Vol. 2 No. 1 (2025)

ONLINE ISSN :3007-309X
PRINT ISSN :3007-3081

Journal of Medical & Health Sciences Review

LIMB SPLINTING FOR INTRAVENOUS CANNULAE IN NEONATES AND ITS EFFECTS ON LIFE SPAN OF INTRAVENOUS CANNULAE

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ARTICLE INFO:

Keywords:
Accidental dislodgment; Leakage; Randomized controlled trial; Complications; Neonatal care.

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Article History:
Published on January 15, 2025

ABSTRACT

Background: Peripheral intravenous (IV) cannulation is essential for administering medications in neonates but often has a short lifespan, leading to repeated procedures and increased risk of complications. The effectiveness of limb splinting in extending the dwell time of IV cannulae remains to be debated, with inconsistent findings reported in the literature. This study aimed to evaluate the impact of limb splinting on the lifespan of IV cannulae in neonates and to compare the incidence of associated.

Methods: A randomized controlled trial was conducted. A total of 248 cannulations were randomized into two groups: 123 received IV cannulation with limb splinting and 125 without splinting. The primary outcome was the dwell time of the IV cannula, measured from insertion to removal. Secondary outcomes included the frequency of complications such as extravasation, accidental dislodgment, and leakage. Data were analyzed using SPSS version 26, with statistical significance at $p<0.05$.

Results: The mean dwell time of IV cannulae was significantly longer in the splinted group (37.64 ± 14.48 hours) compared to the non-splinted group (31.33 ± 11.49 hours, $p=0.005$). Extravasation was the most common cause of cannula removal, observed in 45.2% of the splinted group and 39.1% of the non-splinted group.

Conclusion: Limb splinting significantly increases the lifespan of IV cannulae in neonates, potentially reducing the need for repeated cannulations and associated complications. Further research is recommended to explore additional factors influencing the effectiveness of splinting.

INTRODUCTION:

The use of intravenous (IV) cannulae is paramount for the effective administration of medications in neonatal care. Peripheral intravenous cannulation is the most commonly employed method for obtaining vascular access [1]. However, IV cannulation is often a painful and stressful experience, accompanied by potential adverse effects such as insertion site infections. A major challenge in peripheral IV cannulation in neonates is its short dwell time, which increases the likelihood of adverse events [2].

The dwell time of IV cannulae is a critical concern in neonatal care and depends on several factors, including cannula size, frequency of use, and type of medication administered [3, 4]. Various studies have focused on strategies to increase dwell time while addressing factors contributing to premature removal.

Peripheral IV cannulation is routinely performed in hospitalized neonates, yet it is associated with various complications. According to the literature, 95% of neonatal IV cannulae are removed due to complications [5]. The average lifespan of an IV cannula ranges from 15 to 54 hours, though some studies report durations from 12 to 274 hours [6]. Numerous techniques have been developed to extend cannula dwell time and minimize associated discomfort. Among these, splinting and heparinization are the most widely practiced methods [7].

Limb splinting is a traditional method used to immobilize the limb and potentially enhance cannula dwell time. However, there is no significant consensus regarding its utility. Various studies have reported differing levels of effectiveness with different splinting methods for limbs with IV cannulae. Given these variable results, this randomized controlled trial aims to evaluate the effectiveness of splinting compared to a non-splinted approach. The study assessed the lifespan of IV cannulae following limb splinting in contrast to the non-splinting meth.

Materials and Methods

Ethical Considerations

All procedures were performed in accordance with the ethical standards of the institutional and national research committees and the 1964 Declaration of Helsinki and its later amendments (DoH–Oct 2013). Ethical approval was obtained from the Institutional Research Forum (IRF), Rawalpindi Medical University prior to study initiation ERB number is (RMU-RRF-SUR-007-23). Permission to conduct the study was secured from the responsible authorities of the Department of Pediatric Surgery after a detailed explanation of the study objectives. Written informed consent was obtained from the parents of all enrolled neonates. Confidentiality and anonymity of participant data were strictly maintained throughout the study.

Study Design, Setting, and Population

This randomized controlled trial was conducted in the High Dependency Unit (HDU) of the Department of Pediatric Surgery at a tertiary care hospital in Pakistan. The trial was prospectively registered at ClinicalTrials.gov (Identifier: NCT06615063) and conducted in accordance with CONSORT 2010 guidelines [8].

During the study period (December 2022 to December 2023), 142 neonates were admitted to the HDU. Of these, 72 neonates meeting the inclusion criteria were enrolled, resulting in 248 successful cannulations. Gender distribution was nearly equal, comprising 37 females and 35 males.

The minimum sample size was estimated using a sample size calculator based on the following parameters: population size = 70 (over 3 months), expected population proportion = 50%, margin of error = 5%, and confidence level = 95%. The calculated minimum sample size was 60 neonates. Figure 1 illustrates the participant flow according to CONSORT guidelines [8].

Inclusion criteria:

Term neonates requiring intravenous (IV) cannulation for ≥24 hours

Birth weight ≥2.5 kg

- No requirement for ventilatory support
- No requirement for central venous catheterization
- Absence of major congenital malformations

Randomization and Group Allocation

Eligible neonates were randomly allocated into two groups using the lottery method, performed by the senior nurse on duty. Cannulations were randomly assigned to:

- **Group A (Splint Group):** IV cannulation with splint (n = 125)
- **Group B (No-Splint Group):** IV cannulation without splint (n = 123)

An eligible cannulation was defined as one of the first three successful IV cannula insertions in a neonate, placed over any of the four major joints: wrist, elbow, knee, or ankle. Prior to trial commencement, all healthcare personnel involved in cannulation were briefed on standardized procedures. Only senior nurses performed the cannulations, with junior nurses assisting in fixation. A 24G peripheral IV cannula from the same manufacturer was used for all insertions. Cannulations were performed at a dedicated counter within the HDU under aseptic precautions following standard antiseptic protocols for peripheral IV catheterization [9].

For both groups, the date and time of insertion were recorded, and the cannula was monitored until removal. The dwell time (duration from insertion to removal) was calculated for each case.

Splint Group: After cannula fixation, a firm splint made of hard cardboard wrapped in cotton and gauze was applied immediately to immobilize the joint. Splints measured approximately 2 inches beyond the joint on both sides, with width corresponding to the limb segment above the joint.

No-Splint Group: The cannula was secured using identical adhesive dressing and fixation techniques, but without joint immobilization.

All neonates received prescribed IV fluids and medications through syringe infusion pumps. Post-insertion, the cannula site was inspected hourly by a pediatric surgery resident or senior nurse for early signs requiring removal. Cannula removal was indicated upon the appearance of any clinical sign suggestive of local complication.

Extravasation was identified by swelling or edema around the cannula site, while occlusion was characterized by excessive backpressure in the infusion pump, indicating impaired flow. Inflammation was recognized through local redness, swelling, warmth, or tenderness near the insertion point. Phlebitis was diagnosed when there was inflammation or a palpable cord along the vein where the IV cannula was inserted. Additionally, leakage was considered a criterion for cannula removal. Each event was documented, and the time from insertion to removal was recorded for analysis.

To minimize observer bias, all clinical assessments were performed by trained pediatric surgery residents blinded to group allocation. Standardized data collection forms were used to ensure accuracy and uniformity of documentation. No modifications to the study protocol were made after trial initiation.

Statistical Analysis

Collected data were statistically analyzed using SPSS version 26.0. Quantitative data were summarized as mean and standard deviation, while qualitative data were presented as frequencies and percentages. 2×2 contingency tables were constructed to examine correlations between categorical variables. Two-sample t-tests were used to determine differences in means between groups. Spearman's rank correlation analysis was used to form the correlation matrix between various parameters to identify significant relationships. A statistical significance level of $p<0.05$ was considered significant.

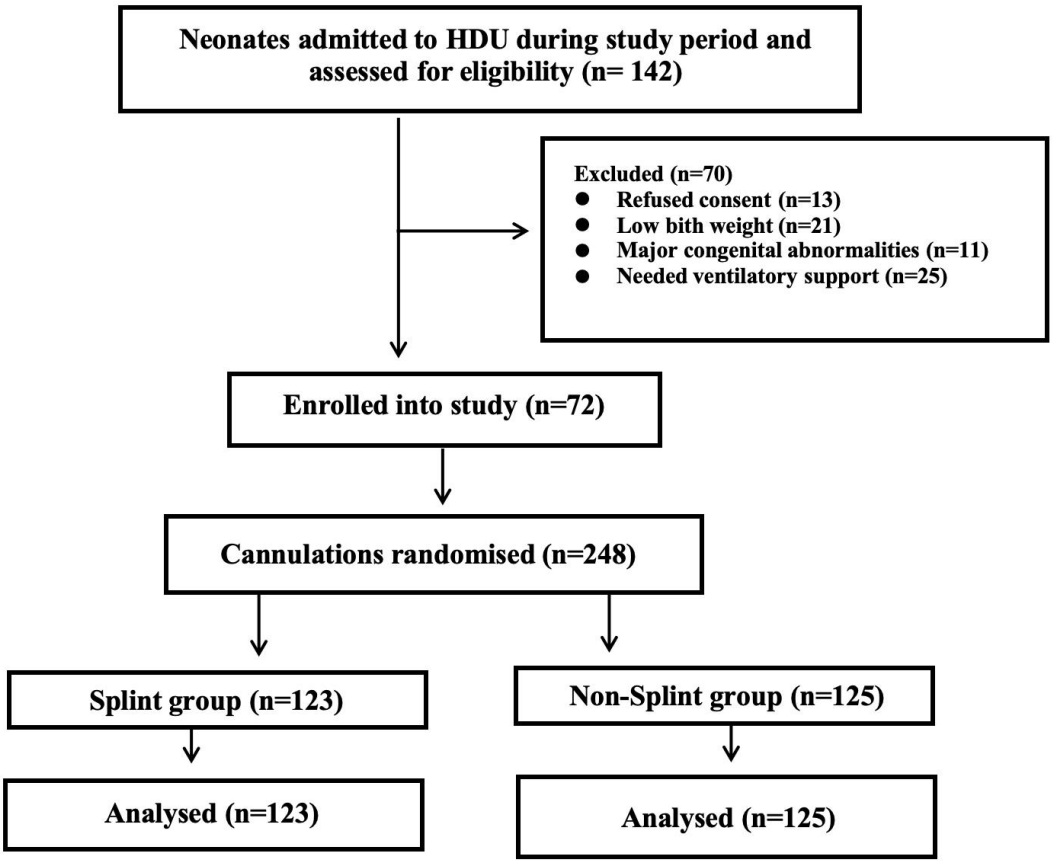

Figure 1. Participants flow diagram

Statistical analysis

The collected data were statistically analyzed using the SPSS version 26.0. Quantitative data were summarized as mean and standard deviation, while qualitative data were presented as frequencies and percentages. 2x2 Contingency Tables were made to check co relations between categorical variables. Two-Sample t-test was used to determine the difference of the means between groups. Spearman's Rank analysis was then used to form the correlation matrix between various parameters to identify the significant relationships. A statistical significance level of $P < 0.05$ was considered.

Results:

The investigation entailed a total of 248 cannulation procedures, with 125 in splint group and 123 in non-splint group. Further, allocation of these cannulations according to gender is given in Table 1.

Table 1: Showing cannulations distribution among groups

		Gender		Total	p-Value
		Male	Female		
Group	Non-Splint	55	68	123	0.252
		22.2%	27.4%	49.6%	
	Splint	66	59	125	
		26.6%	23.8%	50.4%	
Total		121	127	248	
		48.8%	51.2%	100.0%	

The overall mean dwell time for all cannulations was observed to be 34.51 ± 13.43 hours. Further analysis focused on the comparison of mean dwell times between the splinted and non-splinted groups showed a significant difference between both groups (p-value of 0.005), as depicted in Table 2.

Table 2. Mean dwell time for both groups

Group	n	Mean	Std. Deviation	Std. Error Mean	p-value
Non-Splint	123	31.33	11.489	1.036	0.005
Splint	125	37.64	14.479	1.295	

A significant component of our analysis was assessing the mean dwell duration across several variables such as gender, Intermittent or continues infusion technique and transfusion of blood products done via cannulae. This complete analysis, as shown in Table 3, found no significant variation in mean dwell time based on these variables.

Table 3. Assessment of dwell time across different variables

		N	Mean	Std. Deviation	Std. Error Mean	P-value
Gender	Male	121	34.15	14.295	1.300	0.085
	Female	127	34.86	12.602	1.118	
Continues infusion	No	131	33.59	13.736	1.200	0.649
	Yes	117	35.55	13.064	1.208	
Blood Products	Given	94	36.22	14.229	1.468	0.132
	Not given	154	33.47	12.857	1.036	

As far as the fate of cannulations is concerned the majority ended up in extravasation followed by occlusion and leakage. The outcomes of the cannulations,are systematically presented in Table 4.

Table 4. Showing fate of cannulations

	Extravasation	Accidental dislodgment	Infiltration	Phlebitis	Leakage	Occlusion	Other
Non-Splint	97	3	4	1	5	4	9
	39.1%	1.2%	1.6%	0.4%	2.0%	1.6%	3.6%
Splint	112	0	0	0	3	7	3
	45.2%	0.0%	0.0%	0.0%	1.2%	2.8%	1.2%
Total	209	3	4	1	8	11	12
	84.3%	1.2%	1.6%	0.4%	3.2%	4.4%	4.8%

Discussion:

Intravenous access is an indispensable intervention in order to provide effective and fully bio-available form of medications in neonates. The commonly encountered problem related to IV cannula among neonates is short dwell time leading to multiple cannulations and subsequently associated adverse effects. This randomized controlled trial was carried out to access the usefulness of splinting the IV cannula in increasing the lifespan of the IV line.

According to our study finding, the mean lifespan of the cannula was 34.51h that is slightly higher than the study findings by Birhane et al, where the study was

suggesting the mean lifespan of 30h [10]. However, a study by Johnson et al. showed lifespan of 33h [11] that was comparable with our study findings. In contrary to these findings, the studies have also showed the life span of up-to 51h [12]. These variabilities in statistics of cannula lifespan were the reason to mandate the conduction of this particular study to enlighten a bit more on these findings. Among measure available to increase the dwell time of the IV cannula, splinting is most commonly applied technique.

In our study, the most common cause of cannula extrusion was extravasation accounting about 84.3% and this finding is in consistent with the finding from a study by Serane V et al. where the extravasation was 85% [13]. Similarly, in group-wise analysis extravasation leading to cannula removal was observed in 39.1% of the patients in non-splint group and 45.2% in splint group. These findings were slightly less in comparison to a study by Dalal et al [7], however; the trend was similar as splint vs non splint group: 84% vs 76.5%. Similarly, the other causes of cannula removal like infiltration, accidental dislodgment and leakage were the causes other than extravasation to reduce the dwell time of IV cannula. These findings were comparable to other studies as well.

The mean dwell time of IV cannula in splint group was 37.64h and mean dwell time in non-splint group was 31.33h these finding was found to be significant (P=0.005). However; this finding of our study was in contrary to the study findings by Serane V et al, which was showing the reduced dwell time in splint group as compared to non-splint group, 27.68±13.03h in splint group versus 32.87±15.79h in splint-less group [13]. Another study by Gupta et al was also reporting result contrary to our study findings where the splint was associated with reduced dwell time as compared to non-splint [3]. The long dwell time in splint group vs non splint in our study may be explained by the fact that reduced movement of cannula insertion site while splinting can prevent micro-trauma and inflammation in the tunica intima of veins thus increasing dwell time.

In our study, we did not test the effects of different medications on dwell time of the IV cannula, similarly the effect of gestational age was also another untested variable in our study that may limit the genralizability of our study findings. As our study is supporting the use of splint in terms of increasing the dwell time, however; some studies are in contrary to these findings. In order to elucidate the significance of splint in increasing the dwell time our study findings are opening a new horizon to conduct more studies to truly validate the usefulness of this intervention.

Limitations of the study

Despite the significant results of the present study, it needs to be duplicated on a large sample to be able to generalize the findings of the study. A multicenter study should be done.

Conclusion:

In conclusion, splinting does increase the dwell time and also decreases the morbidity. The study results support the study hypothesis. It is recommended that limb splinting for neonatal IV cannulation should be adopted in resource limited countries or where central venous lines are not readily available.

Availability of data and materials

Data will be available from the authors upon reasonable request.

Declaration of competing interest

The authors declare that there are no conflicts of interest.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Acknowledgements

Our sincere thanks go to all preterm neonates who participated in the study and their respected caregivers.

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