

Mechanical Complications of Central Venous Catheters in Hemodialysis Patients: Is Post Procedure X-Ray Chest Mandatory in all cases?

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Objective: To find the ability of physicians to reliably predict in advance complications associated with insertion of temporary venous catheters (TVC), based on a clinical decision design to decide whether an X-Ray Chest (CXR) is warranted post procedure.

Study Design: Case series study

Place and Duration: Department of Nephrology, Pakistan Institute of Medical Sciences, Islamabad from March 01, 2009 to August 31, 2009.

Materials and Methods: This study included 518 consecutive catheterizations performed for hemodialysis, using either internal jugular vein (IJV) or subclavian vein (SCV) approaches. All procedures were performed using anatomical land mark technique without employing fluoroscopy and ultrasonography (USG) guidance. The procedures were categorized as Low or High Risk for complications depending upon intraoperative events. The operator was required to predict for complications of malposition and pneumothorax and thus need for CXR. A post procedure CXR was obtained in all placements.

Results: There were a total of 16(3%) mechanical complications, including 2(0.4%) pneumothorax, 1(0.2%) hemothorax and 13(2.4%) catheter malpositions. High risk group comprised 100 placements. Pneumothorax/Hemothorax were only observed in 3% of High Risk Group and 1.05% of SCV placements. The catheter malpositions, 6% in high risk and 1.67% in low risk did not have significant difference with SCV or IJV route. Prediction for the need or need not of CXR was correct in 98.5% and 96% of procedures in low and high risk groups respectively.

Conclusion: Routine CXR is of little benefit and may not be mandatory when correct size catheters are used and experienced physicians use the proper technique, clinical judgment and reasonable discrimination between low and high risk procedures while placing TVC for dialysis.

Key Words: Hemodialysis, Temporary Central Venous Catheters, Routine post procedure X-Ray Chest.

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Introduction

Vascular access has a central role as the life line for hemodialysis (HD) therapy. The native arteriovenous fistula (AVF) is recommended as the access of first choice.¹ The most recent US Renal Data System (USRDS) Annual Data Report estimated the prevalence of Cath in incident HD patients at approximately 65%.² Of the 70% incident dialysis patients on Catheter in DOPPS study, only 59% converted to permanent access in first year.³

The TVC continue to grow for short term and long term use in dialysis population because of being

cheap and their ease of insertion at bed side without available support of such facilities as real time vascular ultrasonography (USG) and fluoroscopy in many of renal units. Routine post procedure CXR has been advised as mandatory before commencing dialysis therapy to identify procedure related immediate mechanical complications and particularly to ensure that Catheter is well positioned and no pneumothorax/hemothorax had resulted. Thus a considerable time delay may occur in initiation of therapy. The perception of time delay may prompt the resident staff to opt for a femoral access, with its attendant complications of infection, deep vein thrombosis and repeated need for further

catheterizations. In addition an extra cost of radiography is added to hospital budget sources.

The value of post procedure CXR has remained controversial due to limited number of prospective studies in dialysis populations. Therefore the present study sought to determine the ability of physicians to reliably predict in advance complications associated with insertion of TVC, based on a clinical decision design which is based on the procedure experience and patient's symptoms and signs during the procedure to decide whether a CXR is warranted.

Materials and Methods

All patients, requiring HD for End Stage Renal Disease through TVC in Nephrology unit of Pakistan Institute of Medical Sciences Islamabad, during the period March 01, 2009 to August 31, 2009 were included in this study. The route of vascular access either SCV, IJV or femoral vein and side were chosen by the operating physician.

All procedures were carried out either independently by experienced Nephrology residents or house staff and junior resident and resident of internal medicine rotating to nephrology services under direct supervision of senior Nephrology resident, without the assistance of real-time USG or fluoroscopy, by the standard anatomical landmark method.

The standard technique of Seldinger guide wire was followed under local anesthesia using lignocaine 2%, while patient was awake. If a patient had more than one placement of a Catheter during the study period, he or she could be recorded twice for two separate new placements. The operating physician completed a detailed questionnaire for each Catheter insertion, designed to detect potential complications and to predict the necessity or lack of it for a post procedural chest radiograph. The questionnaire documented patient's characteristics, urgent or non urgent need for dialysis, site and side of venous access placement, catheter size and success at initial or alternate site. Depending upon the technical difficulties of arterial puncture, skin hematoma, number of needle passes more than 3, difficulty in advancement of guide wire, vessel dilator or catheter, the procedures were divided into high risk and low risk groups for complications. The operators experience and patients having pain or sensations in neck, ear or chest and symptoms and signs of pneumothorax as shortness of breath, chest pain and cough during or after the procedure were noted and correlated with clinical prediction of complications and thus need or no need of post procedure chest radiograph. Wherever possible 12cm catheters for Right and 15cm for Left SCV or IJV were chosen. Time spent on the actual procedure was recorded.

A post procedure CXR was obtained in each case and the position of the Catheter and mechanical complications as pneumothorax, hemothorax and

mediastinal hematoma were recorded. The appropriate position was considered if the Catheter tip was at the junction of superior vena cava with right atrium. Any placement of catheter tip in right atrium or ventricle, or in the internal jugular vein from a subclavian attempt or cross over to the vein on contralateral side was recorded as malposition. Time required in acquisition of the CXR was recorded.

Results

During the study period a total of 635 temporary vascular catheters were placed for dialysis. Of these 117(18.4%) were femoral cannulation, 89 (76%) of which were placed in evening and night times. Forty one (35%) of femoral cannulations were performed by junior staff. These 117 femoral cannulations were not further included and analyzed in the present study.

The remaining 518 catheter placements were further analyzed in study. The mean age of patients was 48.6 ± 12.3 years and there were 354(68.3%) males and 164(31.7%) females.

Table I: Sites and Successful placements of the TVCs (n=518)

Site	Number(%)
Subclavian	284(54.8)
Right	262 (92)
Left	26(8)
Internal Jugular	234(45.2)
Right	225(96)
Left	9(4)
Successful placements	518(100)
Initial site	495(95.7)
Alternate site	23(4.3)

In 450 (87%) catheter placements, the patients required dialysis for urgent reasons, like severe metabolic acidosis, hyperkalemia, encephalopathy, and fluid overload situations, and 279 (62%) were placed on initiation of first dialysis for their renal failure. Table I shows the sites of catheter placements and the success rate of procedures at initial and alternate sites. Table II shows 100 patients met the criteria for high risk and 418 were classified as being in low risk group.

Table II: Characteristics of High Risk Procedures (n=100)

Complications	Number (%)
Arterial Puncture	14(2.7)
Hematoma at catheter site	17 (3.3)
Needle passes > 3	45(8.6)
Difficult procedure	24(4.7)

Table III shows an overview of the radiological complications observed in this study. All the 3

procedures, the physicians correctly predicted the need or need not of post procedure CXR on clinical grounds.

Table III: Radiological Complications

Procedure type	Total Number(%)	Pneumothorax Number(%)	Hemothorax Number(%)	Mediastinal Hematoma Number(%)	Malpositions Number(%)
All n=518	16(3)	2(0.4)	1(0.2)	0(0)	13(2.4)
Subclavian n=284	8(2.8)	2(0.7)	1(0.35)	0(0)	5(1.76)
Internal Jugular 234	8(3.4)	0(0)	0(0)	0(0)	6(6)
High Risk n=100	9(9)	2(2)	1(1)	0(0)	6(6)
Low Risk n=418	7(1.67)	0(0)	0(0)	0(0)	7(1.67)

complications of pneumo/hemothorax were reported only with SCV vein placements. The catheter malpositions for subclavian and internal jugular placements were not different. No complications of mediastinal hematoma, brachial plexus injury, pericardial tamponade, and catheter or guide wire fractures were reported in entire study.

In the low risk group, no complications of pneumo/hemothorax were reported either with SCV or IJ vein insertion and operating physicians correctly predicted it. A total of 7(1.67%) catheter malpositions were reported in this group, one catheter landed in the ipsilateral internal jugular vein from the subclavian placement and need for x-ray chest was correctly predicted on patient complaining ear ache during the procedure. The rest of all six malposition deep in right atrium from IJV catheter placements occurred without any warning symptoms and thus were not predicted for need of CXR. However 3/6, malposition were later related to bigger size. 15cm catheters being used for right IJ vein in relatively short stature females which could have been avoided by using the appropriate size catheter. So in 412/418 (98.5%) of low risk procedures, the need not prediction of post procedure CXR on clinical grounds was correct.

In the high risk group all the 3 pneumo/hemothorax were reported only in subclavian placements and were related to inexperience of operator, multiple attempts at cannulation (mean 5) and patient's complaints of chest pain/dyspnea and cough. The senior nephrology resident, supervising the procedure, predicted correctly the need for post procedure CXR in all three cases. Of the six catheter malpositions in this group in 2 malpositions catheters landed in ipsilateral IJV from subclavian insertion and need of CXR was correctly predicted by operating physician due to complain of ear ache and sensation in the neck by the patient during the difficult procedure and 3 catheters landed deep in the right atrium from IJ placement and one catheter from a subclavian placement was misdirected to the contralateral side. These 4 malpositions were not predicted for need of CXR. These malpositions were not related to operator's experience. So over all in 96% of these high risk

Discussion

Vascular access type is associated with morbidity and mortality in hemodialysis patients.⁴ The native AVF is recommended as the access of first choice by Kidney Disease: Improving Global Outcomes (KDIGO) guidelines.¹ However despite these efforts, still 70% of the patients in United States, start treatments with a catheter.³ Our study also shows that 62% of our incident HD patient started treatment with TVC and 87% required treatment for an emergent condition for HD. This denotes poor compliance of patients to dialysis therapy and the need of more aggressive efforts to educate the patient for AVF preparation.

In this study, prospective TVC procedures. We report only 16(3%) radiological complications, without the use of real time USG or of fluoroscopy and the procedures were performed by all the residents with variable experience. Only 2(0.4) pneumothorax, 1(0.2%) hemothorax and 13(2.4%) catheter malposition were documented. None of the procedures was complicated by arrhythmias, mediastinal hematoma, pericardial tamponade, brachial plexus injury, fractured catheter and broken guide wire, as reported elsewhere.⁵⁻¹² The SCV placements were more associated with pneumo and hemothorax compared to IJV (0.7%) and (0.35%) Vs (0%) and (0%) respectively. This is in agreement to recent studies reporting pneumothorax with IJV cannulation at 0-1% and with SCV at a rate of 0-3%.^{6,13-15}

The study by Palepu et al using real-time USG and landmark technique reported overall 0% pneumothorax in both groups, Gladwin et al using IJV reported 0.9%, Lanza et al using B mode and color Doppler USG reported one (0.9%) pneumothorax in 107 procedures.^{14,16,17} Pickwer et al reported 13(0.58%) cannulation associated pneumothorax in 22230 catheterizations and reported a significant difference with SCV (1.6%) and IJV (0.37%), supporting the results of our study.¹⁸ Puls et al and Kurdi reported 3% incidence of pneumothorax in their respective studies and Shohaib et al described 2.6% pneumothorax and 0.6% hemothorax in dialysis patients with SCV

catheterization.^{13,15,7} Farrel et al in a study of 460 IJ cannulations for HD, 22.8% of which were performed under US G guidance, reported 0% incidence of pneumothorax.⁶ Thus our study supports the previous observations that IJV cannulation is more safe than SCV, in respect of pneumothorax.

We reported overall a low rate 13/518(2.4%) of catheter malposition, 3.4% in IJV and 1.76% in SCV, 1.67% in low risk and 6% in high risk group. However in 3 cases large 15cm size catheters in short stature female explained the malposition in right atrium from right IJV cannulation and thus were avoidable. Three catheters misdirected in IJV from SCV placement, were predicted for need of CXR due to patient experiencing pain and sensation in neck and ear. Rests of the 7 malpositions were not predicted beforehand for the need of CXR. All these catheter malpositions were subsequently repositioned; none of these complications were of significance because none of them resulted in a serious adverse event. The catheter malpositions in our study are comparable to those reported by Shohaib et al (2%), Puls et al (2%), Brown et al (2.4%), Lessnau (2%).^{7,13,19,20}

As we classified the catheterization procedures into low risk and high risk for complication, based on technical difficulties, all the 3 complications of pneumo/hemothorax were reported only in high risk group 3% VS 0%, all with more than 3 needle passes and procedures were done by the junior residents. This is in agreement to previous reports of McGee and Gould reporting complication rate increasing after three or more needle passes to six times as compared to successful procedures with one needle pass and Mansfield et al noted a similar observation of six times complications with more than two passes.^{21,22} The attending senior resident correctly predicted the need for chest radiograph. The two patients with pneumothorax did not require chest intubation and hospitalization as it was less than 10%. The only single complication (1%) of hemothorax in high risk group needed a chest tube and hospitalization and 210ml blood stained fluid was drained.

Based on the clinical judgment and technical difficulties in high risk group, in 96/100 (96%) procedures the physician correctly predicted the need or need not of post procedure CXR while in the low risk group in 412/418(98.5%) the physician correctly predicted need not of post procedure CXR. Recent studies have questioned the need and utility of these routine post procedure chest radiographs, previously thought to be mandatory. Many of them have enrolled less than 100 patients,^{7,13,20} but the other two studies evaluated 460 and 2230 cannulations respectively and all suggested that routine CXR are not required.^{6,18}

In two other studies, involving imaged guided central venous catheterization, using B mode USG and

color Doppler sonography and comparing with post procedure CXR Lanza et al and Vezzani et al reported a concordance of 98% in the their studies and suggested use of sonography as initial investigation to save time and minimize radiation exposure.^{17,23} Koraglu et al used real time USG and fluoroscopy in emergent dialysis patients and Lucey et al and Brown et al used fluoroscopy for central venous catheters and compared the complication of catheter malposition and pneumothorax with routine CXR and concluded that image guided central venous catheters insertion, do not require a routine post procedure CXR and it can be obtained on a case by case basis at the discretion of the operating physician.^{24,25,19}

The average time spent to obtain the chest radiograph after the procedure in our study was 43±17 minutes, while in another study it was reported as 83±79 compared to contrast enhanced USG.²³ Thus many of the residents in our study may have resorted to attempt femoral vein cannulation, perceiving the time delay in getting chest radiograph.

Conclusion

Routine CXR is of little benefit and may not be mandatory when correct size catheters are used and experienced physicians use the proper technique, clinical judgment and reasonable discrimination between low and high risk procedures while placing TVC for dialysis.

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