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Laboratory Medicine at Concordia Station, Dome C, Interior Antarctica

Antarctica may be the most fascinating, yet isolated and extreme environment on Earth. The Antarctica ice sheet contains 90 percent of the world's ice, and at its thickest point is 15,669 feet deep. With an average annual temperature of -56°F at the South Pole, temperatures are so dangerous that to venture outside during the Antarctica winter requires donning protective gear similar to an astronaut preparing for a spacewalk. Because Antarctica lies below the polar circle, parts of the continent experience up to six months of continuous darkness (depending on specific location) in the winter, and summers have a corresponding period of 24-hour daylight.

For purposes of exploration and scientific research, the world's´ Polar Agencies have populated Antarctica with expedition stations, with most lying along the coastal region. These coastal stations (e.g., Dumont d'Urville of France; Neumayer III of Germany; Casey of Australia; McMurdo of the United States) are relatively easy to resupply via ship and plane, and generally experience normal atmospheric conditions and comparatively milder temperatures as compared to interior stations. The few interior bases (e.g., Concordia Station of France-Italy; Amundsen-Scott South Pole Station of the United States) are at significant elevation and experience persistent hypobaric hypoxia, which is a state of reduced atmospheric pressure combined with reduced oxygen content. Interior bases also experience much more extreme temperatures.

A small number of expeditioners may "overwinter" at an Antarctica station, meaning they stay approximately one year, deploying in the summer transition, remaining during the winter period of darkness and isolation, and returning the following summer. Antarctica overwinter at any station is characterized by the dangers of the extreme environment coupled with the loneliness and stress associated with the profound isolation from the rest of the planet. In fact, Antarctica overwinter conditions are so extreme, it is generally not possible to resupply via air or to even evacuate ill expeditioners, adding a very real factor of danger and seclusion to overwinter deployment. Given these conditions, it is important that bases be as well-equipped as operational constraints allow, including from a clinical care/laboratory medicine perspective.

Concordia: A Unique Station in the Dangerous Antarctic Interior

Concordia station is a French/Italian research facility located approximately 621 miles inland from the Antarctic coast.

The station serves as a research platform for glaciology, astronomy, atmospheric chemistry, seismology, geo-magnetism, and human biology. It is jointly operated by the French Polar Institute and the Italian Polar Institute. The next closest human presence is at the Russian Vostok research facility, 347 miles away. The French coastal research station Dumont D'Urville is 683 miles away, and the geographic South Pole is 1,037 miles from Concordia.

Concordia is situated on a plateau known as Dome Charlie (Dome C). Dome C is at an altitude of 10,606 feet, and its atmospheric pressure is equivalent to an altitude of about 12,467 feet at the equator. The "summer" daylight period lasts three months, while the winter lasts nine months, slightly longer than at the coastal stations. The average temperature is -22°F during the summer and -76°F during the winter, with the lowest recorded temperature being -120°F. During the winter, the extremes of temperature pose a real threat to safety. Frostbite injury is common, and temperatures are so extreme that eyelashes freeze together, camera equipment tends to fail, and it is easy to lose oneself amongst the never-ending darkness. There is relatively little wind and precipitation, in contrast to conditions at many of the coastal stations. The average wind speed is only 6.3 miles per hour. Dome C, essentially a "polar desert," receives a total of less than one inch of snow precipitation per year.

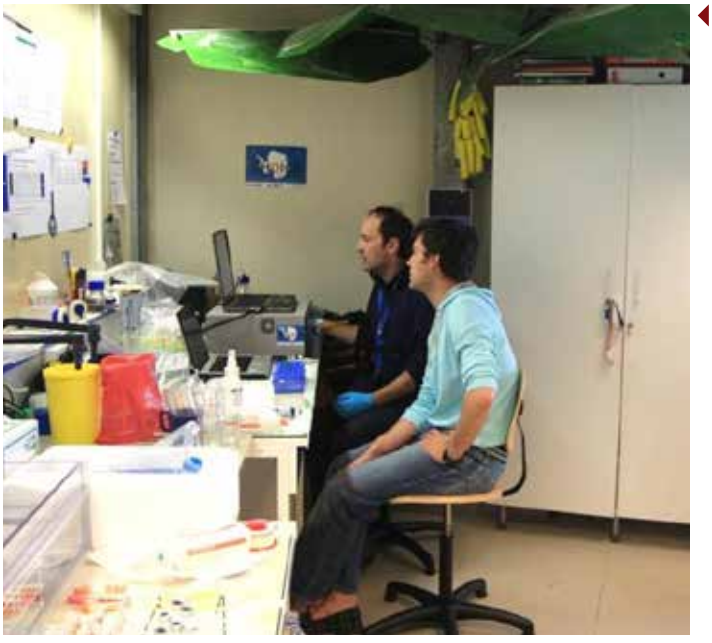
During the summer, the station is populated by 50 to 70 people. Only 12 to 16 scientists and technicians remain for the nine-month winter period, however. During the winter, there is no possibility of evacuation or deliveries to or from Concordia, in part because of the environmental extremes and location of the station. Historically, there had also been no access to the Internet, although a satellite phone is available and recent attempts have been made to better connect the station to the World Wide Web. Crew members are relatively self-sufficient during the winter period, and they must deal with any medical (e.g., appendicitis) or technical (e.g., power failure) emergency themselves.

Clinical Care and Laboratory Medicine at Concordia

Because crew cannot be evacuated during the winter, Concordia is equipped with laboratory space and a basic medicine facility; a medical doctor is assigned to each overwinter crew. The medical facility includes a clinical consultation room; a patient bedroom (which can be observed from the consultation room); a dentist's chair; and an operating room. Blood sample collection also routinely occurs at Concordia, for both medical and research purposes. Equipment includes a hematology indices analyzer, a Roche Reflotron basic chemistry analyzer, a microbiology microscope, a ventilator, an oxygen concentrator (delivery 4 L/min), limited oxygen cylinders, and an inflatable hyperbaric chamber. Basic surgical instruments that would allow for simple neurosurgical, orthopedic, or abdominal surgery are also available. A low-definition video satellite connection is available for remote guidance during surgery, if necessary, and various drugs for common medical conditions (e.g., pulmonary edema, infections, epileptic seizures) are kept on hand. Recently, thrombolysis for myocardial infarctions was added to the formulary. Still, despite these medical capabilities, the ability to manage a critically unwell patient is very limited.

Concordia Station, Dome C was constructed in 2005 as a joint effort of the French and Italian Polar Agencies. During overwinter, 12 expeditioners spend up to one year living at Concordia Station. Winters in Antarctica include up to three months of 24-hour darkness. *Photo courtesy of authors*

Concordia station also has a dedicated clinical research laboratory. The European Space Agency deploys an additional physician, usually general practice, to overwinter in order to implement medical research projects, typically focused on the effects of isolation, confinement, hypobaric hypoxia, or altered circadian rhythms on crew physiology and behavior. These studies may also use clinical laboratory instrumentation. For example, one recent study deployed a water bath, a centrifuge, and a fully functioning flow cytometer for a project investigating the effects of stress and hypobaric hypoxia on the immune system. To our knowledge, this may be the first time flow cytometry has been performed in the harsh environment of the interior Antarctic continent. Generally, the instruments, kindly provided by Partec/Germany, functioned well. However,



Facilities at Concordia Station include general laboratory support areas. *Photo courtesy of authors*

The laboratory at Concordia Station offers blood sample collection support. *Photo courtesy of authors*

Clinical support at Concordia Station includes a basic hematology analyzer capable of providing white blood cell and differential analysis, as well as hemoglobin and platelet values. *Photo courtesy of authors.*

A fully functioning flow cytometer, provided by Partec, was successfully deployed and operated at Concordia Station during the 2009-2010 overwinter season. *Photo courtesy of authors*

significant optical re-alignment was necessary following air transport and initial setup, and the low humidity resulted in a persistent issue with static electricity.

Conclusion

It is important to be able to provide clinical care, including laboratory diagnostics, during remote deployment in hostile environments. As demonstrated by medical support available at Concordia, even at the most remote locations on Earth it is possible to successfully deploy and operate some minimal basic instrumentation. There are real operational constraints, however, to deploying more significant instruments. Shipping conditions, temperature, humidity, and static electricity are all factors that may make operation of instruments difficult in Antarctica. Also, supply of reagents and proper disposal of waste must be appropriately considered. Coastal Antarctica stations, considered less remote and therefore easier to service, may have even more clinical support capability and laboratory instrumentation. Interior stations, particularly those with tenacious air or overland supply capability, may have more minimal facilities. We anticipate the development of novel miniaturized or hand-held diagnostic laboratory devices, such as small blood analyzers or hand-held laboratory instrumentation, which will greatly improve laboratory support capability in these remote locations.

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