

An Analysis of Prior Experience Influencing Quality of Pulmonary Artery Catheter Placement in Residents

Abstract

Background: Prior experience may be important for successful placement of a pulmonary artery catheter (PAC). However, there is no report about the minimum number of the placement to reach acceptable technique for the catheter placement during residency. **Aims:** This study was designed to examine quality of the catheter placement and to assess the effect of prior experience. **Setting and Design:** Prospective, observational, cohort study. **Methods:** This study included eight residents and one experienced staff in our hospital. We prospectively examined the performance of placement of a PAC in eight residents for the first 2 months of their training period and one staff for previous 2 years. We examined the time required for the catheter placement and probability of ventricular arrhythmias during the placement. Each resident and the staff reported approximate number of past experience of the catheter placement according to the self-statement. In addition, we continued to examine the placement of a PAC in one resident with zero experience to show his improvement. **Statistical Analysis:** Statistical analysis was performed by Kruskal–Wallis test, Mann–Whitney test, or Fisher’s exact test as appropriate and Benjamini and Hochberg method was used for multiple comparisons. **Results:** The catheter placement time and probability of the ventricular arrhythmias of two residents with zero experience of the placement were significantly larger than those of the staff. On the other hand, the placement quality of the other residents who experienced at least 20 PAC placements was not significantly different from that of the staff. The placement quality of one resident with zero experience became comparable with that of the staff after 20 placements. **Conclusion:** Our data suggested that about 20 catheter placements may be required to reach acceptable technical level for the PAC placement.

Keywords: Anesthesia residency training, experience, pulmonary artery catheter

Introduction

Pulmonary artery catheter (PAC) placement is a common procedure in anesthetic management of patients undergoing heart surgery.^[1] In our hospital, the catheter is routinely inserted after induction of anesthesia and the placement is performed by observing the pressure waves. Our impression is that experience as an anesthesiologist may be an important factor for successful placement of PAC. In fact, a previous report by Wall *et al.*^[2] showed that the level of training affected the PAC placement time. On the other hand, a recent multivariate analysis failed to show that duration of training as an anesthesia resident is a significant factor to increase the PAC placement time.^[3] We hypothesized that the successful placement of PAC would be dependent on prior experience of PAC placement than duration

of training as an anesthesiologist. Our hospital is a university-affiliated small hospital specialized in heart diseases and we provide anesthesia residents with short-term training for cardiac anesthesia. In this study, we measured the time required for the catheter placement and the effect of prior experience of PAC placement on the placement time. We also observed the incidence of ventricular arrhythmias during placement of a PAC and assessed the effect of prior experience of this incidence during PAC placement.

Methods

This prospective observational study was approved by the IRB of our Hospital (No 15-52) and was registered in the UMIN Clinical Trial Registry (UMIN 000027033) December 12, 2015. Written informed consent was obtained from each patient. The subjects of this study were eight

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residents and one experienced staff in our hospital. We prospectively examined the performance of PAC placement of the eight residents during the first 2 months of each training period and one staff for recent 2 years.

After induction of anesthesia with midazolam with fentanyl or remifentanyl, arterial blood gas analysis was done 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 an experienced staff or a resident. An experienced staff is a certified anesthesiologist of Japan Society of Anesthesiologists and the PAC placements by a resident was supervised by this staff. After the guidewire was placed in the right internal jugular vein in the Trendelenburg position, the introducer sheath was placed and the operating table was positioned flat. Then, the PAC was inserted 20 cm through the introducer sheath and 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. To avoid excessive length of insertion, we did not insert the catheter more than 50 cm.^[4]

In this study, we examined the effect of experience on the quality of PAC placement and we evaluated the quality with two parameters, that is, the time required for PAC placement and incidence of ventricular arrhythmias during PAC placement. According to our previous studies,^[5,6] the time required for PAC placement 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, and we also continuously recorded electrocardiogram tracings during the placement in our monitoring system to review arrhythmias after the catheter placement and we classified arrhythmias as absent or multiple (three or more consecutive) ventricular arrhythmias.

Before starting this study, each resident and a staff reported approximate number of past experience of PAC placement according to the self-statement. We compared the catheter placement time and incidence of multiple ventricular arrhythmias and examined whether the past experience of PAC placement affected these values.

Since the training period was different in each resident and minimum period was 2 months, the data of this study was based on the availability of data from patients during the first 2 months during training period of each resident. This study includes two residents with zero experience, and the training period of these residents was 2 and 6 months, respectively. In addition, we continued to examine the placement of a PAC in one resident with 6 months training period to show his improvement from zero experience.

Data were expressed as means \pm standard deviation, median, interquartile range, or percentage as appropriate. The preoperative patient characteristics were analyzed by the analysis of variance, Kruskal–Wallis test and Fisher’s exact test, as appropriate. The placement times were analyzed by Kruskal–Wallis test, followed by Mann–Whitney test with Benjamini and Hochberg method for multiple comparisons to specify differences between groups.^[7] The occurrence of arrhythmias was analyzed by Fisher’s exact test with Benjamini and Hochberg method for multiple comparisons to specify differences between groups. All analyses were conducted with SPSS version 14.0. $P < 0.05$ was considered statistically significant.

Results

We performed the PAC placement in 137 patients and the placement was successful in all cases. Eight residents and a staff anesthesiologist performed PAC placement in 12, 13, 10, 16, 17, 11, 16, 12, 35 patients, respectively, during each study period [Table 1]. Preoperative patient characters including age, sex, height, weight, preoperative cardiothoracic ratio, left ventricular ejection fraction, and degree of tricuspid regurgitation are also presented in Table 1, and these values were not significantly different among the residents and staff. Table 2 shows the approximate number of past PAC placement according to the self-statement, PAC placement time, and incidence of multiple ventricular arrhythmias for each resident and the staff. The PAC placement time and incidence of the arrhythmias of the R3 and R8 resident who had zero experience of the PAC placement were significantly larger than those of the staff, whereas the placement quality of the other residents who experienced at least 20 PAC placements was not significantly different from that of the staff. Table 3 included additional 33 patients and shows the data of PAC placement in every ten times from zero experience in the R8 resident. The placement quality of the resident with zero experience became comparable with that of the staff after 20 placements.

Discussion

The current data reconfirmed that experience is an important factor for the placement of PAC and the principal finding of the present study is that the PAC placement improved with the number of the placement performed and that about 20 experiences of PAC placement may be required to be familiar with the PAC placement.

Placement of a PAC is a common procedure in anesthetic management of patients undergoing cardiovascular operation. One may imagine that the placement would be improved with the number of the procedure. However, so far, minimal number of placement of a PAC to reach proficiency with this technique has not been well mentioned. In this study, we evaluated the quality of the placement with two parameters, that is, the PAC placement time and

incidence of ventricular arrhythmias during the placement. As shown in Table 2, two residents (R3 and R8) with no experience of the PAC placement needed significant longer placement time, and more frequent ventricular arrhythmias were noted compared with the staff. On the other hand, the PAC placement technique of other residents was not significantly different from that of the staff. Although

their prior experience was based on their self-statement, we suppose that a minimum of 20 cases may be required for residents to obtain satisfactory PAC placement [Tables 2 and 3].

One previous report about the placement of central venous catheters documented that a resident improved rapidly, even

Table 1: Preoperative patient characteristics and operation performed in each anesthesiologist

Anesthesiologist	R1	R2	R3	R4	R5	R6	R7	R8	Staff
<i>n</i>	12	13	10	16	17	11	16	12	35
Age (yrs)	66±12	75±10	73±11	76±9	69±11	67±11	67±12	65±11	65±12
Male/Female	9/3	8/5	5/5	9/7	10/7	8/3	10/6	9/3	29/6
Height (cm)	163±9	160±10	160±11	158±10	163±11	164±12	163±10	163±11	164±8
Weight (kg)	59±9	56±12	56±14	56±12	61±12	65±10	60±12	61±12	60±11
CTR (%)	51±5	52±7	51±5	53±6	52±6	54±5	52±8	52±11	52±6
LVEF (%)	63±15	67±9	57±16	59±16	64±15	59±14	57±18	60±14	57±18
Degree of TR	0.5 (0~1.8)	1 (1~2.5)	0.1 (0~1.3)	1 (0~2)	1 (0~1.5)	1 (0~1)	1 (0.3~2)	0.5 (0~1)	1 (0.8~1.3)
Operation (valve/coronary/aorta/congenital/others)	6/5/1/0/0	7/3/2/1/0	5/4/1/0/0	11/4/1/0/0	9/4/3/1/0	3/3/4/1/0	13/2/1/0/0	6/3/2/0/1	19/9/7/0/0

R: Resident, CTR: Cardiothoracic ratio, LVEF: Left ventricular ejection fraction, TR: Tricuspid regurgitation. Data were expressed as means±SD or as median (interquartile range) (Degree of TR)

Table 2: The pulmonary artery catheter (PAC) placement time and incidence of multiple ventricular arrhythmias in each anesthesiologist

Anesthesiologist	R1	R2	R3	R4	R5	R6	R7	R8	Staff
The number of past PAC placement ^a	20	60	0	70	20	80	70	0	300<
<i>n</i>	12	13	10	16	17	11	16	12	35
PAC placement time (s)	27 (17~62)	40 (37~85)	76* (24~235)	31 (21~60)	30 (20~63)	27 (15~45)	31 (25~39)	54* (36~90)	23 (18~37)
Incidence of multiple ventricular arrhythmias (%)	25	23	60*	31	24	18	25	58*	13

R: Resident, ^aApproximate number of past PAC placement according to the self-statement. Data (PAC placement time) were expressed as median (interquartile range). **P*<0.05 vs Staff

Table 3: Improvement of the pulmonary artery catheter (PAC) placement every ten times from a beginning in the R8 resident

A. Preoperative patient characteristics and operation performed					
The PAC placement number	1 st ~10 th	11 th ~20 th	21 st ~30 th	31 st ~40 th	41 st ~45 th
<i>N</i>	10	10	10	10	5
Age (yrs)	62±10	68±11	74±8	72±10	72±9
Male/Female	9/1	6/4	7/3	5/5	4/1
Height (cm)	166±9	160±13	155±9	159±11	164±12
Weight (kg)	63±11	59±14	54±9	59±14	60±13
CTR (%)	50±10	55±8	52±6	56±8	55±7
LVEF (%)	58±14	61±17	67±16	67±12	49±51
Degree of TR	1 (0~1)	1 (0~1)	2 (1~2)	0 (0~1)	2 (1~2)
Operation (valve/coronary/aorta/congenital/others)	5/2/2/0/1	7/2/0/0/1	8/0/1/0/1	7/2/1/0/0	3/0/2/0/0
B. The PAC placement time and incidence of multiple ventricular arrhythmias					
The PAC placement number	1 st ~10 th	11 th ~20 th	21 st ~30 th	31 st ~40 th	41 st ~45 th
<i>n</i>	10	10	10	10	5
PAC placement time (s)	43.5* (36.25~79)	45* (29.25~67.25)	40.5 (26.5~52.25)	29 (22.25~33)	30 (20~31)
Incidence of multiple ventricular arrhythmias (%)	50*	50*	20	10	20

R: Resident, CTR: Cardiothoracic ratio, LVEF: Left ventricular ejection fraction, TR: Tricuspid regurgitation. Data were expressed as means±SD or as median (interquartile range) (Degree of TR and PAC placement time). **P*<0.05 vs Staff (data in Table 2)

if a resident has zero experience of the placement.^[8] The PAC placement is one of basic techniques that anesthesia residents should learn, similar to the placement of central venous catheters. Thus, the present results that prior experience may influence at the beginning of PAC placement and the influence of experience reduces PAC placement time rapidly are well acceptable.

In the present study, we evaluated the quality of the PAC placement with two variables, that is, the PAC placement time and occurrence of ventricular arrhythmias during the placement. We would argue that these two variables are reasonable because of the following reasons. Previous two reports^[2,3] used the PAC placement time to evaluate the technique of the PAC placement and similar parameter was used to evaluate the technique of the central venous catheters.^[8] On the other hand, ventricular arrhythmias are known to be one of the common complications during PAC placement.^[1] The arrhythmias usually resolve spontaneously but ventricular lethal arrhythmias requiring immediate treatment may appear in spite of rare occurrence.^[7] In this study, we defined three or more consecutive ventricular arrhythmias as ventricular arrhythmias and included these as a variable to evaluate the quality of the placement.

We have to discuss potential limitations in our study. First, the number of prior PAC placement, which is an important information in this study, is dependent on participants' self-statement. Thus, the reliability of their self-statement might be questionable. We cannot completely deny this possibility, but the number each resident stated was not so large; therefore, we think that the memory of each resident may be reliable. At least, the information of two residents who had no experience of the PAC placement was exclusively correct. Second, the technique of the placement may be individually different. Thus, the technical level of them may not be identical, even if residents have similar prior experiment. The present data showed that the quality of the placement was comparable after residents experienced at least 20 PAC placements. Thus, the individual difference may be ignored only after 20 PAC placements. Third, the placement was performed under observation of the staff and this might affect the behavior of the residents. Fourth, we defined ventricular arrhythmias as three or more consecutive ventricular arrhythmias. One may claim that serious ventricular arrhythmias should be defined as four or more consecutive ventricular arrhythmias. This criteria difference might affect the results.

Conclusion

Experience is an important factor for successful placement of PAC at the beginning and the PAC placement improved rapidly with the number of the placement performed. Our data suggested that training process of about 20 PAC placements may be required to be familiar with the PAC placement.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the participants have given their consent for their images and other clinical information to be reported in the journal. The participants understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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