Carotid Scanning Issues: The Distal Stenosis & Post-intervention Scanning

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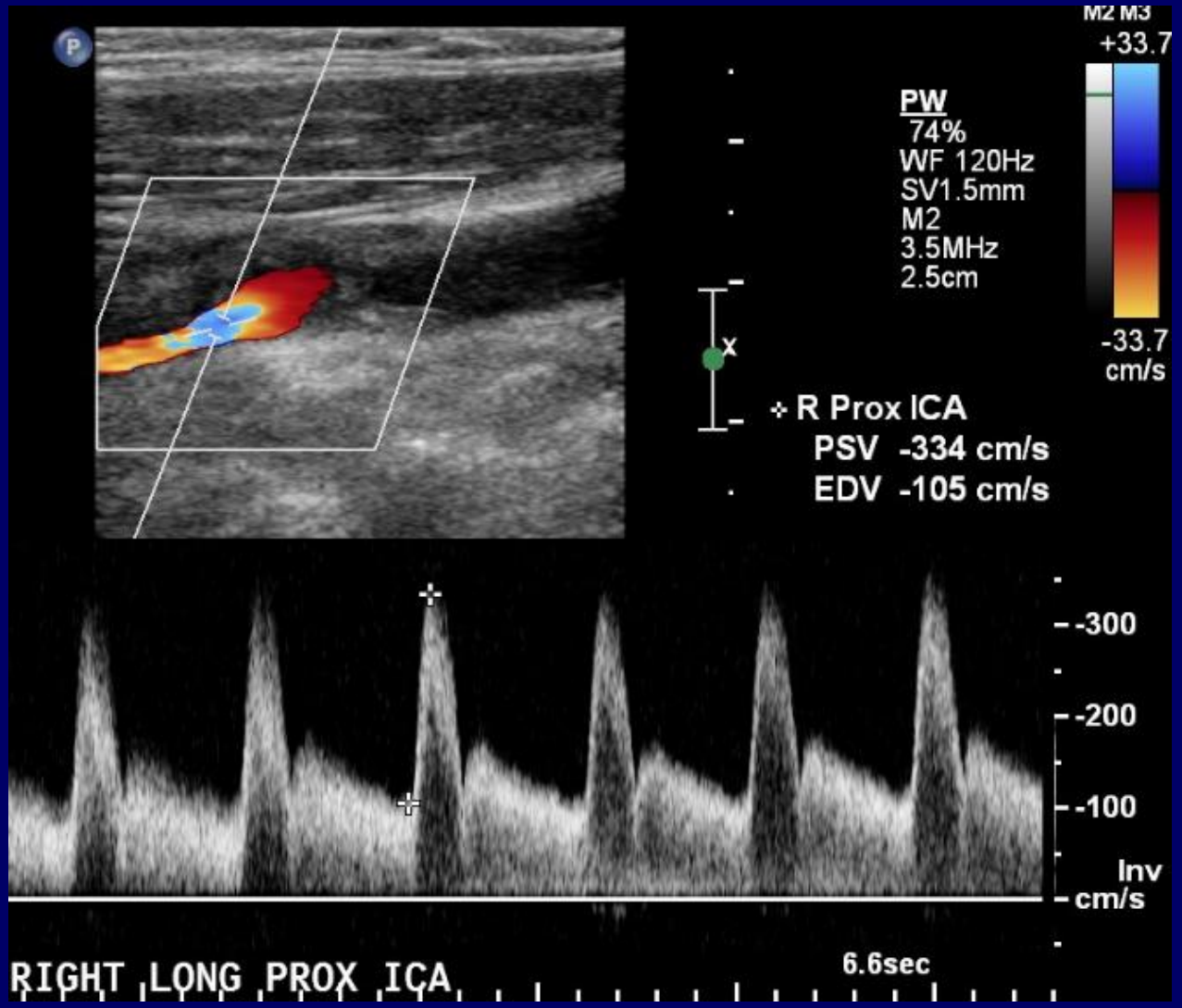
Objectives

- Identify patients where standard carotid criteria should not be applied
- Describe what to do with distal carotid artery disease interpretation
- List criteria accepted for carotid stents
- Discuss challenges associated with interpreting carotid stent restenosis

When does this not work???

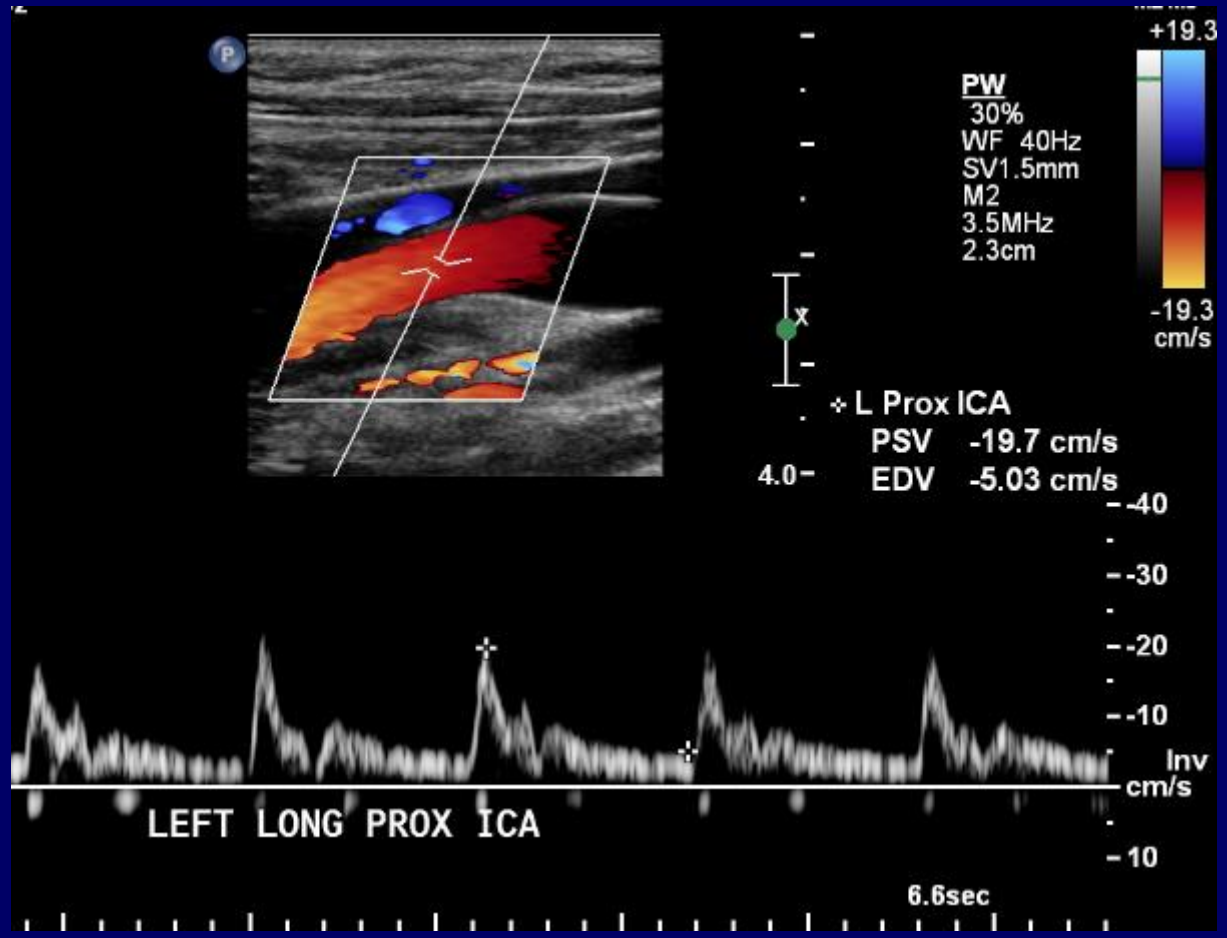
Degree of Stenosis (%)	Primary Parameters		Additional Parameters	
	ICA PSV (cm/sec)	Plaque Estimate (%)*	ICA/CCA PSV Ratio	ICA EDV (cm/sec)
Normal	<125	None	<2.0	<40
<50	<125	<50	<2.0	<40
50–69	125–230	≥50	2.0–4.0	40–100
≥70 but less than near occlusion	>230	≥50	>4.0	>100
Near occlusion	High, low, or undetectable	Visible	Variable	Variable
Total occlusion	Undetectable	Visible, no detectable lumen	Not applicable	Not applicable

Grant EG, et al. Radiology 2003;229:340



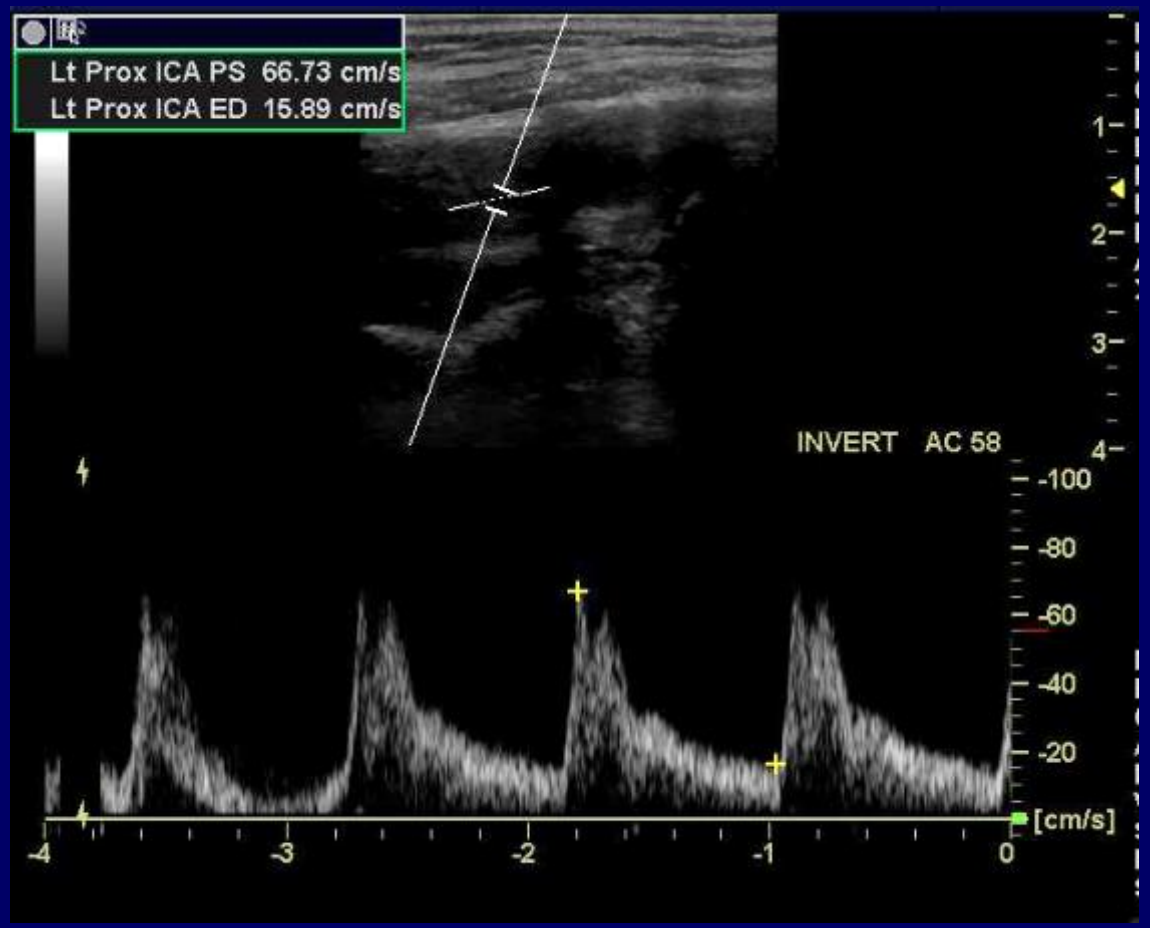
Criteria is only applicable to the first 3 cm of the ICA

Prox ICA PSV 20 cm/s

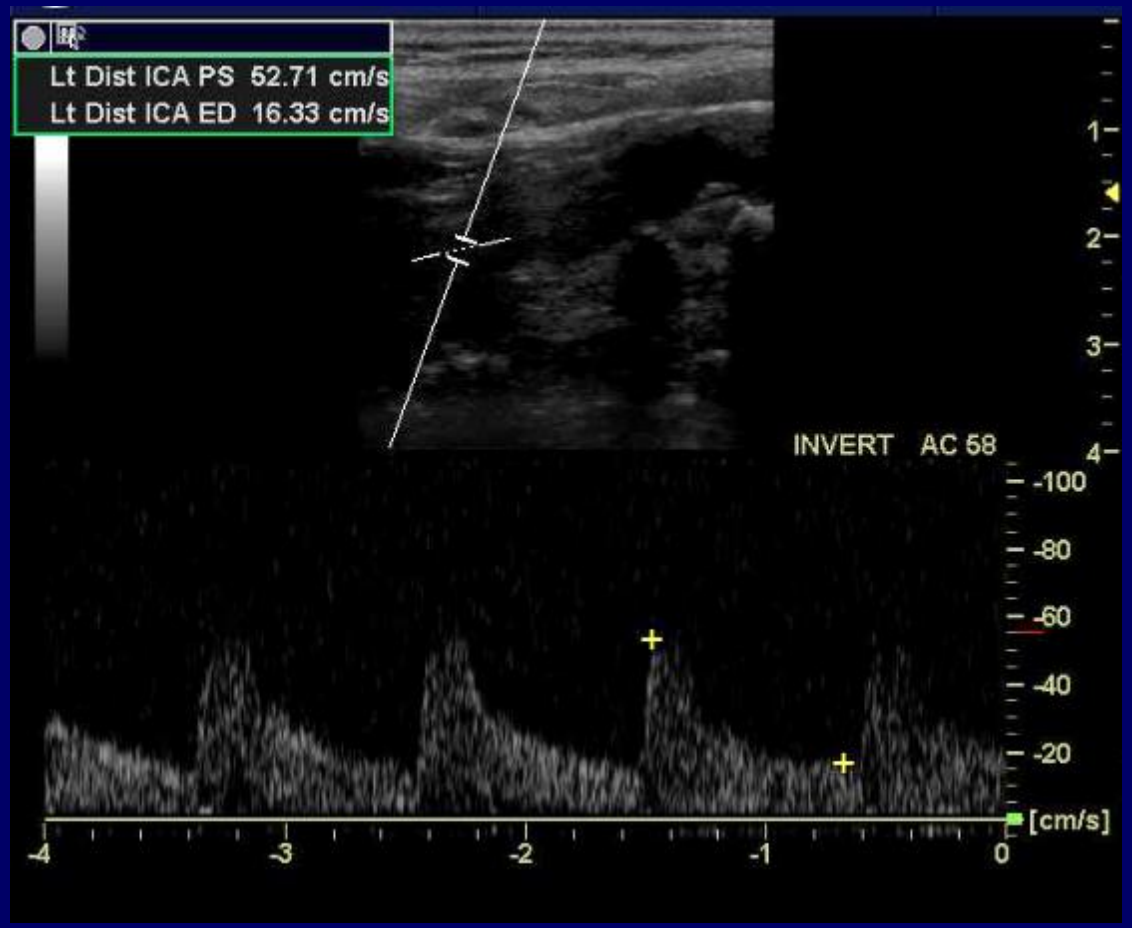


Distal ICA PSV 31 cm/s

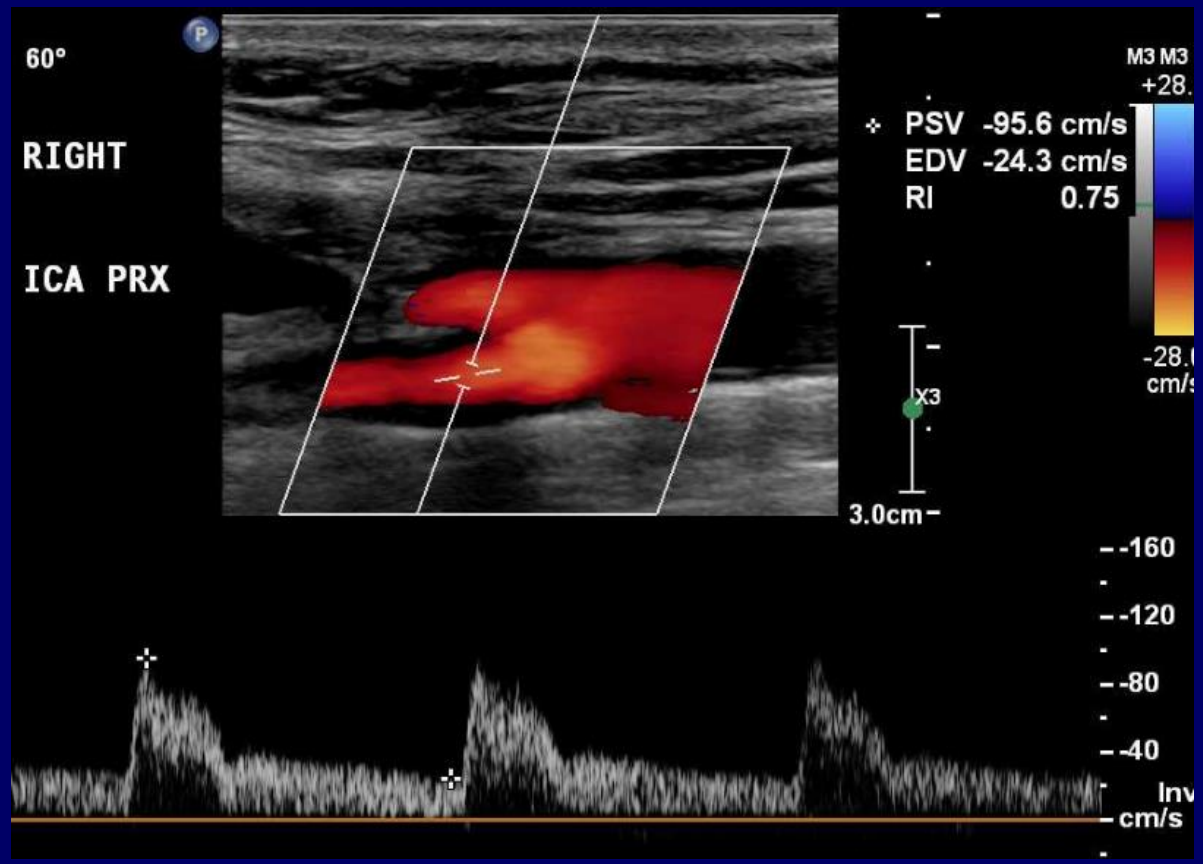
Prox ICA PSV 67 cm/s



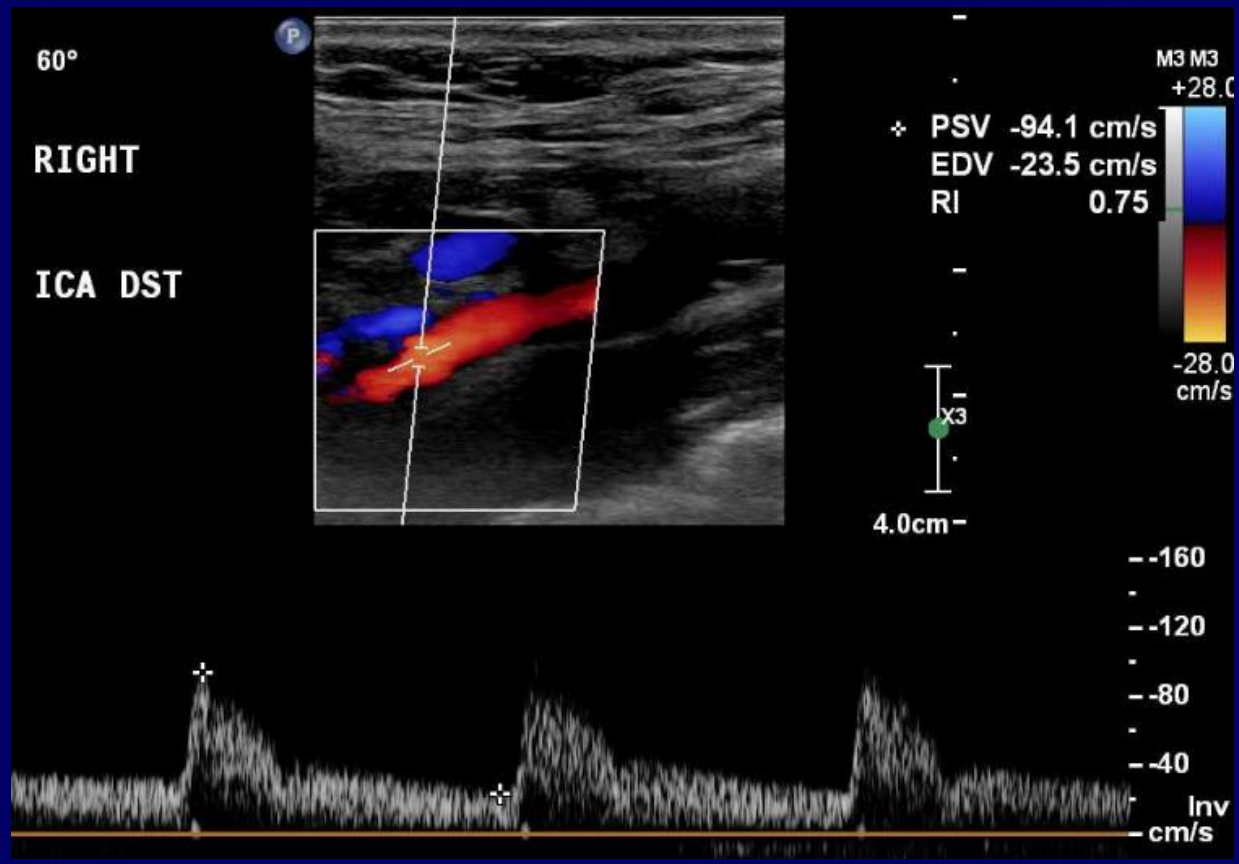
Distal ICA PSV 53 cm/s



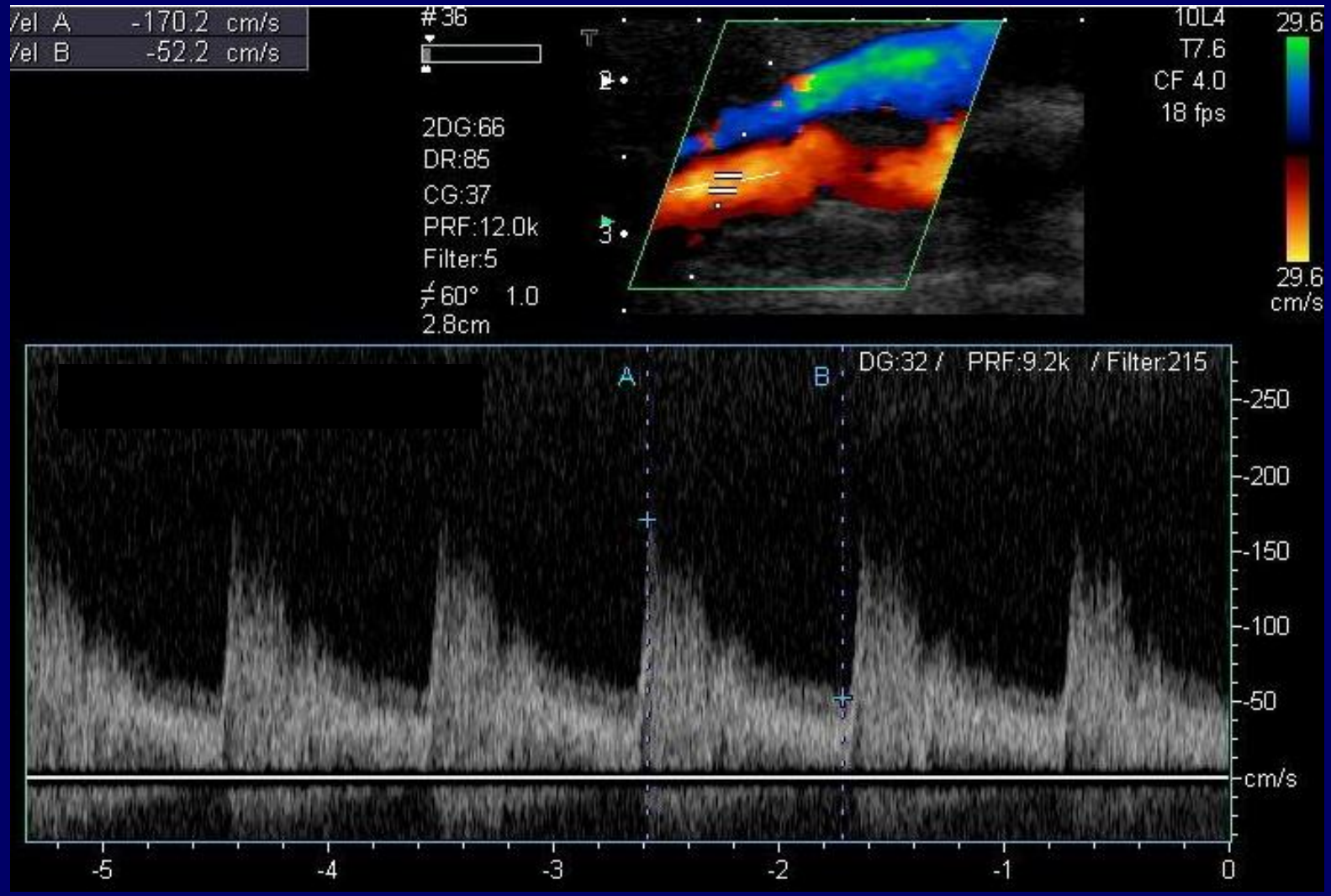
Prox ICA PSV 96 cm/s



Distal ICA PSV 94 cm/s

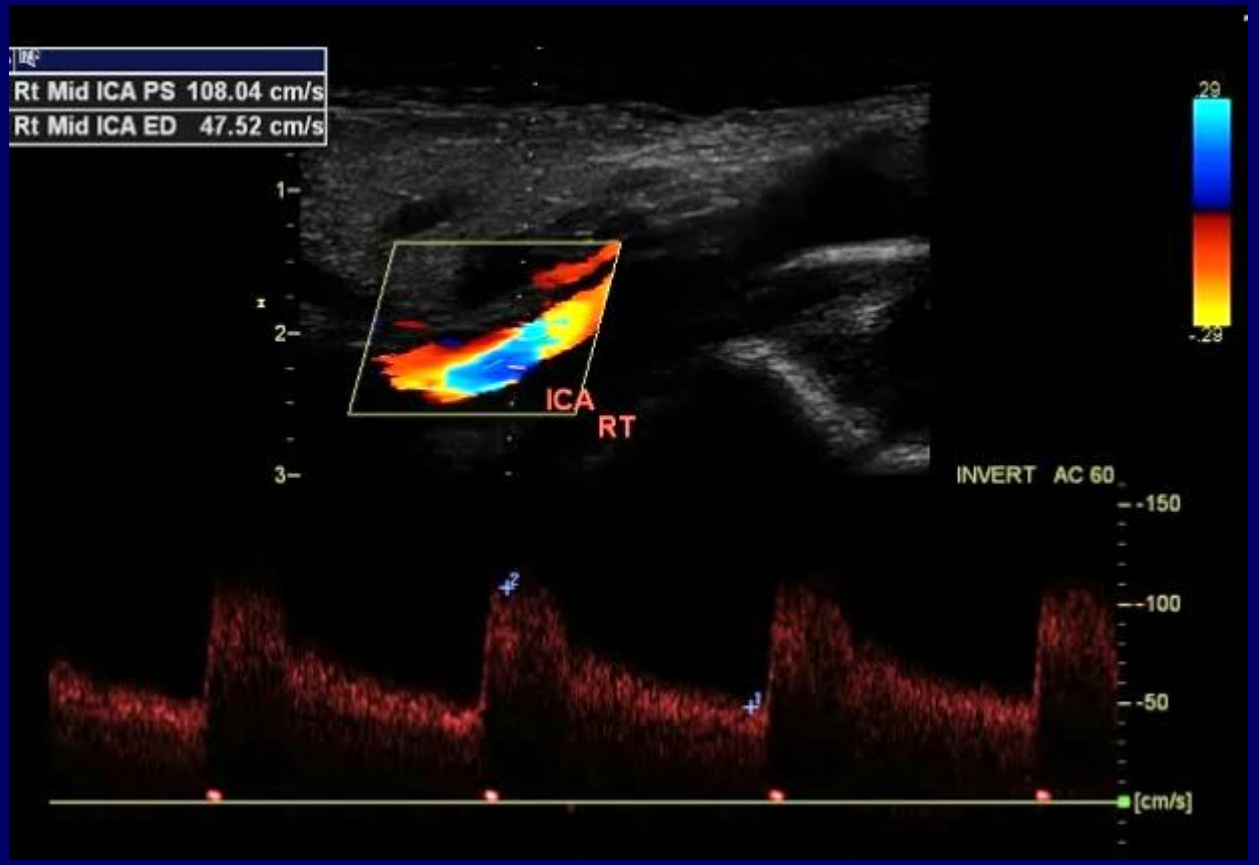


The Distal Carotid Stenosis



General threshold for >50% stenosis

Focal increase of twice the PSV or more compared to the PSV at a normal proximal site

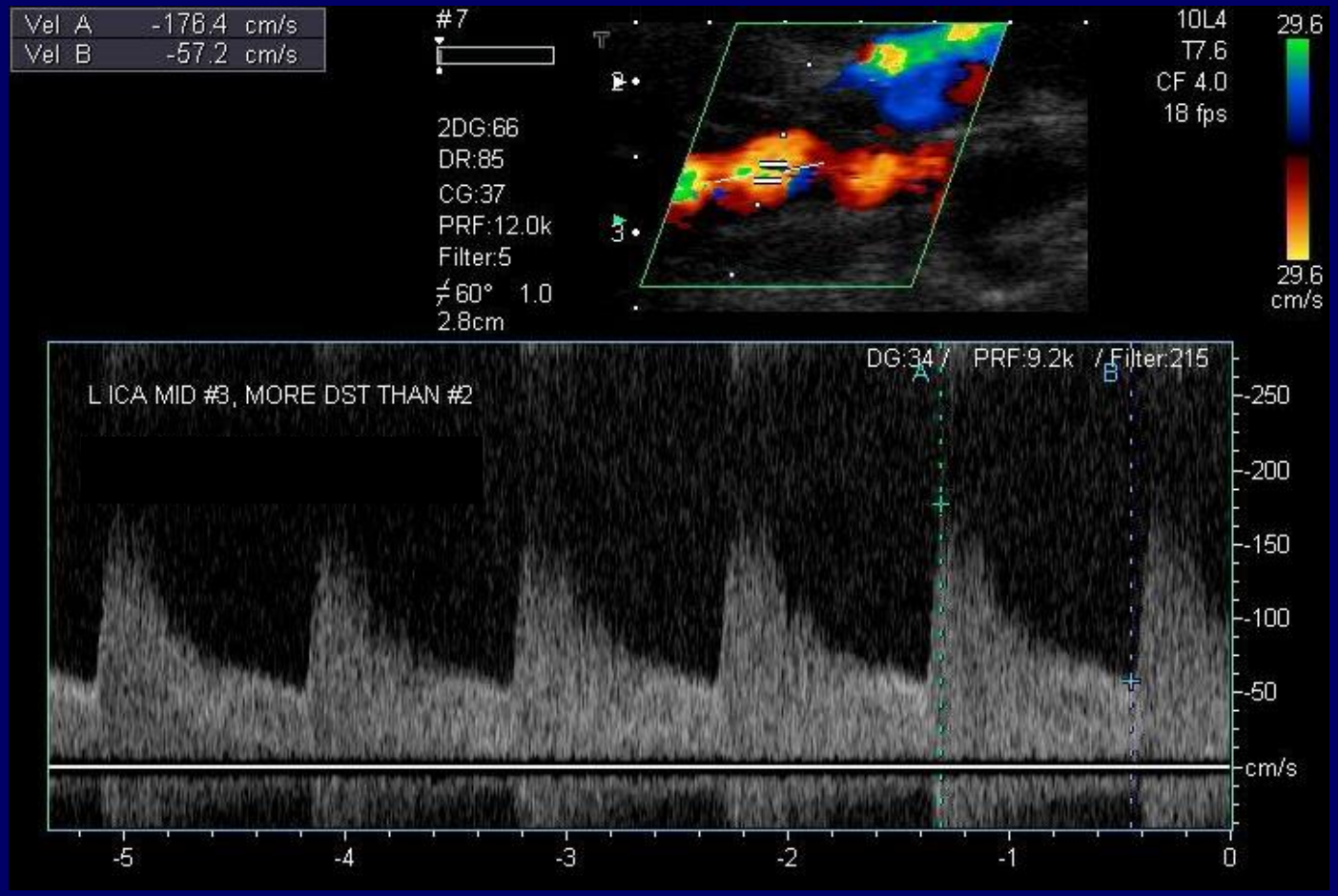


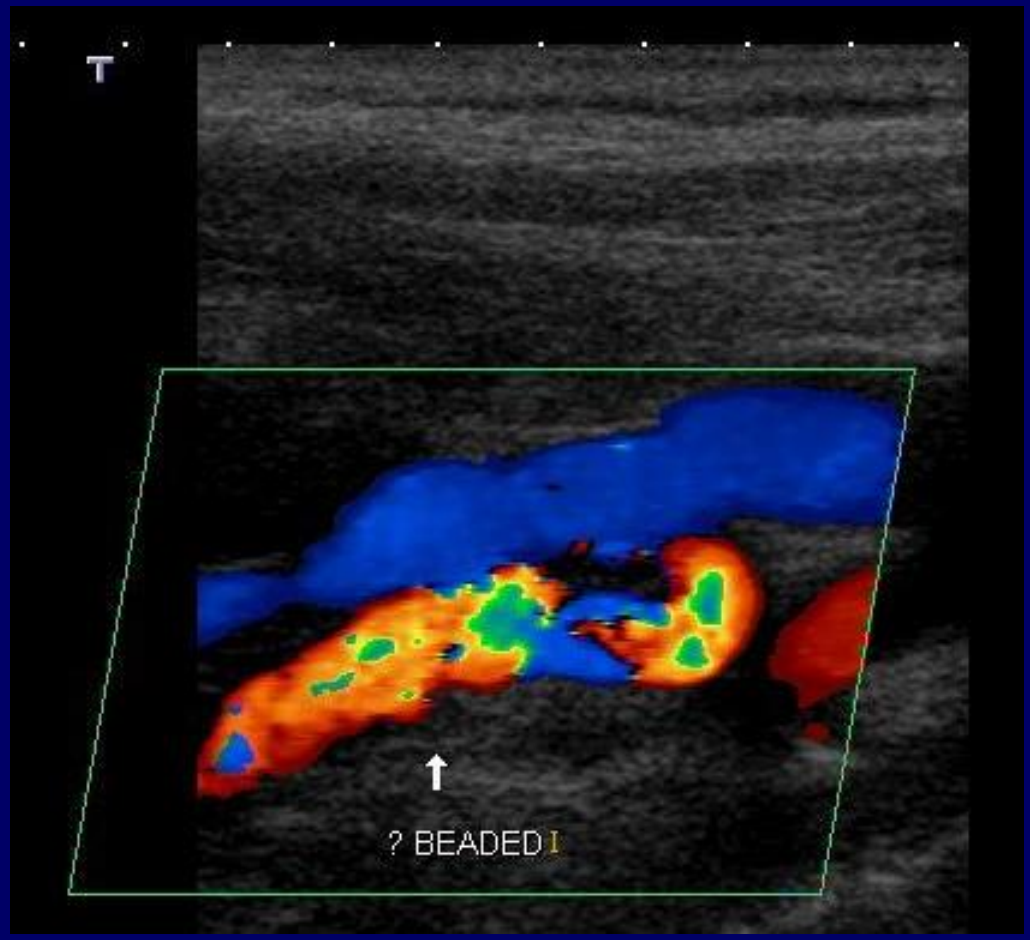
General threshold for >50% stenosis

Focal increase of twice the PSV or more compared to the PSV at a normal proximal site

- Whyman MR et al. Accuracy and reproducibility of duplex ultrasound imaging in a phantom model of femoral artery stenosis. *J Vasc Surg* 1993; 17:524-530
- Leng GC et al. Accuracy and reproducibility of duplex ultrasonography in grading femoropopliteal stenosis. J Vas Surg 1993; 17:510-517.

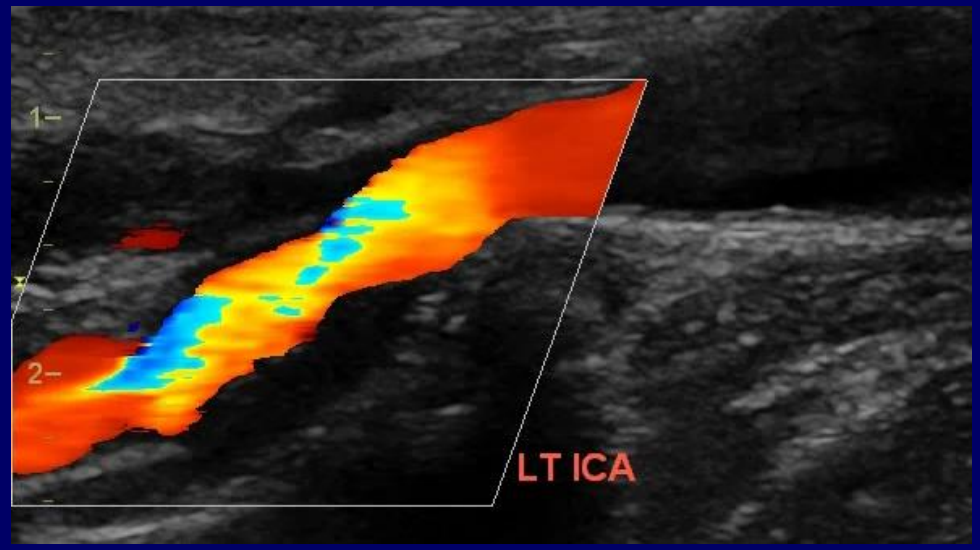
Is it ok to state simply “distal stenosis”



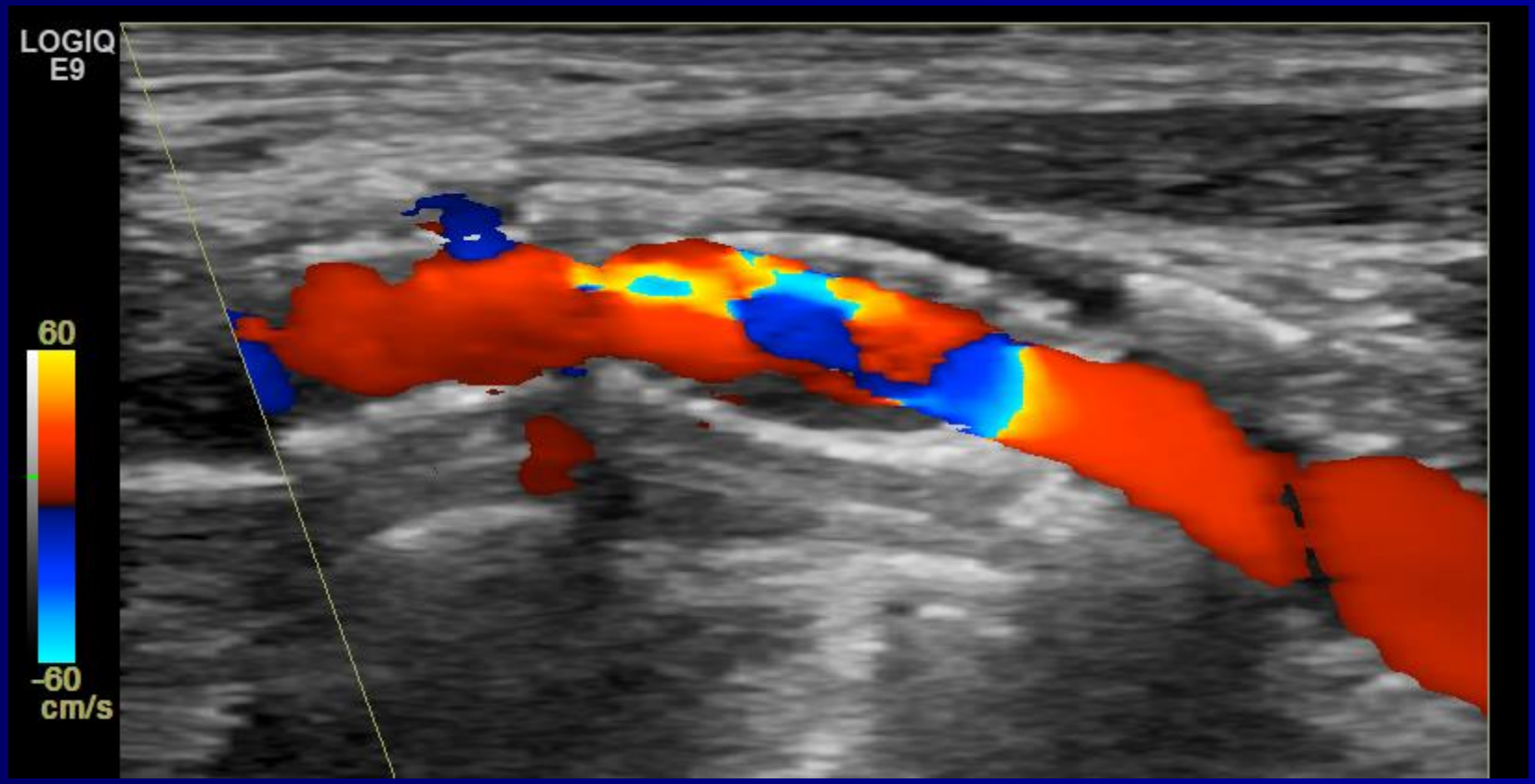


What to do about distal ICA stenosis?

- Describe the findings
  - Image
  - Color
  - Spectral Doppler
- Avoid specific categories

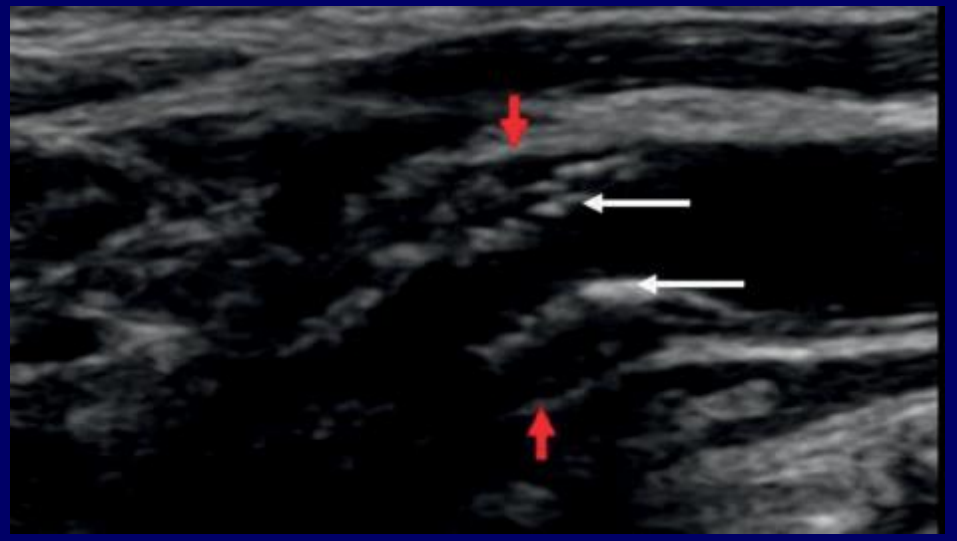


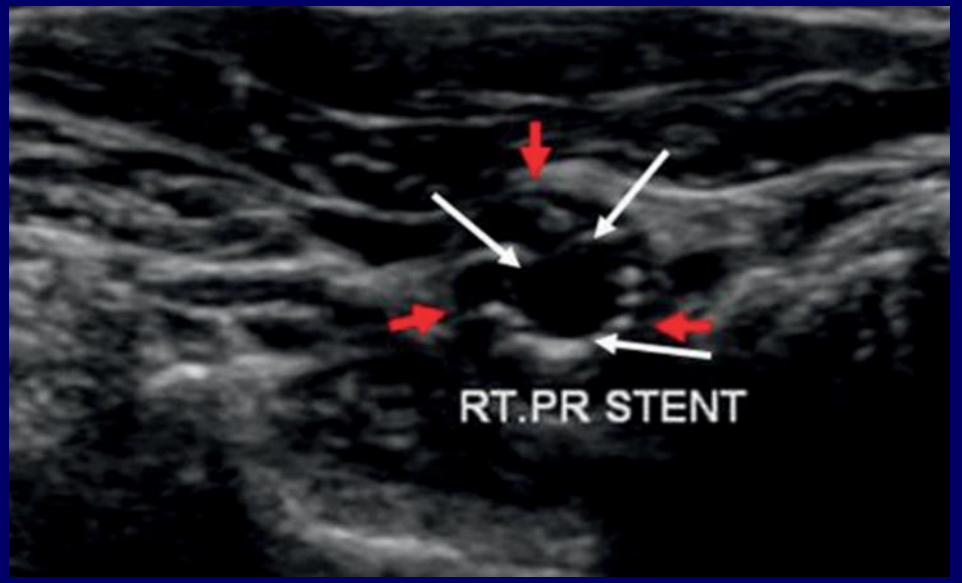
But what about post-stent criteria?



Interpretation must include grayscale assessment

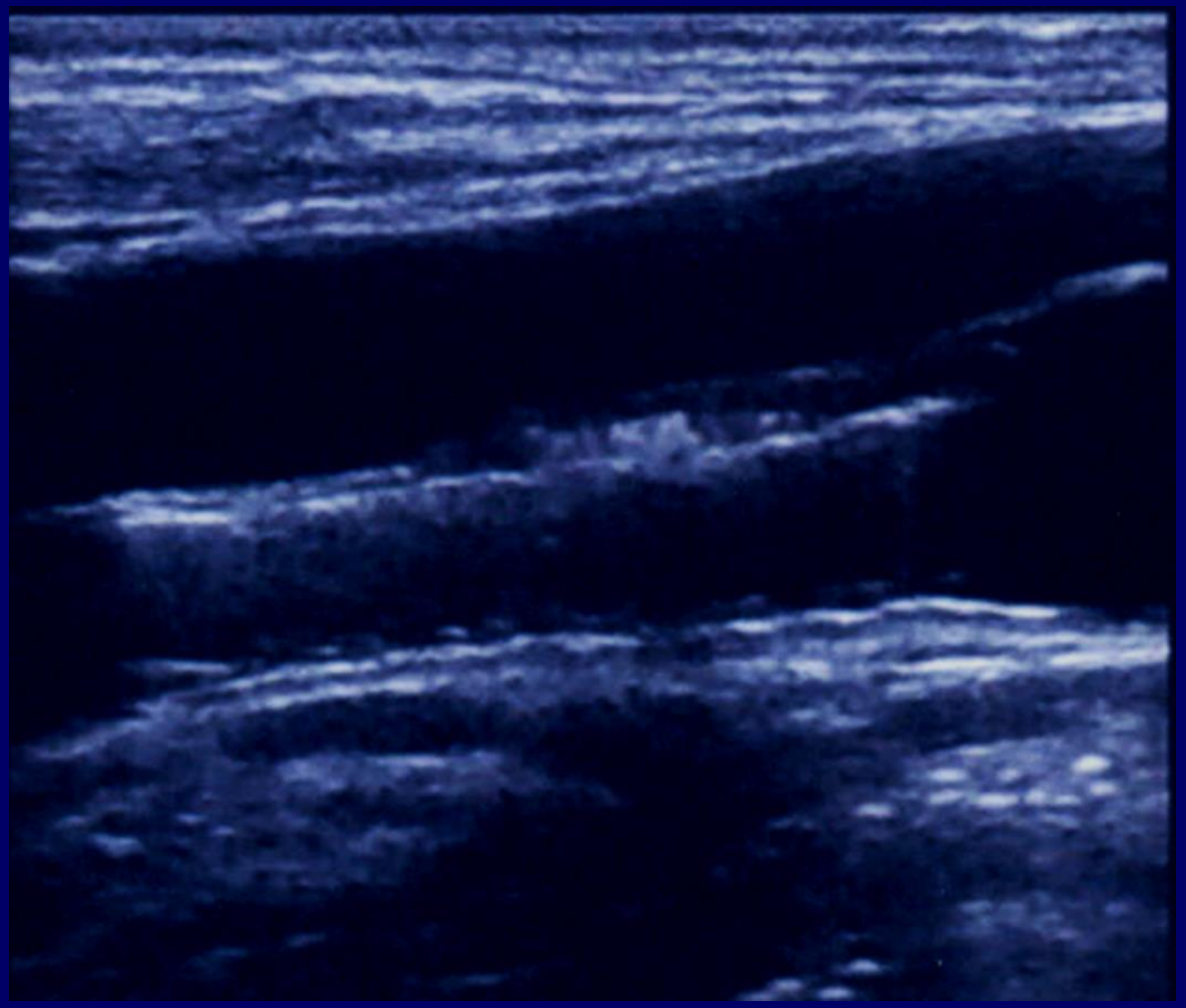
- High resolution grayscale imaging
  - Incomplete stent deployment
  - Stent compression
  - Intimal hyperplasia

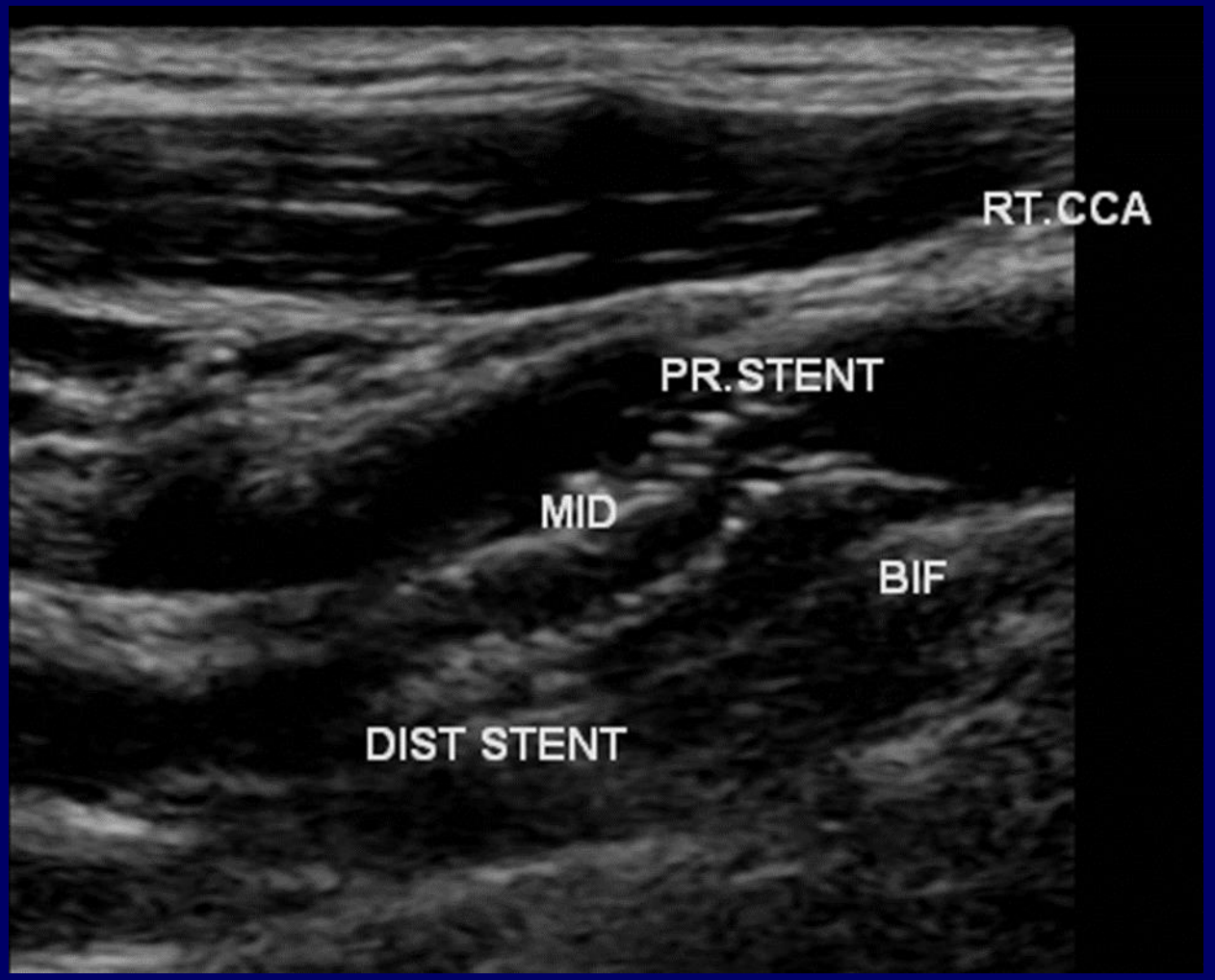




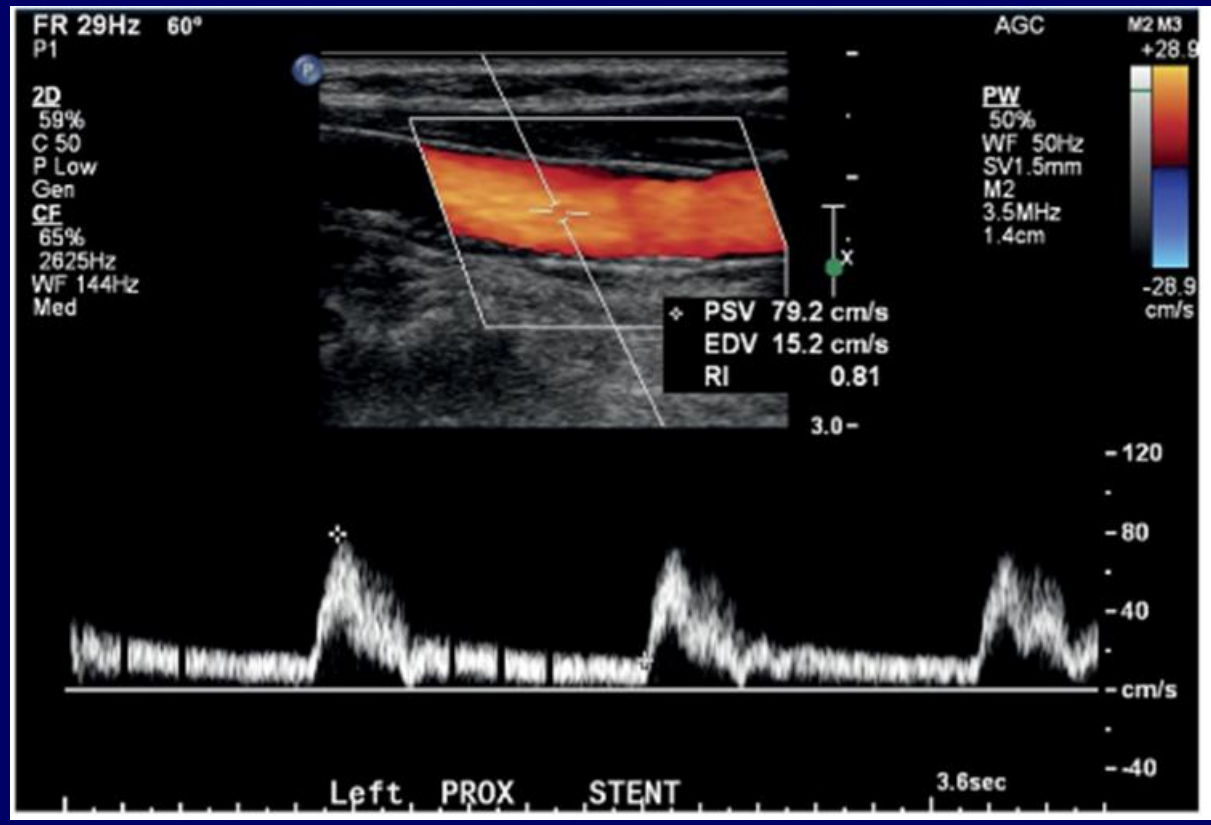
Normal grayscale appearance

-uniform stent deployment

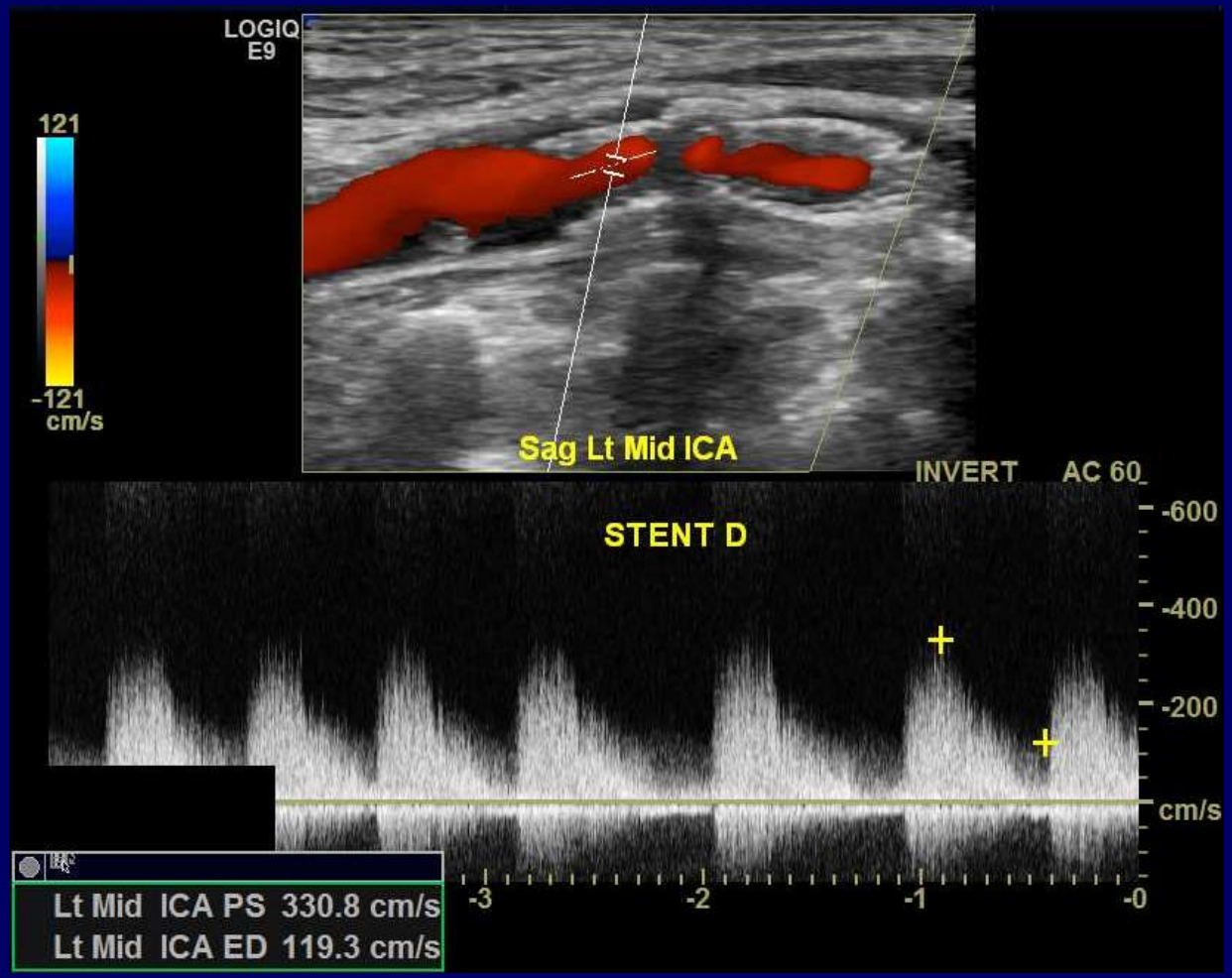


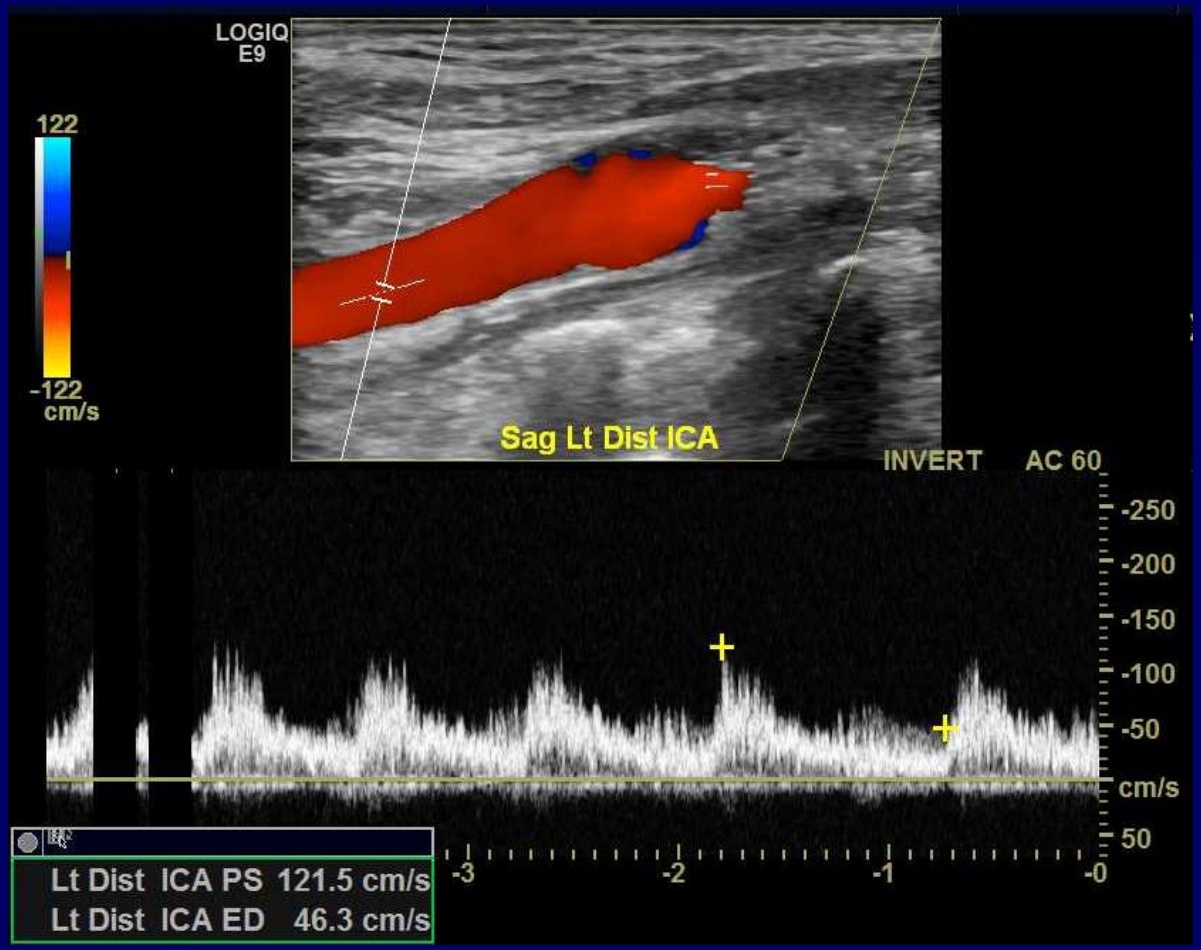


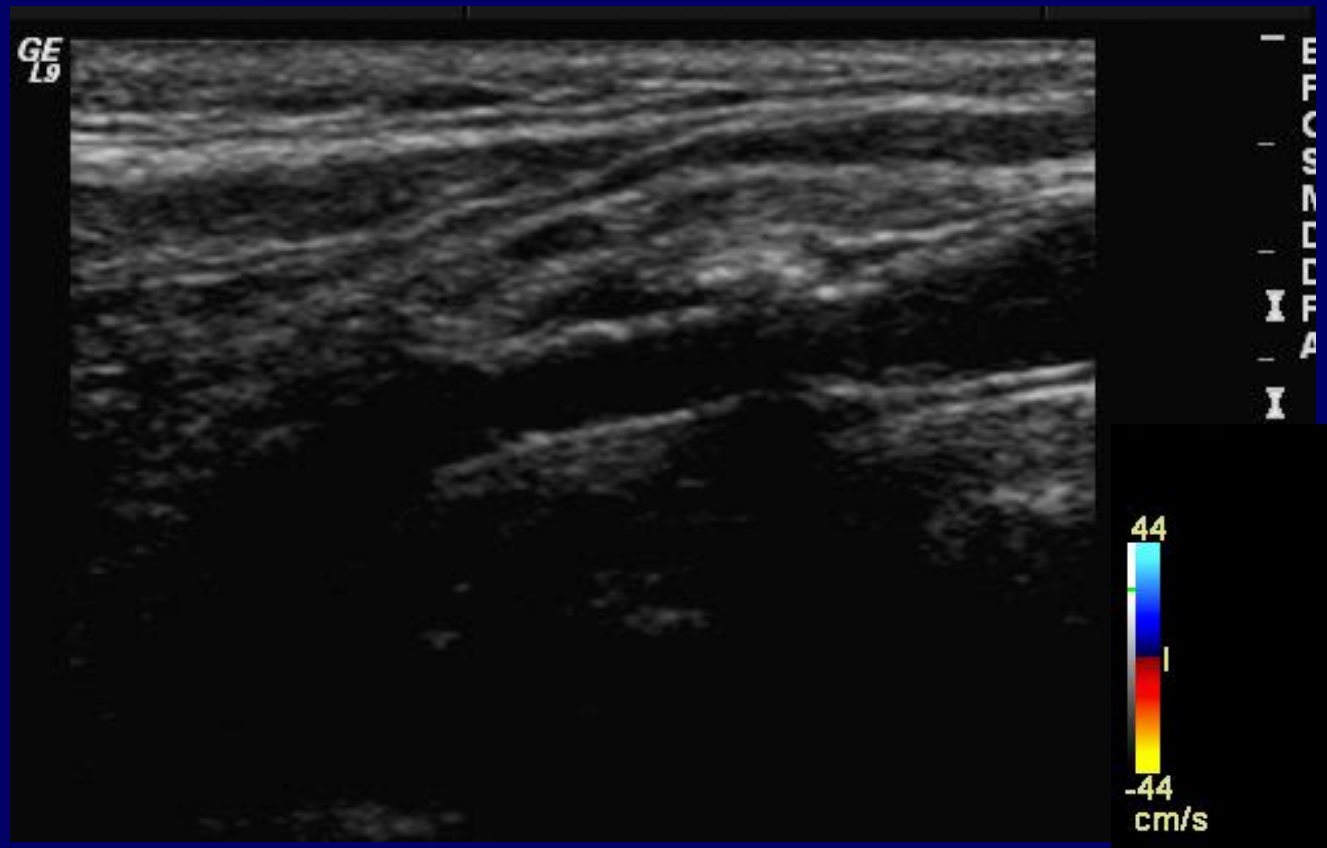
What about the spectral Doppler?

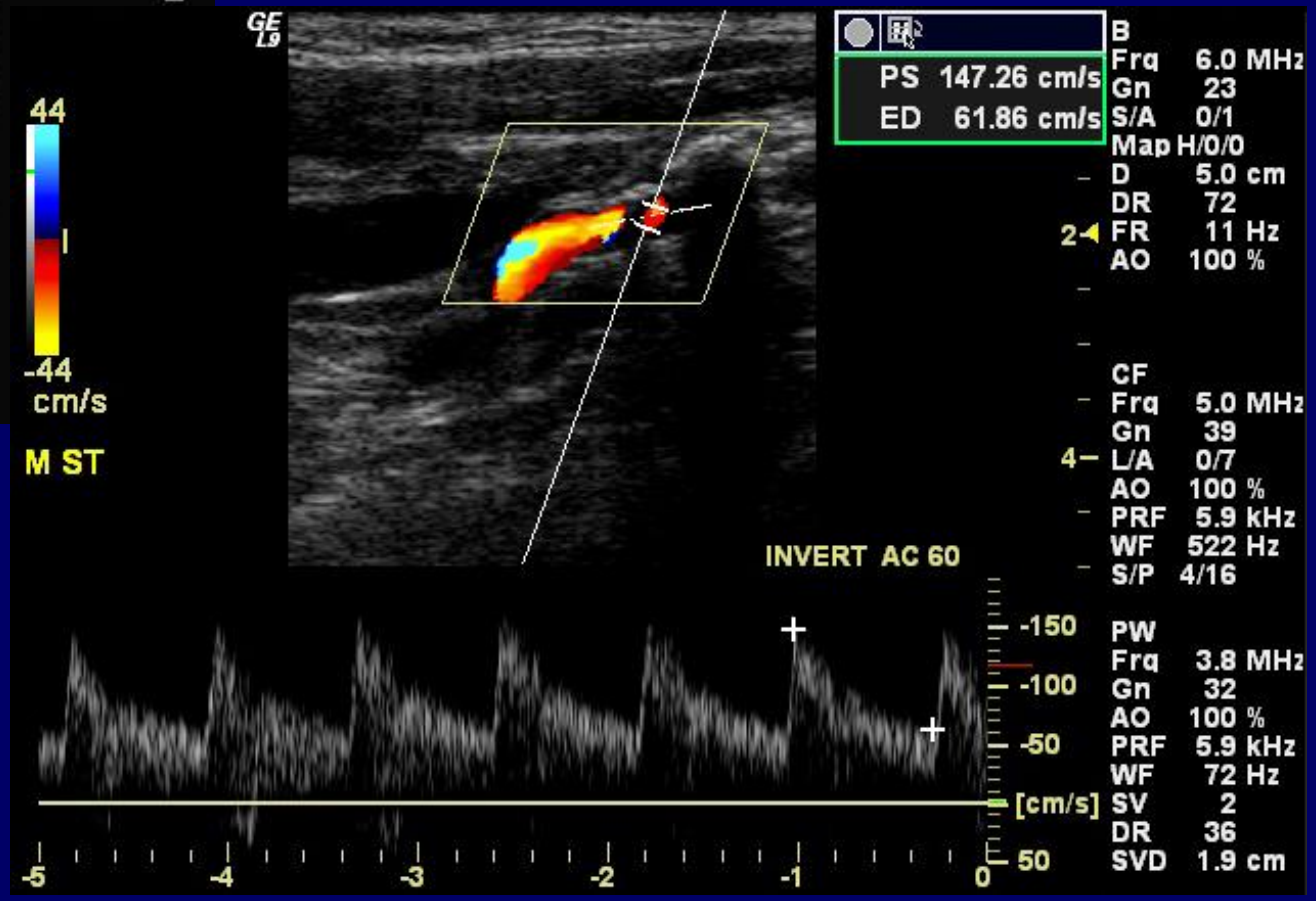



LOGIQ
E9
100
-100
cm/s
Sag Lt Prox ICA
AC 60
400
300
200
100
cm/s
-100
-3
-2
-1
-0
Lt Prox ICA PS 392.8 cm/s
Lt Prox ICA ED 152.4 cm/s


LOGIQ
E9
121
-121
cm/s
Sag Lt Mid ICA
INVERT
AC 60
STENT D
-600
-400
-200
cm/s
-3
-2
-1
-0
Lt Mid ICA PS 330.8 cm/s
Lt Mid ICA ED 119.3 cm/s


LOGIQ
E9
122
-122
cm/s
Sag Lt Dist ICA
INVERT
AC 60
-250
-200
-150
-100
-50
cm/s
50
-3
-2
-1
-0
Lt Dist ICA PS 121.5 cm/s
Lt Dist ICA ED 46.3 cm/s


GE
L9


GE
L9
44
-44
cm/s
M ST
PS 147.26 cm/s
ED 61.86 cm/s
B
Frq 6.0 MHz
Gn 23
S/A 0/1
Map H/0/0
D 5.0 cm
DR 72
FR 11 Hz
AO 100 %
CF
Frq 5.0 MHz
Gn 39
L/A 0/7
AO 100 %
PRF 5.9 kHz
WF 522 Hz
S/P 4/16
INVERT AC 60
PW
Frq 3.8 MHz
Gn 32
AO 100 %
PRF 5.9 kHz
WF 72 Hz
SV 2
DR 36
SVD 1.9 cm
-150
-100
-50
[cm/s]
50
-5
-4
-3
-2
-1
0

Albany Carotid Stent Data

Kupinski AM, et al, JVU 2004, 28:71-75

- In 28 ICA stents, a PSV >125 cm/s was found was found in 9 ICAs (32%)
- No changes were evident on B-mode or color flow imaging
- No PST
- Increased PSV was not focal

Carotid Stent Criteria
University of South Florida

Armstrong PA, Bandyk DF, et al.
J Vasc Surg 2007, 46:460-466

Stenosis Category	PSV cm/s	PSV Ratio	EDV cm/s
<50% None	<150	<2	NA
50-75% Moderate	>150	>2	<125
>75% Severe	>300	>4	>125
Occlusion	NA	NA	NA

Discussion

Peterson, et al

- *Annals of Vasc Surgery, 2005*

- PSV>170 cm/s ***and*** a 50% increase in PSV as compared to immediate post-stent PSV (100% sens & spec)
- EDV>120 cm/s ***and*** a 50% increase in EDV as compared to immediate post-stent EDV (100% sens & spec)
- 13 patients with elevated PSV but not a 50% increase in PSV

TABLE 9-4 Optimal Cutoff Values for PSV, EDV, and ICA/CCA Ratios in Carotid Stents[23]

Stenosis	PSV Cutoff	PSV AUC (95% CI)	SE	EDV Cutoff	EDV AUC (95% CI)	SE	ICA/CCA Ratio Cutoff	ICA/CCA Ratio AUC (95% CI)	SE
≥30%	>154	0.97 (0.93–1)	0.02	>42	0.76 (0.68–0.84)	0.04	>1.533	0.83 (0.77–0.90)	0.03
≥50%	>224	0.95 (0.84–1)	0.05	>88	0.82 (0.69–0.96)	0.07	>3.439	0.88 (0.77–0.99)	0.06
≥80%	>325	0.88 (0.63–1)	0.12	>119	0.90 (0.72–1)	0.09	>4.533	0.86 (0.62–1)	0.12

SE, standard error; AUC, area under curve.

TABLE 9-5 Post-CAS Duplex Ultrasound Criteria

	Stenosis Threshold 20%			Stenosis Threshold 30%			Stenosis Threshold 50%			Stenosis Threshold 70%			Stenosis Threshold 75%			Stenosis Threshold 80%		
Author/Series	**PSV**	**EDV**	**ICA/CCA**	**PSV**	**EDV**	**ICA/CCA**	**PSV**	**EDV**	**ICA/CCA**	**PSV**	**EDV**	**ICA/CCA**	**PSV**	**EDV**	**ICA/CCA**	**PSV**	**EDV**	**ICA/CCA**
AbuRahma[19]				154	42		224	88								325	119	
Setacci[33]				105			175			300	140	3.8						
Chi[27]							240		2.45	450		4.3						
Chahwan[28]	137	20					195	62								300	96	
Lal[22]	150		2.15				220		2.7							340		4.15
Zhou[29]										300	90	4.0						
Armstrong[26]													300	125				
Kwon[30]							200		2.5									
Stanziale[31]							225		2.5	350		4.75						

Discussion

Compliance is altered within the stented carotid artery

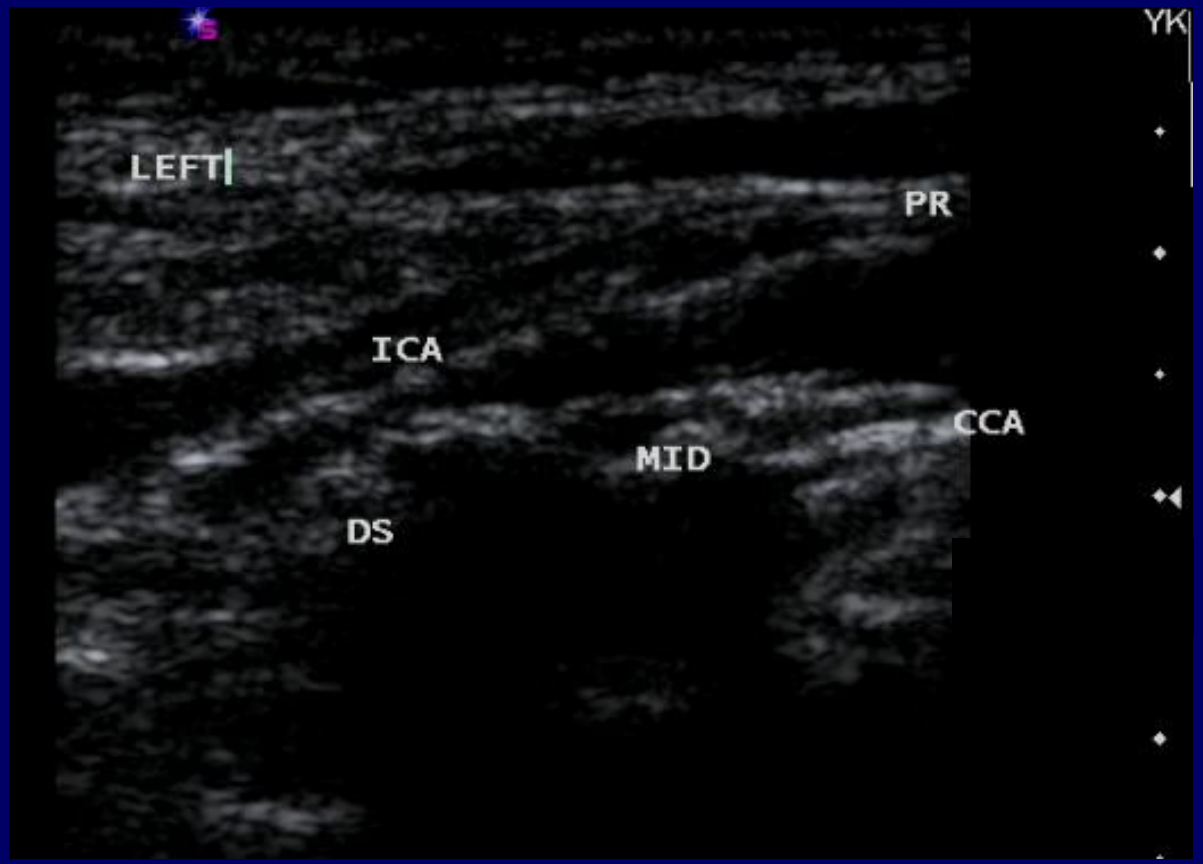
Decreased Compliance

- Due to stent – makes the conduit stiffer
- Due to plaque/calcium load remaining within vessel

Stent Remodeling

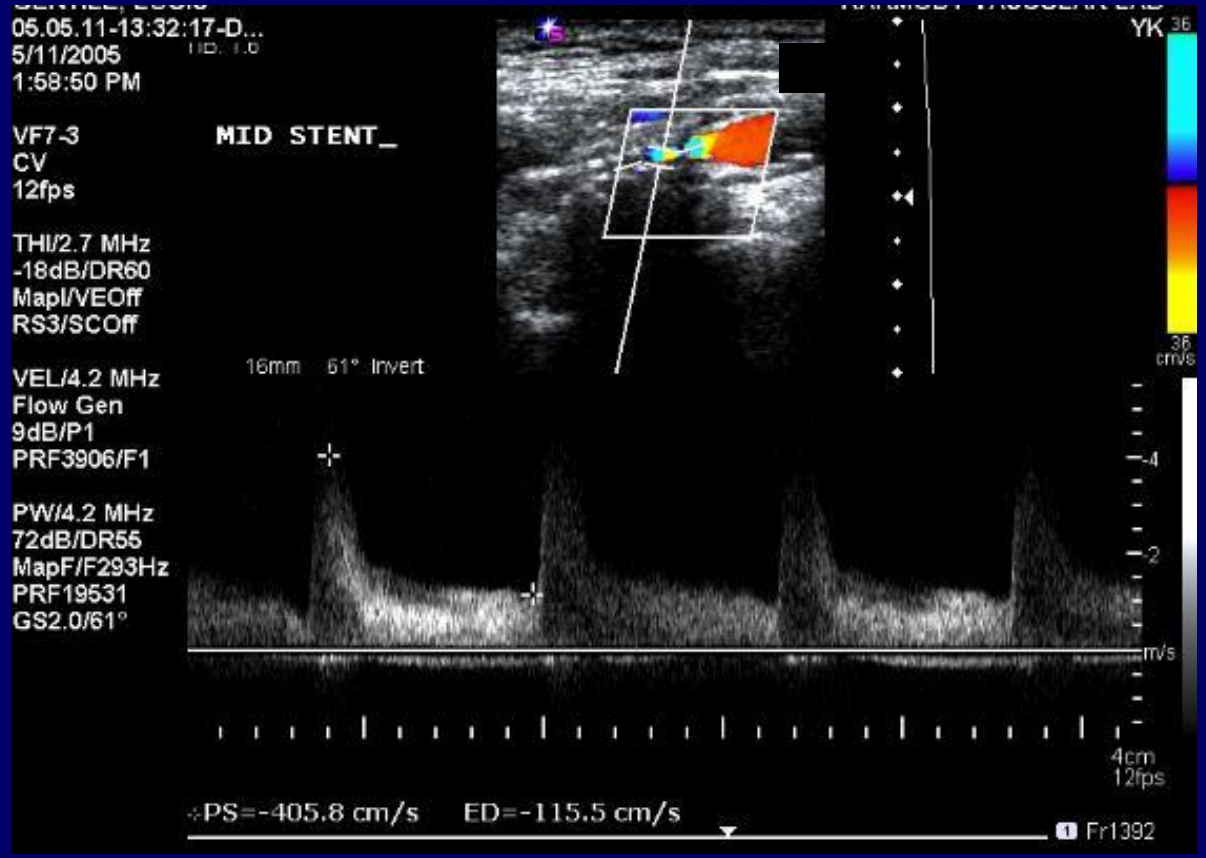
Serial ultrasound imaging has shown

- Positive Remodeling
  - Stent expansion
  - Some expansion is limited by the presence of calcific plaque
- Negative Remodeling
  - Lumen reduction due to myointimal hyperplasia
  - Some hyperplasia is commonly observed but usually stabilizes after 12 months



Problems evident on:

Grayscale
Color
Spectral Doppler



Conclusion

- Classic carotid criteria can not be applied in some circumstances
- With distal ICA disease, describe findings and avoid categories of disease used for proximal ICA disease
- Carotid stent hemodynamics will vary
- Velocity and velocity ratio thresholds are elevated for carotid stents