IMAGING MODALITIES RELEVANT TO INTRACRANIAL PRESSURE ASSESSMENT IN ASTRONAUTS

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Disclosure Information
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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.
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

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>US</th>
<th>MRI</th>
<th>FORMAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anterior chamber survey</td>
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<td>free text based on entire image set</td>
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<tr>
<td>Posterior chamber survey</td>
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<tr>
<td>Antero-posterior Diameter</td>
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<tr>
<td>Papilledema/Disc Edema</td>
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<td>X</td>
<td>semi-quantitative: 0-3</td>
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<tr>
<td>Globe flattening</td>
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<td>semi-quantitative: 0-3</td>
</tr>
<tr>
<td>Optic Nerve Sheath Diameter</td>
<td>X</td>
<td>X</td>
<td>within 3-5 mm from retina; numerical</td>
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<tr>
<td>Characterization of optic nerve sheath structure</td>
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<tr>
<td>Optic Nerve Diameter</td>
<td>X</td>
<td>X</td>
<td>within 3-5 mm from retina; numerical</td>
</tr>
<tr>
<td>Optic Sheath-Nerve Ratio</td>
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<td>X</td>
<td>calculated, numerical, unitless</td>
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<tr>
<td>ON tortuosity</td>
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<tr>
<td>ON sheath hypoechogenicity</td>
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<td></td>
<td></td>
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<tr>
<td>ON T2-hyperintensity</td>
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<td>X</td>
<td>semi-quantitative: 0-3</td>
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<td>Survey of intracranial CSF spaces</td>
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<td>Characterization of sella turcica and pituitary</td>
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<td>free text based on entire image set</td>
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<tr>
<td>Assessment of CSF production rate</td>
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<td>Characterization of CSF flow through the Sylvian aqueduct</td>
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<td>Other Notes: Compared with: [dates]</td>
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</tr>
<tr>
<td>IMPRESSION:</td>
<td></td>
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</table>
Optic Nerve Characterization
ONS Structure
Papilledema
Posterior Pole Thickening
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
Calculate Best Circle and Center
Center = \((-0.737, 19.38)\)
Radius = 18.189

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
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.