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Length of insertion for pulmonary artery catheters to locate different cardiac chambers in patients undergoing cardiac surgery

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Background. Although, guidelines related to length of insertion of a pulmonary artery catheter to reach a particular cardiac chamber are available, these are not backed by clinical studies. We measured the length of insertion of pulmonary artery catheters to locate the right ventricle, pulmonary artery and pulmonary capillary wedge positions in 300 adult patients undergoing elective cardiac surgery.

Methods. The pulmonary artery catheters were inserted using a standard technique through the right internal jugular vein. The right ventricle, pulmonary artery and wedge position of the catheter were confirmed by the characteristic waveforms, and the length of insertion to these points was measured.

Results. The right ventricle was reached at 24.6 (3) cm (95% CI 24.2–24.9 cm), pulmonary artery at 36 (4) cm (95% CI 35.6–36.5 cm) and wedge position at 42.8 (5.7) cm (95% CI 42.2–43.5 cm). The length of catheter to reach the right ventricle, pulmonary artery and wedge position was significantly more in patients undergoing valve surgery as compared with those undergoing coronary artery bypass grafting [26 (3.8) and 24 (2.5) cm; 38.5 (4.6) and 35 (3.2) cm; and 47.8 (6.9) and 41.2 (4.1) cm, respectively, $P<0.001$]. The length of insertion to reach pulmonary artery and pulmonary capillary wedge position was directly related to height of the patient (Pearson's correlation 0.157 and 0.15, respectively).

Conclusions. We have provided the norms related to length of insertion of pulmonary artery catheter, which should be useful in accurate placement of the catheter and minimize complications related to coiling of the catheter.

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The development of balloon floatation pulmonary artery (PA) catheter was a major advance in haemodynamic monitoring.[1] The PA catheter's original capabilities of pressure measurement and blood sampling have expanded to include pacing as well as measurement of thermodilution cardiac output (CO), fibreoptic mixed venous oxygen saturation and right ventricular ejection fraction and continuous CO.[2] There is conflicting evidence from controlled studies regarding the benefit that cardiac surgery patients receive from PA catheterization and practice guidelines are available.[3]

The successful placement of a PA catheter is directed by simultaneous display of the pressure waveform and the guidelines regarding its length of insertion. Although, guidelines in terms of length of catheter insertion to locate a particular cardiac chamber are available, these are not backed by clinical studies.[4] In this study, we attempted to measure the length of insertion of PA catheter to locate the right ventricle (RV), PA and the pulmonary capillary wedge position (PCWP) so that norms for length of insertion can be provided.

Methods

After Institutional Ethics Committee approval and written informed consent, 300 consecutive adult patients undergoing elective cardiac surgery between July 2003 and October 2005, in whom a PA catheter was inserted, were included. The decision to insert the PA catheter in a given patient was based on our institutional practice.

The consultant or a senior resident doctor under supervision performed all the catheterizations. A central approach for the cannulation of right internal jugular vein (IJV) was used in all patients.[5] The needle was inserted at the apex of the triangle formed by medial and lateral heads of sternocleidomastoid muscle and the clavicle. An 8.5 F introducer sheath (Edwards Lifesciences Introflex, CA, USA) was inserted using Seldinger technique. The PA catheter was inserted through the introducer sheath after flushing all the lumens. The distal lumen was transduced to obtain a waveform on the monitor (Datex AS3 Ohmeda Engstrom, Helsinki, Finland). The catheter was initially inserted up to 20 cm and the balloon was inflated with 1.5 ml of air. The catheter was then advanced slowly (approximately 1 cm each time) while watching the waveform on the monitor. At the first appearance of characteristic RV, PA and PCWP waveforms, the length of catheter that was inserted was measured with the help of a scale and the marks present on the PA catheter. For example, if 40 cm mark was visible nearest to the point of insertion, the distance between this mark and the last visible part of PA catheter was measured and subtracted from 40 cm. In addition, the length of the hub of the sheath was measured, which is equivalent to the distance from skin to the last visible part of the PA catheter. This distance was 4 cm and was constant for all patients. Therefore, 4 cm was further subtracted from the earlier value to give the length of insertion from skin. The length of insertion required to reach RV, PA or PCWP was recorded in each patient. In addition, the distance to reach PA from RV and PCWP from PA were calculated by subtracting RV from PA and PA from PCWP, respectively. On reaching the wedge position, the balloon was deflated and the PA catheter was fixed in this position. A postoperative X-ray chest was checked in all patients to rule out coiling of the catheter.

All data are expressed as mean (SD). The data were analysed using Student's *t*-test. A *P*-value <0.05 was considered significant. Pearson's correlation coefficient was calculated to categorize any relation between height or body surface area (BSA) and the length of insertion required to locate different cardiac chambers.

Results

There were 221 males and 79 females with a mean age of 48.5 (16–77) yr and weight of 58.3 (12.8) kg. In total 217 patients underwent coronary artery bypass grafting (CABG) and 83 patients underwent valve replacement surgeries (Table 1).

Table 1 Patient characteristic data (*n*=300)

Age (yr)	48.5 (16–77)
Sex (m/f)	221/79
Height (cm)	165.9 (8.8)
Weight (kg)	58.3 (12.8)
Body surface area (BSA) (m^2)	1.63 (0.18)
Type of surgery	
Coronary artery bypass grafting (CABG)	217
Valve replacement	83
Regurgitant lesions (mitral/aortic)	46/01
Non-regurgitant lesions (mitral stenosis)	36

Table 2 The length of insertion of PA catheter (cm) to reach various chambers. RV, right ventricle; PA, pulmonary artery; PCWP, pulmonary capillary wedge pressure

	Mean (SD) (range)	95% CIs
RV (*n*=300)	24.6 (3.0) (22.5–42)	24.2–24.9
PA (*n*=298)	36.0 (4.0) (27.5–55.5)	35.6–36.5
PCWP (*n*=278)	42.8 (5.7) (36.1–70)	42.2–43.5
RV to PA (*n*=298)	11.33 (3.36)	10.95–11.71
PA to PCWP (*n*= 278)	7.37 (3.81)	6.94–7.8

Table 3 The average length of insertion to reach different chambers in patients undergoing CABG and valve replacement surgeries. RV, right ventricle; PA, pulmonary artery; PCWP, pulmonary capillary wedge pressure; CABG, coronary artery bypass surgery

	Type of surgery	Mean (SD)	*P*-value
RV	Valve replacement	26.0 (3.8)	<0.001
	CABG	24.0 (2.5)	
PA	Valve replacement	38.5 (4.6)	<0.001
	CABG	35.0 (3.2)	
PCWP	Valve replacement	47.8 (6.9)	<0.001
	CABG	41.2 (4.1)	

The RV was reached at 24.6 (3) cm (95% CI 24.2–24.9 cm), PA at 36 (4) cm (95% CI 35.6–36.5 cm) and wedge position at 42.8 (5.7) cm (95% CI 42.2–43.5 cm) (Table 2). In 2 patients PA could not be entered and in 22 others the catheter could not be wedged.

The length of catheter to reach the RV, PA and wedge position was significantly more in patients undergoing valve surgery as compared with those undergoing CABG [26 (3.8) and 24 (2.5) cm; 38.5 (4.6) and 35 (3.2) cm; and 47.8 (6.9) and 41.2 (4.1) cm, respectively, *P*<0.001] (Table 3). Coiling of the catheter was not detected in any patient on postoperative X-ray chest.

No correlation could be established between BSA and length of insertion required to reach different chambers. However, length of insertion to reach PA and PCWP was directly related to the height of the patient (Pearson's correlation 0.157 and 0.15 respectively) (Table 4).

Discussion

Flow-directed PA catheters have been used widely for monitoring surgical patients. They have been reported to

Table 4 The correlation between BSA or height and average length of insertion to reach different chambers. *Correlation is significant at the 0.05 level. RV, right ventricle; PA, pulmonary artery; PCWP, pulmonary capillary wedge pressure; BSA, body surface area

		BSA	Height
RV	Pearson's correlation	−0.003	0.06
	Significance (2-tailed)	0.964	0.29
PA	Pearson's correlation	−0.052	0.157
	Significance (2-tailed)	0.371	0.006*
PCWP	Pearson's correlation	−0.077	0.15
	Significance (2-tailed)	0.198	0.012*

be easy to insert and are generally safe. The average length of insertion to reach various chambers has been documented by some authors, but the basis of this is unknown. Few authors have reported that by using right IJV approach, RV can be reached at 30–35 cm, PA at 40–45 cm and the wedge position at 50–60 cm in the vast majority of patients.[4] In our study, RV was reached at 24.6 (3.0) cm (95% CI=24.2–24.9 cm), PA at 36.0 (4.0) cm (95% CI=35.6–36.5 cm) and wedge position at 42.8 (5.7) cm (95% CI=42.2–43.5 cm). This difference could be because the previous data are from a Western population who are taller and of a better build when compared with the Indian population. In addition, it is not clear how these data were derived. The length of PA catheter to reach RV, PA and wedge position was significantly more in patients undergoing valve replacement surgery as compared with those undergoing CABG ($P<0.001$). This may be related to dilatation of the cardiac chambers, which occurs later in the course of valvular heart disease and it is at this stage that most patients present for surgery in our country.

Attention to these typical distances can help proper placement and avoid complications caused by unintended catheter loops and knots. If an excess length is inserted, the catheter should be withdrawn to the last chamber that was entered, before another attempt is made. It is noteworthy that patients with valvular heart disease may need longer length of insertion. This is especially so for obtaining PCWP, which required nearly 7 cm extra length for patients with valvular heart disease. The results of this study have influenced the practice of PA catheterization in our unit in the sense that, observing the characteristic waveform is practised, but insertion of excessive length is avoided. Repeated attempts are avoided and if excessive insertion is required to reach RV or PA, the procedure is completed under transoesophageal echocardiographic guidance. Due consideration is also given to the fact that the catheter may not be wedged in some patients and we avoid excessive insertion to obtain PCWP.

Knotting of the PA catheter has been reported[6] and although there are methods to successfully treat it, we believe, it can be avoided if the guidelines related to length of insertion are followed. Prevention is the best treatment. It has been suggested that catheter manipulation should be avoided and estimates of average insertion lengths should be used.[7]

In conclusion, we have provided definite norms related to length of insertion of PA catheter, which should be useful in its accurate placement, although, the complications may not necessarily be completely avoided by using these norms. A longer length of insertion may be required in patients with valvular heart disease or those who are taller.

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