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Flow Cytometry Methods to Monitor Immune System Dysregulation in Astronauts

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Persistent immune system dysregulation has been documented to occur in astronauts participating in orbital spaceflight onboard the International Space Station. The phenomenon consists of reductions in T and NK cell function, altered cytokine profiles, persistent inflammation, and the subclinical reactivation of latent herpesviruses. In select crewmembers the dysregulation does actually lead to clinical symptoms, primarily atypical allergy or atopic dermatitis/zoster. Flow cytometry has served a central role defining the ‘immune assessment’ panel of assays that allow monitoring of astronauts. The cytometry assays which have been utilized include:

1. Peripheral leukocyte subsets

2. T cell function

3. Monocyte function

3. NK cell function

4. Intracellular cytokine analysis

5. Virus-specific T cell number (tetramer assay)

6. Virus-specific T cell function (peptide stimulation)

7. Leukocyte-bacterial challenge cytometry

8. Cytometric bead/multiplex array (soluble proteins)

The use of these assays has been validated through various ISS flight investigations to define, to varying degrees, both in-flight, and post-flight immune system alterations. The kinetics of the dysregulation through the various phases of spaceflight, as well as post-flight recovery, have also been documented. To allow the science to occur within the orbital constraints of a spaceflight investigation, particular sample collection and processing techniques were developed compatible with the delays associated with terrestrial processing of in-flight samples. A subset of the assays has been adapted to routine monitoring of astronauts via a NASA ‘ISS Standard Measures’ activity, with the data from a specific crew then provided to all science investigators for that particular mission.

This battery of cytometry assays has also been applied, through ground investigations, to several terrestrial ‘spaceflight analog’ populations. The purpose was to validate the analog which most closely replicates the in-flight observed pattern of alterations, generally believed to be winterover at an Antarctica station. To assist in determination of clinical risk, the assay panel has also been applied to investigations of various terrestrial patient populations, particularly zoster patients.

As NASA is initiating crewed lunar missions via the ‘Artemis’ program, deployment of a miniaturized, microgravity-compatible flow cytometer, would be extremely beneficial to allow real time monitoring of crewmembers. Real time medical data could influence use of several countermeasures options during deep space missions. Several such instruments have been developed and validated to varying degrees of success. Assay details and summary findings across the various flight and ground platforms will be presented, as will current status in developing such technology for in-flight use.