Shoulder Dislocation Cliff

Branch Baseline

The shoulder is the most frequently dislocated joint. It moves almost without restriction but pays the price of stability. The shoulder's integrity is maintained by the glenohumeral joint capsule, the cartilaginous glenoid labrum (which extends the shallow glenoid fossa), and muscles of the rotator cuff.

Anterior dislocations occur in as many as 98% of cases. Anterior displacement of the humeral head is the most common dislocation seen by emergency physicians (Wilson, 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:	3.723E-05

Incidence Comments

Shoulder dislocation has not occurred in space flight. A study to determine the incidence of Musculoskeletal Injuries and Minor Trauma in Space as well as Injury Mechanisms in U.S. Astronauts, reported one Shoulder strain and five shoulder injuries due to exercise activity, 4 in Shuttle and 1 in MIR. Unspecified injuries incidence rate is 0.003 in Shuttle and 0.001 in MIR (Scheuring, 2009). No shoulder dislocations reported.

Lacking phenomenological data on dislocation risk in space, we are using terrestrial data. The annual incidence of shoulder injuries in North American urban settings is 2.19 per 1000 population, with a 1.7% prevalence of shoulder dislocations (Wong, 2007). Based on this data, the incidence of shoulder dislocation among astrounauts in flight is estimated as 0.00003723 events per person years (0.017*0.00219).

Information Regarding Prevention

Selection criteria

Disqualifying conditions in the musculoskeletal category include:

Traumatic, inflammatory, degenerative, congenital and metabolic disorders, or disease of any bone, joint, muscle or supporting structure that interferes with the performance of duties; chronic arthritis with functional disability that interferes with the performance of duties; benign tumors or cysts, single or multiple, sufficiently large to interfere with performance of duties, or to create a fracture potential. Osteochondromatosis or multiple cartilaginous exostoses that interfere with performance of duties; Joint instability e.g. recurrent subluxations or dislocations of an articulation;. Intra-articular loose bodies, osteocartilaginous or metallic foreign objects, in any joint that interfere with performance of duties; Non-union of fractures; mal-union of fractures that interferes with performance of duties. Less than functional range of motion and stability of all joints. A total range of motion of the wrist of 70 degrees dorsal extension plus 80 degrees palmar flexion: ulnar deviation 45 degrees plus 15 degrees radial deviation. Pronation of the hand to 90 degrees and supination to 80 degrees. Chronic or recurrent bursitis, tendinitis, and synovitis sufficient to interfere with the performance of duties.

Conditions requiring special consideration by the MSMB include: history of osteochondromatosis or multiple cartilaginous exostoses that have been successfully surgically excised; history of joint instability that has been medically or surgically corrected; history of intra-articular loose bodies in any joint surgically removed with no residual; any fracture in which hardware, e.g. rod, plate, pin or screw, was used for fixation, if the fixation devices remain in place, will require orthopedic consultation; Minor deviations from the range of motion of the wrist; Osteopenia will require endocrine evaluation and possibly other specialized scanning techniques.

The WHO definition of osteopenia is based on a DEXA measurement of Bone Mineral Density of total lumbar spine less than 0.937gm/cm2 or femoral neck less than 0.738 gm/cm2, or greater trochanter of the femur less than 0.602 gm/cm2. T-score: -1.0 to -2.5 SD. Osteoporosis. The WHO definition of osteoporosis is based on a DEXA measurement of Bone Mineral Density of total **lumbar spine** less than 0.772 gm/cm2 or femoral neck less than 0.572 gm/cm2 or greater trochanter of the femur less than 0.451 gm/cm2. T-score: Lower than -2.5 SD. (NASA, 2007); (International Space Station Program, 2009)

Other

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

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
Wong, 2007	4	Incidence

Alternative Incidence Data

Analog Populations

An analysis of 10 years of data collected on Polaris submarine patrols over the ten year period 1963-1973 reported a total of 1685 medical events treated. Illness rates are indicated as new/cases/1000 man-days. There were a total of 132 bone and joint disease events during the 1963-67 period with an illness rate of 0.041; 664 sick days, and 1 EVAC. There was 1 shoulder dislocation (Table A11). (Tansey, 1979) We calculated an incidence of 0.041 per 1000 man-days (0.000041*365) 0.015 person-years. Shoulder dislocation (1/132) accounted for 0.76% of the total orthopedic events or a rate of 0.00011. No information on which conditions required EVAC.

Another study among US Navy Submarines determined that the incidence of injuries was 0.056 (5.6/100) for officers and 0.201 (20.1/100) for enlisted men per person-years. Information was not stratified by type of injury. The most common cause of limited or no duty days among enlisted men was injury (1824 d), followed by digestive (403 d), and musculoskeletal (350 d). Among officers, the highest morbidity rate was for respiratory illnesses, followed by **injury**, and musculoskeletal disorders. The population was composed of 240 submarine patrols, between 1 January 1997 and 30 September 2000; total of 1389 officers and 11,952 enlisted crew members served aboard participating submarines for 215,086 and 1,955,521 person-days at sea. In summary, potentially mission-impacting medical events reported among officers aboard submarine patrols were rare (36.3 per 100 person-years underway. The officers are most analogous to current space program participants. The majority of the medical events reported among officers and enlisted men could be considered minor and non-life threatening, with little or no impact on unit mission. (Thomas, 2003) Shoulder ICD-9 code is 831. Thomas' study includes codes 800-999 as a group.

A nine-month study of US Navy medical communications and Evacuations at sea (Nice, 1987) determined that 31% of medical communications were related to injuries, mainly fractures and lacerations, and 36% of medevacs included injuries . Medevac was defined as the non routine transfer of a patient from a ship at sea for the purpose of receiving more definitive care.

A longitudinal cohort study of 4,122 US Army deployed to Iraq for 15 months to evaluate all disease and non battle injuries (DNBI) was performed. A casualty in customary military usage means active duty service member lost to the theater of operations for medical reasons. Musculoskeletal injuries were classified in three major categories: upper extremity, lower extremity and axial spine There were 667 total musculoskeletal injuries; a total of 27 upper extremity instability injuries, with 18.5% MEDEVACs (5/27). Shoulder injuries were 11.8% of the total musculoskeletal injuries. The first time shoulder dislocation rate is 1.2 per 1000 person years, (Belmont, 2010) or 0.0012 This rate is lower than military rates and higher than civilian US population. Males (16.3%) when compared with females (15.1%) were not at significantly increased risk for musculoskeletal casualties. The average age was 27 years, range 18 to 52. (Belmont, 2010)

A study to determine the incidence of shoulder dislocation in United States military personnel searched the Defense Medical Epidemiology Database, for acute shoulder dislocation for the years 1998 through 2006.The overall incidence rate was 1.69 dislocations per 1000 person-years, or 0.00169 per person-years. Significant demographic risk factors were male sex, white race, service in the Army, junior enlisted rank, and an age of less than thirty years ($p<0.0001$). (Owens, 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 %: 0 - 7)	100	1	2 - 28	672 - 840 - 1008	0	0	0
ISS-based Treatment (worst case scenario %: 93 - 100)	100	1.5	15 - 49	168 - 252 - 336	0 - 49	100	0
Untreated Best Case	0	0	15 - 49	672 - 840 - 1008	0 - 28	100	0
Untreated Worst Case	0	0	29 - 84	168 - 252 - 336	29 - 84	100	0

[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

Best case scenario is defined as a dislocation with stable capsular tears and no labral ligament lesions that reduces spontaneously or without complication**.** (Baker Type 1)

Worst case scenario is defined as a dislocation with partial or complete labral detachments, mildly to grossly unstable, and mild to large hemarthrosis (Baker type 2 and 3)

Percentages of best case versus worst case scenario

We estimated percentages of best versus worst case based on Jakobsen's study (Jakobsen, 2007), where 6.6 of subjects had Baker type 1, and the remainder 93.4 had type 2 or 3 injuries. To allow for uncertainty our estimate is 93-100% for the worst case and best case is 0-7%

Best Case Comments

Shoulder Dislocation functional impairments (FI) calculation follows the IMM severe non-space adaptation template. Shoulder regional grid fracture ratings are based on Table 15-5, pp.401-405 (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 Shoulder regional grid and CRPS (UEI) ratings are converted to percentage of Whole Person Impairment (WPI), which are based on Table 15-1, p 385. (American Medical Association, 2008) Total 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).

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 one hour. During Clinical Phase II, FI is estimated in 2 to 28%. A stable shoulder dislocation may receive conservative treatment. Recovery from a shoulder dislocation may require up to 4-6 weeks. (American Academy of Orthopaedic Surgeons, 2007)Duration is estimated in 672 to 1008 hours, or 28 to 42 days. In Clinical Phase III, full recovery is expected and FI is 0%. EVAC is not expected. By definition LOCL would not be expected for the best case scenario.

Worst Case Comments

Shoulder Dislocation functional impairments (FI) calculation follows the IMM severe non-space adaptation template. Shoulder regional grid fracture ratings are based on Table 15-5, pp.401-405 (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 Shoulder regional grid and CRPS (UEI) ratings are converted to percentage of Whole Person Impairment (WPI), which are based on Table 15-1, p 385. (American Medical Association, 2008) Total 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).

By definition in Clinical Phase I, FI is 100%. Duration to follow procedures specified in ISS checklist, i.e. physical exam, vital signs, splint, is estimated in one and a half hours. During Clinical Phase II, FI is estimated in 15 to 49%. Duration is estimated in 168 to 336 hours, or 7 to 14 days, considering the time from injury to EVAC. In Clinical Phase III, full recovery may or may not occur and FI is estimated at 0-49%. EVAC is estimated at 100% to allow for transfer to a definitive care facility for surgery or closed reduction. Shoulder dislocation had occurred among astronauts in the ground and required hospitalization; they are Class IIc, event manageable with HMS but may necessitate emergent evacuation if the condition does not improve or worsens. (Johnston, 2008) EVAC has also occurred in analog populations (Belmont, 2010). LOCL is not expected

Untreated Best Case Comments

Shoulder Dislocation functional impairments (FI) calculation follows the IMM severe non-space adaptation template. Shoulder regional grid fracture ratings are based on Table 15-5, pp.401-405 (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 Shoulder regional grid and CRPS (UEI) ratings are converted to percentage of Whole Person Impairment (WPI), which are based on Table 15-1, p 385. (American Medical Association, 2008) Total 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).

During Clinical Phase II, FI is estimated in 15 to 49%. Duration is estimated at 168 to 336 hours, similar to the treated worst case scenario. In Clinical Phase III, recovery may or may not occur. A splint can be improvised with on board supplies, but there are not analgesics to treat pain. FI is estimated at 0-28%., EVAC is estimated in 100% for the untreated best case. By definition LOCL would not be expected for this scenario.

Untreated Worst Case Comments

Shoulder Dislocation functional impairments (FI) calculation follows the IMM severe non-space adaptation template. Shoulder regional grid fracture ratings are based on Table 15-5, pp.401-405 (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 Shoulder regional grid and CRPS (UEI) ratings are converted to percentage of Whole Person Impairment (WPI), which are based on Table 15-1, p 385. (American Medical Association, 2008) Total 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).

During Clinical Phase II, FI is estimated in 29 to 84%. Duration is estimated in 168 to 336 hours, similar to the treated worst case scenario. In Clinical Phase III, recovery is unlikely and FI remains 29-84%. EVAC is estimated in 100%. LOCL is not expected.

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 Medical Association, 2008	3	FI
Jakobsen, 2007	4	BCWC

The Resource Table (RT)

Resource	Units Required Best Case	Units Required Worst Case	Units Available At Start Of Mission	Consumable	Essential	Rationale
Ace bandage 2 inches	1	1	1	No	Yes	For immobilization
Ace bandage 3 inches	1	1	1	No	Yes	elastic bandage (also known as an ACE bandage, elastic wrap or compression bandage) is a "stretchable bandage used to create localized pressure
Ace bandage 4 inches	1	1	1	No	Yes	For immobilization
BZK wipes	2	24	60	Yes	No	Cleanse skin.
CMRS	0	1	1	No	No	Restrain crew member to ensure safety
Dilaudid (Hydromorphone) 2mg/mL, 1mL syringe	1	18	18	Yes	Yes	Pain management
Motrin (Ibuprofen) 400mg	20	30	500	Yes	Yes	For pain and inflammation
Nitrile gloves (large, medium, and small) (pair)	0	1	30	Yes	No	Personal Protective equipment for CMO
SAM splint - Leg/Arm Splint	1	1	1	No	Yes	to support/immobilize joint
Sharps container	1	1	40	No	No	To dispose of medical waste such as used medical needles, scalpels, IV catheters, razors, vials
Syringe (3cc)	1	18	20	Yes	Yes	pain management
Ultrasound gel	1	1	17	Yes	Yes	For use with ultrasound machine
Ultrasound machine	1	1	1	No	Yes	To diagnose type of injury and rule out fracture.
Valium (Diazepam) 5 mg/mL, 2 mL syringe	1	6	2	Yes	Yes	For muscle relaxation
Vicodin HP (Hydrocodone/ Acetaminophen HP) 10 mg/660 mg	8	20	30	Yes	Yes	Pain relief

Resource Comments

The table was revised on 7/26/2011. We deleted bandaids.

ISS address dislocations with a treatment similar to fractures. A triangular “airplane” splint is recommended for shoulder dislocation All resources included in the table are available on board (Mission Operations Directorate (MOD), 2011). ISS Checklist main focus is emergency immobilization of the joint and pain relief while urban standards of care include imaging, reduction and arthroscopy examination (American Academy of Orthopaedic Surgeons, 2007)

Required Resources Level of Evidence (LOE)

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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	2
Resources	2
QUALITY OF EVIDENCE	**3**

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

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