Percutaneous Drainage Capability for Deep Space Exploration

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Disclosure Information

AsMA 89th Annual Scientific Meeting

• We have no financial relationships to disclose
• We will not discuss off-label use or investigational uses
Objectives

• Discuss current evidence based capabilities of percutaneous drainage (PCD) for spaceflight
Exploration Medical Capabilities (ExMC)

- Expanding capability beyond LEO
- New challenges
  - No evacuation
  - Communication delays
  - Mass/volume constraints
- Need robust autonomous capabilities

“Evidence Report: Risk of Adverse Health Outcomes and Decrement in Performance due to In-Flight Medical Conditions,” 2017
Percutaneous Drainage

• Drainage of fluid, abscess or air
• Needle or catheter placement
• Often with image guidance
• Benefits
  – Preferred for many conditions
  – Simple
  – Repeatable
  – Minimally invasive
Equipment

• Low mass and volume
• Alternate medical/non-medical uses
• Ultrasound Imaging likely imaging modality
• Ongoing development
  – Flow is reduced at 0G compared to 1G\textsuperscript{1}

\textsuperscript{1}L. Brown, Personal Communication, October, 23, 2017
Equipment

Hanging strap with spring clip
Suction bellows
Luer lock connector
Stretchable connector tube
Double anti-reflux valve system
Graduated collection bag
Empty port (TCS500D, TCS500DS, TCS300D)
Write-on area

Percutaneous Drainage
Training and Currency: MicroG

• Standard sterile technique
• Tubing and equipment tethering
• Altered fluid mechanics
• Abdomen tends to “circularize”¹
• Parabolic flight tests
  – Successful aspiration of intra-peritoneal fluid
  – No more demanding than 1-G rehearsals
  – Fluid collections more distinct from surrounding viscera²

¹Surgical Capabilities for Exploration and Colonization Space Flight,” 2015.
²A W Kirkpatrick et al., 2002
Training and Currency: Deep Space

• Non-physician versus physician astronaut
• Emergency Physicians (ACEP) training guidelines:
  – Sixteen to twenty four hours\(^1\)
• ISS FAST exam trial: successful exam with
  – three hours of familiarization
  – two hours hands on training\(^2\)
  – Non medical crew
• Augmented reality computer based simulations\(^3\)
  – May provide ongoing review and training on mission

\(^1\)Emergency Ultrasound Guidelines, 2009
\(^2\)Sargsyan et al., 2005
\(^3\)Magee et al., 2007
Percutaneous Drainage

• Integrated Medical Model (IMM) conditions:
  • Appendicitis
  • Acute Cholecystitis
  • Chest Injury
  • Abdominal Injury
  • Urinary Retention
  • Hydronephrosis (kidney stone)
Appendicitis

• Percutaneous drainage
  – Only intervention available in ExMC
  – Ruptured appendix and intra-abdominal abscess
  – 64% success rate with US guided drainage\(^1\)

• Recent meta-analysis:
  – Antibiotic treatment comparable to appendectomy
  – 72% antibiotic success rate\(^2\)
  – 14.2 to 20% subsequent surgical appendectomy\(^3\)

• Modification of success rates needed
  – Healthy crew
  – Quick treatment and no surgical option

\(^1\)Fagenholz et al., 2016
\(^2\)Zhi-Hua Liu, 2014
\(^3\)Flum, 2015
Home Remedies for Appendicitis

Castor Oil Remedy

1. Fold a large flannel cloth into layers and pour 2 tbsp castor oil on it.
2. Lie down on an old towel & put the flannel cloths on your abdomen.
3. Repeat this remedy 3 times a week for 2 to 3 months.

To explore more, visit www.Top10HomeRemedies.com
Acute Cholecystitis

- Drainage via perc. transhepatic cholecystostomy
- Can be definitive procedure
- 94 % technical success rate
- 86 % procedural success rate
- US lower complication /death rate versus fluoroscopy

Wagner et al., 2017
Hemothorax/Pneumothorax

• 100% Success with pneumothorax
• 80% Success with loculated pleural effusions\(^1\)
• Successful with different pleural fluids
• Studies found minimal complications
• Significant clinical improvement\(^2\)

\(^1\)Bediwy & Amer, 2012; Liu et al., 2010
\(^2\)Aziz, Penupolu, & Flores, 2012
Abdominal Compartment Syndrome

- Intra-abdominal pressure >12 mm hg
- Possible etiologies in spaceflight\(^1\)
  - Abdominal trauma
  - Hemorrhage
  - Intestinal obstruction
  - Large Burns
- Percutaneous drainage preferred over laporotomy\(^2\)
- PCD is safe and effective in preventing ACS in burn patients\(^3\)

\(^1\)Backer, 1999
\(^2\)Kirkpatrick et al., 2013
\(^3\)Latenser et al., 2002
Urinary Retention

- Suprapubic catheterization safely performed in remote areas by non-physicians\(^1\)
- Study showed suprapubic catheterization to be:
  - Quick procedure
  - High success rate
  - Minimal complications
  - Recommended after 2 or 3 failed transurethral attempts\(^2\)

\(^1\) Gujral, Kirkwood, Hinchliffe, & Gujral, 1999
\(^2\) Bilehjani E & Fakhari S, 2017
Hydronephrosis

- Kidney stone usual cause
- Found in 89% of suspected stone\(^1\)
- US guided placement success rate 96%\(^2\)
- Complete urinary obstruction
  - One week-complete recovery of kidney function
  - Twelve weeks- Non recoverable kidney damage

\(^1\)Song et al., 2016
\(^2\)Lodh et al., 2014
Complications

- Infection
- Bleeding
- Nephrostomy complication rate 10% \(^1\)
- Abdominal PCD complications < 5%
- Bowel puncture with 21 g needle “inconsequential” in most cases\(^2\)

\(^1\)Pabon-Ramos et al., 2016
\(^2\)Lorenz & Thomas, 2006
Further Research

• Risk mitigation
  – Guidance and training
  – Physician-astronaut utilization

• Optimal catheter size and materials

• 3D printing of supplies
PCD Conclusions

• Achievable skill by physician and non-physician
• Small overall resource burden
• Treat surgical conditions that can occur in spaceflight
• Many advantages of a robust procedural capability
• Decreases mission risk
Thank You
References

References


National Aeronautics and Space Administration

Percutaneous Drainage