and calculated stability indices from each paired experiment demonstrated that administration of these inhalation anesthetics had no appreciable effect on pulmonary surfactant under the conditions of this investigation.

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Central Venous Pressures via Peripheral Veins

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Central venous pressure monitoring to assess myocardial function and right heart filling pressure relationships can be a valuable aid in the treatment of shock or other conditions which significantly alter the cardiac function-filling pressure relationship.[1,2] Venous pressure measurements can be accomplished in a variety of ways. The subclavian vein has frequently been used. However, published reports are sparse and the complications significant.[3-5] The external jugular vein and peripheral veins have been employed with variable success.[6,7] Such variability and lack of a generally acceptable approach prompted this study to develop a safe technic for peripheral placement of a catheter.

The following disadvantages were considered: (1) air embolism, (2) obstruction to catheter advancement, (3) perforation of a central vein, and (4) phlebitis and local tissue reaction. It was reasoned that these risks might be minimized by a technique in which the catheter is initially connected to a conventional intravenous set and the solution allowed to flow during its insertion through a needle, so that the rate of fluid flow could serve to monitor the advancement of the catheter tip.

Methods

A catheter unit** which included a 21-inch long radiopaque plastic catheter (15 gauge) housed in a longitudinally slit plastic tube was used. A 19-inch extension tube attached to the catheter allowed its direct connection to an intravenous solution bottle. The catheter was inserted through a 14 gauge needle introduced into an appropriate arm vein, basilic, median cubital or cephalic, in order of preference, after the infusion system was allowed to fill the extention tubing and catheter. Infusion was begun after tourniquet release. With fluid running rapidly the catheter was ad-

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** Catheter units were supplied by Sorenson Research Corporation, Salt Lake City, Utah.

TABLE 1. Summary of Success of Catheter Insertion

Unsuccessful	Successful	Centrally placed	Total Catheters Used and Placement	Venous Route		Venous Pressure Reading		
				Basilic	Cephalic	Excellent	Good	None
			74 Suprasternal notch	40	34	68	6	—
		124	50 Subclavian region	14	36	49	1	—
	134		9 Axillary region	2	7	3	6	—
			1 Upper arm		1	—	1	—
6			6 Not placed*			—	—	6*
Totals 6	134	124	140	56	78	120	14	6

* Not placed due to inability to accomplish venipuncture.
Excellent—Rapid fluid level response to respiration, cardiac action and movement of manometer.
Good—Acceptable but sluggish response to above.

vanced into the superior vena cava. Based on 23 roentgen-ray examinations, the length of catheter required to reach the superior vena cava was found to correspond to the distance between the site of venipuncture and the suprasternal notch.

During the catheter advancement, the arm was abducted to 90 degrees with a slight anterior flexion as the catheter passed into the axillary vein. Frequently, the catheter would halt near the origin of the subclavian vein as it passed beneath the clavicle and over the first rib. The nearly perpendicular junction of the cephalic with the axillary vein frequently caused obstruction when using the cephalic vein. Elevating the clavicle to stretch the axillary vessels generally resulted in an increase in rate of fluid flow and permitted further advancement of the catheter.

Catheter advancement was halted if (1) the infusion rate slowed or stopped, (2) there was visible kinking of the catheter as seen subcutaneously, or (3) increasing resistance developed. When several manipulations proved unsuccessful, the catheter was withdrawn *with the needle* until an optimum infusion rate was found and a reliable venous pressure reading obtained.

Pressures were read by opening the extention tube to ambient pressure. When maximum fluctuation of the fluid level with respiration cardiac impulse and elevation on lowering of the extention tube was obtained, the venous pressure reading was considered optimal, and the catheter was secured to the arm with tape. A manometer with a centimeter rule was attached to the catheter extention tube to permit either infusion or pressure measurement. Localization of the catheter tip by means of an ECG electrode attached to the fluid-filled catheter was not attempted in this study.[8]

RESULTS

Of 140 attempts in as many patients, 134 catheters were successfully inserted (table 1). The six unsuccessful attempts resulted from the author's inability successfully to accomplish venipuncture. Age and sex of the patient or use of right or left arm had no significant influence on the results. In 5 of the 6 instances of failure obesity was the underlying problem.

The cephalic vein was used in 78 instances, and obstruction was encountered at the subclavian junction 36 times, at the axillary region 7 times, and at the upper arm once. Thirty-four (44%) catheters were passed without obstruction. In 36 patients the basilic vein was utilized. The first rib or subclavian area could not be bypassed 14 times and the axillary region twice. The remaining 40 (71 per cent) catheters were passed successfully.

Reliability of venous pressure reading was evaluated on an arbitrary basis. Two criteria

TABLE 2. Incidence of Reactions Related to Time in Use

Days	Catheters	Reactions
<1	12	0
1–2	26	2
2–3	36	3
3–4	28	4
4–5	15	1
5–6	9	2
6–7	4	1
7–8	3	0
8–9	1	0
Mean 3.1 days	134	13 (10%)

were used: rapidity of fluid level adjustment and sensitivity of fluid level changes when correlated with the respiratory pattern and heart beat. In all instances the readings were satisfactory; however, in 14 (10 per cent) of the cases, dampening was present. On several occasions the catheter tip had to be withdrawn slightly to improve the sensitivity.

Table 2 summarizes catheter reactions.[9] Mild tenderness and localized minimal phlebitis were observed in 11 of the 13 reactions and extensive cellulitis of the upper arm and shoulder in 2. Ten of the 13 reactions occurred with catheters in the axillary region. This compares to a 58 per cent incidence of reactions with short catheters left in place for 48 hours, as reported by Cheney and Lincoln.[10]

COMMENT

The major merits in the use of centrally placed venous catheters percutaneously inserted via peripheral veins as determined by this study were (1) ease of use (96 per cent successful); (2) reliable venous pressure measurement (90 per cent judged excellent and 10 per cent acceptable); (3) predictability of catheter tip positioning by external measurements; (4) minimal incidence of phlebitis (10 per cent), with a 3-day mean duration of catheter retention; (5) absence of significant complications in 134 patients, and (6) avoidance of air embolism and easy insertion by concurrent fluid infusion during catheter insertion.

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