Malposition of Central Venous Catheter

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(Key words: central venous catheter, malposition)

Percutaneous insertion of central venous catheter (CVC) have been widely accepted for monitoring central venous pressure[1] and for total parenteral nutrition[2]. In addition, the catheters have also been used for rapid volume replacement in patients in a state of shock, for insertion of venous pacing electrode and for removal of air emboli that may occur in neurosurgical procedures performed on patients in the sitting position[3]. Much has been written with regard to the complications of CVC[4]. Catheters which are not correctly positioned in the great veins of the thorax are a less commonly appreciated hazard. The author presents a retrospective analysis of malposition of catheter tip based on chest x-ray. Previous reports on malposition of CVC and complications as a result of malposition of CVC in the internal jugular veins will be reviewed. Finally, methods which may be of help in positioning the CVC in the proper location (innominate vein, superior vena cava or right atrium) will be reviewed.

Materials and Methods

One hundred and eighteen percutaneous central venous cannulations performed on one hundred surgical patients admitted to a general adult surgical intensive care unit were evaluated retrospectively as to the location of the catheter tip. A CVC is judged to be positioned correctly on clinical criteria by the length of the catheter inserted, ability to aspirate and inject blood freely via a syringe attached to the catheter, free inflow of fluid and back flow of blood when the infusion unit was lowered below the right atrium of the patient, and fluctuation of the saline meniscus with respiratory cycle. A chest x-ray was taken soon after CVC insertion by a portable system to confirm the course and location of the CVC tip.

The following venous approaches were used, right internal jugular vein (50 occasions); left internal jugular vein (10 occasions); right subclavian vein (45 occasions); left subclavian vein (10 occasions); right external jugular vein (2 occasions); right basilic vein (1 occasion). For cannulating the subclavian veins, the infraclavicular approach at the midclavicular point with the patient's head turned away from the side of the puncture as described by Wilson et al.[5] was used. For cannulating the internal jugular vein, the low central approach described by English et al[6] was used. The CVCs used during the period of study were BARDI-CATH (Pennywell Industrial Estate, Sunderland, England SR4 9EW length 30.4 cm) and CAVAFIX (B. Braun Melsungen AG, W Germany length 32 cm). Both types of catheters are radio-opaque.

Results

One hundred and eighteen percutaneous central venous cannulations were performed on one hundred patients. Table 1 shows the final position of the CVC tip in relation to the sites of venous cannulation.

A catheter tip was considered to be

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Table 1. CVC tip location: A comparison of different routes of cannulation

Site of Cannulation	Number	CVC Tip Locaiton							
		RA		SVC		IV		Malposition	
		No	%	No	%	No	%	No	%
Right internal jugular vein	50	10	20	40	80	–		–	
Left internal jugular vein	10			5	50	3	33	2*	20
Right subclavian vien (infraclavicular approach)	45	10	22.2	27	60			8**	17.7
Left subclavian vien (infraclavicular approach)	10			5	50	5	50		
Right external jugular vein	2			1	50	1	50		
Right basilic vein	1			1	100				
TOTAL	118							10	8.4

RA – right atrium
SVC – superior vena cava
IV – innominate vein
* 1 in left internal mammary vein (fig. 1, 2), 1 in external jugular vein (fig. 3).
** 1 in left subclavian vein (fig. 4)
7 in right internal jugular vein.

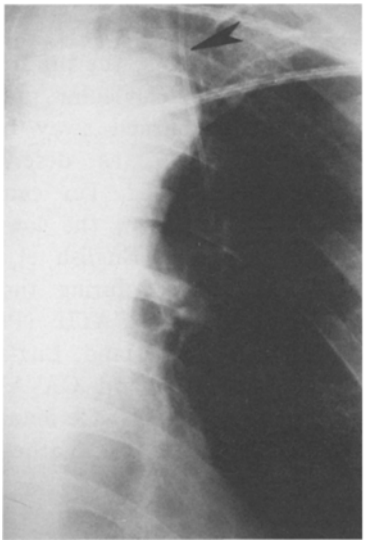

Fig. 1. Anteroposterior chest x-ray shows the unusual left paramedian course of the CVC inserted via the left internal jugular vein (arrow)

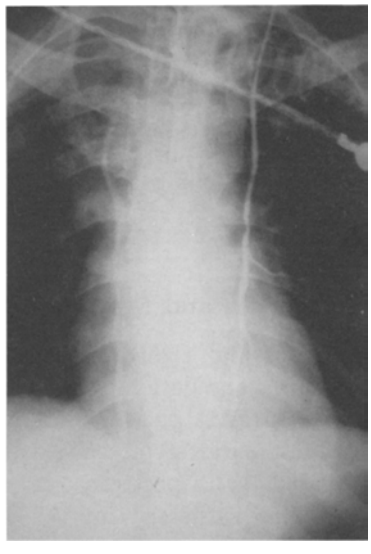

Fig. 2. Venogram delineating the left internal mammary venae comitantes.

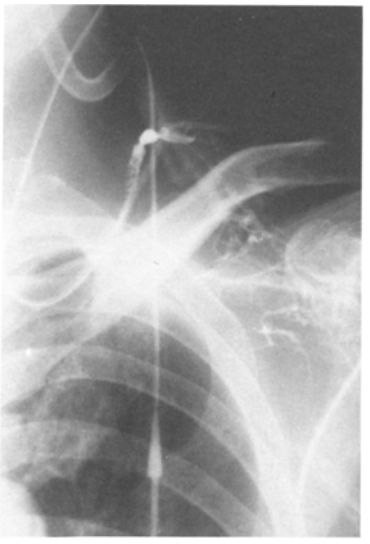

Fig. 3. A CVC inserted into the left internal jugular vein had exited into the left external jugular vein, contrast medium injected into the CVC delineating some of the tributaries of the external jugular vein

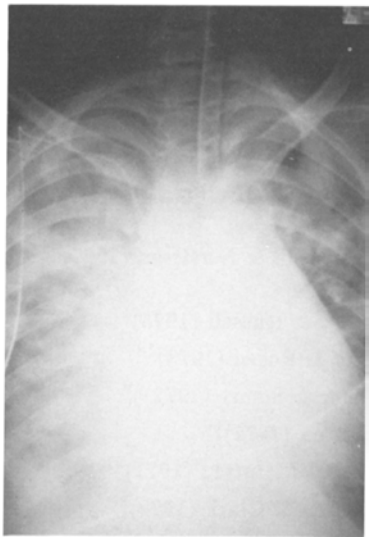

Fig. 4. A CVC inserted into the right subclavian vein had exited into the left subclavian vein (arrow)

misplaced if it is not located in the innominate vein, superior vena cava or the right atrium. 10 out of 118 CVC tips (8.4%) were judged to be misplaced. Seven out of 45 (15.5%) catheters inserted via the right subclavian vein had exited into the right internal jugular vein.

Discussion

The correct location of a CVC tip should always be ensured to avoid serious complications such as thrombosis, thrombophlebitis, perforation of the myocardium[7] and inaccurate pressure reading[8]. The risk of thrombosis is increased because of elevated osmolality and viscosity and the changed pH of the infused solutions[9]. In the literature, little attention is devoted to catheter malposition, however. It is not the malposition per se, but the complications that can arise from a misplaced catheter that make recognition and correction important.

Ideal location of CVC tip

For valid measurement of CVP, the right atrium is the best site for taking accurate CVP reading, several features of peripheral vein dynamics such as the presence of venous valves, venous constriction and narrowing of lumen can predispose to wedging of a catheter and affect the reliability of the measurements. However, placement of the catheter in the right atrium is associated with further risks such as atrial perforation leading to cardiac tamponade[7].

Michenfelder[3] in 1966 recommended the insertion of a catheter into the superior vena cava or right atrium prior to major neurosurgical procedures performed on patients in the sitting position. The value of the catheter was to aspirate air and avoid potential emboli. However, the issue on optimal location of catheter tip in the management of venous air embolism is still unresolved[10–13].

Incidence of malposition of CVC tip in the internal jugular vein (IJV)

The site and frequency of malposition of a catheter tip depend on several factors – the site of insertion, the technique used, and body positioning. The veins that are

Table 2. Summary of reports on malposition of CVC

Authors (with reference no.)	Sites of venous cannulation	Total no of venous cannulation	Total incidence of CVC malposition (%)	Malposition of CVC to IJV(%)
1. Haapaniemi & Slatis (1974)[14]	SV (SC)	600	1.7	*
2. Malatinsky & Kadlic (1976)[15]	EJV, IJV, IV, SV (SC + IC)	378	5.3	1.7
3. Christensen & Nerstrom (1967)[16]	SV (IC) (90 occasions) SV (SC) (8 occasions)	98	8.2	8.2
4. Lumley & Russell (1975)[17]	AV	111	13.0	13
5. Shang & Rosen (1973)[18]	AV, SV (IC)	249	17.6	8.8
6. Kellner & Smart (1972)[19]	AV, EJV, SV (IC)	195	24.6	*
7. Langston (1971)[20]	AV	300	26	16
8. Deitel & McIntyre (1971)[21]	AV, EJV, SV (IC)	245	29	*
9. Johnston & Clark (1972)[22]	AV	73	31.5	15.1
10. Gilday & Downs (1969)[23]	AV	205	33	15

* Unable to calculate percentage of IJV cannulation because of insufficient data presented in the paper

SV (SC) = Subclavian vein (supraclavicular) SV (IC) = Subclavian vein (infraclavicular
EJC = External jugular vein IJV = Internal Jugular vein
IV = Innominate vein AV = Arm vein

Table 3. Complications due to malposition of CVC tip in IJV

Authors (with reference no.)	Complications	Infusate
Christensen KH et al.[16]	one developed poor functioning of the drip	not mentioned
	two developed swelling on the ipsilateral side of the neck	
Neuhaurser EBD[24]	tip eroded into the cervical soft tissues producing cervical and mediastinal tamponade with respiratory compromise	not mentioned
Treels JCC[25]	tip eroded into cervical soft tissue developed right Horner's syndrome and painful swelling of the shoulder and neck	hyperalimentation fluid
Klein HO et al.[26]	headache and stupor	noradrenaline and lignocaine
Saxena VK et al.[27]	raised intracranial pressure and temporary neurological disturbance due to thrombosis of IJV.	hyperalimentation fluid
Souter RG et al.[28]	spreading cortical venous thrombosis	hyperalimentation fluid
Gilner LI[29]	gurgling noise in the ear during infusion	not mentioned
Langston CS[20]	inaccurate central venous pressure reading	not mentioned

used for access have their own peculiarities in anatomical structure which predispose to unique malposition for the catheter inserted.

The author reviewed 10 reports of CVC placement and calculated the incidence of malposition of CVC tip in the IJV (table 2) from the data presented in those reports. Total incidence of malposition = No. of CVC malposition – total no. of CVC insertion × 100 (8.47%). Incidence of malposition of CVC to IJV = No. of CVC tip in IJV ÷ (total no. of CVC insertion minus no. of CVC insertion via the IJV, external jugular veins and innominate vein) × 100 (7/56 or 12.5%). CVCs inserted via the IJV, external jugular veins and innominate vein were excluded from the second calculation, as it is highly unlikely that CVC inserted via these three veins will enter the IJV.

Figures from table 2 show that the total incidence of malposition was lower when the IJV and subclavian veins were used for venous cannulation. When the subclavian veins were used for venous cannulation, the frequency was much lower if the supraclavicular approach was used[14,15,16]. Figures from table 2 also show that malposition of CVC tip in the IJV is a common occurrence (range from 1.7% to 16%).

Total incidence of malposition in this present report is 8.47%, however incidence of malposition of CVC to IJV is 12.5%, this is because 50% of the CVC insertions were done via the IJV. Seven out of forty-five catheters inserted via the right subclavian vein had exited into the right IJV, an incidence of 15.5%.

The cause for this relatively high incidence of malposition of CVC tip to IJV was not clear. It could be because of the small sample size or variation in the insertion technique employed. Although no serious complication arises as a result of malposition of CVC in this present report (all malpositioned CVCs were re-adjusted), a review of reports on complications due to malposition of CVC tip in the IJV was summarized in table 3.

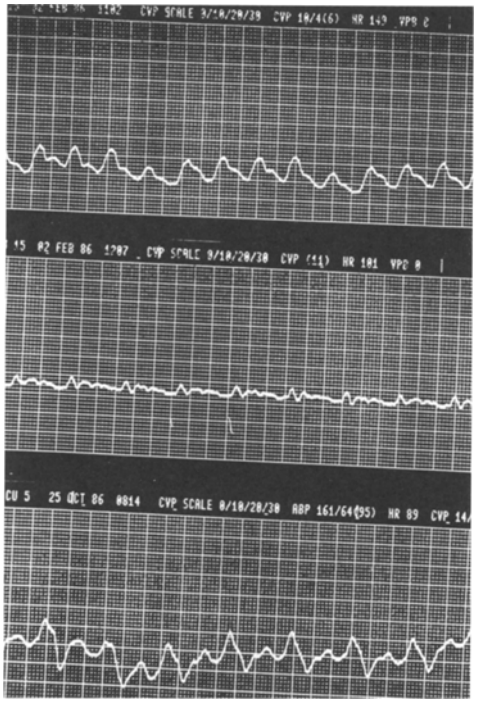

Fig. 5. Venous waveform obtained from CVC tips located in the internal jugular vein (top and middle) mimic the right atrial wave form obtained from a CVC tip located in the right atrium (bottom)

Aids to positioning of CVC tip

1. The catheter (kept in the sterile covering) can be placed against the skin and the length from the intended skin puncture site to an estimated satisfactory central position roughly estimated.
   This is only a very rough guide as the catheter can take an entirely different course after insertion.
2. When the CVC is in place it should be possible to aspirate and reinject blood freely without undue resistance.
3. The catheter is coupled to an infusion unit and a test made to ensure that there is a free inflow of fluid, the infusion unit is then placed below the level of the patient, when a free backflow of blood should be seen in the infusion tubing. Points 2 and 3 merely indicate that the CVC is

communicating with a patent vein and the CVC is not impinged against a valve or completely kinked.

4. Connect the previously charged manometer limb to the catheter lumen with a three way tap, watch the meniscus and look for two distinct oscillatory patterns[30] (a) a larger amplitude (2–4 cms), lower frequency oscillation produced by ventilation; and (b) a smaller amplitude, higher frequency oscillation produced by cardiac ventricular action. Although every catheter tip in a central vein causes respiratory fluctuation, respiratory fluctuation alone is not an indication of central placement.
5. A correctly functioning transducer will reproduce the right atrial waveform. However, similar waveform can be produced when the CVC tip is in the IJV (fig. 5).
6. Accurate placement of the catheter tip in or near the right atrium can be accomplished with intra-atrial electrical recordings, using a teflon-coated wire[31] or else the catheter can be filled with 5% hypertonic saline solution[32] or 8.4% sodium bicarbonate solution[33] the proximal end of the wire or the saline filled catheter is then connected to the exploring lead of the electrocardiogram, when the catheter enter the right atrium, characteristic large, diphasic atrial complexes are recorded.
7. Fluoroscopic guidance during the threading of the catheter is useful but certainly not practical in vast majority of cases.
8. A chest x-ray is the only certain method of identifying the course and tip of the catheter[19,20,22,23] it should be taken soon after each CVC insertion to exclude mechanical complication during percutaneous venepuncture. Infusion of vasoactive drugs or hyperosmolar solution should be commenced only after excluding malposition of CVC tip in the IJV or a small mediastinal vein. Demonstration of proper positioning of the catheter on a chest x-ray ensures only that the catheter is in place at the time the x-ray is taken. Secondary malposition, or migration of the catheter after initial proper placement can occur. Vazquez et al[34] reported 116 consecutive percutaneous silicone CVC inserted via the subclavian vein using mostly the supraclavicular approach from 1981–1984. There were no primary catheter malpositions, however, secondary malposition occurred with 6% of the catheter.

   It has been suggested that because of movement of the catheter tip produced by shoulder movement of an arm through which the catheter has been inserted, and in consideration of the level of pericardial reflection around the superior vena cava, the tip should not be more than 2 cm below a horizontal line joining the lower surfaces of the medial end of each clavicle, and the arm should not be abducted beyond 90 degrees[35].
9. Only radio-opaque catheters are acceptable for central venous catherization. However, when there is any doubt regarding the position of the catheter, angiography with a small volume of contrast material will assist in determining the exact location of the catheter tip. Injection of contrast material may introduce problems of its own, such has hypersensitivity reactions and masking of intrathoracic features on x-ray, in the case of extravasation of the catheter tip.
10. "Half-way" venous catheters[36]: a "half-way" catheter is a venous catheter with the tip located at the boundary between the peripheral veins of the upper extremities and the great intrathoracic veins. This boundary is represented by the lateral margin of the first rib. Practically, in adults the tip of the "half-way" catheter is placed in the proximal axillary vein or in the distal subclavian vein. This will eliminate the following disadvantages associated

with the use of traditional "long-way" basilic and cephalic veins catheters (a) high rate of CVC tip malposition (b) displacement of the CVC tip with arm movements.

11. Most techniques for placing CVC have been refined, resulting in an acceptably low complication rate, with the most common complication being malposition of the catheter. Malposition of CVC tip in the IJV being the commonest especially if a long catheter is used to cannulate the arm veins or subclavian vein (infraclavicular technique). Although chest x-ray is the most reliable mean of checking the course and location of tip of CVC, some immediate bedside checking methods are available to reduce the possibility of malposition of CVC tip in IJV, and permit their early recognition should they occur.
    (a) Dietel and McIntyre[21] suggested turning the patient's head towards the side of insertion might alter the angle between the subclavian and internal jugular vein and so reduce the incidence of this malposition. Lumley and Russell[17] did not find this manoeuvre useful in reducing this complication when they inserted their CVC through an arm vein.
    (b) Lumley and Russel[17] suggested compressing each side of the neck separately (avoid compressing the carotid sinus) and monitor the CVP, an acute rise in the manometer meniscus of more than 10 cm suggests the catheter tip is located well into the corresponding IJV. The same authors also reported one false negative response that occurred when the catheter tip was in the right IJV about 2 cm, and was probably only just above the thoracic inlet, compression on the middle of the neck would have been well clear of the catheter.
    (c) A conscious patient may complain of pain in the neck or pain referred to the ear when the CVC is misplaced in the IJV[34].
    (d) Gilner[29] reported the infusion of fluids through an aberrantly placed catheter in the internal jugular vein is associated with a benign annoyance called the "ear gurgling" sign, which is the sound of a "running stream" rushing past the ear.
12. Saline injection test – Tinker et al.[37] suggested that one method of ensuring proper placement of the catheter tip was to use a precordial Doppler probe which was placed over the site of right atrium, 5 ml of saline solution was forcefully injected into the catheter. The resulting turbullence produced alteration in Doppler sounds that was regarded as signifying both the probe was properly positioned over the right heart and that the catheter tip was located in or near the right atrium. However Colley et al.[38] reported that even when the catheter tip was in the axilla, proximal part of the upper arm or IJV, injection of saline solution also produced a marked alteration in Doppler sounds.
13. Studies[20,21,23] using the traditional approach to pass the catheter into the central vein using the antecubital fossa as the puncture site have shown that the approximately 70–75% of catheters placed this way will be in a satisfactory position (i.e. within the innominate vein, superior vena cava, or right atrium). Bridges et al.[39] reported highest success rate (98 per cent) occured when the basilic vein was used, with the patient positioned so that the upper part of the body was raised at 45–90 degrees to the horizontal and using a soft Bardic 16 gauge catheter with a special insertion technique.

Acknowledgement: The author wishes to thank the editor of Anaesthesia and Intensive Care for giving permission to reproduce figure 2, and Ms Mary Cheong for typing the manuscript.

(Received Sep. 24, 1987, accepted for

publication Nov. 27, 1987)

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