Station Immunology Insights For Earth and Space

June 17, 2013

When we get sick, our immune systems kick into gear to tell our bodies how to heal. Our T cells - white blood cells that act like tiny generals - order an army of immune cells to organize and attack the enemy. Microgravity studies aboard the International Space Station are helping researchers pinpoint what drives these responses, leading to future medical treatments on Earth.

View of European Space Agency (ESA) Andre Kuipers, Expedition 30 flight engineer, working with the Kubik facility in the Columbus Module of the International Space Station. (NASA)

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"The lack of gravity is important, because we are removing a variable," said Millie Hughes-Fulford, Ph.D., a former NASA astronaut; director of the Laboratory of Cell Growth at the University of California, San Francisco; and principal investigator for the Leukin study. This investigation looks at how human immune system cells adapt to microgravity. "Much like in math, whenever you remove a variable, you can solve the equation. The space station laboratory offers us the ability to look at things in a new way and therefore perhaps find a new answer as to how the immune system works."

European Space Agency (ESA) astronaut Thomas Reiter works with Astrolab; one of the experiments for Astrolab was Leukin, an experiment to study how human immune system cells adapt to weightlessness. (ESA)

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Scientists have known since the early days of human spaceflight that living in microgravity suppresses the immune system. During the Apollo Program, for instance, 15 of the 29 astronauts developed an infection either during or right after flight. Forty years later, Leukin results show that immunosuppression begins within the first 60 hours of flight.

Findings from this investigation enabled researchers to pinpoint some specific genetic triggers for the go/no go of the immune system responses in the T cells. "We got really good results!" said Hughes-Fulford. "It was the first time anyone has been able to absolutely prove that gravity is making a difference in activation of the T cell."

Samples were paired person-to-person from four different donors, allowing researchers to look directly at the changes per individual and compare them against each other. This powerful way to look at data is called a paired ANOVA - a two way analysis of variance, based in this case on microgravity. The study used the Kubik facility aboard station to create a control sample with simulated 1g so that all other factors, such as radiation and temperature, would be the same. This helps isolate the response of the samples to the variable of gravitational force for clear results.

Answering the questions of how and why microgravity impacts immunosuppression aids researchers as they identify ways to increase the body's chances in health-related battles. "Once you activate your T cell, you are activating other parts of the immune system," said Hughes-Fulford. "So it's not just the T cell, it's the entire immune system that is affected. When a T cell does not

activate, all the cells that it brings into the war against the invader are not activated or are only activated in a partial way."

A healthy body depends on these T cells giving orders for the immune system to function properly as it marches into battle. There are factors that can hinder victory, however, such as signal interruption, delayed responses or even outright cell death. A suppressed immune system is like an army with an ineffective leader, significantly reducing the chances of a successful fight.

Results revealed that specific genes within T cells showed down regulation - a decrease in cell response - when exposed to microgravity. This combined down regulation in the genetics of T cells leads to a reduction in the body's defense against infections during spaceflight in various ways. For instance, there is a reduced proinflammatory response - the cell's protective reaction to initiate healing. Cells also produce fewer cytokines, the proteins responsible for signaling communications between cells. There is even a negative impact to a cell's ability to multiply, known as mitogenesis - the chromosomal splitting in a cell nucleus necessary for cell reproduction.

Examples of immunosuppression on Earth include the AIDS related HIV infection, rheumatoid arthritis and even age-related impacts to the immune system, which is why the elderly have a difficult time fighting off infections like pneumonia. Identifying how the immune system works at the cellular level provides a powerful tool to develop treatments at the root of the defense response. This is like a negotiation for peace talks before conflict breaks out, instead of trying to raise a white flag in the midst of an already raging battle. If doctors can isolate and control specific immune responses, they increase the chance for recovery.

"What is really important is what we're going to do with the data," said Hughes-Fulford. "Using this method we are able to start looking at the immune system and new control points to either activate or deactivate…That's the whole goal of what we're doing when looking at the bioinformatics to use that in application to immune diseases here on Earth."

Hughes-Fulford currently is in preparation for her next immunology study aboard the space station, funded by a grant from the National Institutes of Health and sponsored by the Center for Advancement of Science in Space (CASIS). Scheduled to launch with the SpaceX-3 commercial resupply mission, the investigation, called T-Cell Activation in Aging, will look at another class of control points in T cells that trigger immune response. Finding the genes that tell the cells to turn on and off is key to advancing medical options to improve immune system functions.

"The base of this grant is the fact that we are able to use T cells from healthy human beings that are younger to look at the control points, like the go/no go from engineering," said Hughes-Fulford. "These are points that tell the cells yes or no, and by looking at those points we can pinpoint new potential pharmaceutical targets to treat immunosuppression."

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› Back To Top