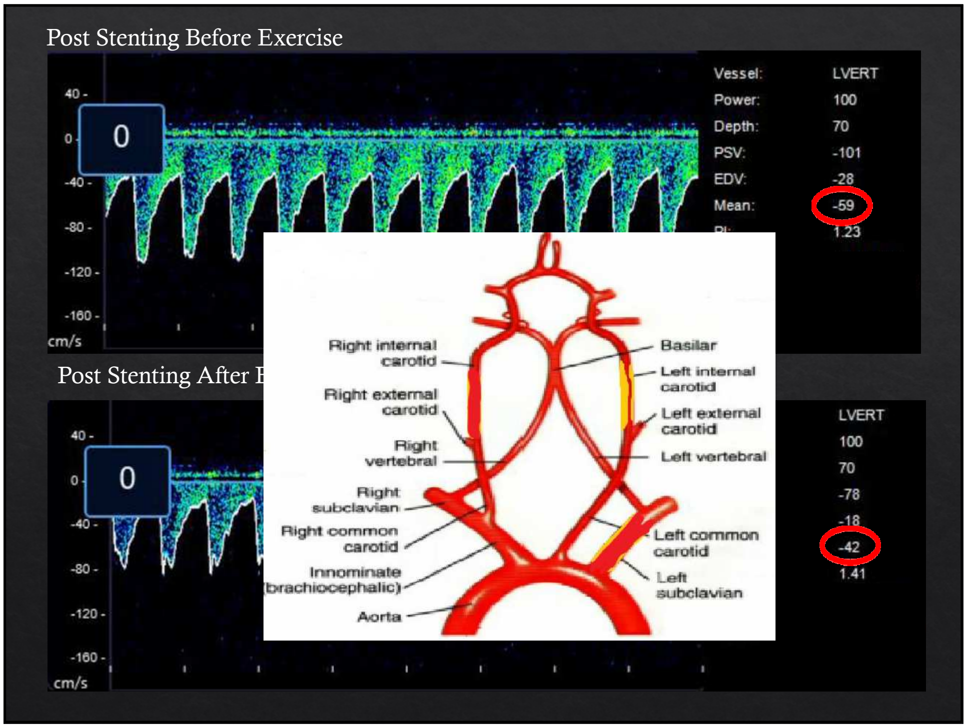


RVERT
70
-55
1.46
-106
-26
100



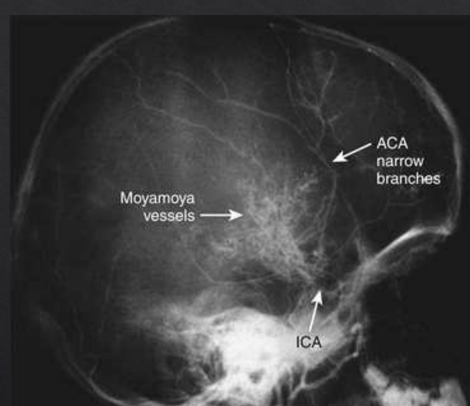
LVERT
70
-60
1.55
-119
-26
100

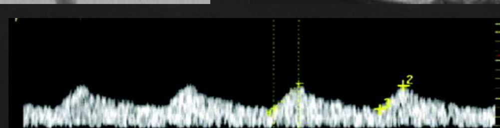




Cerebral Vasoreactivity Testing (CVR)

Vascular Reserve: Can the downstream vascular bed still dilate?





Picture from Neupsy Key https://neupsykey.com/surgical-treatment-of-moyamoya-disease-in-adults/#f0010

CVR Testing Method

6-Minute Recording of MCA velocity in response to changes in end tidal pCO2

- 2 min normal room air
- 2 min 8% CO_2, 21% O_2, 71% N_2 (hypercapnia)
- 2 min normal air hyperventilation (hypocapnia)

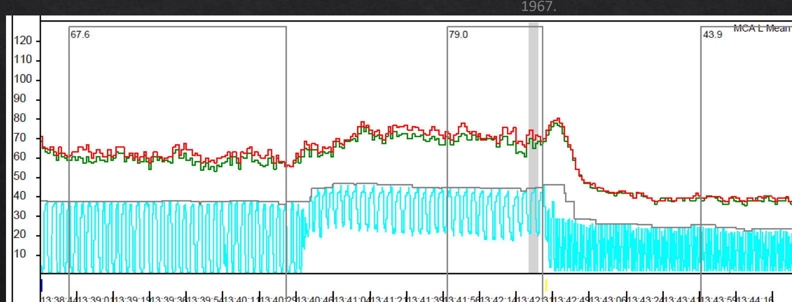
Cerebral Vasoreactivity Testing (CVR)

Baseline BP:		MAP:		HR:	
Left MCA MFV		Right MCA MFV		EtCO2	
Depth:		Depth:			
Hyper:		Hyper:		Hyper:	
RA:		RA:		RA:	
CO2:		CO2:		CO2:	
R:		R:			
CO2R:		CO2R:			
VMR:		VMR:			

$$\frac{\%\Delta\, MFV}{\Delta\, etCO2} =$$

Hypercapnia	Hypocapnia	Interpretation
>10	>10	Normal
5-10	>10	Mild
5-10	5-10	Moderate
0-5	5-10	Severe
0-5	0-5	Critical
<0	any	Critical with Steal

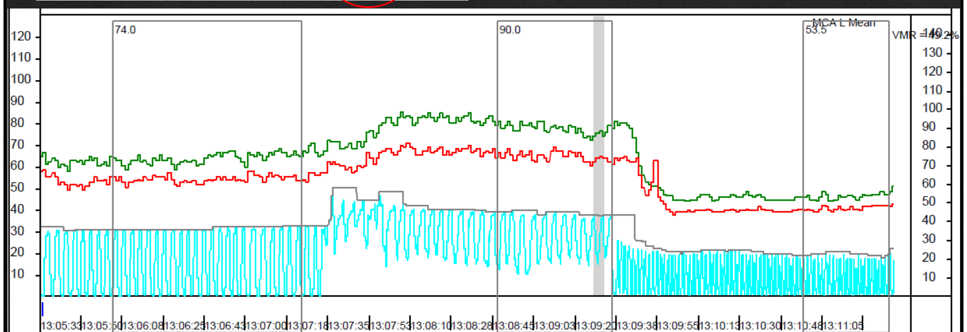
Course of cerebrovascular reactivity in patients with carotid artery occlusions. B Widder, B Kleiser and H Krapf. Stroke. 1994 | Volume 25, Issue 10: 1963–1967.

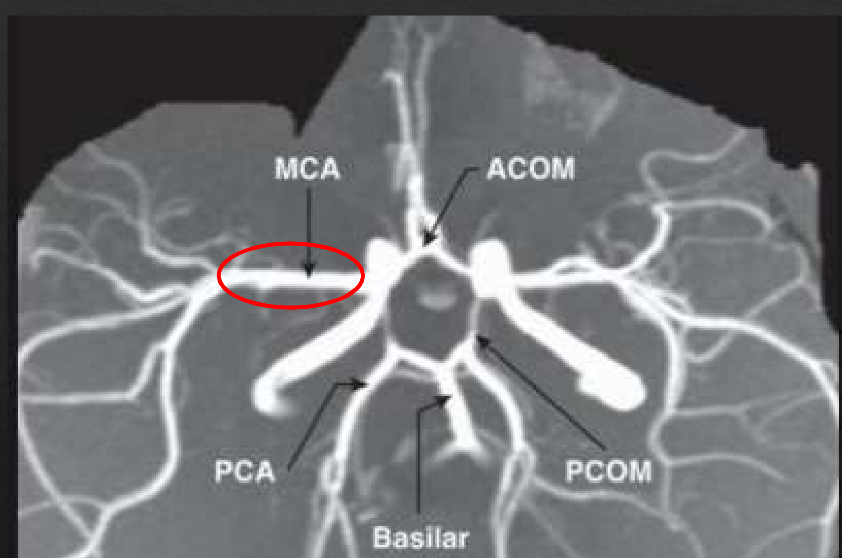


30F healthy normal

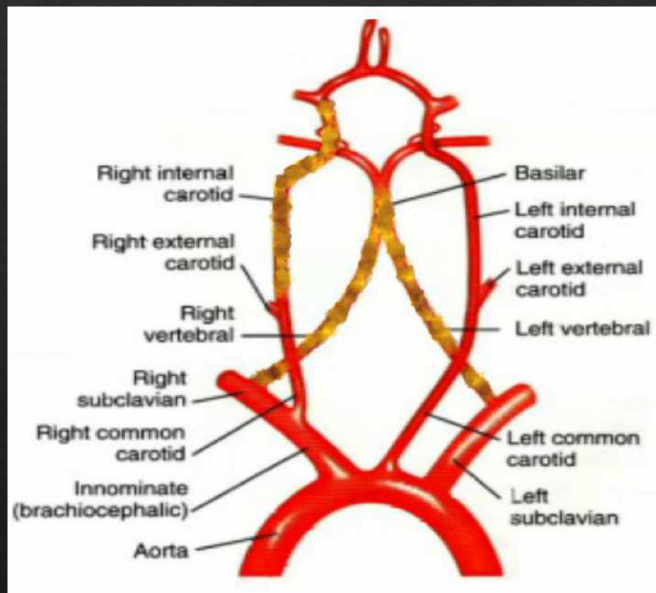
Baseline BP: 92/57		**MAP: 68**			
Left MCA MFV		**Right MCA MFV**		**EtCO2**	
Depth:	53	Depth:	59		
Hyper:	54	Hyper:	47	Hyper:	23
RA:	74	RA:	63	RA:	37
CO2:	90	CO2:	75	CO2:	45
R:	1	R:	1		
CO2R:	2.25	CO2R:	2.02		
VMR:	49.2%	VMR:	44.4%		
Percent change from RA to CO2 on Left:			21.60%		
Percent change from RA to CO2 on Right:			19.00%		

$$\frac{\%\Delta\ MFV}{\Delta\ etCO2} =$$ 17.6 Left NORMAL; 15.4 Right NORMAL

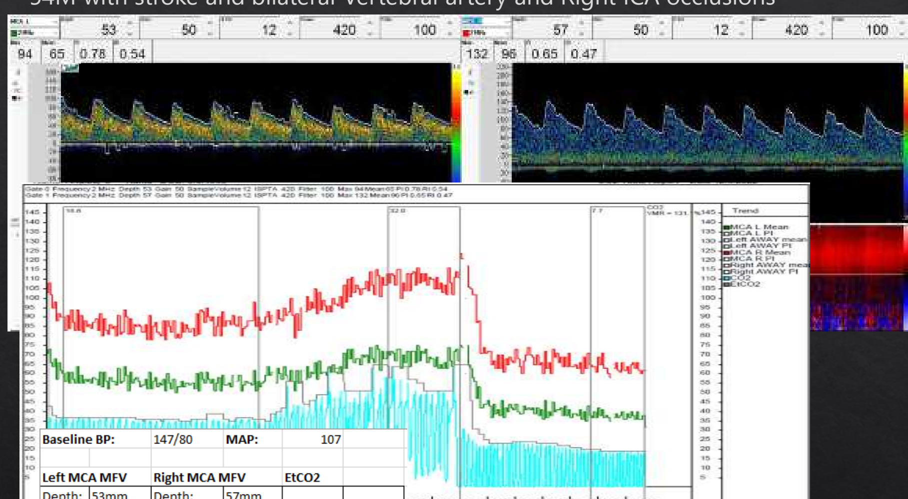




54M with stroke and bilateral Vertebral artery and Right ICA occlusions



54M with stroke and bilateral Vertebral artery and Right ICA occlusions

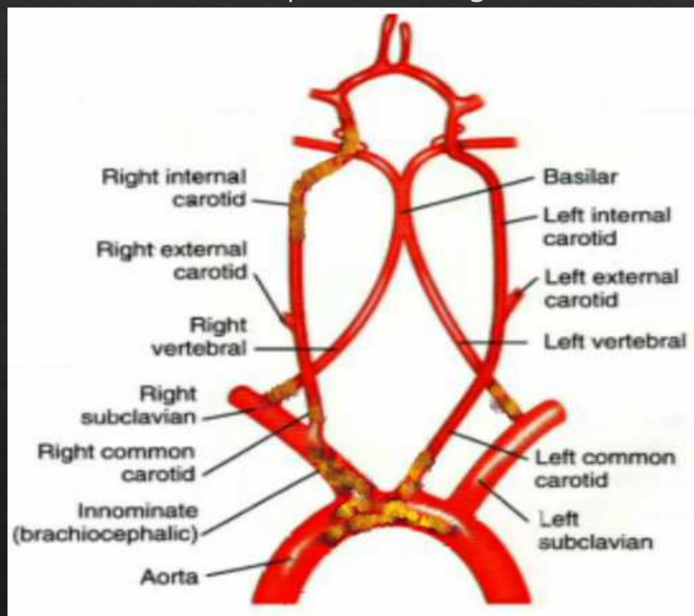


Baseline BP:	147/80	MAP:	107		
Left MCA MFV		**Right MCA MFV**		**EtCO2**	
Depth:	53mm	Depth:	57mm		
Hyper:	38	Hyper:	63.6	Hyper:	20
RA:	56	RA:	85.8	RA:	37
CO2:	68.7	CO2:	109.2	CO2:	57
R:	0.99	R:	1		
CO2R:	1.49	CO2R:	1.40		
VMR:	54.8%	VMR:	53.2%		
Percent change from RA to CO2 on Left:			22.70%		
Percent change from RA to CO2 on Right:			27.30%		

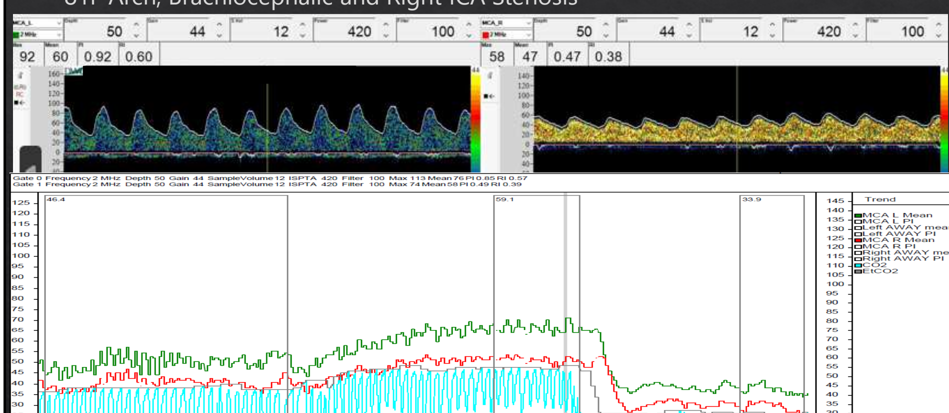
$$\frac{\%\Delta\ MFV}{\Delta\ etCO2} =$$

7.4 Left MILD
8.9 Right MILD

81F Arch, Brachiocephalic and Right ICA Stenosis



81F Arch, Brachiocephalic and Right ICA Stenosis



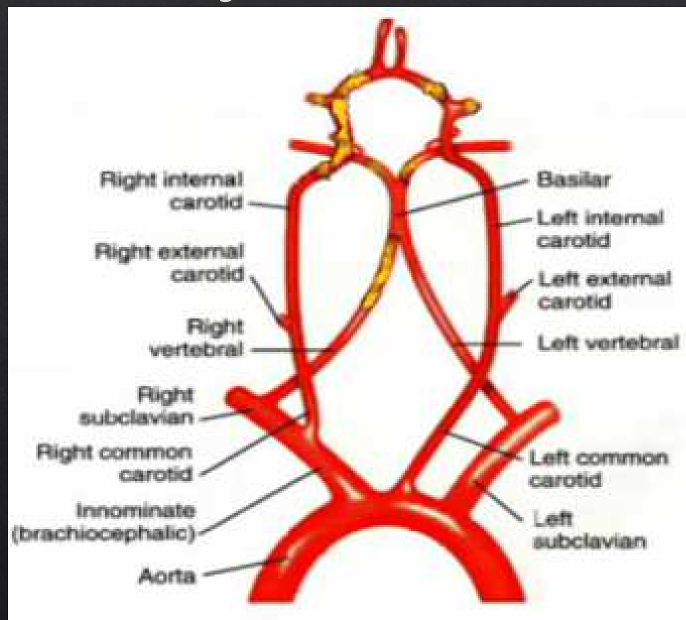
Baseline BP: 147/63			MAP:	91	
Left MCA MFV		Right MCA MFV		EtCO2	
Depth:	50mm	Depth:	50mm		
Hyper:	43.1	Hyper:	33.9	Hyper:	30
RA:	57.6	RA:	46.4	RA:	45
CO2:	76.6	CO2:	59.1	CO2:	56
R:	0.99	R:	1		
CO2R:	2.16	CO2R:	2.08		
VMR:	58.2%	VMR:	54.3%		
Percent change from RA to CO2 on Left:				33.0%	
Percent change from RA to CO2 on Right:				27.4%	

$$\frac{\%\Delta\ MFV}{\Delta\ etCO2} =$$

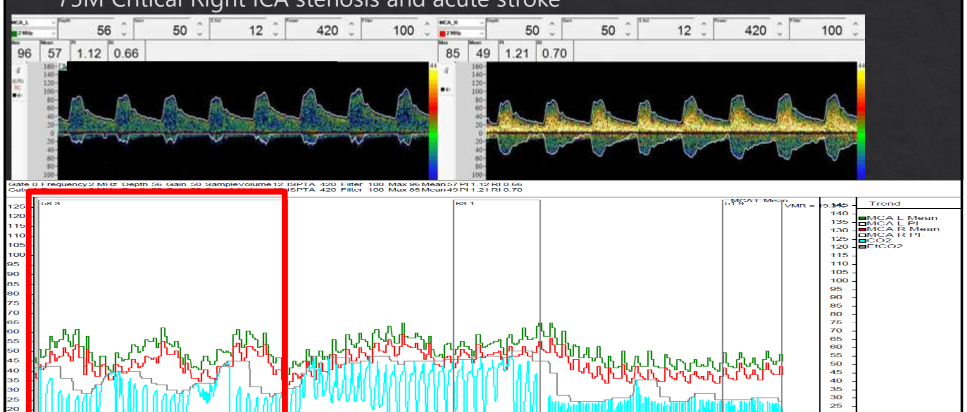
19.5 Left NORMAL

16.2 Right NORMAL

75M Critical Right ICA stenosis and acute stroke



75M Critical Right ICA stenosis and acute stroke



Baseline BP: 177/82

Left MCA MFV		Right MCA MFV		EtCO2	
Depth:	56mm	Depth:	50mm		
Hyper:	51.9	Hyper:	45	Hyper:	30
RA:	58.3	RA:	50.8	RA:	42
CO2:	63.1	CO2:	55.8	CO2:	55
R:	0.99	R:	1		
CO2R:	0.76	CO2R:	0.83		
VMR:	19.3%	VMR:	21.2%		

Percent change from RA to CO2 on Left: 8.20%

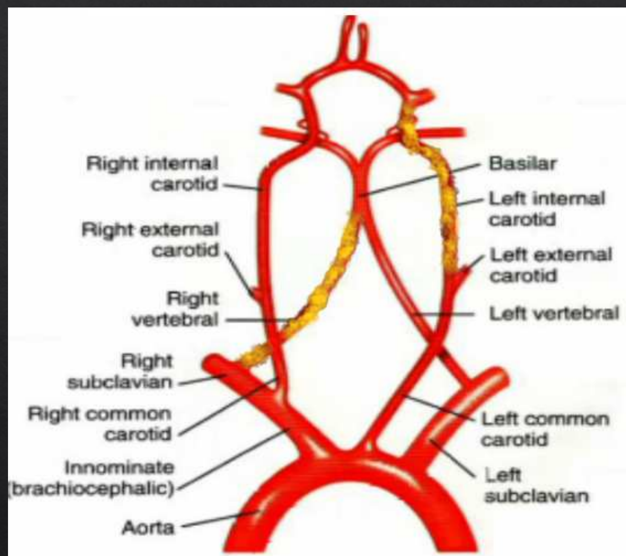
Percent change from RA to CO2 on Right: 9.80%

$$\frac{\%\Delta\, MFV}{\Delta\, etCO2} =$$

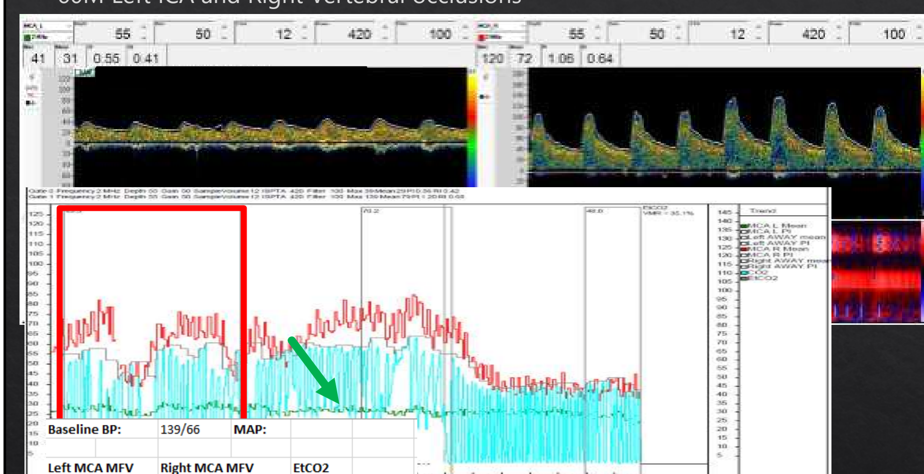
4.1 Left SEVERE

4.9 Right SEVERE

60M Left ICA and Right Vertebral occlusions



60M Left ICA and Right Vertebral occlusions



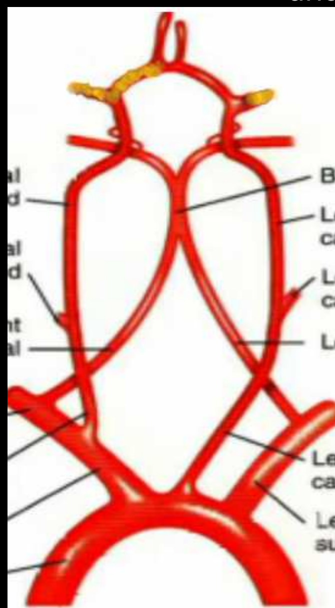
Baseline BP:		139/66	MAP:		
Left MCA MFV		Right MCA MFV		EtCO2	
Depth:	55mm	Depth:	55mm		
Hyper:	27.4	Hyper:	43.2	Hyper:	43
RA:	32.3	RA:	71	RA:	58
CO2:	30.2	CO2:	82.9	CO2:	65
R:	0.74	R:	1		
CO2R:	0.53	CO2R:	2.72		
VMR:	8.8%	VMR:	55.9%		
Percent change from RA to CO2 on Left:				-6.50%	
Percent change from RA to CO2 on Right:				16.80%	

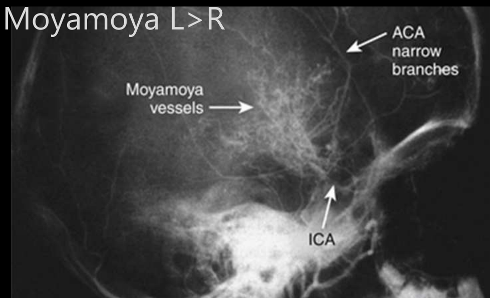
$$\frac{\%\Delta\ MFV}{\Delta\ etCO2} =$$

-6.0 Left — CRITICAL W/ STEAL

15.6 Right — NORMAL

46F occlusion of right and left MCA and right A1 segment, and Moyamoya L>R





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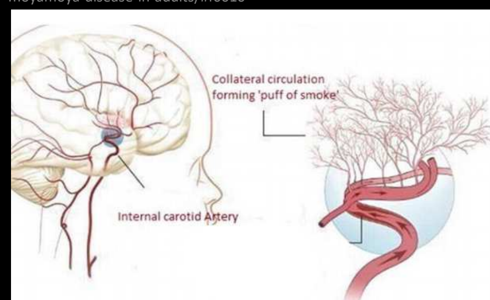
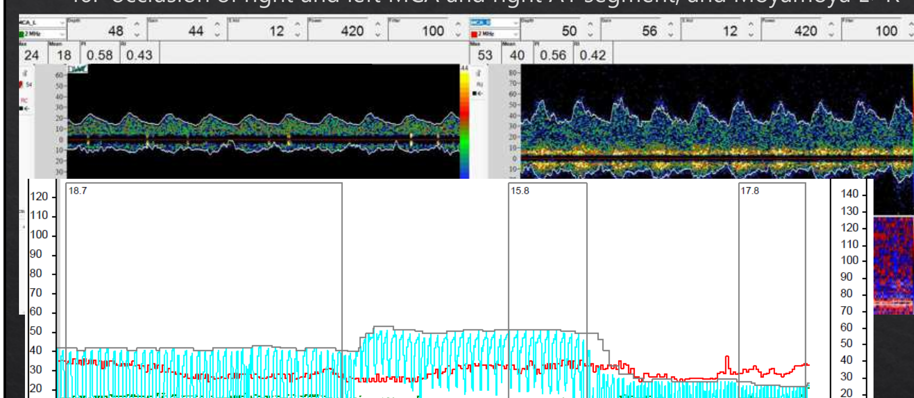


Modified from: http://strokeconnection.strokeassociation.org/Fall-2014/Understanding-Moyamoya-Disease-in-Children/

46F occlusion of right and left MCA and right A1 segment, and Moyamoya L>R

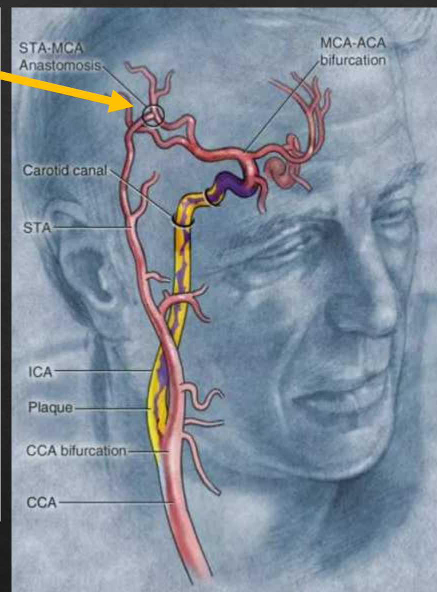


Baseline BP:		155/77	MAP:	109	
Left MCA MFV		**Right MCA MFV**		**EtCO2**	
Depth:	48mm	Depth:	50mm		
Hyper:	17.6	Hyper:	33.8	Hyper:	27
RA:	18.8	RA:	34	RA:	49
CO2:	15.8	CO2:	36.9	CO2:	59
R:	-0.42	R:	0.79		
CO2R:	-0.22	CO2R:	0.24		
VMR:	9.6%	VMR:	9.2%		
Percent change from RA to CO2 on Left:				-16.00%	
Percent change from RA to CO2 on Right:				8.50%	

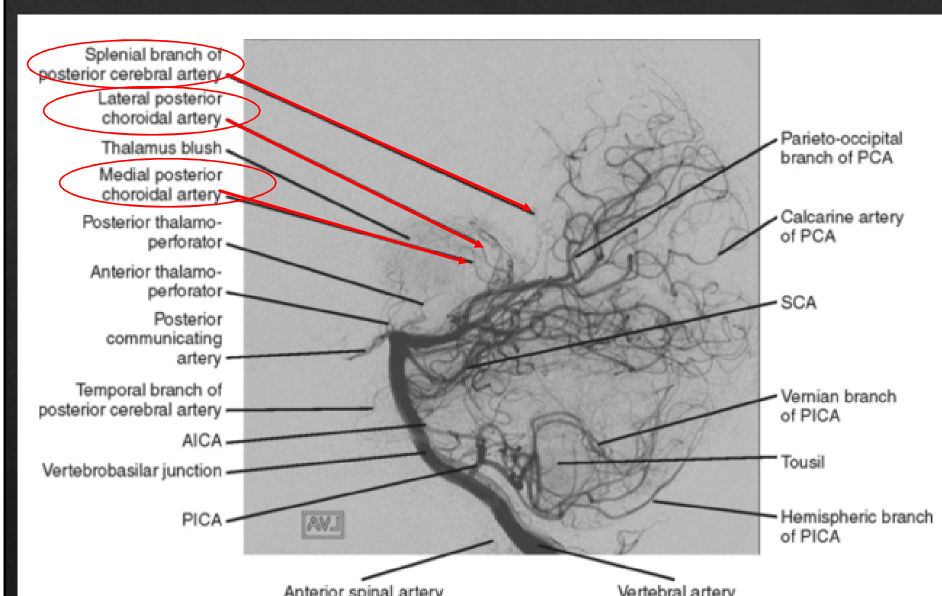
$$\frac{\%\Delta\, MFV}{\Delta\, etCO2} = \begin{matrix}\text{-10.4 Left} \\ \text{5.5 Right}\end{matrix}$$

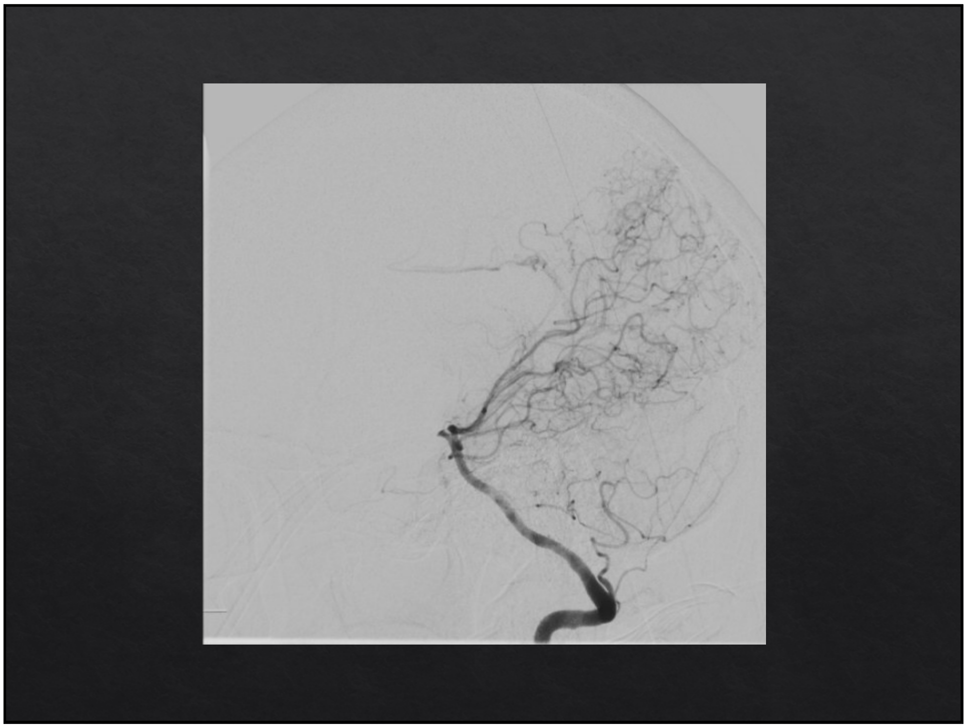
CRITICAL W/ STEAL
MODERATE/SEVERE

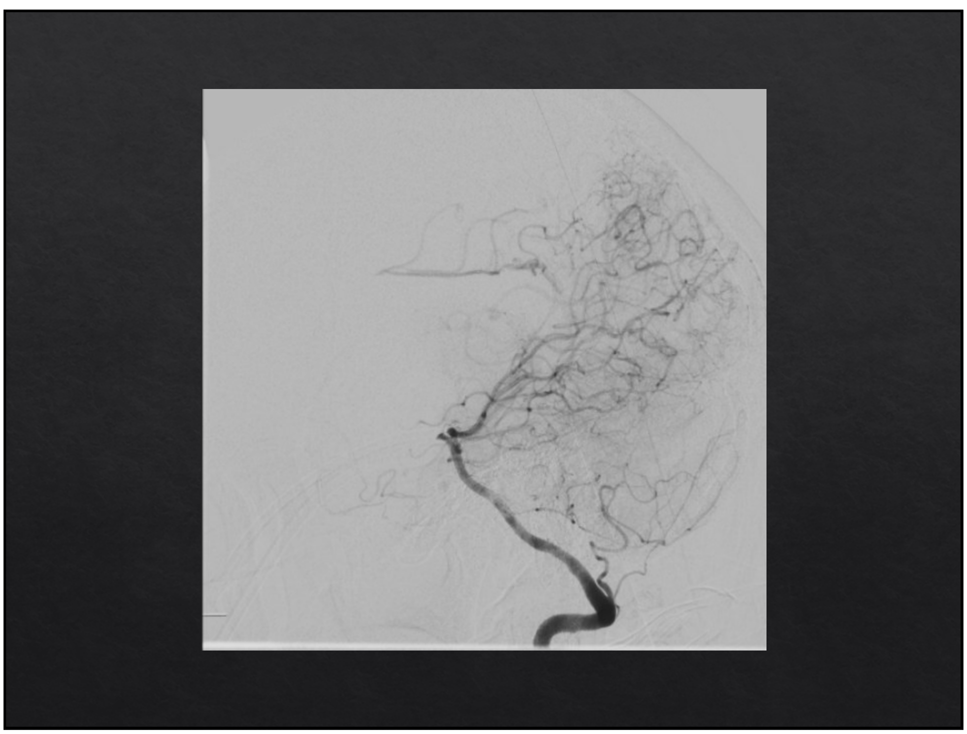
Picture from: Acker G, Fekonja L, Vajkoczy P. Surgical Management of Moyamoya Disease. Stroke 2018;49:476-482.

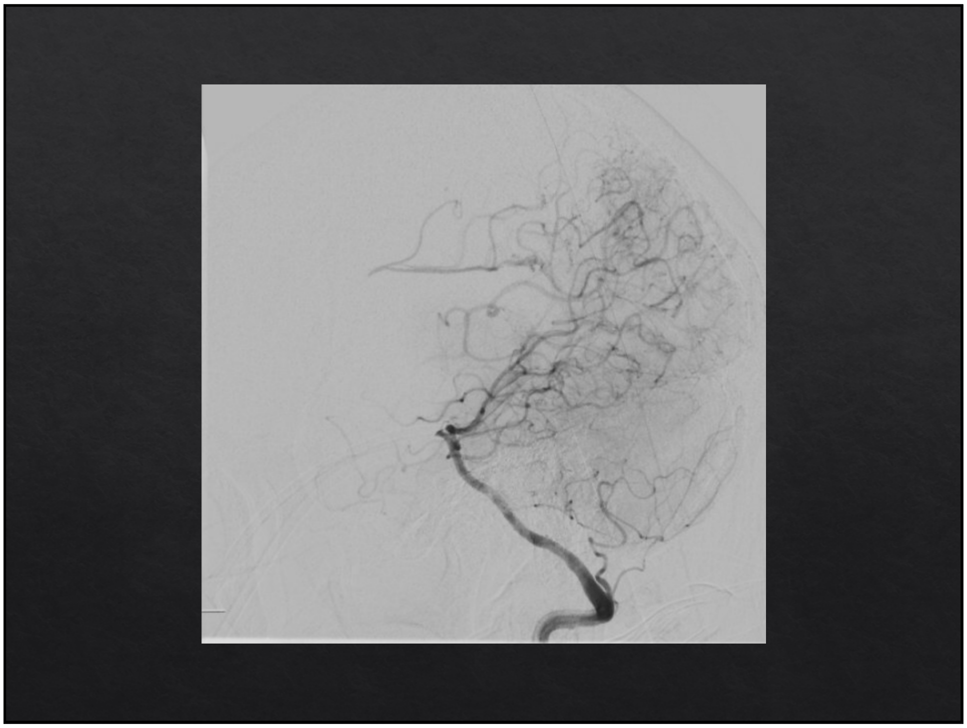


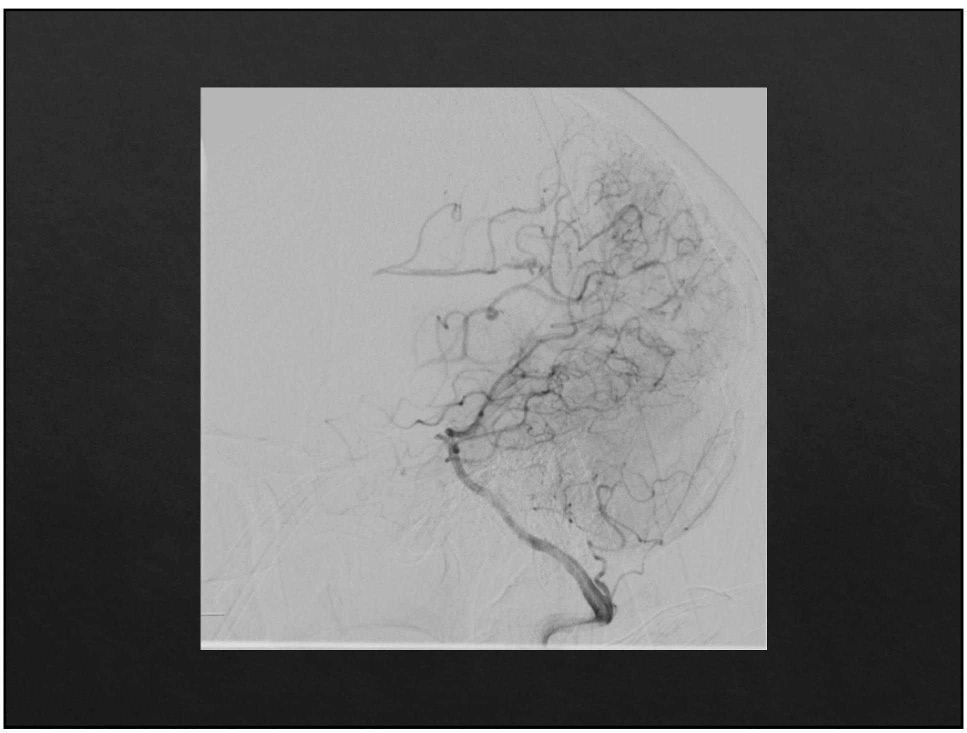
Picture from: Barrow Neurological Institute https://www.barrowneuro.org/about/news-and-articles/guest-columns/sta-mca-bypass-surgery/

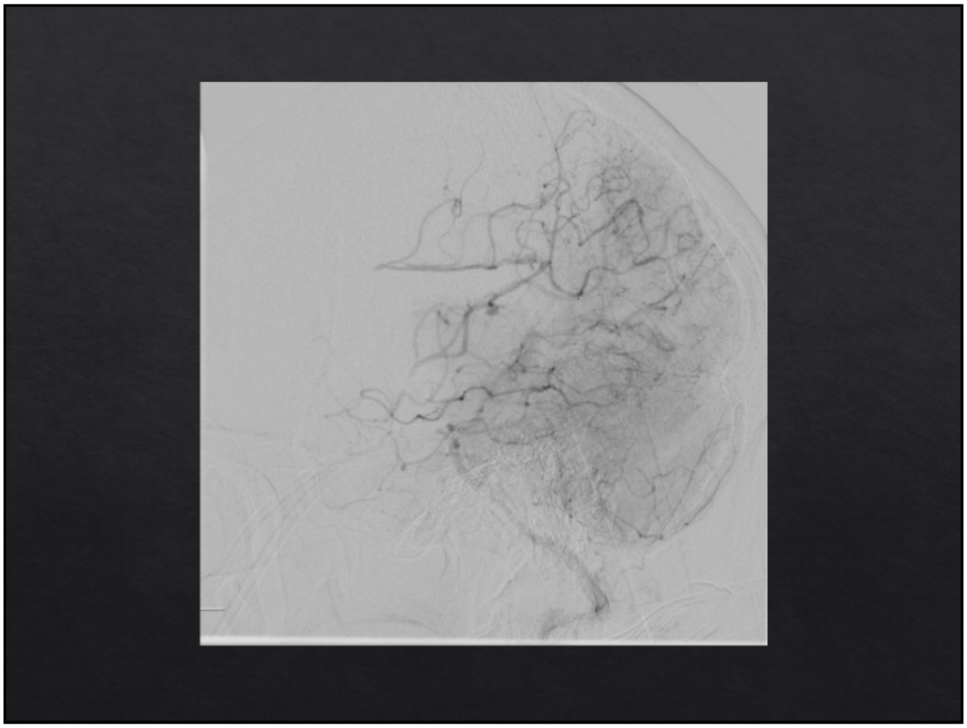


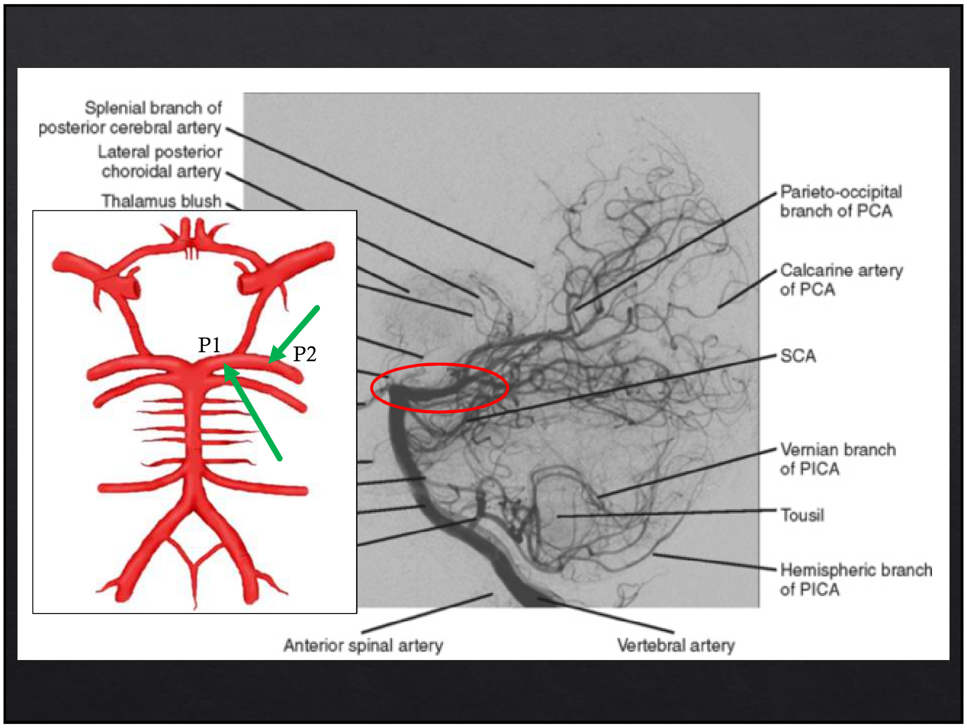




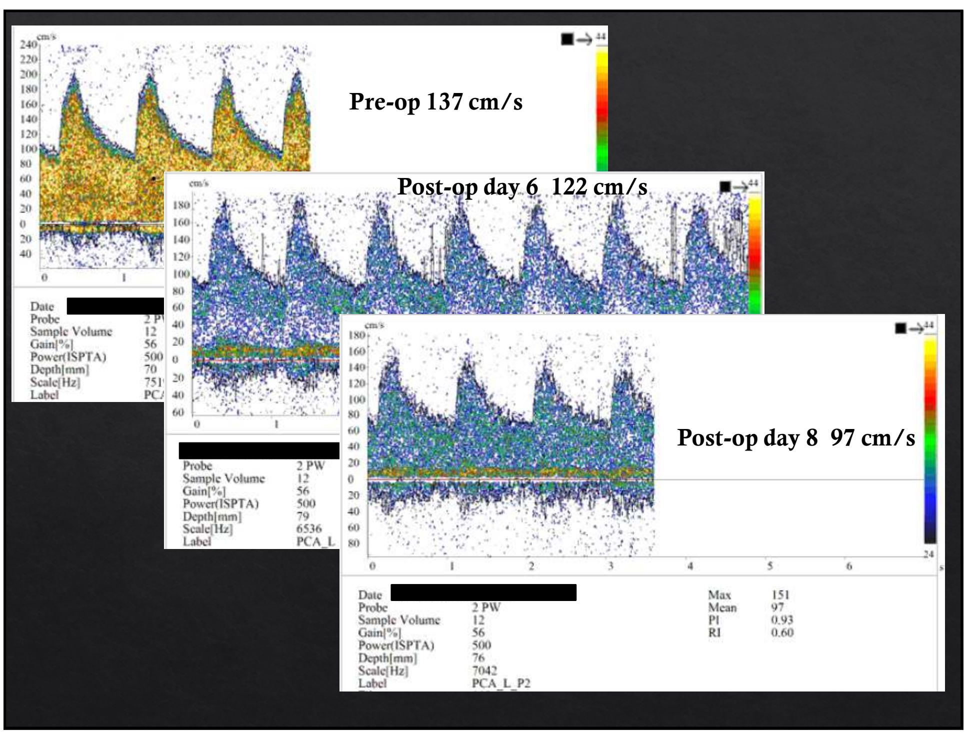




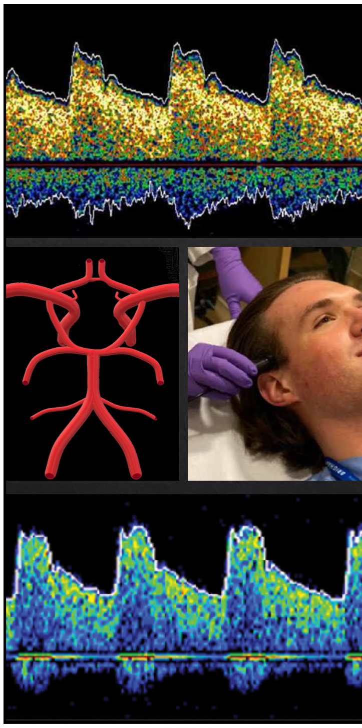




Splenial branch of posterior cerebral artery
Lateral posterior choroidal artery
Thalamus blush
P1
P2
Parieto-occipital branch of PCA
Calcarine artery of PCA
SCA
Vernian branch of PICA
Tousil
Hemispheric branch of PICA
Anterior spinal artery
Vertebral artery



Pre-op 137 cm/s
Post-op day 6 122 cm/s
Post-op day 8 97 cm/s
Date [redacted]
Probe 2 PW
Sample Volume 12
Gain[%] 56
Power(ISPTA) 500
Depth[mm] 76
Scale[Hz] 7042
Label PCA_L_P2
Max 151
Mean 97
PI 0.93
RI 0.60



An Essential Tool for Neurovascular Assessment

- Inexpensive
- Repeatable
- Non-invasive
- Real-time
- Portable

- Localize source of obstruction and embolization
- Aid in treatment evaluation, planning, and follow-up

References

- Acker G, Fekonja L, Vajkoczy P. Surgical Management of Moyamoya Disease. Stroke. 2018:49:476-482.
- Kliewer MA, Hertberg BS, Kim DH, Bowie JD, Courneva DL, Carroll BA. Vertebral artery Doppler waveform changes indicating subclavian steal physiology. AJR Am J Roentgenol. 2000;174(3):815.
- Purkayastha S, Sorond F. Transcranial Doppler Ultrasound: Technique and Application. Semin Neurol. 2012 September. 32(4):411-420.
- Widder B, Kleiser B, Krapf H. Course of cerebrovascular reactivity in patients with carotid artery occlusions. Stroke. 1994 | Volume 25, Issue 10: 1963–1967.