

Influencing the Need for Multiple Peripheral Intravenous Cannulations in Adult Inpatients

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ABSTRACT

Objective: To identify factors predictive of the need for repeated peripheral intravenous cannulations in hospitalized patients.

Study Design: Prospective longitudinal study.

Place and Duration of Study: Pak Emirates Military Hospital, Rawalpindi, Pakistan, from Jan to Feb 2023

Methodology: Adult patients hospitalized for more than two days and with peripheral intravenous cannulas were required for IV injections. Exclusion criteria included the requirement of more than one cannula simultaneously, cannulation of lower extremity veins, and unwillingness. Data on the number, site, size, dwell time, and reason for removal of cannulas were recorded.

Results: There were 615 patients with a median age of 48 years (interquartile range: 32- 63 years), including 490(79.67%) males, who remained admitted for 5.87 ± 2.17 days. A total of 1236 cannulas were inserted, accounting for 2.01 ± 0.83 cannulas per patient, with a mean dwell time of 2.57 ± 0.75 days. 692(55.99%) cannulas were placed on right side and 544(44.01%) on left; 616(49.17%) were passed over the forearms/ antecubital fossa and 620(50.83%) over wrists/ dorsum of hands. Single cannulation was required in 187(30.41%) patients, whereas 428(69.59%) required repeated insertions. Of the 1049 repeat cannulations, 541(51.57%), 63(6.01%), and 17(1.62%) had to be undone because of blockade, dislodgement, and thrombophlebitis, respectively. Increasing patient age (odds ratio 1.026), smaller cannula size (odds ratio 3.497), and placement of cannulas on wrist/ dorsal aspect (odds ratio 3.497) or left upper extremity (odds ratio 1.574) were associated with a subsequent need for repeat cannulation.

Conclusion: The frequency of repeated intravenous cannulations may be minimized by selecting appropriately sized larger-bore cannulas. Placement on the right forearm offers improved durability and venous access, thereby reducing the need for multiple reinsertions.

Keywords: Cannula, Complications, Intravenous Administration, Intravenous Infusions, Peripheral Catheterization, Vascular Access Devices

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INTRODUCTION

Vascular access is often necessary for hospitalized patients to administer intravenous fluids and medications, including antibiotics. This is typically done using peripheral intravenous catheters. It is estimated that at least 80% of admitted patients receive some form of intravenous treatment.¹ With rising life expectancy and an increasing prevalence of chronic medical conditions, hospitalization rates are also rising globally. This trend is expected to lead to a greater use of peripheral intravenous cannulas. Currently, the global market for these devices is valued at \$1.67 billion and is projected to grow by 5.5% over the next five years.²

Despite being the most common indwelling devices in hospitalized patients and the enormous

experience in their use, they are bound to fail in a significant proportion of patients, thus necessitating repeated insertions.³ Complications could occur with as many as 69% cannulas, which lead to premature removal in around 90% cases.⁴ There could be several reasons for this. Phlebitis and infections (both local and systemic) remain the foremost. These devices could also get occluded or dislodged. Even amongst patients with well-functioning cannulas, the Healthcare Infection Control Practices Advisory Committee of the United States Centers for Disease Control recommends changing these catheters regularly, but no more frequently than every 3 to 4 days, to reduce the risk of infection and vessel wall inflammation.⁵ However, a recently published Cochrane systematic review found no significant difference in these complications with either of the two strategies: as per protocol removals or as clinically indicated.⁶ Repetitive insertions are physically and emotionally painful for patients. They also damage the

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veins, thereby reducing viable options subsequently. A subset of such patients may ultimately require central venous catheters, which are substantially more expensive and carry a higher risk of serious complications.⁷ Furthermore, repeated replacement of peripheral cannulas can delay timely drug administration, increase the workload of healthcare personnel, escalate healthcare costs, and contribute to environmental waste.

Considering all these arguments, it is crucial to minimize repeated insertions of intravenous cannulas by lowering the risk of complications. First, it is important to identify factors that predict cannula failure at the time of insertion. This study was designed to find those factors. The findings will help develop strategies to prevent failures and improve outcomes.

METHODOLOGY

This Prospective longitudinal study was carried out at the Department of Medicine, Pak Emirates Military Hospital, Rawalpindi, Pakistan, from Jan to Feb 2023. The study protocol was approved by the Ethics Review Committee of the hospital vide letter no A/28/EC/499/13. Sample size calculation was done with Free Statistics Calculator version 4. Using six predictors and assuming a medium effect size ($f^2=0.15$), a minimum sample size of 97 patients was computed to give a power of 80% at a 5% margin of error. All inpatients gave written consent for participation in this study. They were consecutively recruited from all medical wards of the hospital, provided they satisfied the following selection criteria:

Inclusion Criteria: Adult patients of both genders, from 30 to 60 years of age, who were admitted to the hospital for more than two days and required an IV cannula.

Exclusion Criteria: Patients who required more than one IV cannula at any given time, cannulation of lower extremity veins, and unwillingness to participate were all excluded from the study.

All peripheral intravenous cannulas were passed by trained paramedical staff on advice of the treating teams, and they were kept unaware of this study being carried out. Basic demographic information, such as age, gender, and body mass index (BMI), was recorded for all patients. Data on the use of all peripheral intravenous cannulas were documented for each patient, including the site, size, dwell time, and reason for removal. Cannulas placed at the wrists or

dorsum of the hands were categorized as distal sites, whereas those inserted in the forearms or antecubital fossae were classified as proximal sites. The total number of cannulas passed in each patient and the duration of hospital stay were also noted down. Phlebitis was labelled when at least two of the following were present: pain, warmth, erythema, tenderness, swelling, or a palpable vein proximal to the catheter insertion site. Occlusion was defined as failure to flush the cannula with normal saline, even before injecting the desired medications, in a cannula that worked normally at least once after insertion.

Data analysis was done with all quantitative variables expressed as Mean $\pm$ SD or proportions. Binary logistic regression analysis was done to see if age, gender, BMI, or the size, site, or laterality of the intravenous cannula could predict the need for repeated cannulation. Linear regression analysis was done to determine the relationship between duration of hospitalization and the total number of cannulas passed in each patient. A p -value <0.05 was considered significant for all tests of comparison.

RESULTS

There were 615 patients having a median age of 48 years (interquartile range: 32-63 years). A vast majority of them were males ($n=490$; 79.67%), whereas others ($n=125$; 20.33%) were females. Mean BMI was 22.64 ± 1.80 kg/m², and the mean duration of hospital stay was 5.87 ± 2.17 days.

A total of 1236 cannulas were inserted during the period of this study, accounting for 2.01 ± 0.83 cannulas per patient. The mean dwell time was 2.57 ± 0.75 days. Cannulation on a single occasion alone was required in 187(30.41%) patients, whereas 428(69.59%) required repeated insertions. The number of patients requiring two, three, four, and 5 cannulations was 258(41.95%), 148(24.07%), 21(3.42%), and 1(0.16%), respectively. Other cardinal features about intravenous cannulation are shown in Table-I. Of the 1049 repeat cannulations, 541(51.57%) had to be removed because of blockade, 63(6.01%) because of dislodgement, and thrombophlebitis developed in only 17(1.62%) cases. Data presented in Table-II shows that an increasing patient age, smaller cannula size, and placement of cannulas distally or on the left upper extremity were associated with a subsequent need for repeat cannulation during hospital stay. However, patients' gender and body mass index were not related to this. Figure demonstrates that the total number of cannulas inserted in each patient was dependent on the total

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duration of hospitalization, as evidenced by a strong correlation between the two ($R^2 = 0.716$; $p < 0.001$).

Table-I: Characteristics Of Intravenous Cannulation (n=1236)

Variables	Number of insertions
Side of placement	
Right	692(55.99%)
Left	544(44.01%)
Site of placement	
Proximal	616(49.17%)
Distal	620(50.83%)
Size of Cannula	
18G	437(35.36%)
20G	774(62.62%)
22G	25(2.02%)

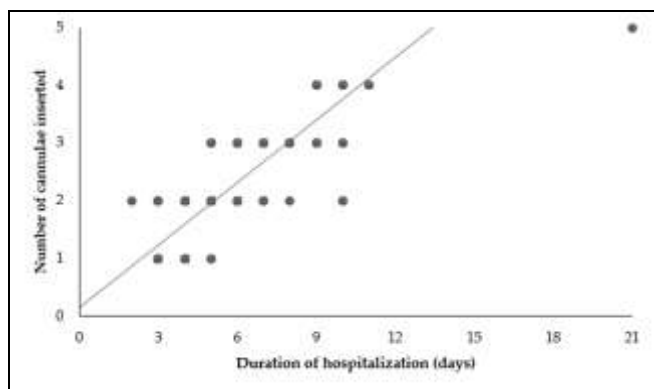


Figure: Linear Regression Between Duration of stay in Hospital and Number of Cannulations (n=615)

significant association was observed between cannula dysfunction and patient gender or obesity.

Despite being the commonest invasive procedure performed in the wards, there were risks associated with the insertion and usage of intravenous cannulas. Variable rates for in-situ failure/malfunction have been described in the literature. Marsh *et al.*, have quoted a composite failure rate of approximately 60% in a systematic review and meta-analysis of 103 studies involving 76977 catheters.⁸ It is noteworthy that even at considerably lower incidence rates, the absolute burden of complications in clinical practice would remain substantial due to the exceedingly high volume of peripheral cannulations performed routinely. Panza *et al.*, highlighted that 350 million cannulas are sold in the United States alone each year, out of which 235 million have been successfully placed.⁹

Phlebitis is generally the most common cause of in-situ catheter failure, as reported by Simin *et al.*¹⁰ It could have a mechanical, chemical, or bacteriological basis. Only a small proportion of patients developed phlebitis during the study period; however, its severity was not graded. To minimize potential bias, paramedical staff responsible for cannula insertion and maintenance were intentionally kept unaware of

Table-II: Factors Predicting Need for Repeated Cannulation (n=615)

Factors	Repeated cannulation		Univariate Logistic Regression			Multivariate Logistic Regression		
	Yes	No	p Value	Unadjusted OR	95% CI for UOR	p Value	Adjusted OR	95% CI for AOR
Age (Median and interquartile range)	52.50 (34.00- 65.0)	43.0 (29.0- 58.0)	0.001	1.018	1.007-1.028	<0.001	1.026	1.012-1.039
Gender*								
Male	343(70.00%)	147(30.00%)	0.664	1.098	0.720-1.675	-	-	-
Female	85(68.00%)	40(32.00%)	1					
Body mass index (kg/m ²)	22.61±1.80	22.72± 1.79	0.459	0.964	0.876-1.062	-	-	-
Size of first cannula (Median)	20	20	<0.001	3.580	2.703-4.742	<0.001	3.497	2.538-4.817
Laterality of first Cannula								
Right	232(66.48%)	117(33.52%)	1			1		
Left	196(73.68%)	70(26.32%)	0.055	1.412	0.993-2.008	0.042	1.574	1.017-2.434
Location of first cannula								
Proximal	324(86.86%)	49(13.14%)	1			1		
Distal	104(42.98%)	138(57.02%)	<0.001	8.774	5.918-13.007	<0.001	7.749	5.010-11.983

UOR = Unadjusted Odds Ratio

AOR = Adjusted Odds Ratio

DISCUSSION

The findings of this study are concerning, demonstrating a markedly high failure rate of peripheral intravenous cannulas in our patient population. While increasing age was identified as a significant risk factor, it remains a non-modifiable variable. Among potentially modifiable factors, optimization of cannula gauge selection and site of insertion may contribute to reducing failure rates. No

the ongoing study. Rates reported in this study were lower than the maximum 5% acceptable limit proposed by the Infusion Nurses Society.¹¹ In a recently published meta-analysis by Lv *et al.*, a total of 35 studies encompassing 20697 cannulas passed in 15791 patients, the incidence of phlebitis was 31% and this was severe in 4% cases.¹² On the contrary, occlusion of cannulas was much more common. The most plausible explanation is that while the

paramedical staff were more conscious of preventing infection at the time of insertion of cannulas, slackness might have occurred in the routine care of these devices subsequently. This highlights the importance of regularly flushing the cannulas after every use.

The slightly higher risk of cannula failure and the need for repeated insertions with age were aligned with results reported by Chen *et al.*¹³ This is probably because of morphological changes that take place in vessel walls with advancing age, and calls for closer monitoring in older patients. It was observed that smaller-sized cannulas required more frequent replacements. Whereas, as the first thought, it seems that this might be because of a greater chance of blockade, there is evidence to relate this occurrence more to the length rather than the diameter/ gauge of the cannula. Smaller caliber cannulas are shorter as well, meaning that the length of the cannula within the vein (referred to as intravascular purchase) would also be shorter, and this affects its performance. Distally inserted cannulas were almost eight times more likely to fail. The most plausible explanation for this is the risk of continuous mechanical irritation of the vein wall with repetitive movements around the wrist. Even cannulas placed over the dorsum of the hands could have their tips approaching close to the wrist joint. Similar findings have been reported by many other authors, including Takahashi, *et al.*¹⁴

As far as the factors significantly associated with cannula failure in our patients are concerned, contradictory results are also available in published literature. As an example, in a Spanish observational study on 711 cannulas, Ian Blanco-Mavillard *et al.*, did not find age, gender, site of insertion, or cannula size to be associated with the risk of cannula failure.¹⁵ Similarly, Kassahun *et al.*, failed to demonstrate any effect of the size of the first cannula inserted in 423 patients or the site of its placement on the risk of failure.¹⁶

The study data did not find an association of gender with cannula failure. This is in contrast to some other studies. Amongst 8200 patients with 11830 catheters, Marsh *et al.*, found that female patients were more likely to develop cannula failure (hazard ratio 1.36).⁴ Similarly, amongst 3283 adult patients with 5907 cannulas, Wallis *et al.*, found the female gender to be associated with an increased risk of both phlebitis (hazard ratio 1.64) and occlusion (hazard ratio 1.44).¹⁷ Any plausible explanation for these causative factors

was not given, whereas it was attributed to the smaller vein size.

Prakash *et al.*, identified obesity as a recognized risk factor for difficult cannulation, but it was not primarily focused on as the risk of in-situ complications in patients was of greater concern.¹⁸ Similar findings have been reported by Kashiura *et al.*, amongst 1357 patients admitted to different intensive care units in Japan.¹⁹

The principal strength of this study lies in its prospective design, which allowed for accurate and complete data collection on all enrolled subjects. The authors were able to verify the occurrence of phlebitis and document the specific reasons for cannula removal. Patients requiring more than one cannula simultaneously were excluded to simplify data collection and analysis. However, certain parameters were not recorded, including the type of dressings used to secure the cannulas and the mobility or functional status of patients. Although Atay *et al.*, suggested an association between dressing type and infection risk,²⁰ and Abolfotouh *et al.*, did not demonstrate any such a relationship.²¹ Furthermore, phlebitis may have developed following cannula removal for alternative reasons, but such events were not captured in our dataset.

The insertion and maintenance of intravenous cannulas involve multiple steps, each contributing to successful patient outcomes. While this study focused on factors influencing success at the time of cannula insertion, it is important to recognize that several additional variables influence cannula longevity. These include dwell time, the nature of pharmacological agents administered, and post-use care practices such as flushing. Future large-scale, multicenter studies should investigate these factors to enhance the generalizability of findings and inform best practices.

CONCLUSION

A substantial proportion of peripheral intravenous cannulas are associated with complications, often necessitating replacement due to phlebitis, occlusion, or dislodgement. Consequently, many patients require multiple cannulations. These events may be mitigated by the use of larger-bore cannulas inserted in the right forearm, along with strict adherence to established standard operating procedures for cannula care.

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Authors' Contribution

Following authors have made substantial contributions to the manuscript as under:

FA & ARA: Study design, drafting the manuscript, data interpretation, critical review, approval of the final version to be published.

GAKN & ARAD: Data acquisition, data analysis, approval of the final version to be published.

AR & UZ: Critical review, concept, drafting the manuscript, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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