Acute Angle-Closure Glaucoma Cliff

Branch Baseline

Acute angle-closure glaucoma is due to a closed anterior chamber angle. Symptoms consist of severe occular pain, reddness, decreased vision, halos, headache, nausea and vomiting. Signs include hazy cornea and red eye. Intraoccular pressure is elevated which may damage the optic nerve.

Angle-closure glaucoma is considered primary when the reason for the appositional or synechial closure of the angle is due to pupillary block. The mechanism of the papillary block must be in the context of normal anatomical structures. Primary angle-closure glaucoma (PACG) can be acute or chronic. If the iris root obstructs the outflow of aqueous through the iridocorneal angle abruptly, acute angle closure is said to occur. (Canadian Ophthalmological Societ, 2009)

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:	5.68E-05

Male Data Characteristics	
Fixed Rate:	2.7E-05

Incidence Comments

Acute angle closure glaucoma has not occurred in-flight. Literature search for glaucoma incidence evidenced the dearth of recent incidence rates from large studies.

Our prior model incidence data was based on Israel's population and an overall rate of 0.000082. (David, 1985)

We updated incidence rates to reflect gender differences and more recent studies in European countries. Rates are consistent across studies, all per 100,000 population 2.46 (Ramesh, 2005); 2.9 (Bojic, 2004); 4.2 (Keenan, 2009); 3.6 (Ng, 2008). We averaged these rates to obtain an overall incidence of 3.29, or. By gender, female rates are higher 5.65 (Ramesh, 2005); 7.5 (Keenan, 2009) and 3.9 (Bojic, 2004); providing an average of 5.68. Male rates are 2.46 (Ramesh, 2005); 3.75 (Keenan, 2009); and 1.9 (Bojic, 2004); average male rate is 2.70. Rates per person-year are overall 0.0000329, female 0.0000568, and male 0.000027

Information Regarding Prevention

Selection criteria

Disqualifying criteria include: disease of either eye or supporting structure that may interfere with the performance of duties; glaucoma identified by pressure greater than 30 mmHg in either eye, characteristic glaucomatous change in the optic nerve or visual field loss characteristic of glaucoma; pre-glaucoma, identified by pressure on two determinations equal to or greater than 25 mmHg or a difference greater than 4 mmHg between eyes (International Space Station Program, 2009)

Other

Intraocular pressure (IOP) has been observed in parabolic flight and during microgravity exposure. It occurs immediately under exposure to microgravity. Chronic exposure to an elevated IOP could cause glaucomatous nerve damage (Manuel, 2008)

We have a record or temporary increase of intra-ocular pressure for 2 crew members (Walton, 2010) These cases were not diagnosed as glaucoma and are not included in the incidence for this CliFF.

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
Ng, 2008	4	Incidence
Ramesh, 2005	4	Incidence
Keenan, 2009	4	Incidence
Bojic, 2004	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:	3.29E-05

Alternative Incidence Data

A report of ocular disease and nonbattle injuries (DNBI) seen at Walter Reed Army Medical Center between January 2003 and September 30 2005. 97 had unilateral and 10 had bilateral ocular involvement. Patients evacuated from Iraq and Afghanistan to the Ophthalmology service and referred after being evacuated for treatment of other conditions. Ophthalmology typically accounts for 2.4 to 5.4% of all Disease Non Battle Injuries and ranks in the top five or six disease categories. Eye findings ranged from minor to vision threatening. 84 soldiers (78.5% returned to duty). Hygiene, contact lens restriction and eye protection should be stressed to reduce ocular morbidity and need for evacuation. Lack of information on the total population at risk during the mission time prevents us from calculating incidence rates from this study. There were three events of glaucoma, which accounted to 2.8% of total eye conditions. (Psolka, 2007) One of them was inflammatory glaucoma secondary to sarcoidosis which required evacuation. Discounting the secondary glaucoma event, the percentage for this condition is 1.9%. Evacuations for eye conditions (n 333) made up 3% of total EVACS.

A review of published data with use of prevalence models was designed to estimate the number of people with open angle (OAG) and angle closure glaucoma (ACG) in 2010 and 2020. Data from population based studies of age specific prevalence of OAG and ACG that satisfied standard definitions were used to construct prevalence models for OAG and ACG by age, sex, and ethnicity, weighting data proportional to sample size of each study. Models were combined with UN world population projections for 2010 and 2020 to derive the estimated number with glaucoma. Of note, **United States** is included in the European derived group. Over 80% of those with ACG live in Asia, Women were disproportionately affected by glaucoma, representing 59.1% of all people with glaucoma (95% CI: 59.0% to 59.2). By comparing estimates from 2010 to 2020, we estimated 20,236 new cases per year.

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 %: 71 - 89)	100	0.5	8 - 47	12 - 18 - 24	0	0 - 100	0
ISS-based Treatment (worst case scenario %: 11 - 29)	100	0.5	28 - 72	24 - 48 - 72	0 - 72	100	0
Untreated Best Case	0	0	28 - 72	12 - 18 - 24	0 - 47	100	0
Untreated Worst Case	0	0	61 - 85	24 - 48 - 72	61 - 85	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 mild unilateral angle-closure glaucoma that responds to topical and systemic treatment.

Worst case scenario is defined as bilateral angle-closure glaucoma with intraocular pressure that does not respond to topical and systemic treatment. It may present with pain and/or vomiting.

Percentages of how often best versus worst case scenarios occur was derived as a range from Lowe's and Hillman's studies. 11.5% and 11% respectively presented with bilateral attack, which made 11% our lower limit. In Lowe's 29% developed an acute attack in the second eye within 12 months which is the upper limit. (Lowe, 1962); (Hillman, 1979) Ergo the worst case percentage is 11-29% and the best case percentage is 71-89%

Best Case Comments

Our functional impairments calculation for Eye Glaucoma Acute follows the IMM severe non-space adaptation template. Impairments of the Visual System and of the Whole Person are based on Table 12-10, p.307. Impairment for Visual System class 3 is divided in 3a and 3b. We are assigning class 3b which provides more severe impairments for all scenarios using the severe non-space adaptation template. (American Medical Association, 2008)

By definition in Clinical Phase I, FI is 100%. Duration to follow procedures specified in ISS checklist, i.e. eye exam and oral medication for the best case scenario is estimated in 30 minutes. During Clinical Phase II, FI is estimated in 8 to 47%. Duration is estimated in 12 to 24 hours. In Clinical Phase III, full recovery is expected and FI is estimated at 0%. Because the ISS is not completely equipped to treat this condition, EVAC is estimated at 0-100% to allow for uncertainty. LOCL is not expected for an eye condition.

Worst Case Comments

Our functional impairments calculation for Eye Glaucoma Acute follows the IMM severe non-space adaptation template. Impairments of the Visual System and of the Whole Person are based on Table 12-10, p.307. Impairment for Visual System class 3 is divided in 3a and 3b. We are assigning class 3b which provides more severe impairments for all scenarios using the severe non-space adaptation template. (American Medical Association, 2008)

By definition in Clinical Phase I, FI is 100%. Duration to follow procedures specified in ISS checklist, i.e. eye exam and applying topical or oral medications for the worst case scenario, is estimated in 30 minutes, or half hour. During Clinical Phase II, FI is estimated in 28 to 72%. Duration is estimated in 24-72 hours based in Wong's study, where resolution of symptoms took 1 to 3 days (Wong, 1997). In Clinical Phase III, full recovery may or may not occur and FI is 0-72%. EVAC becomes necessary for surgical intervention at a definitive care facility. Clinical guidelines recommend Iridiotomy as soon as possible (American Academy of Ophthalmology Glaucoma Panel, 2010)By definition, EVAC is estimated at 100% due to the risk of permanent disability. LOCL is not expected for eye conditions.

Untreated Best Case Comments

Our functional impairments calculation for Eye Glaucoma Acute follows the IMM severe non-space adaptation template. Impairments of the Visual System and of the Whole Person are based on Table 12-10, p.307. Impairment for Visual System class 3 is divided in 3a and 3b. We are assigning class 3b which provides more severe impairments for all scenarios using the severe non-space adaptation template. (American Medical Association, 2008)

During Clinical Phase II, FI is estimated in 28 to 72%. Duration is 12 to 24 hours, similar to the treated best case scenario. In Clinical Phase III, recovery may or may not occur and FI is 0-47%. By definition, EVAC is estimated at 100% for this scenario considering the risk of permanent disability for an untreated acute glaucoma. LOCL is not expected for eye conditions.

Untreated Worst Case Comments

Our functional impairments calculation for Eye Glaucoma Acute follows the IMM severe non-space adaptation template. Impairments of the Visual System and of the Whole Person are based on Table 12-10, p.307. Impairment for Visual System class 3 is divided in 3a and 3b. We are assigning class 3b which provides more severe impairments for all scenarios using the severe non-space adaptation template. (American Medical Association, 2008)

During Clinical Phase II, FI is estimated in 61 to 85%. Duration is 24 to 72 hours, similar to the treated worst case scenario. In Clinical Phase III, recovery is unlikely and FI remains 61-85%. Because of potential significant permanent impairment EVAC is estimated in 100%. LOCL is not expected for eye injuries.

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 Academy of Ophthalmology Glaucoma Panel, 2010	3	EVAC
Lowe, 1962	4	BCWC
Hillman, 1979	4	BCWC

Additional Comments

PubMed searches were conducted using the terms acute angle closure glaucoma AND epidemiology OR incidence; Glaucoma and microgravity OR astronauts; and Glaucoma AND clinical guidelines. Results were refined by relevance and date.

The Resource Table (RT)

Resource	Units Required Best Case	Units Required Worst Case	Units Available At Start Of Mission	Consumable	Essential	Rationale
Cotton swabs	2	4	6	Yes	No	To apply topical eye medications
Diamox (Acetazolamide) 250 mg tablets	12	12	100	Yes	Yes	Prevent and reduce the symptoms of altitude sickness, diuretic (decreases intraoccular pressure)
Gauze pads (4x4)	2	2	50	Yes	No	To absorb blood or fluids from skin
Otoscope (Head, Handle, and USB cable)	1	1	1	No	Yes	Light source for eye exam.
Tonometer	1	1	1	No	Yes	Measurement of Intraocular Pressure
Tonometer tip cover	1	1	150	Yes	Yes	Eye protection during measurement of IOP
Vicodin HP (Hydrocodone/ Acetaminophen HP) 10 mg/660 mg	0	6	30	Yes	Yes	Severe pain

Resource Comments

The ISS medical checklist includes procedures for Intraocular pressure measurement for signs and symptoms of Glaucoma. All resources are listed in the ISS Medical checklist (International Space Station Integrated Medical Group, 2008)

We added resources for eye exam: otoscope handle, ophthalmoscope head, cotton swabs, artificial tears, magnifying glass, and visual acuity card.

Comparison of terrestrial guidelines versus ISS medical checklist procedures:

Terrestrial guidelines recommend use of analgesics, diuretics and steroids to treat symptoms. Iridotomy is performed as soon as feasible. (American Academy of Ophthalmology Glaucoma Panel, 2010)

ISS procedures are aimed at diagnosis and symptomatic treatment and are similar to terrestrial guidelines. Analgesics and topical steroids are available on board while topical Acetazolamide is not. Systemic diuretics may need to be used.

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
American Academy of Ophthalmology Glaucoma Panel, 2010	3	Resources

Level Of Evidence

Input Data	LOE Average
Incidence	4
Functional Impairment	3
Best Case / Worst Case	4
EVAC / LOCL	3
Resources	2.5
QUALITY OF EVIDENCE	**3.3**

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

Reference List

Reference
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