Advances in Technology: Blood-sampling at depth. Focus on “Development of an animal-borne blood sample collection device and its deployment for the determination of cardiovascular and stress hormones in submerged phocid seals”

Paul J. Ponganis
Center for Marine Biotechnology and Biomedicine, Scripps Institution of Oceanography, University of California San Diego, La Jolla, California

Submitted 29 September 2016; accepted in final form 30 September 2016

TAKEI ET AL. (10) recently described the design and application of a programmable backpack blood sampler for seals. This is a significant technological accomplishment because it is only the third time that such a device has been built and successfully used in higher marine vertebrates. Indeed, portable, automated blood sampling in any free-moving animals has been rare.

In 1975, Kawashiro and Scheid (2) and Scheid and Slama (6) developed a device to trap a blood sample by pinching the tubing of implanted arteriovenous shunts in birds. In the 1990s, a series of studies were conducted on exercising greyhounds with backpack microprocessor-controlled blood samplers (3, 4, 7). Sample collection into a collapsed balloon relied on arterial pressure and a vacuum-evacuated receptacle housing the balloon.

In the 1980s, Hill (1) developed an elaborate multisample microprocessor-based unit equipped with a reversible peristaltic pump that was used for sample withdrawal and flushing of the catheter. In the 2000s, Ponganis and coworkers (5) utilized a single-sample programmable device in which blood expulsion into the sample syringe relied on the pressure difference between ambient pressure at depth and surface atmospheric pressure within the sampler housing. The Hill and Ponganis blood samplers were used at isolated dive holes in Antarctica with diving Weddell seals (Leptonychotes weddellii) and emperor penguins (Aptenodytes forsteri), respectively.

The blood sampler of Takei et al. is also programmable, can collect two blood samples (as well as waste samples to clear the line), and relies on application of a vacuum within the sampler housing to create a negative pressure difference between the inner chamber and the external environment. This negative pressure difference allows for blood withdrawal even when the animal is at the surface. The device is equipped with a variety of sensors including a depth transducer, accelerometer, a temperature sensor, and a photosensor. The latter allows activation of the unit with use of a 5-kHz light. Blood sampling can be triggered by elapsed time, depth, temperature, or body angle.

The success rate of blood sampling was 78%. Sampling was conducted on captive seals while the animals were hauled out and also when they were in shallow water (<1.6 m depth). Clotting of the catheter accounted for only a small percentage of the failures, and this occurred while testing smaller bore, heparin-coated catheters. With larger, heparin-coated catheters, clotting was not an issue. The system was simply flushed with a heparin-saline solution at the time of deployment. Most failures occurred when the vacuum inside the pressure chamber was at a higher negative pressure. It was assumed that this greater negative pressure resulted in suction of the catheter against the wall of the vein with subsequent obstruction of the catheter inlet. Therefore, determination of the optimal negative pressure within the chamber is critical and will probably be dependent on blood vessel size, blood viscosity, catheter bore size, and syringe size. However, for animals at great depth, a negative pressure within the chamber may not even be necessary.

There are several limitations to the current version of this blood sampler. First, although successfully deployed on 40- to 60-kg seals and smaller than earlier instruments used in aquatic animals, it is still relatively large (1.2 kg in air, 18 × 8.6 cm). Second, it is designed for shallow water. For animals that dive to 400 m depth, the aluminum housing will probably be heavier. Third, again for greater depths, the t-tube connections between the tubing leading from the catheter to the syringe valves must be pressure resistant as will the syringe valves. Although the authors plan to use stronger electromagnetic valves for the syringe valves, each tubing connection must be securely locked and pressure resistant for animals diving to great depths. The size of such connectors and valves may add to both the size of the entire unit as well as the dead space of the sample tubing.

Despite these limitations, this blood sampler remains a remarkable accomplishment. Pilot studies demonstrated that vasoactive and stress hormones could be reliably identified and quantified from the samples obtained with the blood sampler. This opens the door toward more controlled studies to examine the effects of water immersion versus terrestrial haul out on atrial natriuretic peptide, arginine vasopressin, and angiotensin II in pinnipeds. In addition, the underwater maze system developed at the Seal Mammal Research Unit seal facility at St. Andrew’s by Sparling and coworkers (8, 9) could be ideal for application of this logger/blood sampler to examine biochemical, hormonal, and blood gas changes during spontaneous dives of seals.

Address for reprint requests and other correspondence: P. J. Ponganis, Center for Marine Biotechnology and Biomedicine, Scripps Institution of Oceanography, University of California San Diego, La Jolla, CA 92093-0204 (e-mail: pponganis@ucsd.edu).

http://www.ajpregu.org 0363-6119/16 Copyright © 2016 the American Physiological Society

GRANTS
The author’s work is supported by Office of Naval Research Grant N000141410404.
DISCLOSURES

No conflicts of interest, financial or otherwise, are declared by the author.

REFERENCES