Cardiogenic Shock secondary to Myocardial Infarction Cliff

Branch Baseline

Cardiogenic shock is when inadequate tissue perfusion results from cardiac dysfunction, most commonly following acute myocardial infarction. The clinical definition of cardiogenic shock is decreased cardiac output and evidence of tissue hypoxia in the presence of adequate intravascular volume. The diagnosis of cardiogenic shock is made at the bedside by observing hypotension and clinical signs of poor tissue perfusion. These signs can include distended jugular veins, pulmonary edema, S3 gallop, oliguria, cyanosis, cool extremities, and altered mentation. (Lenneman, 2011) The clinical manifestations of cardiogenic shock in microgravity are unknown, but we would assume that the presentation would be different without a gravity gradient to exacerbated orthostatic hypotension. Therefore the recorded blood pressure may read higher than the patient's condition would suggest. The other signs of central and peripheral perfusion may also be altered on orbit by the cephalad fluid shift. (Marshburn, 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:	Fixed
Space Adaptation:	No
Incidence Type:	Rate

Distribution Data	
Incidence:	Fixed
Occurrence:	Poisson

Female Data Characteristics	
Fixed Rate:	5.29E-06

Male Data Characteristics	
Fixed Rate:	7.49E-06

Incidence Comments

The **female incidence rate** calculation: (5-10%)(0-30%)(0.000470) = 0.00000529

Cardiogenic shock is associated with 5-10% of patients with myocardial infarctions (MI). (Goldberg, 1999) (Goldberg, 2001) (Lenneman, 2011) Since the worst case definition of chest pain/angina includes MI, the incidence rate for cardiogenic shock is estimated to be 5-10% of the incidence of worst case chest pain/angina. Therefore, the incidence of cardiogenic shock is calculated as noted above.

While the **male incidence rate**, is worst case acute chest pain/angina is myocardial infarction and since 5-10% of patient with MI develop cardiogenic shock we calculated: (5-10%)(0-15%(0.000630)=0.00000749 events/person years. (Hollenberg, 2001) Cardiogenic shock is associated with 5-10% of patients with myocardial infarctions. (Goldberg, 1999) (Goldberg, 2001) (Lenneman, 2011) Since the worst case definition of chest pain/angina includes MI, the incidence rate for cardiogenic shock is estimated to be 5-10% of the incidence of worst case chest pain/angina. Therefore, the incidence of cardiogenic shock is calculated as noted above.

Information Regarding Prevention

Selection Criteria

NASA Medical Standards for ISS crewmembers list causes for rejection due to risk factors for heart disease include a history or evidence of hypertrophy, hypertension, pericarditis, myocarditis, endocarditis, congenital abnormalities, and a history of coronary artery disease, clinically significant cardiac dysrhythmias, or valvular disorders. (Department of Defense, 2005)

Other

Periodic and pre-flight examinations and testing includes cardiovascular risk marker lab analysis, resting ECG, exercise stress testing, and a 24 hour Holter monitor. Astronauts have an ongoing cardiovascular conditioning program and pre-flight aerobic functional capacity testing. They also maintain a daily exercise schedule on orbit to maintain cardiovascular and musculoskeletal conditioning during flight. (International Space Station Program Medical Standards for ISS Crewmembers Working Group, 2009) (MSMB Working Group, 2009)

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
Goldberg, 1999	4	Incidence
Goldberg, 2001	4	Incidence
Xiushui, 2011	4	Incidence
Hollenberg, 2001	4	Incidence

Incidence data not included in the model

The model pulls the incidence information from the IMM database ... the information shown below does not go into the model.

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

Distribution Data	
Incidence:	Fixed
Occurrence:	Poisson

Data Characteristics	
Fixed Rate:	4.6E-06

Incidence Comments

Since worst case acute chest pain/angina is myocardial infarction and since 5-10% of patient with MI develop cardiogenic shock we calculated: (5-10%)(0-15%(0.000825)=**0.0000046 events/person years.** (Hollenberg, 2001)

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 - 26)	100	1	5 - 58	24 - 48 - 72	0	100	0
ISS-based Treatment (worst case scenario %: 74 - 100)	100	1 - 2	30 - 82	1 - 12.5 - 24	100	100	100
Untreated Best Case	0	0	30 - 82	24 - 48 - 72	0 - 58	100	0 - 100
Untreated Worst Case	0	0	60 - 100	1 - 12.5 - 24	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

In a study by Goldberg, the probability of death for patients hospitalized with cardiogenic shock was 74% [Goldberg, 2001]. Due to environmental limitations in-flight, we estimate the percentage of worst cases at 74 to 100%. Thus, best cases are estimated from 0 to 26%. (Goldberg, 2001)

Best case scenario describes a crewmember suffering mild cardiogenic shock exhibiting low blood pressures and some minor signs of poor perfusion. The crewmember recovers with minimal interventions.

Worst case scenario is defined as crewmember suffering severe cardiogenic shock. The crewmember suffers altered state of conscious to unconsciousness and exhibits low blood pressure, cyanosis and oliguria. The crewmember is unlikely to survive without significant invasive treatment such as revascularization, intra-aortic balloon pump and appropriate vasopressor and inotropic agents.

Best Case Comments

The functional impairments (FI) calculation for this condition follows the IMM Severe Non-Space Adaptation Medical Conditions template (Kerstman, 2010). Cardiomyopathies, Central Nervous System: Consciousness and Awareness, and Coronary Artery Disease (CAD) conditions are combined for the determination of the FI. According to the template in Clinical Phase II the FI follows Class 1-2 in the Guide to the Evaluation of Permanent Impairment, which translates to 2-23% Whole Person Impairment (WPI) for cardiomyopathy, 1-30% for consciousness and awareness, and lastly 2-23% for CAD (American Medical Association, 2008) (American Medical Association, 2008). Once the scores are combined the CPII is 5-58% WPI for a duration of 24-72 hours. While in Clinical Phase III the FI follows Class 0 for 0% WPI. Consequently, the outcomes in Clinical Phase III are 0% risk of LOCL although the affected crewmember will need to be evacuated to a definitive care facility for further treatment (Goldberg, 2001).

Worst Case Comments

The functional impairments (FI) calculation for this condition follows the IMM Severe Non-Space Adaptation Medical Conditions template (Kerstman, 2010) except during Clinical Phase III to adjust to the severity of outcomes. Cardiomyopathies, Central Nervous System: Consciousness and Awareness, and Coronary Artery Disease conditions are combined for the determination of the FI. According to the template in Clinical Phase II the FI follows Class 2-3 in the Guide to the Evaluation of Permanent Impairment (American Medical Association, 2008) (American Medical Association, 2008). Once the scores are combined the CPII is 30-82% WPI for duration of 1- 24 hours. While in Clinical Phase III the FI is 100%. Consequently, the outcomes in Clinical Phase III are 100% risk of EVAC and LOCL (Goldberg, 2001).

Untreated Best Case Comments

The functional impairments (FI) calculation for this condition follows the IMM Severe Non-Space Adaptation Medical Conditions template (Kerstman, 2010). Cardiomyopathies, Central Nervous System: Consciousness and Awareness, and Coronary Artery Disease conditions are combined for the determination of the FI. According to the template in Clinical Phase II the FI follows Class 2-3 in the Guide to the Evaluation of Permanent Impairment (American Medical Association, 2008) (American Medical Association, 2008). Once the scores are combined the CPII is 5-58% WPI for duration of 24-72 hours. While in Clinical Phase III the FI follows Class 0-2 for 0-58% WPI. Consequently, the outcomes in Clinical Phase III are 0% risk of LOCL although the affected crewmember will need to be evacuated to a definitive care facility for further treatment (Goldberg, 2001).

Untreated Worst Case Comments

The functional impairments (FI) calculation for this condition follows the IMM Severe Non-Space Adaptation Medical Conditions template (Kerstman, 2010) except during Clinical Phase III to adjust to the severity of outcomes. Cardiomyopathies, Central Nervous System: Consciousness and Awareness, and Coronary Artery Disease conditions are combined for the determination of the FI. According to the template in Clinical Phase II the FI follows Class 3-4 in the Guide to the Evaluation of Permanent Impairment (American Medical Association, 2008) (American Medical Association, 2008). Once the scores are combined the CPII is 60-100% WPI for duration of 24-72 hours. While in Clinical Phase III the FI is 100% WPI. Consequently, the outcomes in Clinical Phase III are 100% risk of EVAC and LOCL (Goldberg, 2001).

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
Goldberg, 2001	4	BCWC
	4	EVAC

Additional Comments

PubMed key word searches include cardiogenic shock, myocardial infarction, and tissue perfusion.

The Resource Table (RT)

Resource	Units Required Best Case	Units Required Worst Case	Units Available At Start Of Mission	Consumable	Essential	Rationale
Adrenaline (Epinephrine 1:10000) 10mL	0	4	4	Yes	Yes	Sympathomimetic vasopressor that increases heart rate and constricts blood vessels
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	3	5	60	Yes	No	Cleanse skin.
CMRS	1	1	1	No	No	Restrain crew member to ensure safety
ECG Monitor (Device, USB Charge Cable, Lead Set Cable, Cue Card)	1	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)	6	6	50	Yes	No	To absorb blood or fluids from skin
IV administration set	1	1	3	Yes	Yes	IV Fluids infusion
IV Cap	1	1	5	Yes	No	To attach IV fluids to Y-type catheter
IV Catheter (18G, 20G, or 22G)	1	1	14	Yes	Yes	IV fluid administration
IV Fluid 1L (1000mL)	2	4	5	Yes	Yes	To replenish fluids, increase intravascular volume
IV Fluid Air Filter	1	1	3	Yes	No	To filter air from IV line
IV pressure infuser	1	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.
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	1	1	5	Yes	No	Single-coated tape, pressure adhesive tape

Resource	Units Required Best Case	Units Required Worst Case	Units Available At Start Of Mission	Consumable	Essential	Rationale
Nasal Airway (6mm, 7mm)	0	1	2	No	Yes	Airway management
Needle (23G)	0	3	20	Yes	Yes	For ketamine administration.
Nitrile gloves (large, medium, and small) (pair)	1	2	30	Yes	No	Personal Protective equipment for CMO
Oral Airway	0	1	2	No	Yes	Airway management
Pack of 12 ECG electrodes	1	1	5	Yes	Yes	Measure and monitor ECG
PEEP Valve	0	1	1	No	Yes	Provide positive airway pressure
SGA Cue Card	0	1	1	No	Yes	Guidance for use of supraglottic airway
Sharps container	1	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 auscultate the lungs and heart. To assess blood pressure and blood flow in the arteries and veins.
Suction Cartridge	0	1	1	No	Yes	Provide medical suction
Suction device	0	1	1	No	Yes	To remove excess oral 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 excess oral secretions or vomit
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 suction for airway
Surgical Lubricant	0	1	6	Yes	No	Provide lubrication during the ILMA insertion.
Syringe (35cc)	0	1	1	Yes	Yes	Inflation of SGA tube
Syringe (3cc)	1	3	20	Yes	Yes	For ketamine administration.
T-adapter	0	1	1	No	Yes	Connection for ventilation tubing
Thermometer	1	1	1	No	No	To measure temperature
Tongue depressor	1	1	20	Yes	No	Used to help visualize the oral cavity
Tourniquet	1	1	1	No	No	To stop blood flow and engorge vein, this facilitates IV insertion
Valium (Diazepam) 5 mg/mL, 2 mL syringe	0	1	2	Yes	Yes	For sedation with intubation
Variable Oxygen System	1	1	1	No	Yes	Oxygenate tissues
VOS Intubated Patient Hardware (Ventilator/Respirator)	0	1	1	No	Yes	Mechanical ventilation

Resource Comments

The source of the resource table data was derived from the ISS Medical Checklist (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 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	4
Resources	2
QUALITY OF EVIDENCE	**3.4**

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

Reference List

Reference
American Medical Association. Central and Peripheral Nervous System. Guides to the Evaluation of Permanent Impairment. 6th ed. Chicago: American Medical Association Press; 2008. p. 321-45.
American Medical Association. Cardiovascular System. In: Rondinelli R, editor. Guides to the Evaluation of Permanent Impairment. 6th ed. Chicago: American Medical Association Press; 2008. p. 47-76.
Department of Defense. Medical Standards for Appointment, Enlistment or Induction in the Armed Forces. e1.11. 2005.
Goldberg RJ, Samad NA, Yarzebski J, Gurwitz J, Bigelow C, Gore JM. Temporal trends in cardiogenic shock complicating acute myocardial infarction. N Engl J Med 1999 Apr 15;340(15):1162-8.
Goldberg RJ, Gore JM, Thompson CA, Gurwitz JH. Recent magnitude of and temporal trends (1994-1997) in the incidence and hospital death rates of cardiogenic shock complicating acute myocardial infarction: the second national registry of myocardial infarction. Am Heart J 2001 Jan;141(1):65-72.
Hollenberg SM. Cardiogenic shock. Crit Care Clin 2001 Apr;17(2):391-410.
IMM FI Guidelines. IMM Functional Impairment Guidelines for the Clinical Findings Form (CliFFs). 12-31-2010.
International Space Station Program Medical Standards for ISS Crewmembers Working Group. Medical Evaluation Document (MED): Cardiovascular Volume A. NASA; 2009. Report No.: SSP 50667.
Marshburn TH. Acute Care. In: Barratt M, Pool S, editors. Principles of Clinical Medicine for Space Flight.New York: Springer; 2008. p. 101-22.
MSMB Woring Group. Medical Evaluation Documents (MED): Cardiovascular Volume B Rev 2.0. 2009. Report No.: SSP 50667.
NASA Mission Operations Directorate (MOD). International Space Station Integrated Medical Group Medical Checklist. Mission Operations Directorate (MOD), Systems Operations Data File (SODF) . 6-24-2011. Houston, TX, National Aeronautics and Space Administration (NASA).
Xiushui RLA, Lenneman A. Medscape: Cardiogenic Shock. Ooi H, editor. 2-1-2011. WebMD LLC.