

An Analysis of the Factors Producing Multiple Ventricular Arrhythmias during Pulmonary Artery Catheterization

Abstract

Background: The development of arrhythmias during placement of a pulmonary artery catheter (PAC) is common. **Aims:** This study was designed to examine factors influencing development of ventricular arrhythmias in adult patients undergoing cardiovascular operations during the catheter placement. **Settings and Designs:** Prospective, observational, cohort study. **Methods:** We prospectively studied 174 patients undergoing cardiovascular operations. A PAC was inserted through the right internal jugular vein by staff anesthesiologists. Electrocardiography tracings were recorded as the catheter was advanced from the right atrium to the pulmonary artery. Arrhythmias were classified as absent, single, or multiple (two or more consecutive) ventricular arrhythmias. We examined risk factors to produce ventricular arrhythmias during the placement. **Statistical Analysis:** The data were analyzed using logistic regression analysis to assess factors for the occurrence of ventricular arrhythmias after univariate analyses. **Results:** Ventricular arrhythmias (single and multiple) occurred in 149 patients (85.6%) and multiple arrhythmias were observed in 78 patients (44.8%). There were no factors to facilitate the ventricular arrhythmias (single and multiple), whereas it showed that valvular diseases ($P = 0.049$) and the placement time ($P < 0.001$) are significant factors to produce multiple arrhythmias. **Conclusion:** Both valvular diseases and long placement time were significant risk factors to produce multiple ventricular arrhythmias during placement of a PAC.

Keywords: Arrhythmias, complications, pulmonary artery catheter

Hajime Satoh,
Yuka Miyata,
Tomohiko
Hayasaka,
Tsutomu Wada,
Yukio Hayashi

Department of Anaesthesia
Service, Sakurabashi-Watanabe
Hospital, Osaka, Japan

Introduction

A pulmonary artery catheter (PAC) is applied for anesthetic management in patients undergoing cardiovascular surgery, although usefulness of the catheter during cardiac surgery is controversial.^[1] In our hospital, a PAC are routinely inserted after induction of anesthesia and the placement is performed by observing the pressure waves. The development of arrhythmias during placement of a PAC has been well known and some fetal arrhythmias, although rare, need treatment.^[1] So far, several previous clinical studies examined the incidence of ventricular arrhythmias during placement of PAC and several factors to facilitate ventricular arrhythmias.^[2-5] However, so far, there have been no studies to identify the risk factors to facilitate ventricular arrhythmias during placement of PAC by multivariable analysis. Thus, this study was performed to determine clinical factors which produce the ventricular arrhythmias in adult patients undergoing cardiac operations by multivariable analysis.

Methods

This prospective observational study was approved by the Institutional Review Board of our hospital and written informed consent was obtained from each patient. We prospectively examined 174 patients undergoing cardiovascular surgery. After induction of anesthesia with midazolam with fentanyl or remifentanyl, arterial blood gas analysis was performed to confirm that the electrolyte and acid-base status were within normal range and then the PAC (CCO/SvO₂ Catheter 744HF75, Edwards Lifesciences, Irvine, CA, USA) was inserted through the right internal jugular vein by staff anesthesiologists of our hospital. Every staff is a certified anesthesiologist of Japan Society of Anesthesiologists. 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.

Address for correspondence:

Dr. Yukio Hayashi,
Anesthesiology Service,
Sakurabashi-Watanabe Hospital,
2-4-32 Umeda, Kita-ku, Osaka,
Japan.
E-mail: yhayashi@anes.med.
osaka-u.ac.jp

Access this article online

Website: www.annals.in

DOI: 10.4103/aca.ACA_18_17

Quick Response Code:



How to cite this article: Satoh H, Miyata Y, Hayasaka T, Wada T, Hayashi Y. An analysis of the factors producing multiple ventricular arrhythmias during pulmonary artery catheterization. *Ann Card Anaesth* 2017;20:141-4.

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Then, the PAC was inserted 20 cm through the introducer sheath and the central venous pressure 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. To avoid excessive length of insertion, we did not insert the catheter more than 50 cm.^[6] Electrocardiography tracings during the placement were continuously recorded in our monitoring system for review arrhythmias after the catheter placement and we classified arrhythmias as absent, single, or multiple (two or more consecutive) ventricular arrhythmias.

In this study, we examined risk factors associated with ventricular arrhythmias during placement of a PAC. The factors we examined in this study included the patient's age, sex, height, and weight, cardiothoracic ratio (the ratio of cardiac diameter to thoracic diameter) on preoperative chest X-ray, and ejection fraction, the presence of atrial fibrillation, valvular (mitral and aortic) diseases and time required for the catheter placement. The time was defined as the time taken to advance the catheter from the right atrium to the pulmonary artery.

Based on the first 60 cases including 35 cases of valvular diseases sample size was calculated to be 168 for detecting the multiple ventricular arrhythmias at the significant level of 0.05 with a statistical power of 80%. Thus, we included another 114 cases to clear the sample size.

Data were expressed as means \pm standard deviation (SD) or as median and interquartile range, as appropriate. The data were analyzed by logistic regression analysis to assess factors for occurrence of ventricular arrhythmias 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 version 14.0. (IBM, Chicago, IL, USA) $P < 0.05$ was considered statistically significant.

Results

All 174 patients were catheterized successfully. The summary of the 174 subjects including demographic data of patients is shown in Table 1. Ventricular arrhythmias (single and multiple) occurred in 149 patients (85.6%) and multiple ventricular arrhythmias were observed in 78 patients (44.8%). No serious arrhythmias such as ventricular fibrillation were noted. Table 2 shows the univariate analysis to assess potential factors for the ventricular arrhythmias. There were no factors associated with ventricular arrhythmias, although only placement time tends to be a significant factor ($P = 0.082$). The result of simple and multiple linear regression analysis to assess potential factors for the multiple ventricular arrhythmias show that valvular diseases and the placement time are significant factors to produce the multiple ventricular arrhythmias [Table 3].

Table 1: Summary of the 174 patients

Patient characteristics
Age (year): 68 \pm 12
Height (cm): 161 \pm 11
Weight (kg): 59 \pm 14
BMI: 22.8 \pm 3.9
Disease (n)
AS: 36
AR: 14
MR: 35
MS: 2
AR + MR: 3
AS + MS: 1
AS + MR: 1
CAD: 39
CAD + AR: 1
CAD + AS: 5
CAD + MS: 3
DCM: 5
TAA: 22
PAPVC: 1
Tumor: 4
Constrictive pericarditis: 2

Preoperative examination

CTR (%): 53 \pm 7
LVEF (%): 60 \pm 16
Degree of TR: 1 (0-2)
Placement time (s): 44 \pm 56

Arrhythmias

Ventricular (single and multiple): 149 patients (85.6%)
Ventricular (single): 71 patients (40.8%)
Ventricular (multiple): 78 patients (44.8%)

Data were expressed as means \pm SD or as media (IQR).

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, LA: Left atrium, CTR: Cardiothoracic ratio, LVEF: Left ventricular ejection fraction, TR: Tricuspid regurgitation, IQR: Interquartile range, BMI: Body mass index, SD: Standard deviation

Table 2: Univariate analysis to assess potential factors for the ventricular arrhythmias during placement of a pulmonary artery catheter

Variable	OR	95% CI	P
Age	0.967	0.939-1.015	0.967
Sex (male)	1.403	0.587-3.351	0.446
Height	1.019	0.979-1.062	0.353
Weight	1.012	0.979-1.045	0.488
CTR	0.984	0.929-1.042	0.584
LVEF	0.995	0.969-1.023	0.115
Valvular diseases	0.561	0.221-1.425	0.224
AF	0.481	0.159-1.458	0.196
Placement time	1.016	0.998-1.035	0.082

CI: Confidential interval, OR: Odds ratio, CTR: Cardiothoracic ratio, LVEF: Left ventricular ejection fraction, AF: Atrial fibrillation

Discussion

The present study has demonstrated that both valvular diseases and long placement time significantly facilitate to produce multiple ventricular arrhythmias during placement of a PAC.

The development of ventricular arrhythmias during placement of the catheter is well known. This study showed that ventricular arrhythmias (single and multiple) and multiple ventricular arrhythmias were observed in 85.6% and 44.8% of patients undergoing cardiovascular surgery, respectively. So far, several studies have reported incidence of arrhythmias during placement of the catheter^[2-5,7,8] and these results are summarized in Table 4. Interestingly, the results of these studies were various and our results were a little bit different from the previous data. In this study, we defined the multiple ventricular arrhythmias as two or more consecutive ventricular arrhythmias to distinguish from a single ventricular arrhythmia. However, one may claim that serious ventricular arrhythmias should be defined as

three or more consecutive ventricular arrhythmias. Thus, our incidence of multiple ventricular arrhythmias may be relatively higher than these previous data.

So far, several factors have been reported to facilitate ventricular arrhythmias during the placement of a PAC.^[2-5] Predisposing factors, such as acidosis, hypoxia and electrolyte imbalance, and long placement time has been shown to increase incidence of the arrhythmias,^[2] whereas another report did not show this correlation.^[5] Keusch *et al.*^[3] have examined whether the position of the patient during the placement affect the incidence of the arrhythmias and concluded that the head up and right lateral tilt position is superior to the Trendelenburg position to prevent the arrhythmias. Thus, in the present study, the position is designed to be constant, that is, a flat position, during the placement. The development of arrhythmias during the placement might be caused by mechanical contact with the endocardium. Thus, it may be expected that longer placement time facilitates to produce the arrhythmias. Although previous studies showed conflicting data about role of placement time in genesis of the arrhythmias,^[3,5] our data clearly demonstrated that long placement time was a significant risk factor to produce multiple ventricular arrhythmias during placement [Table 3].

Our data also show that valvular disease is another significant risk factor for the arrhythmias during the placement. Change of the right ventricular shape with enlargement of the right ventricle itself or secondary with the left ventricular enlargement may be present in patients with valvular diseases. We speculated that this change might increase the mechanical contact between the catheter and the endocardium during floating the catheter and the propensity for arrhythmias appears higher.

The present study would have some clinical suggestions. So far, several maneuvers to shorten the placement time of the catheter have been supposed^[9,10] and these techniques may contribute to reduce the arrhythmias during the placement. Especially, they would be more clinically useful in the case of a patient with valvular diseases.

Table 3: Univariate (a) and multivariate (b) analysis to assess potential factors for the multiple ventricular arrhythmias during placement of a pulmonary artery catheter

Variable	OR	95% CI	P
(a) Univariate			
Age	1.004	0.979-1.030	0.760
Sex (male)	0.812	0.431-1.528	0.518
Height	0.990	0.963-1.019	0.508
Weight	0.995	0.974-1.018	0.679
CTR	1.033	0.991-1.077	0.128
LVEF	0.992	0.974-1.010	0.374
Valvular diseases	2.110	1.123-3.964	0.020
AF	1.136	0.456-2.834	0.784
Placement time	1.021	1.010-1.031	<0.001
(b) Multivariate			
Valvular diseases	1.977	1.002-3.899	0.049
Placement time	1.020	1.010-1.031	<0.001

CTR: Cardiothoracic ratio, LVEF: Left ventricular ejection fraction, AF: Atrial fibrillation, CI: Confidential interval, OR: Odds ratio

Table 4: Incidence of arrhythmias during placement of the pulmonary artery catheter by previous reports

References	n	Arrhythmias	Incidence (%)
[2]	60	PVC	48
		Ventricular tachycardia (three or more consecutive PVC)	33
[3]	68	All arrhythmias	81
[4]	100	All arrhythmias	70
		Severe arrhythmias (three or more consecutive PVC at a rate of >100 bpm)	37
[5]	56	Advanced ventricular arrhythmias (three or more consecutive PVC at a rate of >100 bpm)	12.5
[7]	6245	Transient PVC	67.6
		Persistent PVC (treatment needed)	3.1
[8]	1400	Ventricular arrhythmias (one or more PVC)	66.4
		Ventricular tachycardia (three or more consecutive PVC)	3.0

n: Number of subjects, PVC: Premature ventricular contraction

We have to discuss potential limitations in our study. First, we defined multiple ventricular arrhythmias as two or more consecutive ventricular arrhythmias. Several previous studies defined the malignant ventricular arrhythmias or ventricular tachycardia as three or more consecutive ventricular contractions. This difference in the definition might affect the results. Second, in our study, the placement was performed by a certified anesthesiologist to avoid the effect of this factor, because one previous report showed that experience may be important in improvement of the catheter placement.^[11] However, in clinical settings, the placement may be usually done by a resident anesthesiologist from educational point of view^[12] and our study did not consider a relationship between experience and ventricular arrhythmias. Third, although we found that valvular disease is a significant factor to be associated with multiple ventricular arrhythmias, the *P* value (0.049) was a little bit smaller than 0.05. Considering that the number of the subjects was 174, we have to acknowledge the possibility of Type II error. Fourth, our results may reach the statistical significance about the two factors (placement time and valvular disease). However, the results are dependent on statistical analysis and the clinical significance of our data would be interpreted with caution.

Conclusion

The present study showed that valvular operations and long placement time were significant risk factors to produce multiple ventricular arrhythmias during the placement of a PAC.

Financial support and sponsorship

This study was supported by Department of Funding.

Conflicts of interest

There are no conflicts of interest.

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