Ultrasound-Guided Internal Jugular Vein Cannulation Versus Blind Technique in Pediatric Cancer Patients

MOHAMMAD M. HEGAZY, M.D. and MOHAMMAD A. AGGAG, M.D.
The Departments of Anaesthesia and Radiology, Children’s Cancer Hospital.

Abstract

Background: Percutaneous cannulation of the internal jugular vein in infants and children is technically more difficult and carries a higher risk of complication than in adults.

Aim of Study: The authors tested their hypothesis that using an ultrasound scanner would increase the success of internal jugular cannulation and decrease the incidence of complication in pediatric cancer patients.

Methods: After approval from the hospital ethical committee (75375 hospital) and receipt of written informed parental consent, 108 children scheduled for internal jugular vein cannulation were randomized into two groups; landmark group using the traditional method and ultrasound group, using sonography guidance for insertion. The access time, number of attempts, success rate, and incidence of complications were compared for the two groups.

Results: There were no significant differences between the two groups with regard to age, sex, weight and coagulation profile. The success rate was 98.1% in the ultrasound group, with one case of carotid artery puncture, versus 85.2% in the landmark group, with a 14.8% incidence of carotid artery puncture. Both differences were significant \( p < 0.001 \). The access time was less, the number of attempts was fewer significantly in the ultrasound group than in the landmark group. No cases of hemothorax or pneumothorax occurred in this group.

Conclusion: Ultrasonographic localization of the internal jugular vein was superior to the landmark technique in terms of overall success, speed and decreased incidence of complication.

Key Words: Internal jugular vein cannulation – Ultrasonography guided – Pediatric patients.

Introduction

CENTRAL venous catheterization (CVC) is an important part of management of patients in variety of clinical settings [1]. Such a catheterization is commonly attempted to obtain central venous access for different purposes [2].

CVC in infants and children can be difficult and challenging, predominantly because of their small size and carries an associated morbidity and mortality [3]. The success rate and occurrence of complications will depend on factors which include the size and condition of the child, operator experience, the site of cannulation and the presence of vascular anomalies, coagulation abnormalities or previous cannulation [4].

The study conducted by Eisen et al. [5] adds clarity to the literature emphasizing an increase in complications associated with multiple percutaneous sticks. These data suggest that if a central vein is not accessed rapidly within the first 2 venipunctures, complications are likely to increase. These complications include arterial puncture, pneumothorax, hemothorax, cardiac tamponade, hematoma, malposition of catheter, nerve injury and death [6].

In September 2002, the National Institute for Clinical Excellence (NICE) produced a document entitled Guidance on the use of ultrasound locating devices for placing central venous catheters. This document recommends the use of ultrasound guidance as the preferred method for elective insertion of central venous catheters into the internal jugular vein (IJV) in adults and children [7].

The use of ultrasound guidance during IJV catheterization shows controversy; some studies recommend its use [7,8,9], while others do not recommend that [10,11].

Aim of the study: This study was designed to compare the real-time ultrasound-guided approach
with the landmark technique in the cannulation of the IJV in pediatric cancer patients.

**Subjects and Methods**

**Study setting and participant:**

This cross-sectional descriptive study was conducted in the Department of Radiology and procedure room in Children's Cancer Hospital Egypt (57357 Hospital) over a period of six months [from September 2007 till March 2008]. During this period, children aged from 6 months to 15 years and subjected to CVC were recruited for the study. With hospital ethical committee approval and informed parental consent, pediatric patients were subjected to data collection about; age, weight, and coagulation profile. The children then randomly allocated into 2 groups: traditional landmark group (group 1) and ultrasonographic guided group (group 2). Randomization was done using the sealed envelopes technique. Two groups of sealed envelopes are placed together. The patients were asked to withdraw one of the envelopes randomly to allocate him in each group.

During each of the maneuver, the following data were collected; access time, no of attempts, success rate, occurrence of complication and its specification.

**Methods:**

**Landmark technique:**

For the landmark technique, the patient was placed in a supine position. The patient received sevoflurane and laryngeal mask airway with the head turned to the other side. The skin at the top of the triangle between the sternal and clavicular heads of the sternocleidomastoid muscle and the clavicle as a base for the triangle was prepared in a sterile fashion with povidone-iodine. Cannulation of IJV was done with a 5-ml syringe connected to a 19-gauge needle (Plastimed Division, Prodimed, 95321 Saint-LEU-Foret Cedex B.P. 20-France). The technique for IJV puncture was; high but when it failed in some patients we used low technique, all maneuvers were medial to the clavicular head of the sternocleidomastoid muscle and the clavicle as a base for the triangle was prepared in a sterile fashion with povidone-iodine. Cannulation of IJV was done with a 5-ml syringe connected to a 19-gauge needle (Plastimed Division, Prodimed, 95321 Saint-LEU-Foret Cedex B.P. 20-France). The needle and guide wires used were all standard components of catheterization kits and were not modified versions for use with ultrasound. All ultrasound-guided and landmark-guided catheterizations were performed by well-trained attending anesthesiologist and radiologist with similar experience.

**Real-time ultrasound-guided method:**

The neck area was prepared and draped steriley with the patient supine as described above. A 8-15MHz linear-array ultrasound probe connected to a real-time ultrasound unit (Acuson sequoia 512 Siemens. Siemens medical solution. USA INC, Mountain View, CA94043 USA) and focused at 4cm depth, was covered with ultrasonic gel and placed in a sterile plastic condom sheath. By placing the transducer in a sterile sheath, its use in consecutive patients is facilitated. Standard ultrasound two-dimensional (2D) imaging was used to measure the depth and caliber of the IJV, evaluate its patency and compressibility and identify whether there were any thrombi in the vein. In cases of pre-existing thrombus formation and/or failure to gain access due to trauma or other anatomical anomalies, the IJV on the contra lateral side was catheterized. Catheterization was performed under continuous dynamic observation of real-time 2D images obtained by placing the transducer parallel and superior to the clavicle, over the groove between the sternal and clavicular heads of the sternocleidomastoid muscle. This readily visualized the IJV and the carotid artery (Fig. 1). A 19-gauge needle, 5-cm syringe (Plastimed Division, Prodimed, 95321 Saint-LEU-Foret Cedex B.P. 20-France) was advanced through the skin under ultrasound guidance into the IJV (Fig. 2). A guide wire was then placed through the needle into the vein (Fig. 3) and the needle was removed. The dilator then the catheter were placed over the wire and advanced into the IJV. The needles and guide wires used were all standard components of catheterization kits and were not modified versions for use with ultrasound. All ultrasound-guided and landmark-guided catheterizations were performed by well-trained attending anesthesiologist and radiologist with similar experience.

**Statistical analysis:**

A pre-designed SPSS (Statistical Package for Social Science Vs 11.01) file was used for data entry and analysis. Univariate analysis in the form of frequency, percents, mean and standard deviation (SD), median with minimum and maximum were done. The following tests were used for comparison between the two groups; Chi-square for qualitative data and non parametric Mann Whitney U test for quantitative data which is not normally distributed, student’s t-test for normally distributed quantitative data, with 95% confidence intervals (95% CI) and significant p-values of <0.05.
Fig. (1): Ultrasonography view of internal jugular vein and internal carotid artery in transverse view.

Fig. (2): Ultrasonographic appearance of the tip of needle during its introduction into the IJV.

Fig. (3): Ultrasonography view of the guide wire inside the IJV.

Results

Baseline characteristics of the patients are presented in Table (1). One hundred and eight patients were assigned to either ultrasound group or landmark group. There were no significant differences between the two groups of patients as regard to age, sex, weight and coagulation profile. The median age of the total patients was 58 months, ranging from 5 months to 13 years. Male constituted 56/108 (51.9%) of entire sample while females constituted 52 (49.1%). The median weight of the patients was 16kg and ranging from 6 to 54kg. The mean and SD of depth of IJV as measured by ultrasonography was 7.7±1.3.

Table (1): General characteristics of included subject.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Ultrasound group</th>
<th>Landmark group</th>
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<tbody>
<tr>
<td>Age in months:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median [min-max]</td>
<td>55.33 [7-150]</td>
<td>59.19 [5-150]</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Sex:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td>30 (55.6%)</td>
<td>26 (48.1%)</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Females</td>
<td>24 (44.4%)</td>
<td>28 (51.9%)</td>
<td></td>
</tr>
<tr>
<td>Weight in Kg median [min-max]</td>
<td>14 [7-50]</td>
<td>16 [5-54]</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Coagulation profile (mean ± SD)</td>
<td>1.18±0.2</td>
<td>1.25±0.2</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Platelet count (mean ± SD)</td>
<td>248.7±33.8</td>
<td>241.8±33.4</td>
<td>&gt;0.05</td>
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</tbody>
</table>

Results using the landmark technique are in sharp contrast to those obtained by the ultrasound method and are presented in Table (2). Average access time (The time from venipuncture to proper wire insertion) and number of attempts were both significantly reduced using ultrasound compared with the landmark technique (p<0.01). The success rate and success from 1st puncture were significantly higher in the ultrasound group than in the landmark group [53/54 (98.1%) Vs. 46/54 (85.2%) and 40/54 (74.1%) Vs. 21/54 (38.9%) respectively]. The rate of mechanical complications was significantly higher in the landmark group of patients as compared with the ultrasound group (p<0.001). Cannulation in one case only of the ultrasound group was unsuccessful because difficulty in pas-
sage of the guide wire due to presence of huge lymph nodes. Furthermore, in the landmark group, two cases of haemothorax and four cases of pneumothorax which required therapeutic intervention occurred, but no such complication was observed in the ultrasound group.

Discussion

Percutaneous CVC in infants and children is a challenging procedure. Traditionally, an external landmark technique has been used to identify puncture site [12].

Real-time ultrasound guidance of CVC insertion provides the operator with visualization of the desired vein and the surrounding anatomic structures prior to and during the insertion of the catheter. This method appears to improve the success rate and decrease the complication rate associated with CVC placement both in adults [13,14,15] and in children even among infants [8,9,16,17].

The present data further supports the superiority of real-time ultrasound-guided IJV cannulation as compared with the landmark technique in pediatric cancer patients. A significant reduction in the access time and average number of attempt are observed in this study when we use the ultrasound guided IJV catheterization. This result is in agreement with other studies [16,17].

Using the ultrasound guided method, the study shows a successful IJV cannulation rate of 98.1%, which is in accordance with success rates documented in previous reports ranging from 94% to 100% [2,16,18]. This result is not matched with Grebenik et al., who reported success rate of 76% and they explained this by inexperience with the use of the ultrasound probe [4].

Using ultrasound guidance, the incidence of carotid puncture and haematoma was very low in comparison to the figure reported by Chuan et al. [19] (3.1% Vs. 26.7% respectively) and this difference may be due to the fact that their patients were all infants weighting less than 12Kg. Interestingly, in patient in whom carotid puncture occurred, it was noted that the IJV was overlying the carotid artery rather than being more lateral.

The incidence of complication as carotid puncture, hematoma, haemothorax and pneumothorax using the landmark method was greater than the other figure reported by other study [2,19]. The difference is attributable to the criteria of our patients who are pediatric cancer patients receiving chemotherapy with very bad general condition. On the other hand No cases of haemothorax and/or pneumothorax occurred in the ultrasound group.

The use of ultrasound in central venous access is an issue for debit. Some criticized its use because of the equipment cost and the its running cost [10,11]. We used only standard components of catheterization kits and not modified versions that are used by other study [20]. These modified versions are more sophisticated and thus more expensive. Although the major impediments to the widespread implementation of the above method in the developing countries are the purchase costs of the ultrasound machines, previous studies have provided sufficient economic arguments supporting the notion that ultrasound-guided central venous cannulation is cost-effective [7,8,9,21]. i.e although equipment cost is a valid concern, the expense of a major adverse event associated with CVC is potentially much greater.

Another issue in widespread application of the ultrasound method is the fact that it’s technically demanding, requiring well-trained operators and adequate experience in performing it. The benefits of this method may not accrue until after an initial learning period for operators already experienced in the landmark technique [20]. However many studies explored that ultrasound techniques are relatively simple to learn. The equipment is portable and it generally requires minimal training to gain expertise in its use [7,8,9].

Conclusion:

Two-dimensional ultrasound prelocated CVC in infants and children is convenient and can markedly increase cannulation success rate and reduce the incidence of complications.

Acknowledgements:

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