

EVA Related Shoulder Injury 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 Composite Incidence and Level of Confidence	Table 3, 4 BC/WC Loss of Crew and probability	Table 4 - Clinical Phase 1, 2 durations Table 5 – CP 2 Loss of Crew	Table 4 – RTDC % Table 6 – RTDC Loss of Crew	Table 4 – Loss of Crew Life % Table 7 – Loss of Crew Life, Loss of Crew	Table 8 – TI
Score	3	3	2	3	3	3

Comments and limitations:

1. General comments. This CLIFF examines the risk of shoulder injuries associated with EVA's. Due to factors such as suit fit, pre-existing injury, mass of tools, EVA tasks assigned, and training density, EVA-related shoulder injuries are one of the most common MSK disorders encountered by astronauts. These injuries can cause not only mission task impairment but long-term morbidity. Pre-flight training is quite intense and for each EVA performed in spaceflight, crewmembers undergo 6-10 water tank training runs. Water tank training, in which astronauts are neutrally buoyant but still under the influence of gravity, actually has a higher rate of shoulder injury than EVA's performed in microgravity. Suit design has been implicated in shoulder injuries, and important advances have been made throughout the space program to improve the comfort and safety of the shoulder joint. It is unclear how well historical data that documents the rate of injuries in older suits will inform the incidence in newer designs. Since some shoulder overuse injuries during an EVA are of minor consequence, they may go unreported. The best case is considered to be a suit related overuse injury or Grade I or II strain/sprain (minimal or partial muscle or ligamentous tearing) in which symptoms can be readily managed with oral or topical medications and supportive care (physical therapy is encouraged). The worst case is a suit related overuse injury or Grade III strain/sprain (full

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thickness muscle or ligamentous tearing), instability, or suspected labral tear that requires additional treatment. Physical therapy is mandatory in the worst case.

2. Incidence. A review by Scheuring et al. (2009) was used to inform the incidence distribution for this condition. The study reviewed missions from Mercury – ISS Expedition 13. Six shoulder injuries were attributed to the various EVA suits utilized during those missions. The data is not based on the planned xEMU suit for Lunar surface EVAs. Since the exploration space suits will presumably incorporate improvements in design, it is possible that the incidence of shoulder injuries will be lower than historical experience. It is likely that very minor overuse injuries have not been reported in the past which could lead to a small underestimate of the true incidence value. The best case/worst case probabilities used data from a study that provided data on shoulder injuries in US astronauts related to EVA suits. Out of the 40 documented shoulder injuries, 11 required surgery (27.5%). This was assigned as the worst case probability. The clinical phase durations, RTDC and Loss of crew life probabilities are supported by terrestrial evidence, and I am in agreement with their calculation. The Loss of crew life probabilities were considered to be zero given the medical condition definition. The probability density curve that was derived appears to be a reasonable representation of the data presented.

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 is dependent on mission phase as it is only applicable to EVA operations.

6. Limitations

- Under-reporting for this condition could have occurred during past space missions due to subtle overuse injuries that were not of clinical consequence. This may result in underestimation of the incidence.
- The incidence was based on historical data from past spaceflights which used EVA suits that will not be utilized in future missions. Since the exploration space suits will presumably incorporate improvements in design, it is possible that the incidence of shoulder injuries will be lower than historical experience.
- The CLIFF is heavily informed by rotator cuff tears. Best-case scenario data included sprains/strains and partial thickness tears (Grade I-II). Worst-case scenario data included full thickness tears (Grade III). Labral tears were incorporated in the worst-case scenario as available literature allowed. In the NBL most shoulder injuries involve the rotator cuff and/or labrum but shoulder injuries on orbit are generally milder.

Reviewed by:

David C. Hilmers