# Extreme Medicine

Written by: Catharine Paddock, PhD
Article Date: 07 Jun 2011
Source: http://www.medicalnewstoday.com/articles/227629.php

We've heard of extreme sports, where athletic people pursue physically challenging and often dangerous activities to test the limits of human courage, strength and endurance. But there are others who through choice or circumstance also find themselves striving to survive in extreme environments, such as explorers, whether they be up mountains, in outer space, at the poles, in deserts, or deep under the sea; or soldiers fighting in combat zones, and the civilians caught up in conflicts and their aftermath. All these situations have two things thing in common: people living on the edge of endurance, and the "extreme medicine" practitioners and researchers who treat them and study their capacity to survive.

This article describes the work of some of the scientists and clinicians who study and work in some of these environments, and how their efforts benefit the patients they serve and inform us about the field of extreme medicine.

One group that researches and teaches courses on the medicine and physiology of environments that stretch human systems "to breaking point" is the Centre for Altitude Space and Extreme Environment Medicine (CASE Medicine), based at University College London (UCL) in the UK.

They do this not just because it is a fascinating subject in its own right, and they enjoy the physical challenge, but also because it increases scientific understanding of critically ill patients.

For example, a common feature of critical illness is the severe disruption of microcirculation, and the more severe the disruption, the lower the chances of recovery or good clinical outcomes. Microcirculation is that part of the circulation system where blood passes through tiny blood vessels or capillaries into tissue and cells to nourish them with gases (including oxygen) and essential nutrients.


Since May 2007, as part of their flagship project, Caudwell Xtreme Everest, CASE has had a multidisciplinary team on Mount Everest, where they have been measuring levels of oxygen in human blood at 8,400m. The expedition leader and co-founder of CASE is Dr Mike Grocott, who lectures in intensive care medicine and holds a degree in immunology and medicine.

One of the techniques they are using is called SDF, short for Sidestream Dark-Field imaging, a non-invasive way of visualizing microcirculation whereby a camera placed under the tongue allows the clinician to see the blood flowing through the capillaries, arterioles and venules.

By analyzing recorded films of SDF, the CASE researchers are finding that spending long periods of time at high altitude reduces blood flow through the capillaries. They are currently testing whether adding nitrate supplements to drinks has any effect on microcirculation.

Another part of the project is looking at the human body's ability to extract oxygen from blood when challenged by exercise at high altitude. In critically ill patients, prolonged deprivation of oxygen can lead to organ dysfunction and failure.

At high altitudes, oxygen delivery through the arteries reduces, and tissue extraction of oxygen goes up in order to compensate and keep a steady oxygen supply to cells for energy. This aerobic process continues until a point is reached where extraction reaches the maximum and oxygen consumption begins to fall off. This is when cells then switch to anaerobic metabolism.

By using their model of exercise at high altitude the CASE team hopes to discover more about the processes that surround oxygen extraction in critically ill patients.

CASE is also active in a number of other extreme medicine areas, including space, extreme temperatures, aviation, and deep sea diving. As an example of the latter, they are looking at the effects on the body of breathing hyperbaric oxygen, that is oxygen at higher than atmospheric pressure.

We don't know very much about how oxygen under high pressure affects the body's cardiovascular system, the immune system and blood coagulation, although we do know that hyperbaric treatments are effective for a range of conditions, including carbon monoxide poisoning, bone and bladder damage from radiation and helping wounds that are slow to heal.

Another team that is also studying how humans endure at high altitudes, is doing their research on the others side of the world at the top of Argentina's Mount Aconcagua (6,962m in the Andes, the highest mountain in the Western Hemisphere). Bruce Johnson, a professor of Medicine at the Mayo Clinic in Rochester, Minnesota in the US, and his team, collect "real time" data on the physiology, cardiology and pulmonary stress of high altitude explorers and extreme athletes.

Johnson, who is is among other things a doctor in the Aerospace Medicine department, is doing this as part of the Mayo Clinic's new Extreme Medicine and Physiology Program, which aims to discover why some humans are able to excel and endure.

"I've always been interested in athletes because they are the elites of the elite," says Johnson.

What explains their abilities, he asks, "is it the lungs, the heart, the muscles, the blood vessels? What is it that limits people from participating in high-level athletic events?"

The researchers have already collected a lot of data in real time: they took the physiological measurements of the extreme athletes while they were under the extreme conditions, and then stored them, transferred them to laptops and transmitted them to computers back at the Mayo Clinic.

The measurements are from a total of ten climbers who completed the whole ascent of Aconcagua. The youngest climbers were in their 20s and the oldest was in his 60s.

The project was also useful in that it pushed some of the measuring technology to its limits and gave manufacturers invaluable information so they could make products easier to use and more robust.

The data analysis also led to many new questions. Like the researchers at CASE, the Mayo team could see how being able to answer some of them might also help patients with a range of critical illnesses.

For example, while they found that moderate activity at new altitude levels helped to maintain or improve blood oxygenation levels, excessive activity often caused a drop off; also, high levels of oxygenation didn't necessarily result in better acclimatization and fewer symptoms.

They also found some climbers experienced significant and rapid weight loss, while others managed to keep their weight relatively well. This appeared to be some kind of muscle-wasting condition, and they wondered if it followed a similar pattern seen in some patient groups.

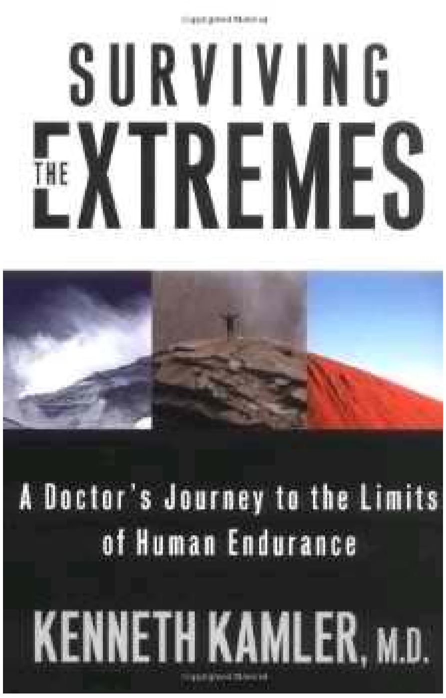
And last, but not least, it is not clear to what extent being "fit" helps one adapt to high altitude, as against one's average metabolic rate during the climb.

One of the extreme athletes Johnson recruited for the project was the former professional tennis player Diane Van Deren [photo], who after 10 years of debilitating epileptic seizures, had surgery to remove part of her brain, then resumed her athletic career. In 2008 she won the Yukon Arctic Ultra 300, a three-hundred-mile marathon, pulling a sled, in frigid conditions. And as if that wasn't enough, she then completed another one of 430 miles.

In March 2010, Johnson told Discovery's Edge, the Mayo's online research magazine, that they wanted to recruit Diane because she was "amazing for a lot of reasons" . She was a mother of three, had a medical history, was pushing 50 when they recruited her, but appeared to be getting stronger with age, competing in events most people would never attempt to train for, let alone take part in.

"She has the drive, the will that goes beyond normal," says Johnson.

Someone likely to agree with this last comment, is microsurgeon and mountain climber Kenneth Kamler, an experienced practitioner and researcher in extreme medicine, who was on Everest on 11 May 1996, preparing for an attempt to reach the summit when a violent storm engulfed three groups of climbers descending from the top. Eight people died that day. Kamler and another doctor improvised a hospital to treat the survivors.




In his book "Surviving the Extremes: A Doctor's Journey to the Limits of Human Endurance", Kamler discusses among other things, what went wrong that day. He says it's all about the brain and willpower:

"If the will is there, the brain initiates actions that are appropriate responses to the environmental stress."

Another example of extreme medicine, is extreme regenerative medicine, where cutting edge research is helping improve treatments for soldiers with the most debilitating war injuries, from lost limbs to permanent burn scars to mangled muscle tissue.

Led by Dr Bernard J. Costello, researchers at the University of Pittsburgh are working on one such Pentagon-backed project, the "bone cement project", which recently received a multi-million dollar injection from the Department of Defense to bring forward the completion date for the clinical trials.

Costello and his team are developing an injectable compound designed to repair cranio-facial bone damage or stimulate the growth of normal bone. They are about to start trials with 20 patients, most of them veterans, within the next 12 months. If all goes well, they will expand the trial to include patients with more serious injuries.

They also hope to extend the treatment to civilians, such as car crash victims. The potential is significant: the cement could eventually replace metal plates, and even help regenerate entire sections of the human skull.

He and his team are also working on trials to regenerate muscle tissue and a new way to treat burn injuries: all covered by the same cash injection, which they hope will help them acquire manufacturing facilities so they can make the products en masse.

Another area where extreme medicine is vital is the treatment of civilians injured in war-torn countries. In these cases, the practitioners themselves are also operating at the extremes of their endurance and skill, sometimes falling victim themselves to the high pressure and workload, and having to deliver life-saving services with scarce resources.

Take for example the legacy of landmines, many of whose victims are children. Despite the efforts by mine-affected countries, non-government organizations and the United Nations to clear mines, to provide education about the risks, and destroy stockpiles, the annual number of casualties worldwide is still around 4,000, although it has come down significantly from a high of 26,000 in 1997.

In a well-cited article he wrote for Scientific American in 1996, Gino Strada, [photo – middle] a one-time heart and lung transplant surgeon who after a spell as a war surgeon founded the humanitarian medical organization Emergency, describes the mutilation that a particular type of anti-personnel mine can cause: "Quite often the lower part of the leg is blown off. A piece of the tibia (the large bone in the shin) may protrude from the stump, and the remaining muscles are smashed and pushed upward, giving the injury a grotesque cauliflowerlike appearance." "Occasionally, the lower leg is blown off completely, along with the knee. Large wounds are often sustained in the thigh, the genitals or the buttocks. In many patients the opposite leg is also damaged, bearing gaping wounds or open fractures."

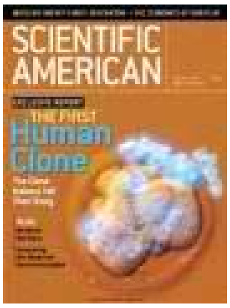
He writes that sometimes, parts of both legs are lost, and that the victim will often also have penetrating injuries of the abdomen or chest.

Even though he describes himself as a "veteran war surgeon", Strada says he can't look at the body of a child "torn to pieces" by such devices without feeling startled and upset.

Strada himself is a victim of the strain of extreme medicine. In 1996, he was a war surgeon in Emergency's first hospital in Sulaimaniya in northern Iraq when Saddam Hussein's troops mounted a strong attack on the Kurds. The hospital received so many wounded soldiers that the surgical teams were working 18 hour shifts, causing Strada to suffer a heart attack. He was transported by jeep to Turkey 400 km away, and from there to Italy where he underwent a quadruple bypass.

Today, Emergency provides free medical and surgical treatment to victims of poverty as well as landmines and war. Since it was founded in 1994, it has treated 4.2 million patients.

Strada would like to see more doctors trained specifically to deal with the medicine of war. A 2002 Scientific American article titled "Extreme Medicine" that describes him as "a veteran of virtually every turn-of-the-new-century conflict" quotes him as saying that while today's medical students receive training in emergency surgery, they are not equipped for operating with limited resources at the frontline.




He says, for example, there is a need to teach surgeons who wish to practise extreme medicine in war zones, how to choose which patients to operate on based on their chances of survival.

"In war, you can't spend three hours operating on someone with little hope of survival, while at the same time other people with more of a chance of making it are dying," says Strada.

He also says before setting out on a relief effort, doctors should learn a wide range of skills, including how to manage the construction of a new clinic. Such courses should teach not only about the medicine of war surgery, but also provide an intensive course in "common sense", where wannabe extreme medicine practitioners learn, among other things, about logistics, communications, how to cope with stress, teamwork, discipline and security issues.

## Sources

Jim Barlow, "Taking Extreme Medicine to New Heights - Studying Physiology in the Field", Discovery's Edge: Mayo Clinic's Online Research Magazine, Mar 2010; www.case-medicine.co.uk; Kenneth Kamler "Surviving the Extremes: A Doctor's Journey to the Limits of Human Endurance", St. Martin's Press, 2003; wikipedia "1996 Mount Everest disaster"; University of Pittsburgh (press release 25 May 2010); www.emergencyuk.org; The United Nations Mine Action (news release, April 2011); Gino Strada "The Horror of Landmines", Scientific American, May 1996; "Extreme Medicine", Scientific American, Jan 2002.