Screening and Management of Asymptomatic Renal Stones in Astronauts

David Reyes, MD, MPH\textsuperscript{1,2,3}, James Locke, MD, MPH\textsuperscript{1}, Ashot Sargsyan, MD\textsuperscript{1,3}, and Kathleen Garcia, RDMS\textsuperscript{1,3}

\textsuperscript{1} NASA – Johnson Space Center, Flight Medicine Clinic
\textsuperscript{2} University of Texas Medical Branch at Galveston, Aerospace Medicine
\textsuperscript{3} KBRwyle, Houston, Tx

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Disclaimer

- No off label uses
- No conflicts of interest
Overview

• Anatomy and pathology
• Epidemiology
• Screening
• Management
• Waiver
Kidney with moderate hydrenephrosis
General Population

- Lifetime prevalence 10% male, 5% female
  - Increasing incidence (20 - 74 y.o.)
- 3.7% to 4.6% of commercial aviation pilots

Mineralized Renal Material (MRM)

- Small areas of calcification found incidentally
- Of uncertain significance
- We need to characterize MRM
  - How common?
  - Do they turn into stones or disappear with time?
  - Is spaceflight a risk factor for clinical stones?
Screening Needs

• Management of MRM/stone has varied widely

• Unknown how many astronauts have MRM

• Understanding is important for future missions
Screening Needs

- Periodic screening → Annual exams
- Low or no radiation → Ultrasound
- Standardized methodology → Ultrasound review panel
- Standardized management → A clinical practice guideline
When to Screen?

- All Active Astronauts: Annual Ultrasound
- History of Renal Stone: Annual Ultrasound and Labs
- SFTL: Ultrasound L - 6 Months
- Post-Flight: Ultrasound R +1 Month

See Management Matrix
Ultrasound Benefits

- Low cost
- No radiation
- Easy to do
- Easy to repeat
- Minimal time commitment for astronauts
## Natural History

<table>
<thead>
<tr>
<th>Size (mm)</th>
<th>Stone Free</th>
<th>Progression</th>
<th>Intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;= 5</td>
<td>28%</td>
<td>40.4%</td>
<td>5.3%</td>
</tr>
<tr>
<td>5 - 10</td>
<td>4.8%</td>
<td>52.4%</td>
<td>9.5%</td>
</tr>
<tr>
<td>&gt;= 10</td>
<td>0%</td>
<td>71.4%</td>
<td>14.3%</td>
</tr>
</tbody>
</table>

Spontaneous Passage vs. Stone Size

Ueno et al. (1977), Relation of spontaneous passage of ureteral calculi to size, Urology, 10(6):544-546
Enhanced U/S Protocol

1. **Echogenic** → seen from 2 or more angles
2. **Shadowing** → opaque to ultrasound
3. **Twinkling** → twinkling in Doppler mode
4. **Dispersion** → spectral frequency dispersion
5. **Measurable** → >3 mm
6. **Location** → parenchymal, papillary or collecting system
Enhanced U/S Protocol

- Standardized and systematic screening
- Multiple scanning positions
- Multiple probe views
- Various ultrasound modes
Clinical Practice Guideline

- **Annual ultrasound** for all active astronauts

- Use of **specialized ultrasound** protocol

- Suspicion for stone → Low-dose, high resolution **CT**

- Stone by CT → **Flexible Ureteroscopy** preferred

- **Mission assignment** affects treatment method

- **Potential waivers** for very small, stable MRM
US Navy Standards

• **Waivers** given for...
  - calcium oxalate, calcium phosphate, uric acid and struvite;
  - retained stones in the **renal parenchyma**;
  - recurrent stones > 12 months apart.

• Medical evaluation & urology consult required
US Navy Standards

- Waivers **NOT** given for...
  - recurrent stones within one year
  - cysteine stones
  - hypercalcuria
  - stones retained in the **collecting system**
Astronaut with Renal Stone History

>1 stone episode per year

Yes

No

Multiple stones at once

Yes

No

Metabolic abnormality

Yes
Where we are…

- All active astronauts have been screened
  - 4 were post-flight
- Seven renal panel meetings done
- Prelim results to NASA-AMB Summer 2017
Ureteral Stone Size and Time to Passage


Thank you.

David Reyes
dpreyes@utmb.edu
<table>
<thead>
<tr>
<th></th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
<th>Dose (mSv)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ultrasound</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Average 2.6 mm (1 – 9 mm, SD 1.15), n = 51 pts, 114 stones [17]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shadowing alone</td>
<td>65 (PPV 90)</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>Twinkling alone</td>
<td>81 (PPV 94)</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>Shadowing + Twinkle</td>
<td><strong>88 (PPV 96)</strong></td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>Average 3.9 mm (1 - 20 mm), n = 105 pts, 65 stones, CT as reference [18]</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Shadowing alone</td>
<td>48 (PPV 81)</td>
<td>99</td>
<td>0</td>
</tr>
<tr>
<td>Shadowing + Twinkle</td>
<td><strong>55 (PPV 67)</strong></td>
<td><strong>99</strong></td>
<td>0</td>
</tr>
<tr>
<td><strong>X-Ray</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>KUB</td>
<td>45 - 58</td>
<td>69 - 77</td>
<td>0.7</td>
</tr>
<tr>
<td>IVP</td>
<td>85</td>
<td>90</td>
<td>3</td>
</tr>
<tr>
<td><strong>CT</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low-dose, non-con.</td>
<td>97</td>
<td>95</td>
<td>3</td>
</tr>
<tr>
<td>Non-contrast</td>
<td>95 – 98</td>
<td>96 - 98</td>
<td><strong>10</strong></td>
</tr>
<tr>
<td><strong>MRI</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>93 - 100</td>
<td>95 - 100</td>
<td>0</td>
</tr>
</tbody>
</table>