

## Cervical Spine Fracture CLIFF Peer Review

1. *Strength of evidence presented in CLIFF in modeling the characteristics and mission impact of this medical condition within the spaceflight environment?*

Score: 3

### **Grading Scale:**

4 - *Confident*

3 - *Somewhat confident*

2 – *Neutral*

1 – *Somewhat unconfident*

0 – *Not confident*

|                                                                                            |                                                            |                                                     |                                                                            |                                                     |                                                                                |              |
|--------------------------------------------------------------------------------------------|------------------------------------------------------------|-----------------------------------------------------|----------------------------------------------------------------------------|-----------------------------------------------------|--------------------------------------------------------------------------------|--------------|
| 2. How confident are you that these data accurately represent the spaceflight environment? | Tables 1, 2<br>Composite Incidence and Level of Confidence | Table 3, 4<br>BC/WC<br>Loss of Crew and probability | Table 4 - Clinical Phase 1, 2 durations<br><br>Table 5 – CP 2 Loss of Crew | Table 4 – RTDC %<br><br>Table 6 – RTDC Loss of Crew | Table 4 – Loss of Crew Life %<br><br>Table 7 – Loss of Crew Life, Loss of Crew | Table 8 – TI |
| Score                                                                                      | 3                                                          | 3                                                   | 3                                                                          | 4                                                   | 4                                                                              | 3            |

### Comments and limitations:

**1. General comments.** Fractures of the cervical spine should be suspected when a patient suffers trauma and is complaining of neck pain. On earth, the most common causes of cervical spine injury are motor vehicle accidents, falls, diving into shallow water, sports injuries, and gunshot wounds. Most commonly these fractures occur in young males 15-24 years of age but also increase in frequency above the age of 55. Neuropathy, spinal cord injuries, poor bone healing and postoperative infection are common complications of cervical spine fractures. Most of the terrestrial causes of these fractures are not applicable to spaceflight. Spinal cord injury is not considered as it is covered in a separate CLIFF. There have been no cervical neck fractures reported during spaceflight.

**2. Incidence.** In keeping with the approach that has been used with other fractures, the microgravity risk of a cervical spine fracture is assumed to be close to zero since nearly all the risk factors found in terrestrial studies are not present during that phase of spaceflight. The incidence from the most relevant terrestrial article was applied to surface EVA only. This will most likely be an overestimate given the lower gravitational field during lunar and Martian EVA's and absence of

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major terrestrial risk factors for cervical spine fractures. However, the composite incidence should be a better approximation of the overall risk than if the incidence was applied to the entire mission, including microgravity operations. The best case/worst case probabilities, clinical phase durations, RTDC and Loss of crew life probabilities are supported by terrestrial evidence, and I am in agreement with their calculation. The probability density curve that was derived appears to be a reasonable representation of the data presented. Because of the large sample size, the study used to compute the composite incidence most likely overestimates the confidence we have in the assigned value.

**3. Clinical phase data.** I am in agreement with the clinical phase 1 duration entered in this CLIFF. This data was compiled by a team of expert clinicians, and I was involved in the discussions leading to the calculation of the clinical phase duration. CP2 was supported by terrestrial evidence.

**4. Task impairment.** The analysis was performed and reviewed by a separate team of expert clinicians. I am aware of the methods that were used but did not directly participate in the discussions.

**5. Dependence on mission phase or duration of mission.** This medical condition will be dependent on mission phase and will only be applied during surface EVA's.

### 6. Limitations

- There is limited data to inform untreated scenarios. Non-operative treatment is not the same as untreated.
- The incidence from the most relevant terrestrial article was applied to surface EVA only. This will most likely be an overestimate given the lower gravitational field during lunar and Martian EVA's and absence of major terrestrial risk factors for cervical spine fractures.
- Because of the large sample size, the study used to compute the composite incidence most likely overestimates the confidence we have in the assigned value.
- Ideally, the likelihood and outcomes for this condition would be based on a biomechanical mathematical model. This was done for several fracture conditions in IMM as well as for IMPACT. However, since there is no biomechanical mathematical model for cervical spine fracture, terrestrial data must be used.
- This CLIFF will need to be updated for IMPACT 2.0 when non-EVA surface operations are considered.

Reviewed by:

David C. Hilmers