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 Decrements 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
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 viscera\(^2\)

\(^1\)Surgical Capabilities for Exploration and Colonization Space Flight,” 2015.
\(^2\)A 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 laparotomy\(^2\)
- 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
