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Anatomic Locations of the Tips of Pulmonary-artery Catheters in Supine Patients

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Pulmonary-artery occluded pressure (PAOP) is considered an accurate indicator of left atrial pressure (LAP) under most circumstances.[1–3] However, several possible measurement errors can make interpretation and utilization difficult. The importance of referencing the zero point of the transducer to the level of the left atrium is well known. In addition, recent studies have stressed the importance of the vertical location of the distal pulmonary-artery (PA) catheter tip.[4–7] They demonstrated that PAOP reflects airway pressure instead of LAP when the catheter tip is positioned vertically above** the left atrium and positive end-expiratory pressure (PEEP) is applied. It has also been demonstrated that when the pulmonary-artery catheter tip is vertically below the left atrium, there is a high correlation between PAOP and LAP even with PEEP as high as 30 cm H_2O.[4–6] Benumof *et al.*[8] reviewed the locations of catheter tips in supine patients by use of anteroposterior roentgenograms, but did not evaluate the true vertical positions of the catheter tips. To clarify the issue of catheter tip location, we utilized both anteroposterior and lateral roentgenograms to locate catheters in supine patients.

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** In the supine patient, "vertically above" refers to ventral and "vertically below" refers to dorsal.

METHODS

Thirty patients (ages 26–83 years) admitted to the Medical–Surgical Intensive Care Unit at the San

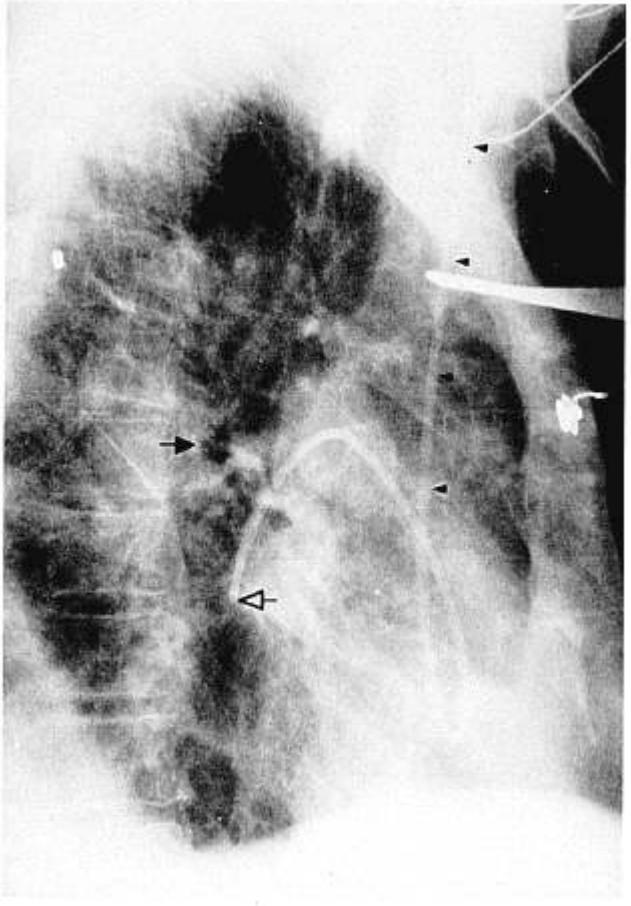

FIG. 1. Roentgenogram of the lateral chest, showing a pulmonary catheter. The course in the superior vena cava is marked by small arrowheads (◄). The catheter tip (◄—) and left mainstem bronchus (—►) are also marked.

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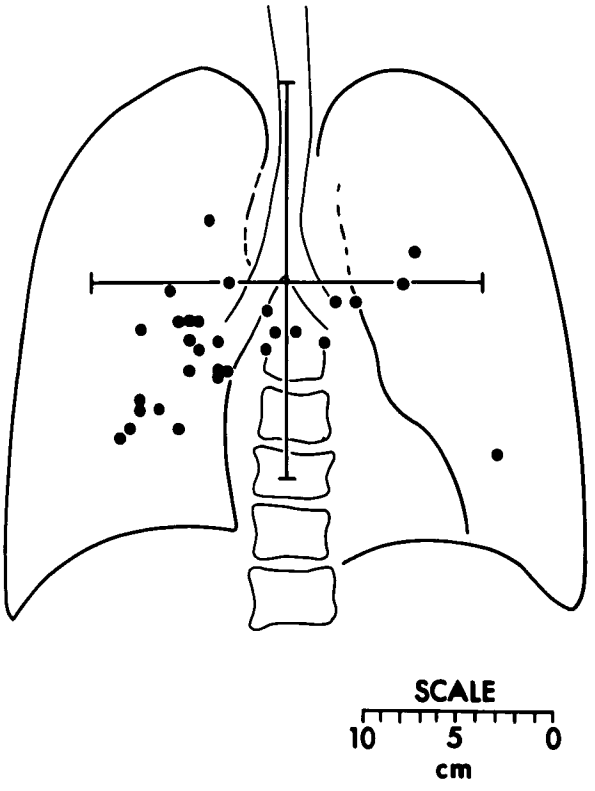

FIG. 2. Distribution of tips of pulmonary-artery catheters on anteroposterior roentgenograms.

Francisco General Hospital had pulmonary-artery catheters placed for clinical indications. At the time of the catheter insertion, 20 patients were being mechanically ventilated for acute respiratory failure, 12 of whom were being treated with PEEP (range 4–12, mean 7 cm H_2O). The catheter was positioned in the most proximal location where PAOP could be measured. Portable anteroposterior and lateral chest roentgenograms were obtained. The position of the catheter tip on the anteroposterior projection was measured relative to the carina and the midline. On the lateral roentgenogram, the route of the catheter through the superior vena cava outlines the anterior border of the left atrium,[9] and the position of the catheter tip was measured relative to this landmark (fig. 1). In addition, pulmonary arterial pressure, PAOP, and thermodilution cardiac output were measured after catheter insertion.

RESULTS

On anteroposterior roentgenograms (fig. 2), 73 per cent of the catheter tips were located in the right lower quadrant ($P < .005$).†† On the lateral view (fig. 3), the tips of the pulmonary-artery catheters were 2.9 ± .4 cm (mean ± SE) vertically below the superior vena cava ($P < .005$).†† Using this distance as a measure of posterior location, there was no statistically significant correlation‡‡ between catheter tip location and the following variables: cardiac output (range 1.5–11.7 l/min), mean pulmonary arterial pressure (range 11–65 torr), PAOP (range 5–26 torr), or PEEP (range 5–12 torr). The mode of ventilation (spontaneous, mechanical ventilation, mechanical ventilation with PEEP) did not alter the location of the catheter tip relative to the superior vena cava.§§

DISCUSSION

This study showed that in supine patients the placement of most catheter tips is vertically below the superior vena cava and thus at or vertically below the left atrium. In addition, 73 per cent of catheter tips

†† χ^2 analysis.

‡‡ Least-squares regression.

§§ Two-tailed Student t test for unpaired data.

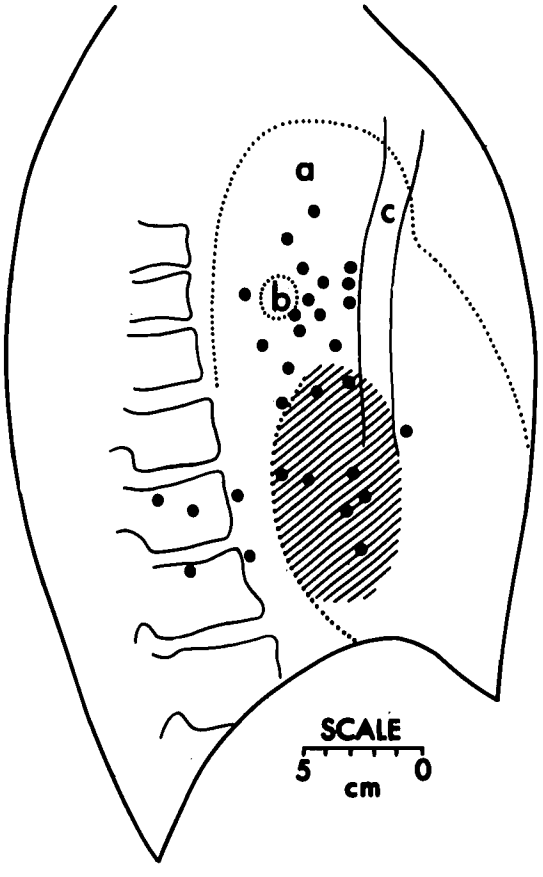

FIG. 3. Distribution of tips of pulmonary-artery catheters on lateral roentgenograms. a = aortic arch; b = left mainstem bronchus; c = superior vena cava. Shaded area is the area of the left atrium.

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were located in the right lower quadrant on the anteroposterior roentgenogram, which confirms the observations of Benumof *et al.*[8]

The pulmonary vasculature has primarily been described as being analogous to the Starling resistor.[10–12] A measurement of PAOP that accurately and reliably reflects LAP depends on a patent vascular system between the left atrium and the catheter tip. Early reports of experiences with flotation pulmonary-artery catheters did not mention experience with coincident mechanical ventilation with PEEP. When alveolar pressure increases with mechanical ventilation and high PEEP to cause collapse of the pulmonary vasculature, PAOP will reflect airway pressure. However, PAOP accurately reflects LAP in animals with high PEEP when the catheter tip is vertically below the left atrium.[4–6] Combining these findings with those of the present study, PAOP should accurately reflect LAP in supine patients when the transducer is referenced to the left atrium.

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Massive Trophoblastic Embolization and PEEP Therapy

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Embolization of trophoblastic tissue to lung is a potentially fatal complication of uterine evacuation of a benign hydatidiform mole. It appears that tissue emboli may result in a progressive hypoxemia and cardiopulmonary instability. To our knowledge all previously reported cases of massive trophoblastic embolization in which ventilatory support has been necessary have been fatal. We present a case in which a patient with this diagnosis was successfully supported with combined ventilatory support and positive end-expiratory pressure (PEEP) therapy.

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Report of a Case

A 19-year-old previously healthy white girl complained of orthopnea, dyspnea on exertion, and a nonproductive cough for six days prior to a scheduled uterine evacuation of a hydatidiform mole. Copious vaginal bleeding necessitated admission to the hospital on an emergency basis, at which time the patient was alert and oriented,

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