Insertion of a 1.9F central venous catheter via the internal jugular vein in neonates

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Abstract
Objective: This study aimed to develop a technique for placing a 1.9 French (F) central venous catheter in the internal jugular vein of newborns.

Methods: In this retrospective study, punctures were performed with a modified ultrasound-guided Seldinger technique with 57 1.9F catheters in 48 newborns. Punctures were performed in the right internal jugular vein in 43 (75.4%) patients and in the left internal jugular vein in 14 (24.6%) patients.

Results: We included 33 (57.9%) boys and 24 (42.1%) girls, aged a median 38 days (range, 2–135 days). The puncture success rate was 100%. Catheterization duration was a median 14 days (range, 1–70 days). Among the catheters, 94.1% were removed after completion of therapy or upon death. Fifty-three (93%) patients experienced no complication, whereas a small amount of bleeding was observed in 2 (3.5%) patients, inflammation of puncture in 1 (1.8%) patient, and occlusion in 1 (1.8%) patient. The method of placement of 1.9F catheters in the internal jugular vein of newborns had a high success rate, with minimal trauma and few complications.

Conclusions: Our method of placing a 1.9F central venous catheter in the internal jugular vein is suggested for level III to VI neonatal intensive care units.

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Introduction
A peripherally inserted central catheter (PICC) through the internal jugular vein (IJV), rather than in veins of the upper extremity, is associated with a lower rate of deep venous thrombosis (DVT). Neonates are characterized by short necks, loose skin and subcutaneous tissue, and a fine and mobile jugular vein. These characteristics make achieving puncture with a high success rate difficult, and puncture attempts are prone to complications. Blind punctures of the IJV are rarely performed in neonates clinically. Owing to ultrasound visualization of blood vessels, the success rate and safety of neonatal jugular vein puncture have significantly improved. This has enabled IJV catheterization to be conducted in the neonatal intensive care unit (NICU).

The purpose of catheter placement in the IJV is to provide venous access for neonates requiring long-term parenteral nutrition, and these catheters often require long-term retention. Currently, IJV catheters used in neonates are 22 gauge (G) (22G diameter = 0.9 mm) 4.0 French (F) and 3.0F. Selection of a vascular access device is based on the smallest outer diameter with the fewest number of lumens and is the least invasive device required for the prescribed therapy. For PICCs, a catheter with a catheter-to-vein ratio of 45% or less should be chosen. Vascular access devices with a larger diameter can lead to DVT more rapidly in patients compared with PICCs with a small diameter. A 22G 3.0F or 4.0F PICC has outer diameters of 1 or 1.35 mm, while the 1.9F (outer diameter = 0.6 mm) PICC has the smallest outer diameter. However, 1.9F central venous catheters have a fine internal diameter and are soft and flexible, with good affinity in humans and low irritability to blood vessels. These features are in line with neonatal vascular characteristics and meeting the requirements of daily NICU clinical treatment.

There have been no reports of successful placement of a 1.9F catheter in the IJV. The puncture needle of the 1.9F catheter is short and the introducer sheath cannot be connected to the syringe. Therefore, this needle is unsuitable for IJV puncture and inserting the catheter via its introducer sheath is impossible.

The preferred method for deep vein catheterization is the modified Seldinger technique, which was first applied in central catheter catheterization of the peripheral vein in an adult by Goodwin in 1989. Subsequently, despite the lack of a guidewire matching the small-sized PICC catheter, Wald et al. attempted the modified Seldinger technique using the guidewire of a small-sized cardiac catheter for insertion of a small-sized pediatric PICC catheter. With improvement in the production process, 1.9F central catheters with matching guidewires have been used clinically. Therefore, we investigated application of a modified ultrasound-guided Seldinger
Technique in catheter insertion in the neonatal IJV. In the case of limited venous choices, we examined 1.9F catheter insertion in the IJV and achieved good results.

Material and methods

Patients

The clinical data of all 1.9F catheter insertions via the IJV using our new technique between January 2017 and December 2017 were reviewed and analyzed retrospectively. Relevant collected data included characteristics of the neonates, the catheter placement success rate, the catheter indwelling time, reasons for removal, and complications. This study was approved by the Ethics Committee of the Children’s Hospital of Zhejiang University School of Medicine. Signed informed consent was obtained from the patients’ guardians.

Two core members of the NICU venous treatment team performed the procedures. The puncture operator was required to have more than 2 years of experience in deep vein puncture or to have successfully performed more than 50 deep vein catheterizations. The inclusion criteria for using our new technique were as follows: patients who were admitted to the NICU whose venous damage was comprehensively evaluated by an expert group and were diagnosed as having difficulty in peripheral venous catheterization; bilateral femoral vein damage or difficulty in femoral venous catheterization, as shown by ultrasound imaging; and requiring more than 1 week of central vein treatment according to the treatment plan.

Materials

A 1.9F central venous catheter with a guide-wire (Pediatric Vascu-PICC; Medcomp, Harleysville, PA, USA), a 22G central venous catheter (Certofix; Braun, Melsungen, Germany), a 20G open indwelling needle (BD Insyte; Becton-Dickinson Infusion Therapy Systems Inc., Sandy, UT, USA), a puncture bag, and disinfectant were used in the study. A Philips CX30 compact portable ultrasound diagnostic device (Philips, Amsterdam, The Netherlands) was used, coupled with an L12-4 superficial probe.

Procedure

The patients were fasted for 2 hours before the procedure. The patient was placed on a radiation bed and underwent electrocardiographic monitoring, and was administered 0.05 to 0.1 mg/kg morphine for analgesia. The patient was placed in the supine position with a roll under the shoulder and the head toward the opposite side of the puncture, with declination of 15° to 30° to fully open the neck. This was performed so that the triangle zone formed by the sternocleidomastoid, trapezius, and clavicle, also called the supraventricular fossa or substernocleidomastoid muscle triangle, was exposed. An assistant maintained the child in this position and avoided a change in posture (Figure 1).

For puncture of the vein, using the ultrasound-guided method, a packaged probe was placed perpendicularly on the clavicular notch and it showed two round or oval anechoic lumens (i.e., the short axis view of the internal carotid artery and IJV) (Figure 2). By gently pressing the probe, one of the round lumens was flattened, which indicated that it was a vein, while the unflattened lumen was an artery. This determined the positions of the internal carotid artery and the IJV and their spatial relationship. After sterilization and draping, the operator held the puncture needle at an angle of 30° to 45° to the skin of the patient, inserted the needle according to the position of the IJV on the ultrasound screen, and stopped needle insertion when the needle tip appeared in the IJV.
cross-section. Dark red returning blood was visible if successful. After inserting the indwelling needle into the vein, the needle core was retracted. A syringe was connected to withdraw the returning blood to ensure that the guidewire of the 22G catheter was indeed inserted into the vein through the indwelling needle before retracting the indwelling needle. After inserting the 22G catheter through the guidewire support, the guidewire was retracted, and the returning blood was withdrawn to ensure that the 22G catheter was inside the IJV. The guidewire of the 1.9F catheter was then placed inside the 22G catheter. While retracting the 22G catheter, the guidewire was inserted so that the length of the guidewire was shorter than that of the catheter that was ultimately inserted to prevent the guidewire from accidently entering the heart. Finally, the 1.9 F catheter was inserted through the guidewire, the catheter length was adjusted, and the catheter was secured (Figure 3).

Figure 1. Photograph showing the patient's posture and operation with ultrasound positioning.

Figure 2. Spatial relationship of the internal jugular vein and internal carotid artery under ultrasound imaging. The dark round area in the left panel is the internal carotid artery and the dark oval area in the right panel is the internal jugular vein. From left to right, the images show changes in the shapes of the carotid artery and jugular vein when the probe is pressed. The artery is small and round, and the vein is thicker than the artery.
Statistical analysis

Data are presented as median and range. SPSS 22.0 software (RRID: SCR_002865; IBM Corp., Armonk, NY, USA) was used for statistical analysis. All probability values were two-sided and $p < 0.05$ was considered as statistically significant.

Results

Thirty-three (57.9%) boys and 24 (42.1%) girls who had a median (range) age of 38 days (2–135 days) were included. The median weight was 2.5 kg (1.19–4.68 kg). Punctures in the IJV were performed with 57 1.9F catheters in 48 patients. Puncture was performed in the right IJV in 43 (75.4%) patients and in the left IJV in 14 (24.6%) patients. The puncture success rate was 100% and the first-attempt success rate was 57/57 (100%). The median duration of catheterization was 14 days (1–70 days). Of the catheters, 94.1% were removed after completion of therapy or upon death. No complications were observed in 53 (93%) patients, whereas a small amount of bleeding was observed in 2 (3.5%) patients, inflammation from puncture in 1 (1.8%) patient, and occlusion in 1 (1.8%) patient (Table 1).

To simplify the procedure, five patients received direct insertion of the 1.9F catheter after successful venipuncture. Among the patients in whom a 22G catheter had been placed as the preset cannula, the catheterization success rate was 100%.

Discussion

Application of the ultrasonic positioning technique

Conventional neonatal jugular vein puncture relies on blind probing through body surface positioning. Because of the unique physiological anatomy of neonates and the lack of the operator’s experience, the procedure has a high failure rate and is subject to many complications; therefore, it is rarely used clinically. Ultrasound imaging is able
to clearly show the location and direction of the IJV, and dynamic ultrasound positioning allows the operator to track the relationship between the needle depth and the vein in real time.\textsuperscript{6} Therefore, the operator can rapidly adjust the puncture angle and depth to avoid repeated puncture of the vein and injury to the adjacent artery, resulting in significant improvements in the procedural success rate and safety.\textsuperscript{3} In patients in our study, dynamic positioning was used to determine the surface location and direction of the IJV to guide puncture, and a first-attempt puncture success rate of 100\% was achieved.

**Application of the modified Seldinger technique**

The main steps in implementing the technique in this study were as follows: (1) using a 20G open indwelling needle instead of a 1.9F catheter introducer sheath for puncture; and (2) using a 22G catheter as the preset cannula on the basis of considerations from clinical practice described below. There is difficulty for the 1.9F catheter introducer sheath meeting the requirements for puncture of the IJV. In conventional 1.9F catheter catheterization, the needle core is retracted after placing the introducer sheath into the blood vessel, and the catheter is inserted through the introducer sheath, which is later removed. This method is simple and maneuverability is easy. However, because of neonates' short neck and thick layer of subcutaneous fat, the IJV is located deeper than the superficial veins, and thus requires a longer subcutaneous penetration distance.\textsuperscript{7} Additionally, because of the lack of support from bone and muscle tissue under the vein, the IJV is prone to sagging or shifting position when a puncture through the body surface is made. The 1.9F catheter used in newborns has a short introducer sheath (Figure 3), which means that the IJV is not easily punctured. The central venous pressure of neonates is usually 5 to 8 mmHg, which is lower than that of the peripheral veins. Therefore, pulling of the syringe while puncturing is required to generate negative pressure to help determine returning blood. However, the introducer sheath cannot be connected to the syringe. The use of a 20G open indwelling needle for puncture can simultaneously address the characteristics of a long puncture path length and low venous pressure, allowing easier operation and achievement of a high puncture success rate.

**Necessity of using a 22G center catheter as the preset cannula**

Generally, when inserting a 1.9F catheter using the Seldinger technique, the 1.9F catheter introducer sheath can be inserted only after the Seldinger guidewire is placed and subcutaneous dilatation is conducted. In this study, we replaced the Seldinger set with a 22G catheter to play a role in dilating the subcutaneous access pathway and the venous insertion site. The main reason for this replacement is that the dilation effect of the guidewire matched to the 1.9F catheter is relatively weak. Additionally, the 1.9F catheter is too fine and soft, causing difficulty in penetration subcutaneously and rendering it unable to enter the blood vessel through the support of the guidewire.\textsuperscript{8} Use of the 22G catheter as a Seldinger kit is appropriate and causes little skin and venous damage. Furthermore, the cost of the 22G catheter is lower than that of the Seldinger kit. To simplify the procedure, five patients in this study received direct insertion of the 1.9F catheter after successful venipuncture. In the process of inserting the catheter through the guidewire, the catheter was unable to enter the IJV along the guidewire after it entered the skin. These five patients were first catheterized with the 22G catheter through the 1.9F guidewire, and after the
Figure 3. Photographs showing the procedural method. (a) Disinfection and draping. (b) A 20G open indwelling needle is used for puncture, and when returning blood is seen, the indwelling needle lumen is inserted and the needle core is retracted. (c) The 22G catheter guidewire is inserted through the 20G lumen. (d) The indwelling needle lumen is retracted. (e) The 22G catheter is inserted through the support of the guidewire. (f) While retracting the guidewire, returning blood is withdrawn using a syringe to ensure that the 22G catheter is indeed within the jugular vein. (g) The fine guidewire of the 1.9F catheter is inserted through the 22G catheter. (h) While retracting the 22G catheter, the guidewire is inserted in a manner such that the length of the guidewire in the body is shorter than that of the 22G catheter that is ultimately inserted to prevent the guidewire from accidently entering the heart. (i) The 1.9Fr catheter is inserted through the fine guidewire. (j) The fine guidewire is retracted. (k) The length of the 1.9F catheter is adjusted and the catheter is secured. (l) Comparison of the 20G open type indwelling needle and the 1.9Fr catheter introducer sheath. The former is fine and long and the latter thick and short. The open type indwelling needle connects to a syringe through a lumen, but the catheter introducer sheath cannot.
22G catheter was removed, the 1.9F catheter was successfully inserted. Among the patients in whom a 22G catheter had been placed as the preset cannula, the catheterization success rate was 100%.

**Prevention of puncture-related complications**

*Myocardial injury.* The distance from the jugular vein to the heart is relatively short in neonates, and monitoring the guidewire real-time once it is inserted into the body is not possible. If the guidewire is inserted too deeply, it may cause myocardial injury. The most effective way to prevent this complication is to measure the length of the guidewire so that the length of the guidewire inserted into the neonate’s body is shorter than that of the catheter eventually inserted. Moreover, when inserting the catheter, the guidewire is retracted during catheter insertion. Using this method, our patients did not experience guidewire insertion-related complications.

*Infection.* In this procedure, two types of guidewires and three types of catheters were used and inserted, involving relatively complex steps. If aseptic procedures are not rigorously followed, operation-related infections may occur. During the procedure, surgical disinfection standards were strictly followed. In this study, the puncture site was wiped twice with cotton balls that were saturated with 5% povidone-iodine, and the disinfection area included the neck and shoulder on the side of puncture, along with the neonate’s chest and face. The incidence of catheter-related bloodstream infections in patients in this study was 0 cases.

In this study, on the basis of ultrasound positioning, a 22G peripheral indwelling needle was used as a puncture needle, a 22G central venous catheter was used as a dilatation cannula, and the guidewire was matched to a 1.9F central venous catheter as support, with the result of successful insertion of 1.9F central venous catheters into the IJVs of neonates. This method achieved good clinical outcomes, and could lead to new ways of solving the problem of newborn intravenous access. However, this procedure has certain technical requirements and must be performed by operators with experience in deep venous puncture.

**Declaration of conflicting interest**

The authors declare that there is no conflict of interest.

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**Notes**

a. Infusion Nurses Society. Infusion nursing standards of practice. J INS, 2016, 39(1s):s42.
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