

Ultrasound guided percutaneous central venous catheters in neonatal intensive care unit

Ufuk Ateş¹, Turan Derme³, Yavuz Yılmaz², Hülya Özkan-Ulu², Fuat Emre Canpolat³

¹Department of Pediatric Surgery, Ankara University Faculty of Medicine, Departments of ²Pediatric Surgery and ³Neonatal Intensive Care Unit, Zekai Tahir Burak Woman Health Training and Research Hospital, Ankara, Turkey.
E-mail: drufukates@gmail.com

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Central venous catheters can be life-saving, especially in very low birth weight and sick newborns for whom peripheral access is difficult. However, the placement of a central venous catheter is technically difficult, especially in premature and newborn infants.

To demonstrate the efficacy of placement of central venous catheters under guidance of ultrasonography (US) in neonatal intensive care units. The patients who were hospitalized in newborn intensive care unit and central venous catheters were placed into the internal jugular vein under the guidance of US were analyzed retrospectively.

Successful cannulation rate was 90.9% in patients. The rate of success at first attempt was 68.1% in patients. The rate of three and more attempts was 9.1% in patients. The rate of complication was 9.1% in patients. The average intervention time was 8 minutes in patients. Central venous cannulation under the guidance of two-dimensional US is an effective method which can be easily and safely applied to low birth weight premature and newborn infants in newborn intensive care units.

Key words: central venous catheterization, newborn, ultrasound.

Central venous catheters are frequently used for intravenous fluid and electrolyte, parenteral nutrition, and drug treatment in newborn intensive care units. Central venous catheters can be life-saving, especially in very low birth weight and sick newborns for whom peripheral access is difficult.¹ Placement of a central venous catheter is a procedure that is frequently applied by pediatric surgeons.² However, the placement of a central venous catheter is technically difficult, especially in premature and newborn infants.^{3,4} During placement of a central venous catheter, various complications may be encountered and can result in carotid artery puncture, pneumothorax, hemothorax, nerve injury, thrombosis, hematoma, and even death.^{2,3,5} Most of the complications are related to multiple attempts to pierce the vein. The landmark technique has been the standard approach applied in the placement of central

venous catheters for many years.² However, as this approach does not allow the surgeon to see the vein and the structures around it, and as it is a blind intervention implemented by using anatomic points over the skin surface, it theoretically increases the number of attempts and complications.^{2,5,6} The initial cannulation failure rate rises to 60% in pediatric patients, while it is only 7-16% in adults. Therefore, visibility of the vein is more important in children.² Many studies that were performed on adults and children showed that when a central venous catheter is placed under the guidance of ultrasonography (US), the success rate increases and the frequency of complications decreases.^{3,4,5,7,8}

These studies mostly covered neonatal groups. We conducted a retrospective study to demonstrate the efficacy and feasibility of use of US in the placement of central venous

catheters in newborn intensive care units and especially in premature and newborn infants with low birth weight.

Material and Methods

The patients who were hospitalized in newborn intensive care unit and central venous catheters were placed into the internal jugular vein under the guidance of US were analyzed retrospectively. The study took place at Zekai Tahir Burak Woman Health Education Research Hospital Neonatal Intensive Care Unit. Approval was granted by Local Ethical Committee (No: 32/26-12-2013). Informed consent was granted from all of the parents. Age, gender, weight of infant at the time of the procedure, number of attempts, time from first insertion of the puncture needle to placement of the catheter in central vein to fixation of catheter to skin upon, and complications (e.g., hematoma, carotid artery puncture, return to cutdown, etc.) during and after the process were recorded.

Surgery procedure: As general anesthesia, 1 mg/kg ketamine and 0.1 mg/kg midazolam was administered to all patients. The preferred size of central venous catheters was 2 Fr single lumen, 3 or 4 Fr double lumen depending (Vygon) on the age and body weight of patients. Two-dimensional US (GE Healthcare Vivid S5) 12 MHz is used to monitorize the vein. After gel was applied on ultrasonography probe, a sterile glove was installed there in and its cable was wound by a special sterile coat. The puncture site was sterilized and then slightly wetted by 0.9% serum physiologic. One person placed the US probe on the puncture site and displayed the artery and vein. The vein was compressed and monitored by US probe. A second person inserted a needle into the skin and made a puncture to the vein in accompaniment with the US probe, and when blood was fed into injector, the US probe was removed from the site. Later, a guidewire was pushed forward through the needle. Then, the central venous catheter was placed by the standard Seldinger technique. A chest X-ray was taken to detect complications and the placement site of the catheter.

Results

Of the patients, 20 (45.5%) were girls and 24 (54.5%) were boys. The average age of

the patients was 13.9 days (minimum 1 day, maximum 28 days). The average body weight of the patients was 2,173 g (minimum 850 g, maximum 3,600 g) in patients for whom US was used. The successful cannulation rate was 90.9% in patients. The rate of success at first attempt was 68.1% in patients for whom US was used. The rate of three and more attempts was 9.1% in patients. None of the patients for whom US was used suffered from carotid artery puncture. Hematoma was observed in four patients (9.1%). Return to cut-down was reported in four patients for whom US was used (9.1%). Pneumothorax or hemothorax was not observed in any patient. The average intervention time was 8 minutes (minimum 2 minutes, maximum 34 minutes) in patients.

Discussion

With this study, it is shown that ultrasound guided central venous catheterization even in very low birth-weighted babies in neonatal intensive care unit is a safe and efficient method and can be used routinely. In recent times, the use of US for monitoring during invasive interventions has gained importance, due to its ability to increase the success rate and reduce of the complication rate of invasive interventions. Use of US for central venous cannulation was first defined in the 1990s.⁹ Use of US during central venous cannulation has significantly increased the success rate and reduced the incidence of traumatic complications associated with cannulation in both children and adults.^{3,8}

In the very few studies of this technique that have been conducted on children and newborns, the benefits of the placement of a central venous catheter under the guidance of US have been reported. However, these studies either did not include premature newborn infants, or only included a few premature newborn infants in their sample. Our study specifically targeted low weight premature and normal newborn infants hospitalized in a newborn intensive care unit. In a study conducted on children, the successful cannulation rate was reported as 97%, but this rate was only 81% in infants younger than three months in age.¹⁰ In a prospective study conducted on 95 infants, placement of a central venous catheter under the guidance of US was successful in all patients, and arterial puncture did not occur in any patient. However, in the traditional landmark technique, the success rate

was 77% and the arterial puncture incidence rate was 25%.⁷ In a group of 149 patients that required a central venous pathway for cardiac surgery, the rate of success was reported as 91.5% in the US group, and 77.8% in the landmark technique group. In this study, the rate of success was reported as 50% in infants younger than three months, as 70.8% in infants between three months and 1 year, as 72.7% in children between one and two years of age, as 82.7% in children between two and six years of age, and as 86% in children six years or older. This indicates that it is difficult to apply central venous cannulation, especially in newborn infants.³ In our study, the successful cannulation rate was 90.9% in patients. The small vein diameter of infants and children increases the number of central venous attempts, which in turn increases complications such as carotid artery puncture, pneumothorax, and hematoma.⁴ In our study none of the patients suffered from carotid artery puncture. Return to cut-down was reported in four patients for whom US was used (9%). All of these patients were infants who weighed less than 1,000 g. Due to the hematoma during the cannulation and small diameter of the vein, the vein could not be shown and cut down was performed.

In a study, it is shown that use of US does not assure the success at first attempt, and sometimes the discharge of venous blood does not absolutely mean success in placement of catheter.² As veins are small and easily deformable in small children, the placement of a central venous catheter may be more difficult in these patients. In small children, proximity of the carotid artery to veins, small vein diameters, and under-development of the sternocleidomastoid muscle are all potential causes for the increased incidence of carotid artery puncture during internal jugular vein cannulation. In the previous studies, although it was easy to penetrate the vein, it was difficult to push the guidewire forward.^{2,3} In our study, we also faced similar difficulties. In addition, in low birth weight babies, the needle may easily move out of the vein due to a very small movement of the needle or if a small movement is made while pushing the guidewire forward. Therefore, we found

out that the procedure is more secure if one person stabilizes the needle while another person pushes the guidewire forward. We further observed that it is difficult to push a guidewire with a sloped tip forward, whereas it is easier to push a guidewire with a soft and smooth tip forward.

One of the factors causing the increase in complication risks and technical difficulties in children is anatomic variation.^{2,6,7} In a study of US conducted by Alderson et al¹¹ venous anatomic abnormalities were shown in 18% of children, and 10% of carotid arteries were in the posterior location. When the US approach was compared to the landmark technique, rate of complications fell from 60% to 20%. In our study, the rate of complications was 9% in patients. It is demonstrated that the vein lumen narrows down and its edge is worn out upon failure of the first attempt of insertion into the internal jugular vein.¹² This in turn reveals the extent to which it is important to use US to show the vein and carotid artery relationship and the structures in the puncture site in order to increase the rate of success and to reduce the frequency of complication. Due to a reduction in the number of attempts and number of severe complications by use of US in central vein cannulation, the use of imaging methods in low birth weight premature and newborn infants must be encouraged.

Central venous cannulation under the guidance of two-dimensional US is an effective method which can be easily and safely applied to infants as small as 850 g.

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