Tartan Intubation for Microgravity

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ABSTRACT

Intubations are a very routine procedure on Earth, but in outer space with a microgravity environment, the terrestrial protocol becomes inefficient and complicated. Tartan Intubation for Microgravity (TIM) is a NASA collaboration to address the lack of airway management capability in space at the patient interface. It is a system including a collapsible backboard restraint to support the patient and a modified terrestrial intubation device to accommodate for changes in the behavior of the body and liquids in microgravity.

MOTIVATION

Scope of Problem

- Level 1 criticality situation: failure to manage the airway could result in loss of the astronaut's life
- As space exploration moves toward longer duration missions, the probability of a traumatic occurrence requiring intubation is increased
  - To date, no intubations have been performed in space
- Astronauts typically are not medical doctors
  - Crew Medical Officer (CMO) has 60 hr basic medical training
- Very limited physical working space on spacecraft
  - NASA Orion working crew area is ~316 ft^3 [1]

Current Treatment

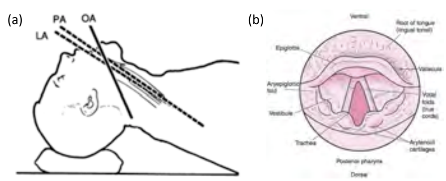

Figure 1: (a) The "sniffing" position is when the oral, pharyngeal, and laryngeal axes are all aligned to easily visualize the (b) vocal cords for proper intubation of the trachea [2,3].

Figure 2: The Crew Medical Restraint System (CMRS) aboard the ISS is designed for patient restraint and transport, spinal stabilization, and electrical isolation for defibrillation [4]. The resin platform contains a main harness with shoulder straps and wrist strap, head restrain, two patient restraints at waist and legs and three restraints for the CMO.

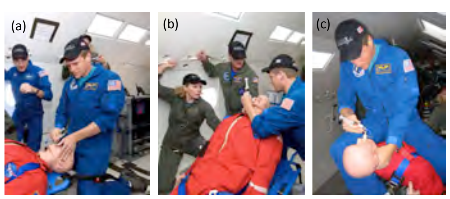

Figure 3: The Medical Operation Support Team (MOST) tested the (a) Kneel, (b) Cradle, and (c) "Trap Doerr" techniques in parabolic flight and determined to be 94% successful [5]. These techniques rely on the caregiver to support the patient's head at an appropriate elevation level.

DESCRIPTION OF DESIGN

Restraint Component

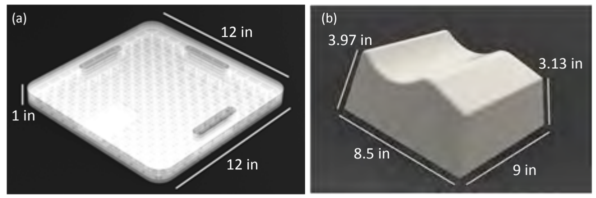

Figure 4: The (a) acrylic board and (b) polyurethane cushion components are compact to minimize the volume taken up aboard the spacecraft.

- **Acrylic Foldable Board**
  - Stabilizes and supports patient in microgravity
  - Small volume dimensions for storage with medical equipment
  - Gridded interior to minimize mass for spacecraft takeoff
  - Multiple handles for simple transport
- **Polyurethane Custom-molded Cushion**
  - Shape optimizes sniffing position
  - Firmness is supporting and comfortable
- **Velcro Nylon Straps**
  - Restrain patient against forces in microgravity
  - Easy and quick adjustability

Figure 5: A 50% female working model demonstrates how the restraint component of TIM would support the patient.

Airway Component

Figure 6: To easily and quickly intubate a patient while minimizing cabin contamination from escaping liquids, the terrestrial (a) King Airway and (b) CPAP facial mask are combined to create the intubation component of TIM [7,8].

- **King Airway LTS-D**
  - Simple insertion and mechanism to pump air
  - Minimal medical expertise necessary to use
  - Minimal trauma to patient
- **Modified Continuous Positive Airway Pressure (CPAP) Facial Mask**
  - Captures excess fluids that may escape from patient
  - Minimizes contamination of spacecraft air supply
  - Includes feature for possible suction devices

RESULTS

Proposed Operation Protocol

Initial

1. Transport patient to medical area of spacecraft
2. Remove TIM from medical equipment storage
3. Unfold restraint board and lock open
4. Position TIM so that patient's head rests in curve of cushion
5. Secure patient's head using head strap
6. Secure patient's arms using chest strap

Intubation

1. Insert King Airway into patient's mouth up to the 4cm marking
2. Attach 60cc syringe
3. Inflate cuffs using syringe
4. Attach manual resuscitating bag
5. Press bag to pump air into patient's lungs

Intubation Functionality

Figure 7: The Laerdal SimMan 3G Manikin is capable of simulating "difficult airways," such as tongue edema, decreased cervical motion, and pharyngeal neck obstruction, and trismis medical conditions.

- The time required to execute the intubation protocol was tested on simulation manikins
- Subjects for the intubation protocol had minimal to no previous intubation experience

Condition	Traditional	King
Normal	110 sec.	12 sec.
Tongue Edema	120 sec.	12 sec.
Decreased Cervical Motion	150 sec.	20 sec.
Pharyngeal Neck Obstruction	180 sec.	25 sec.
Trismis	150 sec.	15 sec.

Table 1: Average time required (in seconds) for subjects to successfully intubate and pump air into manikin's lungs.

FUTURE DIRECTIONS

- Testing of the device and protocol on a zero gravity simulator
- Testing to determine if materials meet regulations for spaceflight safety
- Combining the device with other projects that utilize fluid suction

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