Journal of Neonatal Surgery
ISSN(Online): 2226-0439
Vol. 14, Issue 32s (2025)
https://www.jneonatalsurg.com

OPEN ACCESS

Assessment Of Severity And Identification Of Risk Factors For Extravasation In Neonates Receiving Peripheral Intravenous Therapy

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Cite this paper as: Hasnain Aslam, Syed Imam Naufil, Waqas Ahmad, Bilal Javed, Ali Raza Chaudhry, Fareeba Sabir, Mudassar Fiaz Gondal, (2025) Assessment Of Severity And Identification Of Risk Factors For Extravasation In Neonates Receiving Peripheral Intravenous Therapy.*Journal of Neonatal Surgery*, 14 (32s), 9268-9275.

ABSTRACT

Introduction:Peripheral Iv Cannulation Is A Tool Used Extensively For The Administration Of Fluids, Medications And Blood Products. Iv Cannulation, Especially In Neonates, Can Result In A Number Of Local And Systemic Complications, One Of Which Is Extravasation Which Merits Further Study. Defined As The Penetration Of Substances Into Surrounding Tissues, It Accounts For 23-78 Percent Of Complications Of Peripheral Iv Cannulation. This Study, Conducted In The Hdu Of Pediatric Surgery Department Of Holy Family Hospital, Aimed To Identify The Risk Factors Associated With Peripheral Iv Access In Neonates.

Objectives:The Study Aims To Provide Valuable Information On The Risk Factors For Intravenous Extravasation In This Population And Inform The Development Of Evidence-Based Guidelines And Protocols For The Prevention And Management Of Intravenous Extravasation In Our Set-Up, Improving Patient Outcomes And Reducing Healthcare Costs.

Methods:In Compliance With The Guidelines Issued By The Ethical Review Board, A Prospective Observational Study Was Carried Out Over The Span Of Seven Months. Periodic Evaluation Of Over 93 Neonates Was Carried Out Using Standardized Checklists Which Included The Following Parameters, Accumulated By Rigorous Review Of Previously Available Literature. Type Of Infusion, Pre-Existing Infection, Splinting, Body Temperature, Site Of Cannulation And General Hygienic Practices (Diaper Status, Use Of Masks And Sanitizers By Staff And Attendant). Data Obtained Was Then Subject To Analysis Using Spss V23.

Results:Multivariate Logistic Regression Analysis Showed That Pre-Existing Infection [Aor 2.25 95% Ci (1.01-5.05)] , Anatomical Site Of Cannula, [Lower Limb {Aor 2.77 95% Ci (1.02-7.52)}, Scalp {Aor 2.56 95% Ci (1.02-6.46] } (With Upper Limb Taken As Reference)] Types Of Medications Through Iv Route [Antibiotics {Aor 2.68 95% Ci (1.2-5.96)} Compared To Maintenance/ Resuscitation Fluids], Had A Statistically Significant Association With The Incidence Of Extravasation In Neonates, While The Presence Or Lack Thereof Of Splinting And Hygienic Measures Did Not Correlate Significantly With Iv Infiltration.

Conclusion:Although Numerous, Risk Factors Associated With Intravenous Extravasation Are Easily Avoidable And Can Be Minimized With Appropriate Measures Undertaken By The Concerned Healthcare Staff And Attendants. This, Combined With Better Liaison Between Nurses And Surgeons, Will Not Only Improve Neonatal Outcomes, But Will Also Increase Efficiency Of The Healthcare Machinery.

Keywords: *Peripheral IV cannulation,Neonatal extravasation,Risk factors,Pediatric surgery,Intravenous complications*.

1. INTRODUCTION

Intravenous (IV) catheterization is a common medical procedure in which a small plastic tube is inserted into a vein to provide fluid, medication, or nutrition to a patient. IV catheterization is needed in various conditions such as administering.

maintenance or resuscitation fluids, correction of electrolyte imbalances, administering antibiotics, analgesics or anesthetic agents (1). The process allows for quick and efficient delivery of these treatments directly into the bloodstream, bypassing the digestive system

In spite of all the benefits derived from IV catheterization, there are a number of complications, both local and systemic, that may occur. Local complications include infiltration, extravasation, thrombosis, phlebitis, thrombophlebitis, hematoma, and local infection (2) (3). Systemic complications, not as much prevalent as local complications, include infection, air embolism and sepsis (4).

On extensive literature review we found out that among these complications, extravasation is of particular importance due it being one of the most prevalent (5). This warrants further investigation so that its risk factors can be identified and its occurrence could be reduced. Extravasation refers to the leakage of intravenous fluids or medications outside of the intended vessel. This can occur in one of the following ways: accidental dislodgment or multiple punctures of the vein during insertion, vessel rupture caused by infused fluids such as hyper-osmolar solutions, and leaking at the infusion site due to back-flow of infused fluids. The consequences of extravasation can be severe and may include cellulitis, scarring, gangrene, reduced limb mobility, and nerve damage. Neonates are at an increased risk of extravasation due to various factors specific to this population, including poor venous integrity, a higher risk of capillary leakage, and decreased peripheral circulation (6).

Citing previous studies, we have ascertained several extrinsic risk factors associated with IV extravasation in neonates. These include prematurity (7), low birth weight (8) (9), insertion through ankle or feet (7), systemic infection (8), type of IV catheter placement (10), TPN, blood transfusion in the same IV line (8) (11) and longer duration of catheterization (12).

After a meticulous review, the risk factors found to be pertinent for further study in our existing setup, were as follows:

1-Type of infusion (maintenance fluids, antibiotics and albumin infusion)

2- Pre-existing infection (temperature ≥ 100.4 F at time of cannulation)

3- Splinting (immobilization of cannulated limb)

4- Site of cannulation (upper limb, lower limb and scalp)

5- General hygienic practices (use of masks, head covers, shoe covers and sanitizers by the concerned staff)

Government hospitals in Pakistan have an appalling neonatal mortality rate (39/1000), according to UNICEF (2021) (13). This study aimed to improve neonatal morbidity, through identification of judicious measures that would curb the aggravation of extrinsic risk factors of IV catheterization.

2. METHODOLOGY:

In the span of seven months (from July, 2022 to January, 2023), a prospective observational study was carried out in the HDU of the Pediatric Surgery Ward of Holy Family Hospital, Rawalpindi, Pakistan. Standardized checklists were used to obtain relevant data pertinent to the risk factors aforementioned. These checklists were individually attached to the records of the neonates. The fates of the cannulations were noted along with the date, time, and type of medication administered to the neonate by the senior healthcare staff. All IV cannulations were done at a specified counter in the HDU by qualified nurses. All the cannulas were procured by the same manufacturer and standard antiseptic measures (14) for peripheral IV catheterization were followed. All the catheters were secured by the same material. Inclusion criteria were limited to all neonates with a 24 Gauge IV cannula in place. Neonates with severely debilitating illnesses, warranting further management in NICU, were excluded from the study. Neonates undergoing elective removal of the catheter were also excluded from the study. A total of 93 neonates were monitored, with checklists recording data from the advent of catheterization to failure of IV line or change in medications. A flush-out period of at least 4 hours was observed in between the change of medications to eliminate any bias that could have been caused by the preceding medication. Since a total of 121 cannulations were followed, some neonates received multiple cannulations. Failures of IV cannulation were grouped as either extravasation, dislodgement or blockage of IV line following which a new catheter was inserted at a different site after conservative treatment. In order to provide a quantitative estimate of the extent of extravasation, the following criterion of Table no.1 was used from Flemmer & Chan, 1993 (15).

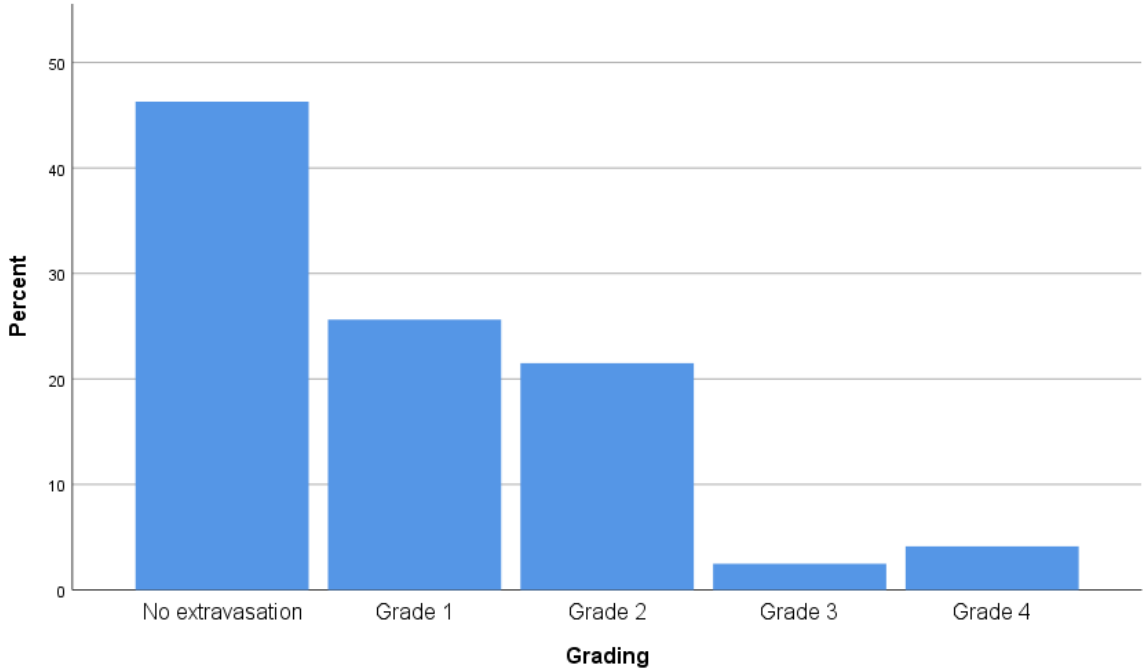
STAGE	CHARACTERISTICS
0	Absence of redness, warmth, pain, swelling, blanching, mottling, tenderness or drainage. Flushes with ease.

1	Absence of redness, swelling. Flushes with difficulty. Pain at site.
2	Slight swelling at site. Presence of redness. Pain at site. Good pulse below site. 1-2 second capillary refill below site.
3	Moderate swelling above or below site. Blanching. Pain at site. Good pulse below infiltration site. 1- to 2-second capillary refill below infiltration site. Skin cool to touch.
4	Severe swelling above or below site. Blanching. Pain at site. Decreased or absent pulse. Capillary refill greater than 4 seconds. Skin cool to touch. Skin breakdown or necrosis.

All grades of extravasation were evaluated by senior resident pediatric surgeons on duty. The informed consent of the attendants was sought before obtaining the data. All ethical considerations were rigorously scrutinized by the Ethical Review Board. Data was then subjected to analysis by SPSS Statistics V23. Chi-square test was used to compare the means of categorical variables. Logistic regression analysis was carried out in order to eliminate possible confounders.

3. RESULTS:

A total of 121 cannulations were followed over the span of seven months i.e. from July, 2022 to January, 2023. Fate of IV cannulations were described as either extravasation [65 (53.7%), dislodgement [31 (25.6%)] or blockage of IV line (23 (19%)]. Following the criteria given above, severity of extravasation was graded on a scale, which showed that no extravasation was observed in 56 cannulations (46.3%). Grade 1 extravasation was observed in 31 cannulations (25.6%). Grade 2 and 3 extravasations were observed in 26 (21.5%) and three (2.5%) cannulations respectively, while there were a total of five Grade 4 extravasation events (4.1%). However, no necrosis or skin breakdown was observed in any of these and all of them were managed conservatively (elevation of affected area to decrease swelling). This is shown in the following figure no.1



Baseline characteristics of the individual IV cannulations are enumerated as follows in Table 2.

Characteristics	**n= 121**
Sex	
Male [n, (%)]	73 (60.3)
Female [n, (%)]	48 (59.6)
Anatomical site of cannulation	
Upper limb [n, (%)]	41 (33.8)
Lower limb [n, (%)]	34 (28)
Scalp [n, (%)]	46 (38)
General Hygienic Measures	
Satisfactory [n, (%)]	62 (51.2)
Poor [n, (%)]	59 (48.7)
Splint	
Present [n, (%)]	23 (19)
Type of infusion	
Maintenance/ resuscitation fluids [n, (%)]	59 (48.8)
Antibiotics [n, (%)]	58 (47.9)
Albumin infusion [n, (%)]	4 (3.3)

Fever **Present [n, (%)]**	58 (47.9)

In 121 cannulations, 73 (60.3%) were done on male neonates and 48 (59.6%) were done on females. With respect to anatomical site of catheterization, 41 (33.8%) cannulations were done on upper limb, while 34 (28%) and 46 (38%) cannulations were performed on the lower limb and scalp respectively. General hygienic measures were classified as either satisfactory (lack of up to one item from the use of mask, sanitizers, headcovers and shoe covers by attendant) or poor (lack of more than one piece of precautionary equipment). General hygienic measures were satisfactory in 62 (51.2%) cases. Splinting (by a piece of cardboard taped to a joint) was done in 23 (19%) cannulations. 59 (48.8%), 58 (47.9%), four (3.3%) cannulations administered maintenance/ resuscitation fluids, antibiotics and albumin infusion respectively. Fever at the time of cannulation was prevalent in 58 (47.9%) cases.

The results of the multivariate logistic regression analysis indicate that three factors are significantly associated with the incidence of extravasation in neonates: pre-existing infection, anatomical site of cannula, and type of medication administered through IV. Results are shown in the following table no. 3

Characteristics	**aOR**	**95% CI**	**p-value**
Pre-existing infection	2.25	(1.01 - 5.05)	0.048*
Anatomical site of cannula			
-Upper limb	1		
- Lower Limb	2.77	(1.02 - 7.52)	0.046*
- Scalp	2.56	(1.02 - 6.46)	0.046*
Types of medications through IV			
-Maintenance fluids	1		
- Antibiotics	2.68	(1.20 - 5.96)	0.016*
- Albumin Infusion	0.99	(0.113 – 8.65)	0.993
General hygienic measures	0.59	(0.272 – 1.3)	0.195
Splinting	1.35	(0.493 – 3.7)	0.559

4. DISCUSSION:

In neonates, IV catheterization is of utmost importance due to the fragile health status of the patients. The infants require close monitoring and support to ensure their quick recovery, and efficient IV catheterization enables the administration of vital medications and fluids bypassing the need for frequent cannulations, which can cause further stress to the neonates.

The complications of IV cannulation can occur in any patient but neonates are particularly susceptible to them due to the distinct characteristics of newborns' veins in comparison to those of children and adults (16). The combination of decreased vessel diameter and venous muscle tone, in addition to more distensible subcutaneous tissue places the neonate at a greater

risk for extravasation (2). The small and distensible veins of neonates may complicate the process of catheter insertion and may be sensitive to changes in pH and osmolality. Low birth weight infants, in particular, are at a greater risk for complications associated with peripheral IV catheterization due to decreased dermal thickness and the presence of an immature muscle layer. Furthermore, extravasation can result in a number of complications such as scarring, pain, edema, blisters and skin necrosis (17). As a result, it is imperative for healthcare professionals to exercise greater caution and concern in the implementation of peripheral IV catheterization in newborns to prevent adverse outcomes.

Fever (temp > 100.4 F) at the time of cannulation was ascertained as the marker for pre-existing infection in neonates. 58 (47.9%) neonates were reported to have fever at the time of cannulation. Pre-existing infection was found to have a significant positive association (p=0.048) with the incidence of extravasation, with an adjusted odds ratio of 2.25 (95% CI 1.01-5.05). This suggests that neonates with pre-existing infections are more than twice as likely to experience extravasation compared to those without pre-existing infections. This is in accordance with a 2013 study (8) which showed that preexisting infection increased the chances of extravasation [RR = 1.26 (95% CI 1.07-1.48)]. The reasons for this association may include weakened immune systems. IV catheters may also serve as the sites where disseminated bacteria can lodge and increase the risk of extravasation.

The anatomical site of cannula was also found to be significantly associated (p=0.046) with extravasation in neonates. Specifically, cannulation in the foot/ankle or the scalp was associated with increased risk of extravasation, with adjusted odds ratios of 2.77 (95% CI 1.02-2.75) and 2.56 (95% CI 1.02-6.46), respectively, compared to upper limb cannulation. The least chances of extravasation were reported in the upper limb, possibly owing to the presence of veins having a relatively straighter course and greater support provided by surrounding tissues. Moreover, greater mobility of head and lower limb may also serve as an aggravating factor for extravasation. A previous study (11) suggested that the incidence of complications was greater in scalp and leg as compared to arm. This study included both neonates and infants. The same pattern was observed in a 2015 study (7), although the results were not statistically significant.

IV administrations were grouped as either antibiotics (vancomycin, cefotaxime, metronidazole, meropenem, linezolid), maintenance/ resuscitation fluids (0.45% NaCl + 5% dextrose, normal saline), or albumin infusion. The type of fluids administered through IV was also found to be significantly associated with the incidence of extravasation in neonates. Antibiotics were associated with an increased risk of extravasation compared to maintenance/ resuscitation fluids, with an adjusted odds ratio of 2.68 (95% CI 1.2-5.96). Previous studies have also reported similar findings (18). The reasons for this association may include the increased potential for irritation or inflammation at the injection site, owing to the extreme pH and osmolarity of IV antibiotics. (6)

Interestingly, the presence or lack of splinting and general hygienic measures did not correlate significantly with IV infiltration in neonates. This suggests that measures to secure the cannula or maintain hygiene may not be as effective in preventing extravasation as other factors, such as cannula placement or the type of medication administered. It is to be noted that these general hygienic measures referred to the use of masks, sanitizers and clean dignity sheets by the attendants and not the antiseptic measures that serve as protocols prior to IV cannulations. However, it is still important to note that proper splinting and general hygiene remain important aspects of neonatal care and should not be disregarded.

In addition to small sample size, a limitation of this study is the omission of all the canulations that transfused blood and blood products in neonates. This is because most of these transfusions were carried out using a 22 Gauge IV cannula in our existing setup and would have significantly confounded our results.

As a consequence, certain measures have been ascertained that will help circumvent the financial, legal and medical complications associated with intravascular therapy in neonates, while at the same time providing an increased level of healthcare to improve neonatal mortality. Further training of the vascular access specialist team is also suggested (5). Measures like diluting hyper osmolar IV solutions (especially caustic ones like calcium and antibiotics), use of aseptic techniques during insertion, hourly monitoring of the IV site, regular replacement of the catheters and preferentially choosing the upper limb as the site for IV cannulation are tried and tested methods to reduce the incidence of IV infiltration in neonates (19). Avoiding tight tapes, improper splints or flexed joints in the extremities has also been suggested to prevent extravasation.

5. CONCLUSION:

An intravenous catheter serves as a conduit between administering treatments and achieving optimal outcomes in neonatal care. A narrower confidence interval and more statistically significant conclusions can be drawn by increasing the sample size, therefore a study with increased sample size is warranted in order to obtain more clinically tangible outcomes. The study was part of The Quality Improvement Project of The Pediatric Surgery Department of Holy Family Hospital designed to improve neonatal care and outcome. Although it is a complex and multifaceted domain of neonatal care, the topic of peripheral IV catheterization in neonates is plagued by a paucity of research, therefore it merits meticulous and resourceful analysis by experts of the field in order to expedite the progress and milestones achieved in the ever-changing world of neonatal care.

Declaration of Competing Interest:

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Financial support and sponsorship:

None

Acknowledgments:

Open Access funding provided by QATAR NATIONAL LIBRARY

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