宇宙での心臓超音波検査により地球上での心臓管理が改善する可能性がある

宇宙飛行士における無重力による早期心機能低下を予知するのに数学的モデルが役立つ可能性がある

Mathematical models may help predict early deterioration of heart function due to weightlessness among astronauts

宇宙飛行士は宇宙探査から帰還した後にしばしばふらふら感を訴えたり意識を失ったりするが、起立性低血圧の原因はいまだ明らかにされていない。研究者らは国際宇宙ステーション（ISS）上で施行した心臓超音波検査のデータを収集し、心筋量が宇宙で減少するか、さらにこれにより宇宙飛行士が地球に戻った時の起立性低血圧に影響するかを調査しその答えを模索している。第60回American College of Cardiology学会で発表された研究結果によると、これらのデータを用いた数学的モデルは無重力による早期心機能低下を予知するのに役立つようである。このスタディの一環として研究者らは、より良いインターフェイスおよびコンピュータプラットホームを開発しており、これにより心臓超音波や磁気共鳴画像（MRI）のデータを心臓モデルに迅速に統合でき、様々なタイプの心疾患を解析することが可能となる。つまり、これにより航空医官および研究者らが宇宙での心血管機能変化を予測しこれらの変化を予防する対策をデザインできる。この予測モデルはまた宇宙プログラムを遥かに超え臨床に適用できることも期待されている。

Full Text

Astronauts frequently become lightheaded or pass out after returning from space explorations, but the reason for orthostatic hypotension remains unclear. Researchers are searching for the answers by collecting data from echocardiograms performed on board the International Space Station (ISS) to determine if the heart loses muscle mass in space and whether this contributes to orthostasis when astronauts return to Earth. Mathematical modeling using these data appear to be promising in helping to predict early deterioration of heart function due to weightlessness, according to research presented at the American College of Cardiology's 60th Annual Scientific Session.

As part of this study, researchers are developing improved interfaces and computational platforms that will allow them to rapidly integrate echocardiography and magnetic resonance imaging (MRI) data into cardiac models to analyze multiple types of heart disease.

In short, this will allow flight surgeons and researchers to predict changes in cardiovascular function in space and design countermeasures to prevent these alterations. This predictive modeling is also expected to have clinical applications well beyond the space program.

"There is a great need to understand what happens to the heart in space before we can venture further out, eventually to Mars and beyond," said James D. Thomas, M.D., staff cardiologist at the Cleveland Clinic and senior author of the study. "This work will also have great impact on the care of patients on Earth since our mathematical modeling will be applicable to all kinds of heart-related problems, such as heart failure and coronary artery disease."

In this study, a group of patients with cardiomyopathy underwent echocardiography to measure cardiac strain, which is said to be one of the best parameters for judging cardiac function. "In its simplest form, strain is the proportional change in length of a muscle," Thomas said. "If a 10-inch rubber band were stretched to 11 inches, this would reflect a 10 percent strain."

Echocardiographic images were obtained with a modern instrument, as well as an aging HDI-5000 at the Cleveland Clinic, similar to the 12-year-old machine on the space station, which was not originally designed to measure strain. The data were analyzed with multiple customized software packages and yielded comparable strain results, both for the heart as a whole and for individual ventricular walls.

"This means that strain measurements made with one instrument can be compared with subsequent imaging on other machines, allowing much wider application of this promising technique, even with machines not specifically designed to measure strain," Thomas added.

This study is part of an extensive project funded by NASA called the Integrated Cardiovascular Study in which astronauts undergo detailed echo and MRI exams before and after flight, as well as monthly echoes in flight, to determine the extent and timing of changes in cardiac function in space.

Armed with these strain maps and other data from astronauts in space and patients on the ground, engineers at the NASA Glenn Research Center in Cleveland and at the University of Auckland, New Zealand, have begun to develop mathematical models to define the heart's response to weightlessness and several disease states. While it will be several years before the Integrated Cardiovascular Study will be completed, authors report that this modeling work is already yielding insights into the diagnosis and treatment of heart disease.

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