

## Percutaneous trans-jugular technique for continuous perioperative monitoring of intra-cardiac and pulmonary artery pressures during cardiac surgery for congenital heart disease

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### Abstract

**Objective:** To observe the safety of trans-jugular pressure-monitoring catheter insertion at a tertiary care teaching hospital in Rawalpindi, Pakistan.

**Methods:** The observational study was carried out at the Armed Forces Institute of Cardiology/National Institute of Heart Diseases, Rawalpindi, from January 1, 2004 to March 31, 2010. All patients electively scheduled to undergo cardiac surgery for congenital heart disease who had percutaneous trans-jugular pressure monitoring catheters inserted peri-operatively were included in the study. Dedicated Medtronic® 3 Fr pressure monitoring catheters were passed through internal jugular vein using the modified Seldinger. The patients were followed up during the hospital stay for complications related to catheter insertion/removal. Data was analysed using SPSS version 15.

**Results:** Of the 572 patients in the study, the catheters were ultimately positioned with the tips in the pulmonary artery in 447 (78.14%) patients, right ventricle 54 (9.44%) patients, left atrium in 52 (9.09%), and in both pulmonary artery and left atrium in 19 (3.32%) patients. Duration of pressure monitoring from all the chambers was 53±19 hours post-operatively. Transient and self-limiting atrial or ventricular ectopic beats were noticed in 163 (27.58%) patients during insertion. Catheter was found to be non-functional in 12 (2.03%) patients. Only one (0.16%) patient experienced recurrent tachyarrhythmia which required the withdrawal of catheter.

**Conclusion:** Insertion of trans-jugular pressure monitoring catheters during cardiac surgery for congenital heart disease is a safe and reliable technique.

**Keywords:** Percutaneous trans-jugular technique, Intracardiac, Pulmonary arterial, Pressure monitoring catheter, Congenital cardiac surgery. (JPMA 62: 924; 2012)

### Introduction

The clinical significance of intra-cardiac pressure monitoring and its impact on peri- and post-operative decision-making after complex cardiac surgery for congenital heart disease (CHD) cannot be overemphasised. Traditionally, during cardiac surgery for CHD, intra-cardiac chamber pressure estimation is performed via surgically-placed transthoracic catheters. In this method a pressure-monitoring catheter is surgically tunneled through the thoracic wall into the cardiac chamber under direct vision at the conclusion of the surgical procedure. This is an invasive technique and associated complications like catheter malfunction, thrombus formation, infection, haemothorax, pneumothorax<sup>1,2</sup> and cardiac tamponade,<sup>3</sup> have been reported with this technique either during the insertion or removal of these catheters. Various other techniques have also been described in the literature to monitor intra-cardiac pressures during surgery for CHD.<sup>4-9</sup> In these studies, catheters were passed either through the internal jugular vein (IJV)<sup>5-8</sup> or femoral vein<sup>9</sup> before the start of the surgery, and

then placed trans-septally into the left atrium (LA) or through the right ventricle (RV) into the pulmonary artery (PA) at the conclusion of the procedure. Specifically, percutaneous trans-jugular technique of intra-cardiac chamber pressure estimation is defined as percutaneous placement of a pressure-monitoring catheter through the IJV and its positioning in the desired cardiac chambers. Being less invasive, the trans-venous placement of catheters for intra-cardiac pressure monitoring has gained more popularity over the years for clinical use and is considered a reliable and a relatively safe alternative to the transthoracic technique. Though this technique is quite well known and practised, there are no large clinical series in the literature analysing the safety of the percutaneous trans-venous approach.

In this study we tried to evaluate the feasibility and safety of this intra-cardiac pressure monitoring technique in a large series of patients who underwent surgery for CHD. To the best of our knowledge, it is the largest clinical series of a single-centre experience of the safety profile of this catheter.

## Patients and Methods

The prospective observational study was carried out at the Armed Forces Institute of Cardiology/National Institute of Heart Diseases, a tertiary care referral hospital in Rawalpindi, from 1st January 2004 to 31st March 2010. The approval of the hospital's ethical committee was obtained prior to the initiation of data-collection. Informed consent from adult patients and from the parents of paediatric patients was also obtained. Of the 2910 adult and paediatric patients who underwent surgical procedures for CHD during the study period, percutaneous trans-jugular pressure monitoring catheter was inserted in 572 patients and only these patients were included in the study for in-hospital follow-up.

As part of the clinical protocol at our medical centre, the site of placement and the indications for the use of the trans-jugular pressure-monitoring catheter were as follows:

**Pulmonary Artery (PA):** Patients with pre-operative pulmonary hypertension (pulmonary artery pressure more than half the systemic pressure) and high pulmonary vascular resistance ( $\geq 4.5$  woods units).

**Left Atrium (LA):** Babies weighing  $\leq 5$ kg undergoing surgical repair for complex congenital cardiac lesions.

**Pulmonary Artery/Left Atrium (Combined):** babies weighing  $\leq 5$ kg undergoing surgical repair for complex congenital cardiac lesions with suspected postoperative pulmonary hypertension.

**Right Ventricle (RV):** Patients undergoing total correction for Tetralogy of Fallot. This was performed as a part of a separate study at the same institution and included post-operative measurement of RV to LV pressures ratio.

After the induction of general anaesthesia and endotracheal intubation and prior to the start of the surgical procedure, right IJV was punctured directly with 22 G syringe needle (Figure-1). A 0.18" (0.46mm) X 45cm Arrow® (Reading PA USA) spring wire guide was passed through this needle (Figure-2). After the removal of the needle, a 20 G intravenous cannula (without stylet) was threaded over the spring wire guide and was used as a dilator so as to avoid bleeding around the catheter due to excessive dilatation with conventional dilator (Figure-3). The cannula was removed subsequently. A Medtronic® (Grand Rapids MI, USA) 3 Fr, 63 cm, pressure-monitoring catheter was taken and sized to reach PA using the topographical landmarks. This pressure-monitoring catheter was then passed through the IJV using the modified Seldinger technique (Figure-4). In those patients who required post-operative monitoring of both LA and PA pressures, two monitoring catheters were inserted through the right IJV using the same technique. The catheters were secured with the skin using silk sutures. Exact location of catheter tip after insertion was determined by visual analysis of pressure

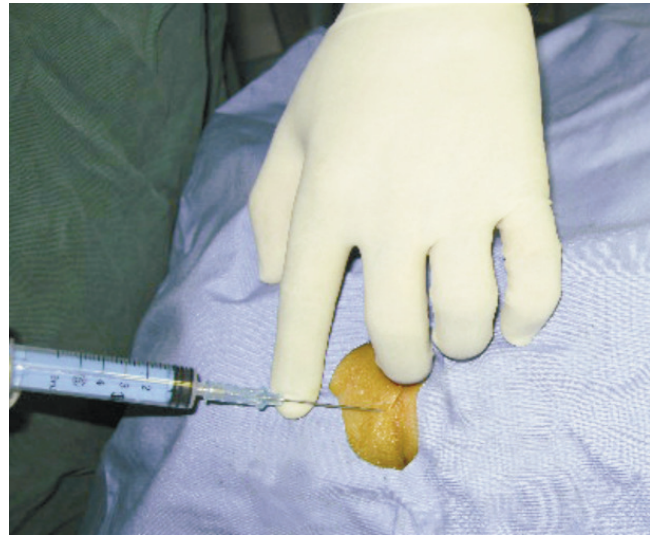


Figure-1: Right internal jugular vein being punctured with needle.

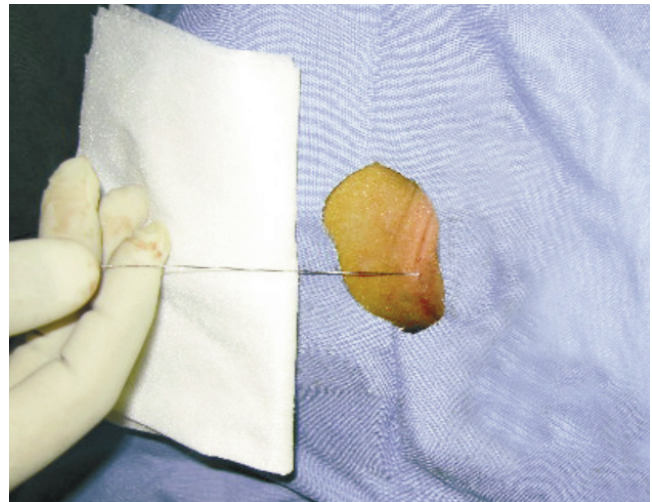


Figure-2: Guide wire has been passed in to the right internal jugular vein.

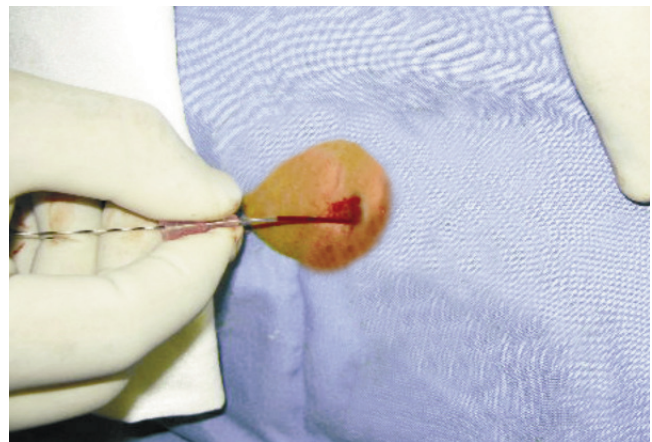


Figure-3: Skin, subcutaneous tissue and vein being dilated with 20 G IV cannula.

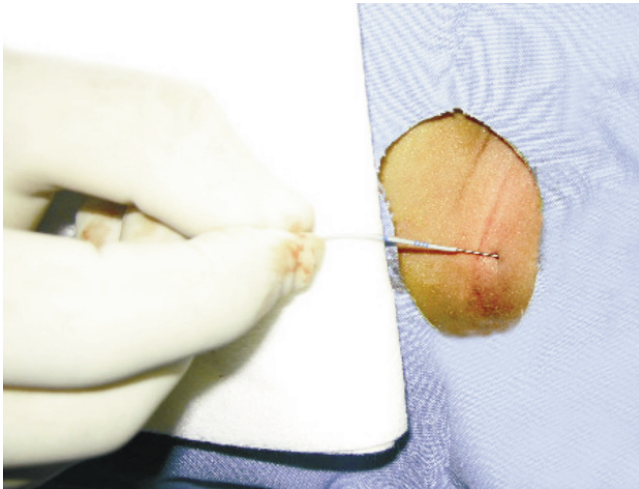


Figure-4: Pressure-monitoring catheter being inserted.



Figure-5: Pressure-monitoring catheter and separate triple lumen venous catheter has been passed in to right internal jugular vein.

waveform display after insertion and this was also confirmed directly when the heart was opened by the surgeon during the initiation of the cardiopulmonary bypass (CPB). A triple lumen central venous catheter of appropriate size was also inserted through the right internal jugular vein on the same side (Figure-5), dedicated for central venous pressure monitoring and the administration of vaso-active agents.

Towards the end of surgical repair and before the closure of RA, the operating surgeon exactly estimated the length of the catheter to reach the chamber desired to be monitored post-operatively. After cutting down the extra length, the catheter tip was directed through the tricuspid and pulmonary valve in to the PA under direct vision; into the LA through a purse string suture

in inter-atrial septum; or was cut short and left in the RV, depending on the ultimate location of the catheter tip required.

Failure of catheter insertion was diagnosed when the pressure-monitoring catheter could not be passed through the left or the right IJV after five attempts. Catheters were diagnosed as 'non-functional' when the pressure tracings were either dampened, could not be obtained or when it was not possible to aspirate blood despite a pressure-waveform tracing. Before separation from CPB, the patency and function of pressure-monitoring catheter were re-checked by gentle aspiration of blood and by confirmation of the relevant pressure waveforms on the monitor. Post-operatively, the patency of catheters was maintained by continuous infusion of a crystalloid solution containing heparin 1 I.U/ml @ 1 - 3 ml/hour. Two dimensional echocardiography was done periodically in paediatric intensive care unit and after the removal of the catheter to rule out internal jugular venous thrombosis. The pressure-monitoring catheters were removed when considered appropriate for individual patients by the intensive-care team. Patient demographics, peri-operative data, including the time of catheter insertion, location of catheter after insertion, cardiac chambers monitored, duration of monitoring with catheter, incidents of complications and the failure of insertion were recorded.

Data was analysed using SPSS version 15.0 (Chicago IL, USA). Descriptive statistics in terms of mean and standard deviation were used to describe the numeric variables and frequency along with percentages for categorical variables.

## Results

Demographic details and the pre-operative characteristics of the patients were noted (Table-1). The age range of the patients was from 6 days to 26 years. Pre-operative diagnoses of the patients were also assessed (Table-2). There were no failures of catheter insertion. After insertion, pressure-monitoring catheter was found to be present in pulmonary artery in 217 (36.71%) patients detected by the pressure waveform on the monitor during insertion and was also confirmed after surgical exposure on CPB (Table-3). There was only one incident of mal-position, in a patient with Tetralogy of Fallot, when the catheter went through the ventricular septal defect and the aortic valve and was seen to be placed in the right coronary artery when the heart was exposed after pericardiotomy. However, this mal-positioned catheter was not associated with

Table-1: Patients Demographics.

Variable	(n=572)
Mean Age (months)	26.1 ± 25.6
Gender: Male	351 (61.3%)
Female	221 (38.6%)
Mean Weight (Kg)	13.131 ± 12.188

**Table-2: Diagnoses in Patients undergoing Surgery (n=572).**

Diagnosis	No. of patients (%)
Ventricular septal defect	343 (59.96%)
VSD + Patent ductus arteriosus	59 (10.31%)
Tetralogy of Fallot	54 (9.44%)
Anomalous pulmonary venous drainage	36 (6.29%)
Double outlet right ventricle	25 (4.02%)
Transposition of great arteries	22 (2.97%)
Complete atrioventricular Canal Defect	14 (2.44%)
Aortopulmonary window	06 (1.04%)
Truncus arteriosus	06 (1.04%)
Aortic stenosis	03 (0.52%)
Mitral regurgitation	03 (0.62%)
Mitral stenosis	01 (0.17%)

VSD: Ventricular septal defect.

**Table-3: Initial Location of pressure-monitoring catheter after insertion (n=591).**

Location of catheter	Number of Patients (%)
Right Atrium	244 (41.28%)
Pulmonary artery	217 (36.71%)
Right Ventricle	89 (15.04%)
Inferior Vena Cava	40 (6.76%)
Right Coronary Artery	01 (0.16%)

**Table-4: Pressure monitoring catheter related complications (n=591).**

Variable	Number of patients (%)
Transient arrhythmias	163 (27.58%)
Carotid artery puncture	21 (3.55%)
Catheter non-function	12 (2.03%)
Recurrent arrhythmias	01 (0.16%)
Slipping of catheter in to RCA after insertion	01 (0.16%)

any dysrhythmias or haemodynamic instability.

The pressure-monitoring catheter was positioned in PA in 447 (78.14%) patients; in RV in 54 (9.44%) patients; LA 52 (9.09%) patients; and two simultaneous catheters were positioned in LA and PA in 19 (3.32%) patients for continuous pressure monitoring post-operatively. The mean time taken for catheter insertion was 7.8±2.4 minutes and for two catheters, it was 11.12±3.1 minutes. The average duration of monitoring (peri- to post-operative period) of various cardiac chambers was 53 ± 23 hours. Complications associated with the use of the catheter were noted down (Table-4).

In the case of inadvertent carotid artery puncture during insertion, firm pressure was applied for 5 to 10 minutes to prevent haematoma formation and IJV cannulation was performed on the contra-lateral side. Catheter insertion was infrequently associated with mostly benign and self-limiting arrhythmias. Only one (0.16%) patient who had an RV pressure-monitoring catheter after total corrective repair for

Tetralogy of Fallot to monitor RV/LV ratio, developed recurrent tachyarrhythmias in intensive care unit which subsided after the monitoring catheter was removed. In 9 (1.6%) patients, the catheters were diagnosed to be non-functional. None of the patients developed internal jugular venous thrombosis.

## Discussion

The results of the study showed that the percutaneous transjugular monitoring of intra-cardiac pressures during surgery for CHD is a safe and feasible technique. We used the technique with a very low complication rate. Considering the high-risk nature of the surgery and the complications associated with the alternative techniques, trans-jugular pressure monitoring seems to be a safe technique. Also, our ability to insert this catheter in the majority of patients with a very low failure rate suggests that it can be used reliably in patients undergoing cardiac surgery for CHD. The management of paediatric patients after high-risk complex CHD is an extremely challenging task. Accurate monitoring of pressures in various cardiac chambers not only helps in early recognition of potentially serious complications, but also guides in the institution of appropriate drug therapy. The monitoring of LA pressure and central venous pressure (CVP) can be reliably used to guide fluid therapy to optimise the RV and LV pre-load.<sup>5,10</sup> Similarly, continuous monitoring of PA pressure after surgical repairs in babies with truncus arteriosus, atrioventricular septal defects, total anomalous pulmonary venous return or neonatal transposition helps in early recognition and management of pulmonary hypertensive crisis.<sup>11</sup>

Traditionally, the intra-cardiac pressures are measured by trans-thoracic technique in which a single-lumen catheter is inserted percutaneously through the thoracic wall into the right superior pulmonary vein<sup>7</sup> or positioned at the junction of the pulmonary vein and the left atrium<sup>1</sup> while PA catheters are introduced through the RV infundibulum.<sup>10</sup> These techniques are not only more invasive during insertion, but are also associated with post-operative complications during removal. In a study,<sup>1</sup> bleeding was associated with the removal of transthoracic catheters in 135 of 448 (35%) cases, and 42 interventions were required in 40 patients. Severe haemodynamic compromise occurred after the removal of 13 (2.6%) catheters in the series. Another study reported 6,690 percutaneous transthoracic intra-cardiac monitoring catheters in 5,666 paediatric patients undergoing cardiac surgical procedures during a 10-year period.<sup>10</sup> It reported a lower incidence of bleeding with RA and LA catheters (RA = 0%, LA = 0.13%) and retention complications (RA = 0.15%, LA = 0.63%). There were more complications with PA catheters in the series (1.07%); unpredictable haemodynamic compromise occurred in approximately 0.5% of these patients. A 7-year series involving 5815 transthoracic LA monitoring catheters and reported bleeding requiring transfusion in 3 patients,

bleeding requiring mediastinal re-exploration in 7 patients and catheter retention in 4 patients.<sup>12</sup> Therefore, the removal of chest tubes in the post-operative period is generally deferred until the trans-thoracic pressure-monitoring lines have been removed and adequate haemostasis is established. At most of the centres as a protocol, availability of blood products and a surgical team is ensured to deal with any emergency after the removal of transthoracic catheters.<sup>13</sup>

In the above context, percutaneous trans-venous technique using IJV (preferably right side), or femoral vein appears to be a safe alternative. But very few studies have been conducted to assess the safety and efficacy using these trans-venous techniques. A trans-femoral approach requiring trans-septal positioning of the catheter during surgical exposure has been described, but femoral cannulation is associated with significant incidence of bacterial colonisation of the insertion site and a risk of systemic sepsis.<sup>14,15</sup> A technique similar to the one used in the current study has also been described in the literature,<sup>6</sup> but the authors excluded neonates and complex cardiac surgical procedures for insertion of this catheter and enrolled a small number of patients in the study (n=20). Yet another study<sup>5</sup> reported having passed catheters through right IJV using Seldinger technique and the catheters were later positioned in the PA by surgeons before the closure of RA. They found this technique to be simple and safe in 200 patients, but their experience remained limited to the PA only and in paediatric population.

The prospectively collected data of the current study, collected over approximately six years, indicated successful employment of percutaneous trans-jugular technique for continuous peri-operative monitoring of LA, PA and RV pressures after congenital cardiac surgery in 572 patients. The technique was found to be extremely reliable as 591 catheters were successfully inserted in all the 572 patients and catheter non-function was encountered only in 1.52% of the attempts. A variety of cardiac chambers (LA, PA, RV) were monitored and patient population ranged from the neonates to the adults. Due to the small size of the pressure-monitoring catheter used in our study (3 F), we were able to successfully simultaneously insert two catheters through the right IJV for simultaneous recording of PA and LA pressures. With this technique, pressure-monitoring catheter can be managed like any other central venous catheter in the operating room and paediatric intensive care units. Furthermore, these catheters can be removed without any special precautions, hence not tying up resources for potential complications after removal. We experienced no major complications with this technique except for one patient with RV catheter who developed recurrent tachyarrhythmias, which subsided after the complete withdrawal of the catheter.

Similarly, we were able to correctly position this catheter in PA pre-operatively in a high percentage of cases (36.71%). The availability of this haemodynamic data prior to the institution of CPB was helpful in the clinical management of these complex cases.

Though the results of our study relate to only a single-centre experience, they are worthy due to the large and diverse study population and the time span.

## Conclusion

Percutaneous trans-jugular technique is safe for intracardiac and pulmonary artery pressure monitoring during and after complex congenital cardiac surgery. It can be easily and reliably inserted without any significant complications and can be removed with negligible morbidity. However, we recommend future studies to compare this technique with the routinely employed trans-thoracic technique in order to establish the superiority of one over the other.

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