IMAGING MODALITIES RELEVANT TO INTRACRANIAL PRESSURE ASSESSMENT IN ASTRONAUTS

Ashot E. Sargsyan[1], Larry A. Kramer[2], Douglas R. Hamilton[1], Jennifer Fogarty[3], JD Polk[3]

1. Space Medicine, Wyle Integrated Science and Engineering, Houston, TX, USA.
2. University of Texas Health Sciences Center at Houston.
3. Space Life Sciences Directorate, NASA Lyndon B. Johnson Space Center, Houston, TX, USA.

Disclosure Information

82nd Annual Scientific Meeting

Ashot E. Sargsyan

I have no financial relationships to disclose.

I will not discuss off-label use and/or investigational use in my presentation

Learning Objectives

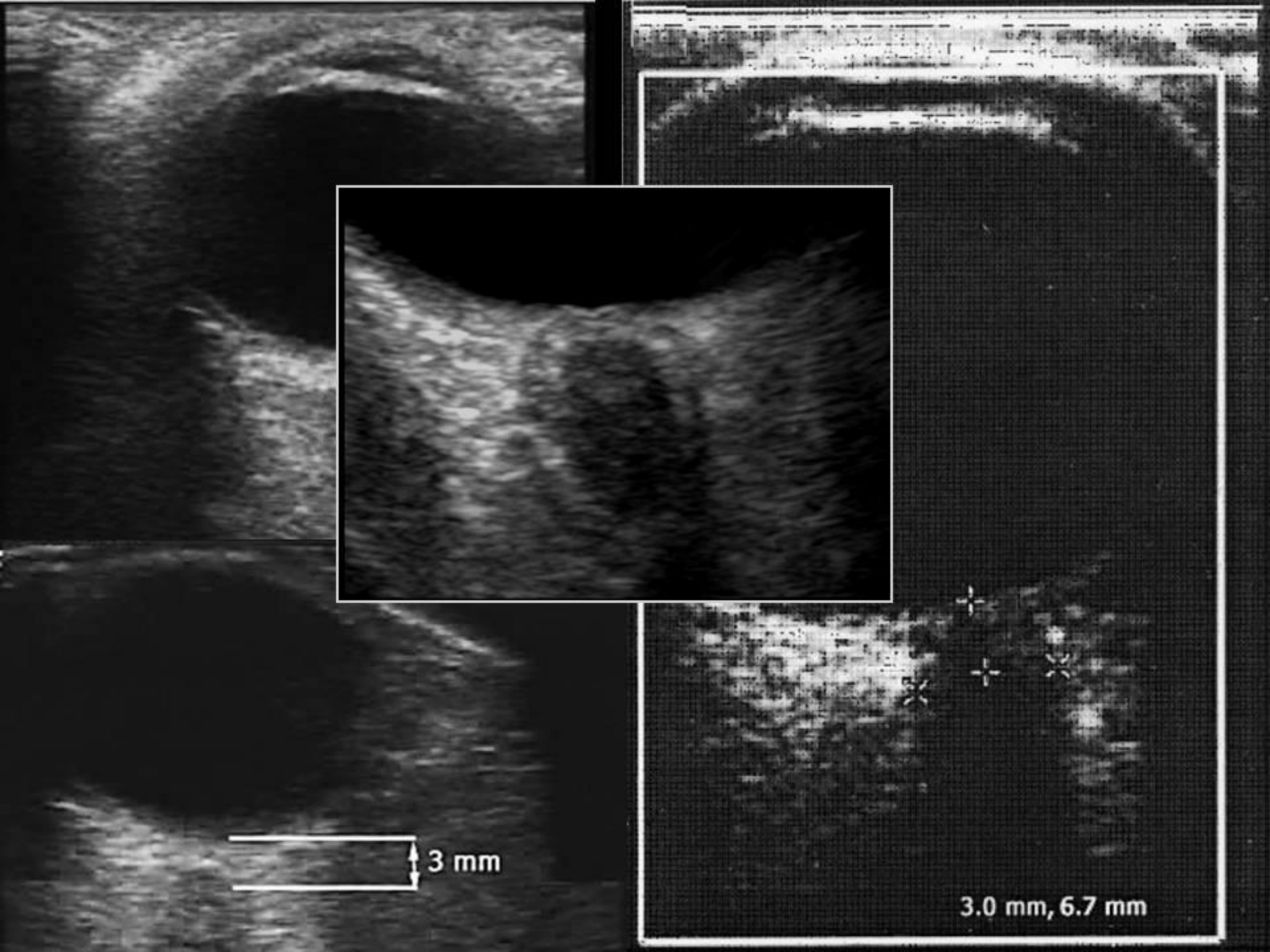
1: To review the morphological changes in orbit structures caused by elevated ICP, and their imaging representation.

2: To learn about the similarities and differences between MRI and sonographic imaging of the eye and orbit.

3: To learn about the role of MRI and sonography in the noninvasive assessment of intracranial pressure in aerospace medicine, and the added benefits from their combined interpretation.

Introduction

- Intracranial pressure (ICP) elevation has been inferred or documented in a number of space crewmembers.
- Recent advances in noninvasive imaging technology offer new possibilities for ICP assessment.
- No standards or applicable evidence-based guidelines/criteria are available for immediate use.
- NASA and its ISS partners adopted a battery of occupational health monitoring tests including:
  - Magnetic resonance imaging (MRI) pre- and postflight;
  - High-definition sonography of the orbital structures in all mission phases including during flight.
- We hypothesize that joint consideration of data from the two techniques has the potential to improve quality and continuity of crewmember monitoring and care.


3 mm
3.0 mm, 6.7 mm

Macroscopic Anatomical Substrate

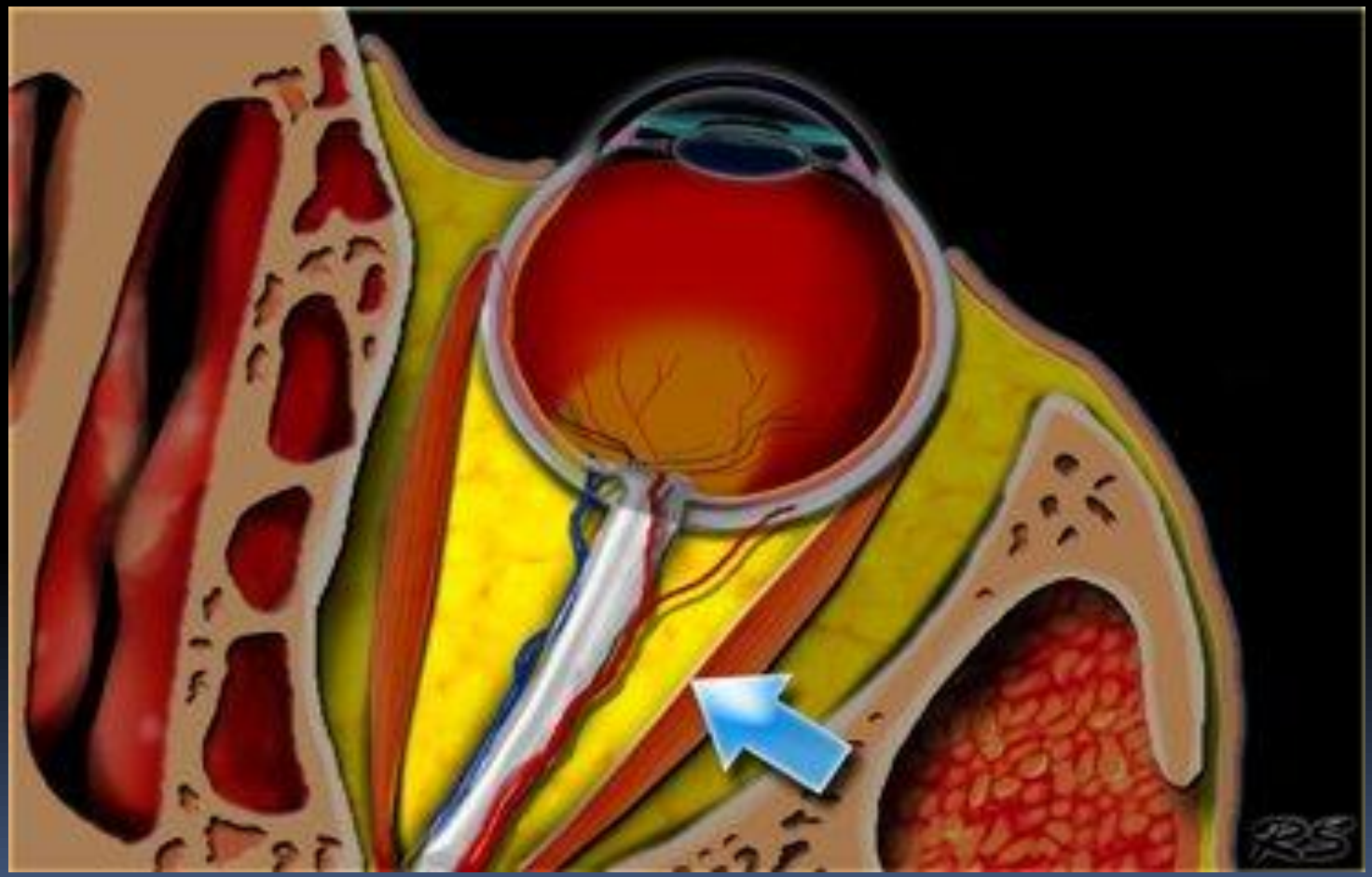
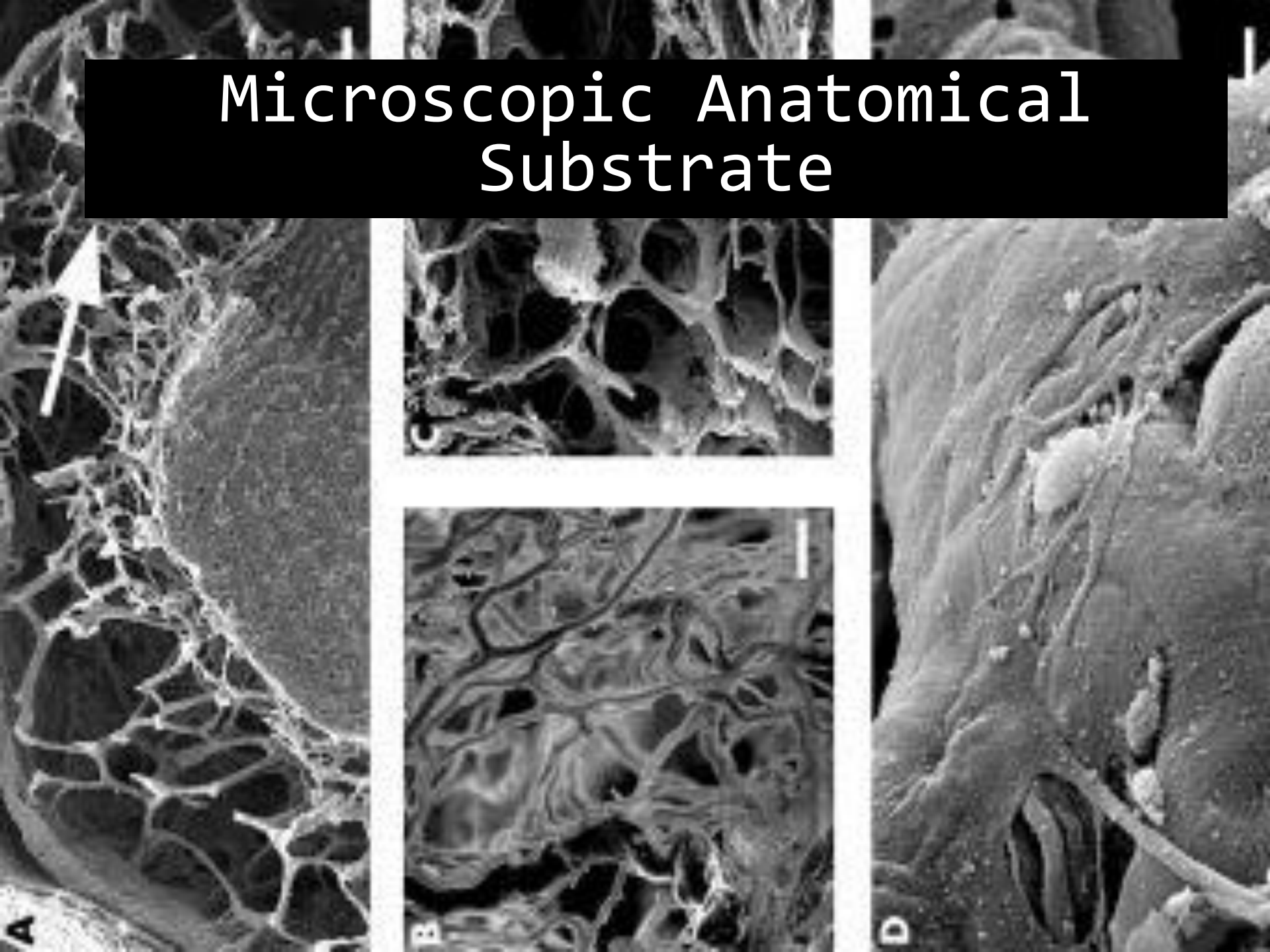


Image Source: Orbital Pathology ***by David Youssem***
Neuroradiology department of the Johns Hopkins Hospital in Baltimore
http://www.radiologyassistant.nl

Microscopic Anatomical Substrate



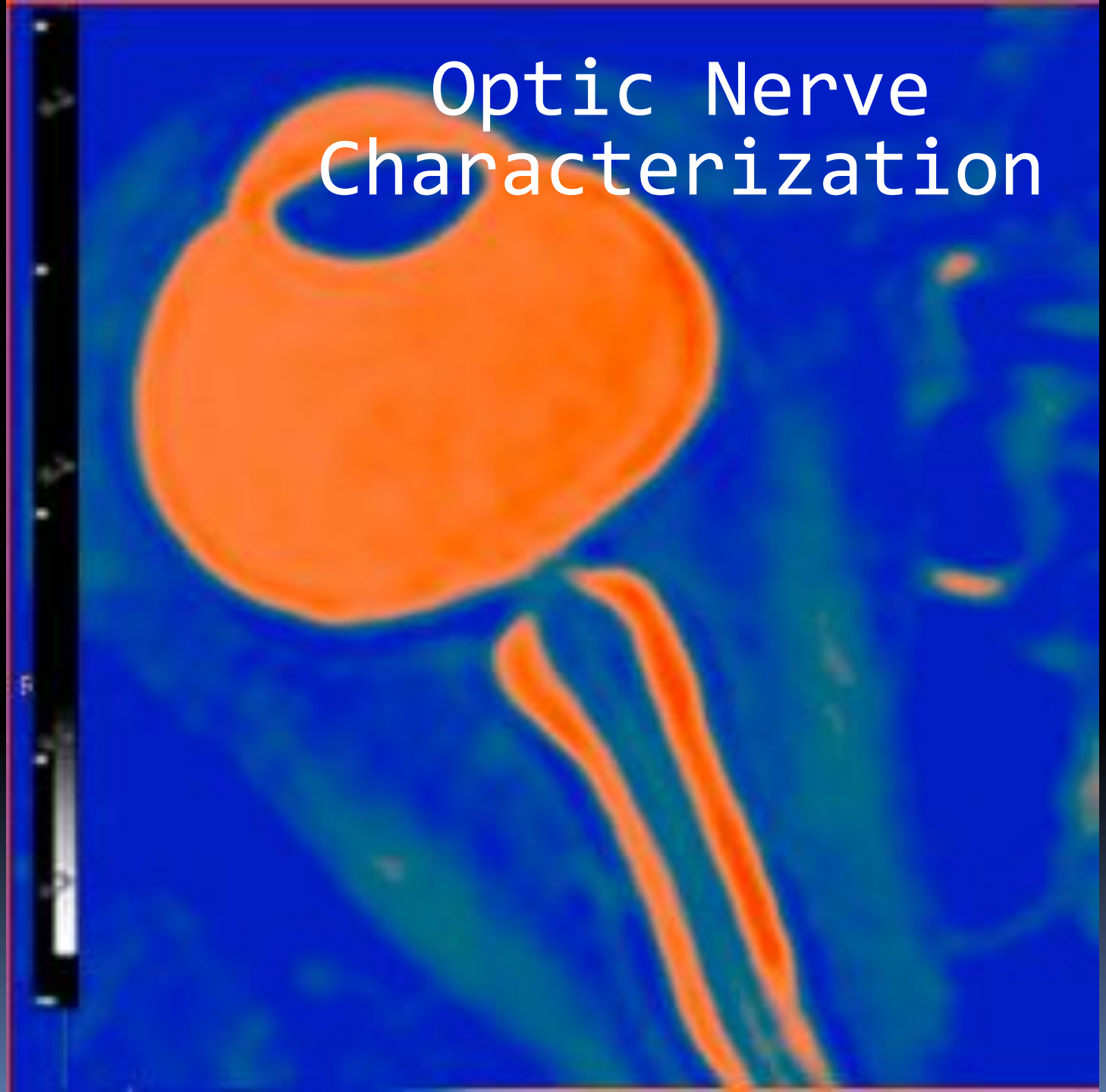
Methods

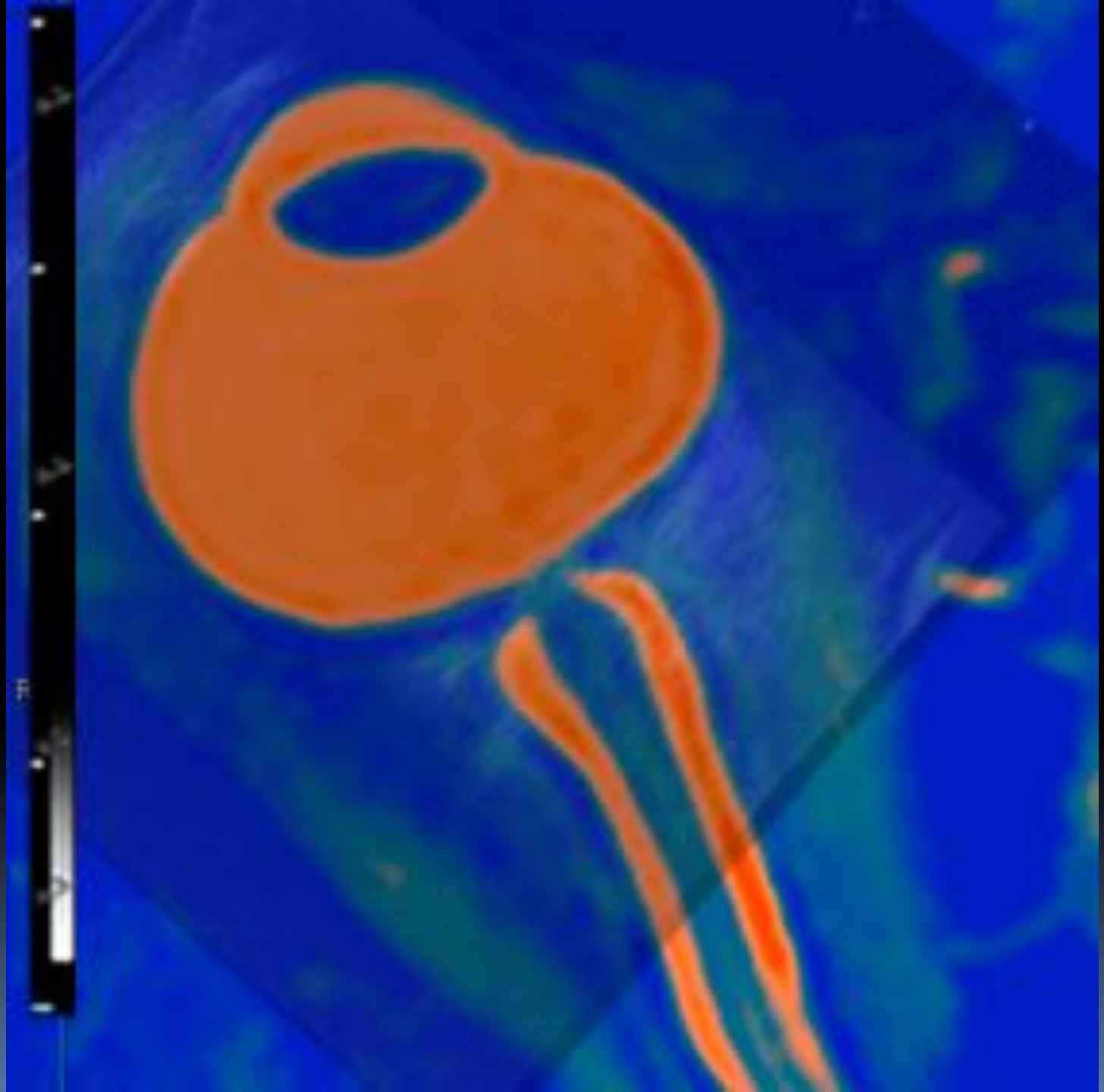
- Identification of redundant parameters in MR and sonographic data sets
- Comparisons of MR and sonographic measurements of the optic nerve and optic nerve sheath
- Comparison of posterior globe curvature measurements from MR and sonographic images
- Assessment of the potential of image “fusion” between MR and sonography

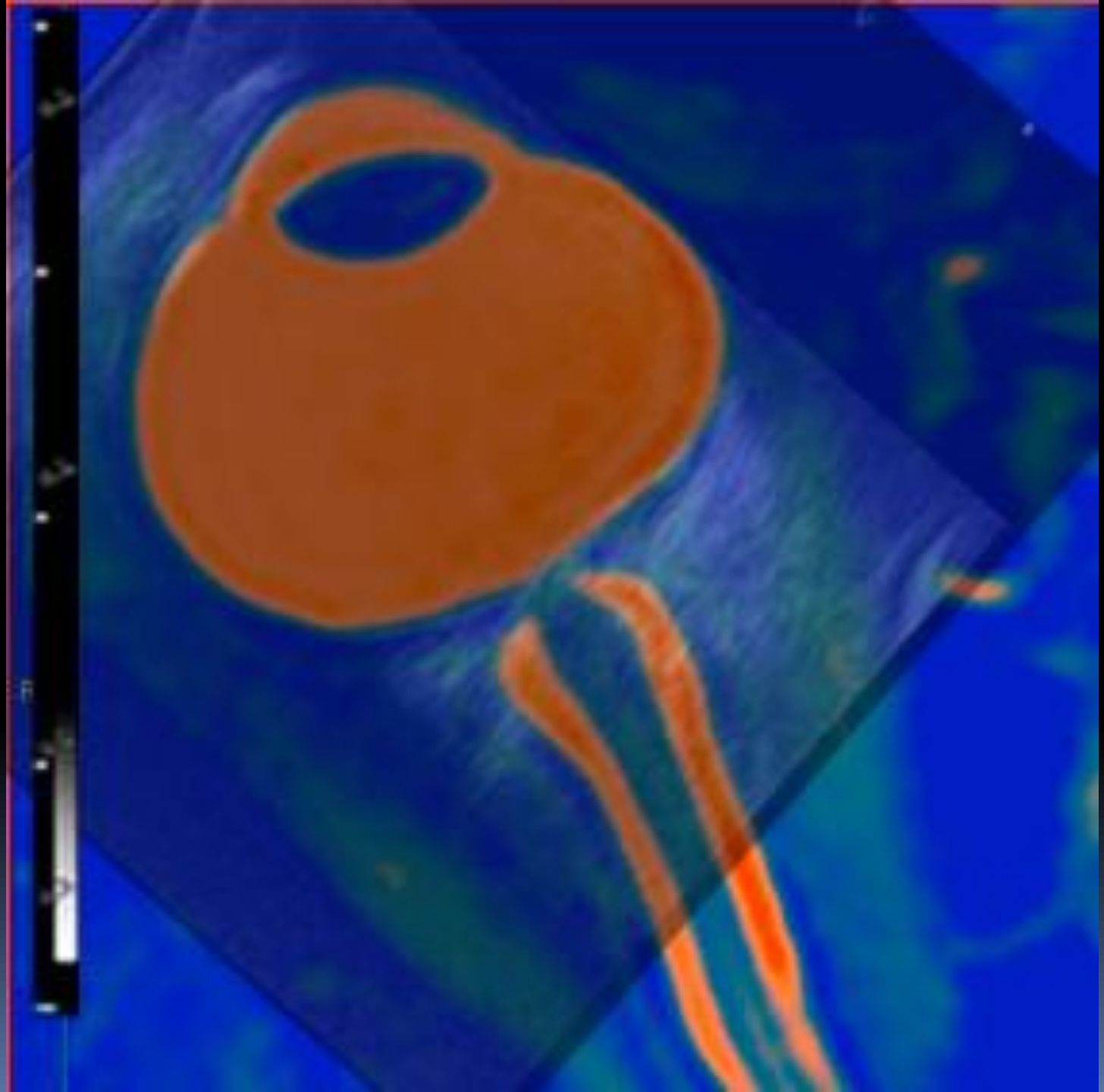
Methods

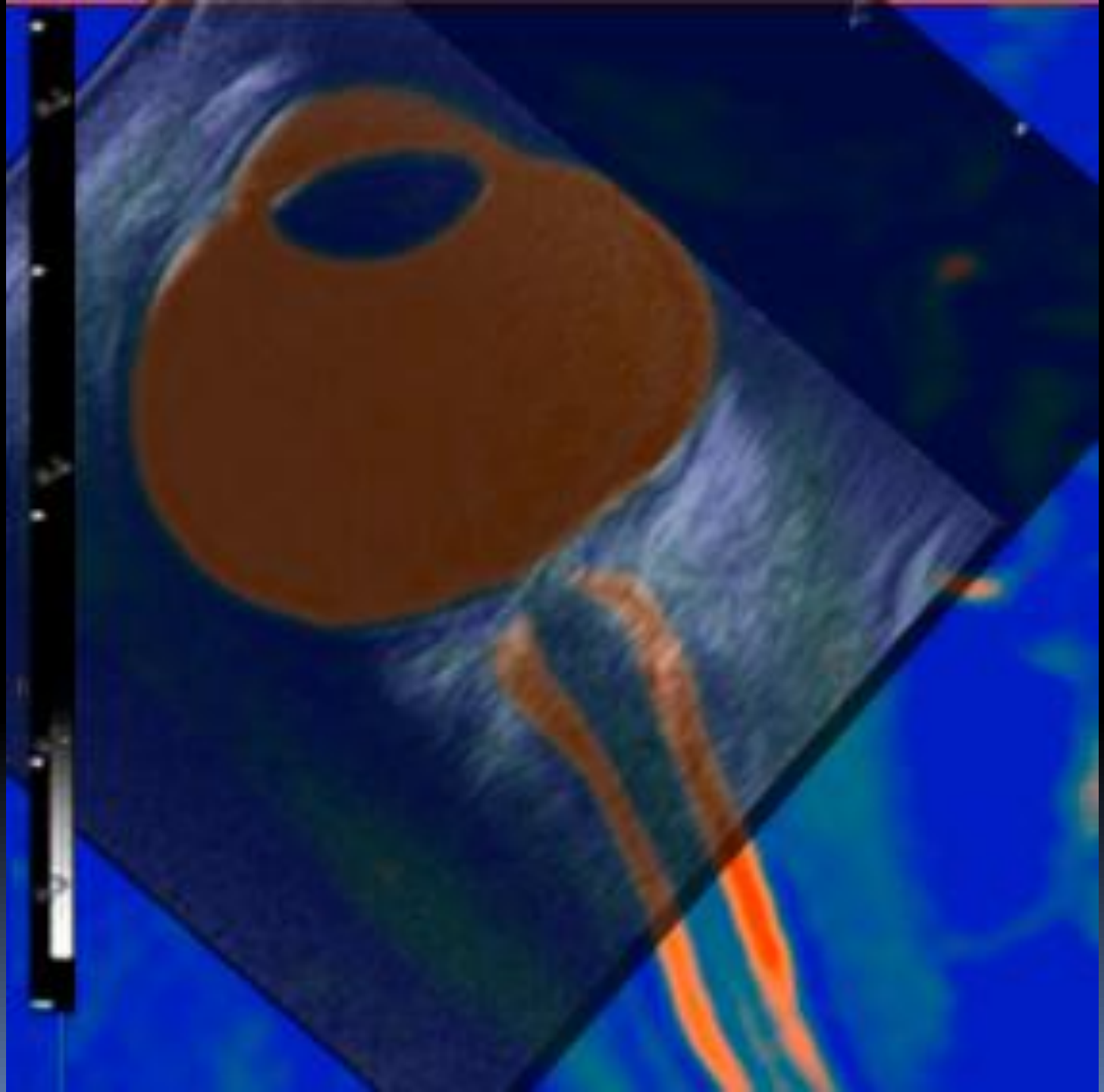
PARAMETER	US	MRI	FORMAT
Anterior chamber survey	X		free text based on entire image set
Posterior chamber survey	X		free text based on entire image set
Antero-posterior Diameter	X		numerical
Papilledema/Disc Edema	X	X	semi-quantitative: 0-3
Globe flattening	X	X	semi-quantitative: 0-3
Optic Nerve Sheath Diameter	X	X	within 3-5 mm from retina; numerical
Characterization of optic nerve sheath structure	X		free text based on entire image set
Optic Nerve Diameter	X	X	within 3-5 mm from retina; numerical
Optic Sheath-Nerve Ratio	X	X	calculated, numerical, unitless
ON tortuosity	X	X	semi-quantitative: 0-3
ON sheath hypoechogenicity	X		
ON T2-hyperintensity		X	semi-quantitative: 0-3
Survey of intracranial CSF spaces		X	free text based on entire image set
Characterization of sella turcica and pituitary		X	free text based on entire image set
Assessment of CSF production rate		X	numerical
Characterization of CSF flow through the Sylvian aqueduct		X	numerical
Other Notes: **Compared with**: [dates] **IMPRESSION**:	x	x	free text

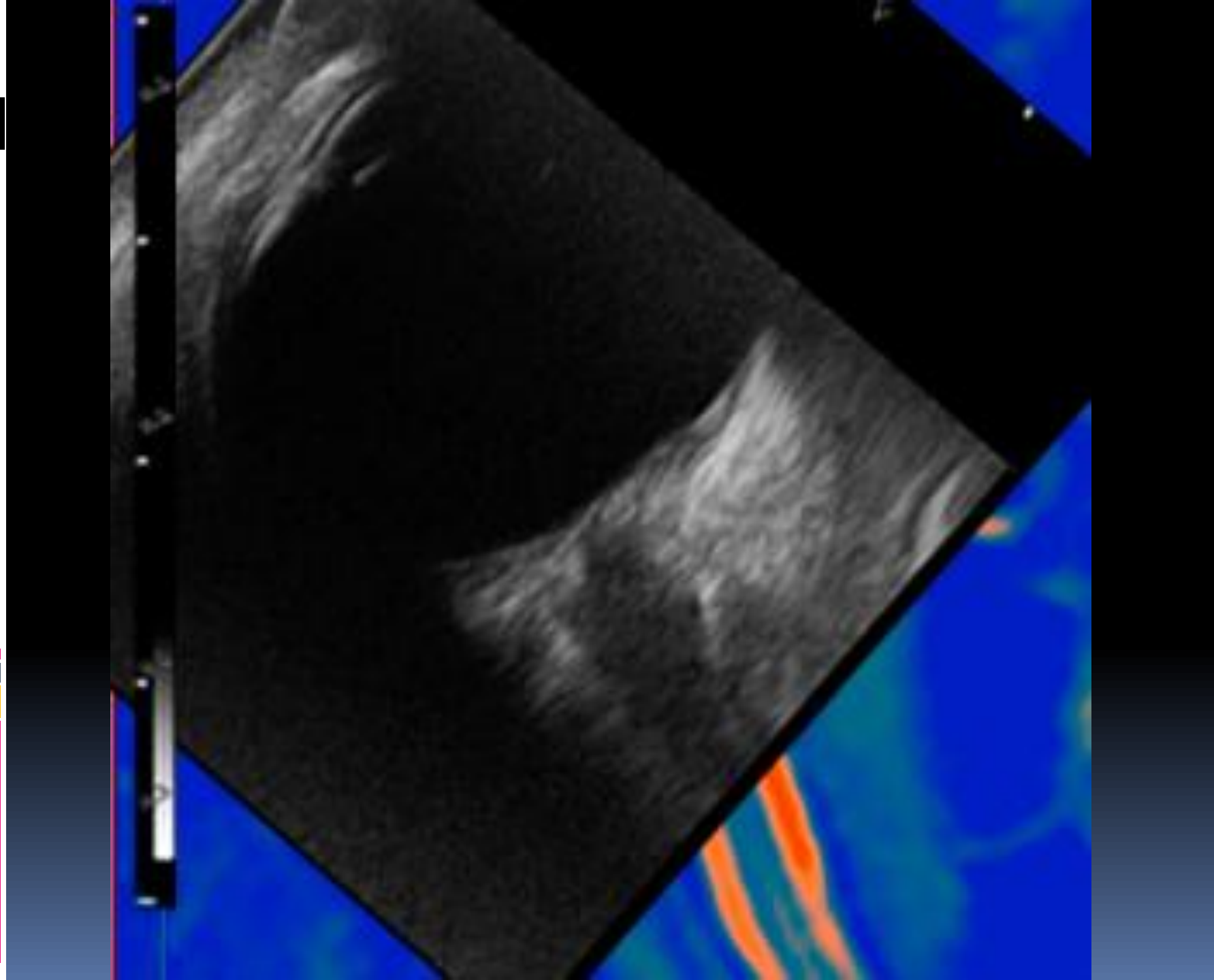
Optic Nerve Characterization

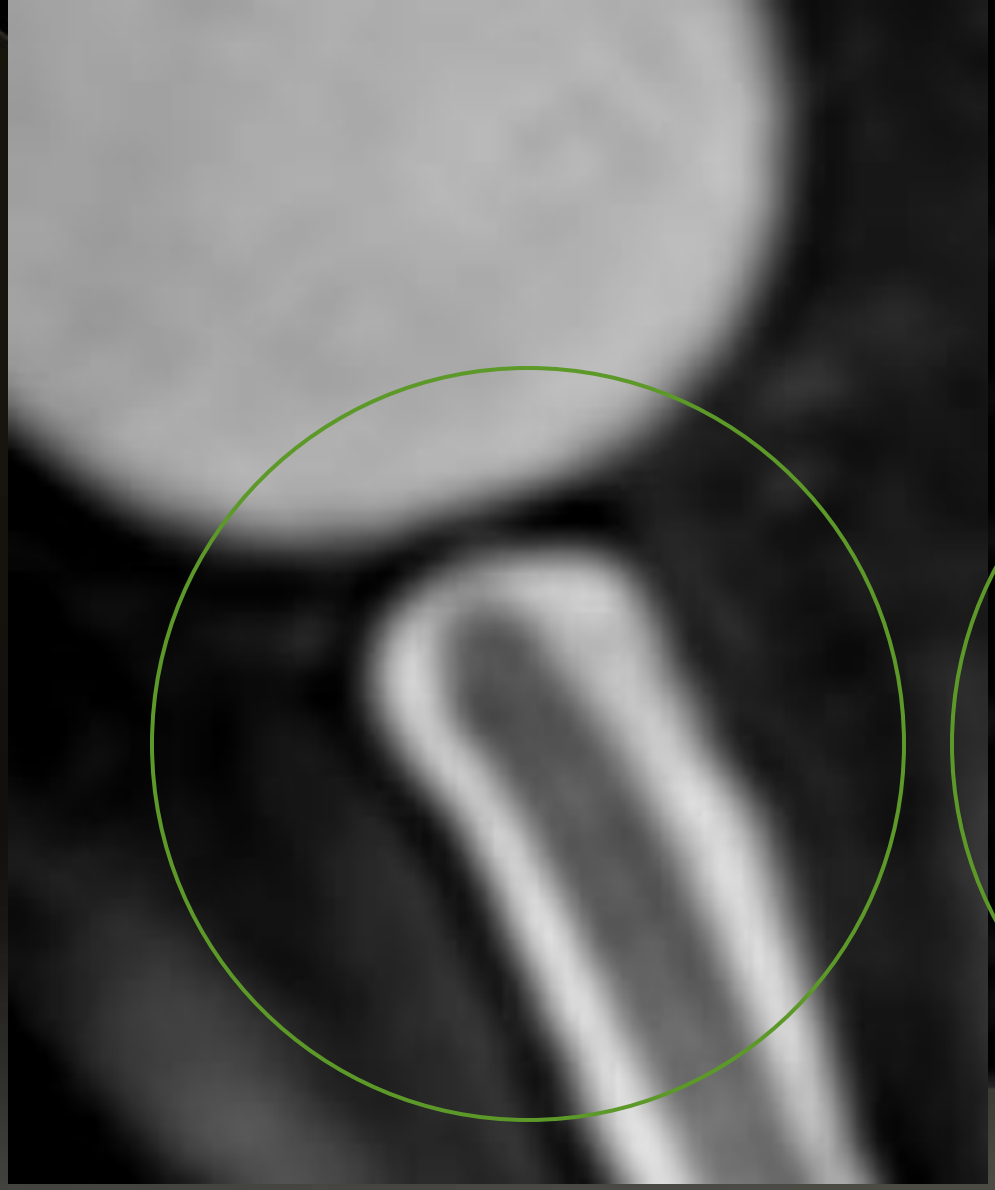


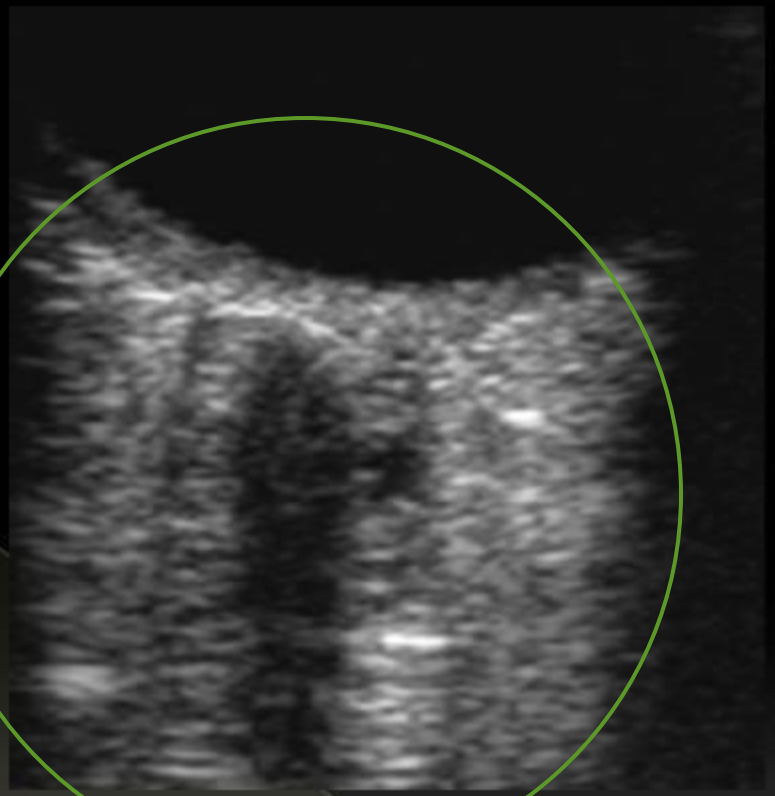




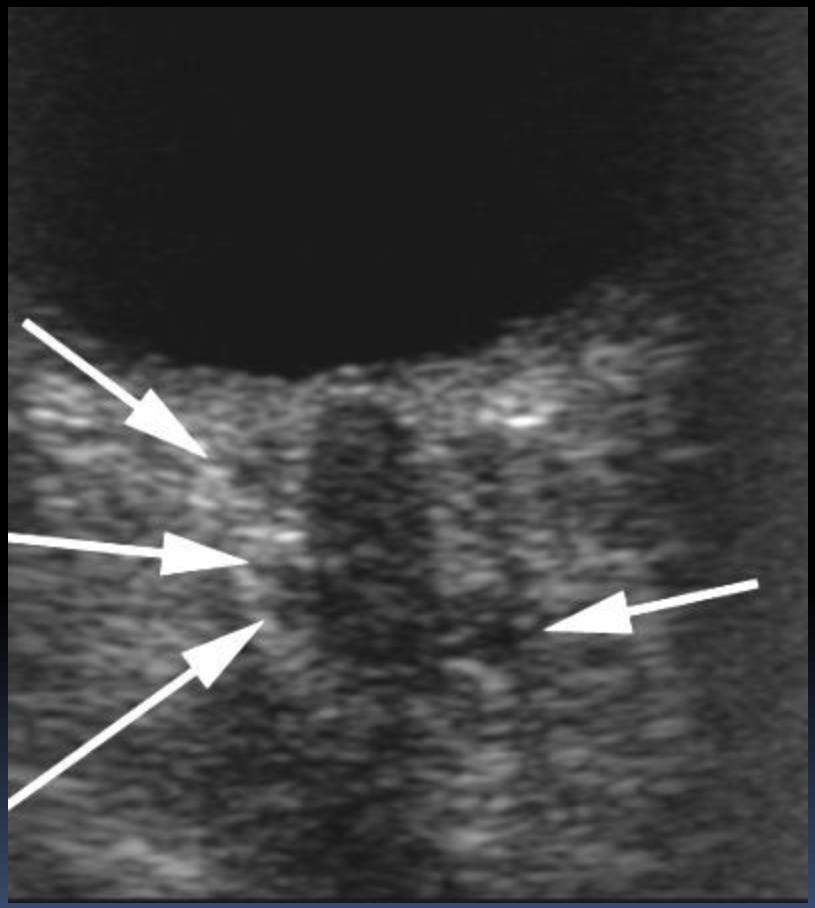




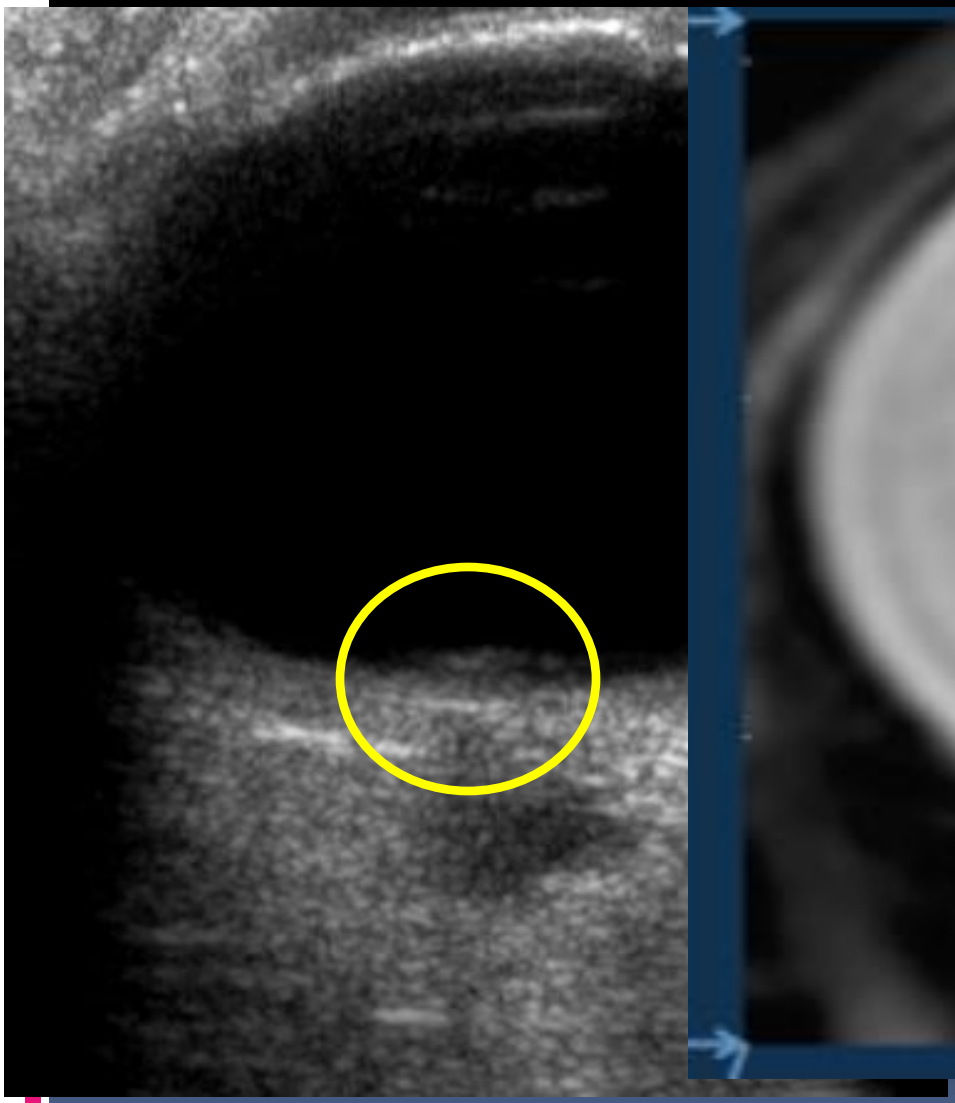


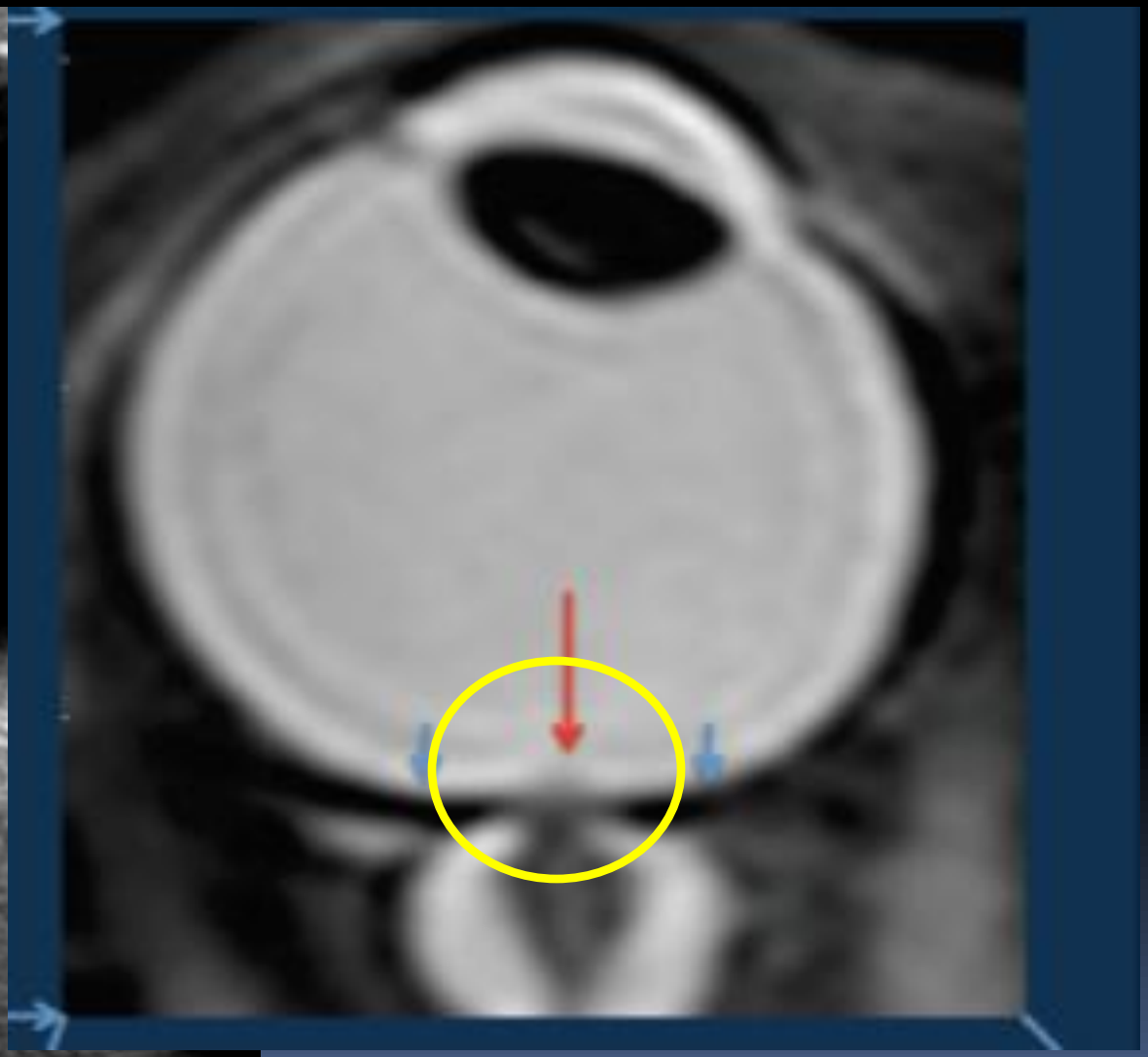


ONS Structure



Papilledema



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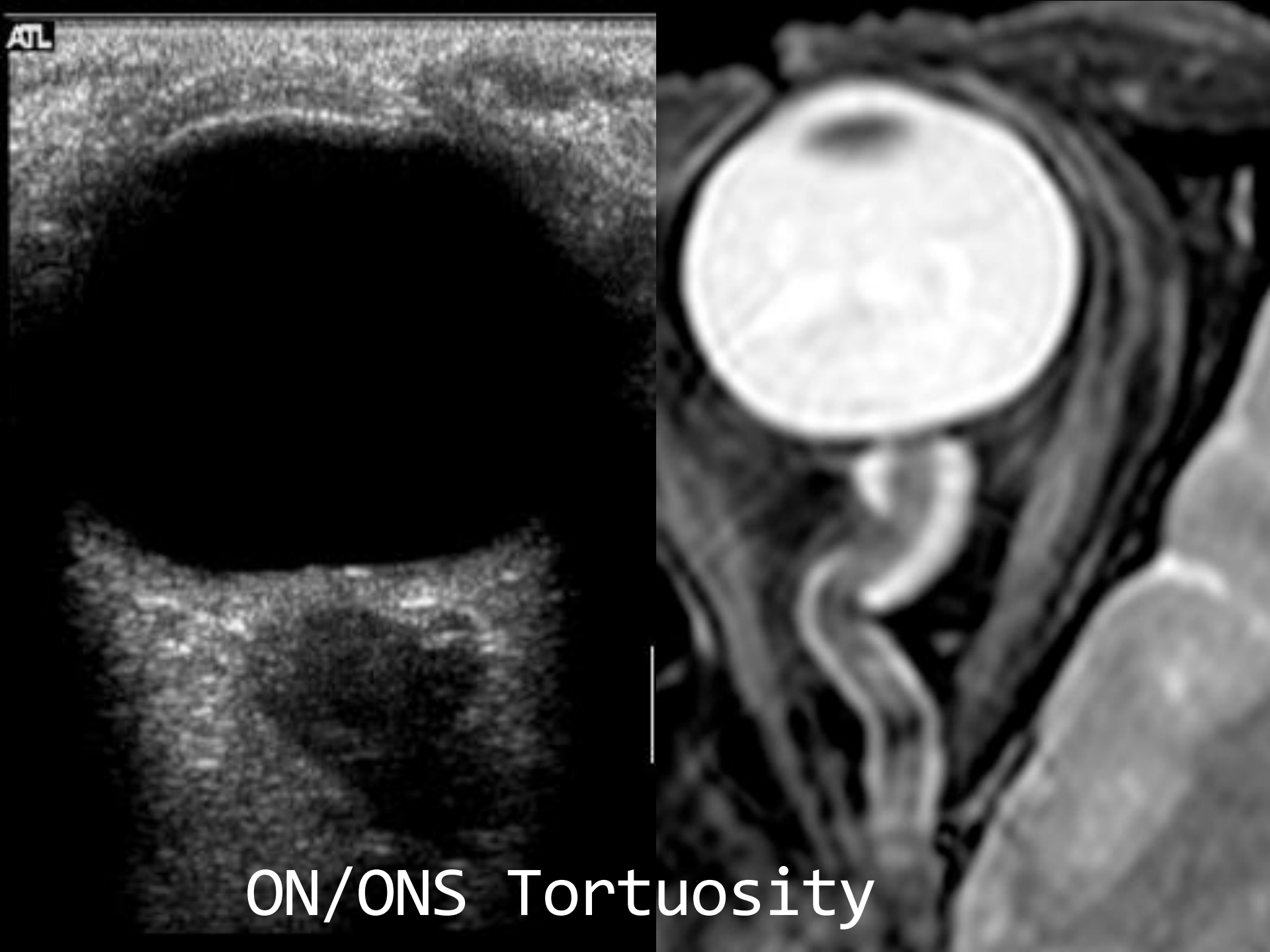
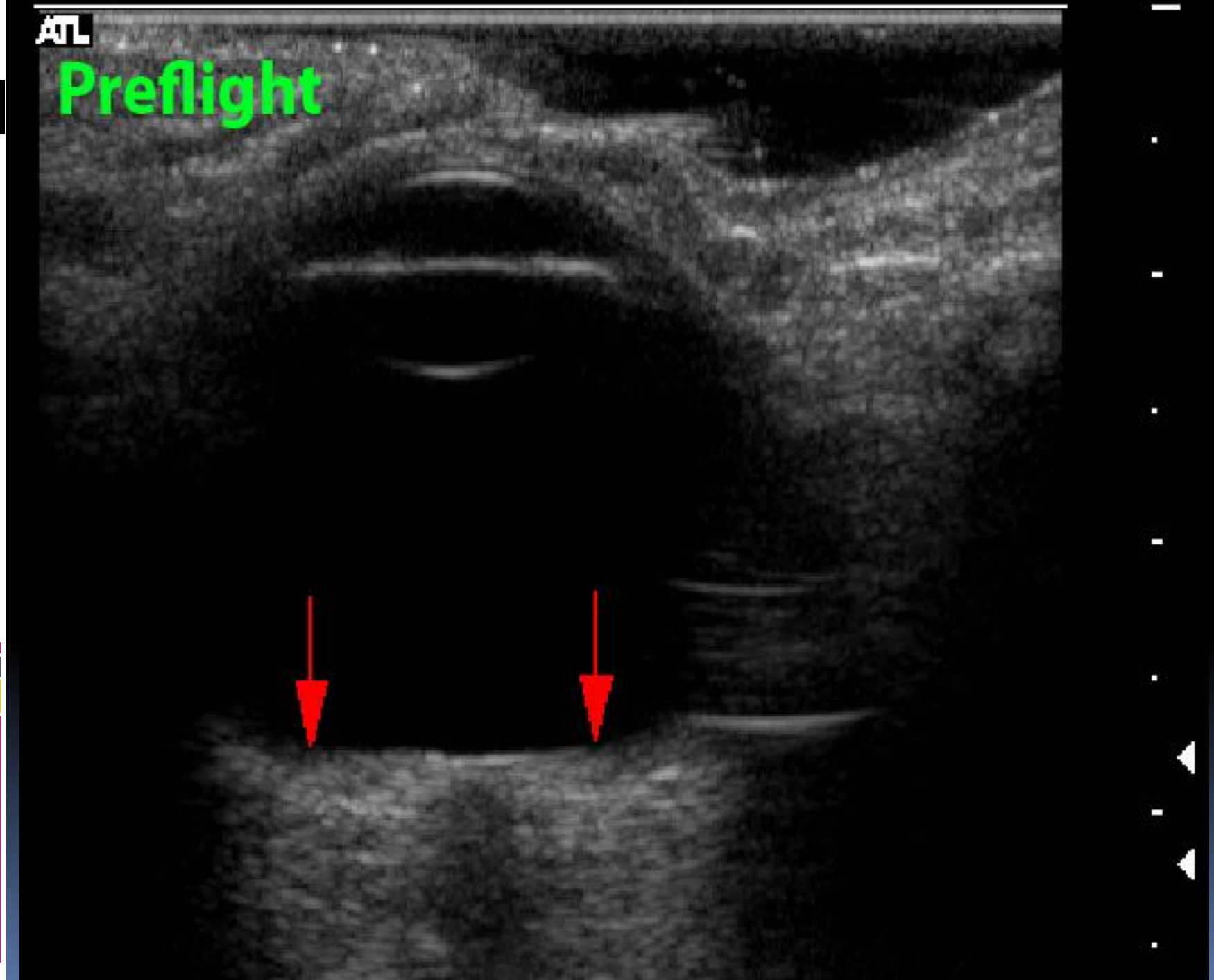


ON/ONS Tortuosity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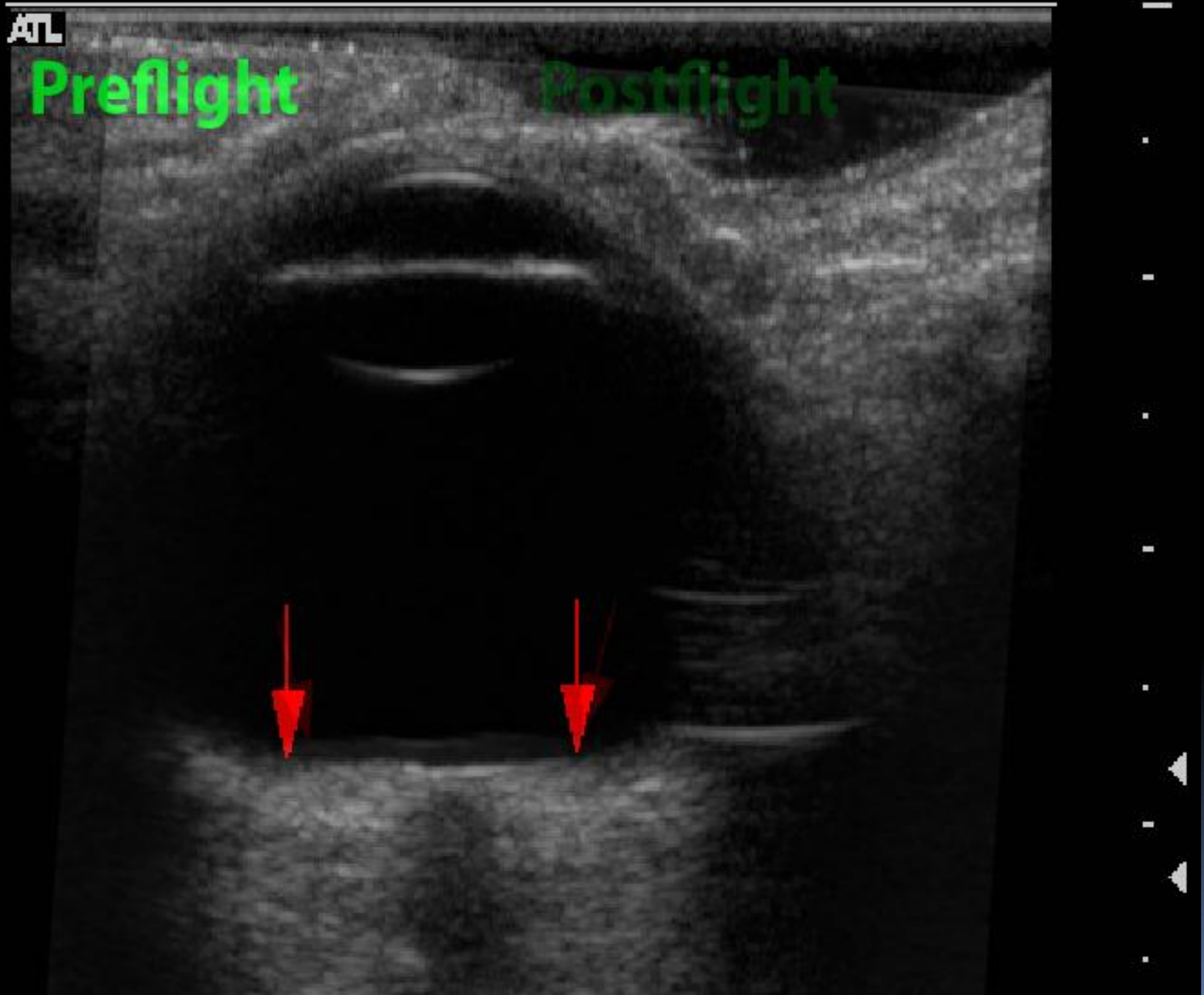
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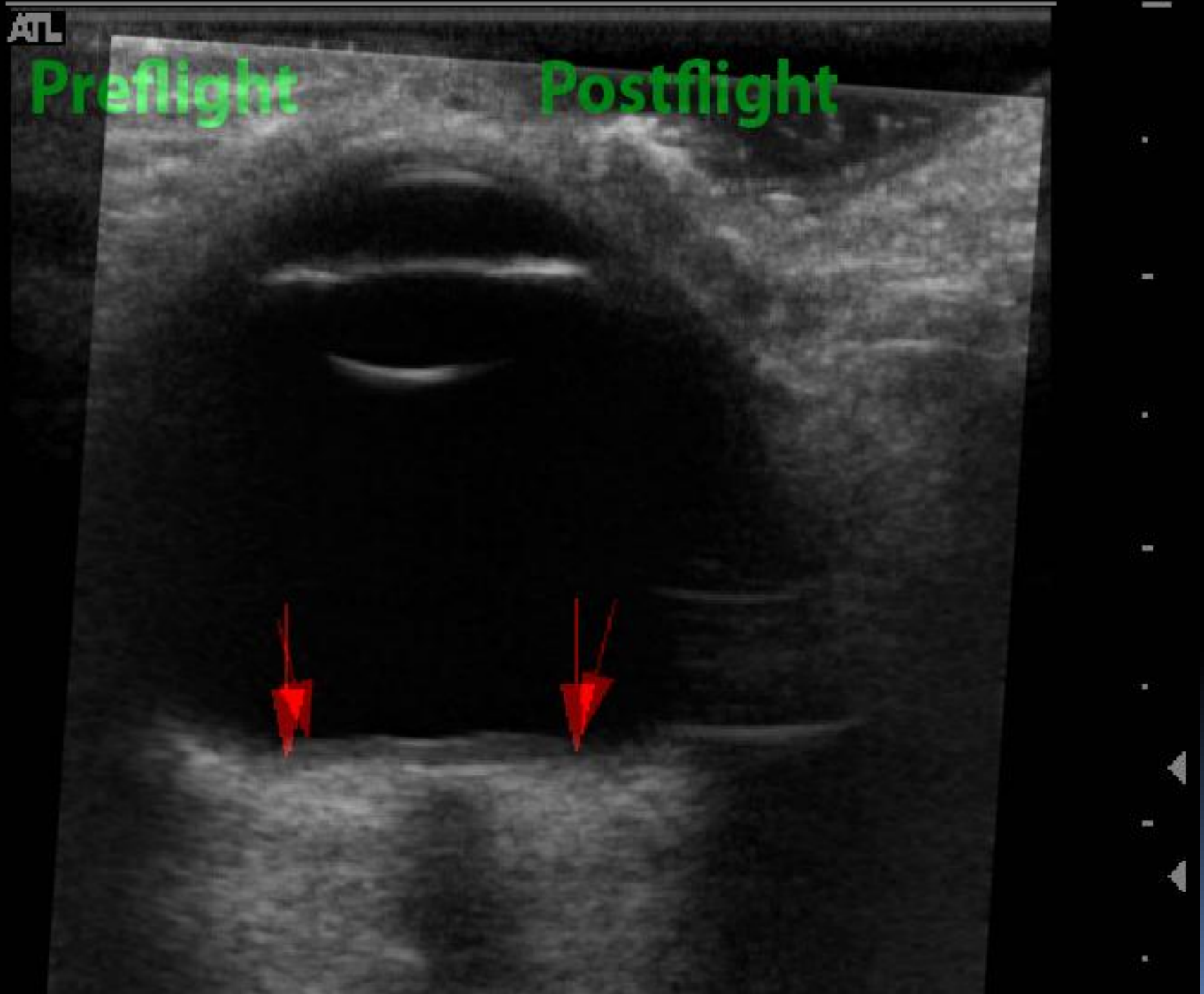
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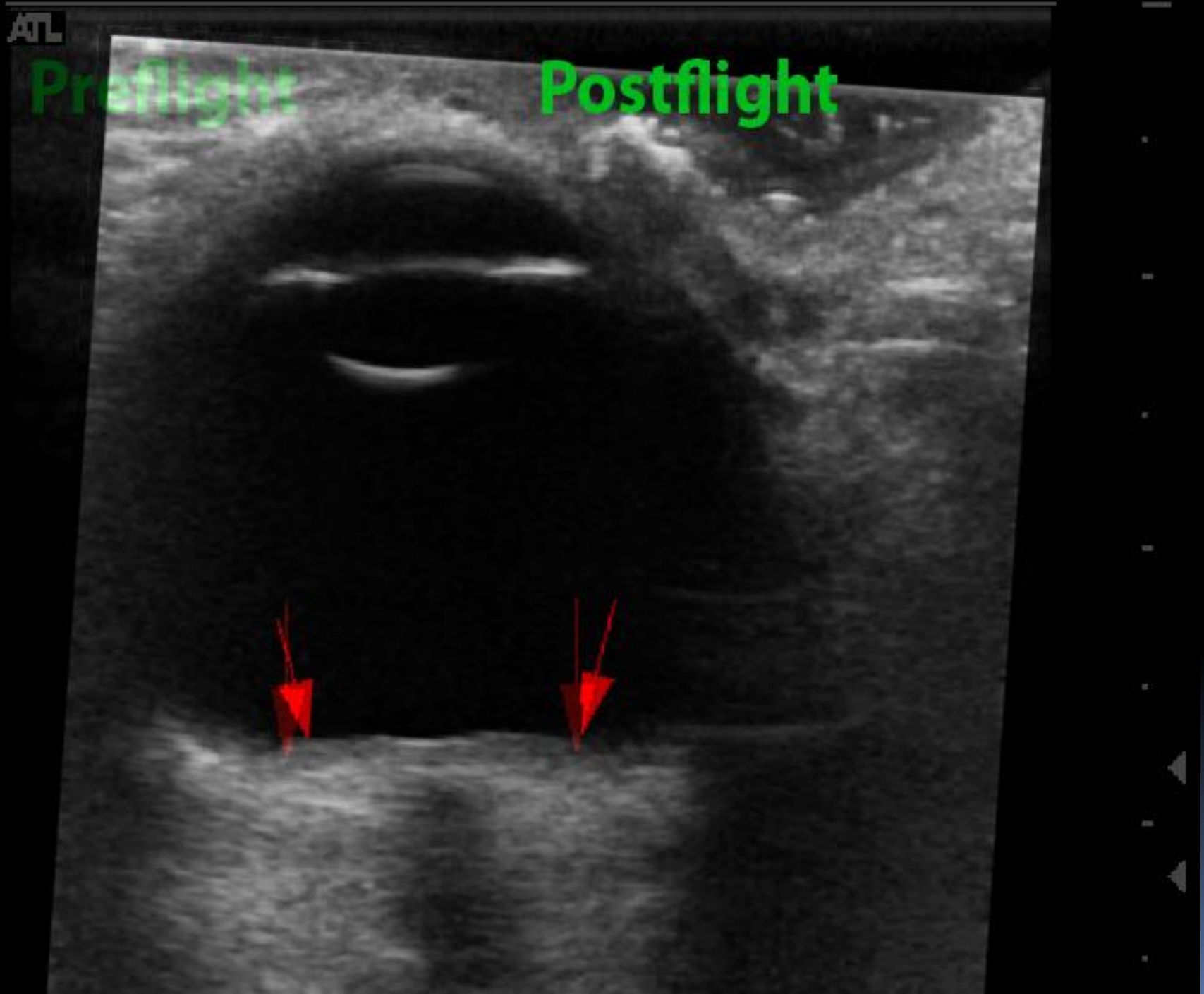
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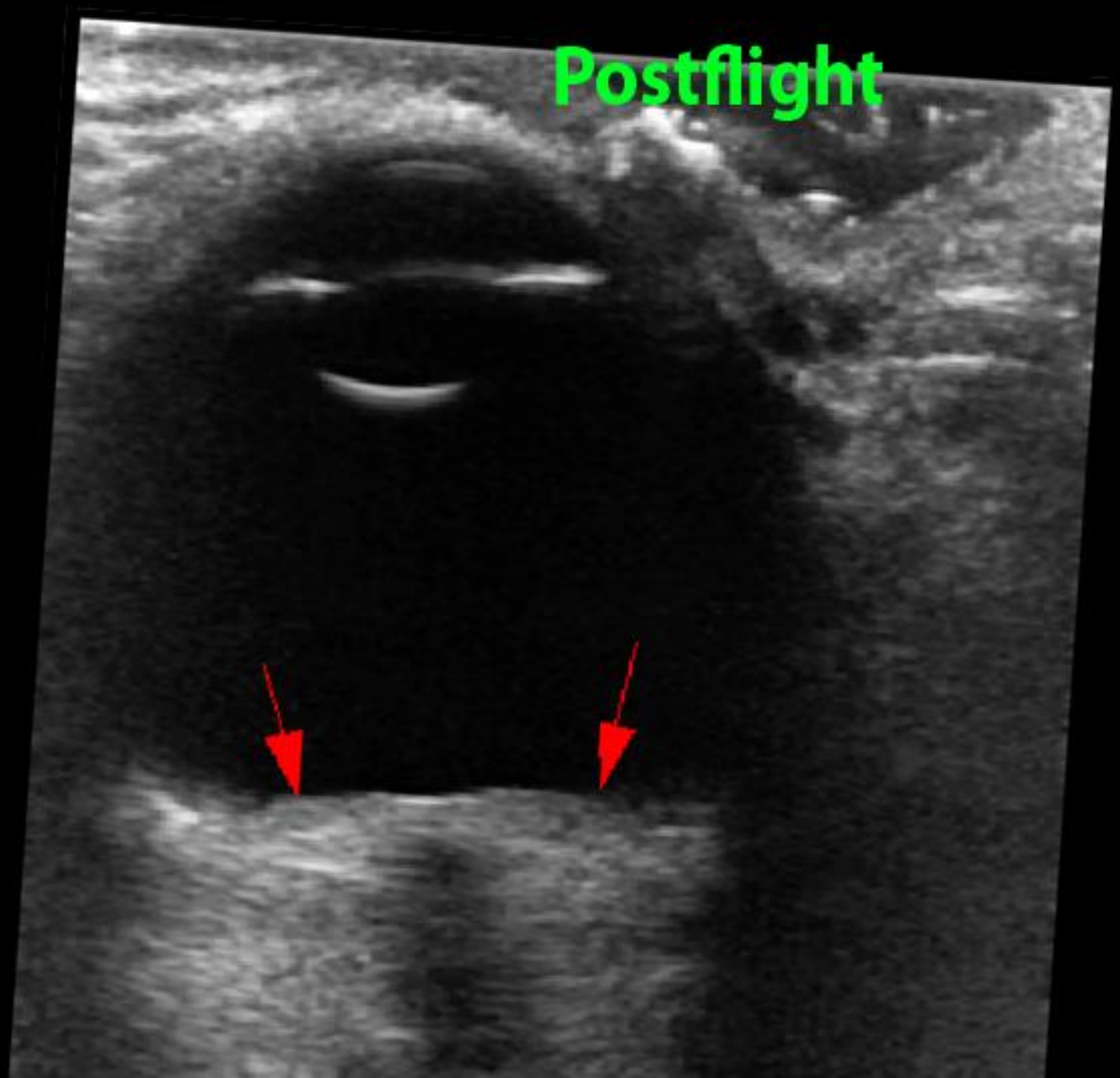
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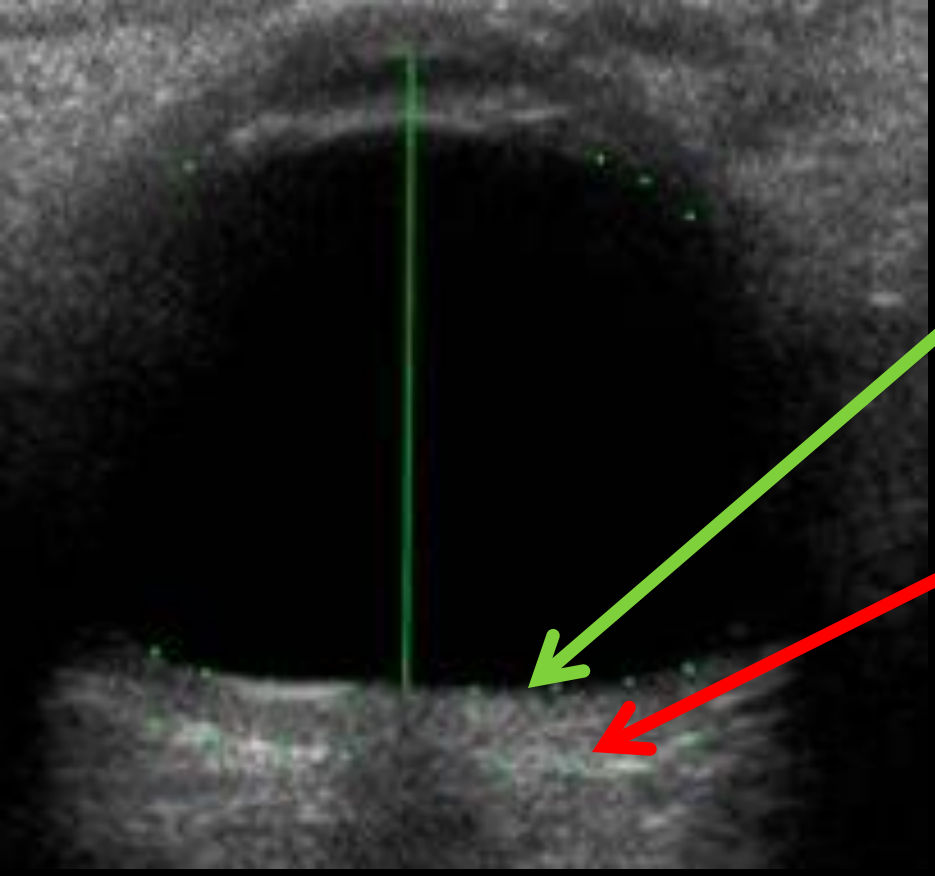
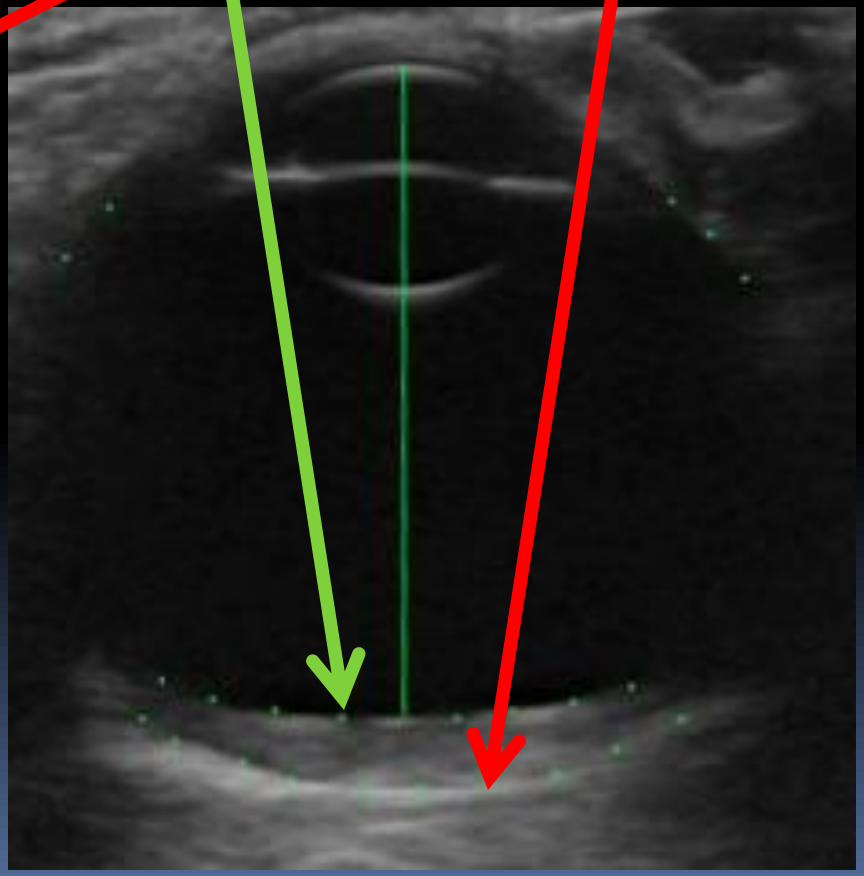
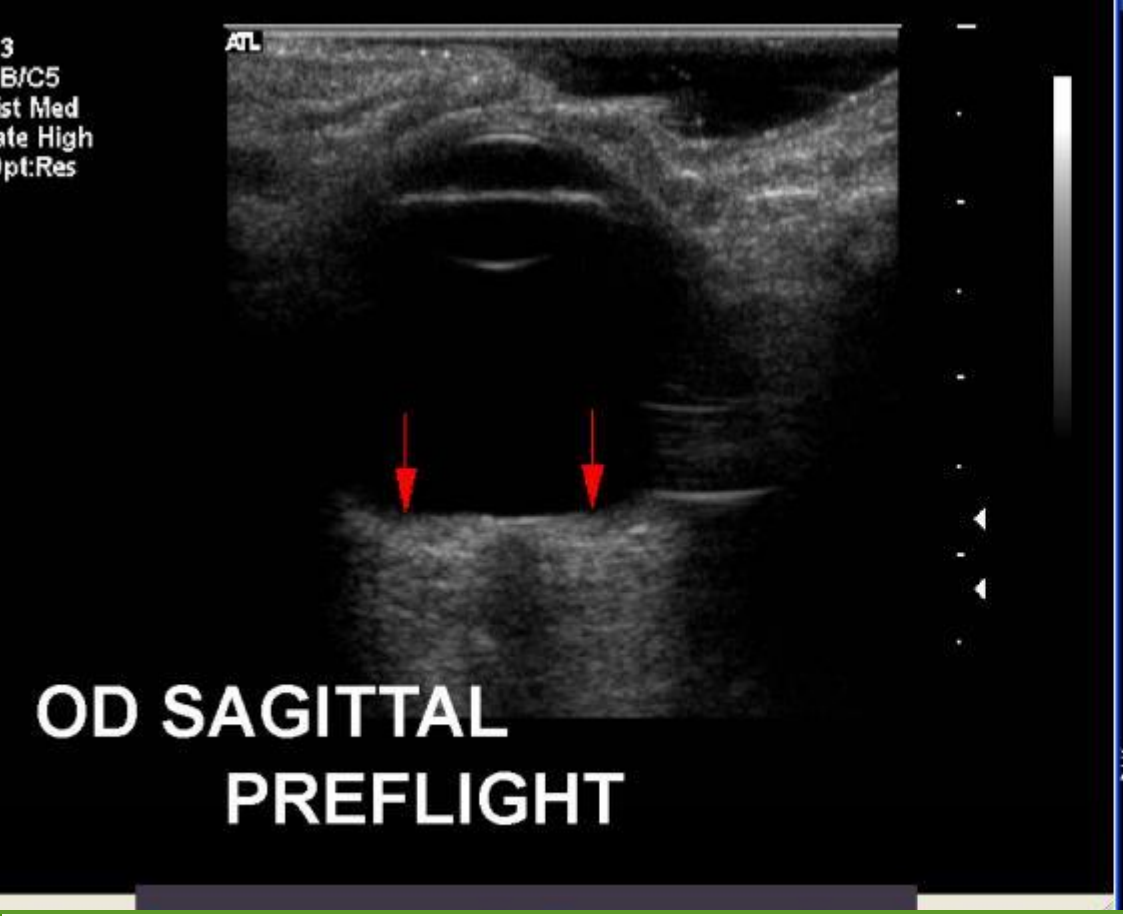




Posterior Pole Thickening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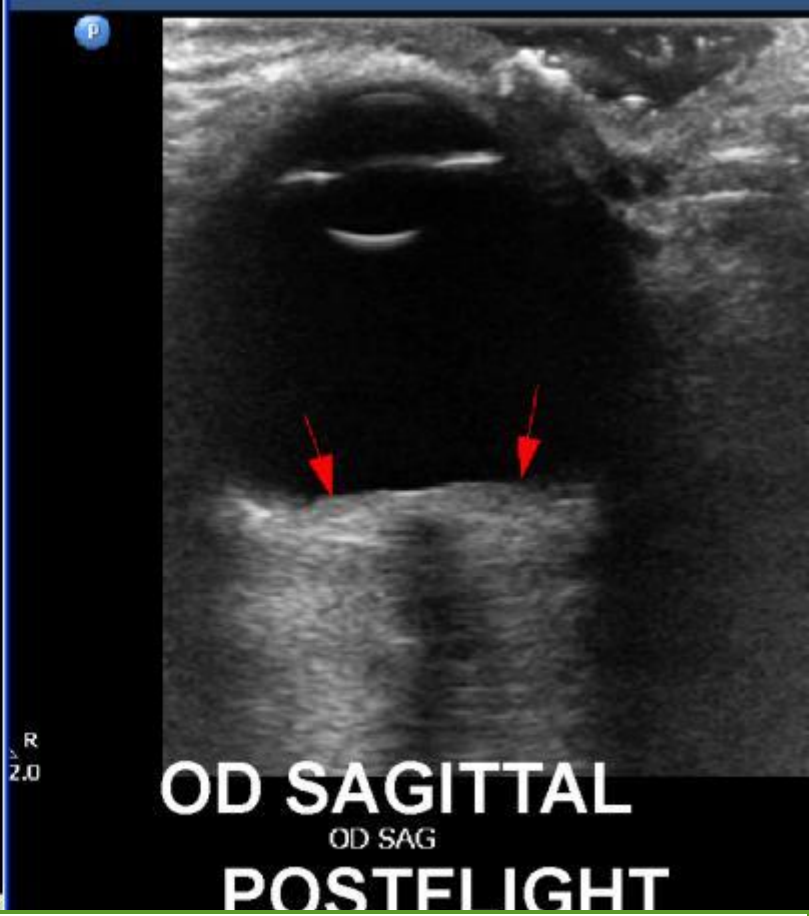
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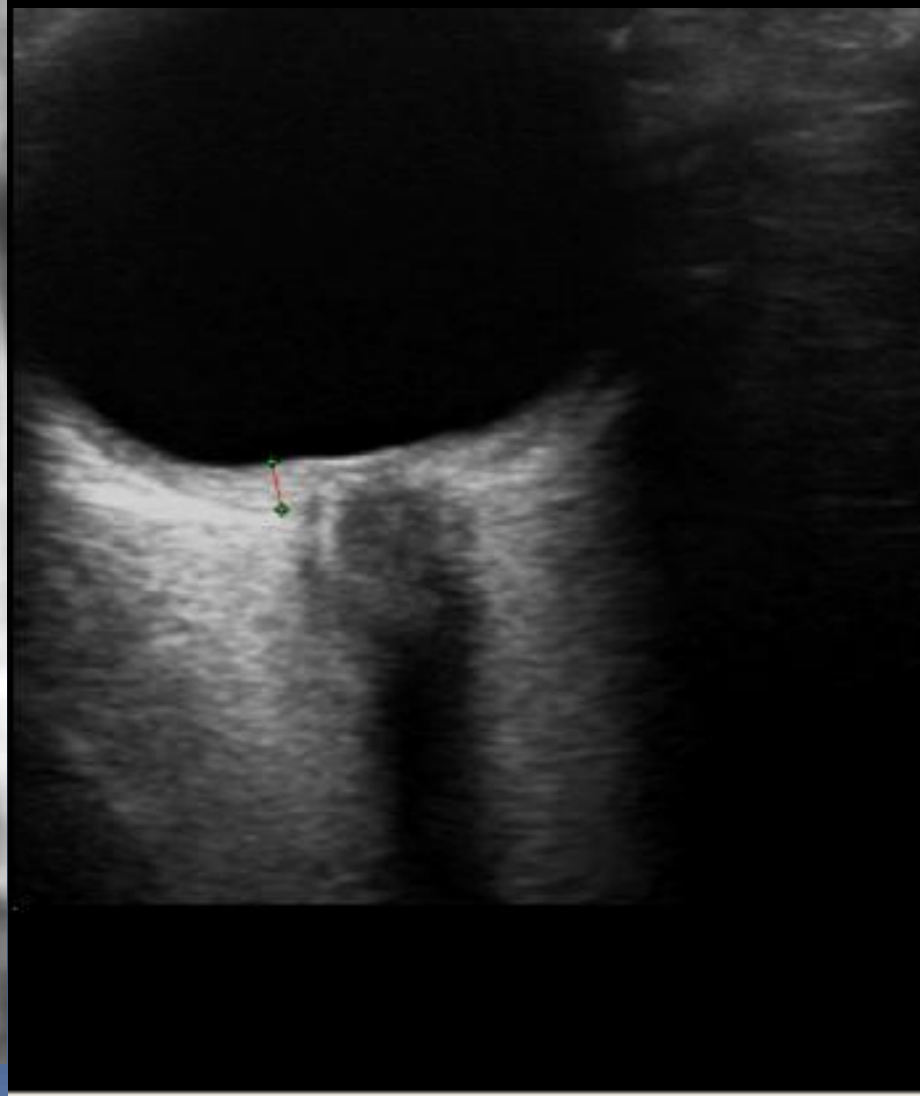
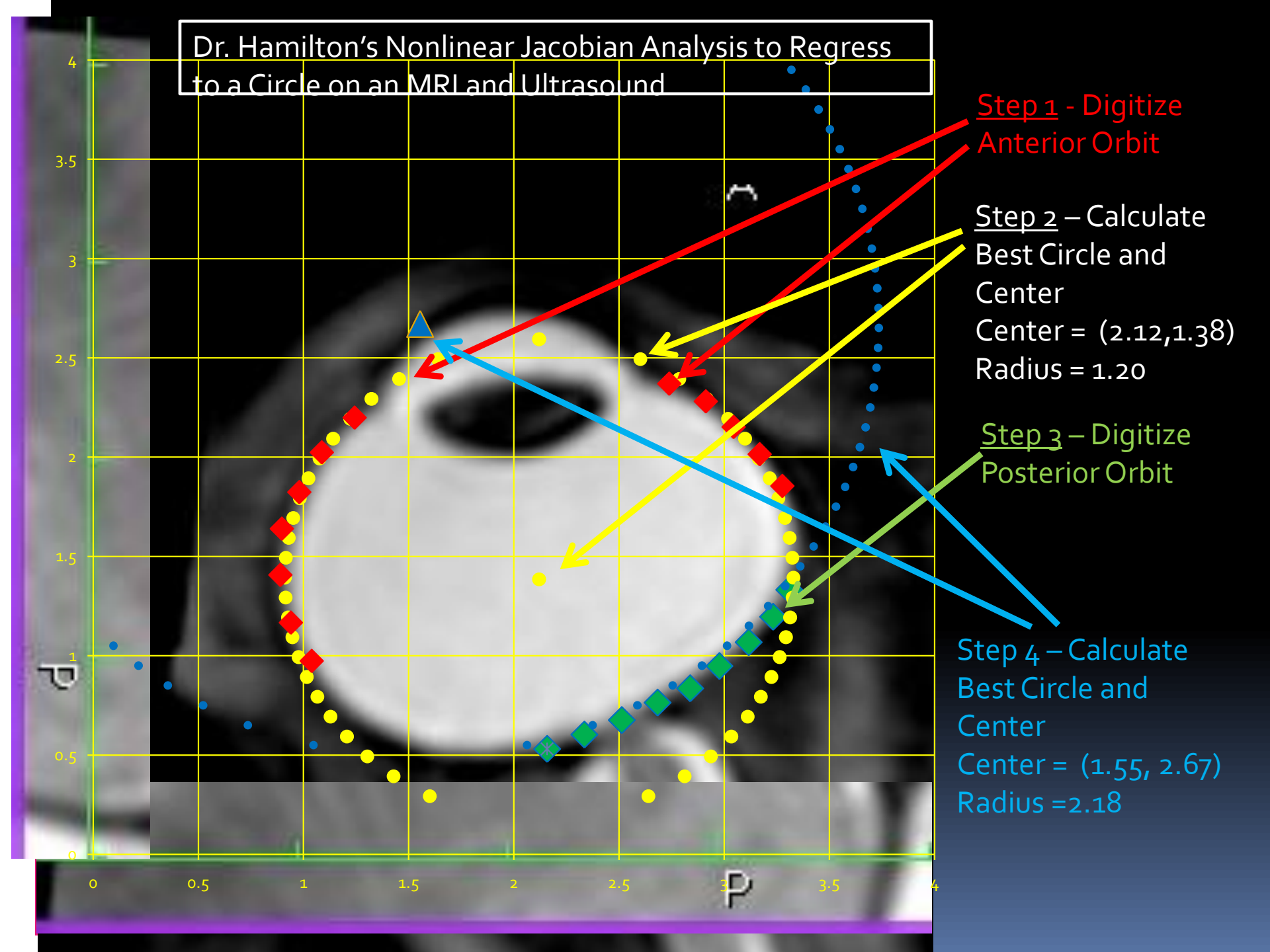
Globe Flattening




Dr. Hamilton's Nonlinear Jacobian Analysis to Regress to a Circle on an MRI and Ultrasound
Step 1 - Digitize Anterior Orbit
Step 2 – Calculate Best Circle and Center
Center = (2.12,1.38)
Radius = 1.20
Step 3 – Digitize Posterior Orbit
Step 4 – Calculate Best Circle and Center
Center = (1.55, 2.67)
Radius =2.18
0
0.5
1
1.5
2
2.5
3
3.5
4
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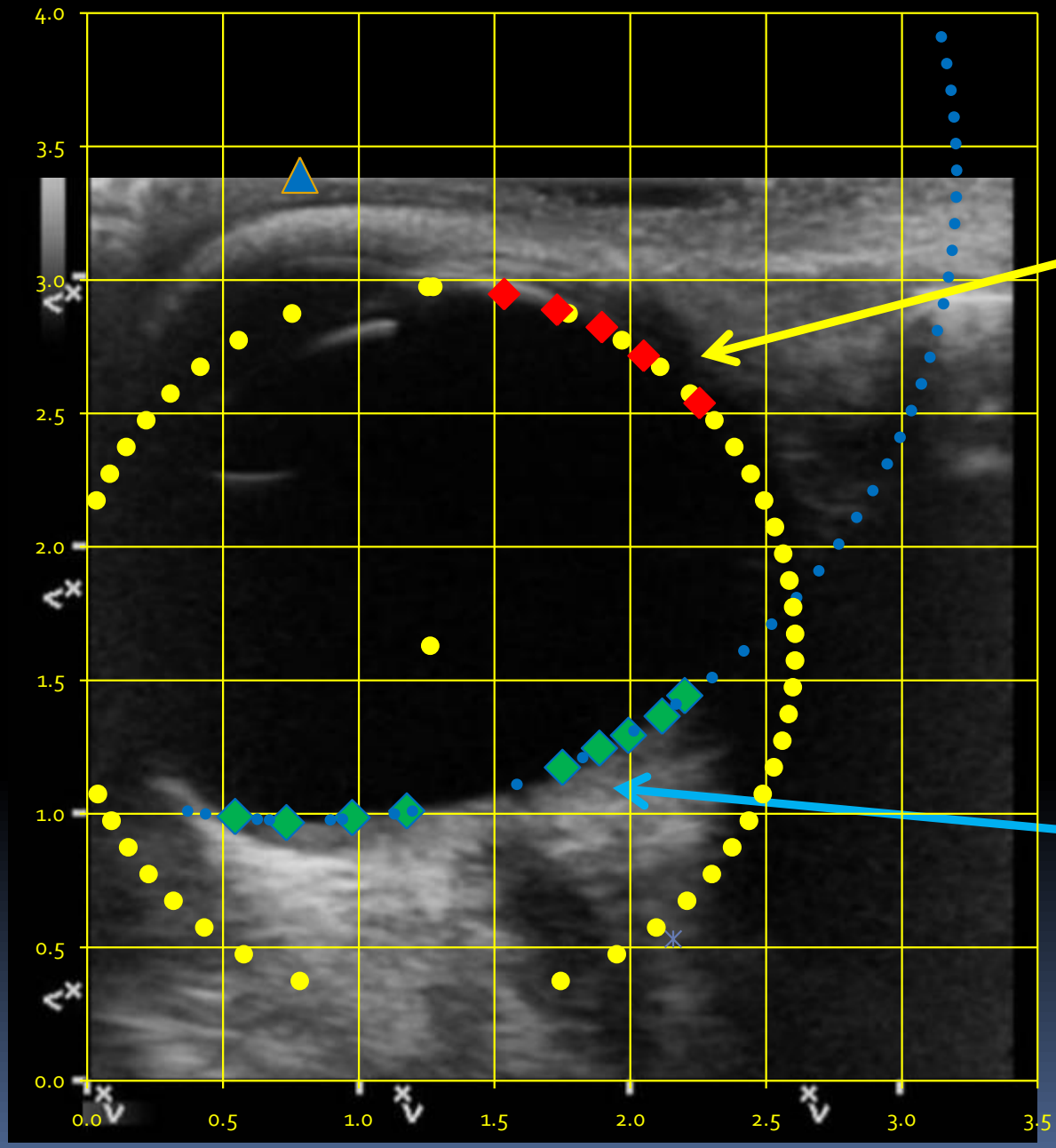
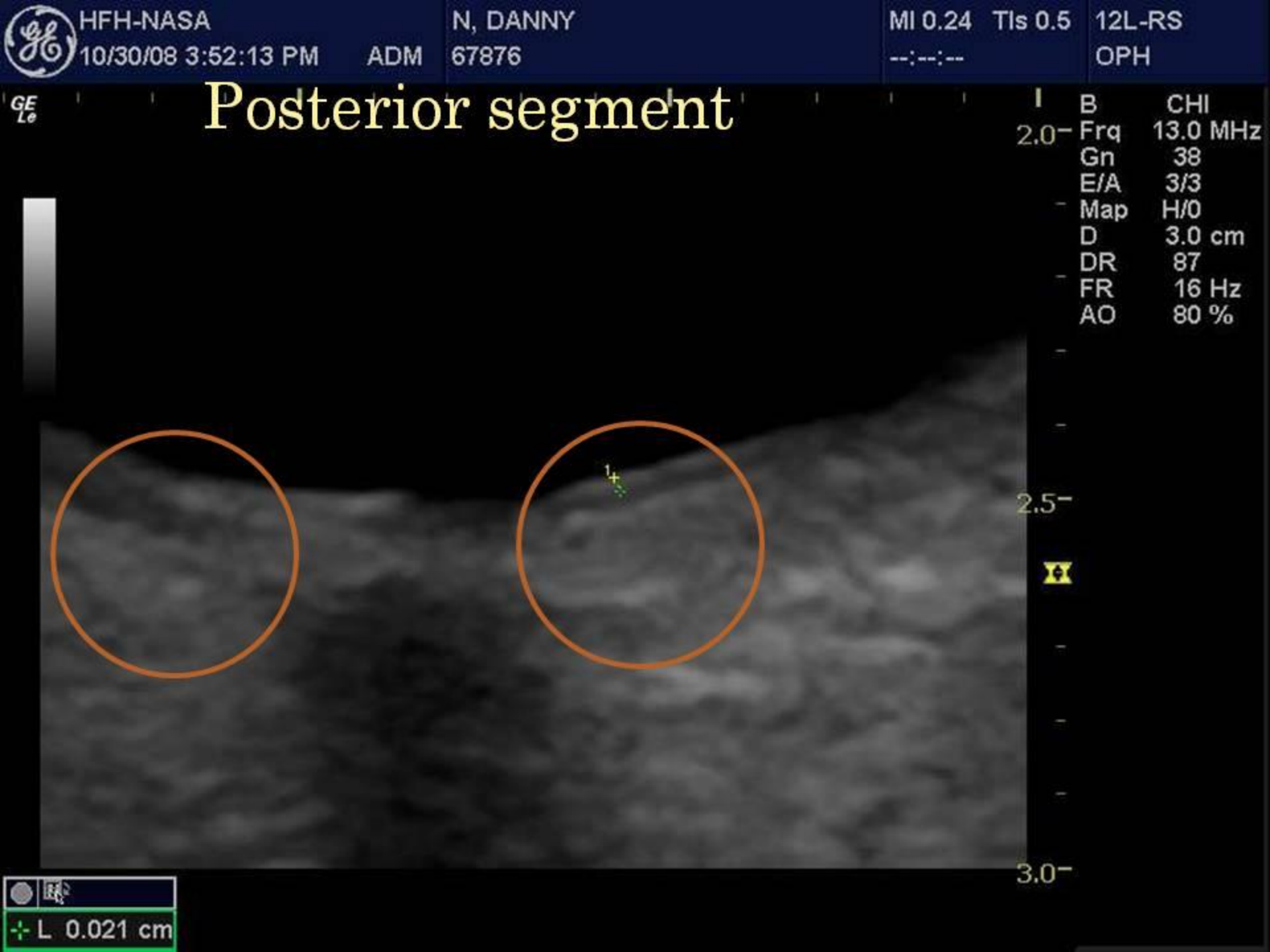


Calculate Best Circle and Center
Center = (1.148,2.146)
Radius = 1.131

Calculate Best Circle and Center
Center = (-0.737, 19.38)
Radius =18.189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MI 0.24 TIs 0.5
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12L-RS
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Posterior segment
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Frq 13.0 MHz
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Map H/0
D 3.0 cm
DR 87
FR 16 Hz
AO 80 %
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2.5
3.0
L 0.021 cm


PHILIPS
MI 0.2
TIS 0.0
SEE-ICP
L12-3
33Hz
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HRes
Gn 88
C 53
1/3/1
MI=0.6
MI=0.2
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G
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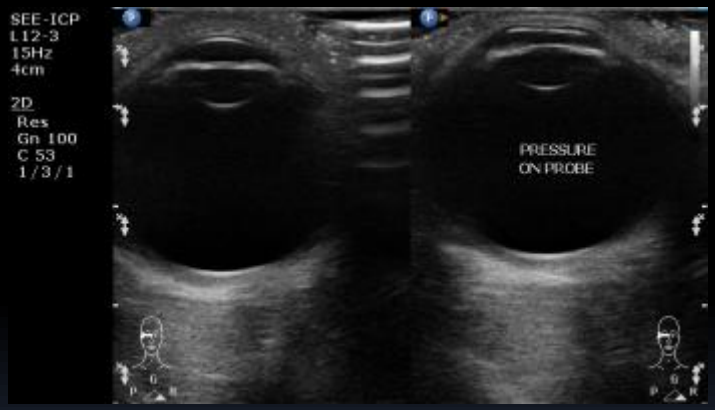
Real-time - maneuvers



Results and Conclusion

- MRI and sonography are tomographic methods, however images obtained by the two modalities are based on different physical phenomena and use different acquisition principles.
- Consideration of the images acquired by these two modalities allows cross-validating findings related to the volume and fluid content of the ON subarachnoid space, shape of the globe, and other anatomical features of the orbit.
- Each of the imaging modalities also has unique advantages, making them complementary techniques.