Head Injury Cliff

Branch Baseline

Head injury and traumatic brain injury (TBI) are 2 distinct entities that are often, but not necessarily, related. A head injury is best defined as an injury that is clinically evident on physical examination and is recognized by the presence of ecchymoses, lacerations, deformities, or cerebrospinal fluid leakage. A traumatic brain injury refers specifically to an injury to the brain itself and is not always clinically evident; if unrecognized, it may result in an adverse outcome.

Acute traumatic intracranial injuries include the spectrum of injuries including isolated fractures of the cranium, subarachnoid hemorrhage, subdurals, epidurals, hemorrhagic, and bland contusions (Jagoda, 2008).

Traumatic brain injury may be associated with concomitant neck injury. Rickels reported 58.7% of all TBI patients have additional injuries including 8.8% of the vertebral column. Neck injuries are covered in the IMM CliFF for Neck Injury. (Rickels, 2010)

Traumatic brain injury is classified by using the Glasgow Coma scale scores. Scores of 8 or less are severe, 9 to 12 are moderate and 13 to 15 are mild (National Center for Injury Prevention and Control, 2003). For complete Glasgow Coma Scale refer to the CliFF Appendix.

To date, no pharmacologic treatment has led to improved outcomes after TBI, but it is becoming increasingly clear that advances in the critical care of TBI patients are contributing to better results. During resuscitation of the TBI patient, medical management in its simplest form strives to return measurable vital signs and laboratory values (e.g. intracranial pressure, mean arterial pressure, blood glucose, PaO_2, or $PaCO_2$ to their normal range. The initial goal is to maintain or reestablish normal homeostasis. The initial injury to the brain is irreversible by any medical modalities available today. After the initial resuscitation, medical maneuvers are directed at limiting secondary damage to the brain. Secondary brain injury occurs in response to inflammatory changes, expanding hematomas, cellular swelling, seizures, and systemic complications (i.e., hemodynamic or pulmonary changes, fever, and pain); vulnerable surrounding brain tissue can be damaged through alterations in cerebral perfusion and metabolism. (Losiniecki, 2010)

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:	129717
Person Years:	307006550
Space Flight Incidence Rate (Events / Person Years):	129717 / 307006550 = 0.000422521929906707

Incidence Comments

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

The 2009 incidence rate for head injury is based on the National Trauma Data Bank (American College of Surgeons, 2010). There were 223,650 overall incidents by AIS body region-head in 2009 (Table 27). We discounted incidents with mechanisms of injury (Table 19) unlikely to occur among our crew population, 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 self inflicted injuries (Table25 Incidents and Case Fatality rate by intent), or 1%. Overall injuries minus our discount resulted in 58% of injuries that may occur on board, or 129,717. The 2009 US census resident population estimates of 307,006,550 served as denominator (U.S.Census Bureau, 2009).

Information Regarding Prevention

NASA requirements and documents support safety first. However, injuries result from an accident and there are no real medical preventive measures available.

Disqualifying criteria for crew members include:

In the head, face and neck area: deformities (e.g. scars, depressions or exostoses) or chronic muscular contractions or spasms (e.g. torticollis) of the skull/head, face, and neck that interfere with wearing equipment/headgear and/ or performance of duties; all maxillofacial skeletal deformities (e.g., benign tumors, large birthmarks, large hairy moles, extensive scars or mutilations due to injuries or surgery, ulcerations, fistulae, and atrophy or paralysis of part of the face or head) that interfere with performance or wearing of equipment.

In the neurologic area: History of craniotomy or skull defects requires neurologic evaluation. History of traumatic brain injury with the following associated conditions: intracerebral hemorrhage with persistent neurologic deficits, intracranial hemorrhage requiring surgery or with persistent neurologic deficits (e.g. subdural or epidural hematoma), parenchymal central nervous system injury, including diffuse axonal injury, with persistent neurologic deficits, imaging evidence of retained intracranial metallic or bony fragments, CNS infections, changes in personality, deterioration of higher intellectual functions, anxiety, headaches, or disturbances of equilibrium for more than 3 months. History of head injury without persistent neurologic deficits and associated with the following conditions requires evaluation: skull fractures, absence of bony substance of skull, cerebrospinal fluid rhinorrhea or otorrhea, changes in personality, deterioration of higher intellectual functions, anxiety, headaches, or disturbances of equilibrium for less than 3 months, any LOC or amnesia.

(International Space Station Program, 2009) (NASA, 2007)

Other:

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).

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. We consider the risk on orbit to be lower than the terrestrial analog and note that microgravity is considered to be somewhat protective in that impact forces tend to be minimized.

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

A study of disease and non-battle injuries (DNBI) sustained by US Army brigade combat Team in Iraqi Operation Freedom presented 75 neurologic and 58 Head, Eyes, Ear, Nose, and Throat (HEENT) events classified by body region, among 1324 total DNBI casualties. All battle injuries were excluded. 24% neurologic and 19% HEENT cases were evacuated (MEDEVAC). 1.7% HEENT died. The death was a result of head trauma from a helicopter crash (Belmont, 2010).

Severe TBI patients transported to trauma centers without prompt neurosurgical care or intracranial pressure monitoring are at risk of poor outcome. A head injury which is potentially life threatening requires removal. In mild cases of disorientation the decision to evacuate should be made upon serial examinations. If the neurologic status is deteriorating the decision to evacuate is clear. Appropriate frequency of examination is not clear. Isolated TBI does not cause shock

A prospective study in Germany (Rickels, 2010), presented an overall incidence of 332 per 1000 person-year (0.332). 6783 patients (58.4% male, 41.6% female; 29.7% children < 16 years) were included; 5220 (73%) received in-hospital treatment. The GCS (Glasgow Coma Scale) or other forms of neurological examinations were performed in only 56% of all cases. According to the GCS status, 90.2% are classified as mild, 3.9% as moderate and 5.2% as severe. Rickels does not report the GCS score used to classify severity of injury. The predominant cause of TBI is falls, with 52.5% of all cases, while 26.3% were due to road accidents. One year after the accident, 50% of all patients still required treatment even after mild TBI.

58.7% of all TBI patients have additional injuries of the facial skull, 8.8% of the vertebral column, 7.2% of the thorax, 2.6% of the abdomen, 3.4% of the pelvis and 19.6% of one or more extremities.

In the 36 to 45 age cohort, 727 patients went to ER, 78.7% required hospital admission and 13.5% required ICU treatment. Deaths were 1%. In the 46 to 55 age cohort, 538 patients went to ER, 79.2% required hospital admission and 15.8% required ICU treatment. Deaths were 0.7%.

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 %: 45)	100	0.5	2 - 44	0 - 24 - 48	0	0	0
ISS-based Treatment (worst case scenario %: 55)	100	1.5	21 - 68	48 - 60 - 72	0 - 68	100	0 - 100
Untreated Best Case	0	0	21 - 68	0 - 24 - 48	0 - 44	0 - 100	0
Untreated Worst Case	0	0	45 - 100	48 - 60 - 72	45 - 100	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 head injury resulting in localized pain/discomfort , diffuse headache, and/or ecchymosis, or a brief change in mental status or consciousness, lasting less than 5 minutes, and requiring only minimal treatment.

The **worst case scenario** is defined as a moderate or severe head or brain injury causing an extended period of unconsciousness, vomiting, diffuse headache or amnesia after the injury. All penetrating injuries are considered severe.

Neck Injuries, Shock, Seizures and sepsis are addressed in the Neck Injury, Hypovolemic Shock, Seizures, 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 3 or greater (Table 28 incidents by body region) (American College of Surgeons, 2010);123,321 serious or greater incidents/ 223,650 overall head incidents = 55%

Based in subject matter expert's opinion (Kerstman, 2010), we are using a discrete number (55%) for the worst case percentage rather than a range for this medical condition.

The Abbreviated Injury Scale (AIS) is designed to stratify victims of motor vehicle crashes. It initiated in 1969 and was last revised in 1990. AIS 3 indicates a serious injury. For complete AIS scale refer to the CliFF Appendix. AIS forms the bases of the Injury Severity Score (ISS) (Association for the Advancement of Automotive Medicine (AAAM), 2004)

The Injury Severity Score (ISS) stratifies injury severity numerically using a 1 to 75 range (1-8 minor, 9-15 moderate, 16-24 severe and >24 very severe) (American College of Surgeons, 2010)

Best Case Comments

Head (Traumatic Brain) injury's functional impairments (FI) calculation follows the IMM severe non-space adaptation template. Consciousness and Awareness ratings are based on table 13-4, p. 327 (American Medical Association, 2008). Alteration in Mental Status, Cognition, and Highest Integrative Function (MSCHIF) ratings are based on Table 13-8, p 331 (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). Refer to the CliFF Appendix for further description of gradings and calculation of FI.

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 in 15 to 30 minutes. During Clinical Phase II, FI is estimated at 2 to 44%. Duration is estimated at 0 to 48 hours. By definition, 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

Head (Traumatic Brain) injury's functional impairments (FI) calculation follows the IMM severe non-space adaptation template. Consciousness and Awareness ratings are based on table 13-4, p. 327 (American Medical Association, 2008). Alteration in Mental Status, Cognition, and Highest Integrative Function (MSCHIF) ratings are based on Table 13-8, p 331 (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). Refer to the CliFF Appendix for further description of gradings and calculation of FI.

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 ATLS, is estimated in 1 to 1.5 hours. During Clinical Phase II, FI is estimated in 21 to 68%. Duration is estimated in 48 to 72 hours. In Clinical Phase III, full recovery may occur though it is not expected and FI is estimated at 0 to 68%.

A retrospective study among US Army troops in Iraq (Belmont, 2010)found that 24% (18/75) cases of non battle disease/neurologic injuries (NBDI)required medevac. Also 19% (11/58) of NBDI/HEENT injuries required medevac ($p<0.0001$). Of note, the US Army has portable trauma services providing care on site. Worst case scenario head/brain injury would be considered as a Class III medical event which requires emergent evacuation (Johnston, 2008), we are estimating 100% EVAC.

The fatality rate in terrestrial studies has been reported as 7.70% (American College of Surgeons, 2010)to 27% (Lu, 2005)in the US; while Germany reported 1% (Rickels, 2010). These data are from trauma centers with high level of care. In space with limited on-board care, mortality is expected to be higher. To allow for uncertainty our estimated range for LOCL is 0 to 100%.

Untreated Best Case Comments

Head (Traumatic Brain) injury's functional impairments (FI) calculation follows the IMM severe non-space adaptation template. Consciousness and Awareness ratings are based on table 13-4, p. 327 (American Medical Association, 2008). Alteration in Mental Status, Cognition, and Highest Integrative Function (MSCHIF) ratings are based on Table 13-8, p 331 (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). Refer to the CliFF Appendix for further description of gradings and calculation of FI.

During Clinical Phase II, FI is estimated at 21 to 68%. 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 44%. EVAC may occur if pain is severe or further evaluation is necessary. By definition, LOCL will not be expected for the best case scenario.

Untreated Worst Case Comments

Head (Traumatic Brain) injury's functional impairments (FI) calculation follows the IMM severe non-space adaptation template. Consciousness and Awareness ratings are based on table 13-4, p. 327 (American Medical Association, 2008). Alteration in Mental Status, Cognition, and Highest Integrative Function (MSCHIF) ratings are based on Table 13-8, p 331 (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). Refer to the CliFF Appendix for further description of gradings and calculation of FI.

During Clinical Phase II, FI is estimated at 45-100%. Duration is estimated in 48 to 72 hours similar to the treated worst case scenario. In Clinical Phase III, recovery is not expected and FI remains 45 to 100%.

In Germany, 77% of patients with brain injury required hospitalization, either at a medical ward or intensive care unit (Rickels, 2010). Worst case scenario head/brain injury would be considered as a Class III medical event which requires emergent evacuation (Johnston, 2008), we are estimating 100% EVAC.

Traumatic brain injury (TBI) is a complex disease process that requires constant attention as one manages the associated body systems. A severe traumatic head or brain injury is a life threatening emergency, requiring resuscitation, intensive care and/or surgery (Losiniecki, 2010). No data are available for severe untreated TBI. We are estimating LOCL as 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
Belmont, Jr., 2010	2	EVAC
Johnston, 2008	2	EVAC
American College of Surgeons, 2010	4	BCWC
Lu, 2005	4	EVAC
Rickels, 2010	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	0	1	1	No	Yes	monitors the oxygen saturation of a patient's blood
Blood Pressure Cuff (regular, large)	0	1	2	No	Yes	Measure blood pressure
Blood Pressure Monitor	0	1	1	No	Yes	Measure blood pressure
BZK wipes	0	3	60	Yes	No	Wound area cleaning (when suturing or stapling); To clean used instruments after surgical repair and prior to re-stowage; Cleaning injection port of saline bag
Camera	0	1	1	No	No	To document rash, or wound
CMRS	0	1	1	No	No	Restrain crew member to ensure safety
Dexamethasone (Decadron) 10mg injectable	0	5	20	Yes	Yes	To decrease cerebral edema
Disposable Otoscope Specula (regular, small)	2	2	90	Yes	No	For use with otoscope for exams
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 insertion
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)	0	15	50	Yes	No	to absorb blood or fluids from skin
Intraosseous Device Starter Kit	0	1	1	Yes	Yes	To provide access fro parenteral fluids & medication.
Intraosseous Injection device	0	1	2	Yes	Yes	Device to provice access site for the parenteral administeration of fluids and medications.
Iodine Swab Stick	0	2	14	Yes	No	to clean wound surrounding area
IV administration set	0	1	3	Yes	Yes	IV fluid administration
IV Cap	0	1	5	Yes	No	To maintain IV when not in use
IV Catheter (18G, 20G, or 22G)	0	1	14	Yes	Yes	IV fluid administration
IV Fluid 1L (1000mL)	0	1	5	Yes	Yes	to replenish fluids

Resource	Units Required Best Case	Units Required Worst Case	Units Available At Start Of Mission	Consumable	Essential	Rationale
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
Medical tape	0	0.03	5	Yes	No	single-coated tapepressure 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)	0	1	30	Yes	No	Personal Protective equipment for CMO
Oral Airway	0	1	2	No	Yes	Airway management
Otoscope (Head, Handle, and USB cable)	1	1	1	No	Yes	Light source for nasal, oral, aural, and eye exams.
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
Promethazine (Phenergan) 25mg/mL 1 mL injectable	0	8	24	Yes	Yes	Nausea relief
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
Skin Staple Remover	0	1	1	No	Yes	To remove staples after wound healed
Skin stapler	0	1	2	Yes	Yes	to close skin wounds
Sterile gloves (large, medium, and small) (pair)	0	1	6	Yes	No	worn when there is contact with sterile instruments or a patient's sterile part
Stethoscope	1	1	2	No	Yes	Audible evaluation of lungs
Suction Cartridge	0	1	1	No	Yes	Provide medical suction
Suction device	0	1	1	No	Yes	to clean out secretions or vomit
Suction device collection bag	0	1	2	Yes	No	To collect fluids suctioned from mouth/airway
Suction device syringe	0	1	1	No	Yes	to remove fluids, secretions, vomit from mouth

Resource	Units Required Best Case	Units Required Worst Case	Units Available At Start Of Mission	Consumable	Essential	Rationale
Suction tip - mouth (curette)	0	1	1	No	Yes	used for suction by inserting into the end of a suction tube
Suction Tubing - Endotracheal Tube	0	1	1	Yes	Yes	Provide airway suctioning
Surgical Lubricant	0	1	6	Yes	No	Provide lubrication during the insertion of the ILMA.
Syringe (35cc)	0	1	1	Yes	Yes	Inflation of SGA tube
Syringe (3cc)	0	7	20	Yes	Yes	For medication administration.
T-adapter	0	1	1	No	Yes	Connection for ventilation tubing
Thermometer	1	1	1	No	No	To measure temperature
Tourniquet	0	1	1	No	No	To stop blood flow and engorge vein, this facilitates IV insertion
Tylenol (Acetaminophen) 325 mg	4	0	150	Yes	Yes	pain relief
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	Ancillary supplies for administration of oxygen
VOS Intubated Patient Hardware (Ventilator/Respirator)	0	1	1	No	Yes	Mechanical Ventilation

Resource Comments

On December 8, 2010 the resources table was revised. The list of resources was updated to include IKA ILMA, BP ECG, respiratory support, IV lock, vital signs, and IV fluids infusion procedures. The procedures lists were compared to the original database list. Duplicate resources were added or merged as necessary to complete the revised list (International Space Station Integrated Medical Group, 2008) (ISS Medical Operations, 2009).

Skin laceration resources may be necessary in case of penetrating injuries. They are similar to the worst case Skin Laceration CliFF. Resources for neck injury, shock, sepsis, or seizures which could occur as a complication of head injury are addressed in the Neck Injury, Shock, Sepsis, or Seizures CliFFs.

Terrestrial guidelines (Brain Trauma Foundation, 2007)acknowledge that analgesics and sedatives are commonly used; they have not shown to improve outcome, and when utilized attention must be paid to potential undesirable side effects. Dosing regimens for analgesics and sedatives (Morphine, 4mg/hr continuous infusion, midazolam, 2-4 mg/hr continuous infusion) are intended for use in intensive care units.

ISS recommends morphine sulfate for pain control and Valium for sedation. ISS doses (Morphine 4.5 mg intravenous every 3 to 4 hours as needed for pain. Valium 5mg intravenous every 2 hours as needed for agitation) are lower and written for use in post resuscitation, not specifically targeted for brain injury.

Terrestrial guidelines (ATLS) recommend reducing elevated intracranial pressure (ICP) by using Mannitol. Furosemide (Lasix) is recommended as an adjuvant (Parks, 2004). We added Furosemide for ICP.

Fentanyl, Mannitol, Propofol, and Sufentanyl are not available on board the ISS (Mission Operations Directorate (MOD), 2011).

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 ISS Medical Operations, 2011	2	Resources
Parks, 2004	3	Resources
NASA Mission Operations Directorate (MOD), 2011	2	Resources

Level Of Evidence

Input Data	LOE Average
Incidence	4
Functional Impairment	3
Best Case / Worst Case	4
EVAC / LOCL	3
Resources	2.33333333333333
QUALITY OF EVIDENCE	**3.26666666666667**

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

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