

Original Article



Comparison of Risks from Central Venous Catheters and Peripheral Intravenous Lines among Term Neonates in a Tertiary Care Hospital, India

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com**Abstract****Introduction:** Venous access in neonates is a basic yet critical component in neonatal intensive care unit (NICU). Central venous access and peripheral intravenous access are mostly preferred for delivering medications and intravenous fluids. This study aimed to compare the risks involved in central venous catheters and peripheral intravenous lines among term neonates.**Methods:** A prospective cohort study was carried out among 78 term neonates in the NICU of a tertiary care center in puducherry in India. Convenience sampling technique was used to enroll the neonates who met the inclusion criteria. Data pertaining to demographic and clinical characteristics, cannulation details, indwelling time, and incidence of thrombosis, phlebitis, occlusion, extravasation, and sepsis were collected by direct observation and from case record. Data were analyzed using SPSS software version 21. To analyze the data, descriptive statistics including frequency, percentage, mean, and standard deviation and inferential statistics including Fisher's exact test were utilized.**Results:** Our findings indicated that the risks of thrombosis and phlebitis were significantly higher in peripheral intravenous line group than the central venous group. There was no statistically significant association between the risks and demographic and clinical characteristics in both of the venous access system.**Conclusion:** According to our results, the use of central venous catheter among neonates showed lower risks than peripheral intravenous lines. Hence, using central venous catheter may be given priority in the NICUs.**Introduction**

Intravenous annulation has been a general practice in neonatal intensive care units (NICU).¹ Neonatal intravenous injections are mostly given through peripheral intravenous cannulas or central venous catheter.² Effective intravenous access plays a vital role in managing neonates to deliver intravenous fluids, inotropes and medications.³ Term and preterm neonates in NICU are at more risk of developing a systemic infection because of their immature immune system. So extra care is needed in choosing appropriate intravenous access for them.⁴ Central venous catheters are used mostly for critically ill neonates in NICU to administer blood products, total parenteral nutrition and also for administration of intravenous fluids for longer period of time.⁵ The first-time success rate of peripheral intravenous line in NICU population was 45%.⁶ Central venous catheters will require frequent flushing and dressing changes.⁷ Potential complications that occur with central catheters can be categorized into two

groups like infection and mechanical. The infection may be localized or systemic. Mechanical includes occlusion, needle dislodgment and extravasation.⁸

During insertion of central venous catheter damage to the blood vessel, malposition and catheter migration can occur.⁹ Although central venous catheter have many benefits like long indwelling time and reduced number of pricks it still have risk like blood stream infection.¹⁰ Though peripheral intravenous lines are simple, not expensive and used for a shorter duration of intravenous therapy it need frequent changes due to phlebitis and extravasations. Other risk includes entry of skin based bacteria through insertion site causing local cellulitis and possible systemic bacteremia.¹¹ Infiltration and injury to extremity from restraints were also common in peripheral intravenous line (PIVL).¹² Use of central venous catheter (CVC) and PIVL both has risks. Liosis et al., conducted a study among infants and reported that 25% of the infants in the CVC group had occlusion.¹³ Xia et al., reported that

in PIVL group 63.8% had obstructive risks and in CVC group it was 27.7%.¹⁴ Parellada et al., revealed that in CVC group out of 53 infants 8 had sepsis whereas in PIVL group among 97 infants 9 had sepsis.¹⁵ A study by Wilson et al.,³ revealed that in CVC group 39% and in PIVL group 28% had sepsis. In NICU, both CVC and PIVL were being used. Reduction of these risks is important to improve the outcome of neonates. Infections in neonates have been studied extensively but little is known about the influence of the type of intravenous access on the incident of infection. Few studies have been conducted to compare the risks from CVC and PIVL. Janes et al., and Ainsworth & McGuire compared the occurrence of sepsis and insertion attempts between CVC and PIVL groups.^{16,17} In addition to sepsis and insertion attempts, the present study compared all other risks like occurrence of thrombosis, phlebitis, occlusion and extravasations because these risks also contribute discomfort and create intense pain in neonates. The idea of ensuring quality care to the neonates is to raise the level of care-through a continuous search for improvement. To guarantee constant improvement in the quality of care and to aid in standardization of venous access system on scientific basis, the present research was aimed to compare the risks involved in the major forms of intravenous access i.e. central venous catheter system and peripheral intravenous access method.

Materials and Methods

Observational descriptive study was adopted to compare the risks from CVC and peripheral intra venous lines among term neonates. This study was conducted in NICU of a tertiary care hospital in puducherry in India during October 2018 to January 2019. Based on previous studies, risk rate of 7.5% in one group and a relative risk of 4.2, with an alpha error of 0.05 and power of 0.8, 39 infants have to be enrolled in each group for a total of 78. Term neonates admitted in NICU with CVC or peripheral intravenous line and whose parent gave willingness to participate the neonate in the study were included in the study. Term neonates who were admitted with sepsis or congenital anomalies were excluded from the study. Everyday neonates who met the inclusion criteria were selected through convenience sampling method. Informed consent was obtained from parents of both groups. In both the groups' demographic and clinical characteristics such as gestational age, birth weight, gender and age of the neonate were noted from the medical record. By observation, the type of intra venous access date and time of cannulation, number of cannulations try, indication for IV access and number of cannulas used were noted by the researcher. It took 45 minutes for each neonate. Then the neonates were observed daily for the presence of risks like phlebitis, thrombosis, occlusion, extravasation, and sepsis and noted and also the date of removal of the cannula was also documented.

Data collection instrument had three sections. The first

section included data regarding clinical and demographic characteristics of the neonates. It comprised of birth weight, gestational age, gender and age of the neonate. Second section had cannulation details. It included the type number of cannulas used, indication for intravenous access, number of cannulations try (number of prick) and durability of the cannula. Third section dealt with data pertaining to risks observed in both the groups like occurrence of thrombosis, phlebitis, occlusion, extravasation, and sepsis. Extravasation is evidenced by infiltration of fluid in to the tissue surrounding the venipuncture site. Occlusion is blockage of fluid flow. Phlebitis is confirmed by swelling along the venous track leading to hardened cord like vein. Sepsis is presence of bacteremia originating from IV. Access method which is confirmed by blood culture positive and correlation with clinical symptoms. Thrombosis is a blood clot occurring inside the blood vessel which is confirmed by fibrin deposition inside or around the catheter tip.

The study was approved by Institute Scientific Advisory Committee (JIP/CON/NRMC/M.S C/2017/PN/5) and ethics committee (No. JIP/IEC/2018/031). Informed written consent was obtained from parent of all neonates under study. Confidentiality of the data, right to withdraw from the study and anonymity of the subjects were explained prior. The content validity of the three sections of the tool was obtained from the experts of neonatology and nursing field. Reliability was examined by cronbach's alpha (alpha=0.38). Data were analyzed using SPSS Ver 21(SPSS Inc., Chicago, Ill., USA). Both descriptive and inferential statistics were used for analysis of data. Descriptive statistics (mean, standard deviation, frequency and percentages) were used to describe the clinical and demographic variables of study participants. Fisher's exact test was used to compare the risks in central venous catheters and peripheral intravenous lines.

Results

In both groups majority of the neonates were in the gestational age group of 37-38 weeks. In Central Venous Catheters group most of the neonates were male whereas in Peripheral Intravenous Lines group it was female. In both groups, majority were in the age group of 1-7 days and birth weight more than 2.5 kg (Table 1).

In central venous catheter group total parenteral nutrition was the major indication for venous access and intravenous fluid administration served as a least indication. In peripheral intravenous line group the major indication was IV fluid administration and it was followed by antibiotics administration (Table 2).

Both number of cannulas and number of cannulation try were higher in peripheral intravenous line group and durability of the cannula was higher in central venous catheter group (Table 3).

Comparison of risks in central venous catheter group and peripheral intravenous lines group represented that

Table 1. Demographic and clinical characteristics of neonates (N=78)

| Variables | CVC group N (%) | PIVL group N (%) |
|------------------------|--------------------|---------------------|
| Gestational age | | |
| 37-38 weeks | 28(71.8) | 26(66.6) |
| 39-40 weeks | 10(25.6) | 12(30.8) |
| 41-42 weeks | 1(2.6) | 1(2.6) |
| Gender | | |
| Male | 21(53.8) | 17(43.6) |
| Female | 18(46.2) | 22(56.4) |
| Age in days | | |
| 1-7 | 34(87.2) | 35(89.7) |
| 8-28 | 5(12.8) | 4(10.3) |
| Birth weight | | |
| 1.5-2.49 Kgs | 15(38.5) | 17(43.6) |
| ≥ 2.5 kgs | 24(61.5) | 22(56.4) |

Table 2. Indication for intra venous access in both groups (N=78)

| Indication for IV access | CVC group(n=39) N (%) | PIVL group(n=39) N (%) |
|----------------------------|--------------------------|---------------------------|
| Antibiotics | 9(23.07) | 18(46.15) |
| IV fluids | 7(17.95) | 21(53.85) |
| Total parenteral nutrition | 23(58.98) | 0 |

Table 3. Cannulation data in both groups (N=78)

| Characteristics | CVC group (n=39) | PIVL group(n=39) |
|-------------------------------------|------------------|------------------|
| | Mean(SD) | Mean(SD) |
| Number of catheter/cannulas used | 1.05(0.23) | 4.62(1.06) |
| Number of cannulation try | 1.23(0.4) | 5.03(1.08) |
| Durability of the cannula (in days) | 7.14(1.91) | 1.58(1.1) |

the thrombosis and phlebitis were higher in PIVL group and it was significant at 0.01 and 0.001 level respectively. Though the incidence of extravasation was higher in peripheral intravenous lines group it was not significant $P=1$. In central line group though the neonates experienced occlusion and sepsis it was not significant (Table 4).

There was no significant association between the risks and demographic and clinical characteristics in both groups (Table 5).

Discussion

This observational descriptive study included 78 term neonates with 39 neonates in each group. The result of this study clearly showed that in central venous catheter group the number of cannulation try were lesser than peripheral intravenous line group which is similar to the study conducted by Janes et al.,¹⁶ ($P<0.01$) and another study by Wilson et al.,³ ($P<0.05$). Similarly, a study carried out by Barria et al.,¹⁸ among 74 neonates also showed the similar results.

In this study, number of catheters used in CVC group was 1.05(0.23) lesser than that used in peripheral intravenous line group 4.62 (1.06). A randomized comparative trial done by Janes et al.,¹⁶ also revealed similar results ($P<0.01$) and another study by Ainsworth & McGuire,¹⁷ also supported the above results with Mean difference of 4.3.

In this study, the mean durability of the catheter was

higher in CVC group than in peripheral intravenous line group, which is similar to the cohort study conducted by Xia et al.,¹⁴ where the durability of the catheter in CVC group was more than peripheral intravenous line group 18.75(7.60) & 1.49(0.55) respectively) and it was significant at 0.01 level. Furthermore, the results of the study by Lioussis et al.,¹³ also demonstrated that in CVC group, the indwelling time was 28 days compared to 1.5 days in peripheral intravenous line group.

When comparing the risks in both the groups incidence of phlebitis, thrombosis and extravasation were higher in PIVL group than in CVC group. In a similar study conducted by Barria et al.,¹⁸ also showed the similar results. Though the incidence of occlusion was higher in CVC group, it was not statistically significant ($P=1$). In a contrary to the above results, a study conducted by Xia et al.,¹⁴ showed that occlusion risk was lesser in CVC group than in PIVL group (27.7% & 63.8% respectively).

Though the incidence of sepsis was higher in CVC group it was not statistically significant ($P=0.49$). Similar findings were noted in Wilson et al.,³ randomized trial where in CVC group the incidence of septicemia was 39% when compared to 28% in PIVL group. Similarly, a study conducted by Ainsworth & McGuire¹⁷ also revealed that in CVC group 46% infant had sepsis compared to 40% in Peripheral intravenous line. In another study by Xia et al.,¹⁴ showed that there was no variation in both the groups. In contrary to the current study results a retrospective study carried out by Parelleda et al., showed that the incidence of sepsis was higher in PIVL group ($n=9/1000$) than in CVC group (8/1000) and another study by Lioussis et al.,¹³ also reported that the incidence was higher in PIVL group ($n=12$) when compared to CVC group ($n=3$). A randomized trial carried out by Janes et al.,¹⁶ also supported that the incidence of sepsis was higher in PIVL group, (48%) than in CVC group (42%).

In CVC group none had extravasation (0/39) & in PIVL group only one (1/39) had extravasation. Similarly, a study carried out by Wilson et al.,³ also revealed that only 2 infants had extravasation in CVC group compared to 278 in PIVL group.

In current study there were no statistical significant association between the risks and demographic, clinical characteristics in both the groups. In contrary to the above results a study conducted by Dubbink- Verheij et al., revealed that in CVC group among the risks septicemia had association with some of the demographic & clinical characteristics like parenteral nutrition, male gender

Table 4. Comparison of risks in both groups (N=78)

| Risks | CVC group (n=39) | PIVL group (n=39) | P ^e |
|---------------|------------------|-------------------|----------------|
| Thrombosis | 0 | 9 | 0.002* |
| Phlebitis | 1 | 29 | 0.00* |
| Occlusion | 1 | 0 | 1 |
| Extravasation | 0 | 1 | 1 |
| Sepsis | 2 | 0 | 0.49 |

*Fisher's exact test, *Statistically significance at $p<0.05$

Table 5. Association of risks with demographic & clinical characteristics (N=78)

| Variables | Risks in CVC group | | | | | p ^e | Risks in PIVL group | | | | | p ^e |
|----------------------------------|--------------------|-----------|-----------|---------------|--------|----------------|---------------------|-----------|-----------|---------------|--------|----------------|
| | Thrombosis | Phlebitis | Occlusion | Extravasation | Sepsis | | Thrombosis | Phlebitis | Occlusion | Extravasation | Sepsis | |
| Age in days | | | | | | | | | | | | |
| 1-7 | 0 | 1 | 1 | 0 | 2 | 1 | 8 | 25 | 0 | 1 | 0 | 1 |
| 8-28 | 0 | 0 | 0 | 0 | 0 | | 1 | 4 | 0 | 0 | 0 | |
| Gestational age in weeks | | | | | | | | | | | | |
| 37-38 | 0 | 1 | 1 | 0 | 2 | | 4 | 21 | 0 | 1 | 0 | |
| 39-40 | 0 | 0 | 0 | 0 | 0 | 0.44 | 5 | 7 | 0 | 0 | 0 | 1 |
| 41-42 | 0 | 0 | 0 | 0 | 0 | | 0 | 1 | 0 | 0 | 0 | |
| Birth Weight in Kilogram | | | | | | | | | | | | |
| 1.5 – 2.5 | 0 | 0 | 1 | 0 | 2 | 0.12 | 4 | 12 | 0 | 1 | 0 | 1 |
| <2.5 | 0 | 1 | 0 | 0 | 0 | | 5 | 17 | 0 | 0 | 0 | |
| Indication for I.V access | | | | | | | | | | | | |
| Antibiotics | 0 | 0 | 0 | 0 | 0 | | 6 | 12 | 0 | 0 | 0 | 1 |
| IV Fluids | 0 | 1 | 1 | 0 | 1 | 0.29 | 3 | 17 | 0 | 1 | 0 | |
| TPN | 0 | 0 | 0 | 0 | 1 | | 0 | 0 | 0 | 0 | 0 | |

^eFisher's exact test

and higher birth weight.¹⁹ Ray- Barruel et al.,²⁰ assessed the effectiveness of insertion and maintenance bundles in preventing peripheral intravenous catheter related complications and expressed that peripheral intravenous catheters are essential for delivery of medical treatments.²⁰ Jayaweera & Sivakumar assessed the children implanted with long term indwelling central venous catheters and revealed that the commonest and the severe complication of CVC is the central line-associated blood stream infection.²¹ Varghese et al., assessed the indications and complications of PICC line in neonates and revealed that central venous catheters are essential in NICU and are commonly used to provide fluids, medications and parenteral nutrition.²²

It has to be mentioned that extreme caution should be exercised in generalizing the findings of the study to other populations because the current study was conducted in one region only, moreover only term neonates were included in the study. The reliability of the tool was established by cronbach's alpha. Since alpha value is 0.38 it is considered as one of the limitations but in future the tool may be revised.

Neonatal intensive care unit nurses play a major role on securing and maintaining IV access for neonates. The findings of the study showed that the incidence of occlusion was higher in CVC group and this can be prevented by nurses by regular flushing of the central line. Extravasation was higher in PIVL group and this can be noticed at once and the cannula needs to be removed immediately. This

is possible only by consistent observation of the neonates by the nurses.

Conclusion

Among term neonates the use of central venous catheter showed lesser risks than peripheral intravenous line. This study adds one more piece of evidence so that the use of central venous catheter may be given priority among other venous access systems in neonatal intensive care units.

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Ethical Issue

There is no ethical issue.

Conflict of Interest

The authors declare no conflict of interest in this study.

Author's Contributions

VP, VR: conception and design; VP, VR: analysis and interpretation of the data; VP, VR: drafting of the article; VP: critical revision of the article for important intellectual content; VP, VR: final approval of the article.

References

1. Gray JW. Surveillance of infection in neonatal intensive care units. *Early Human Development* 2007; 83(3):157-63.
2. Arnsts IJ, Bullens LM, Groenewoud JM, Liem KD. Comparison of complication rates between umbilical and peripherally inserted central venous catheters in newborns. *J ObstetGynecol Neonatal Nurs* 2014; 43(2): 205-15. doi: 10.1111/1552-6909.12278
3. Wilson D, Verklan MT, Kennedy KA. Randomized trial of percutaneous central venous lines versus peripheral intravenous lines. *J Perinatol* 2007; 27(2): 92-6. doi: 10.1038/sj.jp.7211650
4. Orłowski JP. My kingdom for an intravenous line.

Research Highlights

What is the current knowledge?

There are risks in both central venous catheter and peripheral intravenous lines but the extent in current scenario is lacking.

What is new here?

Use of central venous catheter in NICU revealed that it served as an apt intravenous access for neonates with minimal risk.

- Am J Dis Child 1984; 138(9): 803. doi: 10.1001/archpedi.1984.02140470003001
5. Al Raiy B, Fakhri MG, Bryan-Nomides N, Hopfner D, Riegel E, Nenninger T, et al. Peripherally inserted central venous catheters in the acute care setting: a safe alternative to high-risk short-term central venous catheters. *Am J Infect Control* 2010; 38(2): 149-53. doi: 10.1016/j.ajic.2009.06.008
 6. Schneditz NB, Pichler G, Urlesberger B. Peripheral intravenous access in preterm neonates during postnatal stabilization: feasibility and safety. *Front Pediatr* 2017; 5; 171. doi: 10.3389/fped.2017.00171
 7. Levy I, Bendet M, Samra Z, Shalit I, Katz J. Infectious complications of peripherally inserted central venous catheters in children. *Pediatric Infectious Disease Journal* 2010; 29(5): 426-9.
 8. Browne NT. Nursing care of the pediatric surgical patient. 3rd ed. Burlington: Jones and Bartlett Learning; 2007.
 9. MacDonald G, Ramasethu J. Atlas of procedures in neonatology. 5th ed. Philadelphia: Lippincott Williams & Wilkins; 2007.
 10. Chien LY, Macnab Y, Aziz K, Andrews W, McMillan DD, Lee SK; Canadian Neonatal Network. Variations in central venous catheter-related infection risks among Canadian neonatal intensive care units. *Pediatr Infect Dis J* 2002; 21(6): 505-11. doi: 10.1097/00006454-200206000-00006
 11. Adams J, Molzhan A. Fluid, electrolyte, and acid-base balances. 3rd ed. Toronto: Elsevier; 2006.
 12. Verklan MT, Walden M. Core curriculum for neonatal intensive care nursing. 4th ed. Philadelphia: W.B. Saunders Publishing Company; 2009.
 13. Lioussis G, Bardin C, Papageorgiou A. Comparison of risks from percutaneous central venous catheters and peripheral lines in infants of extremely low birth weight: a cohort controlled study of infants < 1000 g. *J Matern Fetal Neonatal Med* 2003; 13(3): 171-4. doi: 10.1080/jmf.13.3.171.174
 14. Xia B, Xiong Y, Hu YL, Mu DZ. Evaluation of peripherally inserted central catheters in high risk newborns. *Zhongguo Dang Dai Er Ke Za Zhi* 2009; 11(2): 100-3. (Chinese)
 15. Parellada JA, Moïse AA, Hegemier S, Gest AL. Percutaneous central catheters and peripheral intravenous catheters have similar infection rates in very low birth weight infants. *J Perinatol* 1999; 19(4): 251. doi: 10.1038/sj.jp.7200182
 16. Janes M, Kalyn A, Pinelli J, Paes B. A randomized trial comparing peripherally inserted central venous catheters and peripheral intravenous catheters in infants with very low birth weight. *J Pediatr Surg* 2000; 35(7): 1040-4. doi: 10.1053/jpsu.2000.7767
 17. Ainsworth S, McGuire W. Percutaneous central venous catheters versus peripheral cannula for delivery of parenteral nutrition in neonates. *Cochrane Database Syst Rev* 2015; 10: CD004219. doi: 10.1002/14651858.CD004219
 18. Barria RM, Lorca P, Muñoz S. Randomized controlled trial of vascular access in newborns in the neonatal intensive care unit. *J Obstet Gynecol Neonatal Nurs* 2007; 36(5): 450-6. doi: 10.1111/j.1552-6909.2007.00171.x
 19. Dubbink-Verheij GH, Bekker V, Pelsma ICM, VanZwet EW, Smits-Wintjens VEJ, Steggerda SJ, et al. Bloodstream infection incidence of different central venous catheters in neonates: a descriptive cohort study. *Front Pediatr* 2017; 5:142. doi: 10.3389/fped.2017.00142
 20. Ray-Barruel G, Xu H, Marsh N, Cooke M, Rickard CM. Effectiveness of insertion and maintenance bundles in preventing peripheral intravenous catheter-related complications and bloodstream infection in hospital patients: a systematic review. *Infect Dis Health* 2019; 24(3): 152-68. doi: 10.1016/j.idh.2019.03.001
 21. Jayaweera JAAS, Sivakumar D. Asymptomatic central line-associated bloodstream infections in children implanted with long term indwelling central venous catheters in a teaching hospital, Sri Lanka. *BMC Infect Dis* 2020; 20(1): 457. doi: 10.1186/s12879-020-05190-5
 22. Varghese NV, Saada OA, Afzal U, Khan n, Hadidi AE, Rahmani A, et al. PICC line in neonates: indications & complications. A single level 3 NICU experience in the UAE and review of literature. *Glob J Pediatr Neonatal Care* 2021; 3(2): 1-5. doi: 10.33552/GJPNC.2021.03.000558