BMC Pediatrics

RESEARCH

Open Access

Association between umbilical venous catheter–related hepatic complications and tip position in neonates: a retrospective ultrasound-based analysis

Baohui Wu[1], Dongqian Wu[1], Chao Wang[2], Xia Sun[1], Fei Dong[2], Ning Liu[1], Zhao Wang[3] and Pengfei Li[3*]

Abstract

Background Umbilical venous catheterization (UVC) is commonly performed in neonates, but improper catheter tip may lead to hepatic complications.

Aim This study aims to retrospectively analyze the relationship between UVC tip position and the occurrence of hepatic complications, utilizing ultrasound for early detection and characterization of hepatic injury.

Methods We conducted a retrospective study of 206 preterm neonates who underwent UVC insertion in a NICU from January 2021 to December 2023. All patients with complete post–UVC insertion abdominal ultrasound follow–up records were included. According to the UVC tip position, neonates were divided into two groups: the Central Group and the Non-central Group. Within the non-central group, cases with the tip located in the ductus venosus (DV) formed the DV Subgroup. The incidence of hepatic complications, including portal venous gas, portal vein thrombosis, and hepatic parenchymal injury, was compared across these groups.

Results Hepatic complications were observed in 23 neonates (11.2%, 23/206), including portal venous gas (6.3%), portal vein thrombosis (1.9%), and hepatic parenchymal injury (2.9%). Among these, 9 cases (39.1%) occurred in the Central Group, while 14 cases (60.9%) were in the Non-Central Group, with 8 of these (57.1%) belonging to the DV Subgroup. The Non-Central Group accounted for the majority of complications, including all cases of hepatic parenchymal injury, with a proportion involving the DV Subgroup. These findings suggest an elevated risk of complications associated with non-central catheter tip position.

Conclusion Non-central catheter tip positions increase the risk of hepatic complications. Regular ultrasound follow-up is crucial for ensuring proper tip position and early complication detection.

Keywords Umbilical venous catheter, Hepatic injury, Neonatal care, Ultrasound, Portal vein thrombosis, Catheter tip position

*Correspondence:
Pengfei Li
pengflyl@163.com
[1]Department of Ultrasound, Harrison International Peace Hospital, Hengshui 053000, China
[2]Department of Neonatology, Harrison International Peace Hospital, Hengshui 053000, China
[3]Department of Science & Education, Harrison International Peace Hospital, No. 180 Renmin Road, Hengshui, Hebei Province 053000, China

Background

The use of umbilical venous catheter (UVC) in neonatal intensive care unit (NICU) is crucial for providing intravenous access to preterm and critically ill newborns. These catheters are essential for the administration of fluids, medications, and total parenteral nutrition (TPN) [1]. The optimal pathway for UVC placement extends from the umbilical vein through the portal sinus and the ductus venosus (DV), terminating at the inferior vena cava-right atrial junction (IVC-RA junction). The IVC-RA junction, clinically designated as the central position, represents the preferred target site due to its hemodynamic stability and reduced risk of direct contact with hepatic vasculature [2–4].

The DV entrance is narrow [5], and the umbilical vein within the hepatic may not align perfectly with the catheter [6], increasing the risk of hepatic injury during insertion. Consequently, hepatic injury can occur during catheter insertion. Additionally, the catheter tip may shift during use, further increasing the risk of hepatic injury [1, 7].

Traditionally, chest radiography has been employed to verify UVC tip position [8]. However, the accuracy of this method has increasingly been questioned because of its limitations in detecting malpositioned catheters. In contrast, ultrasound offers real-time visualization, providing a more precise tool for confirming catheter placement and detecting early hepatic complications [9]. Various hepatic injuries associated with UVC have been reported, including portal vein thrombosis, TPNoma, hepatic hematoma, bile duct venous fistula, solid organ injury, and even hepatic necrosis [7, 10–12]. However, the relationship between the position of catheter tip and the timing of these complications has not been thoroughly investigated. Therefore, this study aims to retrospectively analyze the relationship between UVC tip position and the occurrence of hepatic complications, utilizing ultrasound for early detection and precise characterization of hepatic injury, such as portal venous gas, portal vein thrombosis, and hepatic parenchymal injury. Ultimately, the study demonstrates the critical importance of accurate tip placement in minimizing UVC-related hepatic complications.

This study aims to retrospectively analyze the relationship between UVC tip position and the occurrence of hepatic complications, utilizing ultrasound for early detection and precise characterization of hepatic injury, such as portal venous gas, portal vein thrombosis, and hepatic parenchymal injury.

Materials and methods

Ethics statement

The study was approved by the Ethics Committee of Harrison International Peace Hospital (reference number: 2022-3-008) and conducted in accordance with the Declaration of Helsinki. The requirement for informed consent was waived by our institutional Ethics Committee because of the retrospective nature of the study and the use of existing medical records or data that did not involve the identity or privacy of participants and posed no risk or harm to them. Clinical trial number: not applicable.

Materials

This retrospective study included all neonates who underwent UVC insertion in NICU at Harrison.

International Peace Hospital between January 2021 and December 2023. The NICU specializes in treating critically ill preterm infants, including those with respiratory distress syndrome, neonatal pneumonia, and other severe neonatal conditions.

The inclusion criteria were all neonates who had undergone UVC insertion and had complete post-UVC insertion abdominal ultrasound follow-up records, which included detailed descriptions of the catheter tip position and hepatic ultrasound data. The exclusion criteria included neonates with pre-existing hepatic parenchymal injury or ascites, as well as those with severe systemic diseases such as significant hepatic or kidney failure before UVC insertion.

UVC practice and ultrasound examination

Double-lumen UVC (3.5 F) insertion was performed under sterile conditions. The catheter depth was initially estimated on the basis of the neonate's birth weight [13], with the depth calculated in centimeters according to a specific formula. The catheter was then inserted to this predetermined depth. Following insertion, blood was aspirated via a syringe to confirm venous access, with successful venous puncture indicated by the characteristic color of the aspirated blood, consistent with venous blood. X-ray examination was subsequently performed to assess the position of the catheter tip. On the basis of the X-ray results, the catheter depth was adjusted to ensure that the tip was positioned 0.5 to 1 cm above the diaphragm or at the level of the ninth thoracic vertebra, as marked by bony landmarks. Once the assumed position was confirmed, the umbilical section was secured with purse-string sutures, and the catheter was fixed in a bridge shape using adhesive tape to prevent dislodgement. All nurses performing UVC insertions received specialized training, requiring them to maintain proficiency by performing at least 10 UVC insertions annually. This structured training ensured consistency and accuracy in the catheterization process.

UVC duration was managed in line with the Chinese Guidelines for the Prevention and Control of Neonatal Umbilical Venous Catheter-Related Complications,

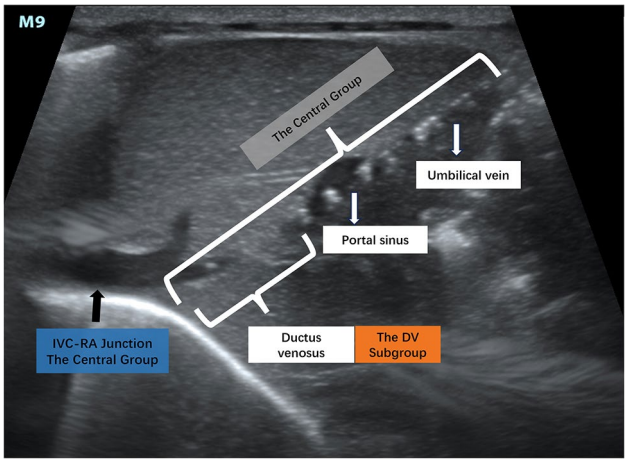

Fig. 1 UVC Pathway and The Catheter Tip Position. The optimal pathway: extends from the umbilical vein, the portal sinus and the venous catheter, ultimately reaching the junction between the inferior vena cava and the right atrium (IVC-RA junction)

with UVCs maintained based on clinical need and a recommended duration of 7–10 days if no infection was present.

During the period of UVC indwelling, all neonates were placed in the supine position for ultrasound examination. A portable Mindray M9 color digital ultrasound diagnostic instrument with an L11-4 high-frequency probe was used for two-dimensional abdominal ultrasound and color Doppler flow imaging. Routine ultrasound examinations were performed by experienced ultrasound physicians within the first five days following catheter insertion, contingent on the neonate's clinical stability and resource availability. Additionally, if clinical symptoms—such as abdominal distension—indicated potential complications, an abdominal ultrasound was performed as soon as possible. If hepatic complications were detected, additional ultrasound examinations were conducted to locate the catheter tip precisely and assess the extent of the injury.

Grouping by catheter tip position

According to the UVC tip position when hepatic complications were present, neonates were divided into two groups: the central group, where the catheter tip was positioned at the IVC-RA junction, and the non-central group, where the catheter tip was located outside the ideal central position. Within the non-central group, cases with the tip positioned in the ductus venosus (DV) formed the DV subgroup, which was specifically analyzed to evaluate complications associated with this location. The catheter path and tip positions are illustrated in Fig. 1.

Table 1 Baseline characteristics

Variable	With Complications ($n=23$)	Without Complications ($n=183$)	*P*-Value
Gestational Age (weeks)	30.7 (IQR 29.4, 32.5)	31.3 (IQR 29.9, 32.7)	0.045
Birth Weight (grams)	1420.0 (IQR 1200.0, 1650.0)	1450.0 (IQR 1225.0, 1700.0)	0.065
Gender (Male, %)	43.5% (10/23)	51.4% (94/183)	0.773
Apgar Score at 5 min	7.0 (IQR 6.0, 8.0)	8.0 (IQR 7.0, 9.0)	0.031
Duration of UVC (days)	5.0 (IQR 3.03, 7.00)	7.5 (IQR 5.5, 9.0)	0.018
Ultrasound Examination Time (days)	2.9(IQR 2.6, 3.8)	3.0 (IQR 2.5, 3.5)	0.755

Observation indicators

We collected the baseline characteristics of neonates, including gestational age, birth weight, gender, Apgar score at 5 min, duration of UVC placement, and ultrasound examination time. These characteristics were analyzed to identify significant differences between neonates with and without hepatic complications, as shown in Table 1.

Statistical analysis

Statistical analyses were conducted via SPSS 25.0 statistical software. Data conforming to a normal distribution are expressed as the mean ± standard deviation ($\overline{x}\pm s$) and were compared via the t-test. Categorical variables were analyzed via Pearson's chi-square test or Fisher's exact test, depending on the data distribution, where as the Mann-Whitney U test was used for continuous variables that did not follow a normal distribution. A p-value of <0.05 was considered to indicate statistical significance.

Results

Patient demographics and UVC insertion characteristics

A total of 206 preterm neonates underwent UVC insertion in the neonatal intensive care unit (NICU) at our hospital between January 2021 and December 2023. Among these, 23 neonates (11.2%) developed hepatic complications, while 183 neonates (88.8%) had no complications during UVC placement (Table 1).The median gestational age was 31.0 weeks (IQR 29.6, 32.6), and the median birth weight was 1429.0 g (IQR 1219.0–1670.0). Among the neonates, 48.5% were male. The median UVC dwell time was 7.92 days (IQR 4.00–11.95), ranging from 1 to 14 days (Table 1). Comparative analysis of neonates with and without hepatic complications revealed that those with complications had significantly lower gestational age ($p=0.045$), lower Apgar scores at 5 min ($p=0.031$), and shorter UVC dwell time ($p=0.018$). In contrast, no significant differences were observed in birth weight ($p=0.065$) or ultrasound examination timing ($p=0.755$).

Hepatic complications of UVC in the neonatal period

Among the 206 neonates who underwent UVC insertion, 23 (11.2%, 23/206) developed hepatic complications. Of these, 9 cases (9/23,39.1%) were observed in the Central Group, while 14 cases (14/23,60.9%) occurred in the Non-Central Group, including 8 cases (8/14,57.1%) within the DV Subgroup. Distinct ultrasound and clinical findings were noted across the different types of injuries, as shown in Fig. 2.

Air in the portal venous system

Air in the portal venous system was detected in 13 of the 23 patients with hepatic complications (6.3%, 13/206). The catheter tip was positioned in the Central Group in 8 cases (61.5%) and in the Non-Central Group in 5 cases, including 4 cases within the DV Subgroup. Ultrasound imaging typically reveals linear or band-like echogenicities of varying lengths within the portal venous system, often accompanied by posterior acoustic shadowing or reverberation artifacts (Fig. 1). Importantly, there was no clinical evidence of necrotizing enterocolitis in these patients. Follow-up ultrasound examinations conducted within one week of UVC insertion revealed complete resolution of the gas within 4 to 5 days.

Portal venous thrombosis

Portal venous thrombosis was identified in 4 patients (1.9%, 4/206). The catheter tip was positioned in the Central Group in 1 case (25%) and in the Non-Central Group in 3 cases (75%), including 2 cases within the DV Subgroup. Therefore, non-central tip positions, particularly those in the DV Subgroup, may increase the risk of portal venous thrombosis.

Ultrasound findings revealed irregular echogenic material attached to the catheter, with blood flow signal showing either filling defects or complete absence. Thrombosis was confirmed after catheter removal. Follow-up abdominal ultrasound at one week revealed that the hepatic had regained its regular condition, without signs of portal hypertension.

Hepatic parenchymal injury related to UVC

Hepatic parenchymal injury was observed in 6 patients (2.9%, 6/206), with all cases identified in the Non-Central Group. Among these, 2 cases (33.3%) had the catheter tip positioned in the DV Subgroup. In this study, the ultrasound manifestations of liver parenchymal injury were primarily categorized into two distinct types.

The first type is a single nodular echogenic injury, observed in 4 patients. These patients presented with homogeneously echogenic, nodular injuries with diameters ranging from 0.5 to 1.5 cm. A lesion was detected in one patient as early as 6 h after UVC insertion, with the catheter tip malpositioned in the external superior branch of the left hepatic lobe. This early detection revealed a small lesion with a diameter of less than 1 cm. All four patients with single nodular echogenic injury achieved complete recovery of hepatic echogenicity within one week. Some patients are shown in Fig. 3.

The second type is a large, irregular heterogeneous injury, observed in 2 patients. In these patients, the injuries were larger and irregular in shape, with a maximum diameter greater than 2 cm, and were associated with hepatic laceration and the presence of perihepatic fluid or ascites. After catheter removal, the volume of ascites decreased within 3 days, and hepatic echogenicity returned to normal after one month.

Discussion

In this study, we found three main hepatic complications following UVC use: air in the portal venous system, portal vein thrombosis, and hepatic parenchymal injury. Air in the portal venous system was the most common complication, occurring in 6.3% of cases (13/206), and was

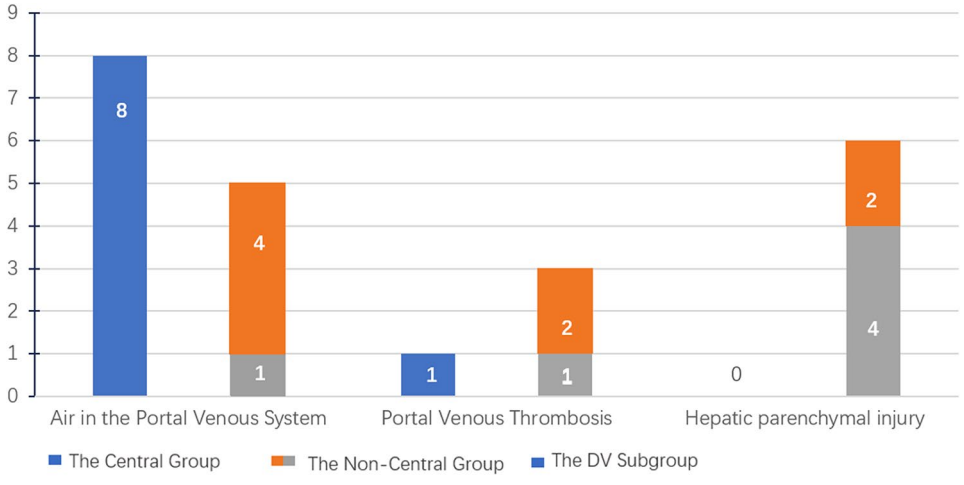

Fig. 2 The relationship between types of hepatic complications and the position of the UVC tip

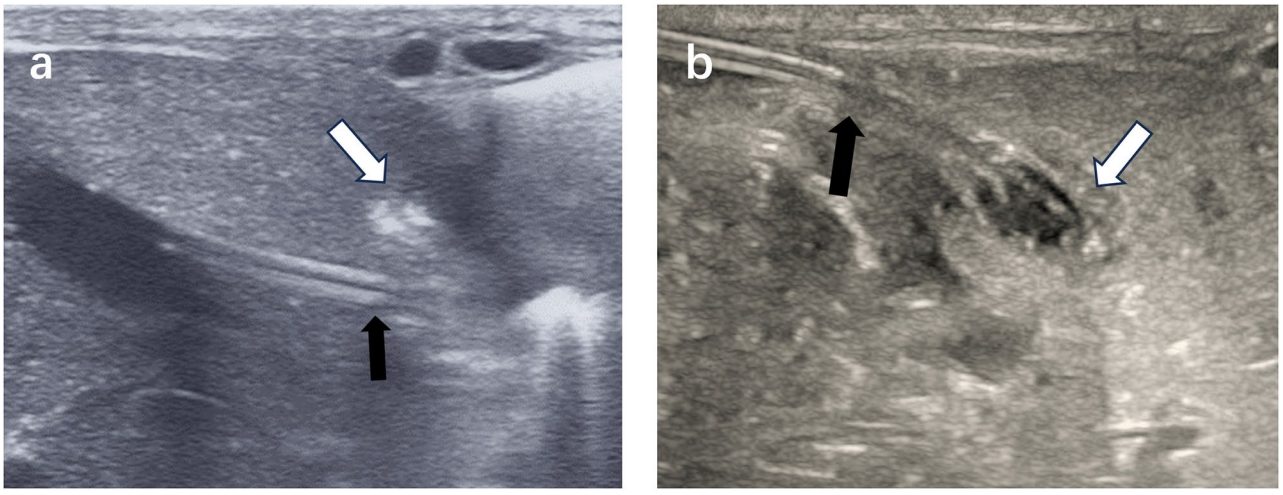

Fig. 3 Hepatic Parenchymal Injury. (**a**) Female infant, born at 29^{+3} weeks gestation, birth weight 1580 g. Six hours after UVC insertion, the catheter tip is positioned in the upper branch of the left hepatic lobe (malposition) (solid arrow). A hyperechoic nodule adjacent to the catheter in the liver (the hollow arrow). (**b**) Female infant, born at 32^{+0} weeks gestation, birth weight 1950 g. On the 5th day after UVC insertion, the catheter tip is located in the umbilical vein at the liver edge (malposition) (solid arrow). A nodule with a hyperechoic periphery and hypoechoic center is visible in the portal sinus (the hollow arrow)

most frequently observed even when the catheter tip was positioned at the Central Group (61.5%). The presence of air in cases with correctly positioned tips suggests that this issue may be related more to the insertion process than to tip location or medication administration. Ultrasound follow-up showed that the air resolved spontaneously within 4 to 5 days, supporting previous findings of its self-limiting nature [15].

In this study, PVT was observed in 4 cases (1.9%, 4/206), and was occurred in 25% of cases with the catheter tip in the Central Group, compared to 75% in the Non-Central Group. These findings align with existing literature [16], suggesting that improper positioning, such as placement within the liver or ductus venosus, increases the risk of thrombosis by disrupting blood flow and causing endothelial injury [17]. This risk may be further compounded by factors such as catheter manipulation during insertion or concurrent infection. Although the existing literature identifies prolonged indwelling of UVCs as a significant risk factor for complications such as thrombosis and infection, our findings suggest that catheter tip position is also an important contributing factor.

In this study, all cases of the cases of hepatic parenchymal injury occurred in the Non-Central Group, suggesting that non-central tip positions, including those in the DV Subgroup, may increase the risk of hepatic injury. Hepatic parenchymal injury related to UVC placement poses significant clinical concerns due to potential complications, such as hepatic dysfunction and hypotension [18]. Early detection and an understanding of the mechanisms and risk factors involved are critical for advancing neonatal care. In our study, hepatic parenchymal injury was observed in 6 cases (2.9%, 6/206), a rate that lies between the 2.5% reported by Hsin-Jen Chen [7] and the 7.4% observed by Betul Emine Derinkuyu [15], possibly due to differences in study populations, imaging protocols, or timing of assessments. Our findings indicate that non-ideal catheter tip positioning [19], particularly near the branches of the left hepatic portal vein, may increase the likelihood of hepatic injury by disrupting blood flow, causing extravasation of substances and/or infusion. This observation aligns with prior studies that identify malposition as a common predisposing factor for hepatic injury [11].

To minimize complication risks and enhance neonatal safety, it is essential to position the UVC tip at the IVC-RA junction (central position). This approach, supported by our findings, underscores the importance of precise catheter placement and real-time ultrasound guidance in clinical practice.

High-resolution ultrasound played a critical role in our study, allowing detection of hyperechoic nodules as small as 5 mm in early injury stages, often before clinical symptoms manifested [12]. Early interventions, such as catheter removal, facilitated rapid recovery of hepatic echogenicity and prevented further complications.

Historically, hepatic injuries associated with UVC have presented various patterns, which are essential to recognize for accurate diagnosis and management. In 1990, Levkoff AH [20] first described the wrap-like changes resulting from intrahepatic injury as the encystment of material infused through catheters. Later, in 2018, Hartley et al. [21] introduced the term 'TPNoma' to describe this phenomenon. Such lesions can present on ultrasound with varied echogenic patterns,

including a hypoechoic center with a hyperechoic rim, entirely hyperechoic areas, or a hyperechoic center with a hypoechoic rim, depending on the injury stage [22]. In contrast, 'hepatic extravasation' [7] is a broader term that includes a spectrum of hepatic injuries, some of which present with more chaotic or heterogeneous echoes. Differentiating between these types enhances diagnostic precision and aids in targeted clinical management, ultimately supporting improved neonatal outcomes.

Given the complexity and risks associated with catheter placement, including potential complications such as hepatic injury and thrombosis, it is crucial to ensure both accurate and consistent UVC insertion practices and proper catheter securement [23]. Standardized training and protocols for UVC placement, particularly with ultrasound guidance, are increasingly recognized as essential for minimizing complications and ensuring optimal catheter tip placement in neonates. Both the recent guidelines on Umbilical Venous Catheterization [24] and the Infusion Therapy Standards of Practice emphasize [25] that ultrasound-guided UVC insertion significantly enhances the accuracy of tip positioning, reducing the risk of malposition-related complications, such as hepatic injury and thrombosis. Targeted training programs allow clinicians to develop proficiency in ultrasound techniques, enabling real-time adjustments during insertion to improve safety and accuracy. Studies demonstrate that comprehensive training, including both theoretical instruction and practical application, enhances clinicians' skills in UVC placement, thus minimizing the need for repeated manipulations and additional imaging checks. Additionally, adhering to structured protocols fosters consistency in clinical practice, aligning catheter placement with current best practices and decreasing the likelihood of adverse events. Ultimately, integrating these practices into routine care supports safer UVC management and improved outcomes for neonates.

This study's retrospective design and small sample size of 206 neonates, including only 23 liver complication cases, limit the statistical power to establish a definitive link between UVC tip position and liver complications. Relying solely on high-resolution ultrasound for detecting hepatic complications provides a non-invasive diagnostic tool but lacks pathological confirmation, which could offer a deeper understanding of the injuries. The short-term focus of this study leaves the long-term effects of these complications on liver function and overall neonatal health unclear. Furthermore, variations in catheter caliber and materials, which may influence complication rates, were not considered, as only a single type of catheter was used in this study. Future studies should explore these factors and employ larger, prospective cohorts to validate these findings.

This study underscores the importance of precise UVC tip placement in reducing hepatic complications in neonates, with findings suggesting a higher risk of injury when the catheter is malpositioned. High-resolution ultrasound proves valuable for early detection and management of these complications. Additionally, standardized training and adherence to placement protocols can further enhance safety and accuracy in UVC insertion. However, further research with larger sample sizes and longer follow-up is needed to confirm these findings and assess long-term outcomes.

Conclusion

This study offers preliminary observations regarding the potential correlation between catheter tip position and hepatic parenchymal injury. The findings emphasize the critical importance of precise UVC placement in reducing hepatic complications and highlight the potential clinical utility of high-resolution ultrasound as an essential tool for early detection and management of catheter-related injuries. Integrating routine ultrasound follow-up into neonatal care protocols may significantly enhance early intervention strategies, thereby improving clinical outcomes in this vulnerable population.

Abbreviations

UVC	Umbilical venous catheter
NICU	Neonatal intensive care unit
TPN	Total parenteral nutrition
DV	Ductus venosus
IVC-RA junction	Junction between the inferior vena cava and the right atrium
PVT	Portal vein thrombosis

Acknowledgements

The authors would like to thank the research staff and clinical personnel for their outstanding performance and patient care.

Author contributions

BW, DW and XS contributed to the conception and the work design; FD, BW and DW contributed to the analysis and interpretation of data for the work; BW, XS and ZW drafted the work and revised it; CW and NL contributed to the drawing of the figures. All authors reviewed the manuscript.

Funding

This study was sponsored by Hebei Provincial Health Commission of China (No: 20232182).

Data availability

The data presented in this study are available on request from the corresponding author.

Declarations

Ethics approval and consent to participate

The study was approved by the Ethics Committee of Harrison International Peace Hospital (reference number: 2022-3-008) and conducted in accordance with the Declaration of Helsinki. The requirement for informed consent was waived by our institutional Ethics Committee because of the retrospective nature of the study and the use of existing medical records or data that did not involve the identity or privacy of participants and posed no risk or harm to them.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Received: 9 September 2024 / Accepted: 27 February 2025
Published online: 17 March 2025

References

1. Anderson J, Leonard D, Braner DA, Lai S, Tegtmeyer K. Videos in clinical medicine. Umbilical vascular catheterization. N Engl J Med. 2008;359(15):e18.
2. Lewis K, Spirnak PW. Umbilical vein catheterization. [Updated 2023 Mar 27]. StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2024. Jan-.
3. Gorski LA, Hadaway L, Hagle ME et al. Infusion Therapy Standards of Practice, 8th Edition. J Infus Nurs. 2021;44:S1-s224.
4. Oestreich AE. Umbilical vein catheterization–appropriate and inappropriate placement. Pediatr Radiol. 2010;40(12):1941–9.
5. Kiserud T. Hemodynamics of the ductus venosus. Eur J Obstet Gynecol Reprod Biol. 1999;84(2):139-47.
6. Eifinger F, Fuchs Z, Koerber F, Persigehl T, Scaal M. Investigation of umbilical venous vessels anatomy and diameters as a guideline for catheter placement in newborns. Clin Anat. 2018;31(2):269–74.
7. Chen HJ, Chao HC, Chiang MC, Chu SM. Hepatic extravasation complicated by umbilical venous catheterization in neonates: A 5–year, single–center experience. Pediatr Neonatol. 2020;61(1):16–24.
8. Gupta R, Drendel AL, Hoffmann RG, Quijano CV, Uhing MR. Migration of central venous catheters in neonates: A radiographic assessment. Am J Perinatol. 2016;33(6):600–4.
9. Cao J, Zhang Y, Yin Y, Liu Y. Accuracy of chest radiography compared to ultrasound for positioning the umbilical venous catheter in neonates: A meta–analysis and systematic review. J Vasc Access. 2023;24(5):1051–60.
10. Fuchs EM, Sweeney AG, Schmidt JW. Umbilical venous catheter–induced hepatic hematoma in neonates. J Neonatal Perinat Med. 2014;7(2):137–42.
11. Kim MJ, Yoo SY, Jeon TY, Kim JH, Kim YJ. Imaging of umbilical venous Catheter–Related hepatic complications in neonates. J Korean Soc Radiol. 2023;84(3):586–95.
12. Selvam S, Humphrey T, Woodley H, English S, Kraft JK. Sonographic features of umbilical catheter–related complications. Pediatr Radiol. 2018;48(13):1964–70.
13. Kieran EA, Laffan EE, O'Donnell CP. Estimating umbilical catheter insertion depth in newborns using weight or body measurement: a randomised trial. Arch Dis Child Fetal Neonatal Ed. 2016;101(1):F10–15.
14. Dubbink–Verheij GH, Visser R, Tan R, Roest AAW, Lopriore E, Te Pas AB. Inadvertent migration of umbilical venous catheters often leads to malposition. Neonatology. 2019;115(3):205–10.
15. Derinkuyu BE, Boyunaga OL, Damar C, et al. Hepatic complications of umbilical venous catheters in the neonatal period: the ultrasound spectrum. J Ultrasound Med. 2018;37(6):1335–44.
16. Dubbink-Verheij GH, Visser R, Roest AA, van Ommen CH, Te Pas AB, Lopriore E. Thrombosis after umbilical venous catheterisation: prospective study with serial ultrasound. Arch Dis Child Fetal Neonatal Ed. 2020;105(3):299–303.
17. Chen TN, Shih HH, Chang YT. Development of portal vein thrombosis due to improper positioning of the umbilical venous catheter tip. Pediatr Neonatol. 2024;65(5):523–4.
18. Coley BD, Seguin J, Cordero L, Hogan MJ, Rosenberg E, Reber K. Neonatal total parenteral nutrition Ascites from liver erosion by umbilical vein catheters. Pediatr Radiol. 1998;28(12):923–7.
19. Gibson K, Sharp R, Ullman A, Morris S, Kleidon T, Esterman A. Adverse events associated with umbilical catheters: a systematic review and meta-analysis. J Perinatol. 2021;41(10):2505–12.
20. Levkoff AH, Macpherson RI. Intrahepatic encystment of umbilical vein catheter infusate. Pediatr Radiol. 1990;20(5):360–1.
21. Hartley M, Ruppa Mohanram G, Ahmed I. TPNoma: an unusual complication of umbilical venous catheter malposition. Arch Dis Child Fetal Neonatal Ed. 2019;104(3):F326.
22. Sari L, Oran Z, Ali Gültekin M, Sharifov R, Toprak H. A rare complication of umbilical vein catheterization: TPNoma: US, X-ray, and MRI findings. Curr Med Imaging. 2023;19(4):398–401.
23. D'Andrea V, Prontera G, Pinna G, Cota F, Fattore S, Costa S, et al. Securement of umbilical venous catheter using cyanoacrylate glue: A randomized controlled trial. J Pediatr. 2023;260:113517.
24. Nickel B, Gorski L, Kleidon T, Kyes A, DeVries M, Keogh S et al. Infusion Therapy Standards of Practice, 9th Edition. J Infus Nurs. 2024;47(1S Suppl 1):S1-s285.
25. Barone G, Pittiruti M, Prontera G, Ancora G, D'Andrea V. A novel neonatal protocol for safe insertion of umbilical venous catheters (SIUVeC): minimizing complications in placement and management. J Vasc Access. 2024:11297298241236220.

Publisher's note