ORIGINAL ARTICLE

FREQUENCY, INDICATIONS AND COMPLICATIONS OF PULMONARY ARTERY CATHETER INSERTION IN ADULT OPEN-HEART SURGERY PATIENTS OF A TERTIARY CARE HOSPITAL

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Background: Patients presenting for cardiac surgery have unstable cardiovascular disease and haemodynamics with multiple coexisting diseases. Optimal monitoring in the perioperative period is very important for best perioperative outcome. The introduction of the flow-directed pulmonary artery catheter (PAC) into clinical practice is one of the most important and popular advances in the field of cardiac anaesthesia. The objective of the study was to determine the frequency, indications and complications of pulmonary artery catheter insertion in adult open-heart surgery patients. **Methods:** A Prospective observational study was conducted at cardiac operating rooms and Cardiac Intensive care unit (CICU) of Aga Khan University Hospital for a period of six months from Nov 2015 to April 2016.Two hundred and seven patients were included in this study. PAC was inserted through right/left internal jugular vein or subclavian vein. Complications noted were arrhythmias (atrial and ventricular), right bundle branch block, coiling and knotting, pulmonary artery rupture, and infection up to 72 hours of PAC insertion. Frequency and percentage were computed for gender, comorbids (Hypertension, Diabetes, Chronic kidney disease, Chronic Obstructive Pulmonary Disease) and PAC frequency of insertion, indications and complications were noted. **Results**: The frequency of PAC insertion was 47.83%. Major indications for PAC insertion were poor left ventricular function, acute coronary syndrome, cardiogenic shock, significant left main disease and valvular heart disease patients. Minor complications were found in 23.22% cases, which included arrhythmia in 19.2% cases and coiling in 4.02%. **Conclusion**: Pulmonary artery catheter insertion is a safe technique with useful clinical application in the management of high-risk cardiac surgical patients. The PAC insertion rationale must be standardized to confirm the judicious use.

Keywords: Pulmonary artery catheter (PAC) insertion; Adult cardiac surgery; Complications
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INTRODUCTION

Patients presenting for cardiac surgery have unstable cardiovascular disease and haemodynamics with multiple coexisting diseases. Optimal monitoring in the perioperative period is very important for best perioperative outcome. The introduction of the flow-directed pulmonary artery catheter (PAC) into clinical practice is one of the most important and popular advances in the field of cardiac anaesthesia.[1, 2]

PAC monitoring provides information about pulmonary artery occlusion pressure, cardiac output (CO), right atrial pressure, systemic vascular resistance and mixed venous O2 (SvO2) and help us in patients management and may reduce perioperative mortality and morbidity.[3,4] It has been over used frequently without proper indications in both the operating rooms and the ICUs.[5,6] There has been considerable controversy regarding the use of pulmonary artery catheter (PAC) in clinical practice because of its complications. In practice, PAC is still used with frequency of 35–68.2%[7,8] and complication rate reported is around 5–10%[9,10].

Different alternate monitoring techniques can be used in open-heart cardiac surgery, but none has been proved to be a true replacement of PAC monitoring. Transoesophageal echocardiography (TEE) is a valuable monitoring technique both during and after cardiac surgery. However, its limitations are that it is a semi-quantitative method and it does not permit continuous monitoring.

Different practices exist among the cardiac anaesthesia consultants and cardiac surgeons regarding the rationale for PA catheter usage. No local guidelines are available for the use of PA catheter insertion. Local data is not available regarding the frequency and rationale of PA catheter insertion in open-heart cardiac surgery patients in the developing countries like Pakistan where health care cost is a major factor. Every monitoring technique should be rationalized so as to take optimal advantage of its use economically and clinically. This audit will help us in gauging our clinical practice with international practice.

MATERIAL AND METHODS

After taking approval from Ethical review committee (Approval no: 3792-Ane-ERC-15) and informed consent from the patients, this prospective observational study was conducted in Cardiac operating room and CICU of tertiary care hospital for a period of six months. All adult male and female elective, urgent and emergent open heart surgery patients including coronary artery bypass grafting (First time and Redo CABG), isolated Valve replacements (mitral valve replacements, aortic valve replacements), combined procedures (CABG plus Valve replacements) and aortic root replacements in the age group 18–80 years were included in the study.

Patients with right atrial thrombus, endocarditis involving tricuspid and pulmonary valve, patients with severe pulmonary stenosis, and patients in which PAC retained for more than 72 hours were excluded.

Sample size calculation was based on previous studies, where insertion of pulmonary artery catheter (PAC) was reported in 35% patients.[7,8] Therefore 207 patients were included to estimate the frequency of PAC insertion within 6.5% level of precision with 95% confidence interval. Decision of PAC insertion was taken by the Anaesthesia consultant on list and if ambiguous in consultation with the Cardiac surgeon. PAC was inserted through internal jugular or subclavian vein. Pressure waveforms and filling chamber pressures guided the floatation of PAC. Complications noted were arrhythmias (atrial and ventricular), right bundle branch block, coiling and knotting, RV rupture, pulmonary artery rupture, and PAC related infection up to 72 hours post-operatively.

All statistical analyses were performed using SPSS-19. Frequency and percentage were computed for gender, comorbids (HTN, DM, CKD, and COPD) and PAC frequency of insertion, indications and complications noted. Mean and standard deviation were also estimated for age, weight, height and BMI. Stratification was also performed to control the effect of age, gender, BMI, comorbid to observe the PAC frequency of insertion, indications and its complications. Chi-square test was used; $p \leq 0.05$ was considered level of significance.

RESULTS

A total of 207 open-heart cardiac surgery patients were enrolled in this study, but 204 patients were followed for 72 hours because 3(1.45%) patients died during surgery and out of 3 patients only 2 patients received PAC. Nine patients were not followed after 72 hours because PAC was retained beyond the standardized duration. Only one patient received PAC postoperatively due to eventful post-pump course.

The mean age of the patients was 57.76±11.59. There were 157 (75.85%) male and 50 (24.15%) female patients. Demographic data is elaborated in table-1. Most of the cases were CABGs (81.2%), 13% were valve replacements 4.8% cases were combined procedures and only 1% were ASD closure.8.2% cases were emergent and all received PAC. Out of 207 patients, 99 (47.83%) were monitored with PAC. Major indications were analysed in the study shown in Figure-1.

Minor complications were found in 23.22% cases, which included arrhythmia in 19.2%, and coiling was found in 4.02% cases. These complications were managed after withdrawing or manipulation of PAC; only one patient had recurrent arrhythmias in which PAC was removed postoperatively within few hours. No major complications like PA or RV rupture were found.

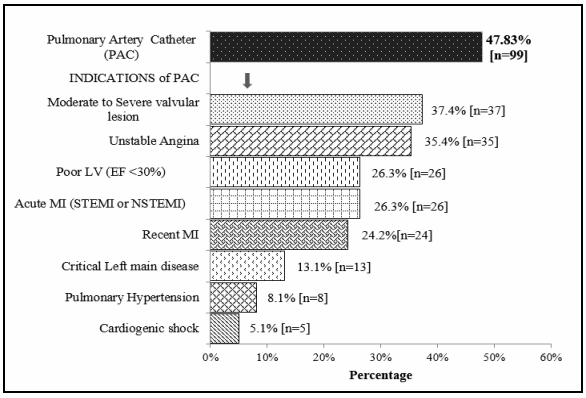

Figure-1: Frequency and indications of pulmonary artery catheter (PAC) insertion in adult open-heart surgery patients

Table-1: Demographic characteristics of patients (n=207)

Variables	
Age (Years)	57.76±11.59
Weight (Kg)	71.66±11.78
Height (cm)	163.54±7.29
BMI (kg/m^2)	26.78±4.07
Gender	
Male	157 (75.85%)
Female	50 (24.15%)
Co-Morbid:	
Hypertension	130 (62.8%)
Diabetic Mellitus	82 (39.6%)
Ischemic heart disease	55(26.6%)
Chronic kidney disease (CKD)	10 (4.8%)
Hypothyroidism	7 (3.4%)
Chronic obstructed pulmonary disease (COPD)	6 (2.9%)
Acute myocardial infarction (AMI)	4 (1.9%)
Other	6 (2.9%)

Other: Asthma, Hepatits C, Valvular heart disease, Rheumatic heart disease, Acute kidney injury.

Table-2: Angiographic finding and procedure (n=207)

Variables	n (%)
Angiographic finding	
Grading of coronary artery disease	
Normal Vessel	25 (12.1)
Single Vessel	2 (1)
Double Vessel	15 (7.2)
Triple Vessel	165 (79.7)
Significant left main disease	
Yes	23 (11.1)
No	184 (88.9)
Ejection Fraction (%)	49.88±12.88
Pulmonary Hypertension	34 (16.4)
Mild	17
Moderate	12
Severe	5
Procedure	
CABG	168 (81.2)
Mitral valve replacement (2 of 15 redo MVR)	15 (7.2)
Aortic valve replacement	6 (2.9)
Double valve replacement	6 (2.9)
CABG + AVR/MVR	10 (4.8)
Atrial septal defect	2 (1)
Urgency of procedure	
Elective	181 (87.4)
Urgent	9 (4.3)
Emergent	17 (8.2)

Results are presented as n (%) and mean±SD

Table-3: Frequency of complications related to PAC insertion (n=99)

Complications	Frequency	Percentage
Arrhythmias: Atrial (A. Fibrillation, A. flutter)	9	9.1
Ventricular (Pre-mature Ventricular Contractions, Ventricular – Tachycardia. V- Fibrillation.)	10	10.1
Coiling	4	4.04

Table 4: Comparison of characteristics with and without PAC

Variables	PAC Used n=99	PAC Not Used n=108	*p*-values
Age (Years)	56.43±13.19	58.98±9.80	0.11
Weight (Kg)	70.27±11.89	72.94±11.58	0.10
Height (cm)	162.84±7.52	164.18±7.0	0.18
BMI (kg/m^2)	26.55±4.64	26.99±3.49	0.44
Gender			
Male	72 (72.7%)	85 (78.7%)	0.31
Female	27 (27.3%)	23 (21.3%)	
Co-Morbid:			
Hypertension	62 (62.6%)	68 (63%)	0.96
Diabetic Mellitus	43 (43.4%)	39 (36.1%)	0.28
IHD	26 (26.3%)	29 (26.9%)	0.92
CKD	10 (10.1%)	0 (0%)	0.001
Hypothyroidism	6 (6.1%)	1 (0.9%)	0.041
COPD	4 (4%)	2 (1.9%)	0.34
AMI	3 (3%)	1 (0.9%)	0.27
Other	5 (5.1%)	1 (0.9%)	0.07

Table-5: Comparison of Angiographic finding and procedure with and without PAC (n=207)

Variables	PAC Used n=99	PAC Not Used n=108	*p*-Value
Angiographic finding			
Grading OF CAD			
Normal Vessel	22 (22.2%)	3 (2.8%)	0.0005
Single Vessel	1 (1%)	1 (0.9%)	0.99
Double Vessel	6(6.1%)	9 (8.3%)	0.59
Triple Vessel	70 (70.7%)	95 (88%)	0.002
Significant left main disease			
Yes	16 (16.2%)	7 (6.5%)	0.027
No	83 (83.8%)	101 (93.5%)	
Ejection Fraction (%)	44.60±14.24	55.11±8.68	0.0005
Pulmonary Hypertension	23 (23.2%)	11 (10.2%)	
Mild	8	9	0.011
Moderate	10	2	
Severe	5	0	
Procedure			
CABG	67 (67.7%)	101 (93.5%)	0.0005
MVR (2 of 15 redo MVR)	14 (14.1%)	1 (0.9%)	0.0005
AVR	5 (5.1%)	1 (0.9%)	0.106
DVR	6 (6.1%)	0 (0.0%)	0.011
CABG + AVR/MVR	7 (7.1%)	3 (2.8%)	0.19
ASD	0 (0%)	2 (1.9%)	0.49
Urgency of Procedure			
Elective	73 (73.7%)	108 (100%)	0.0005
Urgent	9 (9.1%)	0 (0%)	
Emergent	17 (17.2%)	0 (0%)	

DISCUSSION

Pulmonary artery catheter was proudly announced first in 1970,[11] then grew rapidly and gained popularity till 1986, after that it was challenged in clinical practice. There has been considerable controversy regarding the use of pulmonary artery catheter (PAC) in clinical practice.[12,13] Many studies have indicated poor outcome in patients who were monitored with PAC.[10] However, these studies, that have condemned the use of PAC, were conducted on patients in intensive care units, where the clinical scenarios with regard to patients clinical status were somewhat different as compared to those of cardiac operating room.[9] Although some studies disapproved PAC in cardiac surgery[6,8] but still studies proved that PAC is used more as monitoring tool in cardiac surgery than any other monitoring devices[14]. The use of PAC in cardiac surgeries varies considerably from a routine use to no PAC at all and majority follow indications, which we followed in this study. Although guidelines for PAC insertion are available in non-cardiac surgeries, [15] none are available for adult cardiac surgical patients undergoing open-heart procedures.

No PAC related study has been conducted in cardiac surgery patients in Pakistan. Our institution is one of the leading centres for cardiac surgeries in Pakistan, where around 800–1000 adult open-heart surgeries are performed yearly. We routinely use PAC for monitoring in high risk cardiac surgery

patients including Acute coronary syndrome, valve replacements, poor LV and cardiogenic shock, therefore we had designed and conducted this study to share our experience about PAC with respect to its frequency of insertion, indications and complications. In our clinical practice, PAC insertion has been found to be very useful in differentiating ~~between~~ cardiogenic and vasoplegic shock. PAC also helps in rational and objective use of inotropes and vasopressors.

The current study showed that PAC was used in 47.83% of enrolled cases of which majority were elective triple vessel coronary artery disease patients scheduled for CABG. We used PAC in almost all valve replacement surgeries and emergent/urgent cardiac surgeries. Surgeon choice was found in very few cases. There were few cases in which we didn't use PAC despite poor LV function. There were no major complications except arrhythmias 19.2% and coiling 4.04% of patients, all of which were settled by just withdrawing or re-adjustment of catheter. Literature showed that rate of major complications related to PAC is low in cardiac surgery and also when inserted and managed by an experienced Anaesthesiologist/Intensivist.[16]. There is wide range of complications mostly related to arrhythmias 12.0–70% reported.[16] Other complications like thrombosis (8–22%), endocarditis (2.2-7.1%), PA rupture (0.03–0.20%), knotting (0.03%), sepsis (1.3-2.2%) were reported in western literature.[16,17] If we compared this study with the other study on PAC in ICU conducted at Aga khan university hospital in 2006, the frequency of PAC insertion was 19% and complication rate was 30%.[18]

We did not analyze the cost of PAC in cardiac surgery but roughly it cost about 15,000–17,000 PKR per PAC, so in developing country like Pakistan risk and benefit ratio should be considered while placement of PAC.

In cardiac surgeries there are some other non-invasive or semi invasive cardiac output monitoring devices available like Pulse index continuous cardiac output (PiCCO), lithium dilution cardiac output (LidCO), Bio-impedance, Oesophageal Doppler, with very limited data available.[14] Among all of these monitoring devices Trans-oesophageal echocardiography (TEE) is an alternating tool for monitoring in cardiac surgery.[19] TEE is one of the evolving modality with standard of care application in many international cardiac centres. TEE needs expertise and experience for continual monitoring. At present, cardiac Anaesthesiologist's choice of PAC or TEE monitoring is strongly influenced by their expertise and availability. PAC and TEE are not competitors; albeit they are subsidiary monitoring tools. Of course, the definition of correct use and a correct indication may vary according to local policy, economic considerations and the patient population.

The limitation of the study is that it is a prospective observational study with no comparison with any other cardiac monitoring modality and no standardization in the choice of PAC. The choice of PAC insertion was predominantly at the discretion of the cardiac anaesthesiologist. The study was limited to 72 hours' post-operative period with no data collection of long-term mortality and morbidity.

CONCLUSION

Pulmonary artery catheter insertion is safe technique with useful clinical application in the management of high-risk cardiac surgical patients. Risk benefit ratio must be considered during the selection of PAC insertion**.** The PAC insertion rationale must be standardized to confirm the judicious use.

AUTHORS' CONTRIBUTION

SSA: Writing protocol, data collection and manuscript writing. MIA: Conception of research question, Review of protocol and critical review of manuscript. RK: Conception of research question, Review of protocol and critical review of manuscript.

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