Elbow Dislocation Cliff

Branch Baseline

When the joint surfaces of an elbow are separated, the elbow is dislocated. Elbow dislocations can be complete or partial. In a complete dislocation, the joint surfaces are completely separated. In a partial dislocation, the joint surfaces are only partly separated. A partial dislocation is also called a subluxation.

When an elbow dislocates, any or all of these structures can be injured to different degrees.

A *simple dislocation* does not have any major bone injury.

A *complex dislocation* can have severe bone and ligament injuries.

In the most *severe dislocations*, the blood vessels and nerves that travel across the elbow may be injured. If this happens, there is a risk of losing the arm.

(American Academy of Orthopaedic Surgeons, 2007)

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:	5.21E-05

Incidence Comments

Lacking phenomenological data on elbow dislocation in space, we are using terrestrial data.

Our prior incidence rate was also based on terrestrial data. The rate of elbow dislocation is 6-13 cases per 100,000 people, and this injury occurs more frequently in males than in females. Of all elbow dislocations, 10 to 50% are sports related. More than 90% of elbow dislocations are posterior dislocations. (Halstead, 2008)

A recent study estimated the incidence of elbow dislocations in the United States population, using a national database (National Electronic Injury Surveillance System - NEISS)and US census data; the incidence rate is 5.21 per 100,000 person years; 95% Confidence Interval (CI) 5.20-5.22 . A total of 1,068 elbow dislocations were identified, representing a weighted estimate of 36,751 acute dislocations nationwide. The incidence rate ratio comparing dislocations in males to females was 1.02 ; 43.4% of total dislocations were sustained in sports (Sykes, 2011) Rates per person year are 0.0000521, 95% CI 0.0000520-0.0000522

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. (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
Sykes, 2011	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:	SME
Space Adaptation:	No
Incidence Type:	Rate

Distribution Data	
Incidence:	Pert
Occurrence:	Poisson

Data Characteristics	
Minimum:	6E-05
Maximum:	0.00013
Most Likely:	9.5E-05

Alternative Incidence Data

Analog Populations

A longitudinal cohort study of 4,122 US Army deployed to Iraq for 15 months was performed (Belmont, 2010). A casualty in customary military usage means active duty service member lost to the theater of operations for medical reasons. This study covers only disease and non battle injuries (DNBI). Musculoskeletal injuries were classified in three major categories: upper extremity, lower extremity and axial spine There were 667 total musculoskeletal injuries; a total of 66 fractures, with 19.7% MEDEVACs (13/66). Total instabilities to the upper extremity were 27, with 5 MEDEVCAS, 18.1%. 4.2% injuries occurred to the elbow. Musculoskeletal injury incidence rates were fivefold greater than the general population. By gender, the incidence for females was 408.6 per 100 combat-years and for males 244.0 per 1000 combat years Total 257.0 per 1000 combat years, 0.257 per person-year. We cannot determine elbow dislocation incidence rates from the data.

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 fractures and lacerations. Medevac was defined as the non routine transfer of a patient from a ship at sea for the purpose of receiving more definitive care.

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) Elbow dislocation ICD-9 code is 832. Thomas' study includes codes 800-999 as a group.

Non Analog Populations

A study among NFL players determined an incidence of 10.6 total injuries per 1000 athlete exposures. Incidence for elbow injuries was 0.21 per 1000 athlete exposures. 51% of instability injuries were in the elbow. Total events 44. Mean number of days lost to elbow dislocation was 14 and to injury 18. The surveillance was for a ten year period, 1996-2005, with a total of 24,432 injuries reported, 859 were to upper extremity, and 494 involved the elbow. There were a total of 2,304,184 athlete exposures during the 10 seasons studied. 69% occurred during games and 31% during practice. (Carlisle, 2008) Rates are not presented by year, rather by athlete exposures. Of note, a season is not a full year. There is no information on the specific type of dislocation or its treatment. We calculated the rate per season to be 0.00021 (0.21/1000), not surprisingly, higher than the US population

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 %: 74 - 100)	100	1	2 - 28	336 - 420 - 504	0	0	0
ISS-based Treatment (worst case scenario %: 0 - 26)	100	1	15 - 49	336 - 420 - 504	0 - 49	100	0
Untreated Best Case	0	0	15 - 49	336 - 420 - 504	0 - 28	0 - 100	0
Untreated Worst Case	0	0	29 - 84	336 - 420 - 504	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 simple dislocation, without a major injury to the bone, that responds to conservative treatment, resolves in less than 2-4 weeks, and does not involve neurovascular compromise.

Worst case scenario is defined as a complex dislocation which may involve ligament or bone injuries, does not resolve in 2-4 weeks, potentially involves neurovascular compromise, and that may require surgery.

Percentage of best case versus worst case scenario

In 1999, a study reported that up to 20% of dislocations were complex, including fractures. (Hildebrand, 1999). More recently, a review study in the Netherlands determined that the annual incidence of complex elbow dislocations in children and adults is 1.6 per 100,000, or 26% percent of all elbow dislocations (de Haan, 2010). To allow for uncertainty we are estimating 0-26% for the worst case scenario, thus the best case scenario is 74-100%

Best Case Comments

Elbow Dislocation functional impairments (FI) calculation follows the IMM severe non-space adaptation template. Elbow regional grid fracture ratings are based on Table 15-4, pp. 398-400. (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 Elbow 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 splint for the best case scenario, is estimated in half hour. During Clinical Phase II, FI is estimated in 2 to 28%. Duration is estimated in 336 to 504 hours, or 3 to 4 weeks. In Clinical Phase III, full recovery is expected and FI is 0%. By definition EVAC and LOCL are not expected for the best case scenario.

Worst Case Comments

Elbow Dislocation functional impairments (FI) calculation follows the IMM severe non-space adaptation template. Elbow regional grid fracture ratings are based on Table 15-4, pp. 398-400. (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 Elbow 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 at 1 hour. During Clinical Phase II, FI is estimated in 15 to 38%. Duration is estimated in 336 to 504 hours, or 3 to 4 weeks. For complex dislocations reduction under anesthesia or surgery may be required. (Halstead, 2008) 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 if surgery or closed reduction is required. Elbow dislocations have not occurred among astronauts in the ground.(Johnston, 2008) EVACs have occurred among analog populations (Belmont, 2010). LOCL is not expected

Untreated Best Case Comments

Elbow Dislocation functional impairments (FI) calculation follows the IMM severe non-space adaptation template. Elbow regional grid fracture ratings are based on Table 15-4, pp. 398-400. (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 Elbow 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 336 to 504 hours, similar to the treated best 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 0 to 100% for the untreated best case. By definition LOCL is not expected for this scenario.

Untreated Worst Case Comments

Elbow Dislocation functional impairments (FI) calculation follows the IMM severe non-space adaptation template. Elbow regional grid fracture ratings are based on Table 15-4, pp. 398-400. (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 Elbow 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 336 to 504 hours, or 3 to 4 weeks, similar to the treated worst case scenario. In Clinical Phase III, recovery is unlikely and FI remains 29-84%. By definition, EVAC is estimated in 100% because of intractable pain. 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
American Medical Association, 2008	3	FI
Belmont, Jr., 2010	2	EVAC
de Haan, 2010	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	0	1	1	No	Yes	For elbow support and immobilization.
Ace bandage 3 inches	1	1	1	No	Yes	For elbow support and immobilization.
Ace bandage 4 inches	0	1	1	No	Yes	For elbow support and immobilization.
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	4	8	60	Yes	No	Cleanse skin.
CMRS	0	1	1	No	No	Restrain crew member to ensure safety
Dilaudid (Hydromorphone) 2mg/mL, 1mL syringe	0	8	18	Yes	Yes	Severe pain relief
Hot and Cold Pad	1	1	1	No	No	For pain and swelling
Motrin (Ibuprofen) 400mg	15	6	400	Yes	Yes	For pain and inflammation
Needle (23G)	2	10	20	Yes	Yes	For medication administration
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 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)	2	10	20	Yes	Yes	Administration of the Hydromorphone and Valium
Ultrasound gel (2 packets)	1	1	17	Yes	Yes	Use with ultrasound machine.
Ultrasound machine	1	1	1	No	Yes	For diagnostic purposes.
Valium (Diazepam) 5 mg/mL, 2 mL syringe	2	2	2	Yes	Yes	For relaxation during reduction procedure and for maintenance of muscle relaxation.
Vicodin HP (Hydrocodone/ Acetaminophen HP) 10 mg/660 mg	8	0	30	Yes	Yes	Pain relief

Resource Comments

The table was revised on 8/8/2011. We deleted band aids.

The ISS Medical Checklist addresses dislocations and recommends treating them as fractures. All resources included in the table are available on board (International Space Station Integrated Medical Group, 2008)

ISS Checklist main focus is emergency immobilization of the joint and pain relief similar to terrestrial standards of care (American Academy of Orthopaedic Surgeons, 2007)

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
International Space Station Integrated Medical Group, 2008	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

Reference List

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