Journal of Cardiovascular Disease Research
ISSN: 0975-3583, 0976-2833 VOL15, ISSUE 02, 2024

Original Article Research

RETROSPECTIVE RANDOMIZED STUDY OF USE OF PULMONARY ARTERY CATHETER IN CARDIAC SURGERY PATIENT IN HIGH VOLUME TERTIARY CENTER

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Abstract

Background: Pulmonary artery catheter (PAC) is a diagnostic and haemodynamic monitoring tool. The PAC is used by clinicians in adult medical ICUs, cardiac catheterization laboratories and coronary care units (CCUs).

Objective: To determine the indications for the use of pulmonary artery catheter (PAC) in patients undergoing cardiac surgery and to study the outcome of patients with PAC undergoing cardiac surgery.

Methods: The present study was carried out in Department of Anesthesiology, Narayana Hrudayalaya, Bangalore. In our study 1000 patients with PAC were assessed retrospectively and data of patients was collected from 2017-2019. EuroSCORE of patients was calculated to assess preoperative condition of the patient prior to surgery.

Results: Data of one thousand patients with PAC was collected. The following observations were seen. 71.5% patients were of age <60 years. 77.8% patients weremales, and 22.8% patients were female. The most common indication for PAC insertion was PAH (pulmonary artery hypertension) (37.2%), followed by hemodynamic monitoring (33.2%), followed by heart failure with reduced ejection fraction (low EF) (24.3%), hypertrophic obstructive cardiomyopathy (HOCM) (3.1%), severe right ventricular (RV) dysfunction (1.0%), ventricular assist device (VAD) & cardiac transplant (0.8%), others (0.4%). During PAC insertion 0.5% patients developed transient cardiac arrhythmia, 0.2% patients had mild bleeding at insertion site. Post-operative data analysis showed that in patients with PAC post op 23.5% required IABP, 13.9% had cardiac arrest, death (12.9%), stroke (5%), septicemia (4.1%). Among patient with (EuroSCORE 1-3, n=188), (EuroSCORE 4-6, n=529), (EuroSCORE 7-10, n=212), (EuroSCORE >10, n=55); ICU stay was >10 days in 15.4%, 16.44%, 20.75%, 60% respectively with $p<0.001$. Hospital stay was 10 ±5days in 47.3 % cases, 23 ± 7days among 38.5% patients,

38 ± 7 among 14.8% patients, 53 ± 7days among 0.4% patients and 75 ± 14.5among 0.3% patients.

Conclusion: PAC is an important tool to monitor continuous cardiac output, systemic vascular resistance, pulmonary artery pressure. Use of PAC has shown to guide appropriate vasopressor and ionodilator therapy. Our study showed 0.7 % complications during procedure which were reversible and could be managed conservatively. Patient with high EuroSCORE and severe cardiac dysfunction had higher mortality, and hence mortality cannot be directly attributed to PAC.

Keywords: Pulmonary Artery Catheter, Cardiac Surgery Patients, EuroSCORE, Outcome, hospital stay.

INTRODUCTION

In 1929[1] the concept of right heart catheterization was first introduced by Dr Warner Forssmann. In 1970 Dr H J Swan and Dr William Ganz introduced the flow directed balloon-tipped catheter that led to a shift in the way right heart catheterizations are performed at bedside using intracardiac pressure tracings, without utilising fluoroscopy. Since then, the pulmonary artery catheter (PAC), also called Swan-Ganz catheter, has been utilized in the management of patients for the past 48 years[2] and has advantages over clinical assessment alone for predicting certain cardiac indices, detecting hemodynamic abnormalities and facilitating oxygen delivery-based protocols that may decrease mortality during major cardiac as well as non-cardiac surgery[4]. Apart from these, additionally derived variables like continuous cardiac output, systemic vascular resistance, peripheral vascular resistance, pulmonary artery pressure, central venous pressure, pulmonary capillary wedge pressure, cardiac index, stroke index, oxygen delivery, oxygen uptake, oxygen extraction ratio are used to guide treatment of critically ill patients.

PAC is a diagnostic and hemodynamic monitoring tool. The PAC is used by clinicians in operation theatres, adult medical intensive care units (ICU), cardiac catheterization laboratories and coronary care units (CCU). It is used for pre- operative optimization of hemodynamic, intraoperative monitoring and postoperative management of critically ill patients, and in cardiothoracic surgery patients with impaired left ventricular (LV) function such as coronary artery bypass graft (CABG, or bypass surgery) and complex valvular surgeries to guide therapy and differentiate various types of shock states.

MATERIALS AND METHODS

This Observational, Retrospective study was conducted among 1000 Adult patients undergoing an isolated CABG, isolated valve, aortic procedure, complex non-valvular procedures, multi-procedures or a heart transplant who receive a pulmonary artery catheter

(PAC) for monitoring purposes in Narayana Institute of Cardiac Science, Bommasandra, Bengaluru. Duration of study was 2017- 2019 (3 years).

Eligibility criteria

a. Age Eligible for Study : 18 years and older
b. Sex Eligible for Study : Male and female

Inclusion Criteria: Adult patient undergoing a cardiac surgery between 2017 to 2019 with placement of pulmonary artery catheter.

Exclusion Criteria: Cardiac surgery patients with age <18 years.

Method:

Procedure of PAC: The balloon-tip PAC is floated through a central venous access, into the right atrium and the right ventricle, from there to the pulmonary artery. It is left in position to measure pressures of the heart. When the balloon is inflated it measures pulmonary capillary wedge pressure or occlusion pressure, which is indirect measure of left ventricular end-diastolic pressure. Newer PACs have capability of measuring central venous oxygen saturation and continuous cardiac output. Advanced training and ultrasound guidance of line insertions have reduced the risk of complications in recent years[5]. Though major morbidity related to PAC insertion is uncommon, transient arrythmias may occur

Sample Size Calculation:

Sample size was calculated using statistics and sample size project management office(pmo) version 1.0. Based on the expected complication rates as 10%[6], 95% confidence interval, 5% precision, the minimum required sample size is 139

$N = Z_{1-\alpha/2} P(1-P) / d^2$ where n+ no of sample, α= α error, P= proportion, d= precision

However, the study included a sample size of 1000 patients to obtain a larger sample of patient population.

Statistical Analysis: Data was analysed using R software. Continuous variables were expressed using mean and standard deviation. Categorical variables were expressed using frequency and percentage.

RESULTS

Among 1000 patients, 715 were below the age of group of 60 and 285 cases weremore than 60 years. The median age group was 58.5 $\pm$ 5 years. Among the 1000 patients included in the study, 778(77.8%) were male and222(22.2%) were females. Male is to female ratio was 3.5:1.

Table 1: Indications for PAC insertion

Indication for PAC	No. of Cases	Percent
PAH	372	37.2
Hemodynamic monitoring	332	33.2
Low EF	243	24.3
HOCM	31	3.1
Severe RV dysfunction	10	1.0
VAD, Cardiac transplant	8	0.8
Others	4	0.4
Total	1000	100.0

PAH- Pulmonary artery hypertension, Low EF- low ejection fraction, HOCM- hypertrophic obstructive cardiomyopathy, RV- right ventricle, VAD- ventricular assist device.

Among 1000 cases, the most common indication for PAC insertion was PAH (37.2%), followed by hemodynamic monitoring (33.2%), followed by heart failure with reduced ejection fraction (Low EF) (24.3%). The other indications for PAC included HOCM (3.1%), severe RV dysfunction (1.0%), VAD & cardiac transplant (0.8%), others (0.4%).

Table 2: Operative procedures

Operated		
	No of Cases	Percentage
CABG	500	50%
MVR	165	16.5%
PTE	114	11.4%
AVR	89	8.9%
DVR	63	6.3%
Septal myomectomy	27	2.7%
Dor procedure	15	1.5%

Bentall	13	1.3%
Cardiac transplant, VAD	8	0.8%
CABG + Valve replacement	6	0.6%
Total	1000	100.0

CABG- Coronary artery bypass grafting, MVR- Mitral valve repair, PTE- Pulmonary thromboembolectomy, AVR- Aortic valve repair, DVR- Double valve repair, VAD- Ventricular assist device

Among 1000 patients with PAC, CABG was performed in 500 (50%) patients, PTE was performed in 114 (11.4%) patients, MVR in 165 (16.5%), AVR in 89 (8.9%) patients, DVR in 63 (6.3%), CABG + Valve replacement in 6 (0.6%), septal myomectomy 2.7 (2.7%), cardiac transplant, VAD 8 (0.8%), Dor procedure in 15 (1.5%), Bental procedure in 13 (1.3%) patients.

The duration of PAC was <3 days in 64.5% patients, 3-5 days in 30.2% patients, 6-7days in 4.7% patients and >7 days in 0.6 % patients.

Table 3: EuroSCORE

EuroSCORE	**No of Cases**	**Percent (%)**
0	16	1.6
1-3	188	18.8
4-6	529	52.9
7-10	212	21.2
>10	55	5.5
Total	1000	100.0

The EuroSCORE of all 1000 patients was calibrated, of which 52.9% patients had a EuroSCORE between 4- 6, 21.2% patient had EuroSCORE between 7-10, 18.8% had EuroSCORE between 1-3 and 5.5%, 1.6 % had EuroSCORE >10, 0,respectively.

Table 4: Outcome

Post-operative data	No of Cases	Percent
Renal Dysfunction	260	26
IABP	235	23.5
Cardiac arrest	139	13.9
Death	129	12.9
Stroke	50	5
Septicemia	41	4.1

IABP- intra aortic balloon pump

Post-operative data of all 1000 patients was analysed, 23.5% required IABP, 13.9% patients had an event of cardiac arrest, death occurred in 12.9% patients, stroke occurred in 5% patients, septicemia in 4.1%.
Among 1000 patients, 44.1% patients required ICU stay for less then 5 days, 36.6% patients had an ICU stay of 5-10days and 19.3% patients had an ICU stay of > 10 days.

Table 5: Comparison of Euro SCORE subgroup with duration of ICU stay

EuroSCORE	ICU stay (in days)				
	< 5	5 - 10	> 10	Total	Mortality
0	16	0	0	16(100%)	0
1-3	81(43.04%)	78(41.4%)	29(15.4%)	188(100%)	17(9.04%)
4-6	241(45.5%)	201(37.9%)	87(16.44%)	529(100%)	53(10.01%)
7-10	97(45.75%)	71(33.49%)	44(20.75%)	212(100%)	36(16.98%
>10	6(10.9%)	16(29.09%)	33(60%)	55(100%)	23(41.81%)

Total	441	366	193	1000	129
Chi Square Test P<0.001, Highly Significant					

Out of 16 patients with EuroSCORE=0, all the patients had ICU stay <5 days

Among patient with (EuroSCORE 1-3, n=188), (EuroSCORE 4-6, n=529), (EuroSCORE 7-10, n=212), (EuroSCORE >10, n=55), ICU stay was <5days in 43.04%, 45.5%, 45.75%, 10.9% respectively.

Among patient with (EuroSCORE 1-3, n=188), (EuroSCORE 4-6, n=529), (EuroSCORE 7-10, n=212), (EuroSCORE >10, n=55), ICU stay was 5-10 days in 41.4%, 37.9%, 33.49%, 29.09% respectively.

Among patient with (EuroSCORE 1-3, n=188), (EuroSCORE 4-6, n=529), (EuroSCORE 7-10, n=212), (EuroSCORE >10, n=55), ICU stay was >10 days in 15.4%, 16.44%, 20.75%, 60% respectively.

An increase in duration of ICU stay with increase in EuroSCORE and is statistically significant.
Among 1000 patients, duration of hospital stay was 10 ± 5days in 47.3 % cases, 23

± 7days among 38.5% patients, 38 ± 7 among 14.8% patients, 53 ± 7days among 0.4% patients and 75 ± 14.5among 0.3% patients. The mean duration of hospitalstay was 12.8 $\pm$ 5.2.
Out of 16 patients with EuroSCORE=0, all the patients had hospital stay 10 ± 5 days

Among patient with (EuroSCORE 1-3, n=188), (EuroSCORE 4-6, n=529), (EuroSCORE 7-10, n=212), (EuroSCORE >10, n=55), hospital stay was 10 ± 5 days in 54.25%, 50.28%, 37.26% and 18.8% respectively.

Among patient with (EuroSCORE 1-3, n=188), (EuroSCORE 4-6, n=529), (EuroSCORE 7-10, n=212), (EuroSCORE >10, n=55), hospital stay was 23 ± 7days in 34.04%, 38.37%, 40.56%, 34.54% respectively.

Among patient with (EuroSCORE 1-3, n=188), (EuroSCORE 4-6, n=529), (EuroSCORE 7-10, n=212), (EuroSCORE >10, n=55), hospital stay was 38 ± 7days in 11.7%, 11.34%, 18.86%, 48.2% respectively.

Among patient with (EuroSCORE 1-3, n=188), (EuroSCORE 4-6, n=529), (EuroSCORE 7-10, n=212), (EuroSCORE >10, n=55), hospital stay was >45 days in 0%, 0%, 3.41%, 3.6% respectively.

Patient with higher EuroSCORE had a longer duration of hospital stay (p value <0.001).

Table 6: EuroSCORE subgroup comparison with number of mortality

EuroSCORE	Outcome		
	Survived	Died	Percentage ofdeath
0	16	0	0
1-3	171	17(9.04%)	9.04
4-6	476	53(10.01%)	10.01
7-10	176	36(16.98%	16.98
>10	32	23(41.81%)	41.81
Total	871	129	12.9
Chi Square Test P<0.001, Highly Significant			

Among patient with (EuroSCORE=0, n=16), (EuroSCORE 1-3, n=188), EuroSCORE 4-6, n=529), (EuroSCORE 7-10, n=212), (EuroSCORE >10, n=55), death occurredin 0, 9.04%, 10.01%, 16.98%, 41.81% respectively

Among 1000 patients, complications during PAC insertion occurred in 7 patients(0.7%), of which 2 patients (0.2%) had bleeding at insertion site and 5 patients (0.5%) had transient cardiac arrythmia.

DISCUSSION

Pulmonary artery catheter is used for hemodynamic monitoring in critically illpatients and patients undergoing cardiac surgery etc.

The findings were compared with those of the previous workers and disparity so observed is discussed with possible hypothesis**.**

In the present study the median age group of the patients was 58.5 ± 5 years, of which 71.5% patients were of age <60 years and 28.5%patients were of age >60 years. Sandham et al [20] in a similar study reported the mean age of patients with PAC 72.3± 6.97. ESCAPE trial reported the mean age in their study as 56 years.

Male to female ratio was 3.5:1. Sandham et al[7] reported 70.4% males and 29.6% females. Schwan et al[8] reported 69.1% patients as male. Shaw et al [9] reported 69% males and 31% females. Our observation shows malepredominance most probably attributed to increase smoking, tobacco consumption, in males which play a key role in cardiac events, hence requiring major cardiac surgeries.

In our study the most common indications for PAC were hemodynamic monitoring and patients with low Ejection fraction (Left ventricular impairment) together contributing (575) 57.5% cases followed by PAH 372(37.2%) cases, HOCM 31(3.1%) cases, severe right ventricular dysfunction 10 (0.1%) cases, VAD & cardiac transplant contributing to 8(0.8%) cases. Jacka et al[10] conducted a survey from 345 anaesthesiologist and 87% agreed that the most appropriate indicationfor PAC was ventricular impairment and unstable angina. Choosing wisely et al[11] in a survey by practicing anaesthesiologists concluded that, the use of PAC could be recommended for specific indications in cardiac surgery including coronary artery bypass grafting (CABG) with poor left ventricular (LV) function, LV aneurysmectomy, recent myocardial infarction, pulmonary hypertension, diastolic dysfunction, acute ventricular septal rupture and insertion of left ventricular assist device. The appropriate indications remain debatable. However, although the PAC has no role in routine perioperative care, the existence of a specific subpopulation for which the use of this device may be beneficial cannot be excluded.

In our study, among patients who received PAC, CABG was performed in 500 (50%) patients, PTE was performed in 114 (11.4%) patients, MVR in 165 (16.5%), AVR in 89 (8.9%) patients, DVR in 63 (6.3%), CABG + valve replacement in 6 (0.6%), septal myomectomy 31 (3.1%), cardiac transplant 31 (3.1%), Dors procedure in 15 (1.5%), Bental procedure in 13 (1.3%) patients. Brovnmann et al[12] and Chiang et al [13] involved all types of cardiac surgery patients (e.g., coronary artery bypass grafting and heart valve surgery). Thus, in comparison to above studies in our study patients with variety of cardiac surgery were performed in patients with PAC.

EuroSCORE of all the patients with PAC was assessed to know the preoperative status of the patient with PAC. 529 (52.9%) patients had a EuroSCORE of 4-6, 212 (21.2%) patients had a score of 7-10, 16 (1.6%),188 (18.8 %), 55 (5.5%) had a score of 0,1-3, >10 respectively. Schwan et al[8] et al reported a EuroSCORE of >4 in 41.3% patients. In study by Andrew et al the mean EuroSCORE II was 0.03. There appears a lack of standard preoperative assessment methodology like to compare the status of patients preoperatively and a lack of comparison of the same with hospital stay, ICU stay or death.

Among 1000 patients, 44.1% patients required ICU stay for less than 5 days, 36.6% patients had an ICU stay of 5-10days and 19.3% patients had an ICU stay of > 10 days. In our study, in view of the above EuroSCORE ICU stay of each subgroup was assessed separately and an observation made, ICU stay greater with patients with higher EuroSCORE e.g.: In subgroup patient with

(EuroSCORE 1-3, n=188), (EuroSCORE 4-6, n=529), (EuroSCORE 7-10, n=212), (EuroSCORE >10, n=55), ICU stay was >10 days in 15.4%, 16.44%, 20.75%, 60% respectively. Thus, it was observed that patient with higher EuroSCORE hada longer duration of hospital and ICU stay and there was a statistical significance for the same with p value <0.01.
In our study hospital stay duration of hospital stay was 10 ± 5days in 47.3 % cases, 23 ± 7days among 38.5% patients, 38 ± 7 among 14.8% patients, 53 ± 7days among 0.4% patients and 75 ± 14.5among 0.3% patients. In subgroup analysis Among patient with (EuroSCORE 1-3, n=188), (EuroSCORE 4-6, n=529), (EuroSCORE 7-10, n=212), (EuroSCORE >10, n=55), hospital stay was >45 days in 0%, 0%, 3.41%, 3.6% respectively. Sandham et al [20] reported the median length of hospital stay as 10 days.

In patients who received PAC, post operatively IABP was required in 235 (23.5%) patients, 139 (13.9%) patients had an event of cardiac arrest, death occurred in 129 (12.9%) patients, stroke occurred in 50 (5%) patients, septicemia in 41 (4.1%) patients. In study conducted by Desai et al[3] 40% of the patients were started on inotropes in patients with PAC. Whereas Xu et al[14] concluded that the patients who were managed with PAC more often received intraoperative vasoactive drugs dopamine (70.9% vs. 45.5%; P<0.001). Brovman et al[12] showed that the presence of a PAC did not alter the risk of cardiac arrest intraoperatively. A nonsignificant decrease in mortality was associated with catheter placement.
Among patient with (EuroSCORE=0, n=16), (EuroSCORE 1-3, n=188), (EuroSCORE 4-6, n=529), (EuroSCORE 7-10, n=212), (EuroSCORE >10, n=55), death occurred in 0, 9.04%, 10.01%, 16.98%, 41.81% respectively. Overall mortality was 12.9%. Chiang Y et al reported a death of 12.2% in patient with PAC. Sandham et al reported 7.8% death in patients with PAC. Shaw et al[9] reported that there was no difference in the 30-day in-hospital mortality rate between treatment groups (OR, 1.17; 95% CI, 0.65–2.10; p = 0.516). Our study showed that majority of the death occurred in patients with high EuroSCORE with 53 death in patient with EuroSCORE>10. Thus, indicating a poor preoperative condition that must have contributed to death of the patient.

In our study it was observed that only 0.7% cases developed complications during PAC insertion, of which 0.5% developed transient cardiac arrythmia and 0.2% developed mild bleeding at insertion site. Sandham et al reported a higher rate of pulmonary embolism in the catheter group than in the standard-care group in PAC versus non-PAC group (8 events vs. 0 events, P=0.004).
On comparing with previous studies, it was observed that there is lack of therapeutic protocols, treatment algorithms and insufficient guidelines for interpreting the findings obtained by PAC. Also, in certain studies it was seen that the use of PAC was left at the discretion of treating physician. Also, PAC was used in patients who are critically ill but not on patients in whom invasive hemodynamic monitoring was thought of value.

CONCLUSION

Our study showed 0.7% complications during procedure which were reversible and not life threatening. Patient with high EuroSCORE and severe cardiac dysfunction had higher mortality, and hence mortality cannot be directly attributed to PAC.

We believe that PAC is a useful technique for monitoring physiological function especially if used before the onset of derangement prior to the surgical procedure. Hence, we recommend the use of PAC especially in patients requiring hemodynamic monitoring, heart failure with reduced ejection fraction (Low EF), PAH etc. During operative procedures like CABG, MVR, DVR, Dors procedure, VAD, cardiac transplant PAC can play a key role and help in early diagnosis of any variations in physiological parameters. However, PAC is a monitoring tool, and a tool is onlyuseful if the user can derive benefit from the data. It also has a good cost benefitratio and a low complication rate. Also, no monitoring device, no matter how simpleor sophisticated, will improve patient-centred outcomes unless it is coupled with a treatment that can itself improve the outcome.

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