

## Air Embolization during Percutaneous Swan-Ganz Catheter Placement

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The Seldinger technique<sup>1</sup> is used with increasing frequency for the percutaneous placement of Swan-Ganz catheters.<sup>2</sup> The technique consists of placing a needle into a vein, usually the internal jugular vein, passing a guide-wire through that needle, then removing the needle while the guide-wire remains in the track from the skin to the lumen of the vein. The wire is used to direct subsequent dilators and the catheter introducer into the vein. The 7-French balloon-tipped catheter requires an 8-French introducer. The size of this introducer (about 2.5 mm in diameter) has provoked more than one observer to ask about the incidence of air embolism during the placement of Swan-Ganz catheters. The period of concern is between the removal of the wire and dilator from the lumen of the introducer and insertion of a catheter through the introducer. At this point the hub may be open to atmospheric pressure. Fatal air embolization through smaller-bore cannulas has been reported.<sup>3,4</sup>

Utilizing clinical criteria (hypotension, arrhythmia, "mill-wheel" murmur) for diagnosis,<sup>5</sup> air embolization has not been detected during Swan-Ganz catheter placement on the cardiac anesthesia service. The frequency with which questions about the possibility of air embolization recurred prompted us to design a study to detect even small amounts of air entering the right heart during Swan-Ganz catheterization of the internal jugular vein.

### METHODS

Twelve adult patients having Swan-Ganz catheters placed percutaneously in preparation for coronary-artery surgery or cardiac valvular surgery were studied. ECG and direct arterial blood pressure monitoring were established. A Fetosonde 2000® Doppler unit, modified to function at 2.5 mHz (optimum frequency for air embolus detection) was utilized. The Doppler transducer was placed over the right parasternal area

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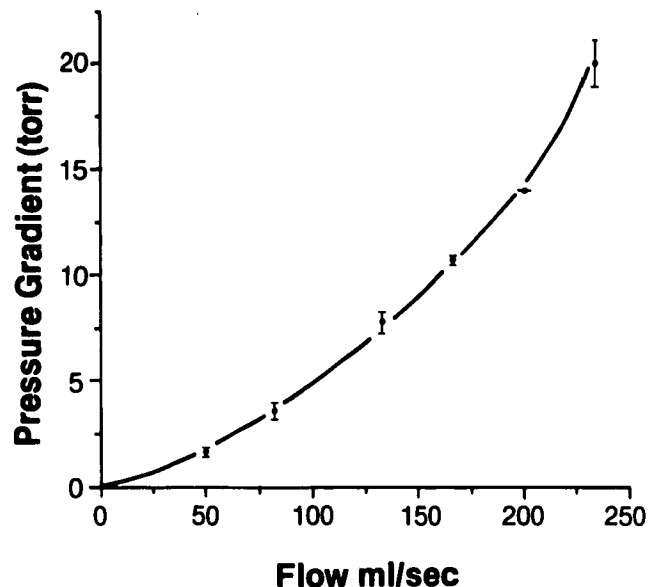


FIG. 1. Pressure gradients at various flow rates through 8-French, 12.5-cm Swan-Ganz catheter introducer. Each point is the mean of results of three studies. Flags represent one standard deviation.

and its position adjusted so that characteristic sounds of blood moving through the heart and heart wall motion were audible. The position of the transducer was checked after each study by the injection of .25 ml of air through the central venous pressure lumen of the Swan-Ganz catheter. Proper placement was confirmed in each instance. An observer monitored the Doppler output continuously, listening for the higher-pitched sound characteristic of air in the Doppler beam. After the transducer has been positioned, the patient was tilted head down (20 degrees) and the right internal jugular vein cannulated, utilizing the Seldinger technique.

In a separate study the relationship between the pressure gradient across the Seldinger introducer and gas flow through its lumen was determined by recording the pressure drop when known oxygen flows were passed through the lumen of the introducer.

### RESULTS

Air was detected in the heart of one patient of the 12 studied. This occurred between removal of the

dilatator and introduction of the catheter into the sheath. There was no change in blood pressure or heart rate, nor were any of the other signs of air embolization detected, despite the presence of air within the heart for five cardiac cycles, as determined by the Doppler monitoring. We found that the relationship between flow through an 8-French introducer and the pressure drop across the introducer was curvilinear (fig. 1). At a pressure gradient of 4 torr, flow rate was 90 ml/sec.

#### DISCUSSION

This study demonstrates that air can enter the heart during percutaneous placement of the Swan-Ganz catheter, and that the catheter introducer will accept potentially fatal air flow rates at clinically attainable pressures. It has been shown that a flow of 1 ml/kg/sec is sufficient to cause fatal air embolism.<sup>4</sup> Hence, a 4-torr gradient would be sufficient to induce a fatal air embolus in an adult patient.

There was no obvious cause of the air embolus detected in our patient. She had been tilted head down (20 degrees) and did not appear to attempt to breathe while the introducer hub was open.

The Seldinger technique for introducing Swan-Ganz catheters into the internal jugular vein has been used thousands of times worldwide without any report of air embolization. We scrupulously adhere to the common-sense maneuvers likely to decrease the chances of entry of air into the internal jugular vein. These

include increasing the pressure within the internal jugular vein by head-down tilt (approximately 20 degrees), having the patient hold his breath in inspiration and perform a Valsalva maneuver during the critical moment, and minimizing the time the cannula is exposed to atmospheric pressure.<sup>†</sup>

Although this study has provided both laboratory and clinical evidence that air embolization can occur during Swan-Ganz catheter placement, we have not, in more than 400 applications of the technique, generated a clinically detectable air embolus, and we believe that the maneuvers outlined above have contributed to that record.

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<sup>†</sup> Since this study was performed, several manufacturers have introduced diaphragm-occluded catheter introducers designed to decrease the likelihood of entry of air. We have no data regarding their efficacy.

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## A Simplified Endotracheal Tube for Microlaryngoscopy, Laryngoscopy, and Bronchoscopy

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In 1943, Mushin devised a self-inflating endotracheal tube cuff by puncturing two holes in the wall

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of a conventional-sized tube so that the lumen communicated with the interior of the cuff. The cuff automatically inflated when positive pressure was applied to the system, thereby effecting a seal, and deflated when the pressure was released. The expired gases escaped both around the tube and through the lumen.<sup>1</sup> We have applied this principle to endotracheal tubes of small caliber (5 mm ID) to facilitate administration of anesthesia for bronchoscopy, microlaryngoscopy, and allied procedures by use of standard anesthesia equipment in the conventional manner. This obviates the need for the more complex or the less safe apparatus requiring high insufflatory pres-