..DOPPLER ULTRASOUND FOR DETECTION OF "BENDS"

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Since the Doppler ultrasound was first introduced for bubble detection in cardiovascular work by the Japanese worker, Taratka in 1975, many different applications have been made of this technique. One of the earliest attempts at the use of the Doppler ultrasonic flow meter for the objective detection of circulating bubbles in the blood stream of larger arteries and veins was done by Spencer and Campbell in 1968. Since that time refinements in electronics and instrumentation, coupled with improved clinical application have produced a technique of monitoring the vascular systems for the presence of inert gas bubbles that hold much promise for the study and prevention of dysbarism.

Basically the technique of Doppler ultrasonic detection is applied transcutaneously by means of a piezo-electric crystal of five to ten megahertz applied at usually ten milliwatts per square centimetre of the body surface. Utilizing a pair of focused quartz crystals in a contoured probe placed over the pulmonary arteries and veins just to the left of the sternum at the third to fourth interspace, one can monitor the entire return of the vascular system. Hence, bubbles arising in any portion of the body, and gaining entrance into the vasculature will be sooner or later passed in front of the view of the doppler transmitter and result in reflections of the ultrasound beam at the gas-water interface. With the improvement in electronics, the use of larger crystals with reduced background-to-signal distortion have allowed greater flexibility in placement of the ultrasound probe over the chest wall. The radiated area encompassed by the quartz crystals then becomes sufficiently large, so that all of the significant blood flow is examined upon its return to the heart. The presence or absence of venous gas emboli can be determined with a fair degree of accuracy. The arterial system is not monitored, since it has been determined that only under the most unusual circumstances do gas emboli ever appear on the arterial side of the vascular system. To date, a fairly consistent pattern of detection of venous gas emboli prior to the onset of any symptoms of the bends, has been recognized by most investigators using the Doppler ultrasound technique. Since many venous gas emboli can be detected by the Doppler ultrasound technique and no symptomatology whatsoever developed in the subject, it is quite obvious that the body has an extremely large tolerance of gas emboli before it produces any clinical signs or symptoms.

The application of the Doppler ultrasound, of course, would be mostly aptly applied directly on a diver during his dive. With surface or self-monitoring, one could detect the immediate development of gas emboli in the blood vascular system, and thus be able to shorten or terminate the dive. Unfortunately, present equipment and technique do not allow monitoring of divers during their dive conveniently, except in the chamber stimulations. Thus in the actual field work, the best that can be accomplished at this point is surveying the diver after he has completed his dive, and returned to the surface vessel. Even with this modified technique, it is quite important to be able to detect those individuals who do manifest a significant amount of bubbling in their blood vascular system, and who, therefore, should be kept under surveillance for the possible onset of bends symptomatology. Also, those individuals wishing to perform a repeat dive excursion can be warned away from this endeavour if their Doppler ultrasound examination shows a significant number of bubbles in their blood vascular system from their first exposure.

Concomitantly, the ultrasound detector can also be utilized as a monitoring system for individuals undergoing therapeutic recompression and staged decompression for the treatment of their bends. The elimination of the venous gas emboli can be used

as a predictor of effectiveness of treatment, and delineate how much treatment must be administered to the individual to produce therapeutic recompression. Also, it has been shown that in many instances of simple bends, a shortened procedure both in time and depth of recompression can be utilized as effectively as more prolonged methods. Typical Doppler ultrasound equipment can be made quite compact and portable, and easily utilized in the field. This makes the application on shipboard quite feasible, and limits it only by personnel and time.

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