Acute Arthritis Cliff

Branch Baseline

In adults, arthritis is the most common cause of disability and is among the leading conditions causing work limitations. Although arthritis prevalence is higher in those over 65 years, nearly two-thirds of the adults reporting doctor diagnosed arthritis are younger than 65 years. More than 60% are women. (Jacobs, 2008).

Arthritis and other rheumatic conditions (AORC) include more than 100 kinds of arthritis and rheumatic diseases. Of interest in this Clinical Findings form is: Rheumatoid arthritis, Gout and other Crystal Arthropathies, and Spondyloarthropathies. (Jacobs, 2008)

Osteoarthritis (OA), also known as degenerative joint disease, is the most common type of arthritis. It causes progressive damage to the cartilage and other joint tissues, and frequently affects the hand, knees, and hips. Rheumatoid arthritis (RA) is a chronic autoimmune disease that causes pain, stiffness, swelling, and limitation in the motion and function of multiple joints. (Jacobs, 2008)

Gout is a painful, episodic and recurrent form of arthritis, caused by deposition of crystal in joints and elsewhere. Symptoms typically consist of intense episodes of painful swelling in single joints, most often in the feet and especially in the big toe. (Jacobs, 2008)

The Spondyloarthropathies family include Ankylosing spondylitis (AS), reactive arthritis (formerly known as Reiter's syndrome), psoriatic arthritis, enteropathic arthritis (associated with ulcerative colitis or Crohn's disease), and undifferentiated spondyloarthropathy. (Jacobs, 2008)

Acute septic arthritis may develop as a result of hematogenous seeding, direct introduction, or extension from a contiguous focus of infection. Most septic joints develop as a result of hematogenous seeding of the vascular synovial membrane due to a bacteremic episode. Although a rare cause, acute septic arthritis may also occur as a result of joint aspiration or local corticosteroid joint injection . In addition, bacterial arthritis may arise secondary to penetrating trauma (such as human or animal bite or nail puncture) or after trauma to a joint without an obvious break in the skin (Shirtliff, 2002).

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:	0.00376

Male Data Characteristics	
Fixed Rate:	0.00153

Incidence Comments

Acute arthritis has never been reported in flight. Lacking phenomenological data we determined the incidence from terrestrial data, using a study to determine incidence of inflammatory joint diseases in Finland.

The annual incidence rates per 100,000 adults were overall 271.1 (95% CI 233.7–312.7), male 153.3 (95% CI 113.8–202.8), and female 375.5 (95% CI 315.5–443.7). The incidence rates per person-year were overall 0.00271 (95% CI 0.00234–0.00313), male 0.00153 (95% CI 0.00114–0.00203), and female 0.00376 (95% CI 0.00316–0.00444). (Savolainen, 2003)

All physicians in the Kuopio Health Centre, private clinics, and occupational health services or in various departments of the Kuopio University Hospital were requested to refer their patients who had inflammatory joint diseases and no previously diagnosed rheumatic disorder and who were residents of Kuopio City to the rheumatological outpatient clinic of the Health Centre, the Municipal Hospital, or the University Hospital for evaluation as a part of the Kuopio 2000 Arthritis Survey. All patients referred because of inflammatory arthritis to the Health Centre or the University Hospital for the first time during the year 2000 and who were registered in Kuopio City were evaluated. At least one joint with peripheral synovitis or signs of an inflammatory disorder in the sacroiliac, glenohumeral, or hip joints assessed by ultrasonography (US), scintigraphy, or magnetic resonance imaging (MRI) had to be registered on the first visit. Most of the diagnoses were clinical. The study population was 188, 138 women and 50 men. (Savolainen, 2003)

The study included Rheumatoid Arthritis, Ankylosing Spondylitis, Psoriatic Arthritis, Reactive Arthritis, other spondyloarthropaties, connective tissue disease, crystalline arthritis, viral arthritis and undifferentiated arthritis (Savolainen, 2003)

Information Regarding Prevention

Selection Criteria

Disqualifying conditions in the musculoskeletal category include: traumatic, inflammatory, degenerative, congenital (or hereditary) 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; Active infections of bone, joint, muscle or tendon (e.g. osteomyelitis, soft tissue infections and septic arthritis). (International Space Station Program, 2009).

Other

Known risk factors for acute septic arthritis in the general population include: rheumatoid or osteoarthritis, joint prosthesis, low socioeconomic status, intravenous drug abuse, alcoholism, diabetes, previous intra-articular corticosteroid injection, cutaneous ulcers, skin infection, recent trauma (blunt, closed, or open), and previous or local surgery. (Weston, 1999); (Mathews, 2010)

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
Savolainen, 2003	4	Incidence
	4	Incidence

Alternative Incidence Data

Analog populations

Tansey reported on health data from 10 years of Polaris submarine patrols, from 1963 to 1973, including 7,650,000 person-days. The study reported five arthritides among 240 general medical conditions: 1 osteoarthritis, 2 gout, 1 rheumatoid arthritis and 1 post-streptococcal arthritis; lost days were 7, 10, 27 and 6 respectively. The same study also reported four septic arthritides among 264 bone and joint conditions, which caused 44 sick days. (Tansey, 1979)

The estimated incidence for arthritides is 0.00024 person-years. (5/7,650,000 person days * 365 p-d/1p-y =2.38 e-4). The estimated incidence of septic arthritis is 0.00019 (4/7,650,000 person days * 365 p-d/1p-y =1.91 e-4). Of note, the number of septic arthritis compared to all arthritides is higher than in the general population.

Another study among US Navy Submarines determined that the incidence of arthropathies was 0.007 (0.7/100) for officers and 0.011 (1.1/100) for enlisted men per person-years. Information was not stratified by type of joint or type of disease (ICD-9 710-719). Arthropaties of interest for this CliFF are codes 711-715. Among officers most lost duty days were due to musculoskeletal conditions (46 days), and among enlisted men lost duty days (350 days) for musculoskeletal conditions were third, after injury and digestive. The population was composed of 240 submarine patrols, from 1 January 1997 to 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. (Thomas, 2003)

Non Analog populations

There is a dearth of arthritis data. The National Arthritis Data Workgroup (NADW), found that for estimates of specific conditions they often had to rely on a few, small-sized studies of uncertain generalizability to the U.S. population. (Jacobs, 2008).

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 %: 96 - 99)	100	0.5	0 - 10	168 - 204 - 240	0	0	0
ISS-based Treatment (worst case scenario %: 1 - 4)	100	0.5 - 1	2 - 19	240 - 288 - 336	0 - 10	0 - 37	0
Untreated Best Case	N/A	N/A	2 - 19	168 - 204 - 240	0 - 10	0 - 100	0
Untreated Worst Case	N/A	N/A	12 - 34	240 - 288 - 336	2 - 34	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

The **best case scenario** is defined as non-septic arthritis with mild to moderate symptoms that responds to treatment.

The **worst case scenario** is defined as septic arthritis requiring antibiotic treatment and with severe symptoms requiring prolonged treatment.

Percentages of best case vs. worst case scenario

A meta –analysis including articles published in English from 1951 to 2008 estimated the incidence of acute septic arthritis in western Europe as 4-10 per 100,000 patient-years (Mathews, 2010) (0.00004-0.0001 person years). The overall incidence of inflammatory diseases in Finland was estimated as 271.1 per 100,000 person-years (Savolainen, 2003)(0.00271 person years). Based on these two studies we estimated the percentages of worst case scenario as 1.5-3.7% (0.00004/0.00271 and 0.0001/ 0.00271 respectively). To allow for uncertainty we estimated worst case as 1-4%, thus the best case scenario is 96-99%.

Best Case Comments

Acute Arthritis functional impairments (FI) calculation follows the IMM mild non-space adaptation template. Lower Extremity impairment (LEI) ratings are based on Table 16-1, pp.495 (American Medical Association, 2008). Complex Regional Pain Syndrome-Upper Extremity CRPS (LEI) is based on Table 16-15, p 541 (American Medical Association, 2008). The Lower Extremity (LEI) and CRPS (LEI) ratings are then converted to percentage of Whole Person Impairment (WPI), which are based on Table 16-1, p 495 (American Medical Association, 2008). Combined FI ratings are calculated combining the mentioned tables using the Combined Values Chart as indicated in Appendix A, pp 604-606. (American Medical Association, 2008)

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 30 minutes. During Clinical Phase II, FI is estimated in 0 to 10%. Duration is estimated in 168 to 240 hours, 7 to 10 days (Reed, 2005). In Clinical Phase III, full recovery is expected and FI is 0%. By definition EVAC and LOCL would not be expected for the best case scenario.

Worst Case Comments

Acute Arthritis functional impairments (FI) calculation follows the IMM mild non-space adaptation template. Lower Extremity impairment (LEI) ratings are based on Table 16-1, pp.495 (American Medical Association, 2008). Complex Regional Pain Syndrome-Upper Extremity CRPS (LEI) is based on Table 16-15, p 541 (American Medical Association, 2008). The Lower Extremity (LEI) and CRPS (LEI) ratings are then converted to percentage of Whole Person Impairment (WPI), which are based on Table 16-1, p 495 (American Medical Association, 2008). Combined FI ratings are calculated combining the mentioned tables using the Combined Values Chart as indicated in Appendix A, pp 604-606. (American Medical Association, 2008)

By definition in Clinical Phase I, FI is 100%. Duration to follow procedures specified in ISS checklist, i.e. physical exam, vital signs, and medication, is estimated in half to 1 hour. During Clinical Phase II, FI is estimated in 2 to 19%. Duration is estimated in 240 to 336 hours, 10 to 14 days, for antibiotic treatment. In Clinical Phase III, full recovery may or may not occur and FI is estimated at 0-10%. Septic arthritis of the knee has occurred in the astronaut corps Arthritis is a Class IIC event, manageable with HMS but may necessitate emergent evacuation if condition does not improve. (Johnston, 2008)Based in a study in Scotland, where 37% of patients with septic arthritis underwent surgical intervention with arthroscopic and open synovial lavage. (Gupta, 2001), EVAC is estimated at 0-37%. LOCL is not expected for this scenario.

Untreated Best Case Comments

Acute Arthritis functional impairments (FI) calculation follows the IMM mild non-space adaptation template. Lower Extremity impairment (LEI) ratings are based on Table 16-1, pp.495 (American Medical Association, 2008). Complex Regional Pain Syndrome-Upper Extremity CRPS (LEI) is based on Table 16-15, p 541 (American Medical Association, 2008). The Lower Extremity (LEI) and CRPS (LEI) ratings are then converted to percentage of Whole Person Impairment (WPI), which are based on Table 16-1, p 495 (American Medical Association, 2008). Combined FI ratings are calculated combining the mentioned tables using the Combined Values Chart as indicated in Appendix A, pp 604-606. (American Medical Association, 2008)

During Clinical Phase II, FI is estimated in 2 to 19%. Duration is 168 to 240 hours, similar to the treated best case scenario. In Clinical Phase III, recovery may or may not occur. FI is estimated at 0-10%., Based on potential intractable pain, EVAC is estimated at 0 to 100% for the untreated best case. By definition, LOCL would not be expected for this scenario.

Untreated Worst Case Comments

Acute Arthritis functional impairments (FI) calculation follows the IMM mild non-space adaptation template. Lower Extremity impairment (LEI) ratings are based on Table 16-1, pp.495 (American Medical Association, 2008). Complex Regional Pain Syndrome-Upper Extremity CRPS (LEI) is based on Table 16-15, p 541 (American Medical Association, 2008). The Lower Extremity (LEI) and CRPS (LEI) ratings are then converted to percentage of Whole Person Impairment (WPI), which are based on Table 16-1, p 495 (American Medical Association, 2008). Combined FI ratings are calculated combining the mentioned tables using the Combined Values Chart as indicated in Appendix A, pp 604-606. (American Medical Association, 2008)

During Clinical Phase II, FI is estimated in 12 to 34%. Duration is 240 to 336 hours, or 10 to 14 days, similar to the treated worst case scenario. In Clinical Phase III, recovery is unlikely and FI remains 2-34%. EVAC is estimated at 100% without treatment. 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
Johnston, 2008	2	EVAC
Gupta, 2001	4	EVAC
Mathews, 2010	4	BCWC
Savolainen, 2003	4	BCWC

The Resource Table (RT)

Resource	Units Required Best Case	Units Required Worst Case	Units Available At Start Of Mission	Consumable	Essential	Rationale
Bandaid strip	0	3	20	Yes	No	Cover injection site from intramuscular pain medication.
Blood Oximeter	1	1	1	No	Yes	For VS monitoring
Blood Pressure Cuff (regular, large)	0	1	2	No	Yes	Measure blood pressure
Blood Pressure Monitor	0	1	1	No	Yes	Measure blood pressure
BZK wipes	0	8	60	Yes	No	to clean skin prior to injection
Ertapenem 1gm	0	3	6	Yes	Yes	Anti-infective, first line
Lidocaine (Xylocaine) plain 1%, 10mL multi dose vial	0	3	3	Yes	Yes	Anesthetic for ertapenem injection
Motrin (Ibuprofen) 400mg	28	42	400	Yes	Yes	Pain relief , 1st line
Needle (23G)	0	10	20	Yes	Yes	For medication administration
Nitrile gloves (large, medium, and small) (pair)	1	1	30	Yes	No	For standard precautions
Prednisone 20 mg	0	3	40	Yes	Yes	To treat inflammation
Rocephin (Ceftriaxone) 1 GM	0	7	3	Yes	Yes	Treatment of infection
Sharps container	0	1	40	No	No	Disposal of medical waste sharps.
Stethoscope	1	1	2	No	Yes	For VS monitoring
Syringe (3cc)	0	10	20	Yes	Yes	For medication administration
Thermometer	1	1	1	No	No	to measure temperature
Tylenol (Acetaminophen) 325 mg	20	0	150	Yes	Yes	Pain relief.
Vicodin HP (Hydrocodone/ Acetaminophen HP) 10 mg/660 mg	0	18	30	Yes	Yes	Pain management.

Resource Comments

The table was created on August 2, 2012. The ISS Medical Checklist (International Space Station Integrated Medical Group, 2008)does not address arthritis. Treatment recommendations are based in the NICE Guidelines (NHS-NICE, 2009)and Mathews' article for worst case scenario (Mathews, 2010)

Terrestrial Guidelines recommend, pain management, Cox inhibitors and Disease-modifying antirheumatic drugs (DMARDs). (NHS-NICE, 2009) The last two are not available on board. Motrin, a non steroid anti-inflammatory drug (NSAID) is available.

Regarding antibiotics for septic arthritis (Mathews, 2010) the recommendation is Intravenous flucloxacillin (2 g four times a day). Local policy might add oral fusidic acid (500 mg three times a day) or intravenous gentamicin

If allergic to penicillin, use clindamycin (450–600 mg four times a day) or second-generation or third-generation cephalosporin. If at risk for atypical infection, Second-generation or third-generation cephalosporin (eg, cefuroxime 1‧5 g three times a day).

All resources in the table are available on board (International Space Station Integrated Medical Group, 2008)

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
Unknown, 2009	3	Resources
Mathews, 2010	3	Resources

Level Of Evidence

Input Data	LOE Average
Incidence	4
Functional Impairment	3
Best Case / Worst Case	4
EVAC / LOCL	3
Resources	3
QUALITY OF EVIDENCE	**3.4**

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

Reference List

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