Problems with Measurement Using the Swan–Ganz Catheter

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The introduction of the Swan-Ganz balloon-tipped double-lumen catheter in 1970 has enabled pulmonary catheterization to be performed at the bedside.[1–3] The relative simplicity and safety of the procedure have led to its acceptance and addition to existing intensive care monitoring. During our experience with its use in our 12-bed Shock-Trauma Unit since 1971 we have observed certain pitfalls which may arise when it is adopted into routine monitoring with pulmonary arterial pressure (PAP) and pulmonary wedge pressure (PWP) values obtained and recorded hourly at the bedside.

With many catheters, apparently in good position as evidenced by x-ray examination, it was not possible to obtain a "wedge." On other occasions when acceptable PAP and PWP values had been obtained there would be a sudden change to a much higher or lower PWP.

The purpose of this report is to identify the potential sources of error in the measurement of PAP and PWP in man using balloon-flotation catheters.

MATERIALS AND METHODS

Eight patients in whom we had found aberrations of PWP were studied. They had sustained major blunt trauma in high-speed automobile accidents. All had respiratory insufficiency and were being mechanically ventilated by Engström ventilators utilizing a positive end-expiratory pressure of 10 cm H_2O. All had percutaneous arterial and pulmonary-artery catheters in place. By use of Statham P23Ia pressure transducers, waveforms were continuously displayed at the bedside on an SM1052 oscilloscope (Statham).

FIG. 1. Eccentric inflation of "free" balloon.

Radiopaque contrast medium (Conray 60) was injected into the balloon. A chest x-ray was immediately obtained, following which the balloon was emptied and flushed out several times with saline solution to eliminate any residual contrast medium and obviate subsequent difficulties with deflation of the balloon. Studies were performed on two consecutive days in each patient, on the second day after adjustment of catheter position to demonstrate the correction.

When the catheters were finally removed from the patients, the balloons were examined for eccentric inflation tendencies both "free" without any surrounding restriction (fig. 1) and when inflated within clear plastic suction tubing with an internal diameter of 7 mm.

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RESULTS

In four cases where, despite an acceptable "wedge" trace, the values of PWP were either the same or greater than PAP's, x-ray demonstrated either occlusion of the catheter tip by an overdistended balloon or impingement of the tip of the catheter on the vessel wall. We postulate that when the tip of the catheter was impinging on the vessel wall rapid inflation of the balloon trapped blood under pressure between the catheter tip and the vessel wall. The use of a continual-flush system will magnify the apparent PWP elevation.

In two patients, in whom the catheters were demonstrated by both PAP trace and x-ray to be in good positions, and for whom a PWP tracing could not be obtained, x-ray examination demonstrated eccentric inflation of the balloon (fig. 2).

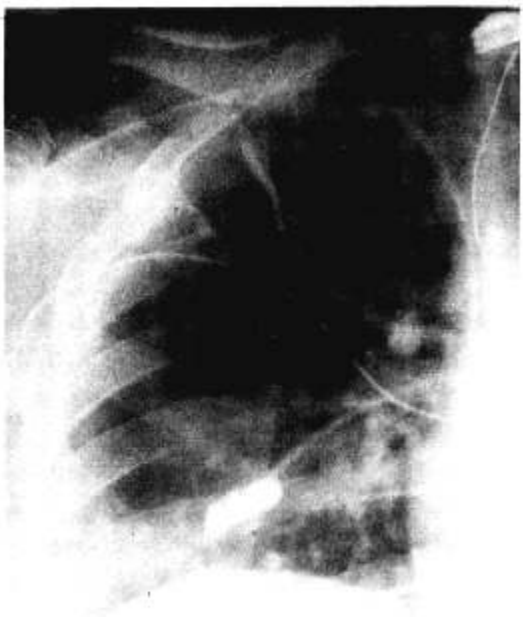

FIG. 2. Eccentric inflation of balloon into a branch artery, tip remaining in main stream. PWP not obtainable.

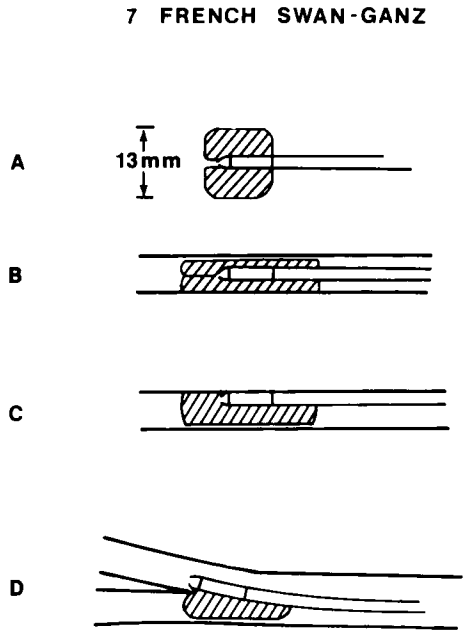

FIG. 3. *A*, normal full cuff inflation of "free" balloon. *B*, occlusion of catheter tip by overdistended balloon. *C*, eccentric balloon inflation with catheter tip impinging on vessel wall. *D*, eccentric inflation of balloon with catheter tip in main stream.

In the two remaining cases, the balloon was visualized in the main pulmonary artery. This was associated with a "pseudo-wedge" tracing which resulted from a damping of the PAP on inflation of the cuff.

DISCUSSION

Complications associated with herniation of the cuffs of endotracheal and tracheostomy tubes and the resultant problems with airway pressures and gaseous exchange are common knowledge to the anesthesiologist. We postulated that such problems might be the explanation for the aberrations of PWP we had found in the course of using the Swan-Ganz catheter. X-ray examination with radiopaque dye in the balloon confirmed our suspicions. The possible mechanisms of these phenomena are illustrated in figure 3. When it is impossible to obtain a "wedge" position or when the trace is unsatisfactory, the catheter tip may have relocated in the pulmonary artery or the balloon may be inflating eccentrically

into a branch while the tip remains in the main stream (figs. 2 and 3, *D*).

While such malfunctioning of the balloon may occur from the time of the initial placement of the catheter, we believe that aberrant function may be initiated following the introduction of a high positive end-expiratory pressure, high-tidal-volume ventilation, positional change of the patient, coughing, or even movement of the catheter tip with contraction of the heart. Distortion of surrounding lung tissue due to existing disease might also be a causative factor.

Since the initiation of this study, Lozman *et al.* have raised the question of the accuracy in PWP measurements in patients being ventilated with high positive end-expiratory pressure. They reported a single dog experiment in which they demonstrated uneven inflation of the balloon causing impinging of the catheter tip on the wall of the pulmonary artery. This report confirms that such phenomena occur in man, necessitating stringent interpretation of values obtained.

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Anaphylactic Reaction to Cephalothin during Anesthesia

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Allergic reactions to cephalothin (Keflin) are reported to occur in 3–5 per cent of patients.[1,2] There are no data concerning frequency of anaphylactic reactions to cephalothin, but its widespread use since introduction in 1964 has been associated with few reports of anaphylaxis during anesthesia and operation.[3] The following, representing the third known anaphylactic reaction to cephalothin during anesthesia, is presented because: 1) the patient survived; 2) the intra-arterial oxygen tension was monitored continuously.

Report of a Case

A 48-year-old man who had chronic back pain and sciatica was scheduled for lumbar laminectomy with fusion. Past history was noncontributory except for chronic osteoarthritis and penicillin allergy. Nine months previously he had had an appendectomy followed by several orthopedic procedures, all with general anesthesia and no complication. Twenty years previously the patient had had a reaction to an intramuscular injection of penicillin. He remembered that six hours after injection his tongue had "shed" and he had expectorated blood. A diffuse erythematous, urticarial rash had followed, accompanied by lower-extremity edema persisting for three days.

Physical examination and laboratory data disclosed no abnormality. After premedication with pentobarbital, 100 mg, morphine, 5 mg, and atropine, 0.4 mg, im, the patient arrived in the operating room, where the usual monitors were placed. With the patient's informed consent, a left radial arterial cannula was inserted. Through this an indwelling continuous P_{O_2} electrode‡ was threaded.

Anesthesia was induced with thiopental (200 mg) and tracheal intubation was facilitated by succinylcholine (100 mg). The patient was placed in the prone–flex position and anesthesia maintained with enflurane and N_2O/O_2. Pancuronium, 4 mg, was administered, and respiration was controlled with a mechanical ventilator. Two hours and 45 minutes after induction, 1 g cephalo-

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