Background: Pulmonary artery (PA) catheter provides a variety of cardiac and hemodynamic parameters. In majority of the patients, the catheter tends to float in the right pulmonary artery (RPA) than the left pulmonary artery (LPA). We evaluated the location of PA catheter with the help of transesophageal echocardiography (TEE) to know the incidence of its localization. Three views were utilized for this purpose; midesophageal ascending aorta (AA) short-axis view, modified mid esophageal aortic valve long-axis view, and modified bicaval view.

Methods: We enrolled 135 patients undergoing elective cardiac surgery where both the PA catheter and TEE were to be used; for this prospective observational study. PA catheter was visualized by TEE in the above mentioned views and the degree of clarity of visualization by three views was also noted. Position of the PA catheter was further confirmed by a postoperative chest radiograph. Results: One patient was excluded from the data analysis. PA catheter was visualized in RPA in 129 patients (96%) and in LPA in 4 patients (3%). In 1 patient, the catheter was visualized in main PA in the chest radiograph. The midesophageal AA short-axis, modified aortic valve long-axis, and modified bicaval view provided good visualization in 51.45%, 57.4%, and 62.3% patients respectively. Taken together, PA catheter visualization was good in 128 (95.5%) patients.

Conclusion: We conclude that the PA catheter has a high probability of entering the RPA as compared to LPA (96% vs. 3%) and TEE provides good visualization of the catheter in RPA.

Key words: Pulmonary artery catheter; Right and left pulmonary artery; Transesophageal echocardiography

INTRODUCTION

Pulmonary artery (PA) catheter is a useful diagnostic and monitoring device that provides an important information about a variety of cardiac and respiratory parameters.[1] The balloon tipped catheter is floated across the right heart to reach the pulmonary circulation in a wedged position.

The catheter tends to float with the blood flow and it has been seen that it localizes more commonly in the right pulmonary artery (RPA) than in the left pulmonary artery (LPA). This may be related to the anatomical factors such as a straighter course of the RPA as compared to LPA, but the exact incidence of localization is not well studied.[2] It can be visualized intraoperatively by echocardiography; both by transthoracic and transesophageal probes, and also postoperatively by a chest radiography. Transesophageal echocardiography (TEE) is now a standard monitoring and diagnostic modality during cardiac surgery. We examined
the location of the PA catheter by TEE with the aim of calculating the incidence of placement in the RPA or LPA. In addition, which of the views provides better visualization was also assessed.

METHODS

After obtaining approval from the Institutional Review Board and Research Committee, we conducted this prospective observational study. Informed consent was waived, given the use of TEE and the PA catheter is routine in our institution.

Inclusion criteria

One hundred and thirty-five consecutive adult patients undergoing elective cardiac surgery in whom PA catheter was inserted and TEE was performed were included in the study. Use of PA catheter and TEE is a standard practice in a select group of patients in our institution.

Exclusion criteria

Patients in whom TEE was contraindicated due to any reason were excluded.

The PA catheter was inserted either by a consultant or a senior resident under supervision as per the standard institutional protocol. A central approach was used for the cannulation of the right internal jugular vein and a PA catheter 7.5 F (Edwards Life Sciences Swan Ganz, CA, USA) was inserted through the 8.5 F introducer sheath (Edwards Life Sciences Introflex, CA, USA). The distal port was transduced and the catheter was guided into the PA by watching the corresponding waveform until a most proximal wedge position was obtained. The balloon was deflated and the catheter was fixed in the position. The corresponding length of the catheter required to enter the right ventricle, PA, and wedge positions was noted.

After the induction of general anesthesia, a TEE probe was inserted and the position of PA catheter in the main pulmonary artery (MPA) and its bifurcation into RPA and LPA was checked in the midesophageal ascending aorta (AA) short-axis view [Figure 1]. The location was then checked in the short-axis of RPA in other two views that is, modified aortic valve long-axis and modified bicaval view [Figures 2 and 3 respectively]. The PA catheter was visualized as a bright echogenic mobile spot in the RPA in all the three views. If the catheter was not seen in the RPA, an attempt was made to visualize it in the LPA [Figure 4]. However, since the visualization of LPA is extremely difficult due to interposed left bronchus (air filled), nonvisualization of the catheter in RPA and MPA was assumed to have it reached LPA. A note was made about the quality of visualization in...
all the above mentioned views and it was graded as 1, 2, or 3 corresponding to good, moderate, and poor clarity of visualization respectively. Soon after the patient was transferred to Intensive Care Unit (ICU), the position of the catheter was confirmed postoperatively by a chest radiograph. Any manipulation of the catheter intraoperatively or in the ICU before the chest radiograph was performed was also noted.

**Statistical analysis**

All statistical calculations were performed using SPSS 16.0 software (SPSS Inc., Chicago, IL, USA). Continuous variables are presented as a mean ± standard deviation (SD) and categorical variables presented as absolute numbers and proportions. A binomial test was applied to ascertain the probability of the catheter entering the RPA versus LPA.

**RESULTS**

Of 135 patients, one patient expired before the chest radiograph could be performed, he was excluded and data from 134 patients were analyzed. Table 1 shows the demographic profile and the types of operations performed; most patients underwent coronary artery bypass grafting (CABG). PA catheter was visualized in RPA and LPA in 129 (96.2%) and 4 (3%) patients respectively. These findings were confirmed on chest radiograph. In 1 (0.7%) patient, the catheter could not be visualized by TEE but was seen in MPA in chest radiograph. The probability of the catheter entering the right side was obtained by binomial test and was highly significant (two-tail P < 0.001). Considering a type I error of 0.05 and the distribution of 96% versus 3% in a sample size of 134 patients, the power of the study was estimated to be 85%.

**DISCUSSION**

A significantly higher probability of the PA catheter entering the RPA than LPA (96% versus 3%, P < 0.001) was observed in this study. The PA catheter tends to float into the RPA because it is larger in size, receives more blood flow, and has a straighter origin from MPA as compared to the LPA.[2] There are a few reports describing the exact incidence of the location of the PA catheter. Benumof et al., using radiograph reported that the majority of PA catheters are located in the RPA,

---

**Table 1: Patient characteristic data (n=134)**

| Characteristic                      | Value               |
|-------------------------------------|---------------------|
| Age (year) [mean (SD)]             | 54.5 (9.03)         |
| Sex (male/female)                  | 116/18              |
| Height (cm), [mean (SD)]           | 167.1 (7.16)        |
| Body weight (kg), [mean (SD)]      | 66.7 (11.1)         |
| Body surface area (m²)             | 1.74 (0.16)         |
| Type of surgery                    |                     |
| Coronary artery bypass grafting    | 129                 |
| Aortic aneurysm surgery            | 03                  |
| Coronary artery bypass grafting +  | 1/1                 |
| valve replacement (aortic/mitral)  |                     |
| PA catheter visualised in right PA | 129                 |
| PA catheter visualised in left PA  | 04                  |
| PA catheter visualised in main PA  | 01                  |
| TEE view providing good visualisation of PA catheter (percentage of patients) | | |
| Modified bicaval                   | 62.3                |
| Modified aortic valve long-axis    | 57.4                |
| Midesophageal ascending aorta short-axis | 51.4            |

SD: Standard deviation, PA: Pulmonary artery, TEE: Transesophageal echocardiography
but the exact incidence was not reported by them.\[^{[3]}\] In a review of 30 patients of catheter induced PA rupture, the authors report 93% incidence of RPA rupture, implying that most catheters reach RPA.\[^{[4]}\] In another prospective study of 132 patients undergoing cardiac surgery, Tripathi, and Pandey confirmed the location of PA catheter by chest radiograph.\[^{[2]}\] The authors reported that in patients with mitral valve stenosis, the leftward placement of catheter was more frequent (71%) as compared with patients undergoing CABG (18%) due to enlargement of left atrium and consequent straightening of the angle of origin of LPA from the PA trunk. Moreover, the left atrium size was found to be greater in the CABG patients in whom the PA catheter floated to the left side as compared to those with right sided PA catheter.

The location of PA catheter has also been evaluated using transthoracic echocardiography (TTE). In a report of 68 patients from coronary or intensive care units (ICUs), Kasper et al. reported that TTE correctly predicted the location of PA catheter in 62 patients. In their study, PA catheter was located in RPA in 41 patients and in LPA in 24 patients.\[^{[4]}\]

The different incidence of placement of PA catheter in the LPA observed in these studies and the present one can be explained on the basis of the different study populations. The series by Tripathi and Pandey included patients with large left atrial size and the one by Kasper et al., included patients from the coronary or intensive care units.

Our results showed no discrepancy between TEE and radiograph findings. The midesophageal AA short-axis, modified aortic valve long-axis, and modified bicaval views together provided good visualization in 128 (95.5%) patients. Overall PA catheter visualization by TEE was satisfactory except in one patient in whom the catheter could not be visualized in the PA and in 5 (3.7%) patients catheter visualization was of moderate quality.

The mean length of catheter required to enter right ventricle, PA, and wedge positions was 24.8 (3.84) cm (95% CI: 24.22–25.53 cm), 35.3 (3.85) cm (95% CI: 34.7–36.01 cm), and 42 (4.48) cm (95% CI: 41.31–42.84 cm) respectively, which is in agreement with the earlier report.\[^{[5]}\]

The TEE has earlier been used to guide the PA catheter insertion.\[^{[7]}\] The present study confirms that visualization of PA catheter is easily possible by TEE. Peripheral catheter location is one of the key factors of PA rupture and a proximal PA catheter is the optimal position during cardiopulmonary bypass.\[^{[4]}\] Hence, TEE can be a useful tool to ensure such an optimal location.

There may not be much clinical significance to our findings and some clinicians may argue that the location does not make any difference to the hemodynamic data derived from the PA catheter and hence the patient management. However, our main objective was to provide epidemiological data in terms of the exact incidence of the PA catheter placement in patients undergoing cardiac surgery; which has not been reported so far. Further, although TEE has been used to guide the catheter placement, we have shown that modified bicaval view should perhaps be the preferred view for this purpose, as it provided good visualization in largest number of patients. One limitation of the study is that the grading of visualization is subjective and may be operator dependent.

**CONCLUSION**

The PA catheter is likely to enter the RPA in most patients with a probability of 96% versus 3% for LPA. The visualization of PA catheter by TEE is satisfactory.

**Financial support and sponsorship**

Nil.

**Conflicts of interest**

There are no conflicts of interest.

**REFERENCES**

1. Stocking JE, Lake CL. The role of pulmonary artery catheter in year 2000 and beyond. J Cardiothorac Vasc Anesth 2000;14:111-2.
2. Tripathi M, Pandey M. Intrathoracic pulmonary artery catheter allocation in the background of left atrial dilatation. J Cardiovasc Surg 2003;44:719-24.
3. Benumof JL, Saidman LJ, Arkin DB, Diamant M. Where pulmonary arterial catheters go: Intrathoracic distribution. Anesthesiology 1977;46:336-8.
4. Urschel JD, Myerowitz PD. Catheter-induced pulmonary artery rupture in the setting of cardiopulmonary bypass. Ann Thorac Surg 1993;56:585-9.
5. Kasper W, Meinertz T, Kerstin F, Just H, Wollschläger H, Schuster CJ, et al. Echocardiographic control of Swan-Ganz catheters. Chest 1980;77:380-2.
6. Tempe DK, Gandhi A, Datt V, Gupta M, Tomar AS, Rajesh V, et al. Length of insertion for pulmonary artery catheters to locate different cardiac chambers in patients undergoing cardiac surgery. Br J Anaesth 2006;97:147-9.
7. Tempe DK, Datt V, Banerjee A, Goel S, Arora D, Tomar AS, et al. Case 5-2004: Transesophageal echocardiography-guided insertion of a pulmonary artery catheter. J Cardiothorac Vasc Anesth 2004;18:657-62.