

Original Research Article

The practice of umbilical vessels catheterization in neonatal intensive care units: a survey

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ABSTRACT

Background: Umbilical venous catheterization and umbilical arterial catheterization provides easy access for administering fluids, exchange transfusion, medications, parenteral nutrition, blood pressure monitoring and blood sampling in neonates. Objective was to know the common practices related to the placement and maintenance of umbilical catheters, along with the associated complications in the level 3 and 4 neonatal intensive care units in the USA.

Methods: A questionnaire-based survey study was conducted among NICU practitioners across United States. Only one survey was sent to each NICU.

Results: Among the survey respondents, 50.8% represented level 3 NICUs, while 49.2% represented level 4 NICUs. The maximum duration for both UVC and UAC use was commonly reported as up to 7 days. Birth weight was the predominant method (86.8%) used for calculating catheter length. X-rays were universally employed for position confirmation. Heparin was widely utilized through UVC (96.7%), with a concentration of 0.5 IU/ml (73.7%). In cases of malpositioned UVC, practitioners employed techniques such as inserting another catheter, utilizing twisting movements during insertion, adjusting the UVC to a low position, and replacing the malpositioned UVC with a peripheral intravenous line. Common complications associated with UVC included line occlusion, thrombosis, and infections, while poor extremity perfusion and thrombosis were reported with UAC. Most units allowed feeding even when patients had a UAC in place.

Conclusions: Despite the presence of institutional policies in most NICUs, practitioners encountered several complications during the use of umbilical catheters.

Keywords: Umbilical catheterization, Complications, Malposition

INTRODUCTION

Umbilical venous catheter (UVC) and umbilical arterial catheter (UAC) placement is a common practice for managing sick newborns in the neonatal intensive care units (NICU). Achieving vascular access, particularly in extremely preterm infants, poses a significant challenge. Umbilical catheters offer a painless, rapid, stable, and reliable means of vascular access immediately after birth in high-risk newborns. This approach eliminates the time-

consuming and painful skin punctures required for alternative vascular access methods such as peripheral intravenous or arterial catheters, peripherally inserted central catheters (PICCs), and surgically inserted central venous catheters (SCVCs).¹

Umbilical arteries remain patent for 7-14 days but are typically accessible only within the first day or two after birth. Subsequently, vasoconstriction and clotting occur, making access challenging. These arteries serve purposes

such as frequent blood sampling, continuous monitoring of arterial blood pressure, angiography, resuscitation, and exchange transfusion.² Proper UAC placement, correlating with the 7th to 10th thoracic vertebrae on chest X-ray, is recommended exclusively.³ However, UAC use may lead to complications, including thrombosis, shunting blood supply to vital organs, and potential issues such as peritoneal perforation, false aneurysm, embolism, vasospasm, extremity loss, hypertension, congestive heart failure, infection, hemorrhage, Necrotizing enterocolitis (NEC) and ascites.⁴ For UVC, appropriate positioning is at the junction of the inferior vena cava and the right atrium, correlating with the 8th and 9th thoracic vertebrae or just above the diaphragm on chest X-ray. During resuscitation, UVC is inserted as a low line, advanced (2-4 cm) only until an adequate blood return is obtained. Although generally considered safe, an indwelling UVC is associated with complications that may cause morbidity and mortality. Complications include infection (central line-associated blood stream infections CLABSI), thromboembolism, pericardial effusion/cardiac tamponade, arrhythmias, hepatomegaly, NEC, ascites, peritoneal perforation, and extravasation of parenteral nutrition fluids.⁴ Contraindications for both umbilical arteries and veins include omphalocele, gastroschisis, omphalitis, and peritonitis. In umbilical arterial catheterization, evidence of vascular compromise in the lower limbs or buttocks is considered an additional relative contraindication.⁵ Various strategies have been suggested to reduce the risk of complications associated with umbilical catheters and other central lines. These include appropriate patient selection, education and training of healthcare providers, proper insertion procedures, catheter location, documentation of position by X-ray or Ultrasound, catheter size and composition consideration, catheter care, minimizing manipulations and dwell time, maintaining maximum sterile barrier precautions, and incorporating low-dose heparin in fluids running through UAC/UVC.^{6,7} Guidelines for appropriate patient selection for umbilical catheter insertion based on gestational age, birth weight, or severity of illness have been proposed by various authors. However, the feasibility of their implementation, staff compliance rates, and accrued benefits with the adoption of these guidelines remain unreported. Despite various calculations based on both birth weight and external measurements for estimating correct positioning, a lack of consensus exists in the literature regarding the most accurate method. Moreover, there is a scarcity of information about current practices across various NICUs. Only a few surveys have been conducted regarding UAC/UVC practices in NICUs across the USA, with none published recently.^{8,9}

Aim and objectives

Current study was aimed to survey the practices related to the placement and maintenance of umbilical catheters, along with the associated complications observed in diverse neonatal intensive care units across the USA. The study focused on addressing a range of methodologies

employed by practitioners, encompassing the calculation of catheter length, corrective insertion techniques, position confirmation, and the spectrum of complications encountered during the utilization of umbilical catheters.

METHODS

This survey was conducted by the Division of Neonatology, Department of Pediatrics at John H. Stroger Jr. Hospital of Cook County, Chicago. The survey was distributed to various NICU providers of different level 3 and level 4 NICUs across the USA between March 2021 and December 2022. The survey questionnaire, developed by the study team drawing upon their NICU expertise and literature review, comprised sixteen pertinent questions (Appendix). These questions encompassed aspects such as the institution's name and level, existence of policies for umbilical catheter placement, maximum duration of catheter use, methods for catheter length calculation, heparin usage, utilization of low line UVCs, application of UVCs for blood draws, radiological techniques for position confirmation, corrective measures for misplacement, complications encountered with UVCs and UACs, feeding practices with indwelling UAC, and the frequency of X-ray repetition after catheter adjustment.

This descriptive study gathered survey data from diverse NICUs across the United States, focusing on providers actively engaged with umbilical catheters. Participation primarily involved Neonatologists, in-training fellows, or nurse practitioners in Level 3 and 4 NICUs. The survey was predominantly distributed via email, facilitated by an electronic link through RedCap. Email addresses were obtained through FREIDA (American Medical Association's Residency and Fellowship database) and online searches. The electronic survey underwent two distributions, with a reminder sent after a two-week gap from the initial distribution. Additionally, a printed version of the questionnaire was distributed in-person at the Pediatric Academic Societies 2022 conference to NICU providers. Only one response per institute was considered. After collecting the data, statistical analysis was conducted by comparing frequencies using Microsoft Excel 2021.

RESULTS

Among the 126 NICU practitioners who received the survey, 63 (50%) responded, and 2 were excluded as their responses originated from the same institute. Out of the remaining 61 responses, 31 (50.8%) were from Level 3 and 30 (49.2%) were from Level 4 NICUs. As indicated in (Table 1), approximately 54 (88.5%) of the practitioners were aware of having an institutional policy. Most practitioners kept UVC and UAC in place for up to 7 days (59% for UVC, 52.4% for UAC). Birth Weight was the predominant method for calculating the length of the umbilical catheter (86.8%).

Table 1: Results from the survey.

Questions	N	%
Institutional policy		
Yes	54	88.5
No	7	11.4
Maximum duration of use of UVC (days)		
Up to 7	36	59
Up to 10	19	31
Up to 14	5	8.1
Maximum duration of use of UAC (days)		
Up to 3	13	21.3
Up to 5	13	21.3
Up to 7	32	52.4
>7	3	4.9
Method of calculation of umbilical catheter length		
Birth weight	53	86.8
Umbilical shoulder length	11	18
Birth length	3	4.9
Use of heparin through UVC		
Yes	59	96.7
No	2	3.2
Ratio of heparin used in the catheters (IU/ml)		
0.5:1	45	73.7
1:1	11	18
Both 0.5:1 or 1:1	2	3.2
0.25:1	2	3.2
Use of low line UVC		
Yes	39	63.9
No	22	36
Use of UVC for blood draws		
Yes	26	42.6
No	35	57.3
Techniques used to confirm the position of catheters		
X ray	61	100
X ray and Ultrasound	2	3.2
If the UVC is in the Liver, what steps do you take to ensure the UVC is in place?		
Place another UVC along the existing UVC and remove the previous one	30	49.1
Press the Liver while inserting the UVC	5	8.1
Insert UVC in twisting movement	20	32.7
Other techniques	7	11.4
Remove UVC and insert a PIV	11	18
Feeding while a UAC is placed		
Yes	52	85.2
No	10	16.3
Do you always re do X rays after adjusting lines to ascertain proper position?		
Yes	51	83.6
No	12	19.6

The majority of NICUs utilized Heparin (96.7%) through umbilical catheters and a concentration of 0.5 IU/ml was most commonly used (73.7%). Around 63.9% of NICUs accepted and utilized a low line UVC, and 42.6% used it for blood draws. All NICUs (100%) employed X-ray for confirming catheter positions, and 83.6% repeated X-rays after adjusting the position of the catheters. The survey highlighted diverse techniques used to ensure correct UVC positioning. Methods such as inserting another

catheter along the existing one (49.1%), applying pressure against the liver (8.1%), and using a twisting movement during insertion (32.7%) were reported in cases of UVC malposition. If proper UVC positioning was not achievable, 11.4% NICUs opted for low line UVC. The majority of NICUs (83.9%) reported continuing feeds while patients had a UAC, emphasizing the recognition of the importance of early nutrition in neonatal care. As illustrated in (Table 2), reported

complications with UVC included line occlusion (47.5%), thrombosis (39.3%), line infections (39.3%), migration of the catheter during removal (19.6%), pericardial effusion (18%), peritoneal extravasation (11.4%), cardiac tamponade (9.8%), air embolism (8.1%), and other complications such as arrhythmia and ascites (4.9%). Complications encountered with UAC included poor perfusion to extremities (68.8%) and thrombosis (34.4%).

Table 2: Results from the survey-complications encountered with UVC and UAC.

Parameters	N	%
UVC complications		
Line occlusion	29	47.5
Thrombosis	24	39.3
Line infections	24	39.3
Catheter migration while removal	12	19.6
Pericardial effusion	11	18
Peritoneal extravasation	7	11.4
Cardiac tamponade	6	9.8
Air embolism	5	8.1
Others (arrythmia, ascites)	3	4.9
None	3	4.9
UAC complications		
Poor perfusion to the extremities	42	68.8
Thrombosis	21	34.4
None	10	16.3
Necrotizing Enterocolitis	0	0

DISCUSSION

Among the responding NICUs, an equal distribution was observed between level 3 and level 4 facilities, indicating a balanced representation of both higher and lower acuity neonatal care units. The widespread presence of institutional policies on umbilical vessel catheters in most NICUs underscores the establishment of guidelines and protocols for their safe and effective utilization. Guidelines from the Center for Disease Control (CDC) recommend that a UAC should not be left in place for more than 5 days.¹⁰ However, our results showed that most places used UAC for up to 7 days. This finding aligns with a survey by Ragavan et al where catheters were used for a longer duration (8-14 days). The survey revealed birth weight (86.8%) as the predominant method for calculating umbilical catheter length, emphasizing the use of a standardized measurement parameter. Heparin use through umbilical catheters was prevalent in the majority of NICUs, with a concentration ratio of 0.5 IU/ml, consistent with CDC recommendations to prevent catheter occlusion. While textbooks acknowledge the controversy surrounding concomitant enteral nutrition during umbilical arterial catheter usage in high-risk newborns, our survey indicated that the majority of NICUs are comfortable continuing feeds while patients have a UAC. A 2003 survey by Tiffany et al reported that only 30% of respondents practiced giving trophic feeds to the newborns with a UAC. This underscores the evolving

recognition of the importance of early nutrition in neonatal care over the years. Previous studies emphasized confirming the UVC tip position through ultrasound (US) examination.^{11,12} Despite the increasing use of US for this purpose in some institutions, our survey revealed a predominant reliance on X-rays for confirming catheter tip position.

Limitations

Limitations of our survey include potential response bias due to non-responses, with a response rate of only 50%. Some survey questions lacked specificity, such as variations in catheter use based on gestation or birth weight, use of single versus double lumen catheters, trophic feeds versus full feeds, and catheter position (high versus low lying), which may have influenced responses.

CONCLUSION

Current survey revealed that, despite some variability in the practice of umbilical catheters among different NICUs, most units have established institutional policies and share a similar approach to placing and managing the catheters. This includes aspects such as the duration of catheter use, utilizing birth weight for measuring insertion length, employing Heparin with a consistent concentration ratio, and confirming catheter positions through various methods. The survey findings also underscore a diversity of practices in managing malpositioned catheters, emphasizing the need for further research to establish optimal methods in such cases. Considering the encountered complications, additional research and collaborative efforts are imperative to develop evidence-based guidelines that enhance the safety and efficacy of umbilical vessel catheterization in NICUs.

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