

Internal Jugular Vein Occlusion Test for Rapid Diagnosis of Misplaced Subclavian Vein Catheter into the Internal Jugular Vein

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Background: During subclavian vein catheterization, the most common misplacement of the catheter is cephalad, into the ipsilateral internal jugular vein (IJV). This can be detected by chest radiography. However, after any repositioning of the catheter, subsequent chest radiography is required. In an effort to simplify the detection of a misplaced subclavian vein catheter, the authors assessed a previously published detection method.

Methods: One hundred adult patients scheduled for subclavian vein cannulation were included in this study. After placement of subclavian vein catheter, chest radiography was performed. While the x-ray film was being processed, the authors performed an IJV occlusion test by applying external pressure on the IJV for approximately 10 s in the supraclavicular area and observed the change in central venous pressure and its waveform pattern. The observations thus obtained were compared with the position of catheter in chest radiographs, and the sensitivity and specificity of this method were evaluated using a 2 × 2 table.

Results: In 96 patients, subclavian vein cannulation was successfully performed. In four patients, cannulation was unsuccessful; therefore, these patients were excluded from the study. There were six misplacements of venous catheters as detected by radiography. In five (5.2%) patients, the catheter tip was located in the ipsilateral IJV, and in one (1.02%), the catheter tip was located in the contralateral subclavian vein. In the patients who had a misplaced catheter into the IJV, IJV occlusion test results were positive, with an increase of 3–5 mmHg in central venous pressure, whereas the test results were negative in patients who had normally placed catheters or misplacement of a catheter other than in the IJV. There were no false-positive or false-negative test results.

Conclusion: The IJV occlusion test successfully detects the misplacement of subclavian vein catheter into the IJV. However, it does not detect any other misplacement. The test may allow avoidance of repeated exposure to x-rays after catheter insertion and repositioning.

CENTRAL venous catheters provide an important means of long-term vascular access and a tool to measure central venous pressure (CVP). Internal jugular veins (IJVs) and subclavian veins are commonly used. The most common cause of early catheter malfunction is incorrect

placement of the catheter tip. This is usually detected by chest radiography.¹ Malposition of the central venous catheter is more common with the subclavian approach. Commonly, the misplacement is cephalad into the ipsilateral IJV, although the catheter tip may also be placed in the contralateral IJV or brachiocephalic, azygous, or superior intercostal veins.¹ This may increase the risk of chemical or bacterial thrombophlebitis in addition to impairing the CVP measurement.²

Based on our daily experiences, we previously described a method for detecting misplaced subclavian vein catheters.³ However, we had not formally evaluated the sensitivity and specificity of that method. Therefore, in this prospective study, we studied the incidence of subclavian vein catheter misplacement in IJVs and evaluated the sensitivity and specificity of this bedside test in its detection.

Materials and Methods

The study was approved by the institute's ethics committee (Ethics Committee for Human Studies, Sanjay Gandhi Post Graduate Institute of Medical Sciences, Lucknow, India), and informed written consent was obtained from the patients or the next of kin. One hundred adult surgical patients of either sex who were scheduled to undergo central venous cannulation through the subclavian approach were included in this study. All patients were anesthetized and paralyzed and were receiving controlled ventilation of the lungs. With the patient in the supine position, the skin on both sides of the neck and the infraclavicular area were prepared aseptically. A point at the junction of the medial one third and lateral two thirds of the clavicle in the right infraclavicular area was used as the puncture point. After subcutaneous local infiltration (1% lidocaine, 2–3 ml), a 22-gauge hypodermic needle on syringe was used to locate the subclavian vein. An 18- or 16-gauge introducer needle was then inserted at the pilot puncture point and was directed toward the sternoclavicular joint. Free flow of venous blood on aspiration was confirmed in 96 patients, whereas in 4 patients, the procedure was abandoned because of repeated puncture of the subclavian artery and inability to cannulate the subclavian vein. A J-tipped guide wire was inserted, and the needle was removed. The central venous catheter (Hydrocath; Becton Dickinson Critical Care System Pte Ltd., Singapore) was passed over the guidewire, 10–12 cm into the subclavian vein. On aspiration with the syringe, free flow of blood was

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confirmed. The catheter was connected to the pressure transducer (Sirecust 1261; Siemens, Ehmk Schmidt & Co. GmbH, Germany). The ventilator was disconnected, and baseline pressure was noted. Chest radiography was performed. While the x-ray film was being processed, firm pressure was applied for approximately 10 s over the ipsilateral IJV in the supraclavicular area. The change in transducer pressure and waveform were noted. The same maneuver was repeated on the contralateral side. Occlusion of the IJV impedes venous return and increases venous pressure proximal to the occlusion. An increase of 3 mmHg or more from baseline value was considered to be positive and suggestive of misplacement of the catheter into the IJV. The test was repeated if the increase in CVP was 2 mmHg. The test was considered to be negative if there was no change in the value of CVP or if the change was less than 2 mmHg. The data obtained were computed in a 2×2 table, and the sensitivity and specificity of the test were calculated, with chest radiography as the gold standard.

Results

Among 96 successful subclavian vein cannulations, there were six (6.2%) misplaced catheters detected by chest radiography. Five (5.2%) patients had misplacement of the catheter into the ipsilateral IJV, and one (1.04%) had misplacement of the catheter into the contralateral subclavian vein. The IJV occlusion test was positive in five patients (5.2%) and negative in 91 (94.8%) patients. IJV occlusion test showed that the increase in CVP was in the range of 3–5 mmHg and was associated with flattening of its waveform. No such change in CVP value or its waveform was observed in patients who had the catheter tip in the superior vena cava, right atrium, or contralateral subclavian vein.

There were five subclavian vein catheters misplaced into the IJV, and all were detected by IJV occlusion test. One catheter was misplaced elsewhere (contralateral subclavian vein) and was not detected by this method. There were no false-positive or false-negative tests in any of the patients. After analyzing the 2×2 table, we found that the test has 83.3% sensitivity and 100% specificity to detect the misplacement of a subclavian vein catheter.

Discussion

Correct placement of the central venous catheter is an essential prerequisite for accurate monitoring of CVP and long-term use of the catheter. Misplacement of the tip may enhance the risk of clot formation, chemical or bacterial thrombophlebitis, and catheter erosion in addition to impairing the CVP measurement.^{2,4} The highest rates of misplacement occur in the cubital, external jugular, and saphenous veins. The incidence of misplace-

ment of CVP catheters through the internal jugular vein and the infraclavicular technique of the subclavian vein have been described as 5.7% and 5.5%, respectively.⁵ The most common misplacement of the subclavian vein catheter is into the IJV (5.4%) and does not vary with the side of insertion or whether the head is turned toward or away from the selected side.⁶ Commonly, the misplacement is cephalad into the ipsilateral IJV, although the catheter tip may also be placed in the contralateral IJV or the brachiocephalic vein.¹

Our study shows a 6.2% incidence of misplacement of subclavian vein catheter through the right infraclavicular approach. In 5.2% of patients, the misplacement was in the ipsilateral IJV.

The pressure exerted on the IJV in the supraclavicular area impeded free venous return from this vein, increased CVP proximal to occlusion, and confirmed the catheter's misplacement in the patients who had the catheter in the IJV. Occlusion of the IJV also caused flattening of the CVP waveform in patients who had the catheter tip in IJV, whereas no such change in CVP waveform or value was observed in patients who had the catheter tip in the superior vena cava or right atrium or misplacement of the catheter other than in the IJV.

During inspiration and expiration, intrapleural pressure varies, and this variation in pressure is transmitted to the great veins, leading to fluctuation in CVP of approximately 1–3 mmHg. CVP decreases during negative-pressure breathing and increases during positive-pressure breathing. The variations in atrial pressure are transmitted to the great veins to produce the A, C, and V waves of the venous pressure-pulse curve.⁷ To avoid the fluctuations in CVP due to respiration, we monitored CVP when the patients were not breathing and were disconnected from the ventilator. After IJV occlusion for approximately 10 s, an increase of 3–5 mmHg in baseline value of CVP was observed in patients who had misplaced catheters in the IJV. The flattening of the CVP waveform in these patients could have been due to impedance in transfer of atrial activity in the occluded IJV.

In this study, we performed the occlusion test in patients undergoing controlled ventilation. The test can be performed in conscious and spontaneously breathing patients as well, in which case the patients may be asked to hold their breath at the end of normal expiration during the recording of CVP to avoid respiration-related fluctuation in CVP.

Chest radiography still remains the gold standard and the most commonly used diagnostic tool to detect misplacement of the catheter or pneumothorax. Our method is simple and quick and can be performed at the bedside with no extra cost. Although the use of this bedside test does not eliminate the need for a chest x-ray, the patient can be spared from some added exposure to x-rays after catheter repositioning.

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