**A 45° set Square Method for Accurate Needle Insertion in Ultrasound-guided Internal Jugular Venous Catheterization**

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**Purpose:** Until now, there has been no standardized method for insertion of the introducer needle in ultrasound-guided internal jugular venous catheterization (IJVC). The needle insertion site and angle have been determined by the performer’s experiences. In an effort to improve first attempt success rates and reduce complications, we designed a new standardized approach (called the 45° set square method) for determination of the site and angle of needle insertion during ultrasound-guided IJVC. This study investigated that the clinical usefulness of the novel 45° set square method for ultrasound-guided IJVC in the emergency department.

**Methods:** We conducted a prospective study in the emergency department (ED) of a tertiary teaching hospital. Forty-one patients requiring central venous catheterization were enrolled in the study. They were randomized to either the conventional ultrasound guidance group or the 45° set square group. The primary outcome measure was success rate within three attempts and secondary measures were the number of trials, first-attempt success, puncture time, complications, and technical difficulty score.

**Results:** All 41 participants completed this study successfully. Twenty-one consecutive patients were enrolled in the 45° set square group and 20 were enrolled in the conventional group. The 45° set square group (100%) was superior to the conventional group (60%) in overall success rate within three attempts ($p<0.001$) and the number of attempts ($p<0.001$). Significant differences in puncture time ($p=0.004$), hematoma ($p=0.048$), and technical difficulty score ($p<0.001$) were observed between the groups.

**Conclusion:** The 45° set square method is an effective and safe method for ultrasound-guided internal jugular venous catheterization.

**Key Words:** Ultrasound, Central venous catheterization, Complication

**Introduction**

Catheterization of the central vein is an essential procedure for hemodynamic monitoring, delivery of blood products and drugs, emergency hemodialysis, and fluid resuscitation in the emergency department (ED)\(^1\). Central venous catheterization has been usually attempted at the internal jugular, subclavian, or femoral vein.\(^1\) Internal jugular and subclavian, as sites of central venous catheterization, are preferred because both sites have lower overall rate of mechanical complications than that of the femoral site and benefit for hemodynamic monitoring\(^2\). Moreover, Internal jugular vein catheterization (IVJC) is less likely than subclavian catheterization to be complicated by pneumothorax and hemothorax, and to be improper location of catheter\(^3\). Ultrasound-guided subclavian catheterization is more difficult and less reliable than landmark-based catheterization by the fixed anatomical relation between the subclavian vein and the clavicle\(^4\). There is yet another argument in favor of the jugular catheterization. The jugular approach should be chosen if a fast and proper placement of catheter tip should be required for hemodynamic monitoring\(^5\).

During IJVC, ultrasound guidance reduces not only mechanical complications such as arterial puncture and hematoma, but also catheter-placement failures and procedure time\(^6\). However, ultrasound guidance has not entirely eliminated such mechanical complications\(^7\). Despite ultrasound guidance, Hind et al. reported that five of 296 cases (1.68%) of IJVC placement failed.
Leung et al\textsuperscript{8}, also reported that three mechanical complications including arterial puncture and hematoma occurred among 65 cases (4.6\%). Many studies have been conducted to overcome these problems\textsuperscript{7,9,10}. Until now, there was no standardized method for insertion of the introducer needle in ultrasound-guided IJVC. The needle insertion site and angle have been determined on the basis of the performer’s experiences. We designed a new standardized approach (called the 45° set square method), which determines the site and angle of needle insertion during ultrasound-guided IJVC to improve first attempt success rates and reduce complications. The purpose of this study was to investigate the clinical usefulness of the novel 45° set square method for IJVC with ultrasound guidance in the ED.

**Materials and Methods**

1. Study design and participants

We conducted a prospective study in the ED of a tertiary teaching hospital with approximately 65,000 patient visits between February 2012 and April 2012. The study was approved by the institutional review board. The study was explained to participants, and written informed consent was obtained from all participants. The study population was enrolled when one of three study investigators was available. Patients were randomized to either the conventional or new method using a computer-generated random sequence before catheterization. The randomization was performed independently of subject’s experiences for ultrasound-guided IJVC. The inclusion criteria were patients who required central venous catheterization in the ED. The exclusion criteria were 1) pediatric (<18 years) patients; 2) patients receiving mechanical ventilation; and 3) trauma patients requiring cervical immobilization. The study was performed by a research team consisting of seven operators, four assistants, and three investigators. Operators were emergency medicine residents with experience of at least thirty conventional ultrasound-guided IJVC. They were no previous experiences in 45° set square method. Open questions were posed to all operators on previous techniques used for ultrasound-guided IJVC based on their experiences before providing instructions. All operators were given a 30-minute lecture on the principle and procedure of 45° set square method and performed a 30-minute practical training by observing the procedure of experienced investigators.

2. Study protocol

Ultrasonography was performed using a SonoSite M-Turbo (SonoSite Inc, WA, U.S.A.) with 5 to 10 MHz linear array transducer. The transducer was placed in a sterile plastic cover with ultrasonic gel. Catheterization was under real-time ultrasound visualization in the transverse plane. All catheterization were approached to the right side of patients. Operators in the conventional group determined the insertion site and angle of introducer needle based on their discretion, while operators in 45° set square group inserted the needle at a specific distance from ultrasonic probe with a 45° angle. Specifically, an assistant measured the depth of the IJV. The depth was defined as the distance from the skin surface to central point of the IJV using the measuring function on the ultrasound machine display monitor. The operator determined the insertion site as the same distance away from the probe proximally. An aseptic 45° set square with ruler was placed perpendicular to the patient’s skin with the help of an assistant, and was moved away to the distance measure by a ruler on the set square. The tip of set square was located at the insertion point. The operator inserted the introducer needle (ARROW\textsuperscript{®}, Arrow international Inc, PA, U.S.A.) into the insertion point at 45° to the skin surface using the set square (Fig. 1A, B).

3. Outcome variables

The primary outcome measure was overall success rate and the secondary measures were the number of attempts, first-attempt success rate, puncture time, complications, and technical difficulty score. Definitions for outcome variables were as follows: 1) overall success rate of catheterization: catheterization was successfully conducted within three attempts; 2) the number of attempts: one attempt was a single pass of the introducer needle without withdrawal or redirection within the skin. Each withdrawal or redirection after skin puncture was counted as another trial; and 3) puncture time: from complete preparation of ultrasound guided IJVC to first blood aspiration through introducer needle without resistance (seconds).