


Nurse performed peripheral intravenous catheter first time insertion success in pediatric patients in Bhutan: An observational study

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Abstract

Introduction: Peripheral intravenous catheter insertion is a clinical procedure commonly performed by nurses for pediatric patients in Bhutan. This study describes peripheral intravenous catheter first attempt success and factors associated with such insertions.

Methods: A cross-sectional survey was conducted from October 2016 to March 2017, comprised of a national sample of the Bhutan pediatric patient population (0–12 years). We collected data on peripheral intravenous catheter first time insertion success rate of admitted pediatric patients, to identify predictors of a successful first time attempt. Clustered log binomial generalized linear models were used to obtain the prevalence of first time attempt success and predictors of success.

Results: The prevalence rate of successful first time attempt adjusted for clustering was 64% (95% confidence interval: 51%–80%). Predictors of a successful first time attempt were older patient age, lighter skin color, the vein being visible with a tourniquet, and the left hand being used for insertion. A transilluminator was used in 52 patients, and the peripheral intravenous catheter was eventually successfully placed in 82% of the patients.

Discussion: Our first time successful cannulation rate is substantially lower than that found in similar studies in other countries. Considering the impact a peripheral intravenous catheter has on patients' clinical outcomes and cost implications, reducing the number of failed attempts should be of high importance. Better education and simulation, combined with the adoption of vessel locating technology, are required to improve insertion practice in Bhutan. This could lead to greater efficiency of the health facilities in Bhutan.

Keywords

Pediatrics, neonatal nursing, nursing care, catheterization

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Introduction

Peripheral intravenous catheter (PIVC) insertion is an essential invasive treatment procedure commonly performed in pediatric patients for the administration of intravenous medication, collection of blood samples, and resuscitation of patients. For nurses in Bhutan, PIVC insertion is a clinical responsibility. However, nursing staff are not always able to access the vein at the first attempt, resulting in repeated punctures. Studies have reported a first attempt success rate for PIVC between 60% and 80%.¹ Multiple punctures can become a traumatic experience for children and induce a lifelong fear of needles and cause distress to both children and parents.² Unsuccessful

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attempts may also cause discomfort and distress among the healthcare providers. Furthermore, unsuccessful attempts are costly, time-consuming, and may increase complications such as nerve injury,³ in addition to stress for the pediatric patients and guardians, damage to peripheral vasculature, and PIVC-associated infection.

The reasons for repeat attempts in the neonate and pediatric literature include factors such as clinician role, age of the child, gender, visibility of the vein, skin color, and body mass index (BMI).^{4,5} However, there are limited studies, which have evaluated all these risk factors together.

This study aimed to determine the prevalence of first time nurse-inserted PIVC success in pediatric patients, and factors influencing success.

Methods

Study design and sampling method

This was an observational study using an analytic cross-sectional survey, comprising of a national sample of the pediatric patient population (0–12 years) in Bhutan. A stratified randomized cluster design sampling methodology was used to represent all regions of Bhutan with selection in proportion to inpatient caseload in 2014.

Using this methodology, it was determined that 76% of patients should come from the Jigme Dorji Wangchuck National Referral Hospital (JDWRH), the main acute hospital in Bhutan. The remaining patients were enrolled at randomly selected grade 1 basic health units (BHUs) spread within three regions of East (12%), Central (8%), and West (4%) Bhutan. The sites chosen were Chukha grade 1 BHU to represent a Western cluster, Sarpang grade 1 BHU for Central region, and Nganglam grade I BHU for Eastern Bhutan.

Data collection

Study researchers observed nursing staff perform PIVC insertions. The primary outcome was first time insertion success. Potential factors that might influence first attempt success were underpinned by the current pediatric literature and included the age and sex of the patient, BMI, and patient's skin shade. As is current practice in Bhutan's health setting, and for the purpose of this study, the World Health Organization (WHO) growth chart (weight–age) was used to categorize children aged 0 to 5 years into obese, normal, underweight, and severe underweight. For children aged 5 to 12 years, BMI was calculated and CDC BMI-for-age growth chart was referenced to categorize each child into obese, overweight, normal, and underweight. Skin shade was assessed using the Fitzpatrick skin shade tool which we refined to range from light, medium, dark, and extra dark.⁶ Data collected about the PIVC procedure included visible vein with a tourniquet, hand selected (left/right), site on hand selected, size of cannula,

number of attempts required, whether someone was asked to assist, transilluminator/vein-scope used, and success after use of transilluminator.

Additional questions included an open question to illuminate reasons for failed first time PIVC insertion. Eight nurses were involved in observing procedures performed by total of 79 nursing staff across the above study sites. Prior to visiting the study sites, research nurses were trained in objective recording and compilation of data, and familiarized with the study questionnaire.

Sample size and statistical analysis

The sample size was based on having sufficient participants to estimate the proportion of patients with a successful cannulation on the first attempt with sufficient accuracy. Based on the global literature, which suggests the proportion of successes on the first attempt to be typically 60% to 80%, the study aimed to measure an estimated proportion at 60% with a precision of at least $\pm 10\%$ with 95% confidence interval (CI) and thus required a sample of 91 pediatric patients. The data are clustered by hospital and staff member; however, we expected the hospital effect to be much stronger than the staff member effect. We therefore allowed for clustering by hospital using a conservative intraclass correlation coefficient (ICC) of 0.1 to determine a likely design effect of 2 and thus recruited 200 pediatric patients.

Simple counts and percentages were used to describe patient and nurse characteristics, as well as features of the PIVC. The proportion of first time PIVC insertion success was calculated, along with the 95% CI using a log binomial generalized linear model with clustering by hospital. Similar regression models were used to determine predictors of first time successful insertion, both at the univariate level and at the multivariable level. Variables with $p \leq 0.05$ at the univariate level were entered into the multivariable model. A two-sided p value of ≤ 0.05 was regarded as indicating statistical significance. All statistical analyses were performed using statistical software Stata version 14 (StataCorp, College Station, TX, USA).

The study was approved by the Bhutan Research Ethics Board of Health, REBH/Approval/2016/019.

Results

Demographic background of the study population

Among the total of 200 patients for which a PIVC procedure was observed: 48 (24%) patients were from the grade I BHUs of Nganglam (24), Sarpang (16), and Chukha (8), and 152 (76%) were from the tertiary hospital JDWRH in Thimphu, the capital of Bhutan.

Table 1 shows that just over half of the sample (56%) were male, with medium being the most common skin shade (58%). The mean (standard deviation (SD)) age of

Table 1. Demographic background of the study population, aged 0 to 12 years.

Variable	Category	N	%
Age of patient	<2 years	159	80.7
	≥2 years	38	19.3
	Total	197	100.0
Sex of the patient	Male	109	55.6
	Female	87	44.4
	Total	196	100.0
BMI, ages ≤5 years	Obese	5	2.9
	Normal	121	69.9
	Underweight	15	8.7
	Severe underweight	32	18.5
	Total	173	100.0
BMI, ages >5 years	Obesity	4	20.0
	Overweight	4	20.0
	Normal	10	50.0
	Underweight	2	10.0
	Sever underweight	0	0.0
	Total	20	100.0
Patient's skin shade	Light	54	27.0
	Medium	116	58.0
	Dark	22	11.0
	Extra dark	8	4.0
	Total	200	100.0

BMI: body mass index.

the patients was 1.3 (2.5) years. The mean (SD) BMI was 16.3 (16.7) kg/m².

Descriptive information of the staff who performed the PIVC procedures

The BHUs that were included in the study had total nursing staff roster ranging from five to nine in each BHU. Nearly all of the nurses in each BHU took part in the study and represented 24% of the total 79 staff involved. The remaining 76% were from the JDWNRH tertiary hospital. The majority of the staff who participated in the study (72%) were general nurses and midwives. Nine nurses (11%) were assistant nurse midwives, and the remaining 13 (16%) had a BN or higher nursing qualification. Their mean (SD) length of time working at their health center was 3.0 (2.7) years, and the mean (SD) of number of successful IV cannulations in the past month was 65.8 (17.2).

PIVC characteristics

PIVC insertion was successful in 128/200 (64.0%) of attempts, with 95% CI adjusted for clustering of 51.0%–80.4%. The clinical indication for a PIVC was a blood test in 130/199 (65.5%) and for IV therapy in 141/198 (71.2%) of the time. Table 2 displays descriptive information about

the PIVC procedures and that the most common size of PIVC chosen for the initial attempt was a 24G.

Despite the use of a tourniquet, nonvisible veins occurred in 23.5% of the population. The most popular anatomical site for insertion was the back of the hand. In over 80% of the time, a successful insertion was achieved after first time failure at the second or third attempt. In one-third of cases where first time PIVC insertion was not achieved, the assistance usually of a general nurse and midwife was sought.

Vessel locating technology

Among the study sites, only a few units under the Pediatric Department in JDWNRH used a transilluminator to aid in accessing the vein during the procedure. A transilluminator was used in 52 patients in JDWNRH during which IV line was successfully placed in 43 patients (82%) at first attempt.

At the end of the survey, staffs were asked if they had any other comments about the PIVC procedure. Out of the 195 responses, the most common comments related to factors that caused increased difficulties in accessing vein were on the patient characteristics such as dark skin color, chronic patients who had repeated punctures, dehydrated patients with flaccid vein, and patients who were obese. Ergonomic responses included the need for a well-ventilated room, naturally bright for clearly spotting a suitable vein. Nearly all of the staff who used a transilluminator found it useful and recommended the procurement of additional equipment. Currently, there are no transilluminators available in the BHUs (study sites), and their staff strongly suggested that the provision of this equipment would reduce failed attempts at PIVC insertion.

Factors associated with peripheral intravenous cannulation

Table 3 shows that at the univariate level, years worked at the hospital, patient's age, skin shade, and the vein being visible with a tourniquet were all associated with a successful first insertion, and these variables remained statistically significant in the multivariable model.

Discussion

This study found a first time PIVC successful insertion rate of 64%. Previous studies have found first attempt failure rates of one in four and one in five; therefore, our failure rate of one in three is of clinical concern and provides opportunities for improvement in this vulnerable pediatric population, considering most failures should be preventable.⁷

Our finding of the PIVC first time insertion success being associated with increasing patient age is consistent

Table 2. Descriptive information about the PIVC procedures.

Variable	Category	N	%
Visible vein with tourniquet	No	47	23.5
	Yes	153	76.5
	Total	200	100.0
Side of hand selected	Right	95	47.5
	Left	105	52.5
	Total	200	100.0
Site of hand selected	Hand	119	59.8
	Lower forearm	35	17.6
	Leg	38	19.1
	Other site	7	3.5
	Total	199	100.0
Size of cannula at first attempt	<24	7	3.5
	24	178	89.0
	26	15	7.5
	Total	200	100.0
If unsuccessful, number of attempts required before successful attempt	2	39	54.2
	3	21	29.2
	4+	6	8.3
	Unsuccessful	6	8.3
	Total	72	100.0
If unsuccessful, someone was asked to assist	No	48	66.7
	Yes	24	33.3
	Total	72	100.0
Transilluminator/vein-scope used	No	147	73.9
	Yes	52	26.1
	Total	199	100.0
IV line successfully placed after the use of transilluminator	No	9	17.3
	Yes	43	82.7
	Total	52	100.0
Site of successful insertion	Hand	101	53.2
	Leg	54	28.4
	Lower forearm	30	15.8
	Other	5	2.6
	Total	190	100.0
Size of cannula at successful attempt	<24	7	3.5
	24	170	85.9
	26	15	7.6
	Unsuccessful	6	3.0
	Total	198	100.0

PIVC: peripheral intravenous catheter.

with other studies,¹ as is our finding of increased difficulty with very dark skin.⁴ We found that the visibility of the vein with the use of a tourniquet was a strong predictor of a successful first attempt. The importance of vein visibility is further emphasized by the higher success rate when a transilluminator which helps to view the vein using red light was used.⁸

Years working at the hospital was not associated with a successful first time attempt; however, although not statistically significant, staff working at the main hospital were

1.5 times more likely to achieve a successful first PIVC insertion. Staff working at this busy tertiary hospital cannulate a far greater number of children each shift than those in the BHUs, and other studies have shown a greater success rate with more experienced staff.¹

The trauma and experiences associated with multiple punctures and relatively lower success rate at first attempt gives room for improvement on current practices of PIVC. We found that using the left-side hand of the patient was a predictor of first time success in our study.

Table 3. Predictors of first time success.

Variable	Univariate model ^a			Multivariable model ^a		
	RR	95% CI RR	Significance	RR	95% CI RR	Significance
Other type of staff	1.00					
General nurse and midwife	1.19	0.95–1.50	0.135			
Works in BHU	1.00					
Works in tertiary hospital	1.48	0.91–2.42	0.116			
Years worked at health center	1.00	0.98–1.02	1.000			
Successful insertions in last month	1.01	1.00–1.02	0.151			
Patient age (years)	1.04	1.01–1.06	0.003	1.02	1.01–1.03	0.001
Patient female	1.00					
Patient male	0.93	0.85–1.02	0.107			
Patient BMI	1.00	0.98–1.01	0.488			
Light skin color	1.00			1.00		
Medium skin color	0.93	0.76–1.15	0.502	0.95	0.81–1.12	0.549
Dark skin color	0.93	0.55–1.58	0.785	1.17	0.80–1.71	0.425
Extra dark skin color	0.55	0.49–0.61	<0.001	0.66	0.56–0.78	<0.001
IV for blood test	0.93	0.61–1.42	0.752			
IV therapy	0.95	0.86–1.04	0.243			
Visible vein with tourniquet	2.15	1.37–3.38	0.001	2.13	1.40–3.23	<0.001
Right side selected	0.78	0.59–1.03	0.078			
Hand site selected	1.18	0.99–1.42	0.071			
Left hand selected	1.23	1.01–1.51	0.044	1.24	1.04–1.49	0.018
Cannula size 24G used	0.87	0.71–1.06	0.160			

RR: rate ratio; CI: confidence interval; BHU: basic health unit; BMI: body mass index.

^aLog binomial generalized linear model with clustering by hospital.

With respect to limitations, there are many other possible predictors of first attempt PIVC success that were not measured in this study, including the presence of diseases, previous surgery and prematurity, and inserter confidence.⁹ Overall, we believe the patient population described in this study is representative of the pediatric patient population of Bhutan and may indeed be generalizable to similar populations in developing countries.

Considering the impact of PIVC on patients' clinical outcomes and cost implications, reducing the number of failed attempts should be a high priority for nurses working with this pediatric population. Better nurse training, support, and equipment are required to improve insertion practice in Bhutan, and would lead to greater efficiency of the health facilities by saving staff time and waste of healthcare equipment. It would also improve the experience of staff, patients, and caregivers, enhancing the quality of healthcare services.

Declaration of conflicting interests

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