

# Percutaneous Drainage Capability for Deep Space Exploration

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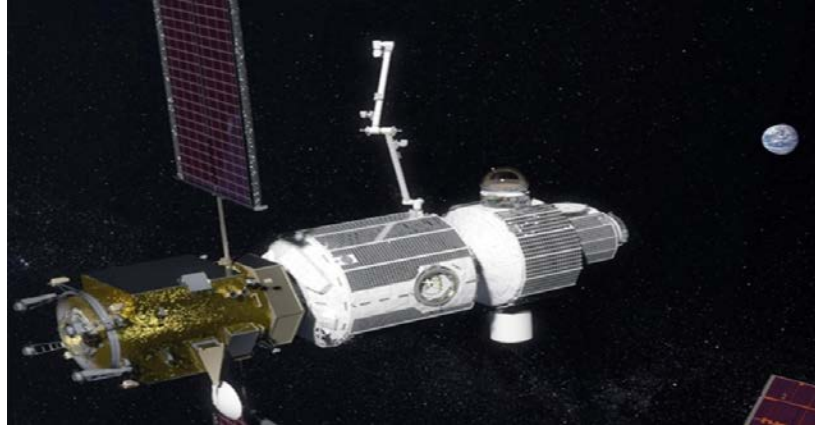
# Disclosure Information

*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

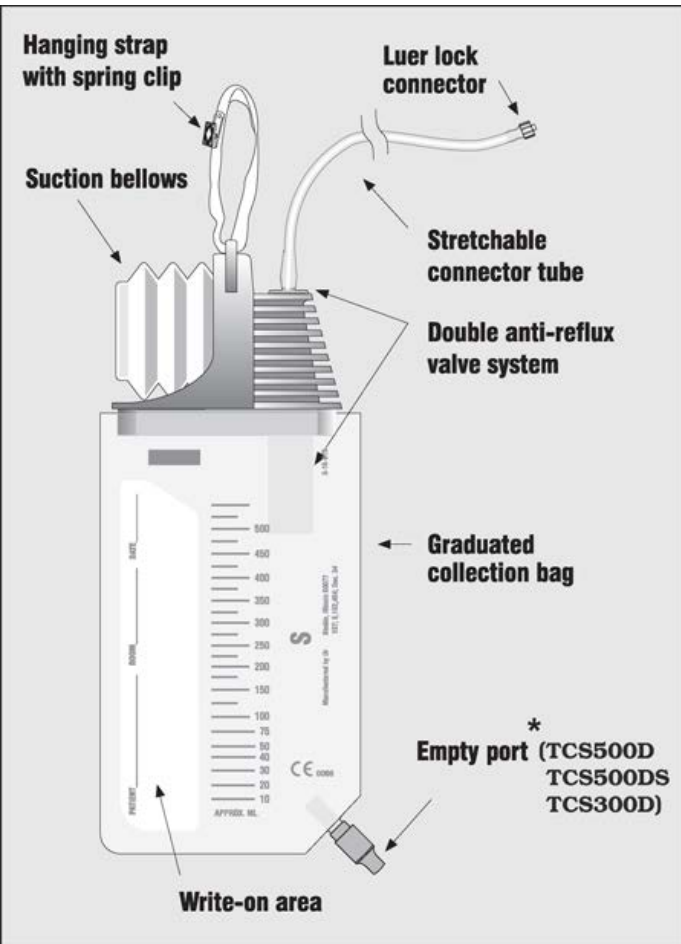
# Equipment

- Low mass and volume
- Alternate medical/non-medical uses
- Ultrasound Imaging likely imaging modality
- Ongoing development
  - Flow is reduced at 0G compared to 1G<sup>1</sup>



<sup>1</sup>L. Brown, Personal Communication, October, 23,2017

# Equipment



# Training and Currency: MicroG

- Standard sterile technique
- Tubing and equipment tethering
- Altered fluid mechanics
- Abdomen tends to “circularize”<sup>1</sup>
- Parabolic flight tests
  - Successful aspiration of intra-peritoneal fluid
  - No more demanding than 1-G rehearsals
  - Fluid collections more distinct from surrounding viscera<sup>2</sup>



<sup>1</sup>Surgical Capabilities for Exploration and Colonization Space Flight,” 2015.

<sup>2</sup>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<sup>1</sup>
- ISS FAST exam trial: successful exam with
  - **three** hours of familiarization
  - **two** hours hands on training<sup>2</sup>
  - Non medical crew
- Augmented reality computer based simulations<sup>3</sup>
  - May provide ongoing review and training on mission

<sup>1</sup>Emergency Ultrasound Guidelines,2009

<sup>2</sup>Sargsyan et al.,2005

<sup>3</sup>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<sup>1</sup>
- Recent meta-analysis:
  - Antibiotic treatment comparable to appendectomy
  - 72% antibiotic success rate<sup>2</sup>
  - 14.2 to 20% subsequent surgical appendectomy<sup>3</sup>
- Modification of success rates needed
  - Healthy crew
  - Quick treatment and no surgical option

<sup>1</sup>Fagenholz et al., 2016

<sup>2</sup>Zhi-Hua Liu, 2014

<sup>3</sup>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 cloth on your abdomen.
3. Repeat this remedy 3 times a week for 2 to 3 months.



## Garlic



## Ginger



## Fenugreek Seeds



## Lemon



## Mint

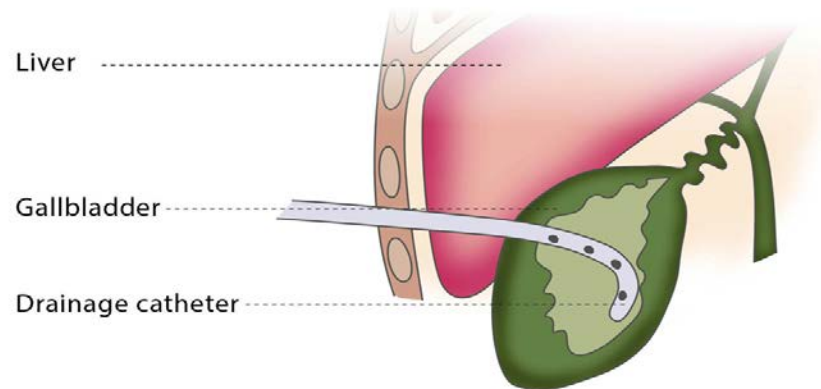
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# Acute Cholecystitis

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

## Cholecystostomy (drainage)



Wagner et al., 2017

# Hemothorax/Pneumothorax

- 100 % Success with pneumothorax
- 80 % Success with loculated pleural effusions<sup>1</sup>
- Successful with different pleural fluids
- Studies found minimal complications
- Significant clinical improvement<sup>2</sup>

<sup>1</sup>Bediwy & Amer, 2012; Liu et al., 2010

<sup>2</sup>Aziz, Penupolu, & Flores, 2012

# Abdominal Compartment Syndrome

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

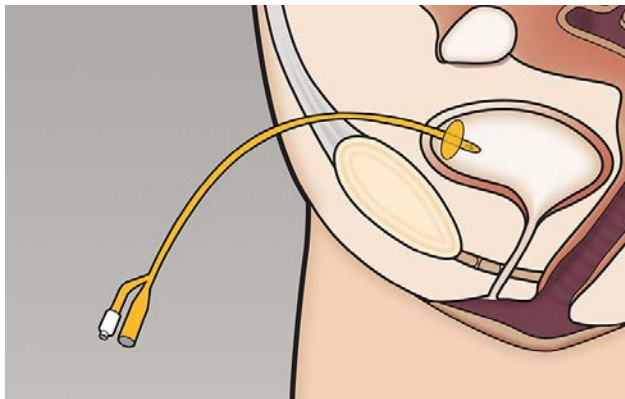
<sup>1</sup>Backer, 1999

<sup>2</sup>Kirkpatrick et al., 2013

<sup>3</sup>Latenser et al., 2002

# Urinary Retention

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



<sup>1</sup>Gujral, Kirkwood, Hinchliffe, & Gujral, 1999

<sup>2</sup> Bilehjani E & Fakhari S, 2017



# Hydronephrosis

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

<sup>1</sup>Song et al., 2016

<sup>2</sup>Lodh et al., 2014

# Complications

- Infection
- Bleeding
- Nephrostomy complication rate 10% <sup>1</sup>
- Abdominal PCD complications < 5%
- Bowel puncture with 21 g needle “inconsequential” in most cases<sup>2</sup>

<sup>1</sup>Pabon-Ramos et al., 2016

<sup>2</sup>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



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