The THAI Journal of SURGERY 2004; 25:125-128.
Official Publication of the Royal College of Surgeons of Thailand

Can "Fluctuation of the Fluid Level" Predict "the Position of the Tip of Central Venous Catheter" ?

Monthien Lueprapai, MD
Mawin Vongsaisuwon, MD, MSc
Department of Surgery, Lerdsin Hospital, Bangkok, Thailand

Abstract

Objective: **To determine correlation between the clinical parameter (fluctuation of fluid level) and the position of the tip of central venous catheter.**

Design: **Prospective, observational study.**

Setting: **Patients in surgical ward or ICUs at Lerdsin Hospital, Rajvithi Hospital, and Nopparatana Rajathanee Hospital.**

Patients: **Consecutive patients (n = 80) requiring central venous cannulation.**

Intervention: **After each basilic venous cutdown, the patients were instructed to have chest radiography. The tip of central venous catheter was assumed to be in proper position if the fluctuation of fluid level reached 4 cm. Actual radiologic findings were subsequently compared against clinical predictions.**

Main Outcome Measurements: **Ability of the clinical parameter (good fluctuation of fluid level) to correctly predict the position of the tip of central venous catheter.**

Results: **Good fluctuation of fluid level can be obtained in 90% of patients. The ability of this clinical parameter to predict the position of the tip of central venous catheter was quite high (94.2% sensitivity, 36.0% specificity, 90.2% positive predictive value, 50.0% negative predictive value).**

Conclusion: **This parameter is reproducible with high sensitivity, but low specificity. The number of patients may not be enough to draw a decisive conclusion.**

Key Words: **Basilic venous cutdown, venesection, the tip of central venous catheter, radiography**

Patients in critically ill period need closed monitoring. Following the classic work on venous pressure, central venous pressure monitoring has been used to guide volume replacement after hemorrhage, surgery, accidental trauma, sepsis, and other emergency conditions with suspected blood volume deficit or excess.

There is little consensus regarding the most efficient or the safest method to place a central venous catheter[1]. In Thailand, almost all physicians are familiar with the basilic venous cutdown due to its simplicity, rapidity, and safety. Controversy still exists as to whether chest radiography is needed after the procedure. The main purpose of chest radiography is to check the position of the tip of catheter whether it locates in the neck (internal jugular vein) or in the chest (SVC or right atrium). The disadvantages include increased costs, delay the use of central lines, and radiation exposure. Early recognition and management of malpositioned central venous catheters not only guard against serious complications[2-4] but also allow proper catheter function and prevent delay of intra-venous therapy[5]. No evidence suggests chest radiography after basilic venous cutdown.

The presence of venous valves in the internal jugular and subclavian veins at the thoracic inlet has been well documented[6,7]. The internal jugular vein valve is present just above the termination of the

internal jugular vein[8]. Valve in the internal jugular vein prevents transmission of pressure from great vessels in the chest to the neck[6].

We hypothesized that good fluctuation of fluid level could correctly predict the position of the tip of central venous catheter. To test this hypothesis, we compared clinical predictions against actual radiologic findings.

Materials and Methods

The need for informed consent was waived by the hospital ethics committee, because this was purely an observational study involving no alteration of standard care.

During a 12-month period from April 2002 to April 2003, all surgical residents assigned to the adult surgical wards and SICU at our institutions were instructed to complete a detailed data form (Appendix) immediately after completion of basilic venous cutdown.

All patients, 15 years of age or older, having basilic venous cutdown in our institutions were enrolled in this study. Indications for basilic venous cutdown included difficulty to assess volume and difficulty to assess peripheral venous line. Patients with unsuitable basilic venous access site were excluded.

Pilot study was performed in 30 patients to determine the mean value of fluctuation of fluid level when the catheters were positioned properly. The result of pilot study showed that 4 cm represented "good fluctuation of fluid level".

Basilic venous cutdown was done by surgical residents, using the same technique as followings. All catheters were introduced under local anesthesia and sterile condition. An incision was made 2 finger breath radial and proximal to medial epicondyle of the humerus. The catheters used were no. 8 Fr. opaque feeding tubes.

The catheter tip was assumed to be in correct position if the shortest approximate anatomic length (by surface-landmark guidance) can be reached easily without undue resistance during catheter insertion, or the fluctuation of fluid was greater than 4 cm during full inspiration and expiration or good venous blood was returned

After basilic venous cutdowns, portable antero-posterior or standard posteroanterior chest roentgenography was obtained. After the procedure, a preprinted procedure note was completed. The operating physician interpreted the films for catheter position. If improper position was detected, the catheter placement was revised.

Definition

Proper Position[9] The tip of central venous catheter is in SVC above the junction with right atrium or within 2cm of superior vena caval - atrial junction. The lower end of superior vena cava is seen as it enters the right atrium, the point of entry is marked by a shallow angle as it meets the laterally convex border of the right atrium.

Improper Position Tip of catheter located outside superior vena cava

Good Fluctuation According to pilot studies, difference in fluid column more than 4 cm H_2O during full inspiration and expiration

Sensitivity, specificity, and positive and negative predictive values were then calculated for each procedure.

Results

During the study period, 80 basilic venous cutdowns were performed. Data were collected prospectively. Table 1 shows demographic data of the patients.

Of the 80 basilic venous cutdowns, good fluctuation of fluid level could be obtained in 72 (90%) patients. Of these 72 patients, 65 (86.25%) were placed in proper position, in the remaining seven patients, the tip of the catheters were placed too deep into the right atrium. In 8 patients where fluctuation of fluid level was less than 4 cm, 4 were placed properly, 3 were placed in the ipsilateral internal jugular vein, 1 was placed in the ipsilateral subclavian vein as shown in Table 2.

Of the 80 catheterizations performed, 72 were predicted to be placed in proper position. The overall incidence of improper position was 13.75 per cent.

Table 1 Demographic data of patients

Gender	Age (range, mean)	No. of patients
Male	26-85 yr, 51.95 yr	47 (58.75%)
Female	16-90 yr, 49.6 yr	33 (41.25%)

Table 2 Position of the tip of central venous catheter after basilic venous cutdown

Tip position	SVC	Right atrium	Ipsilateral Internal jugular vein	Ipsilateral subclavian vein	
Fluctuation >4 cm	65	7	0	0	72 (90%)
Fluctuation < 4 cm	4	0	3	1	8 (10%)
	69 (86.25%)	7 (8.75%)	3 (3.75%)	1 (1.25%)	

Table 3 Diagnostic analytic study

		Radiologic results		
		Proper position	Improper position	
Clinical results	Fluctuation > 4 cm	65	7	72
	Fluctuation < 4 cm	4	4	8
		69	11	

Sensitivity = 94.2 % (65/69)
Specificity = 36.0 % (4/11)
Positive predictive value (PV +) = 90.2 % (65 / 72)
Negative predictive value (PV-) = 50.0 % (4 / 8)
Post test likelihood if test negative (1 - PV-) = 50.0 %
Likelihood ratio = 1.48

The vast majority (7 in 11) of the improper positions were in the right atrium. All catheters that located in the internal jugular vein had fluctuation of fluid level less than 4 cm.

The average elapsed time from the completion of basilic venous cutdown until chest radiography confirmation by resident was 60.2 minutes. Our institute currently charges 120 bahts for a stat portable chest radiography.

Discussion

In Thailand, the basilic venous cutdown remains one of the most common procedures performed in critically ill patients. Constant anatomy makes it easy to access with less complications. Injury to brachial artery is the major concern. No dissection deeper than the fascia is the rule. However, each academic center in Thailand has different protocol regarding chest radiography after basilic venous cutdown. The main purpose of chest radiography is to check the position of catheter whether it locates in the neck (internal jugular vein) or in the chest (SVC or right atrium).

In 1989, the US FDA published a precautionary statement regarding the positioning of central venous catheters. It stated that "the catheter tip should not be placed in or allowed to migrate into the heart"[10,11]. It is still unclear how dangerous catheter tip malpositions truly are, particularly in the high right atrium. In the absence of more information, recommendations will continue to base on case reports of complications arising from misplaced catheters.

In addition to the gold standard parameter of chest radiography, we apply clinical parameter, fluctuation of fluid level, to determine the position of the tip of the catheter. The cyclical variations in intrapleural pressure which normally accompany ventilation of the lungs are directly transmitted to the heart and great vessels. In one study, invasive venography indicated that the internal jugular valve was usually competent during sudden increases in intrathoracic pressure, such as during coughing, which caused reverse flow of venous blood[12]. Thus, thoracic inlet venous valves prevent transmission of pressure from the right atrium into the internal jugular vein[8]. If "good fluctuation of fluid level" can be obtained after central venous cutdown, the tip is assumed to place in the SVC or right atrium.

This parameter (good fluctuation of fluid level) is easy to obtain (72/80). Sensitivity and positive predictive value were high (94.2%, 90.2% respectively) but specificity and negative predictive value were low (36.0%, 50.0%, respectively. The clinical parameter (fluctuation >4 cm) give false positive rate of 9.72%, all

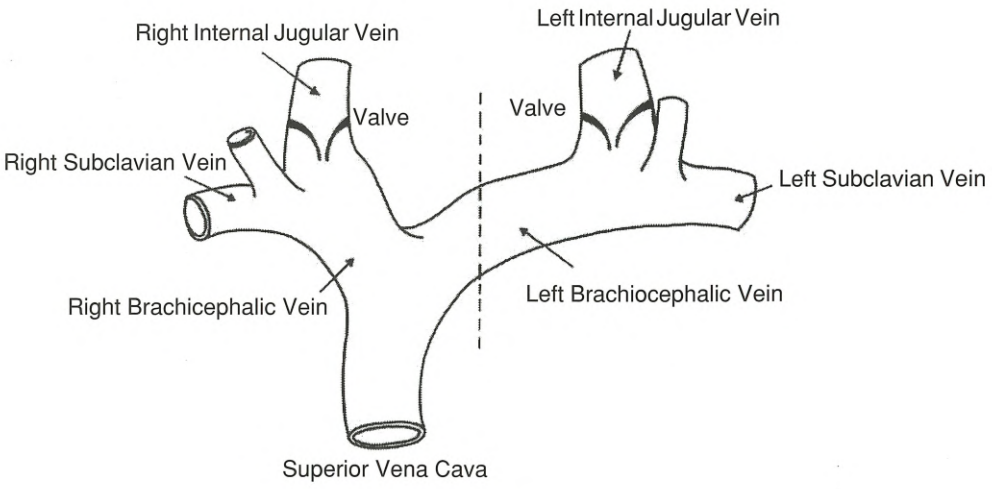

Figure 1

of those were 10 cm too deep (in the right atrium). Good fluctuation of fluid level still fails to prospectively predict proper placement rostral to the right atrium. As we limited the subject of this study, the number of patients may not be enough to draw a decisive conclusion.

To abandon the practice of obtaining routine post central venous cutdown radiography offers several potential benefits. Such a change in practice offers the potential for cost and time savings. Furthermore, the patient would be subjected to less radiation, and more importantly, to less manipulation with its associated pain and potential complications. Finally, such a change in practice offers the potential for better education and uniformity of care.

Conclusions

In most cases, the fluctuation of fluid level greater than 4 cm can be achieved, this represents reliable parameter for proper position of the catheter. These clinical parameters are simple, reproducible, and objective.

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