Devices for Air Detection During Dialysis

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Air detection is of paramount importance for both home and centre dialysis, if air embolism is to be avoided.

Different photocell detectors have been devised. Their use has, however, been limited: first by the great variability of size and transparency of commercially available blood lines, and second by variations in colour, optical density and osmolality of the various fluids infused in the blood lines during dialysis. The present system has been designed to overcome these difficulties.

PRINCIPLE

The capacitance between electrodes rises when the dielectric constant of the medium decreases. When electrodes are placed side to side around a tubing, a capacitor is built whose dielectric is formed by the wall and the content of the tubing. Any fluid, even if non conductive, increases capacitance as its relative dielectric constant is much higher than that of air. The introduction of air in the tubing thus induces, between the electrodes, a change in capacitance which can be easily detected.

DESCRIPTION (Figure 1)

The air detector consists of three elements: a cell, an oscillator and a detector.

1. Cell three electrodes are placed in a row around the blood tubing. The two outer electrodes are electrically cold, whereas the middle one carries a weak high frequency voltage provided by the oscillator.

2. Oscillator integrated with the cell and shielded against high frequency in order to avoid interference. The oscillator generates a high frequency voltage which is detected. Cell and oscillator are coupled alternately. The amplitude of the oscillator depends upon the cell's capacitance.
Figure 1. Schematic representation of a capacitive air detection system. Localization of the air detector on the blood lines is illustrated in the upper part of the figure. Two models of air detectors are represented (see also Figures 2 and 3).
Figure 2. Blood level detector (for schema see Figure 1). This detector is to be adapted on the bubble trap

Figure 3. Blood line air detector (for schema see Figure 1). This detector may be adapted on any blood line whatever the transparency of its wall
3. **Detector** in addition to a preamplifier the detector contains a Schmitt trigger that activates a command relay. These circuits are supplied stabilised at 9 V.

**OPERATION**

As long as fluid or blood fills the tubing between the electrodes, the electric voltage at the output of the detector remains high. This voltage (which is preamplified) drives the Schmitt trigger into its high position. As a result, current reaches a power transistor that keeps the alarm relay activated. If air enters the tubing, the electrode capacitance rises; the electric voltage at the output of the detector falls below the threshold of the Schmitt trigger. Consequently, no more current reaches the power transistor and the relay is inactivated. In this state, the contacts of the relay switch on to visual alarm and the blood pump is stopped.

**CONCLUSION**

Different models of capacitance air detectors have been developed (Figures 2 and 3). Clinical use of these models has shown them to be highly reliable. No false alarms were noted. This finding is in marked contrast with the observations made with photocell air detectors which gave false alarms whenever saline was infused in the blood line. Finally, the fact that the air detector could be applied on non-transparent tubing increased its versatility.

**SUMMARY**

An air detector based on the detection of changes in capacitance has been demonstrated. The main advantages of this device are its reliability — no false alarms — and its versatility — it may be used on non-transparent tubings.