A Doppler Flowmeter for Detecting Air and Other Emboli,
Incorporating A Simple Method of Screening
Against Interference

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A better method of detecting air emboli (i.e., during neurosurgical procedures) than listening for the classical mill-wheel murmur is now possible. The work of Edmonds-Seal and Maroon on the use of ultrasound for detecting air emboli prompted us to look for a suitable, satisfactory device to use for this purpose.

A new instrument, now available in North America, is the Hewlett-Packard Model 8026A Ultra Sound Monitor. This works on the same principle as the Doptone or Sonicaid units, described in earlier papers. An ultrasonic beam generated by a Piezo electric crystal is reflected by moving erythrocytes and picked up by a second similar crystal mounted in the same pick-up head. The change of frequency between the transmitted and reflected ultrasound is amplified, demodulated and presented as an audible signal through a loudspeaker. The presence of air in the blood causes a characteristic "chirp," heard over and above the normal noises of blood flow.

THE UNIT

The unit is shown in figure 1. It has a separate charging unit, a battery level indicator and a jack plug. It is light (0.40 kg) and small, 50 mm x 40 mm, making it easily handheld, and it will run for five hours without recharging or it can be run with the charger unit connected for indefinite periods. The ultrasonic frequency generated is 2.1 mHz and the angle of the field of this beam is approximately 10 degrees. We understand that pick-up heads of different frequencies and angles will soon be available, to enable the device to be used in wider fields than described here.

CLINICAL APPLICATION

The apparatus, as described, has been found especially useful during ventriculocavai shunt procedures in infants and small children. This particular surgical procedure is frequently performed during the same sitting as the pneumogram and therefore creates the distinct possibility of shunting air mixed with cerebrospinal fluid from within the ventricles of the brain into the right atrium. Should this occur, the doppler meter would detect it immediately. This phenomenon did not occur in the seven cases reported here. We did find that in every instance the proper functioning of the Spitz-Holter valve could be determined, since with each compression of the valve by the surgeon a small bolus of cerebrospinal fluid was released into the superior vena cava, producing a corresponding characteristic sound emitted by the doppler. It was pitched slightly higher than the background sound of cardiac contraction and blood flow, but somewhat lower than the "chirping" sound of air entering the right atrium. Final positioning of the distal end of the tubing leading from the installed valve was confirmed radiologically in each instance.

The doppler meter was also used for three infants having extensive craniectomies for the
surgical treatment of craniosenosis. These procedures are notorious for blood loss and invariably necessitate transfusion. Warmed blood was administered employing a standard three-way stopcock and syringe arrangement. In two cases the start of the transfusion was associated with the production of numerous “chirpings,” which disappeared as the rate of injection was decreased or stopped entirely. The system previously had been cleared of all free air, but nevertheless the “chirpings” did somehow arise from the transfused blood. The reason for this was presumed to be the introduction of platelet aggregates; these artifacts must not be mistaken for actual air emboli. Slowing the rate of transfusion appeared to prevent the “chirpings.”

A SIMPLE SYSTEM TO ELIMINATE INTERFERENCE

Interference caused by diathermy, which causes buzzing noises to come from the instrument, can be distressing to members of the operating room staff as well as dangerous for the patient, since air embolism can occur while the diathermy is being used and interference is blocking out the normal sounds. Various methods of eliminating interference were thought out (such as causing the diathermy pedal switch to switch off the speaker of the doppler flowmeter when the pedal was pressed). The simplest and cheapest turned out to be the most effective. The instrument, lead and pick-up head were wrapped in aluminum baking foil. The only precautions necessary were to ensure continuity of foil and to place acoustic gel between the pick-up head and the foil and between the foil and the patient. Due to the fact that there is foil all around the pick-up head, some “feedback” was experienced with the volume control turned up high, causing whistling noises to come from the speaker, but at normal volumes this did not occur. The instrument functioned perfectly whether diathermy was being used or not with no loss of signal.

A more sophisticated but equally simple method is to stick pressure-sensitive aluminum foil tape (Sellotape 7402) inside the casing of the flowmeter around the pick-up head. Best of all, of course, would be for the manufacturers to shield the instrument. Since the instrument (and the Doptone and Sonicaid) originally was designed for detecting fetal heartbeats in pregnant women no screening was considered necessary by the manufacturers.

The authors thank Messrs. Hewlett-Packard Ltd. for the loan of the instrument and Mr. Don Teiser for his assistance in the evaluation of the screening system.

REFERENCES