Original Article

An analysis of the factors influencing pulmonary artery catheter placement in anesthetized patients

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ABSTRACT

Background: Pulmonary artery catheters are usually placed by resident anesthesiologists with pressure wave monitoring from educational point of view. In some cases, the placement needs longer time or is difficult only by observing the pressure waves. **Aims:** We sought to examine the time required for the catheter placement in adult patients and determine factors influencing the placement. **Settings and Designs:** Prospective, observational, cohort study. **Methods:** We examined the time required for the catheter placement. If the catheter is placed in longer than 5 min, this could be a difficult placement. We examined the effect of the patient's age, body mass index, cardiothoracic ratio (CTR) and tricuspid regurgitation, left ventricular ejection fraction (LVEF) and training duration of a resident on the difficult catheter placement. Next, we excluded the difficult cases from the analysis and examined the effect of these factors on the placement time. **Statistical Analysis:** The data were analyzed by logistic regression analysis to assess factors for the difficult catheter placement and multiple linear regression analysis to evaluate the factors to increase the placement time after univariate analyses. **Results:** The difficult placement occurred in 6 patients (5.7%). The analysis showed that LVEF was a significant factor to hinder the catheter placement (P = 0.02) while CTR was a significant factor to increase the placement time (P = 0.002). **Conclusion:** LVEF and CTRs are significant factors to be associated with the difficult catheter placement and to increase the placement time, respectively.

Received: 10-06-15
Accepted: 02-09-15

Key words: Catheter; Education; Equipment; Pulmonary arterial; Resident

INTRODUCTION

A pulmonary artery catheter (PAC) is used for perioperative management in patients undergoing cardiovascular surgery, although the application of the catheter during cardiac surgery is controversial.[1] In our hospital, a PAC are usually inserted after induction of anesthesia by a resident anesthesiologist managing patient from educational point of view and the placement is performed by observing the pressure waves. However, in some cases, the placement needs longer time or is difficult only by observing the pressure waves. In these cases, some guidance, such as X-ray fluoroscopic photographing system, is introduced.

We hypnotized that patient's basal characteristics, the cardiac size of patients, driving force, and obstruction for floatation of the PAC into the pulmonary artery and experience of a resident may affect the catheter placement. In this study, we sought to examine the time required for the catheter placement in adult patients undergoing cardiovascular surgery and determine patient factors which increase the placement time and are associated with the difficult catheter placement.

Access this article online
Website: www.annals.in
DOI: 10.4103/0971-9784.166442
Quick Response Code:

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Cite this article as: Hakata S, Ota C, Kato Y, Fujino Y, Kamibayashi T, Hayashi Y. An analysis of the factors influencing pulmonary artery catheter placement in anesthetized patients. Ann Card Anaesth 2015;18:474-8.

METHODS

This observational study was approved by the Institutional Review Board of Our University Hospital (no. 13146) and written informed consent was obtained from each patient. We prospectively examined the time required for the PAC placement in 106 patients undergoing cardiovascular surgery. After induction of anesthesia with propofol with fentanyl or remifentanil and rocuronium, the PAC (continuous cardiac output/SvO_2 Catheter 744HF75, Edwards Lifesciences, Irvine, CA, USA) was inserted through the right internal jugular vein by residents of our department. After the guidewire was placed in the right internal jugular vein in the Trendelenburg position, the introducer sheath was placed, and the operating table is positioned flat. If the cannulation of the right jugular vein was unsuccessful, the patient was excluded from this study. Then, the PAC was inserted 20 cm through the introducer sheath, and the central venous pressure (CVP) position of the PAC was confirmed by the pressure wave. At this placement, the curvature of the catheter was orientated posterior. Then, the balloon is inflated, and the catheter was floated into the pulmonary artery. During floating the catheter, staff physicians supervising residents did not give any instruction for first 5 min.

The catheter placement time was defined as the duration of time required for the catheter to float from the CVP position through the right heart chambers to the pulmonary artery, that is, the beginning time point is just after inflation of the balloon to start floating the catheter and the ending time is that we can confirm the pressure wave of the pulmonary artery. The time was measured by another resident or staff physician who did not contribute the catheterization. If the placement was done within 5 min, we regarded this case as successful. On the other hand, if the placement failed to precede the catheter into the pulmonary artery in 5 min, this attempt was defined as a difficult case. Then, the placement was continued by the same resident under the supervision of a staff physician, or a more experienced doctor made the next attempt. If needed, some guidance such as transesophageal echocardiography (TEE) or X-ray fluoroscopic system to visualize intracardiac catheter orientation was used.

In the present study, we examined the effect of the following factors, which covered the patient's characteristics, cardiac size and functions, and experience of the residents performing the placement, on the difficult catheter placement and the catheter placement time; the patient's age and body mass index, cardiothoracic ratio (CTR) by the preoperative chest X-P, degree of tricuspid regurgitation and left ventricular ejection fraction (LVEF) by the preoperative transthoracic echocardiography and the training duration of the resident anesthesiologists.

Our sample size was based on the first 30 cases. The analysis of the preliminary data showed that correlation coefficient between CTR and the catheter placement time was 0.29, and a sample size of 98 patients had 80% power at the 5% level of significance. Thus, we included 100 successful cases for analysis.

Data were expressed as means ± standard deviation or as a median and interquartile range, as appropriate. The data were analyzed by logistic regression analysis to assess factors for the difficult catheter placement and multiple linear regression analysis to evaluate the factors to increase the placement time and after univariate analyses. Factors included in the multivariate regression model were selected among variables yielding $P < 0.1$ by univariate analysis. All analyses were conducted with SPSS (IBM Corporation, USA) version 14.0. $P < 0.05$ was considered statistically significant.

RESULTS

The cannulation of the right jugular vein was successful in all cases in this study. We had encountered 6 difficult cases before we collected 100 successful data collection. Thus, the successful rate within 5 min was 94.3%. The summary of the 100 successful subjects including demographic data of patients is shown in Table 1. The average PAC placement time was 44 s [Table 1] and distribution of the PAC placement time was presented in Figure 1. The outcome of the difficult 6 cases is presented in Table 2. We could finally place the PAC into the pulmonary artery.

The result of logistic regression analysis including successful 100 and difficult 6 cases shows that low LVEF was the only significant factor to be associated with the difficult catheter placement [Tables 3 and 4]. The result of simple and multiple linear regression analysis using the 100 successful cases is shown in Tables 5 and 6 and CTR was an only significant factor to increase the catheter placement time.

DISCUSSION

The principal finding of this study is that low LVEF is a significant factor to be associated with the difficult PAC

Table 1: Summary of the 100 successful data

Variant characteristics	Values
Patient characteristics	
Age (years)	68±14
Height (cm)	158±11
Weight (kg)	56±11
BMI	22.3±3.2
Disease (*n*)	
AS	39
AR	6
MR	16
MS	4
AR + MR	1
CAD	16
CAD + AR	1
CAD + AS	1
DCM	7
TAA	6
PAPVC	1
LA mixoma	1
Constrictive pericarditis	1
Preoperative examination	
CTR (%)	54±6
LVEF (%)	60±15
Degree of TR	1 (0-2)
Resident data	
Duration of training (years)	2.6±1.4
Placement time (s)	44±44

Data were expressed as means±SD or as median (IQR) (TR). SD: Standard deviation, AS: Aortic stenosis, AR: Aortic regurgitation, MR: Mitral regurgitation, MS: Mitral stenosis, CAD: Coronary artery disease, DCM: Dilated cardiomyopathy, TAA: Thoracic aortic aneurysm, PAPVC: Partial anomalous pulmonary vein connection, CTR: Cardiothoracic ratio, LVEF: Left ventricular ejection fraction, TR: Tricuspid regurgitation, BMI: Body mass index

Table 2: Outcome of difficult 6 cases

Case number	Disease	Outcome
1	CAD	A staff physician did, but it took more than 10 min (total)
2	DCM	The resident continued and at last placed successfully, but it took 9 min and 30 s (total)
3	CAD	A staff physician did, but it took 9 min and 5 s (total)
4	TAA	The resident continued and placed successfully under X-ray fluoroscopic system, but it took another 4 min and 20 min
5	CAD	A staff physician did, but it took more than 10 min (total)
6	DCM	The resident continued and placed successfully under TEE, and it took another 45 s

CAD: Coronary artery disease, DCM: Dilated cardiomyopathy, TAA: Thoracic aortic aneurysm, TEE: Transesophageal echocardiography

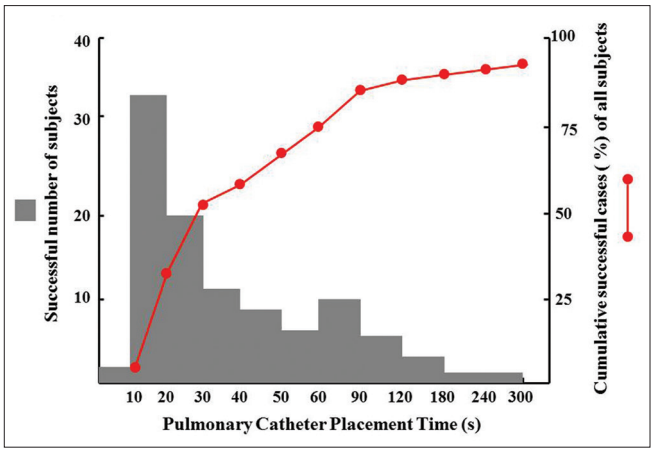

Figure 1: Distribution of the pulmonary artery catheter placement time

placement [Tables 3 and 4]. On the other hand, CTR is a significant factor to increase the catheter placement time [Tables 5 and 6].

The placement of PAC is favored to insert after induction of anesthesia[2] and saving time during the PAC placement is favorable. Some previous case reports suggested several factors to be associated with difficult PAC placement.[3-6] However, no study has determined risk factors predicting the difficult placement of a PAC in patients undergoing cardiovascular operations. To our knowledge, this is the first report to demonstrate that low LVEF is a significant factor to be associated with the difficult PAC placement [Tables 3 and 4]. Cardiac function may offer important driving force for floatation of the PAC into the pulmonary artery. If available, we should definitely have chosen a parameter of the right ventricular function. However, the accurate evaluation of the right ventricular function may be practically difficult, so we substituted ejection fraction of the left heart for the right heart in this study.

On the other hand, this study showed that CTR was a significant factor to increase the PAC placement time [Tables 5 and 6]. A previous study documented that Balloon flotation is more important than the effect of flow direction during insertion of a balloon flotation catheter.[7] Thus, upward flotation of the air-filled balloon in the right ventricle usually allows forward progress into the pulmonary artery valve. However, the variation of the position of the right ventricle outflow tract and pulmonary artery due to the cardiac enlargement would complicate the progress of the catheter into the pulmonary artery, resulting in time-consuming for the PAC placement. The present

Table 3: Univariate analysis to assess potential predictors for the difficult catheter placement

Variable	OR	95% CI	*P*
Age	0.971	0.925-1.020	0.239
BMI	1.028	0.799-1.324	0.829
CTR	1.131	0.997-1.283	0.055
LVEF	0.943	0.903-0.986	0.009
Degree of TR	1.507	0.707-3.212	0.288
Training duration	0.949	0.873-1.032	0.221

CTR: Cardiothoracic ratio, LVEF: Left ventricular ejection fraction, TR: Tricuspid regurgitation, OR: Odds ratio, CI: Confidence interval, BMI: Body mass index

Table 4: Multivariate association with the difficult catheter placement: Logistic regression model

Variable	OR	95% CI	*P*
CTR	1.088	0.945-1.251	0.240
LVEF	0.952	0.909-0.997	0.038

CTR: Cardiothoracic ratio, LVEF: Left ventricular ejection fraction, OR: Odds ratio, CI: Confidence interval

Table 5: Simple linear regression model of potential predictors of increased pulmonary artery catheter placement time

Variable	Parameter estimation (95% confidence limits)	SE	*P*
Age	0.180 (−0.443-0.803)	0.314	0.568
BMI	−1.478 (−4.215-1.260)	1.379	0.287
CTR	2.533 (1.214-3.851)	0.664	0.001
LVEF	−0.197 (−0.782-0.388)	0.295	0.505
Degree of TR	10.530 (2.252-18.809)	4.172	0.013
Training duration	−0.060 (−0543-0.422)	0.243	0.805

CTR: Cardiothoracic ratio, LVEF: Left ventricular ejection fraction, TR: Tricuspid regurgitation, BMI: Body mass index, SE: Standard error

Table 6: Multivariable linear regression model of potential predictors (*P*<0.1 with simple liner regression) of increased pulmonary artery catheter placement time

Variable	Parameter estimation (95% confidence limits)	SE	*P*
CTR	2.224 (0.865-3.582)	0.684	0.002
Degree of TR	6.870 (−1.344-15.083)	4.138	0.100

CTR: Cardiothoracic ratio, TR: Tricuspid regurgitation, SE: Standard error

study also showed that the placement is completed within 2 min in 90% of the patients [Figure 1]. Thus, when the PAC placement exceeds more than 2 min, and the patient's CTR is large, some guidance such as TEE or X-ray fluoroscopic system would be used.

Tricuspid regurgitation might affect the travelling of the PAC through the tricuspid valve. However, the present data has documented that degree of tricuspid regurgitation did not affect the PAC placement time or difficult PAC placement [Tables 3-6]. Thus, it would be thought that tricuspid regurgitation does not influence the PAC placement. Here, we may pay an attention to our data that the odd ratio of the degree of tricuspid regurgitation was relatively high compared with other factors [Tables 3 and 5]. However, it did not reach statistical significance, because the confidential interval was very wide, suggesting a large variation of the subjects. Thus, it might be possible that the PAC placement is awkward in a certain patient with severe tricuspid regurgitation in clinical situations.

One previous study showed that as experience increases, the PAC placement time decreases.[2] However, our study did not show that the training duration of residents did not affect the time significantly [Tables 3 and 5]. In our study, the catheter placement was performed by only residents. If we included more experienced doctors in this study design, the experience might reach statistical significance.

The present study would have some clinical suggestions. The PAC placement may be expected to take a long time in patients with wide CTR and low LVEF, for example, dilated cardiomyopathy. In these cases, we should not hesitate to introduce some guidance such as TEE or X-ray fluoroscopic photographing system.

We have to discuss potential limitations in our study. First, we defined the cut-off time for successful placement of PAC as 5 min. If this cut-off time was changed, our statistical analysis would show different results. However, we think that this duration would be reasonable to allow residents to place the PAC without disturbing scheduling issues of the operating room. Second, although we found that low LVEF is a significant factor to be associated with the difficult PAC placement, the *P* value (0.038) was a little bit smaller than 0.05. Considering that the number of the subjects was 106, we have to acknowledge the possibility of type II error. Third, in this study, we chose the six variables, but it might be likely that we overlook another important factor to affect the catheter placement and with the factor our results would have to be reexamined. Fourthly our results may reach the statistical significance about the two factors (CTR and LVEF) [Tables 4 and 6]. However, the results are dependent on statistical analysis and the clinical significance of our results would be interpreted with caution.

CONCLUSION

The present data showed that low LVEF is a significant factor to be associated with the difficult PAC placement while CTR is a significant factor to increase the PAC placement time.

Acknowledgment

The authors would like to thank Dr. Hiroyashu Terashima, Dr. Yu Matsumoto and Dr. Takashi Iritakenishi for their help throughout the present study.

Financial support and sponsorship

This study was supported by department of funding.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Gómez CM, Palazzo MG. Pulmonary artery catheterization in anaesthesia and intensive care. Br J Anaesth 1998;81:945-56.
2. Wall MH, MacGregor DA, Kennedy DJ, James RL, Butterworth J, Mallak KF, *et al*. Pulmonary artery catheter placement for elective coronary artery bypass grafting: Before or after anesthetic induction? Anesth Analg 2002;94:1409-15.
3. Larson LO, Edwards SM. Difficult placement of a pulmonary artery catheter prior to coronary artery bypass grafting. J Cardiothorac Vasc Anesth 1991;5:505-6.
4. Menéndez B, García del Valle S, Marcos RC, Azofra J, Gomez-Arnau J. Left superior vena cava: A vascular abnormality discovered following pulmonary artery catheterization. Can J Anaesth 1996;43:626-8.
5. Rimensberger PC, Beghetti M. Pulmonary artery catheter placement under transoesophageal echocardiography guidance. Paediatr Anaesth 1999;9:167-70.
6. Safwat AM. Difficult flotation of a pulmonary artery catheter: Echocardiographic diagnosis. J Clin Anesth 2001;13:239-40.
7. Parlow JL, Milne B, Cervenko FW. Balloon flotation is more important than flow direction in determining the position of flow-directed pulmonary artery catheters. J Cardiothorac Vasc Anesth 1992;6:20-3.