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Factors Affecting Pulmonary Artery Catheterisation in Patients Undergoing Coronary Artery Bypass Grafting: A Cross-sectional Study

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ABSTRACT

Introduction: The Pulmonary Artery (PA) catheter continues to be used for monitoring haemodynamic parameters in the majority of patients undergoing Coronary Artery Bypass Grafting (CABG) surgeries, despite concerns raised regarding cost-effectiveness and safety issues. Sometimes, placement takes longer or is difficult just by looking at the pressure waves. There are several factors that may influence the duration of Pulmonary Artery Catheter (PAC) insertion.

Aim: To determine the factors affecting PAC in anaesthetised patients undergoing elective CABG.

Materials and Methods: A single-centred, cross-sectional study was conducted in the Cardiothoracic and Vascular Surgery operation theartre at IPGME&R and SSKM Hospital, Kolkata, India including 138 patients aged 35-65 years of either sex undergoing elective CABG surgery in a tertiary care hospital in Eastern India. The attempt to perform successful first-time catheterisation or failure of the PAC done by a resident cardioanaesthesiologist was noted, as well as whether catheterisation was successfully done within a specified time or not. This time was obtained as the 75th percentile of the time taken for catheter placement for the first 30 cases catheterised in the first attempt. For ease of analysis, all first attempt successful cases were considered as Group A (n=125), and all first attempt failure cases as Group B (n=13). The study data on various parameters were recorded on a proforma and summarised as the mean and standard deviation for normally distributed numerical variables, median and interquartile range for skewed numerical variables, and counts and percentages for categorical variables. A p-value <0.05 was considered statistically significant.

Results: A total of 138 patients were analysed during the entire study. There was a predominance of male patients (82.6%) with a male-to-female ratio of 114:24. The first attempt failure rate of successful PAC was 13 out of 138, i.e., 9.42% (95% confidence interval 4.55% to 14.29%). The cut-off time for the procedure as the 75th percentile of the first 30 successful cases is 269 seconds. The number of cases in which it was done within this time was 109 cases, i.e., 78.99%. There was a significant difference (p<0.05) in terms of body weight, body surface area, and neck length between the two groups.

Conclusion: Increased body weight and increased body surface area are significant factors associated with difficult PAC placement. On the other hand, short neck length is a significant factor for taking more time in the placement of the catheter.

Keywords: Cardiac surgery, Catheter insertion, Influencing parameters

INTRODUCTION

The PAC is a major advanced tool for haemodynamic monitoring and is widely used by cardiovascular anaesthesiologists in patients undergoing CABG surgery [1-3]. The flow-directed PAC has provided valuable diagnostic information at the bedside, apart from repeated blood sampling. It is mainly used for diagnostic and monitoring purposes as it can generate detailed information about cardiac filling pressure, cardiac output, and mixed venous oxygen saturation continuously [4]. It provides PA diastolic, systolic, mean, and capillary wedge pressure, central venous pressure, right-sided intracardiac pressure, continuous cardiac output, cardiac filling pressure, mixed venous oximetry, and pacing [4]. Right ventricular ejection fraction can also be estimated by it. So, PAC has a definite beneficial effect on perioperative and postoperative management in patients undergoing CABG who are at risk of major haemodynamic disturbance. Although indications for using PAC vary from place to place and its routine use is controversial [1], it can provide valuable information in patients with recent myocardial infarction [5,6], unstable angina, poor left ventricular function with low ejection fraction, congestive heart failure, and hypovolemic shock, cardiogenic shock. The PAC is inserted percutaneously under sterile conditions through the right Internal Jugular Vein (IJV), directed by a simultaneous display of pressure waveform [1,7] and guidelines regarding its length of insertion, which requires knowledge about the procedure and skill of the anaesthesiologist. Therefore, factors influencing its insertion should also be known to cardiovascular anaesthesiologists. The availability of this haemodynamic data has generally been believed to allow for making therapeutic decisions at critical moments. So, it has been considered a valuable device for perioperative and postoperative fluid and vasoactive drug management [1]. However, recent studies have raised concerns regarding the effectiveness [1], cost [1], and safety [2,8] of PAC, leading some to recommend their abandonment. Although controversial, as PAC helps in haemodynamic optimisation of patients and ultimately improves patient outcomes and also from an educational point of view [1], a PAC is usually inserted in patients posted for CABG after the induction of anaesthesia [9] by an anaesthesiologist by observing the pressure waves. In a few cases, the situation needs longer time or is troublesome, as it were, by watching the weight waves [1]. Decreased left ventricular ejection fraction [1], increased tricuspid regurgitation [1], increased cardiothoracic ratio [1], dilated aortic root and ascending aorta [10], unrecognised persistent left-sided superior vena cava [11,12], dilated akinetic or fibrillating left atrium [13], dextrocardia with anomalous venous connection [14], and the training duration of the anaesthesiologist [1] have been seen to be altogether associated with the troublesome catheter arrangement and to extend the arrangement time separately [1]. In some difficult cases, guidance from video fluoroscopy [1,15] or Transesophageal Echocardiography (TEE) [1] was also taken for PAC insertion. Considering the existing merits and demerits of PAC and due to the paucity of Indian studies [16] in this regard, a cross-sectional, observational study was conducted to evaluate the factors influencing PAC placement in adult anaesthetised patients undergoing elective off-pump CABG in a tertiary care hospital in eastern India.

MATERIALS AND METHODS

A single-centred, cross-sectional study was conducted in the Cardiothoracic and Vascular Surgery operation theatre at IPGME&R and SSKM Hospital, Kolkata, India (a university-affiliated tertiary care hospital and teaching institution) from February 2017 to September 2018, after prior approval from the Institutional Ethics Committee (IEC) (Memo no. IPGMER/IEC/2017/095 dated 06.02.2017).

Inclusion and Exclusion criteria: All adult patients (n=138), aged between 35-65 years, of either sex, without significant cardiac arrhythmia, stenosis, or mass in the right heart chamber, who were scheduled for elective CABG surgery and willing to participate in the study with written consent, were included as the study population. Patients aged >65 years with pulmonary stenosis, tricuspid stenosis, mass-like tumours, thrombus in the right atrium, right ventricle, or PA, Tetralogy of Fallot, endobronchial mass, significant arrhythmia, bundle branch block, coagulopathy, and thrombocytopenia were excluded from present study.

Sample size: The sample size of present study was calculated based on the proportion successfully catheterise at the first attempt. Assuming that the proportion would be atleast 90% based on an earlier study [1], it was calculated that 138 subjects would be required to define this proportion with a 5% margin of error and a 95% confidence level. This calculation assumes no limitation of the population size.

Study Procedure

After recruiting the study participants based on inclusion/exclusion criteria, they were provided with an explanation of the operational procedure and admitted one day prior to their scheduled operation date. Preoperative routine diagnostic procedures were performed, and a standard anaesthesia protocol was followed according to institutional practice on the day of the operation. Venous access and radial artery catheterisation for measuring arterial blood pressure and blood sampling for arterial blood gas analyses were performed prior to induction with local anaesthesia. Oxygen saturation and a two-lead electrocardiogram (leads II and V5) were continuously monitored. Basal narcosis was induced using intravenous opiate anaesthetic with fentanyl (2 to 5 μg/kg), midazolam (0.1 mg/kg), and thiopentone (4 to 5 mg/kg).

Neuromuscular blockade was achieved with intravenous rocuronium (1 mg/kg) before intubation. After intubation, all patients were mechanically ventilated. Anaesthesia was maintained with a combination of oxygen, nitrous oxide, isoflurane, and intermittent intravenous top-up doses of Inj. fentanyl (1-2 μg/kg), Inj. midazolam (0.1 mg/kg), and Inj. vecuronium (0.02 μg/kg). A multilumen internal jugular catheter was inserted for measuring central venous pressure and for fluid/medication administration. The PAC was then inserted through the right Internal Jugular Vein (IJV) by the anaesthesiologist. A central approach for cannulation of the right IJV was used in all patients, with the needle inserted at the apex of the triangle formed by the medial and lateral heads of the sternocleidomastoid muscle and the clavicle. If cannulation of the right IJV was unsuccessful, the patient was not included in the study. After inserting the guidewire into the right internal jugular vein within the Trendelenburg position [17], an 8.5 F introducer sheath was inserted using the Seldinger technique [18], and the operating table was positioned flat. The PAC was then inserted through the introducer sheath after flushing all the lumens. The distal lumen was transduced to obtain a waveform of the right atrium, right ventricle, pulmonary artery, and pulmonary artery wedge position on the monitor. Initially, the catheter was placed through an inserter sheath up to 20 cm and the position of the PAC was confirmed by observing the pressure waveform.

In this arrangement, the curvature of the catheter was directed posteriorly. The balloon was then inflated with 1.5 mL of air, and the catheter was floated into the PA. The catheter was advanced slowly (1 cm at a time) while observing the waveform on the monitor. No instructions were given during this specific time by the staff physicians supervising the resident while they were floating the catheter. Catheter insertion time was defined as the duration calculated from the insertion of the needle into the right IJV to the time required for the catheter to float from the central venous pressure position through the right chambers of the heart into the pulmonary artery. The start time was immediately after the needle was inserted into the right IJV and the end time could be confirmed by the PA pressure wave. The time was measured by another resident or staff physician who did not participate in the catheterisation. If the placement was successful within five minutes, the case was considered successful. If the pulmonary artery catheter placement took longer than the specified time, it was considered a difficult placement [19]. In such cases, the placement was continued by the same resident under the supervision of a staff physician, or a more experienced physician made the next attempt. If necessary, guidance such as TEE was used to visualise the intracardiac catheter orientation. All procedures in this study were performed by a single resident anaesthesiologist, and the timing and other observations were recorded by another resident anaesthesiologist who did not participate in the study. To facilitate analysis, it was considered that if the catheter was placed in PA within a specified time (which was obtained as the 75th percentile of the time taken for PAC placement for the first 30 cases in the first attempt), the case was considered successful. If it took longer than that specified time, it was considered a difficult placement.

Study variables: Age (years), sex (M/F), height (cm), weight (kg), body surface area (m^2), neck length (cm) (distance between right angle of mandible to right sternoclavicular joint at 30° right lateral position), cardiothoracic ratio (ratio of the summation of the widest length from the midline of the heart to the right heart border and left heart border) [20], widest diameter of thorax, left ventricular ejection fraction (%), left ventricular end diastolic volume (mL), cardiac function (LV regional wall motion abnormality, systolic function), degree of tricuspid regurgitation (Grade 1-4) [21], PAC placement time (seconds), PA pressure (mmHg), and experience of the resident were considered as study variables. All data were collected using a predesigned validated proforma during the study period.

STATISTICAL ANALYSIS

The study data were recorded on a master sheet and summarised as mean and standard deviation for normally distributed numerical variables, median and interquartile range for skewed numerical variables, and counts and percentages for categorical variables. Univariate analysis was conducted to identify factors that potentially influenced the successful outcome. Those found to be significant on univariate analysis were entered into a binary Logistic Regression (LR) model, if feasible. A p-value <0.05 was considered statistically significant. The software used in this study were Statistica version 6.0 (Tulsa, Oklahoma: Stat Soft Inc., 2001) and GraphPad Prism version 5 (San Diego, California: GraphPad Software Inc., 2007).

RESULTS

A total of 138 patients were analysed during the entire study. There was a predominance of male patients (82.6%), with a male-to-female ratio of 114:24. There were no dropouts, and the demographic characteristics of the patients before the analysis of study variables have been described in [Table/Fig-1].

Variables (N=138)	Age (years)	Height (cm)	Body weight (kg)	Body surface area (m²)	Neck length (cm)	Cardiothoracic ratio
Range	35.0-68.0	135.0-176.0	44.0-95.0	1.2-2.1	8.0-16.0	0.3-0.8
Mean±Standard deviation	55.7±7.43	158.5±.25	59.8±8.12	1.6±0.14	11.7±1.54	0.5±0.07

[Table/Fig-1]: Age and anthropometric variables of whole study population.

The failure rate for successful PAC insertion on the first attempt was found to be only 13 cases out of 138, or 9.42% (95% confidence interval 4.55% to 14.29%). For ease of analysis, all first attempt successful cases were considered as Group A (n=125) and all first attempt failure cases as Group B (n=13). The age and anthropometric variations among the two study groups were analysed, and there was a significant difference ($p<0.05$) in terms of body weight, body surface area, and neck length among the two groups, as shown in [Table/Fig-2].

Variables	First attempt successful cases Group A (n=125)	First attempt failure cases Group B (n=13)	p-value
Age (years)			
Range	35.0-67.0	37.0-68.0	0.833
Mean±SD	55.7±7.35	55.3±8.43	
Height (cm)			
Range	138.0-176.0	135.0-174.0	0.347
Mean±SD	158.3±6.63	160.3±11.94	
Body weight (kg)			
Range	44.0-86.0	45.0-95.0	**<0.001**
Mean±SD	59.07±6.99	67.3±13.41	
Body surface area (m²)			
Range	1.2-1.9	1.2-2.1	**0.038**
Mean±SD	1.5±0.12	1.6±0.26	
Neck length (cm)			
Range	8.0-16.0	9.0-13.0	**0.016**
Mean±SD	11.8±1.49	10.6±1.64	
Median (IQR)	12.0 (11.00-13.00)	10.0 (9.50-12.00)	
Cardiothoracic ratio			
Range	0.3-0.8	0.4-0.7	0.161
Mean±SD	0.5±0.07	0.5±0.07	
Median (IQR)	0.5 (0.48-0.56)	0.5 (0.51-0.60)	

[Table/Fig-2]: Comparison of age and anthropometric variables between the study groups (N=138).

The cardiac and haemodynamic variables among the two groups were depicted in [Table/Fig-3], which shows that there was no significant variation in the assessed parameters.

Variables	Total study population (n=138)	First attempt successful cases Group A (n=125)	First attempt failure cases Group B (n=13)	p-value
Left ventricular ejection fraction (%)				
Range	23.0-78.0	23.0-78.0	37.0-70.0	0.297
Mean±SD	50.7±11.34	50.3±11.45	53.85±10.09	
Left ventricular end diastolic volume (mL)				
Range	32.2-411.9	32.2-411.9	58.2-212.9	0.939
Mean±SD	119.8±63.53	120.08±64.69	117.65±53.19	
Median (IQR)		104.19 (78.89-151.85)	109.01 (78.53-122.35)	
Pulmonary Artery (PA) systolic pressure (mmHg)				
Range	20.0-70.0	20.0-70.0	26.0-45.0	0.517
Mean±SD	34.8±9.80	35.05±10.02	32.3±7.21	
Median (IQR)		32.0 (28.00-40.00)	29.0 (27.00-39.00)	
Pulmonary Artery (PA) diastolic pressure (mmHg)				
Range	10.0-42.0	10.0-42.0	14.0-29.0	0.702
Mean±SD	20.9±6.11	21.05±6.28	20.0±4.34	
Median (IQR)		19.0 (17.00-25.00)	19.0 (17.0-21.0)	
Pulmonary Artery (PA) mean pressure (mmHg)				
Range	15.0-55.0	15.0-55.0	16.0-35.0	0.548
Mean±SD	24.8±7.83	25.03±8.004	23.0±5.91	
Median (IQR)		24.0 (20.00-29.00)	24.0 (17.00-25.00)	

[Table/Fig-3]: Comparison of cardiac and haemodynamic variables among the two groups (N=138).

When the duration of the procedure and experience of the anaesthesiologist were compared, there was no significant difference between the groups, as shown in [Table/Fig-4].

Variables	First attempt successful cases Group A (n=125)	First attempt failure cases Group B (n=13)	p-value
Time 1 (sec)			
Range	2.0-14.0	2.7-13.0	0.519
Mean±SD	8.01±2.67	7.5±3.28	
Median (IQR)	8.0 (6.00-10.00)	8.0 (5.00-9.00)	
Time 2 (sec)			
Range	2.5-101.0	6.7-18.0	0.782
Mean±SD	12.3±8.67	11.5±3.46	
Median (IQR)	12.0 (10.00-14.00)	11.0 (9.00-14.00)	
Time 3 (sec)			
Range	4.4-103.0	10.0-22.0	0.528
Mean±SD	19.8±15.48	17.2±4.41	
Median (IQR)	18.0 (15.00-20.00)	18.2 (13.00-20.00)	
Time 4 (sec)			
Range	10.0-24.0	10.0-17.8	0.198
Mean±SD	12.4±3.14	11.6±2.52	
Median (IQR)	11.0 (10.00-13.00)	10.0 (10.00-12.00)	
Time 5 (sec)			
Range	12.0-26.0	12.0-25.0	0.881
Mean±SD	14.9±3.07	15.2±3.88	
Median (IQR)	13.6 (12.70-16.80)	13.2 (13.00-16.00)	
Time 6 (sec)			
Range	60.0-240.0	60.0-210.0	0.433
Mean±SD	156.0±46.76	152.3±42.67	
Median (IQR)	180.0 (120.00-180.00)	168.0 (144.00-180.00)	
Total procedure time (sec)			
Range	106.7-299.0	106.2-291.8	0.610
Mean±SD	219.3±50.99	215.4±50.76	
Median (IQR)	236.5 (182.98-253.90)	225.8 (206.00-247.00)	
Experience of anaesthesiologist (months)			
Range	8.0-16.0	9.0-15.0	0.580
Mean±SD	11.8±1.78	11.6±1.55	
Median (IQR)	12.0 (11.00-13.00)	11.0 (11.00-12.00)	

[Table/Fig-4]: Comparison of duration of procedure and experience of anaesthesiologist between the study group (N=138).
p-value is the last column is from Student's unpaired t-test for normally distributed variables and from Mann-Whitney U test for skewed variables.
Time 1: Time from Seeker Needle placement to Cannulation Needle placement in Rt. IJV
Time 2: Time from Cannulation Needle placement to Guidewire insertion
Time 3: Time from Guidewire insertion to Introducer Sheath placement along with Dilator
Time 4: Time to reach PAC to RA
Time 5: Time to reach PAC from RA to RV
Time 6: Time to reach PAC from RV to PA

The cut-off time for the procedure, determined as the 75th percentile of the first 30 successful cases, was found to be 269 seconds.

A total of 109 cases (78.99%) completed the catheter placement within that time. The distribution of left ventricular regional wall motion abnormality was comparable among the study groups and was statistically insignificant, as shown in [Table/Fig-5].

Group	Male	Female
Group A		
(First attempt successful)	103	22
Row %	82.40%	17.60%
Group B		
(First attempt failure)	11	2
Row %	84.62%	15.38%

[Table/Fig-5]: Distribution of left ventricular regional wall motion abnormality in the two study groups (N=138).
Fisher's-exact test 2-tailed p-value 1.000

The observation regarding tricuspid regurgitation was analysed and compared between the two groups, which also was found to be statistically insignificant, as shown in [Table/Fig-6].

Group	TR Grade 0 (Absent)	TR Grade 1 (Trivial)	TR Grade 2 (Mild)	TR Grade 3 (Moderate)	TR Grade 4 (Severe)
Group A					
(First attempt successful)	77	11	24	12	1
Row %	61.60%	8.80%	19.20%	9.60%	0.80%
Group B					
(First attempt failure)	8	1	3	1	0
Row %	61.54%	7.69%	23.08%	7.69%	0.00%

[Table/Fig-6]: Distribution of Tricuspid Regurgitation (TR) among the study groups (N=138).
Chi-square test p-value 0.992. Tricuspid Regurgitation is examined in Modified Bicaval View

Interpretation of the study data with Logistic Regression (LR) analysis: The variables included in the LR analysis were age, body weight, body surface area, and neck length. The overall model quality was not adequately satisfactory, as indicated by Nagelkerke's R2 value of 0.2518 (indicating that only about 25% of the variability is accounted for by the selected variables) [Table/Fig-7]. The power of the model's predicted values to discriminate between positive and negative cases has been quantified by the area under the curve value, which, is close to 1 at 0.862, indicating moderate discriminating power. The cases that converted were correctly predicted to the extent of 89.86%. The coefficient and standard error indicate that body weight and neck length are the only two significant factors upon multivariate analysis, with increasing weight reducing the odds of success, while increasing neck length increases the odds of success [Table/Fig-8].

Dependent variable Y	First attempt
Sample size	138
Positive cases	125 (90.58%)
Negative cases	13 (9.42%)
Null model-2 log likelihood	86.155
Full model-2 log likelihood	68.998
Chi-square value	17.157
Degree of freedom	4
Significance level	P=0.0018
Cox and Snell R^2	0.1169
Nagelkerke R^2	0.2518

[Table/Fig-7]: Logistic Regression (LR) to ascertain the difference between univariate and multivariate analysis.

DISCUSSION

In the current study, a total of 138 patients were evaluated to assess various factors that affect/influence the PAC in patients undergoing

Variables	Coefficient	Standard error	p-value
Age	0.020783	0.043273	0.631
Body surface area	2.59258	2.51075	0.302
Weight	-0.13144	0.047360	0.006
Neck length	0.51708	0.22409	0.0210

[Table/Fig-8]: Distribution of coefficient and standard error values.

CABG. Among them, PAC insertion was successfully completed in the first attempt in 125 patients. However, in 13 patients, PAC could not be inserted in the first attempt, resulting in a first attempt failure rate of 9.42% (95% confidence interval 4.55% to 14.29%). Based on the number of attempts needed for successful PAC insertion, all patients were divided into two groups. Group A included patients in whom PAC could be successfully inserted in the first attempt (n=125), while Group B included patients in whom PAC could not be inserted in the first attempt (n=13). The principal finding of present study, as determined through univariate analysis, is that increased body weight and increased body surface area were significant factors ($p<0.05$) associated with increased catheter placement time. Additionally, a short neck length was also identified as a significant factor ($p<0.05$) affecting the time required for catheter placement.

There was no significant difference between the two groups in terms of age, height, sex, cardiothoracic ratio, left ventricular ejection fraction, left ventricular end diastolic volume, left ventricular regional wall motion abnormality, degree of tricuspid regurgitation, PA pressure (systolic, mean, diastolic), and experience of the resident in the present study. However, in a study by Hakata S et al., in 2015, it was shown that low left ventricular ejection fraction and left ventricular regional wall motion abnormality were significant factors associated with difficult PAC placement [1]. Cardiac function may play a significant role in facilitating the floating of the PAC into the PA. Although the evaluation of right ventricular function would have been preferable, it is often challenging to accurately assess it. Therefore, in this study, we substituted the ejection fraction and wall motion abnormality of the left heart as proxies for the right heart. Hakata S et al., also demonstrated that an increased cardiothoracic ratio was a significant factor in prolonging PAC placement time [1]. The study revealed that the buoyancy of the balloon is more important than the influence of flow direction when inserting a balloon buoyancy catheter. Normally, the inflated balloon exerts an upward force in the right ventricle, which helps advance the catheter through the pulmonary valve. However, changes in the position of the right ventricular outflow tract and pulmonary artery due to cardiac enlargement make it challenging to advance the catheter into the PA, resulting in a time-consuming PAC placement process. Hakata S et al., reported that 90% of patients completed the placement within two minutes. They also did not find tricuspid regurgitation to be a significant factor influencing PAC placement.

In 2012, Tripathy M and Pandey M, demonstrated that a taut giant aortic root with a dilated ascending aorta can mechanically hinder the passage of a fully inflated balloon (1.5 mL air) to the PA wedge track. Any attempt to advance the catheter under these conditions can cause it to retract and repel in the right ventricle, potentially leading to cardiac arrhythmia. To overcome this problem, the balloon of the continuous cardiac output catheter should be inflated with a lower air volume (1 mL) [10]. However, in the present study, the diameter of the aortic root and ascending aorta was not included as a study variable.

In 2004, Tripathy M et al., reported a case of a young patient with situs solitus and a right-sided heart, where PAC attempts for urgent mitral valve replacement required an excessively long (50 cm) catheter to enter the right ventricle and posteriorly into the PA [14]. In present study, the presence of dextrocardia and congenital anomalous venous connection were also not considered as study variables.

Therefore, apart from increased body weight, body surface area, and short neck length, which may affect PAC placement time, other factors such as age, height, sex, cardiothoracic ratio, left ventricular ejection fraction, left ventricular end diastolic volume, left ventricular regional wall motion abnormality, degree of tricuspid regurgitation, PA pressure (systolic, mean, diastolic), and experience of the resident were not identified as predictive factors in present study. There is no possibility of interobserver bias in present study, as all assessments were carried out by a single observer.

Limitation(s)

It was assumed that 269 seconds would be the cutoff time for successful PAC placement. If this time limit had been changed, our statistical analysis might have yielded different results. However, the author believes that this duration is reasonable to allow residents to place the PAC without causing scheduling issues in the operating room. Secondly, although we found that increased body surface area is a significant factor associated with difficult PAC placement, the p-value of 0.038 was only marginally significant. Considering the number of subjects recruited within the study duration, we must acknowledge the possibility of a type II error. Thirdly, we acknowledge that we selected only a limited number of variables for the study, and it is possible that we overlooked other important factors that could have influenced catheter placement. Fourthly, for ease of evaluation in practical field, authors had to consider left heart function instead of right heart function. This was a practical limitation of the study. Lastly, the catheter placement was performed by a single resident anaesthesiologist only. If more experienced doctors had been included in present study, the outcome might have been different.

CONCLUSION(S)

The study concluded that increased body weight and increased body surface area may be significant factors associated with difficult PAC placement. In anaesthetised patients undergoing elective offpump CABG surgery with short neck length, increased body weight, and increased body surface area, the positioning of PAC may take longer than usual. These factors were found to significantly hinder catheter insertion in the study. In such difficult cases, the guidance of TEE in the operating theater or in the Intensive Care Unit (ICU) may be considered to facilitate these maneuvers.

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