Direction of the J-Tip of the Guidewire, in Seldinger Technique, Is a Significant Factor in Misplacement of Subclavian Vein Catheter: A Randomized, Controlled Study

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Misplacement of central venous catheters, predisposing to poor functioning including inability to aspirate blood, is common with the subclavian approach. In this prospective study we sought to determine whether the direction of the guidewire J-tip influenced the catheter tip placement during right subclavian catheterization. In this randomized, double-blind clinical study, we observed the placement of catheters via the right subclavian vein while keeping the J-tip directed either caudad in Group 1 ($n = 147$) or cephalad in Group 2 ($n = 148$) patients. The majority of catheters (97% and 57%) in Groups 1 and 2 respectively entered the superior vena cava/right atrium ($P < 0.05$). The incidence of catheter misplacement into the ipsilateral internal jugular vein was 2% and 40% in Groups 1 and 2, respectively ($P = < 0.01$). Subsequent experimental study confirmed that the direction of the J-tip was retained inside a model of vascular tubes and its tip led the guidewire into the tubing on the same side even at the acute angulation formed between tubings representing the subclavian, internal jugular, and superior vena cava junction complex. The authors conclude that the simple measure of keeping the guidewire J-tip directed caudad increased correct placement of central venous catheters towards the right atrium during right subclavian catheterization.

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The most common cause of early malfunctioning of the central venous catheter is related to malpositioning (1). Location of the central venous catheter tip at other than the normal site near the junction of the superior vena cava (SVC) and right atrium (2) is more frequent after the right subclavian than the right internal jugular vein (IJV) approach (3,4). A flexible angiographic guidewire is used in the Seldinger technique for central venous cannulation. The flexible end of the wire is either straight or J-shaped to facilitate atraumatic passage into vein. The guidewire may have a significant role in some of the complications related to subclavian vein cannulation with looping and entrapment of the guidewire related to perforation of the wall of the vein (5). J-tip guidewires are thus preferred over the straight tip, being less traumatic and easier to negotiate past acute angulations. We postulated that the direction of the J-tip of the guidewire during its insertion via the subclavian vein might determine its ultimate location.

Methods

A randomized, controlled, double-blind study was performed simultaneously in two tertiary care hospitals to test this hypothesis. Approval from the institute's ethical committee and informed written consent from the patients were obtained. Based on power analysis using a lower smaller proportion incidence (5%) (6,7) and the significant relative risk value of 5, at 95% confidence and $P < 0.05$, the calculated sample size was 137 in each group. Thus 300 patients were planned for the study, in which central venous cannulation through the subclavian approach was part of their anesthetic management. Patients with chest or neck deformities were excluded.

Normally the J-tip of the guidewire remains straight inside its sheath until exiting the hub of the puncture needle. As the guidewire leaves the needle, it returns to the J-shape inside the vein. With due care taken at the time of its insertion, the J-tip can be directed either cephalad or caudad (Fig. 1). Thus, based on the direction of the J-tip, patients were divided into two

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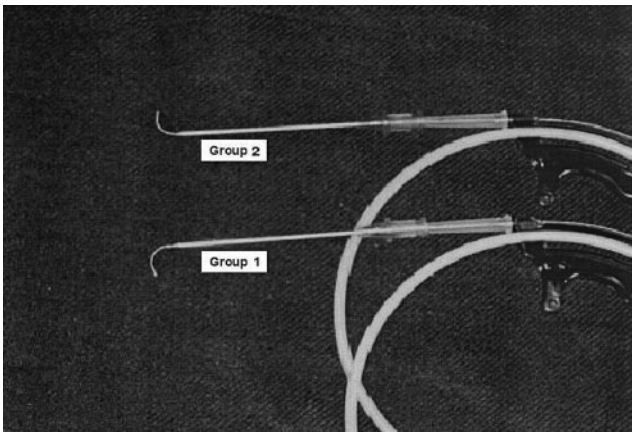

Figure 1. Showing the two different directions taken by the J- tip of the guidewire after coming out of the bevel of the puncture needle in two study groups.

groups. In Group 1 patients, the J-tip of the guidewires was maintained caudad (towards heart), and the J-tip of the guidewires was maintained cephalad in Group 2 patients (Fig. 1).

After the induction of general anesthesia, we placed patients supine, with the right arm along the side of the patient and a wedge underneath the opposite left shoulder (7). The right subclavian vein was punctured by infraclavicular approach in all patients. The puncture site was identified 2.5 cm lateral to the point of junction of the inferior border of the clavicle and the line connecting the apex of the medial head of the clavicle with the lower margin of the coracoid process (7,8). Under full aseptic conditions, the right subclavian vein was punctured using an 18-gauge needle directed medially while keeping the needle horizontal. The free aspiration of venous blood confirmed correct needle placement into the subclavian vein. An independent physician prefixed the direction of the J-tip of the guidewire to either direction in a random fashion using presealed envelopes for the two study groups so that the anesthesiologist was blinded as to the J-tip direction.

After insertion of the guidewire to a depth of 15 cm (9), the introducer needle was removed and the track to subclavian vein puncture was enlarged using the dilator provided in the central venous catheter set (Certofix®, B Braun Melsungen AG, Melsungen, Germany). A triple-lumen catheter (7F) was subsequently passed over the guidewire and fixed at the 10 to 15 cm mark at skin level depending on the body habitus of the patient. Free aspiration of blood through the catheter and the central venous wave form reconfirmed correct placement. Location of the tip of the central venous catheter was determined using preoperative fluoroscopy. Malpositioned catheters, defined as residing anywhere other than SVC/right atrium, were repositioned under fluoroscopic control with the help of the reinserted guidewire.

The incidence of catheter misplacement and untoward effects were noted. The Student *t*-test was applied to compare the mean values of the two groups and χ^2 test for the proportions and at the 95% confidence interval, the calculated value of $P < 0.05$ was considered statistically significant.

To demonstrate the functioning of the J-tip of the guidewire inside a vessel and at the junction of the veins, we studied the performance of the J-tip of the guidewire and its placement inside polyvinyl tubings constructed to simulate the junction of the subclavian, IJV, and SVC complex (Fig. 2A-C). The tubing representing the subclavian vein was punctured with the same 18-gauge needle. The J-tip of the guidewire was then directed randomly downwards as in Group 1 (i.e., towards SVC) and then upwards as in Group 1 (i.e., towards IJV) in 30 attempts respectively. We noted the direction of the J-tip as it left the needle in both groups and also the tubing into which the guidewire entered after negotiating the junction. Photographs were also taken at these two steps to record the movement of the J-tip (Fig. 2A–D).

Results

Subclavian vein puncture and catheterization was successful in 295 of 300 patients. Five patients in whom subclavian vein puncture failed were excluded from the study. In three patients the subclavian vein could not be entered with the needle, and in two patients hematoma developed after arterial puncture and the site was changed. The two groups were similar in terms of age, sex, weight, and height distribution (Table 1).

Of the total misplaced (location other than the SVC or the right atrium) catheter tips (69 of 295; 23.3%), the majority of these catheters (63 of 69; 91%) entered the ipsilateral IJV. There were significantly more misplaced catheters ($P < 0.01$) in guidewires with the J-tip directed cephalad (Group 2) compared with those directed caudad (Group 1) (Table 2, Fig. 3). No other clinically significant adverse effects were observed except cardiac arrhythmia in 48 of 147 (33%) patients of Group 1 in whom guidewire frequently entered into the right atrium, in contrast to 6% of patients with arrhythmia in Group 2.

In our experimental *in vivo* study, with 30 attempts, the J-tip maintained upward and downward direction once it came out of the needle. At the simulated vessel junction the J-tip took its natural curve leading the guidewire into the respective side of the tubing (i.e., downward into the SVC in Group 1 and upward into the IJV in Group 2). In none of the attempts did we observe the J-tip rotating as advanced through the tubes (Fig. 2A-D).

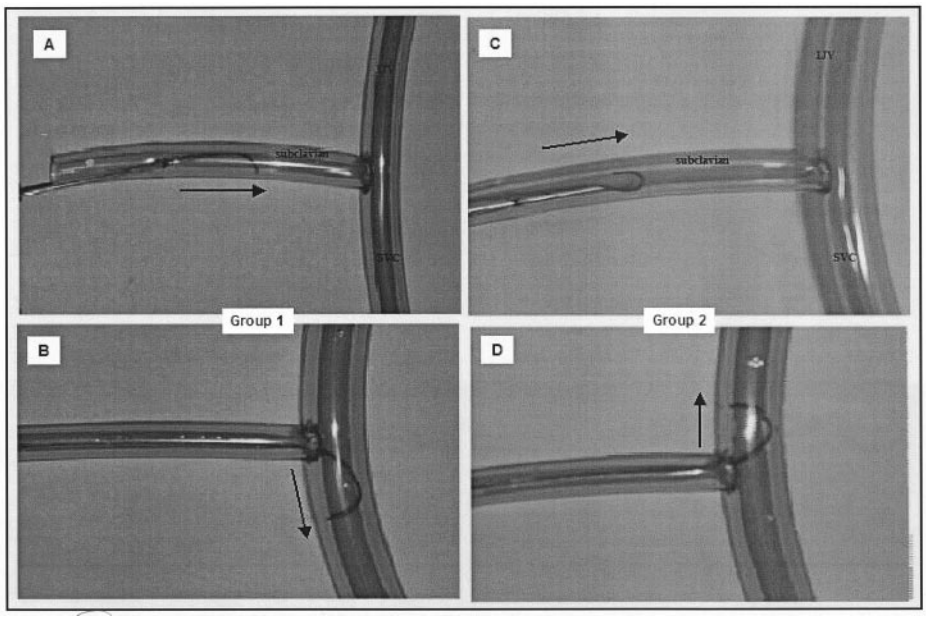

Figure 2. Different stages of the guidewire J-tip as it is passed through simulated central venous vessel model for subclavian puncture. The J-tip acquires the same direction at the needle and leads into the respective side of the tube at the junction. A, the downward directed J-tip when directed caudad and entering the downward directed tube "B" at the junction as in Group 1. C and D showing again the upward direction taken by the J-tip at needle level and again entering into the cephalad tube at the junction as in Group 2.

Table 1. Demographic Data

	Group 1 (n = 147)	Group 2 (n = 148)
Male:Female	81:66	76:72
Age (yr)	49 ± 16	47 ± 19
Height (cm)	161 ± 15	158 ± 18
Weight (kg)	57 ± 11	56 ± 14
Direction of guidewire	Caudad	Cephalad

Values are mean ± SD.

Discussion

Central venous catheter tip placement at the junction of SVC and right atrium is important for accurate central venous pressure (CVP) measurement (2). A misplaced catheter tip not only defeats the purpose of correctly measuring CVP but also predisposes it to the risk of obstruction to aspiration, clotting, thrombophlebitis, erosion of the venous wall, cardiac tamponade, and failure to aspirate air in the event of air embolism (10–12). In subclavian vein cannulation, misplacement into the ipsilateral IJV is common, although it can also access the brachiocephalic trunk or the contralateral IJV, azygos, or superior intercostal veins (1). Drugs administered into a catheter that lies very cephalad in the IJV may produce cerebral effects with little or no desired therapeutic effect on the heart (13).

Blitt et al. (14,15) originally described the use of the J-tip guidewire and its success to negotiate the sharp bend of the external jugular vein for central venous cannulation. Smith et al. (16) also reported more than 90% proper placements of J-tip angiographic wire catheters for central placement through the antecubital vein. However, no study has reported the performance of a J-tip guidewire in subclavian vein puncture, especially in terms of the direction of the J-tip. Because we used the image intensifier for detection of catheter location, we could observe the frequent misplacement of catheter tips into sites other than the normally intended site of the SVC and right atrial junction. All the misplaced catheters were repositioned to the SVC, thus avoiding potential adverse consequences from malpositioning.

The incidence of catheter misplacement through the infraclavicular technique of subclavian vein catheterization has been reported to be 5.5% in one study (3). Sanchez et al. (6) have also shown that 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 towards or away from the side of insertion. Another study reported that 6.2% of catheters from the right infraclavicular approach were misplaced (other than right atrium) and in 5.2% of the patients it entered the ipsilateral IJV only (17). However, none of these studies controlled the direction of the J- tip during insertion.

Similarly, we also have observed that the majority of the misplaced catheters had entered the ipsilateral IJV (63 of 69). However, it was significantly ($P < 0.01$) less in Group 1 patients with a caudad direction of the J-tip of guidewire. The observed significant increase in ipsilateral IJV cannulation to 40% further corroborated that the direction of the J-tip had a significant role in controlling misplacement of a guidewire through the subclavian route.

Our *in vitro* experiment confirmed that the J-tip of the guidewire at acute angulation of the simulated vessel junction followed the path of its inherent curve. This helps to explain the significantly frequent placement of CVP catheters into the ipsilateral IJV. Although rotation

Table 2. Incidence of Catheter Misplacements

	Group 1 (n = 147)	Group 2 (n = 148)
Misplacement detected by image intensifier	5 (3%)	64 (43%)*
Misplacement into ipsilateral IJV	3 (2%)	60 (40%)*
Misplacement into contralateral IJV or Brachiocephalic vein	2 (1%)	4 (3%)

IJV = internal jugular vein.
* Statistically significant ($p < 0.01$) difference from Group 1.

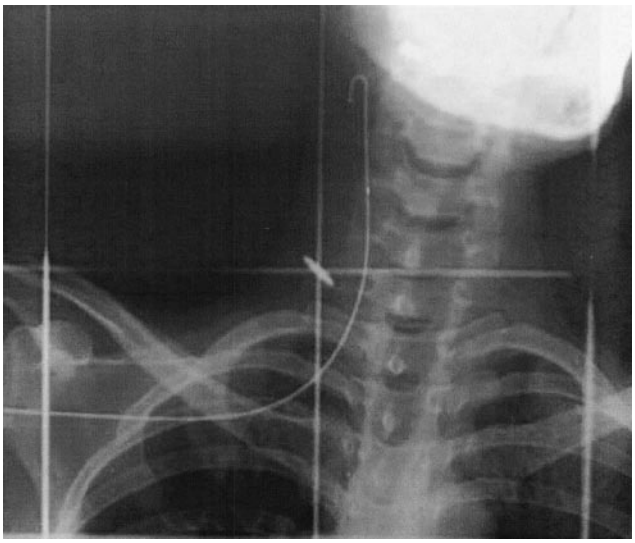

Figure 3. Chest radiograph AP view taken in a Group 2 patient showing the cephalic direction of the J-tip and retaining the same relation even in the internal jugular vein.

of the J-tip did not take place in this experimental design with rigid tubes and 100% of the attempts followed the curve of the J-tip into the same side tubing at the junction, rotation could occur inside veins that are more compliant. This may explain failure to achieve 100% "success" of the guidewire entering the IJV in Group 2 patients in whom the J-tip was directed cephalad.

One study has reported that the manual occlusion of the ipsilateral IJV during subclavian vein cannulation reduced catheter advancement into the ipsilateral IJV from 7.14% to 2.06% (18). However, the procedure may be contraindicated in neurosurgical patients because of the risk of increasing intracranial pressure. The simple maneuver of ensuring caudal direction of the J-tip not only improved correct placement of the central venous catheter into the SVC/right atrium but also reduced the incidence of ipsilateral IJV cannulation to a comparable level of 2% achieved with the IJV compression technique.

We conclude that in right subclavian catheterization, the simple measure of directing the guidewire J-tip caudad significantly facilitates central venous catheter tip placement into the SVC/right atrium and also reduces risk of misplacement into the ipsilateral IJV.

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