Toxic Exposure (Ammonia) Cliff

Branch Baseline

At room temperature ammonia is a colorless, flammable gas with a pungent, suffocating odor. It becomes a clear, colorless liquid under increased pressure. Anhydrous ammonia is the form used primarily in refrigeration and agriculture. (NC Department of Health and Human Service, 2012) Ammonia and ammonia solutions may be harmful by all routes of exposure. (Pritchard, 2011) Ammonia dissolves in water to form ammonium hydroxide, a corrosive solution.

The most common way for ammonia to enter the body is through the respiratory system. The extent of injury produced by exposure to ammonia depends on the duration of the exposure, the concentration of the gas, and the depth of inhalation (Borak, 2011). Signs and symptoms of ammonia inhalation can include: coughing, hoarseness, narrowing of bronchi, narrowing of throat and swelling causing upper airway obstruction, accumulation of fluid in the lungs, chest pain, runny nose, tearing of the eyes, impaired vision, headache, and/or dizziness. The symptoms become more severe as the concentration of ammonia increases. (NC Department of Health and Human Service, 2012) Substantial exposures can cause burns of all depths in the oral cavity, nasopharynx, larynx and trachea, together with airway obstruction and bronchiolar and alveolar edema. Exposure to a massive concentration of ammonia gas may be fatal within minutes. (Pritchard, 2011) </

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:	Fixed
Space Adaptation:	No
Incidence Type:	Rate

Distribution Data	
Incidence:	Fixed
Occurrence:	Poisson

Data Characteristics	
Fixed Rate:	0.000164

Incidence Comments

The incidence rate is derived from the results of the ISS PRA Fire and Ammonia Model version 3.2.0 (ISS PRA Model v.3.2.0, 2015). The ISS PRA Model estimated the likelihood of an ammonia release in the ISS habitable environment ("EVAC (NH3)"), for a 6 month mission. The mean was 8.22E-05, and 5th-95th percentiles were 1.52E-05 and 2.26E-04 respectively ({ISS PRA Model v.3.2.0, 2015)}. Therefore, the IMM annual incidence of toxic exposure: ammonia is estimated as 0.000164 events/person years (0.0000822 * 2 to convert from 6 months to 1 year).

Information Regarding Prevention

Vehicle requirements

The US Spacecraft Maximum Allowable Concentrations, considered acceptable-risk levels, are below the US National Institute for Occupational Safety and Health Standards (NIOSH) and US Occupational Safety and Health Administration (OSHA) (Macatangay, 2009)

Contingency measures

There are ammonia monitoring capabilities on ISS such as extended-range Ammonia Detection Kit (US), Portable Breathing Apparatus (PBA) with 10 minutes oxygen, where Positive-pressure minimizes chance of ammonia entering the side of the mask. The Ammonia Respirator Kit contains Small, medium, or large hooded respirators, with dual seal: face mask and neck dam, 6 pairs of ammonia-specific cartridges, certified to 1200 parts per million (ppm) Ammonia, stored in the Functional Cargo Block (FGB) (Macatangay, 2009); (Prokhorov, 2008)

Other

Toxic exposure results from an environmental situation where there are no real medical preventive measures available.

The most probably entry into the ISS cabin is through a gas trap (lowest maximum design pressure (MDP) in the Internal Active Thermal Control System (IATCS). The gas trap is assumed to be the weakest link in the IATCS, lowest MDP – proofed to 212 Pounds per Square Inch Differential (psid). (Macatangay, 2009)

The main goals of ammonia response are to maintain crew safety, and to maintain ISS operations. (Macatangay, 2009)

On board the ISS ammonia is periodically estimated with detector tubes provided by Russian environmental experts. Ammonia is effectively removed by charcoal activated or treated with 10% phosphoric acid. This type of charcoal is used in the trace contaminant control filters but it cannot be thermally regenerated, hence such filters would be unable to control a large release of ammonia into the cabin. (James, 2008)

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
ISS PRA Model v.3.2.0, 2015	3	Incidence

Alternative Incidence Data

Space Flight

A close call occurred in 2001. The incident was generally described as a minor mishap in the shuttle Atlantis' mission to complete the space station's Destiny science module. During a spacewalk ammonia leaked from a cooling line and coated the crewmember's spacesuit and helmet with ice crystals an inch thick. (Schwartz, 2006), (Jones, 2011)

Mission controllers instructed another crewmember to get a brush out of a tool kit and brush away as much of the frost as he could. They then had the affected crewmember remain outside the shuttle for an entire orbit of Earth to let the heat of the Sun evaporate the remaining ammonia. The potential for contamination affected the entire crew. After crewmembers were back inside, they pressurized and then vented and repressurized the air lock to purge ammonia, and the crew wore oxygen masks for about 20 minutes while the life-support systems filtered poisons from the air. (Schwartz, 2006)

Non Analog populations

Unfortunately, available data on ammonia levels during an accidental release are limited, since in most cases the air concentrations were neither measured nor estimated. In addition, since in certain cases an explosion of the storage tank or fire in the nearby facilities accompanied the discharge, it was difficult to assess the damage caused by the gas leak itself. (Makarovsky, 2008)

The North Carolina Department of Health and Human Services, Division of Public Health studies and describes the public health effects associated with releases of hazardous substances, such as ammonia, as part of the Agency for Toxic Substances and Disease Registry's Hazardous Substances Emergency Events Surveillance (HSEES) system. From 1993 to 1997, there were 82 ammonia releases, with 10 (12.1%) involving 39 victims. 33 events required evacuation (40.2%), 31 victims had respiratory injuries (79.4%) (NC Department of Health and Human Service, 2012). Clinical reports of these events are not available.

Makarovsky provided a review of 7 events, between 1973 and 2006, all accidental. A 1976 event in Houston, TX, when ammonia was released on a highway, caused 6 deaths, 78 hospitalizations, and 100 others needed medical care. In 2002, a railroad accident in Minot, North Dakota caused 1 death, 11 sustained major injuries and 322 minor injuries. In a 2006 leak in a factory in Be'er Tuvia, Israel, 20 were injured, One severely injured had to get respiratory support, resuscitation and decontamination on scene and was in an intensive care unit for 6 weeks. (Makarovsky, 2008)

In 1987, a crew of 12, on board a deep sea fishing vessel sustained respiratory burns of varying degrees as a result of exposure to anhydrous ammonia gas. They were categorized in three groups based on the severity of the respiratory tract involvement. The first group of four was asymptomatic on admission, with mild respiratory burns; bronchoscopy showed all have inflamed tracheobronchial tree; Lung scan was positive for injury in two and inconclusive in one. Length of stay (LOS) was 7 days and all recovered. The second group of six had moderate respiratory burns and all required intubation. Five of them were intubated in the emergency room. One was not dyspneic on admission but was intubated 24 hours later. Ventilatory support ranged from three to fourteen days. Lung scan showed pulmonary parenchyma damage in five patients.LOS range was 16 to 46 days. The third group included 2 patients with severe respiratory burns. Lung scans evidenced severe burn damage. One died after 9 days. On the second, extubation was unsuccessful on several attempts. LOS was 7 months. At discharge, the chest X-ray showed bronchiectasis in the right lung (Leung, 1992).

Thirty men working in a warehouse were exposed to anhydrous ammonia when an explosion caused collapse of one of the building's walls, damaging a large ammonia storage tank. A strong odor of ammonia forced evacuation of the warehouse. Seven patients were evacuated to a local hospital with hoarseness and respiratory difficulty; five were intubated for airway obstruction (71%). The symptoms of the two non intubated patients resolved during the next 24 to 48 hours, and they did not require transfer. The remaining five patients were transferred to the U.S. Army Institute of Surgical Research Burn Center, Fort Sam Houston, Texas, arriving on post burn day (PBD) 4. All of them have different levels of respiratory problems. Given the likelihood of life-long ventilator dependence, one case asked to receive comfort care only. He died on PBD 100.The remaining cases had follow up care ranging from 9 days (lost to follow up) to 8 months with long term obstructive lung disease. (White, 2007)

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 %: 0)	100	0.25	3 - 46	0.25 - 0.625 - 1	0	0	0
ISS-based Treatment (worst case scenario %: 100)	100	0.5 - 1	21 - 70	18 - 27 - 36	0 - 70	100	0 - 100
Untreated Best Case	0	0	21 - 70	0.25 - 0.625 - 1	0 - 46	0	0
Untreated Worst Case	0	0	48 - 100	18 - 27 - 36	48 - 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** describes, even though the probability is 0% based on ISS PRA Fire and Ammonia Module, a crewmember with mild exposure (ammonia inhalation) that resolves without treatment or is easily treated. The crewmember can resume their duties with no threat to the mission.

The **worst case scenario is defined** as a significant exposure (Ammonia inhalation), which may result in acute respiratory failure or other significant end-organ dysfunction.

Percentages of how often best versus worst case scenarios occur

The percentages of best case versus worse case are based on the ISS PRA Fire and Ammonia Module results (ISS PRA Model v.3.2.0, 2015). As per the ISS PRA Fire Module, ammonia is considered to be Hazardous Release Level 4 (Tox 4 - a ctastrophic release of a toxic compound with poor contatinment). The spacecraft maximum allowable concentration (SMAC) limit on ammonia is very low and would be violated almost immediately, likely requiring the crew evacuate the ISS. Therefore, the probability of a worst case scenario is estimated to be 100%.

Best Case Comments

Toxic exposure: Ammonia through inhalation affects respiratory function and may cause unconsciousness. The 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). Consciousness and Awareness is based on Table 13-4, p.327 (American Medical Association, 2008). Combined FI ratings are calculated combining the Pulmonary dysfunction FI and Consciousness and Awareness using the Combined Values Chart as indicated in Appendix A, pp 604-60 (American Medical Association, 2008). Refer to this CliFF Appendix for further description of grading and calculation of functional impairment.

In **Clinical Phase I,** by definition FI is estimated as 100%. Time to follow ISS procedures for best case toxic exposure inhalation will take approximately 15 minutes.

During **Clinical Phase II,** FI is estimated to be 3 to 46%. Follow-up treatment as per the ISS checklist is estimated in fifteen minutes to 1 hour, considering that vital signs are assessed for 30 minutes and the crew member may need to contact surgeon for PMC.

Clinical Phase III: Full recovery is expected in this scenario and FI is estimated to be 0%. By definition EVAC and LOCL are not expected for the best case scenario.

Worst Case Comments

Toxic exposure: Ammonia through inhalation affects respiratory function and may cause unconsciousness. The 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). Consciousness and Awareness is based on Table 13-4, p.327 (American Medical Association, 2008). Combined FI ratings are calculated combining the Pulmonary dysfunction FI and Consciousness and Awareness using the Combined Values Chart as indicated in Appendix A, pp 604-60 (American Medical Association, 2008). Refer to this CliFF Appendix for further description of grading and calculation of functional impairment.

In **Clinical Phase I,** by definition FI is estimated at 100%. Time to follow ISS procedures for worst case toxic exposure inhalation may take half to one hour for respiratory support.

During **Clinical Phase II:** FI is estimated to be 21 to 70%. Duration is estimated in 18 to 36 hours, as the minimum time for undocking two Soyuz from the time decision is made to evacuate (Macatangay, 2009).

In **Clinical Phase III:** FI is estimated to be 0 to 70%. Worst case toxic exposure inhalation is a Class III medical event, e.g. a significant medical event requiring evacuation if occurring in orbit (Johnston, 2008). EVAC is estimated at 100% for this scenario based on engineering analysis (Macatangay, 2009) (ISS PRA Model v.3.2.0, 2015). Terrestrially, astronauts have been hospitalized after inhalation exposure, although not caused by ammonia (Johnston, 2008). Acute respiratory distress has been reported (Leung, 1992), (Makarovsky, 2008), (White, 2007). Given the fact that the astronaut population is routinely six in the ISS and there is limited equipment available, in a mass inhalation event it may not be possible to treat more than one crew member. Terrestrially, ammonia inhalation has caused deaths (Leung, 1992), (Makarovsky, 2008), (White, 2007). Therefore, to account for uncertainty, LOCL is estimated at 0 to 100% for this scenario.

Untreated Best Case Comments

Toxic exposure: Ammonia through inhalation affects respiratory function and may cause unconsciousness. The 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). Consciousness and Awareness is based on Table 13-4, p.327 (American Medical Association, 2008). Combined FI ratings are calculated combining the Pulmonary dysfunction FI and Consciousness and Awareness using the Combined Values Chart as indicated in Appendix A, pp 604-60 (American Medical Association, 2008). Refer to this CliFF Appendix for further description of grading and calculation of functional impairment.

During **Clinical Phase II,** FI is estimated to be 21 to 70%. Duration is similar to the treated best case scenario.

In **Clinical Phase III,** FI is estimated to be 0 to 46%. Recovery might be possible based in the amount of toxic contaminant inhaled, the reaction to it, and scrubbing of the environment by on-board resources, or simply by moving away from the source. By definition, EVAC and LOCL are not expected for this scenario.

Untreated Worst Case Comments

Toxic exposure Ammonia through inhalation affects respiratory function and may cause unconsciousness. The 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). Consciousness and Awareness is based on Table 13-4, p.327 (American Medical Association, 2008). Combined FI ratings are calculated combining the Pulmonary dysfunction FI and Consciousness and Awareness using the Combined Values Chart as indicated in Appendix A, pp 604-60 (American Medical Association, 2008). Refer to this CliFF Appendix for further description of grading and calculation of functional impairment.

During **Clinical Phase II:** FI is estimated to be 48 to 100% and duration is 18 to 36 hours similar to the treated worst case scenario.

In **Clinical Phase III,** recovery is unlikely without treatment and FI is estimated to remain 48 to 100%. Worst case toxic exposure is a Class III medical event, a significant medical event requiring evacuation if occurring in orbit (Johnston, 2008). EVAC is estimated as 100%, similar to the treated worst case scenario. Considering the seriousness of ammonia inhalation and the lack of medical resources to treat the condition in this scenario, LOCL is estimated as 100%.

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
Macatangay, 2009	2	EVAC
Johnston, 2008	2	EVAC
Leung, 1992	4	EVAC
Makarovsky, 2008	4	EVAC
White, 2007	4	EVAC
ISS PRA Model v.3.2.0, 2015	3	BCWC

The Resource Table (RT)

Resource	Units Required Best Case	Units Required Worst Case	Units Available At Start Of Mission	Consumable	Essential	Rationale
Albuterol inhaler (Proventil) 90 mcg, 6.7 gm	0	1	3	Yes	Yes	bronchodilator, to relieve wheezing
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	7	60	Yes	No	Cleanse skin.
CMRS	0	1	1	No	No	Restrain crew member to ensure safety
Dexamethasone (Decadron) 10mg injectable	0	2	20	Yes	Yes	steroid anti-inflammatory, to inject intravenously or intramuscularly
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)	0	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 (18G, 20G, or 22G)	0	1	14	Yes	Yes	IV fluid administration
IV Fluid 1L (1000mL)	0	4	5	Yes	Yes	Parental replacement of fluides.
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

Resource	Units Required Best Case	Units Required Worst Case	Units Available At Start Of Mission	Consumable	Essential	Rationale
Medical tape	0	1	5	Yes	No	single-coated tapepressure adhesive tape
Nasal Airway (6mm, 7mm)	0	1	2	No	Yes	Establish and maintain patent airway and ventilation
Needle (23G)	0	6	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	Establish and maintain patent airway and ventilation
Pack of 12 ECG electrodes	0	1	5	Yes	Yes	Measure and monitor ECG
PEEP Valve	0	1	1	No	Yes	Provides 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 airway suctioning
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
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	To lubricate bottom of ILMA mask, roof of the mouth, ET Tube
Syringe (10cc)	0	2	6	Yes	Yes	to inflate balloon in ET tube (10 cc)
Syringe (35cc)	0	1	1	Yes	Yes	Inflation of SGA
Syringe (3cc)	0	8	20	Yes	Yes	to inflate resuscitation mask if necessary and 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 depress tongue and facilitate airway exam
Tourniquet	0	1	1	No	No	To stop blood flow and engorge vein, this facilitates IV insertion

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	ventilatory support
VOS Intubated Patient Hardware (Ventilator/Respirator)	0	1	1	No	Yes	Mechanical Ventilation

Resource Comments

The Resource Table was revised on October 25, 2012. Resources for skin or eye burns are addressed on the Burns and Eye chemical burn CliFFs respectively. All resources are included in the ISS Medical Checklist and/or Medical Hardware Catalog (Mission Operations Directorate (MOD), 2011); (ISS Medical Operations, 2009)

Comparison between the Medical Checklist and Urban treatment guidelines:

The Med Checklist addresses the immediate medical crisis in the same way the urban treatment does with extracting the crewmember or patient to a safe environment and initiating cardiopulmonary resuscitation and/or ACLS. The ongoing critical care treatment will present limitation in microgravity.

Terrestrially there is no specific antidote. On-site management consists of personal protection, rapid evacuation, respiratory and fluid support, as well as decontamination. (Makarovsky, 2008), (Borak, 2011), (Haywood, 2012), (White, 2007). Early intubation is recommended (White, 2007). Inhaled corticosteroids, and heparin are not available on board.

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	3
Functional Impairment	3
Best Case / Worst Case	3
EVAC / LOCL	3.2
Resources	2
QUALITY OF EVIDENCE	**2.84**

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

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