



## Review article

## A review in emergency central venous catheterization

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## ABSTRACT

Central venous catheterization is widely used in the emergency setting. This review aims to assess central venous catheterization from the perspectives of types of catheters, sites of insertion, and techniques. In emergency conditions, non-tunneled catheters are preferred because the technique for its insertion is not complicated and less time-consuming. The size of catheter depends on the purpose of catheterization. For example, a large bore catheter is needed for rapid infusion. The ideal catheterization site should bear fewer thromboses, lower infectious rate, and fewer mechanical complications. Thus the femoral vein should be avoided due to a high rate of colonization and thrombosis while the subclavian vein seems to exhibit fewer infectious complications compared with other sites. The ultrasound-guided technique increases the success rate of insertion while decreases the mechanical complications rate.

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## Introduction

Central venous catheterization was brought to attention when Dr. Werner Forssmann self-inserted a ureteric catheter through his cubital vein into his right heart. Since then the technique has been developed and used for various indications.<sup>1</sup> The type and size of catheter, the catheter site, and the technique for insertion need to be considered in order to choose the right catheter for a patient. Indications for central venous catheterization include<sup>2</sup>:

- Inadequate peripheral venous access
- Rapid fluid resuscitation
- Special drug administration such as high concentration of KCL
- Need for total parenteral nutrition administration
- Invasive hemodynamic monitoring
- Placement of pulmonary artery catheters
- Transvenous pacing
- Renal replacement therapy

Types of catheters<sup>3</sup>

## Non-tunneled catheters

Non-tunneled catheters are commonly used in emergency situations since it is easy to place and does not need special surgical

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skills for insertion. As the duration of this catheter usage is short, the catheter should be removed as soon as possible.

## Tunneled catheters

Tunneled catheters are used when access to a patient's blood stream is needed for multiple times over a period longer than 30 days. The tunneled catheters can be cuffed or uncuffed. Compared with non-tunneled catheters, they cause fewer infectious complications.

## Implanted ports

Implanted ports are suitable for long term use, cause fewer infectious complications and render better cosmetic results compared with the aforementioned catheters. However, they require surgical implantation with a high cost.

## Dialysis catheters and peripherally inserted central catheters (PICCs)

Dialysis catheters have large bores which necessitate heparinization to prevent clotting while PICCs are usually inserted at a peripheral vein at the antecubital area.

In emergency conditions, non-tunneled catheters are preferable since they can be inserted in less time and do not need special surgical skills.

Another consideration in emergency venous catheterization is the 'size' of the catheter which should depend on the purpose of the

insertion. To measure the central venous pressure, the catheter should be long enough to reach the junction of the superior vena cava and the right atrium. Therefore, in an emergency where a large amount of fluid needs to be administered, size does matter.

According to the Hagen–Poiseuille equation,<sup>4</sup> the velocity of the flow depends on the difference of pressure between the two ends of the tube, the diameter and the length of the tube and also the viscosity of the fluid. For trauma resuscitation, the ideal catheter should therefore be short with a large diameter with an introducer sheath applied. The flow rate varies with different sizes of catheter.

Using a Level 1® Fast Flow Fluid Warmer, a machine with a pressure chamber for rapid infusion of a warm fluid and a 7 Fr catheter can provide rapid infusion at a rate of 546 mL/min, while a 20 gauge catheter can provide a flow rate of only 140 mL/min.<sup>4</sup>

### Sites of catheter placement

The three most common sites for central venous access are the subclavian vein, internal jugular vein, and femoral vein.

#### Techniques and landmarks

##### Subclavian vein

The most common approach for subclavian vein catheterization is the infraclavicular approach.<sup>5</sup> The operator stands at the same side of the vein and turns the patient's head to the opposite direction. The skin is punctured around 1 cm caudal to the junction of the medial and middle thirds of the clavicle. Point the needle toward the sternal notch (Fig. 1).

##### Jugular vein

The central approach is done as the operator stands at the head of the bed and turns the patient's head to the opposite side of the target site. The triangle between the medial and lateral portions of the sternocleidomastoid muscle is identified and the puncture is at the apex of the triangle. The needle is pointed toward the ipsilateral nipple (Fig. 1).

There exist advantages and disadvantages in the right and left jugular veins. The right jugular vein runs straight to the superior vena cava while the apex of the left lung is slightly higher than the right which brings greater risk of pneumothorax.<sup>5</sup> Therefore, the right jugular vein is more commonly accessed than the left. Sulek

et al<sup>6</sup> conducted a randomized controlled trial that compared the left and right jugular central venous access by anatomical landmark technique and ultrasonographic guided access and found that the left jugular venous access demonstrated a higher rate of arterial puncture, hematoma, and failed guidewire.

##### Femoral vein

The landmark is midway between the anterior superior iliac spine and pubic tubercle where the femoral artery locates. The femoral vein is slightly medial to the artery (Fig. 2).

The ideal site should have fewer infectious, thrombotic and mechanical complications with a higher success rate of insertion.

### Comparison between subclavian vein, jugular vein, and femoral vein

#### Subclavian vein vs. jugular vein

In 2012, a meta-analysis that compared sites of catheterization with fewer thromboses, stenoses, and infections was published on the Cochrane Database<sup>7</sup> and concluded that there were no differences in infectious and thrombotic complications between the subclavian vein and the jugular vein. However, Parienti et al<sup>8</sup> published a meta-analysis to address solely the infectious complications and argued that the subclavian vein site was associated with fewer catheter-related infections compared with other alternative sites (1.3 vs. 2.7 per 1000 catheter-days,  $p < 0.001$ ). Catheter-related infections were also fewer in subclavian vein when compared to internal jugular vein (incidence density ratio 0.46, 95% CI: 0.3–0.7,  $I^2 = 0\%$ ) and femoral vein (incidence density ratio 0.27, 95% CI: 0.15–0.48,  $I^2 = 31\%$ ).

#### Femoral vein vs. subclavian vein

The femoral and subclavian vein sites were compared in a randomized controlled trial where they were studied in critically ill patients.<sup>9</sup> The primary endpoint of the trial was the occurrence of catheter-related complications. Among 145 femoral venous catheterizations and 144 subclavian catheterizations, patients who had a femoral catheterization exhibited a higher overall infection (19.8% vs. 4.5%,  $p < 0.001$ ) and thrombosis (4.4% vs. 1.5%,  $p = 0.07$ ) rate.

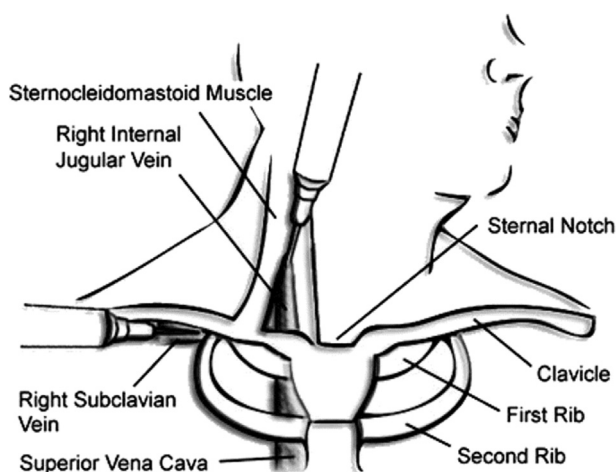


Fig. 1. Diagram of infraclavicular approach for subclavian and jugular venous access (from Taylor RW, Palagiri AV. Central venous catheterization. *Crit Care Med.* 2007;35(5):1390–1396).<sup>5</sup>

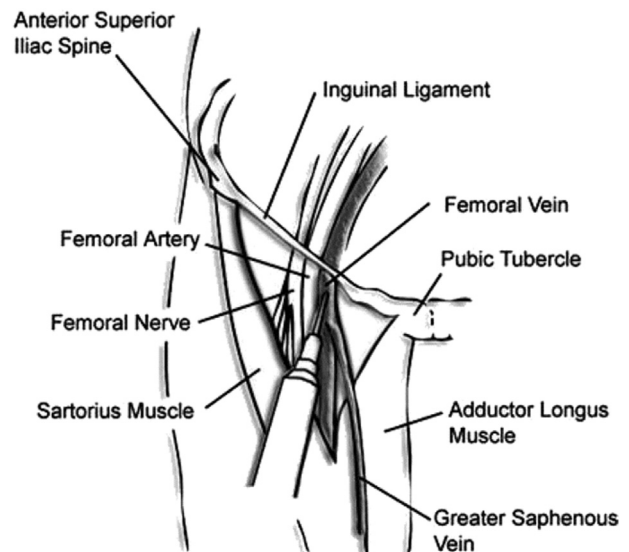


Fig. 2. Diagram of central approach for femoral venous access (from Taylor RW, Palagiri AV. Central venous catheterization. *Crit Care Med.* 2007;35(5):1390–1396).<sup>5</sup>

### Femoral vein vs. jugular vein

Only one randomized controlled trial compared the femoral and jugular vein sites.<sup>10</sup> The study was conducted in acute renal replacement therapy catheterization and found jugular insertion led to a higher rate of hematoma (3.6% vs. 1.1%,  $p = 0.03$ ). However, there was no difference observed in catheter colonization (40.8 vs. 35.7 per 1000 catheter-days; hazard ratio (HR) 0.85,  $p = 0.31$ ). In the subgroup analysis of the obese patients which were defined as BMI >28.4, the number of colonizations was higher in the femoral vein group (24.5 vs. 50.9 per 1000 catheter-days; HR 0.40,  $p < 0.001$ ). Another analysis from two randomized trials published by Timsit et al<sup>11</sup> observed similar results. Though the study showed no difference in catheter-related blood stream infection, major catheter-related infection and colonization were higher in females (HR 0.39,  $p = 0.001$ ) and in catheters that were in place for more than 4 days (HR 0.75,  $p = 0.05$ ).

In summary, there are inconsistencies in the evidences concerning the catheter sites when complications are compared between the subclavian vein and jugular vein; however, the subclavian vein seems to exhibit better outcomes when it comes to infectious complications. Femoral vein catheterization should be avoided, especially in females and obese patients and the catheters should not remain in place for more than 4 days.

### Other modalities to reduce infection

#### Single-lumen vs. multi-lumen central venous catheters

Since the multi-lumen venous catheter was introduced, it has gained popularity as it has advantages in dealing with patients who need numerous drug infusions. However, it is controversial as to whether or not multi-lumen venous catheters increase the risk of infection. Dezfulian et al<sup>12</sup> published a meta-analysis to compare the single-lumen and the multi-lumen central venous catheters and reached the conclusion that the overall catheter-related blood stream infection (CRBSI) rate was higher in multi-lumen catheters (OR 2.15, 95% CI: 1.00–4.66) but there was no difference when only high quality studies were included.

#### Antimicrobial impregnated catheters

Antimicrobial impregnated catheters have been associated with reduced CRBSI.<sup>13</sup> A meta-analysis of 7 randomized control trials found that rifampicin-impregnated central venous catheters led to a significant reduction in the CRBSI rate (OR 0.23, 95% CI: 0.14–0.40).<sup>14</sup> However, another study of peripherally inserted central catheters that compared chlorhexidine (CHG) impregnated and non-CHG catheters found no difference in CRBSI between the groups.<sup>15</sup> The latest review published in 2016 from Cochrane indicated that the antimicrobial impregnated central venous catheter significantly reduced CRBSI (RR 0.62, 95% CI: 0.52–0.74) but no effects were observed in minimizing sepsis or mortality.<sup>16</sup>

### Ultrasound-guided central venous catheterization

Ultrasound-guided cannulation has been widely used since the literature demonstrated an increased success rate.<sup>17</sup> The early studies were done on ultrasound-guided internal jugular vein catheterization, possibly because the anatomy allows ultrasonography to be performed more easily compared to the subclavian and femoral veins. However, an arterial puncture from internal jugular venous access leads to more serious complications such as airway compromise from extensive hematoma or stroke from carotid injury. Hind et al<sup>17</sup> conducted a meta-analysis to compare the

landmark method and the real time two-dimensional ultrasound guidance, indicating that the ultrasound-guided method significantly reduced the failure rate of internal jugular venous access (RR 0.14, 95% CI: 0.06–0.33). Ultrasound-guidance for subclavian venous access was studied in a randomized controlled trial in a critical care and non-emergency setting. It was found that ultrasound guidance increased the success rate and reduced mechanical complications except for catheter misplacement.<sup>18</sup> Another study was conducted on ultrasound-guided femoral vein catheterization under cardiopulmonary resuscitation situations in which the arterial pulses were absent. The results showed that real-time ultrasound-guided vein catheterization had a fewer number of needle passes ( $2.3 \pm 3$  vs.  $5.0 \pm 5$ ,  $p = 0.0057$ ) and fewer arterial catheterizations (0% vs. 20%,  $p = 0.025$ ).

To sum up, the ultrasound-guided central venous catheterization will become the standard practice since a higher success rate and fewer complications were demonstrated in the data.

### Central venous access in coagulopathy

Emergency venous access sometimes needs to be done in coagulopathic patients. Correction of coagulopathy before insertion has been debated without a consensus. Doerfler et al<sup>19</sup> published 104 access procedures done in patients with hemostatic disorders in which 73% had platelet counts less than 100,000/mL and 40% had abnormal prothrombin time and partial thromboplastin time levels. It was found that 6.5% bleeding were at the catheter sites. A later study by Tercan et al<sup>20</sup> used ultrasound-guided access for 133 access procedures in coagulopathic patients in which 89.5% were treated by single wall puncture technique. Minor complications including oozing and small hematoma were reported in 6% of the patients.

According to the data, central venous access in patients with hemostasis disorder caused certain complications. Whether to correct the coagulopathy has to be considered alongside the urgency of the access, time to wait for blood products, and risk from blood product transfusion.

Based on the discussions above, the following conclusions can be reached: first, in emergency situations, non-tunneled catheters are preferred; second, a large bore catheter is required in rapid fluid resuscitation; third, femoral venous access should be avoided due to a higher colonization rate; fourth, the ultrasound-guided technique increases the success rate of insertion, especially in internal jugular venous catheterization.

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