Eye Penetration (foreign body) Cliff

Branch Baseline

With corneoscleral lacerations care must be taken to exclude a full thickness penetrating injury. Lacerations can be sutured directly with 10.0 nylon sutures under an operating microscope, though some can be managed with a bandage contact lens if small and self-sealing. Conjunctival lacerations heal rapidly and rarely need suturing. A 7.0 vicryl absorbable suture may be used if required. Topical antibiotics must be prescribed for 1 to 2 weeks post-injury.

Penetrating eye injuries have a single entrance wound whereas perforating eye injuries have entrance and exit wounds. The signs are often obvious with an entry/exit site and extrusion of ocular tissue. There is often anterior segment disruption, vitreous hemorrhage and retinal breaks. The eye should be protected by a shield and the patient admitted for bed rest and primary repair.(Blanch, 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

Data Characteristics	
Fixed Rate:	9.331E-06

Incidence Comments

A penetrating eye injury has not occurred in space flight. Our incidence rate is derived from terrestrial data.

A retrospective chart review was conducted in United States emergency department patients with penetrating eye injuries seen for evaluation from July 1987 to January 1999. The estimated incidence rate is 0.000031 (3.1 penetrating eye injuries per 100,000 person-years). The authors reported 96 events, Or 30.1% (95% CI 25 to 35) for foreign body orbit/globe confirmed by physical or radiologic findings from 319 events evaluated for this variable. More than 25% in the study had enucleation and 35% had visual acuity less than 20/200. The complication rate, mainly cataract and infection, was 25%. (Smith, 2002)We calculated the incidence rate for foreign body at 0.000009331 (30.1% of 0.000031).

Information Regarding Prevention

Selection criteria

Disqualifying conditions in the eye category include: disease of either eye or supporting structure that may interfere with the performance of duties; any condition of the eyelids that impairs normal eyelid function; chronic blepharitis or blepharospasm; dacrocystitis; herpetic ulcer or history of herpetic ulcer; and inflammation of the uveal tract (iris, ciliary body, choroid) , acute, chronic or recurrent with the exception of uncomplicated post-traumatic iritis.(International Space Station Program, 2009)

Contingency measures

Treatment is with systemic antibiotics.

Other

Portable ultrasound devices have been tested terrestrially in a gelatinous ocular model for use on board. They may be used to detect foreign objects of varying location, size (0.5-2 mm), and material (glass, plastic, metal) It can be used by operators with varying training to detect the presence, location, and composition of intraocular foreign bodies with high sensitivity, specificity, and accuracy. (Sargsyan, 2008)

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
Smith, 2002	4	Incidence

Alternative Incidence Data

Analog populations

Submariners did not provide incidence data for penetrating eye injuries (Tansey, 1979), (Thomas, 2003), (Nice, 1987)

Ocular disease and nonbattle injuries (DNBIs) seen at Walter Reed Army Medical Center between January 2003 and September 30 2005 were 107, 97 unilateral and 10 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 DNBIs s and ranks in the top five or six disease categories. Lack of information on the total population at risk during the mission time prevents us from calculating incidence rates from this study. There was one Intraocular foreign body, which accounted to 0.9% of total injuries. The outcome was no light perception. The patient was injured while hammering metal to repair a tire on a military vehicle. Extensive surgery was required to repair the damage caused by a 12-mm, metallic, intraocular, foreign body which might have been prevented with the use of appropriate eye protection. (Psolka, 2007)

A retrospective case series study to evaluate the number of intraocular foreign body (IOFB) injuries that occurred in Operation Iraqi Freedom, collected data from fifty-five United States military personnel with an IOFB injury during Operation Iraqi Freedom. The foreign body was caused by a propelled explosive in 20 patients (36%) and a non propelled explosive in 31 patients (56%), and the cause of the foreign body was not known in 4 patients (7%). The laceration of the cornea and/or sclera averaged 5.4 mm (range, 0.2-18). There were an average of 1.7 foreign bodies in the injured eye, range, 1-6. The size of those foreign bodies measured ranged from less than 1 mm to 12 x 14 mm. The time from injury to foreign body removal averaged 20.6 days (range, 0-90). No cases of endophthalmitis were seen. Unlike trauma in the civilian sector, IOFB injuries in a military setting tend to be caused by explosive devices, which often result in multiple foreign bodies and simultaneous injuries to other body systems. Because of the lack of availability of specialty care in the combat theater, there is often a delay in removal of the foreign body. Pars plana vitrectomy, foreign body removal, and additional surgical procedures were done upon return (Thach, 2005)

Non Analog populations

The rate of emergency department–treated eye injury in the United States is 3.15 per 1000 population (95% confidence interval, 2.66-3.63). Rates were highest among those in their 20s and 30s, among males, and The most common injury to the eye was a contusion or abrasion (44.4%), followed by foreign bodies (30.8%), burns (10.2%), and conjunctivitis (9.9%). Punctures were 0.5%. These rates include only eyeball injuries and exclude adnexa. (McGwin, 2005). We calculated 0.5% of 0.00315 to be 0.001575 for puncture. This may be an under estimation because some events may have been listed under the foreign body category.

A study in southern Italy reported the average annual rate of eye injuries at 4.9 per 100,000 (95% CI, 4.8–5.0) – 2.4 per 100,000 (95% CI, 2.35–2.45) for open globe injuries and 2.5 per 100,000 (95% CI, 2.4–2.55) for closed globe injuries. The rates in urban (4.2/100,000; 95% CI, 4.1–4.3) and rural areas (5.5/100,000; 95% CI, 5.4–5.65) were not statistically different. The final visual acuity was 20/40 (6/12) or better in 144 eyes (48.3%), 20/40–20/200 (6/12–6/60) in 90 eyes (30.2%), and <20/200 (6/60) or less in 46 eyes (15.5%). Eighteen eyes (6%) had a final acuity of no light perception. Of those eyes that presented with hand motion vision or better, 220 (86.6%) had a final vision better than 20/200 (6/60). Those patients with an initial acuity of no light perception had a poor prognosis. Initial visual acuity was found to be correlated with final visual acuity (Cillino, 2008)

A prospective surveillance to estimate the incidence of penetrating injuries with retained intraocular foreign bodies (IOFBs) in the United Kingdom, and to provide epidemiological data on the etiology, management, and visual outcome of such injuries. Data were available on 97 patients at presentation and 95 patients at follow-up. The minimum estimated incidence of IOFBs in the United Kingdom identified in this study was 0.16 per 100 000 (0.0000016) All patients were male. Hammering was the most common mechanism of injury, occurring in 62% of patients. The IOFB was found in the anterior segment in 24%, the posterior segment in 73%, and involved both segments in 3%. Endophthalmitis was diagnosed in 9% of patients. Best-corrected visual acuity of the injured eye at final follow-up was 6/12 or better in 67%, 6/18 to 6/60 in 11%, and worse than 6/60 in 22%. Prognostic factors for a poor visual outcome included poor visual acuity at presentation, prolapse of intraocular tissue, development of endophthalmitis, development of retinal detachment, and large size of IOFB. (Imrie, 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 %: 0 - 100)	100	0.5	8 - 47	24 - 48 - 72	0 - 47	0 - 100	0
ISS-based Treatment (worst case scenario %: 0 - 100)	100	0.5	28 - 72	336 - 336 - 336	0 - 72	100	0
Untreated Best Case	0	0	28 - 72	24 - 48 - 72	0 - 47	0 - 100	0
Untreated Worst Case	0	0	61 - 85	336 - 336 - 336	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 scleral laceration which has minimal effect on vision.

Worst case scenario is defined as a penetrating or perforating foreign body with serious effect on vision.

Percentages of how often best versus worst case scenarios occur were estimated at 0-100% due to the fact that military analogs and terrestrial studies, show extreme variations on their outcomes.

Smith's study reported 60% of negative outcomes in the United States (More than 25% had enucleation and 35% had visual acuity less than 20/200) (Smith, 2002). Colyer's study 31% in the US military (10.3% evolved to no light perception or had been enucleated by the 6-month follow-up visit and 21% experienced proliferative vitreoretinopathy) (Colyer, 2007). Cillino's reported 21.5% negative outcomes in Italy (15.5% with less than 20/200, 6/60, and 6% had a final acuity of no light perception) (Cillino, 2008). Imrie's final outcome was 22% with vision worse than 6/60 in the United Kingdom. (Imrie, 2008)

Best Case Comments

Our functional impairments calculation for Eye Penetration (foreign body) follows the IMM severe non-space adaptation template except for the best case scenario, because total recovery without definitive care is uncertain. 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 eye conditions 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 eye shield. 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 24 to 72 hours. In Clinical Phase III, full recovery is not expected and FI is estimated at 0-47%. EVAC has occurred among military analogs due to battle and nonbattle eye injuries. (Ari, 2006). EVAC is estimated in 0-100% due to the fact that surgery is the recommended treatment for scleral laceration. LOCL is not expected for an eye injury.

Worst Case Comments

Our functional impairments calculation for Eye Penetration (foreign body) follows the IMM severe non-space adaptation template except for the best case scenario, because total recovery without definitive care is uncertain. 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 eye conditions 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 eye shield, 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 14 days, 336 hours. In Clinical Phase III, full recovery is not expected without definitive care and FI is 0-72%. By definition, EVAC is estimated in 100% due to the risk of permanent disability. LOCL is not expected for eye injuries.

Untreated Best Case Comments

Our functional impairments calculation for Eye Penetration (foreign body) follows the IMM severe non-space adaptation template except for the best case scenario, because total recovery without definitive care is uncertain. 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 eye conditions using the severe non space adaptation template. (American Medical Association, 2008)

During Clinical Phase II, FI is estimated in 28 to 72%. Duration is 24 to 72 hours, similar to the treated best case scenario. In Clinical Phase III, recovery may or may not occur and FI is 0-47% s. EVACs have occurred among military analogs for battle and nonbattle injuries (Ari, 2006). Even minor injuries may incapacitate personnel and if untreated cause severe visual loss. (Aslam, 2005) EVAC is estimated in 0 to 100% for this scenario similar to the treated best case. LOCL is not expected for eye injuries

Untreated Worst Case Comments

Our functional impairments calculation for Eye Penetration (foreign body) follows the IMM severe non-space adaptation template except for the best case scenario, because total recovery without definitive care is uncertain. 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 eye conditions using the severe non space adaptation template. (American Medical Association, 2008)

During Clinical Phase II, FI is estimated in 61 to 85%. Duration is 336 hours, 14 days, 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
Ari, 2006	2	EVAC
Aslam, 2005	2	EVAC
Smith, 2002	4	BCWC
Colyer, 2007	2	BCWC
Cillino, 2008	4	BCWC
Imrie, 2008	4	BCWC

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	2	6	Yes	No	to apply medications
Eye shield	1	1	1	No	Yes	to cover eye
Fluorescein 1mg strips (2 strips)	1	1	10	Yes	Yes	fluorescent chemical used to examine the cornea.
Gauze pads (4x4)	2	2	50	Yes	No	to absorb blood or fluids from skin
Medical tape	0.03	1	5	Yes	No	single-coated tapepressure adhesive tape
Moxifloxacin (Avelox) 0.5%, 3ml bottle	0	0.5	4	Yes	Yes	Treat infections. Instill one drop in the affected eye 3 times a day for 7 days
Otoscope (Head, Handle, and USB cable)	1	1	1	No	Yes	Light source for eye exam
Penlight	1	1	2	No	Yes	eye exam
Penlight Blue Filter	1	1	2	No	Yes	eye exam
Proparacaine eye drops 0.5%, 15mL bottle	0.013	0.013	1	No	No	eye anesthetic
Refresh artificial tears (Carboxymethylcellulose) 0.5%, 0.4mL bottle	1	1	40	Yes	Yes	Relief dryness/irritation of the eyes
Tylenol (Acetaminophen) 325 mg	0	12	150	Yes	Yes	pain relief
Vicodin HP (Hydrocodone/ Acetaminophen HP) 10 mg/660 mg	0	12	30	Yes	Yes	Pain relief

Resource Comments

Eye penetration (foreign body) is addressed in the ISS Medical Checklist (International Space Station Integrated Medical Group, 2008). All resources included in the table are part of the ISS resources.

Comparison of ISS Medical checklist versus terrestrial guidelines

Treatment recommended in military guidelines for eye penetration is similar to the ISS Medical checklist for first aid. Terrestrial guidelines recommend suture of the sclera. For eye penetration the military guidelines recommend tetanus toxoid vaccine, CT scan, primary surgical repair to close the eye wall and definitive secondary surgery at a later date. (Blanch, 2009)

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	3.5
EVAC / LOCL	2
Resources	2
QUALITY OF EVIDENCE	**2.9**

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

Reference List

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