

Simulated high-altitude exposure for 24 hours is well tolerated despite single-ventricle physiology

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(from left) Dr Julian Alexander Härtel and Dr Nicole Müller from the Department of Paediatric Cardiology at the UKB, who jointly led the study, with study nurse and coordinator Ute Baur. Credit: M. Steinhauer, University Hospital Bonn (UKB)

A long-haul flight or an overnight stay in the mountains: For many patients with a Fontan circulation (single-ventricle physiology), this was previously unimaginable, as there was insufficient medical research into how acute changes in altitude affect their cardiovascular system.

A study conducted by the University Hospital Bonn (UKB) together with the German Aerospace Center (DLR) and other cooperation partners now provides more certainty. Thanks to this study, extensive data was obtained and the research team was able to prove that an overnight stay up to 24 to 30 hours at artificial altitude of 2,500 meters does not impair cardiac function in these [patients](#).

[The results](#) have now been published in the journal *Circulation*.

The researchers conducted a study over four days, including overnight stays, with 18 subjects at the DLR medical research center in Cologne. At a simulated altitude of 2,500 meters above sea level, the influence of hypoxia (oxygen deficiency) on hemodynamic and metabolic parameters was investigated.

The central venous pressure via a catheter and the blood flow in the lungs using [real-time](#) magnetic resonance imaging were evaluated. The results showed that neither the pulmonary pressure nor the [blood flow](#) changed significantly. All patients able to tolerate a longer stay at altitude of 24 to 30 hours without complications.

Oxygenation levels stable even during sleep

Additionally, the research team analyzed the oxygen saturation values during sleep. "The breathing pattern during sleep at altitude can be fundamentally different," explains Dr. Nicole Müller, head of the study and senior physician at the Department of Pediatric Cardiology at the UKB.

"Even in healthy people, breathing is altered with short pauses. It was therefore exciting for us to observe if and how the high altitude exposure affects patients with Fontan physiology during sleep." Fortunately, the analyses showed that oxygen saturation is also sufficient during sleep and that the decrease is comparable to that of healthy people.

"These are great results," says Dr. Müller. "I think that this offers many patients with Fontan circulation new perspectives. Previously, there was only data on how short-term hypoxia affects their cardiovascular system—but data on prolonged hypoxia, including overnight stays, has been lacking until now.

"Many of those affected have therefore never dared to spend a longer period at ambient hypoxia, such as an overnight stay in the mountains or a long-haul flight to Australia. Our study now shows that, under certain conditions, there is no health risk."

The findings may provide guidance for physicians caring for individuals with Fontan circulation considering long-duration airplane travel or shorter stays at high altitude.

"DLR's :envihab at the Cologne site offers unique opportunities for patient-oriented research," says Prof Dr. Jens Tank, Head of the Cardiovascular Aerospace Medicine Department at DLR. "The invasive pressure measurement in the Fontan circulation and the examination with real-time MRI cannot be realized at altitude under real conditions.

"In the :envihab, we were able to examine the Fontan patients over several days and nights under very comfortable conditions and safely expose them to an oxygen-reduced atmosphere. We very much hope that we will be able to conduct further exciting studies together in the future."

"This is a great development for medicine and contributes to better quality of life for all patients with congenital heart defects," adds Sylvia Paul, CEO of the Children's Heart Foundation.

"We are delighted to be able to support the joint study by the UKB, the DLR and the German Sport University Cologne and thus contribute to giving Fontan patients a better quality of life."

More information: Nicole Müller et al, Peripheral Oxygenation and Pulmonary Hemodynamics in Individuals With Fontan Circulation During 24-Hour High-Altitude Exposure Simulation, *Circulation* (2024). [DOI: 10.1161/CIRCULATIONAHA.123.067601](https://doi.org/10.1161/CIRCULATIONAHA.123.067601)

Provided by University Hospital Bonn

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