MRIにより一流ダイバーの無呼吸中の心血管系変化が示された(SSK04_06)

一流のフリーダイバーにおける無呼吸の生理学的変化は心不全における血行動態変化と類似している

Physiological effects of apnea in elite free-divers similar to hemodynamic changes seen in heart failure

呼吸を止めて海面から数百フィート下に潜るフリーダイビングの過激なスポーツに従事するアスリートにおいては、有意な心血管変化が起きている、と2015年Radiological Society of North America年次集会で発表された。これらの変化は、特に経験の浅いまたは心臓が鍛えられていないダイバーにおいては危険な可能性がある。旧式の方法によるフリーつまり無呼吸ダイビング人口は過去10年の間に世界中で非常に増大している。このスポーツは、ダイバーが非常な水圧下で身体的変化を来しながら長時間にわたり呼吸を止めなくてはならないため危険であり得る。研究者らは17人の一流フリーダイバー（23～58歳）においてMRIを用いてフリーダイビングの心血管系に対する影響をシミュレーションした。ダイバーらは、呼吸を最大に止めている間およびその後の心臓MRIおよびMR位相コントラスト画像検査を施行された。呼吸を止めている平均は299秒（5分弱）であった。長時間の無呼吸はダイビング反応から予測された様に心臓に対する大きな血行動態変化をもたらし、脳血流を増加させた。特に、無呼吸は一過性の心拡大、左室駆出率および左室内径短縮率の減少-心不全患者において認められるパターン-を引き起こした。

Full Text

Athletes who engage in the extreme sport of free diving, descending hundreds of feet below the surface of the ocean while holding their breath, undergo significant cardiovascular changes, according to a new study presented at the 2015 annual meeting of the Radiological Society of North America (RSNA). These changes can pose potential dangers, particularly to inexperienced or cardiac untrained divers.

Apnea is the temporary suspension of breathing. The ancient practice of free or apnea diving has experienced immense growth worldwide over the past decade, due to coverage in the media and increased competition and training opportunities for elite and recreational divers. The sport can be dangerous, because divers must hold their breath for prolonged periods while undergoing massive water pressure and physiological changes.

Recreational divers are at greatest risk because of lack of conditioning, but even elite divers have suffered lasting or fatal effects resulting from free diving. Most recently, champion diver Natalia Molchanova was reported missing and presumed dead off the coast of Spain during a dive in August 2015.

Researchers at the University of Bonn in Bonn, Germany, used MRI to study the simulated effects of free diving on the cardiovascular systems of 17 elite free-divers from Germany and Austria (age range 23 to 58). To study the effects of a lack of oxygen on heart function and blood flow, respectively, the divers underwent cardiac MRI and MRI of the carotid arteries before, during and after a maximum breath hold.

"We wanted to look at the changes that occur in the heart during apnea in real time," explained study author Jonas Dörner, M.D., who is now a radiology resident at the University Hospital of Cologne.

The average apnea was 299 seconds (just under five minutes) and 279 seconds or about four and a half minutes for the first and second MRI exams, respectively. The maximum breath hold (or apnea) during the exams was eight minutes and three seconds.

"These athletes train to be able to hold their breath for long periods," Dr. Dörner said. "When they get into the water, they are able to hold their breath even longer due to the diving reflex."

When submerged underwater without access to oxygen, the body responds with what is called "diving reflex," which includes a decreased heart rate, a constriction of blood vessels in the extremities, and a shift in blood flow from the extremities to the brain. These changes also occur - to a lesser degree - during prolonged breath holding without being submerged. As oxygenated blood is diverted from the rest of the body to the brain, blood pressure increases.

The MRI exams allowed the researchers to observe the cardiovascular changes involved in the diving reflex in real time. During apnea, the amount of blood flowing to the brain through the carotid arteries increased and then leveled off.

Prolonged apnea led to massive hemodynamic changes to the heart and an increased blood-flow to the brain as expected from the diving reflex. In particular, apnea led to a transient cardiac dilation, decrease of left ventricular ejection fraction and fractional shortening – a pattern seen in patients with heart failure.

"At the beginning of the apnea period, the heart pumped more strongly than when the heart was at rest," Dr. Dörner said. "Over time, the heart dilated and began to struggle." By the end of the apnea period, Dr. Dörner said the divers' heart function began to fail. At that point, not enough blood is being pumped to the brain," he said. "The heart is unable to pump against the high resistance of the blood vessels."

Although the changes in the divers' systolic heart function during apnea are similar to those in patients with systolic heart failure, Dr. Dörner said that the condition was transient in the divers.

"The divers' heart function recovered within minutes of breathing again," said Claas Nähle, M.D., head of this cardiac magnetic resonance research group. "It appears that elite divers develop compensatory mechanisms that help them adapt to the cardiovascular changes that occur during apnea."

However, for individuals with less training, free diving may be problematic.
"As a recreational activity, free diving could be harmful for someone who has heart or other medical conditions and is not well trained for the activity," said one of the study's leaders, Lars Eichhorn, M.D., from the Department of Anesthesiology and Intensive Care Medicine at the University Hospital of Bonn.

Dr. Eichhorn added that deaths among highly trained divers are mostly seen in the discipline called deep diving, a special type of apnea diving that combines the risk of prolonged apnea with changes of ambient pressure.

Other co-authors on the study are Jean-Marc Lunkenheimer, Julian A. Luetkens, M.D., Juergen Gieseke, D.Sc., Rainer Meyer, Ph.D., Andreas Hoeft, M.D., and Hans H. Schild, M.D.

RSNA2015特集

Cardiology
3D MRIは糖尿病患者における脳卒中リスクの早期徴候を示す

早期段階の脳疾患と心疾患とに関連が認められた

MRIにより一流ダイバーの無呼吸中の心血管系変化が示された

Oncology
Subsolidの肺結節は男性よりも女性におけるがんリスクを増大させる

乳腺密度のみではがんのリスクファクターにならない

Psychiatry
小児において親がいないことは脳の発達を遅延させる可能性がある

肥満小児において食物のにおいは脳の衝動性領域を活性化させる

患者の気分は医療処置の結果に影響を及ぼし得る