

# A Risk-Benefit Analysis of Prophylactic Surgery before Extended-Duration Spaceflight

Danielle Carroll, MD, PGY-1<sup>1</sup>; David Reyes, MD, MPH, MS<sup>2,3</sup>; Marlei Walton, PhD, MSE<sup>2,4</sup>; Eric Kerstman, MD, MPH<sup>2,3</sup>; and Erik Antonsen, MD, PhD<sup>2</sup>

<sup>1</sup> UC San Diego Department of General Surgery

<sup>2</sup> NASA, Johnson Space Center, Exploration Medical Capability

<sup>3</sup> UTMB, PMCH-Aerospace Medicine

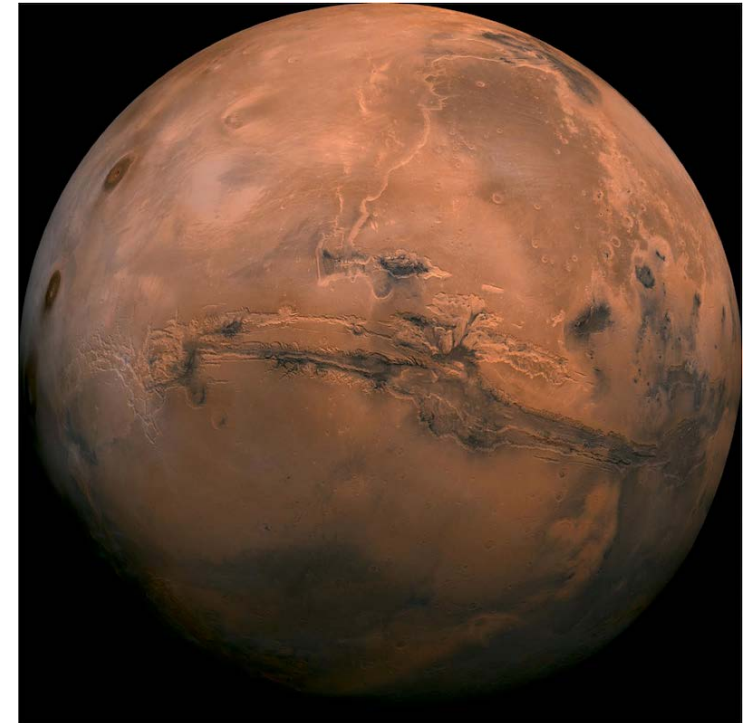
<sup>4</sup> KBRwyle, Houston, TX

# Disclaimer

- No off label uses
- No conflicts of interest

# During the cruise phase to Mars...

- A crewmember complains of a dull, aching periumbilical pain
  - The pain migrates to the RLQ within several hours of onset
  - Followed by nausea, anorexia, and general feeling of malaise
- 
- The Crew Medical Officer finds...
    - Fever to 38.9°C
    - Positive Psoas and Obturator signs on exam
    - Ultrasound is inconclusive
- 
- **Now what?**



# Background

- Even the healthiest persons can develop surgical disease
- Most common operative illnesses in a healthy population
  - Acute Appendicitis → 7-8% lifetime risk\*
  - Acute Cholecystitis → 20% U.S. adults >40 yo w/ biliary calculi\*
- The Fear: Rupture → Peritonitis → Sepsis → Death
- Extremely limited surgical capacity aboard spacecraft

*\*Stewart B, et al. Br J Surg 2014.*

# Prior Research Did Not Quantify Risk

## Surgical Care in Space

MARK R. CAMPBELL, M.D.

CAMPBELL MR. *Surgical care in space*. *Aviat Space Environ Med* 1999; 70:181-4.

The following article was reprinted with permission from *Texas Medicine*, February 1998, p. 69-74.

mission, as they often require medical evacuation (1-5). The annual incidence of minor surgical diseases in these analogue populations appears to be 1/8000 to 1/13,000 person-days. Thus, we could expect a single surgical

NASA/TM-2012-217362



## Anaphylaxis, Intra-abdominal Infections, Skin Lacerations, and Behavioral Emergencies: A Literature Review of Austere Analogs for a Near Earth Asteroid Mission



## ENDOSCOPIC SURGERY AND TELEMEDICINE IN MICROGRAVITY: DEVELOPING CONTINGENCY PROCEDURES FOR EXPLORATORY CLASS SPACEFLIGHT

JEFFREY A. JONES, SMITH JOHNSTON, MARK CAMPBELL, BRIAN MILES, AND ROGER BILLICA

REVIEW • REVUE

## Prophylactic surgery prior to extended-duration space flight: Is the benefit worth the risk?

Chad G. Ball, MD, MSC\*  
Andrew W. Kirkpatrick, MD\*  
David R. Williams, MD†  
Jeffrey A. Jones, MD, MS‡§  
J.D. Polk, DO MS CPE‡  
James M. Vanderploeg, MD, MPH¶  
Mark A. Talamini, MD\*\*  
Mark R. Campbell, MD††  
Timothy J. Broderick, MD‡‡

This article explores the potential benefits and defined risks associated with prophylactic surgical procedures for astronauts before extended-duration space flight. This includes, but is not limited to, appendectomy and cholecystectomy. Furthermore, discussion of treatment during space flight, potential impact of an acute illness on a defined mission and the ethical issues surrounding this concept are debated in detail.

Cet article explore les avantages possibles et les risques définis associés à des interventions chirurgicales prophylactiques (notamment appendicectomie et cholécystectomie) chez les astronautes devant effectuer des séjours prolongés dans l'espace. Le traitement pendant le séjour dans l'espace, les répercussions éventuelles d'une maladie grave au cours d'une mission particulière et les enjeux éthiques entourant la question y sont débattus en profondeur.

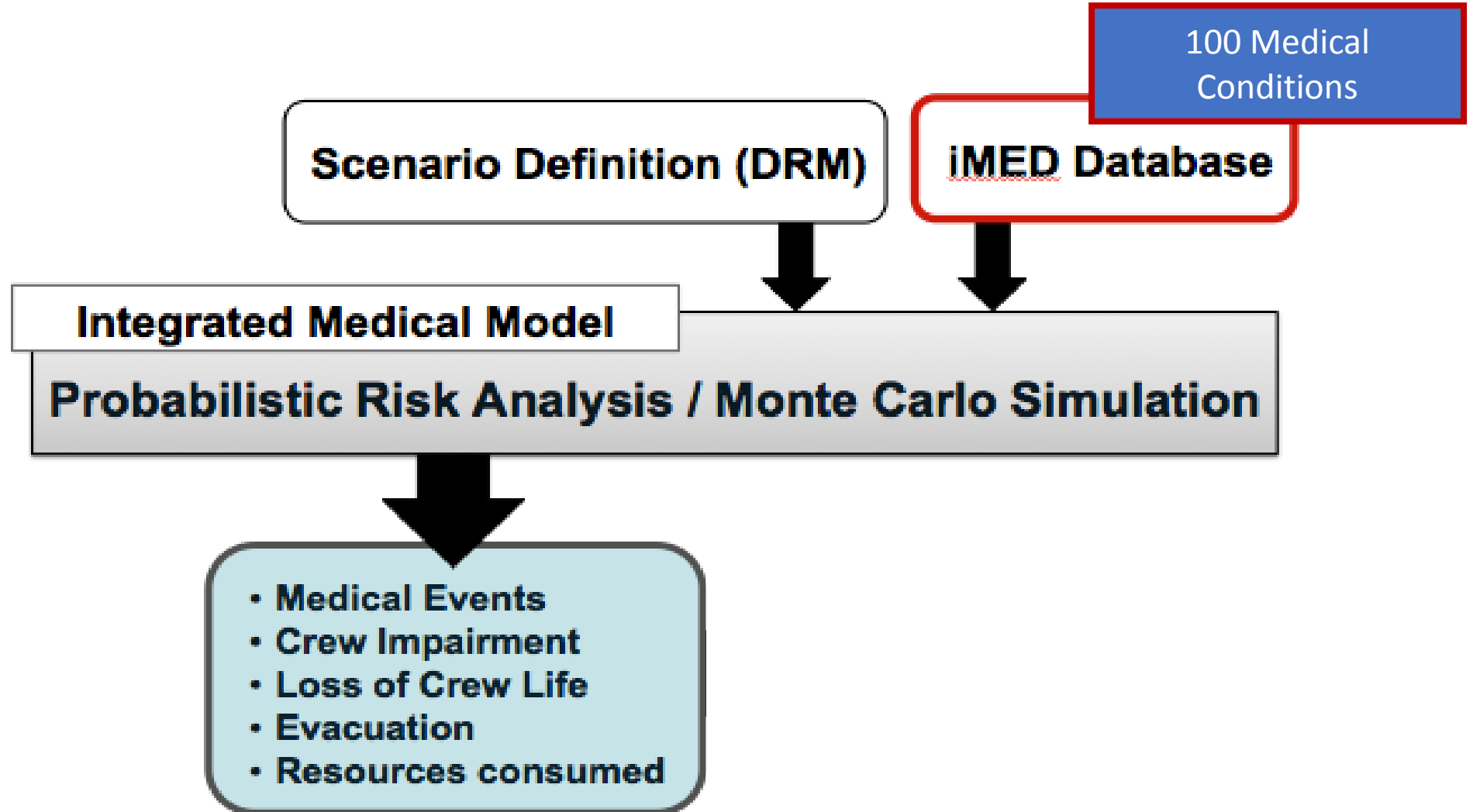
## Nonoperative Treatment of Suspected Appendicitis in Remote Medical Care Environments: Implications for Future Spaceflight Medical Care

Mark R Campbell, MD, FACS, Smith L Johnston III, MD, Tom Marshburn, MD, John Kane, MD, Desmond Lugg, MD, FAFOM

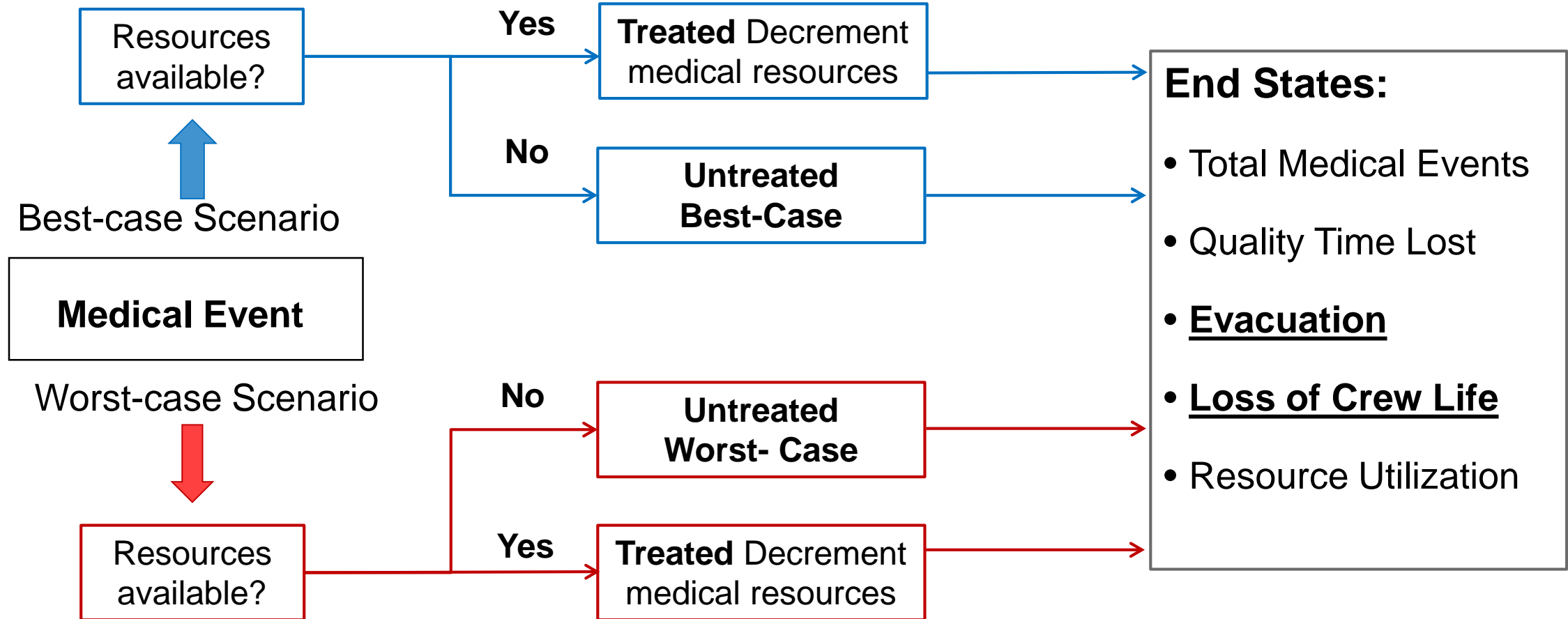
# Hypothesis

- Are there benefits to prophylactic surgery for exploration missions?
- The incidence of small bowel obstruction (SBO) associated with prophylactic surgery will NOT exceed the risk of acute appendicitis and/or cholecystitis during an extended-duration space mission
- If true, then prophylactic surgery may be useful

# Methods – Integrated Medical Model



# Methods – Integrated Medical Model





# Methods – Design Reference Mission (DRM)

- 6-person crew
- 2.5-year Mars mission
- Model parameters
  - Sex
  - Coronary Artery Calcium Score
  - Dental Crowns
  - Number of Extravehicular Activities
  - **History of Prior Abdominal Surgery**
- 231 EVA excursions

# Methods – Design Reference Missions (DRMs)

DRM	Description	SBO (mean events per person year)*	Best Case / Worst Case
Control	No abdominal surgery	0	n.a.
LA	Prophylactic LA, appendicitis = 0	0.0016	75% / 25%
LC	Prophylactic LC, cholecystitis = 0	0.0006	67% / 33%
LA + LC	Prophylactic LA & LC, both = 0	0.0022	67% / 33%

\*Angenete E, et al. JAMA 2012.

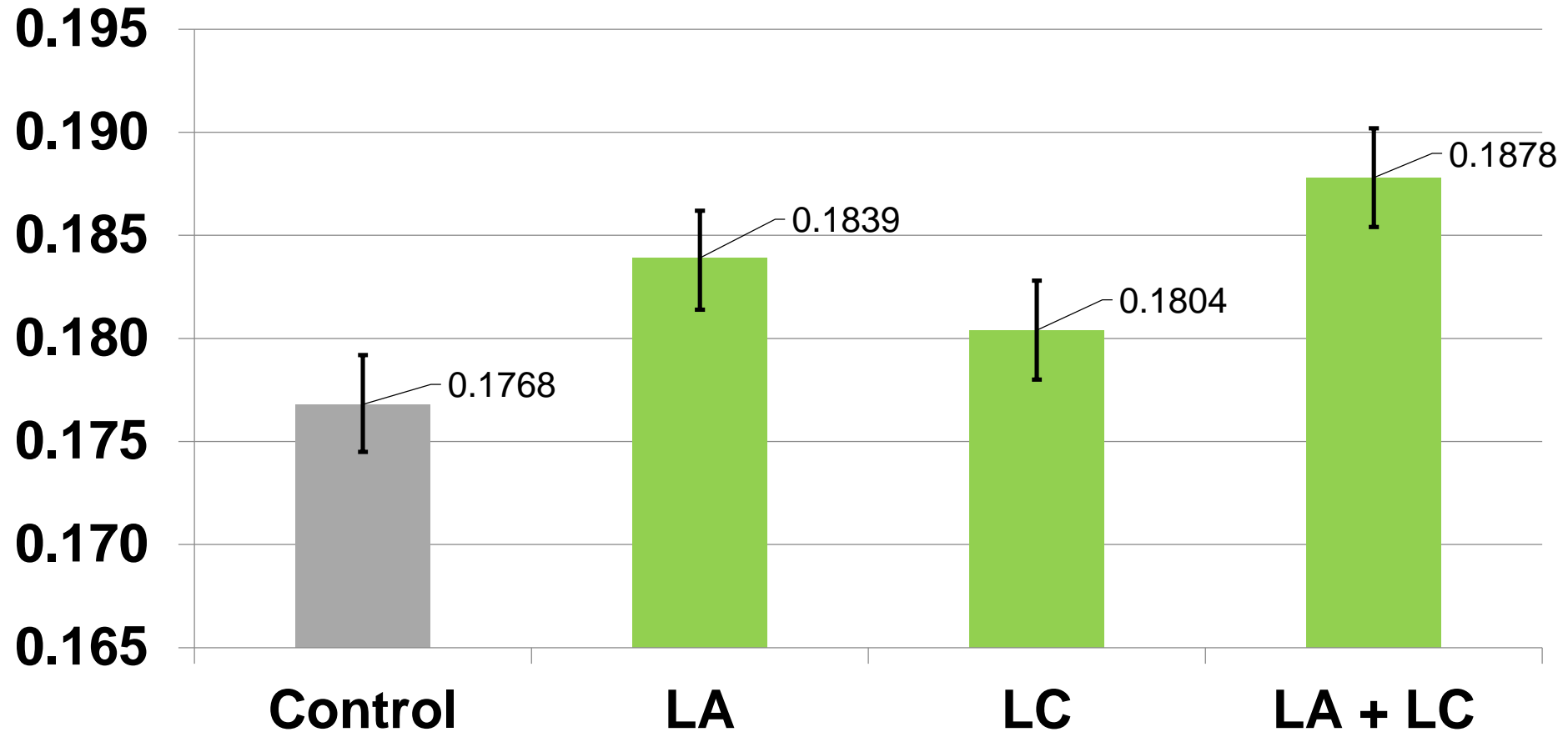
# Model Limitations

- Baselined to the ISS medical capabilities and environment
  - Medical conditions are all correctly diagnosed
  - All treatments are 100% effective
  - No timeline
  - Medical conditions are independent of each other
    - Same crewmember can EVAC/LOCL more than once
- Uncertainty ranges not represented in the modified input data
- Model limitations generally result in conservative estimates when compared to the real world

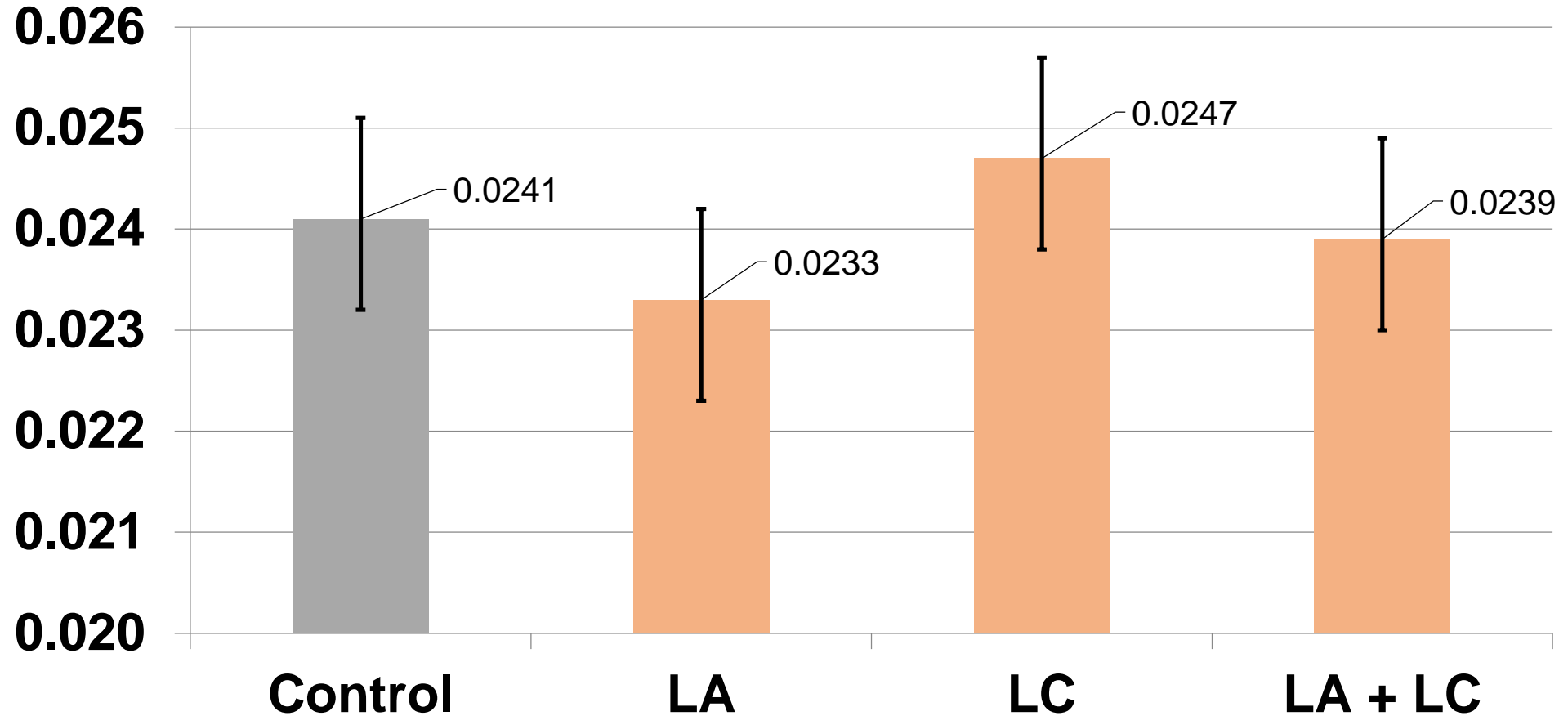
# Model Outcomes of Interest

- Evacuation (EVAC):
  - Consideration of evacuation when treatment capability exceeded
  - EVAC from Mars is not an option, still useful to assess risk
- Loss of Crew Life (LOCL):
  - Death due to severity of illness or exceeding treatment capacity

# Results – EVAC Probability



# Results – LOCL Probability

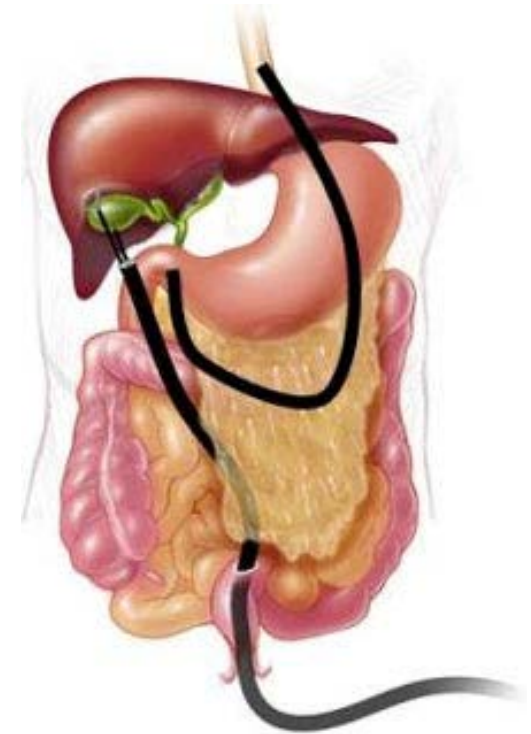


# Results

Benefits of prophylactic surgery do NOT outweigh the risks of small bowel obstruction

# Discussion

- Surgical advances may alter true risk
  - Single-incision laparoscopy
  - Natural Orifice Transluminal Endoscopic Surgery (NOTES)
  - Robotic surgery
- Other risks that are not in the model:
  - Risk of abdominal wall hernias
  - Physiologic changes with spaceflight
  - Effectiveness of conservative treatment





# Additional Considerations

- Ethics
  - Prophylactic surgery itself is not without risks
  - Surgery could lead to disqualifying complication
  - Crewmember autonomy vs. pressure to comply
- NASA is obligated to minimize as many risks as possible
- Changes to policy?
  - Agreement/participation of partner countries?

# Summary

- Acute Appendicitis and Cholecystitis may threaten crew health
- Prophylactic surgery does not justify risks at this time
- Future surgical techniques may negate risks of SBO
- Addressing uncertainty range in input data, and applying newest version of IMM may addresses model limitations

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- Marlei Walton, PhD, MSE
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- Jerry Myers, PhD

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- Jennifer Law, MD, MPH
- Elisca Hicks



# Thank you!

- Carroll, D., et al., *A Risk-Benefit Analysis of Prophylactic Surgery before Extended-Duration Spaceflight*, In-Preparation, to be submitted to AMHP, May 2017

**Questions?**

# Results - EVAC and LOCL Probabilities

<b>DRM</b>	<b>EVAC*</b>	<b>EVAC 95% CI</b>	<b>LOCL*</b>	<b>LOCL 95% CI</b>
Control	0.1768	0.1745 - 0.1792	0.0241	0.0232 - 0.0251
LA	0.1839	0.1814 - 0.1862	0.0233	0.0223 - 0.0242
LC	0.1804	0.1780 - 0.1828	0.0247	0.0238 - 0.0257
LA + LC	0.1878	0.1854 - 0.1902	0.0239	0.0230 - 0.0249

\* Probability of one or more events