Chest Injury Cliff

Branch Baseline

Thoracic injury is a common reason to be admitted to major trauma centers. The degree of thoracic injuries ranges from brief, uneventful complications to critical conditions requiring treatment in intensive care units (ICUs) such as pneumothorax, hemothorax, rib fracture, flail chest, and acute respiratory distress syndrome (ARDS). It accounts for 25% of traumatic deaths, and the mortality rate ranges from 10-40%. (Wang, 2007)

Chest trauma is traditionally classified as blunt or penetrating. In blunt trauma the chest wall remains intact; in penetrating injuries the integrity of the chest wall is breached. Blunt trauma is more common than penetrating chest injury. Ribs may be fractured and produce bruising or puncture the lung. Associated pain may impair breathing. Pneumothoraces and hemothoraces are space-occupying lesions that interfere with gas exchange primarily by compressing otherwise healthy lung parenchyma. Pneumothorax is the collection of air within the pleural cavity. As the pneumothorax enlarges, the lung becomes smaller. A hemothorax can accommodate approximately 40% of the total blood volume. A lung contusion is usually a combination of alveolar hemorrhage with interstitial hemorrhage and edema. Most patients have minimal respiratory deficit as a result of the injury. Extensive contusions may result in respiratory difficulty or progress to acute respiratory distress syndrome (Khan, 2008).

Pneumothorax is the presence of gas in the pleural space. A spontaneous pneumothorax is one that occurs without antecedent trauma to the thorax. A primary spontaneous pneumothorax occurs in the absence of underlying lung disease, while a secondary pneumothorax occurs in its presence. A traumatic pneumothorax results from penetrating or nonpenetrating chest injuries. A tension pneumothorax is a pneumothorax in which the pressure in the pleural space is positive throughout the respiratory cycle. (Light RW, 2008)

Incidence Data Included in the Model

The model imports the following incidence information from the IMM database: incidence data category, space adaption status, incidence data, incidence and occurrence distribution data and incidence data characteristics. Data category defines the type of data available for incidence calculations (i.e. raw data vs. fixed data). Space adaptation identifies medical events that onset occurs in the first 5 days of flight and does not reoccur. Incidence values vary by data category and define the number of medical events per person-year or medical events per person-at-risk for each medical condition. Incidence values can be modified by crew characteristics such as gender. Modifying characteristics are noted below and incidence values are listed individually for each characteristic. Distributions are assigned to medical events incidence values and occurrences in the model. For each crew member in a given trial, the incidence and number of occurrences of each medical condition are randomly selected from these probability distributions. Detailed descriptions of the distributions are included in the IMM Technical Description Document.

Incidence	
Data Category:	Raw Data
Space Adaptation:	No
Incidence Type:	Rate

Distribution Data	
Incidence:	Gamma
Occurrence:	Poisson

Data Characteristics	
Events:	78725
Person Years:	307006550
Space Flight Incidence Rate (Events / Person Years):	78725 / 307006550 = 0.000256427753740107

Incidence Comments

Terrestrial analogs data, i.e. polar exploration, are either not comparable or lacking. (Glover, 1981) (Thomas, 2003) Consequently, terrestrial data is used as a surrogate for risk estimation.

The 2009 incidence rate for thoracic injury is based on the National Trauma Data Bank. (American College of Surgeons, 2010) There were 135,733 overall incidents by AIS body region-thorax in 2009 (Table 27). We discounted incidents with mechanisms of injury (Table 19) unlikely to occur among our crew population on orbit. Percentages per gender were averaged and rounded to the nearest integer to determine the discounts; e.g. 30% of motor vehicle traffic, 5% of transport/other, 4% of fire arms, 2% of pedal/cyclist. We also discounted 1% of self-inflicted injuries (Table 25 - Incidents and Case Fatality rate by intent). Overall injuries minus our discounted data resulted in 58% of injuries that may occur on board, or 78,725. The US census resident population estimates for 2009 (U.S.Census Bureau, 2009)of 307,006,550 served as denominator.

Information Regarding Prevention

NASA requirements and documents support safety first. However, injuries result from a mishap. There are no medical preventive measures available.

Selection criteria: NASA Medical Standards for ISS Crew Members list 19 types of causes for rejection due to risk factors for pneumothorax including general or segmental over-inflation conditions, and anatomic abnormalities such as blebs, bullae, or cysts. Also excluded is a history of multiple segmental resections, tumor, pleural effusion or chronic infection. These should prevent secondary pneumothorax in our population. (International Space Station Program, 2009) (NASA, 2007)

Traumatic injury strikes unexpectedly and has been an inevitable companion of exploration throughout history. (Kirkpatrick, 2009) In 1996, Billica and colleagues ranked traumatic injury at the highest level of concern regarding the probable incidence versus impact on mission and health. (Billica, 1996)

Airway obstruction, hemo-pneumothoraces, and bleeding are a critical focus for space trauma planning. Loss of bony density during weightlessness may greatly increase the risk of fractures and cause degradation of the thoracic cage which provides significant protection to vital viscera. Pneumothoraces (PTXs) are the most common serious intra-thoracic injury following blunt trauma. PTXs may be exacerbated by the hypobaric stresses associated with EVA. (Kirkpatrick, 2009)

Conceivable mechanisms of injury on ISS could include sudden deceleration in translation, direct bodily or vehicular impact by a high mass object, or penetration due to a high speed projectile.

Contingency measures

Sites of massive internal hemorrhage may be intrapleural, intraperitoneal, and retroperitoneal. On earth, the use of sonography to quickly localize such bleeding has become standard practice. Studies in both parabolic flight and true space suggest that both thoracic and abdominal blood will remain quickly detectable in weightlessness with accuracy. Controlled porcine studies in parabolic flight revealed that abdominal sonography appears at least as sensitive for the detection of intraperitoneal and intrathoracic fluid in weightlessness. This is presumably related to the enhanced importance of surface tension forces in determining intra-abdominal fluid behavior in the absence of gravity. Tension pneumothoraces have been easily decompressed with both needle and tube thoracostomies in parabolic flight. In many cases however, it may be more difficult to detect hemo-pneumothoraces than to actually treat them. (Kirkpatrick, 2009)

Studies performed on the NASA Microgravity Research Laboratory showed that ultrasound is sensitive for ruling out or confirming pneumothorax and hemothorax. Its sensitivity appears comparable to routine radiography. It could prevent an unnecessary tube thoracostomy and subsequent crew evacuation. It could detect lung sliding after chest decompression and subsequent lung expansion allowing time to monitor pnemothorax or hemothorax on orbit over several days. (Hamilton, 2004)

Incidence Level of Evidence (LOE)

The IMM level of evidence appropriate assessment of the quality of the IMM input data. Since IMM incorporates input data from a wide variety of sources including astronaut population, terrestrial or analog populations, and external models, an innovative approach to assess the quality of input data was required. Information obtained from the astronaut population and/or space flight is the more relevant so it is assigned the highest level of evidence and less relevant data sources are assigned a lower level of evidence.

Citation	LOE Value	LOE Category
American College of Surgeons, 2010	4	Incidence
U.S.Census Bureau, 2009	4	Incidence

Alternative Incidence Data

Thoracic injury is a common reason to be admitted to major trauma centers. It accounts for 25% of traumatic deaths, and the mortality rate ranges from 10-40%. The degree of thoracic injuries ranges from brief, uneventful complications to critical conditions requiring treatment in intensive care units (ICUs). A study in Central Taiwan, between January 2002 and December 2003, was conducted to determine risk factors of mortality in patients with blunt chest trauma. Blunt chest trauma was usually associated with injuries to other organ systems, especially of the abdomen and head.

Consecutively admitted patients were candidates for the study. A total of139 patients were admitted, 127 of which met the inclusion criteria. Falls from height or pedestrian were the cause for 16% of injuries. 69% of patients were intubated, 22% developed ARDS, and 47% developed shock, 11% died in the ICU.

Intra-thoracic injuries were pneumothorax 39%, hemothorax 65%, rib fracture 69%, flail chest 15%, and ARDS 11%. Length of stay (LOS) mean was 5.5+ days and 8.9 standard deviation. Blood transfusion mean was 5 units in the first ICU day and 9 standard deviation. IVF resuscitation volume mean was 4697 ml and 4025 ml standard deviation in the first ICU day. (Wang, 2007)

Diaphragmatic injury occurs in 5% of all patients undergoing laparotomy or thoracotomy. The estimated incidence is 2.1% of blunt trauma and 3.4% of penetrating trauma. (Morgan, 2010)

Blunt diaphragmatic rupture (BDR) is a rare event and represents a diagnostic challenge. A study reviewed the experience with BDR at the Sunnybrook Health Sciences Centre (Sunnybrook), the largest trauma centre in Canada, between January 1986 and December 2003. BDR occurred to 1.9% of patients with blunt trauma, 208/10779. Of these 64.4% of patients were men.

The liver, spleen and small bowel/mesentery were often injured in patients with BDR. Most patients with BDR had rib fractures and pulmonary contusions. Of note, the thoracic aorta was injured in 7.7% of patients with BDR compared with 1.2% of all blunt trauma patients, representing a 6-fold increased risk.

Site of chest injury was identified by percentage of patients: rib fracture 75.5, pulmonary contusion 63, hemothorax 40.4, hemopneumothorax 22.1, flail chest 20.7, pneumothorax 19.7, cardiac contusion/laceration 18.8, and lung laceration 8.7.

With respect to management of BDR, 93.3% of patients received laparotomy and 1.4% received thoracotomy; the BDR was diagnosed at autopsy in 5.3%.

The mortality reported in the literature is high (10%–35%). Mortality in this study (28.8%) was on the higher end reported in the literature attributed to the higher ISS (Injury Scale Score) in reported patients. The most common causes of death reported in the literature were shock, multiple organ failure and head injuries. (Chughtai, 2009)

Treatment and Outcomes

Based on the best evidence available best and worst case percentage ranges are assigned. The medical condition is divided into three clinical phases in all three clinical phases a functional impairment is assigned. The clinical phase I and II's functional impairments remain for the duration for that respective clinical phase. The function impairment in clinical phase III represents final impairment for this medical condition and remains for the rest of the mission. Other mission end states include evacuation and loss of crew life.

The IMM checks medical resource availability once the number of medical events and scenarios has been established. If there is not sufficient essential resources called out in the CliFF, then the medical condition will go down an untreated best or worst case scenario pathway.

The table below summarizes the treated and untreated best and worst case scenarios.

	Clinical Phase I Diagnosis & Initial Treatment[1]		**Clinical Phase II On-going Treatment / Convalescence[2]**		**Clinical Phase III Recovered / Mission End State[3]**		
	FI[*] (%)	**Duration (hrs)**	**FI[*] (%)**	**Duration (hrs) (Min - ML - Max)**	**FI[*] (%)**	**EVAC[**] (%)**	**LOCL[**] (%)**
ISS-based Treatment (best case scenario %: 35)	100	0.5	4 - 51	0 - 36 - 72	0	0	0
ISS-based Treatment (worst case scenario %: 65)	100	2.5	30 - 77	72 - 120 - 168	0 - 77	0 - 100	18 - 100
Untreated Best Case	0	0	30 - 77	0 - 36 - 72	0 - 51	0 - 100	0
Untreated Worst Case	0	0	59 - 95	72 - 120 - 168	59 - 95	100	100

[1]Clinical Phase I: Clinical phase I covers only the initial assessment of the affected crew member to define his or her medical condition, and completion of appropriate initial treatment to stabilize the crew member. While the affected crew member is being assessed, he or she is not able to perform any assigned tasks, thus Functional Impairment during this phase is considered 100%. In the untreated case, there is no diagnosis performed or treatment given, therefore Functional Impairment and Duration will always be "not applicable".

[2]Clinical Phase II: On-going Treatment and Convalescence- During clinical phase II, the affected crew member is receiving any appropriate follow-on treatment for his or her medical condition to allow the crew member to recover as much as he or she is able to recover in the ISS environment. Clinical phase II also encompasses relapses or reoccurrences of the same original medical condition in clinical phase I necessitating additional treatment or recovery time due to unsuccessful primary treatment response. The duration in Clinical Phase II is expressed in minimum, most likely (ML) and maximum hours. This was updated for future capabilities in IMM but is currently not being used by the model.

[3]Clinical Phase III: Recovered/Mission End State- Clinical phase III is reached once the affected crew member has recovered from the medical condition as much as he or she is able to recover in the ISS environment. This may or may not be recovery from the given medical condition to the full extent possible. If this "recovered" state results in an evacuation or loss of the crew member, this will be noted in the mission end state results.

*Functional Impairment (FI) is a measure of the affected crew member's health and performance ability.

**Two mission end state results are addressed in the CliFF: 1) Evacuation (EVAC) - crew and patient are evacuated from the spacecraft due to the medical condition, and 2) Loss of crew (LOCL) - death of affected crew member due to medical condition. EVAC is considered as an end state result if any of the following criteria are met: 1) potential LOCL, 2) potential significant permanent impairment, or 3) potential intractable pain. Probability distributions are assigned for each range of values within the Table of Treatments and Outcomes.

Refer to the Integrated Medical Model Technical Document for more information on how risk is reported by the IMM, Crew Health Index (CHI) and Quality Adjusted Mission Time calculations.

Definition and Probability of Best and Worst Case Scenario: (includes definitions of best and worst case scenarios and identifies the probability of those scenarios.)

Scenario Comments

The **best case scenario is defined** as a mild or moderate blunt chest injury resulting in localized pain/discomfort and/or ecchymosis, requiring only minimal treatment.

The **worst case scenario is defined** as severe chest injury resulting in chest cavity penetration, which may develop into hemorrhage and/or shock; or a blunt chest trauma that causes damage of the internal chest organs with secondary complications of hemothorax, pneumothorax, diaphragmatic rupture, ribs fracture, shock or sepsis.

Shock and sepsis are addressed in the Hypovolemic Shock and Sepsis CliFFs respectively. Penetrating injuries requiring dressing are addressed in the skin laceration CliFF.

Percentages of how often best versus worst case scenarios occur were estimated using the NTDB with AIS (Abbreviated injury scale - see bleow) of 3 or greater (Table 28 incidents by body region) (American College of Surgeons, 2010) 88,534 serious or greater incidents 135,733 overall. Thorax and Pneumothorax incidents represented 65%.

Based in subject matter expert's opinion (Kerstman, 2010) we are using a discrete number (65%) for the worst case percentage rather than a range for this medical condition.

Abbreviated Injury Scale (AIS)

The AIS was originally designed to stratify victims of motor vehicle crashes. On its own its not designed to provide any outcome prediction. It forms the basis of the ISS. It has undergone six revisions since its initial first description in 1971. AIS - 90 has 1300 individual injuries. The AIS injury severity values are consensus-derived and range from 1 (minor) to 6 (fatal). Only blunt injuries were included in the first AIS.

Injury - AIS Score: 1=Minor, 2=Moderate, 3= Serious, 4= Severe, 5=Critical, 6= Unsurvivable.

Limitation of AIS: 1) Score 5 and 6 represent the "threat to life" associated with an injury and are not intended to provide a comprehensive measure of severity, 2) Ais-90 makes no provision for open or comminuted femoral fractures, important for functional outcome, less important in predicting mortality, 3) AIS on its own is unable to predict mortality or outcomes, 4) AIS assigned rather than derived viz inter and intra rater error, and 5) AIS not a true scale (ie difference between AIS 1 and 2 is not the same as between AIS 4 and 5).

Best Case Comments

Chest injury's functional impairments (FI) calculation follows the IMM severe non-space adaptation template. Pulmonary dysfunction ratings are based on Table 5-4, p.88 (American Medical Association, 2008). Complex Regional Pain Syndrome-Upper Extremity CRPS (UEI) is based on Table 15-26, p 454 (American Medical Association, 2008). The CRPS (UEI) ratings are then converted to percentage of Whole Person Impairment (WPI), which are based on Table 15-1, p 385 (American Medical Association, 2008). Bleeding disorder ratings are based on Table 9-11 p.205 (American Medical Association, 2008). Combined FI ratings are calculated combining the mentioned tables using the Combined Values Chart as indicated in Appendix A, pp 604-606 (American Medical Association, 2008). For further description of grading on each system and calculation refer to this CliFF Appendix.

By definition in Clinical phase I, FI is 100%. Duration to follow procedures specified in ISS checklist, i.e. physical exam, vital signs, and observation period for the best case scenario, is estimated to be 30 minutes. During Clinical Phase II, FI is estimated as 4 to 51%. Duration is estimated as 0 to 72 hours. In Clinical Phase III, full recovery is expected and FI is 0%. By definition, EVAC and LOCL would not be expected for the best case scenario.

Worst Case Comments

Chest injury's functional impairments (FI) calculation follows the IMM severe non-space adaptation template. Pulmonary dysfunction ratings are based on Table 5-4, p.88 (American Medical Association, 2008). Complex Regional Pain Syndrome-Upper Extremity CRPS (UEI) is based on Table 15-26, p 454 (American Medical Association, 2008). The CRPS (UEI) ratings are then converted to percentage of Whole Person Impairment (WPI), which are based on Table 15-1, p 385 (American Medical Association, 2008). Bleeding disorder ratings are based on Table 9-11 p.205 (American Medical Association, 2008). Combined FI ratings are calculated combining the mentioned tables using the Combined Values Chart as indicated in Appendix A, pp 604-606 (American Medical Association, 2008). For further description of grading on each system and calculation refer to this CliFF Appendix.

By definition in Clinical Phase I, FI is 100%. Duration to follow procedures specified in ISS checklist, i.e. physical exam, vital signs, dressing to contain bleeding, intravenous fluids, and ultrasound for the worst case scenario, is estimated in 1 hour. Another 45 minutes may be added for chest tube insertion. Total duration is estimated as 1 to 2.5 hours. During Clinical Phase II, FI is estimated in 30 to 77%. Duration is estimated in 48 to 168 hours (2-7 days). NTDB (American College of Surgeons, 2010 3042 /id }length of stay (LOS) has a median of 4 days in the intensive care unit (ICU). Wang reported LOS in ICU 5.5 days. {Wang, 2007) We are estimating the time as 7 days for on board care In Clinical Phase III, full recovery is not expected and FI is 0 to 77%. A retrospective study among US Army troops in Iraq found 66.7% (2/3) cases of non-battle disease and pulmonary injuries required medevac ($p<0.0001$). (Belmont, 2010)Of note, the US Army has portable trauma services providing care locally. Terrestrial evidence for patients requiring surgery after traumatic chest injury ranges from 74.4% (Hanna, 2008) to 93.3% (Chughtai, 2009) in Canada. Because worst case scenario chest injury and/or traumatic pneumothorax would be considered as a Class IIc medical event, i.e. an event manageable with HMS but **may** necessitate urgent evacuation if condition does not improve or worsens (Johnston, 2008), we are estimating EVAC as 0% to 100%.

Fatality rates reported terrestrially are 8.55% (American College of Surgeons, 2010),18% (Hanna, 2008), and 28.8% (Chughtai, 2009). Terrestrial data are from trauma centers with high level care. In space with limited on-board care, mortality is expected to be higher. We estimated the lower limit by averaging the percentages of deaths, i.e. 8.55, 18, and 28.8% .Thus our LOCL range is 18% to 100%.

Untreated Best Case Comments

Chest injury's functional impairments (FI) calculation follows the IMM severe non-space adaptation template. Pulmonary dysfunction ratings are based on Table 5-4, p.88 (American Medical Association, 2008). Complex Regional Pain Syndrome-Upper Extremity CRPS (UEI) is based on Table 15-26, p 454 (American Medical Association, 2008). The CRPS (UEI) ratings are then converted to percentage of Whole Person Impairment (WPI), which are based on Table 15-1, p 385 (American Medical Association, 2008). Bleeding disorder ratings are based on Table 9-11 p.205 (American Medical Association, 2008). Combined FI ratings are calculated combining the mentioned tables using the Combined Values Chart as indicated in Appendix A, pp 604-606 (American Medical Association, 2008). For further description of grading on each system and calculation refer to this CliFF Appendix.

During Clinical Phase II, FI is estimated at 30 to 77%. Duration is estimated at 0 to 72 hours, similar to the best case scenario. In Clinical Phase III, recovery may or may not occur and FI is estimated in 0 to 51%. EVAC may occur if pain is severe, or further evaluation and treatment are necessary. By definition, LOCL will not be expected for the best case scenario.

Untreated Worst Case Comments

Chest injury's functional impairments (FI) calculation follows the IMM severe non-space adaptation template. Pulmonary dysfunction ratings are based on Table 5-4, p.88 (American Medical Association, 2008). Complex Regional Pain Syndrome-Upper Extremity CRPS (UEI) is based on Table 15-26, p 454 (American Medical Association, 2008). The CRPS (UEI) ratings are then converted to percentage of Whole Person Impairment (WPI), which are based on Table 15-1, p 385 (American Medical Association, 2008). Bleeding disorder ratings are based on Table 9-11 p.205 (American Medical Association, 2008). Combined FI ratings are calculated combining the mentioned tables using the Combined Values Chart as indicated in Appendix A, pp 604-606 (American Medical Association, 2008). For further description of grading on each system and calculation refer to this CliFF Appendix.

During Clinical Phase II, FI is estimated at 59 to 95%. Duration is estimated in 48 to 168 hours (2-7 days). NTDB (American College of Surgeons, 2010) length of stay has a median of 4 days in the intensive care unit (ICU). Wang (Wang, 2007) reported LOS in ICU 5.5 days. We are estimating the time as 7 days for on board care. In Clinical Phase III, recovery is not expected and FI remains 59 to 95%.

Because worst case scenario chest injury and/or traumatic pneumothorax would be considered as a Class IIc medical event, i.e. an event manageable with HMS but may necessitate urgent evacuation if condition does not improve or worsens, (Johnston, 2008) we are estimating 100% EVAC. Pneumothorax is a medical emergency which can result in hemodynamic instability and death, unless immediately treated. Diaphragmatic injury will have similar results. We are estimating EVAC and LOCL in 100% for the untreated case scenario.

Treatment and Options Level of Evidence (LOE)

The IMM level of evidence appropriate assessment of the quality of the IMM input data. Since IMM incorporates input data from a wide variety of sources including astronaut population, terrestrial or analog populations, and external models, an innovative approach to assess the quality of input data was required. Information obtained from the astronaut population and/or space flight is the more relevant so it is assigned the highest level of evidence and less relevant data sources are assigned a lower level of evidence.

Citation	LOE Value	LOE Category
American Medical Association, 2008	3	FI
American Medical Association, 2008	3	FI
American Medical Association, 2008	3	FI
American Medical Association, 2008	3	FI
Belmont, Jr., 2010	2	EVAC
Johnston, 2008	2	EVAC
American College of Surgeons, 2010	4	BCWC
Hanna, 2008	4	EVAC
Chughtai, 2009	4	EVAC

The Resource Table (RT)

Resource	Units Required Best Case	Units Required Worst Case	Units Available At Start Of Mission	Consumable	Essential	Rationale
Ambu bag and mask	0	1	1	No	Yes	Hand-held device used to provide positive pressure ventilation to a patient who is not breathing or is breathing inadequately
Blood Oximeter	1	1	1	No	Yes	Monitors the oxygen saturation of a patient's blood
Blood Pressure Cuff (regular, large)	1	1	2	No	Yes	Measure blood pressure
Blood Pressure Monitor	1	1	1	No	Yes	Measure blood pressure
BZK wipes	0	12	60	Yes	No	Cleanse skin.
CMRS	0	1	1	No	No	Restrain crew member to ensure safety
ECG Monitor (Device, USB Charge Cable, Lead Set Cable, Cue Card)	0	1	1	No	Yes	Measure and monitor ECG
Endotracheal Stylet	0	1	1	No	Yes	Assist with advanced airway placement
Endotracheal Tube 7.0/8.0	0	1	4	Yes	Yes	Establish and maintain patent airway and ventilation
EtCO2 Monitor with EMMA adapter	0	1	1	No	Yes	Measure end tidal CO2
Gauze pads (4x4)	3	6	50	Yes	No	To absorb blood or fluids from skin
IV administration set	0	1	3	Yes	Yes	IV Fluids infusion
IV Cap	0	1	5	Yes	No	To attach IV fluids to Y-type catheter
IV Catheter (14G)	0	2	2	Yes	Yes	For needle decompression of the chest
IV Catheter (18G, 20G, or 22G)	0	1	14	Yes	Yes	IV fluid administration
IV Fluid 1L (1000mL)	0	1	5	Yes	Yes	Parental fluid replacement for hydration.
IV Fluid Air Filter	0	1	3	Yes	No	To filter air from IV line
IV pressure infuser	0	1	1	No	No	IV Fluids infusion
Ketamine 50 mg/mL, 10 mL multi dose vial	0	0.3	6	Yes	Yes	For sedation in case of intubation/ventilation.
King Supraglottic Airway (SGA) Tube (size 3/size 4)	0	1	2	Yes	Yes	Establish and maintain patent airway and ventilation
Laryngoscope (blade)	0	1	1	No	Yes	For intubation
Laryngoscope handle	0	1	1	No	Yes	For intubation
Lidocaine w/ Epinephrine (Xylocaine) 2 %, 2-mL units 1:100,000 epi, 20 mL. Multi dose vials.	0	1	2	Yes	Yes	Local anesthetic

Resource	Units Required Best Case	Units Required Worst Case	Units Available At Start Of Mission	Consumable	Essential	Rationale
Medical tape	0.2	0.2	5	Yes	No	Medical adhesive tape
Nasal Airway (6mm, 7mm)	0	1	2	No	Yes	Airway management
Needle (23G)	0	3	20	Yes	Yes	For medication administration.
Nitrile gloves (large, medium, and small) (pair)	1	3	30	Yes	No	Personal Protective equipment for CMO
Oral Airway	0	1	2	No	Yes	Airway management
Pack of 12 ECG electrodes	0	1	5	Yes	Yes	Measure and monitor ECG
PEEP Valve	0	1	1	No	Yes	Provide positive airway pressure during ventilation
SGA Cue Card	0	1	1	No	Yes	Guidance for use of supraglottic airway
Sharps container	0	1	40	No	No	To dispose of medical waste such as used medical needles, scalpels, IV catheters, razors, vials
Stethoscope	1	1	2	No	Yes	To listen to lung, heart, and bowel sounds, to blood flow in arteries and veins
Suction Cartridge	0	1	1	No	Yes	Provide medical suction
Suction device	0	1	1	No	Yes	Suction for removing secretions
Suction device collection bag	0	1	2	Yes	No	Resevoir for the collection of secretions collected by suction.
Suction device syringe	0	1	1	No	Yes	Syring used to create suction.
Suction tip - mouth (curette)	0	1	1	No	Yes	Provide oral suctioning
Suction Tubing - Endotracheal Tube	0	1	1	Yes	Yes	Tubing used in endotracheal suctioning.
Surgical Lubricant	0	2	6	Yes	No	Provide lubrication during the ILMA insertion.
Syringe (10cc)	0	1	6	Yes	Yes	To inflate endotracheal tube cuff
Syringe (35cc)	0	1	1	Yes	Yes	To inflate SGA
Syringe (3cc)	0	3	20	Yes	Yes	For medication administration
T-adapter	0	1	1	No	Yes	Connection for ventilation tubing
Thermometer	0	1	1	No	No	To measure temperature
Tongue depressor	0	1	20	Yes	No	To facilitate oral exam
Tourniquet	0	1	1	No	No	To stop blood flow and engorge vein, this facilitates IV insertion
Tylenol (Acetaminophen) 325 mg	10	0	150	Yes	Yes	Pain relief
Ultrasound gel (2 packets)	2	2	17	Yes	Yes	To use with ultrasound machine
Ultrasound machine	1	1	1	No	Yes	For diagnostic purposes

Resource	Units Required Best Case	Units Required Worst Case	Units Available At Start Of Mission	Consumable	Essential	Rationale
Valium (Diazepam) 5 mg/mL, 2 mL syringe	0	1	2	Yes	Yes	For sedation with intubation
Variable Oxygen System	0	1	1	No	Yes	Therapeutic oxygen from ship's supply
Vicodin HP (Hydrocodone/ Acetaminophen HP) 10 mg/660 mg	0	18	30	Yes	Yes	Pain relief
VOS Intubated Patient Hardware (Ventilator/Respirator)	0	1	1	No	Yes	Mechanical Ventilation

Resource Comments

On December 8, 2010 the resources table in the IMM database included 36 items. The list of resources was updated to include IKA ILMA, BP ECG, respiratory support, IV lock, vital signs, chest drainage for pneumothorax, and IV fluids infusion procedures. The procedures lists were compared to the original database list. Duplicate resources were added or eliminated as necessary to complete the revised list (Mission Operations Directorate (MOD), 2011) (ISS Medical Operations, 2009).

Skin laceration resources may be necessary in case of penetrating injuries. They are addressed in the Skin Laceration CliFF. Resources for shock or sepsis, which could occur as a complication of chest injury, are addressed in the Shock and Sepsis CliFFs.

Intracardiac Lidocaine might be used as a result of arrhythmias, whic is addressed in the Cardiogenic Shock. Should Shock or Sepsis arise from chest injury the resources are addressed in Hypovolemic Shock and Spesis CliFFs respectively. Also a penetrating injury might require dress or suturing so please refer to the skin laceration CliFF for detailed resources required.

Required Resources Level of Evidence (LOE)

The IMM level of evidence appropriate assessment of the quality of the IMM input data. Since IMM incorporates input data from a wide variety of sources including astronaut population, terrestrial or analog populations, and external models, an innovative approach to assess the quality of input data was required. Information obtained from the astronaut population and/or space flight is the more relevant so it is assigned the highest level of evidence and less relevant data sources are assigned a lower level of evidence.

Citation	LOE Value	LOE Category
NASA Mission Operations Directorate (MOD), 2011	2	Resources
NASA ISS Medical Operations, 2011	2	Resources

Level Of Evidence

Input Data	LOE Average
Incidence	4
Functional Impairment	3
Best Case / Worst Case	4
EVAC / LOCL	3
Resources	2
QUALITY OF EVIDENCE	**3.2**

Description	Range
Excellent	1-2
Good	2.1-3
Fair	3.1-4
Poor	4.1-5

Reference List

Reference
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