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PERIPHERAL INTRAVENOUS CANNULATION AND PHLEBITIS RISK AT CAPE COAST TEACHING HOSPITAL

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Abstract

Introduction: Intravenous (IV) cannulation is the commonest invasive procedure among hospitalised patients. It is however associated with risks and complications that can have an adverse impact on the clinical outcome of the patient.

Aim: To assess the incidence of and risk factors for development of phlebitis following peripheral IV cannulation at Cape Coast Teaching Hospital (CCTH), and establish the optimal day for routine replacement of IV cannulas in our setting.

Method: A prospective observational study was conducted over a period of three months from September 2013 to December 2013 at the Medical and Surgical Wards at CCTH. Patients were assessed using the Visual Infusion Phlebitis (VIP) Score. Results were analysed and chi square was used to test associations and significance level set at p value ≤ 0.05.

Results: A total of 224 patients were assessed. The incidence rate of phlebitis was 52.2%. Phlebitis was higher among patients who had cannulas in situ beyond day four (66.3%) compared to those who had cannulas for up to four days (44.4%)(p=0.002). Phlebitis was also higher among patients with ongoing infections (69%) (p=0.023).

Conclusion: Over half of cannulated patients studied developed phlebitis. Phlebitis rates were significantly increased four days post-cannulation and in patients with ongoing infections. Routine replacement of cannulas by day four is therefore recommended.

Key Words: Phlebitis, IV cannulation, Cannula, Routine replacement

Introduction

Peripheral intravenous (IV) cannulas provide relatively easy and comfortable venous access for hospitalised patients allowing for sampling of blood as well as administration of fluids, medications, parenteral nutrition, chemotherapy, and blood products. Although cannulas provide necessary vascular access, there are some associated complications such as phlebitis, local site infection, occlusion, extravasation and cannula-related bloodstream infections (CRBSI). These complications lead to patient discomfort, increased medical treatment, length of hospital stay and cost of treatment, as well as increased morbidity and mortality. Phlebitis or vein inflammation is a common complication of IV therapy with between 2.3%[1] and 60%[2] of patients developing phlebitis; depending on the populations studied. When accompanied by thrombus formation it is referred to as thrombophlebitis. The more serious complication of IV therapy, bacteraemia, occurs in about 0.8%[3] of cases.

Many risk factors of phlebitis have been identified in other studies. These include lengthy cannulation periods, cannula material, cannula size and infusate characteristics. Factors which are more patient specific include gender, insertion site, concurrent infection and presence of underlying medical illnesses[4].

Early phlebitis is possibly related to the insertion procedure such as poor hand hygiene, poor skin preparation, inexperienced personnel doing insertion and multiple attempts at different sites with the same IV cannula. Phlebitis that occurs later is possibly caused by colonisation along the skin tract or contaminated hubs or fluids[5].

Contamination of the cannula hub contributes substantially to intraluminal colonization of long-term cannulas. Occasionally, cannulas might become haematogenously seeded from another focus of infection. Rarely, infusate contamination leads to cannula-related bloodstream infections (CRBSI). Cannulas that are left in longer also have increased exposure to handling and drug infusions which may explain the higher rate of phlebitis for longer duration of cannulation[6].

In view of the above, Centre for Disease Control (CDC) recommends routine replacement of peripheral IV cannulas every 72 to 96 hours in adult patients to restrict the potential of developing phlebitis[5, 7]. Current guidelines from the United Kingdom and Australia recommend routine replacement of peripheral intravenous cannulas every 48-72 hours to prevent infusion phlebitis and rare but life threatening peripheral cannula related bacteraemia[8]. Other studies suggest that it is better to re-site the IV cannula only when clinically indicated due to highly improved IV cannula materials and dressings used in the hospitals under study[1, 4, 9]. To date however, no studies have been done in Ghana to inform local practice.

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Various grading systems have also been proposed to facilitate and clarify the diagnosis of phlebitis. These include the Maddox scale and the Baxter scale, which rank infusion thrombophlebitis according to the severity of clinical signs and symptoms[9]. The tool recommended by the Royal College of Nursing - the Visual Infusion Phlebitis (VIP) score was first developed by Jackson in 1998 as a standardized approach for monitoring peripheral IV cannula sites. It has content validity, reliability and is clinically feasible. It facilitates the timely removal of peripheral IV cannulas at the earliest sign of phlebitis. It is also recommended by the Department of Health (UK), Infusion Nursing Standards of Practice INS (US), Royal College of Nursing (RCN) (UK) and the English Department of Health and Health Protection, Scotland.
This study seeks to identify the optimal day for routine replacement of IV cannulas and to explore the factors that influence the development of peripheral IV cannula-related phlebitis in our local hospital. The paper specifically examines the direction and strength of association between cannula dwell time and ongoing infections, and the incidence of phlebitis. Findings from the study would provide useful information for the improved care of IV cannula sites and subsequently decrease the incidence of peripheral IV cannula-related complications.

Methods

Design and setting

A prospective observational study was conducted on patients admitted to the medical and surgical wards of Cape Coast Teaching Hospital, Ghana, over three months(16^{th} September – 20^{th} December, 2013). The study sample included all patients aged 12 years and above who had at least one IV cannula in situ during their hospital stay. Only patients who gave informed consent participated in the study. Patients were assessed visually to determine the degree of associated phlebitis after cannulation. Additional information included patients' age and sex, ward of admission, diagnosis, co-morbidities, ongoing infections, antibiotic infusion, other in-dwelling catheters (central venous catheters, urinary catheters), insertion site of cannula, personnel who did the cannulation and the cannula dwell time. The patients were seen daily and examined for signs of phlebitis using the Visual Infusion Phlebitis (VIP) Score until the time of removal of cannula (i.e. development of phlebitis, discharge or death). The VIP score is a phlebitis assessment scale which classifies IV cannula sites on a scale of 0 – 5 based on signs and symptoms. A score of 0 implies no signs of phlebitis; a score of 1 indicates possible first signs of phlebitis; a score of 2 indicates early stage of phlebitis; 3, 4 and 5 indicate medium stage of phlebitis, advanced stage of phlebitis / start of thrombophlebitis and advanced stage of thrombophlebitis, respectively (Appendix).

Analytical technique

The data was entered using the Statistical Package for Social Sciences (SPSS) version 16.0 and transferred to Stata 11.0 software for analyses. Univariate analyses were conducted to provide a summary on the study sample, while bivariate and multivariate analysis procedures were employed to assess the factors influencing the phlebitis. The dependent variable (Phlebitis) was derived from the VIP scores and constructed as a binary variable for the purpose of this study. A VIP score of "0" and "1" was categorized as "no phlebitis" and coded "0", while any score from 2 to 5 was coded "1" and categorized as "phlebitis". Cannula dwell time and presence of ongoing infection were considered as the main independent variables. Cannula dwell time was captured as a count variable, but was re-categorized into a dichotomous variable (1-4 days and >4days) to suit the aim of the study. Similarly, ongoing infection was grouped into two; present and absent.

In order to examine the strength and direction of association between the dependent variable and the main independent variables, there was the need to control for the effect of other mediators. Theoretically relevant covariates of phlebitis were identified and classified into clinical factors (insertion site, co-morbidities, presence of other in-dwelling catheters and antibiotic infusion) and "other" factors (age, sex, ward of admission and personnel who cannulated). Since the dependent variable (Phlebitis) was constructed as a binary outcome, binary logistic regression was used in the multivariate analysis. Three successive logistic regression models were estimated, starting with a model with cannula dwell time and ongoing infections (Model 1). In Model 2, clinical factors were tailored in to assess their influence on the association between the factors in Model 1 and the outcome variable. Then in Model 3, "other factors" were fitted in to assess their influence on the factors in the preceding models. Using the results from the final model (Model 3), the overall effect of number of days of cannulation and presence of infection on phlebitis was assessed. The results were presented in the form of odds ratios.

Results

Univariate analysis

A total of 224 patients with cannulas were assessed of which over 50% were males (Table 1). The mean age of participants was 43.4 (+/- 19.07) years.

More than half of the patients had no co-morbidities, about a third had ongoing infections (surgical site infection, diabetic foot infections, cellulitis, pneumonia, urinary tract infections, osteomyelitis and septic arthritis); and more than two - thirds were on antibiotic infusion.

Table 1: Patient Characteristics (N=224)

Characteristics	Frequency	%
Sex		
Male	121	54
Female	103	46
Age		
10 – 19	25	11.2
20–29	36	16.1
30–39	38	17.0
40–49	45	20.1
50–59	31	13.8
60–69	18	8.0
70+	31	13.8
Ward of admission		
Female Medical	55	24.6
Female Surgical	48	21.4
Male Medical	57	25.4
Male Surgical	64	28.6
Personnel who cannulated		
Doctor	68	30.4
Nurse	145	64.7
Student	11	4.9
Insertion site		
Cubital fossa	35	15.6
Forearm	87	38.8
Hand (dorsum)	66	29.5
Wrist	36	16.1
No. of comorbidities		
None	129	57.6
One or more	95	42.4
Other in-dwelling catheter		
Absent	151	67.4
Present	73	32.6
Ongoing infections		
Absent	151	67.4
Present	73	32.6
Antibiotic infusion		
Absent	72	32.1
Present	152	67.9
Cannula dwell time		
1 - 4 days	144	64.3
>4 days	80	35.7
Outcome		
No phlebitis	107	47.8
Phlebitis	117	52.2
VIP score		
0	98	43.8
1	9	4
2	101	45.1
3	16	7.1
4	0	0
5	0	0

The duration of cannula placement ranged from one to eighteen days with mean cannula dwell time of 3.94 (+/- 2.55) days. About six out of ten patients had cannulas in situ for four days or less compared to about three out of ten patients who had cannulas in situ for more than four days. Over 50% of the patients in the study developed phlebitis. Among those who developed phlebitis, over 80% had early stages of phlebitis (a VIP score of 2).

Trend of phlebitis

As shown in figure 1, the incidence of phlebitis rose gradually from day one of insertion to day three of insertion after which there was a slight decrease on day four. After day four, there was a steep rise until it reached its maximum at day eight and beyond.

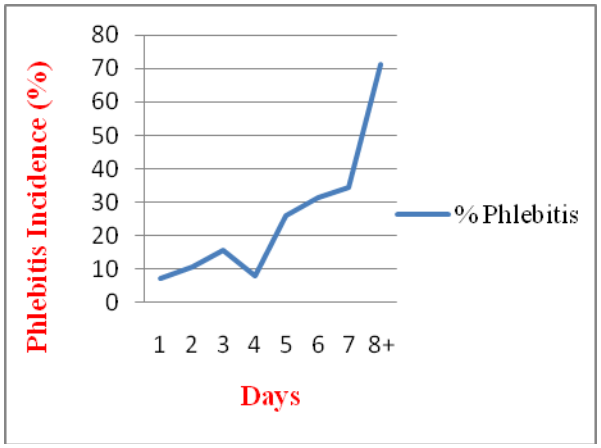

Fig. 1: Trend of phlebitis in relation to IV annula dwell time

Cannula dwell time	No phlebitis	Phlebitis	Population at risk*	Phlebitis Incidence (%)
1	208	16	224	7.1
2	170	20	190	10.5
3	129	24	153	15.7
4	96	8	104	7.7
5	60	21	81	25.9
6	37	17	54	31.5
7	19	10	29	34.5
8+	4	10	14	71.4

*Denominator for calculating each corresponding phlebitis incidence

Bivariate analysis

Results at the bivariate level (Table 2) show a significant ($p = 0.002$) association between cannula dwell time and phlebitis. About seven in ten patients cannulated for more than four days developed phlebitis

compared to about five in ten cannulated for at most four days. A similar association (p = 0.023) was also found between patients with ongoing infections and phlebitis. The proportion of patients with phlebitis did not vary between men and women.

The highest proportion of phlebitis was observed among patients aged 70 years and above, although there was no statistical significance across all age groups.

Almost two-thirds of patients with cannulas situated at the wrist developed phlebitis. The male medical ward had the highest incidence of phlebitis (57.9%).

Table 2: Clinical characteristics by Phlebitis (N=224)

	No Phlebitis	Phlebitis	Total	Percentage Phlebitis	X^2	P-value
Sex						
Male	59	62	121	51.2	0.10	0.747
Female	48	55	103	53.4		
Age						
10 – 19	10	15	25	60.0	2.96	0.813
20 – 29	17	19	36	52.8		
30 – 39	19	19	38	50.0		
40 – 49	24	21	45	46.7		
50 – 59	17	14	31	45.2		
60 – 69	8	10	18	55.6		
70 +	12	19	31	61.3		
Ward of admission						
Female Medical	27	28	55	50.9	2.31	0.511
Male Medical	24	33	57	57.9		
Female Surgical	21	27	48	56.3		
Male Surgical	35	29	64	45.3		
Personnel who cannulated						
Doctor	33	35	68	51.5	0.26	0.877
Nurse	68	77	145	53.1		
Student	6	5	11	45.5		
Insertion site:						
Cubital fossa	16	19	35	54.3	3.97	0.265
Forearm	44	43	87	50.0		
Hand (dorsum)	35	31	66	47.0		
Wrist	12	24	36	66.7		
No. of comorbidities						
None	65	64	129	49.6	0.84	0.360
One or more	42	53	95	55.8		
Other in-dwelling catheter						
Absent	77	74	151	49.0	1.93	0.165
Present	30	43	73	58.9		
Ongoing infections						
Absent	76	77	153	50.3	5.18	0.023
Present	22	49	71	69.0		
Antibiotic infusion						
Absent	31	41	72	56.9	0.94	0.331
Present	76	76	152	50.0		
Cannula dwell time						
1 – 4 days	80	64	144	44.4	9.80	0.002
>4days	27	53	80	66.3		

Multivariate analysis

To answer the main objective and adequately explore the hypotheses of the study, three logistic regression models were estimated as shown in Table 3.

Cannula dwell time and ongoing infections were the main variables considered in Model 1. The results indicate that, patients who had cannulas in situ for more than four days were significantly more likely to

Table 3: Results of multivariate logistic regression on incidence of IV cannula-related phebitis among patients on admission at the CCTH

Factor	Model 1	95% CI	Model 2	95% CI	Model 3	95% CI
Cannula dwell time						
1-4 days						
>4 days	2.70**	[1.48,4.92]	2.72**	[1.45,5.09]	2.71**	[1.42,5.16]
Ongoing infections						
Absent (Ref)						
Present	1.91*	[1.03,3.54]	2.98**	[1.45,6.09]	2.85*	[1.27,6.38]
Insertion site						
Cubital fossa (Ref)						
Forearm	N/A	N/A	0.77	[0.32,1.86]	0.57	[0.22,1.47]
Hand	N/A	N/A	0.75	[0.30,1.87]	0.58	[0.22,1.49]
Wrist	N/A	N/A	2.01	[0.72,5.59]	1.94	[0.66,5.69]
No. of comorbidities						
None (Ref)						
At least one	N/A	N/A	1.07	[0.60,1.92]	0.88	[0.41,1.85]
Other in-dwelling catheter						
Absent (Ref)						
Present	N/A	N/A	2.18*	[1.09,4.33]	3.20**	[1.39,7.38]
Antibiotic infusion						
No (Ref)						
Yes	N/A	N/A	0.39*	[0.18,0.80]	0.43*	[0.19,0.95]
Age						
10-19 (Ref)						
20-29	N/A	N/A	N/A	N/A	0.63	[0.18,2.18]
30-39	N/A	N/A	N/A	N/A	0.53	[0.15,1.88]
40-49	N/A	N/A	N/A	N/A	0.44	[0.13,1.50]
50-59	N/A	N/A	N/A	N/A	0.27	[0.072,1.0]
60-69	N/A	N/A	N/A	N/A	0.52	[0.11,2.34]
70+	N/A	N/A	N/A	N/A	0.80	[0.20,3.12]
Sex						
Female (Ref)						
Male					0.54	[0.16,1.81]
Ward of admission						
Female medical (Ref)						
Female surgical	N/A	N/A	N/A	N/A	1.03	[0.37,2.83]
Male medical	N/A	N/A	N/A	N/A	3.67	[1.33,10.10]
Male surgical	N/A	N/A	N/A	N/A	-	-
Personnel who cannulated						
Doctor (Ref)						
Nurse	N/A	N/A	N/A	N/A	1.26	[0.64,2.47]
Student	N/A	N/A	N/A	N/A	0.488	[0.09,2.38]

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

N/A – Not applicable

develop phlebitis compared with those who had cannulas in situ for up to four days. The odds of developing phlebitis were higher among patients with ongoing infections compared with those without ongoing infections. The inclusion of clinical factors in Model 2 neither changed the direction nor the strength of association between the cannula dwell time and the incidence of phlebitis. The association between phlebitis and patients with ongoing infections became stronger in Model 2. Among the clinical factors fitted in model 2, the odds of developing phlebitis were significantly higher for patients with other in-dwelling catheters, but significantly lower for those on antibiotic infusion. The "other" variables (age, sex, ward and personnel who cannulated) in the final model (Model 3) had little effect on the associations observed in the preceding models.

The results of the final Model are thus used to measure the main objective of the study, as well as the two hypotheses the study set out to test. The composite model shows that, the odds of developing phlebitis were about three times higher ($p = 0.002$) for patients who had cannulas in situ for more than four days compared to those who had cannulas in situ for four days or less. Similarly, patients with ongoing infections were about three times ($p = 0.011$) more likely than those without ongoing infections to develop phlebitis. In addition, the odds were over three times higher for patients with other in-dwelling catheters such as central venous catheters and urinary catheters ($p = 0.006$), than others without other in-dwelling catheters. On the contrary, patients on antibiotic infusions had significant lower odds ($p = 0.039$) of developing phlebitis compared with those not on antibiotic infusions.

Discussion

The insertion and daily use of IV cannulas is associated with risks and complications that can have an impact on the clinical outcome of the patient. The present study was undertaken to investigate various risk factors responsible for the occurrence of phlebitis and to find the optimal day for routine replacement of IV cannulas at CCTH.

The incidence of phlebitis in this study was more than 52%. This is much higher than the recommended rate of 5% or less by the Infusion Nursing Society (INS) [10]. That notwithstanding, previous research have recorded rates between 2.3% and 60%[1, 2]. The cannula dwell time is the most significant risk factor identified in this study for the development of phlebitis. The current study found a gradual rise in the incidence of phlebitis from day one to day three and a drop by day four; after day four (96 hours) phlebitis rate rose steeply (Figure 1). This supports the conclusion of Cicolini et al that phlebitis risk increases after 96 hours[11]. In contrast to other studies[12], this study found significantly higher incidence of phlebitis after day four of IV cannulation at both the bivariate and multivariate levels. Although it is argued that replacing cannulas only when clinically indicated would provide significant cost savings and spare patients the unnecessary pain of re-siting cannulas, this current finding favours the routine replacement of intravenous cannulas by day four as recommended by CDC.

Patients who had ongoing infections had significantly increased phlebitis. This is expected and is possibly due to the spread of microorganisms by septic emboli from the focus of infection to the cannula tip.

Other in-dwelling catheters may have also served as a nidus predisposing these patients to other infections, (bacteraemia from central venous catheters and urinary tract infections from urinary catheters), accounting for the increased phlebitis in this group.

Patients who were on antibiotic infusions had less phlebitis compared to patients who did not use antibiotic infusions. In contrast to this finding, other studies reported that the use of IV antibiotics which are vein irritants, increased the incidence of phlebitis[14].

As seen in this study, the majority of patients cannulated at the wrist and the cubital fossa developed phlebitis. Flow of infusate can be affected by flexion and extension movement at joints and this increases the risk of mechanical phlebitis[13]. This makes these sites less preferable.

Females had slightly higher phlebitis rates compared to males; however, there was no statistical significance. Some studies showed female preponderance[8] and others, male preponderance[17]. A study by Uslusoy and Mete show no difference between the two sexes[13]. Similarly, correlation between age and phlebitis was not significant though patients 70 years and above had the highest phlebitis rate. One such study established that patient aged 60 years and over were more at risk of phlebitis[14].

Patients with at least one co-morbidity had slightly higher incidence of phlebitis and this could be explained by the possibility of reduced immunity to infections compared to patients who had no co-morbidity.

The cannula material used – Teflon (polytetrafluoroethylene) may have adversely influenced the development of phlebitis as shown in previous studies[14, 15]. One of such studies demonstrated that Teflon had higher bacterial adherence compared to Vialon (polyurethane). Also, Vialon softens at body temperature thereby generating lesser degree of endothelial injury and therefore less risk of mechanical phlebitis. Vialon (polyurethane) was associated with a decrease of 30 – 45% on the incidence of phlebitis, when compared to Teflon [15].

This study did not evaluate the gauge size of the cannulas and the technique of peripheral IV cannula insertion and their effects on phlebitis. The identification of cannula-related bloodstream infections was not part of this study. The stringent CDC

definition defines CRBSI as a positive blood culture from a peripheral vein; clinical signs of infection; no other apparent source for the bloodstream infection except the intravenous cannula; and colonised intravenous cannula tip culture with the same organism as identified in the blood[10].

Conclusion

There is a high incidence of phlebitis in the CCTH, mainly from cannula dwell time of over four days and the presence of ongoing infections. Routine replacement of cannulas on day four is recommended for all adult patients. The cannulas must be reviewed on a daily basis and the condition of the site documented using the VIP score system (Appendix). Additionally, patients who have ongoing infections prior to or during the event of cannulation have to be adequately treated as infections contribute to the development of phlebitis. A readily available policy and care documentation system must be put in place to provide a standard for peripheral intravenous cannulation practices.

Appendix

V.I.P Score (Visual Infusion Phlebitis Score)

OBSERVATION		ACTION
I.V. site appears healthy	**0**	**No signs of phlebitis** ☐OBSERVE CANNULA
One of the following is evident: • Slight pain near I.V. site or slight redness near I.V. site	**1**	**Possible first signs of phlebitis** ☐OBSERVE CANNULA
Two of the following are evident • Pain near I.V. site • Erythema - (redness) • Swelling	**2**	**Early stage of phlebitis** ☐RESITE CANNULA
All of the following are evident: • Pain along path of cannula • Erythema • Induration (Tissue feeling firm and swollen)	**3**	**Medium stage of phlebitis** ☐RESITE CANNULA ☐ CONSIDER TREATMENT
All of the following are evident and extensive: • Pain along path of cannula • Erythema • Induration • Palpable venous cord	**4**	**Advanced stage of phlebitis or start of thrombophlebitis** ☐RESITE CANNULA ☐ CONSIDERTREATMENT
All of the following are evident and extensive: • Pain along path of cannula • Erythema • Induration • Palpable venous cord • Pyrexia	**5**	**Advanced stage of thrombophlebitis** ☐INITIATE TREATMENT ☐ RESITE CANNULA

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