

The impact of multiple insertions on peripheral intravenous access in low-birth-weight infants in perinatology

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Abstract

Low-Birth-Weight (LBW) infants have very small veins, and there is a risk of needing multiple insertions to establish peripheral

intravenous access. This study aimed to examine the impacts of multiple insertions during peripheral intravenous access in LBW infants. This cross-sectional study involved 216 respondents. Data were analyzed with the Spearman correlation. The results showed a significant relationship ($p < \alpha$) between multiple insertions to establish peripheral intravenous access to LBW infants with increased pain, heart rate, respiratory rate, duration of crying, delayed treatment, duration of insertion, and high cost of care ($p < 0.001$; $r = 0.358-0.836$). Meanwhile, multiple insertions might decrease oxygen saturation and body temperature ($p < 0.001$; $r = 0.358$). In this study, multiple insertions were correlated with several negative impacts on the physiological function and discomfort of LBW infants. The study also highlights the effect on time of treatment precision and cost effectiveness. Recommendation: It is necessary to develop preventive measures to reduce the impact of multiple insertions to establish peripheral intravenous access in LBW infants.

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Introduction

Infants with Low-Birth-Weight (LBW) have difficulty adapting to the extrauterine environment, and they are at risk for health problems that require treatment in an intensive care unit,¹ with various invasive procedures.^{2,3} Installation of Intravenous (IV) access is an invasive procedure that is performed often. As many as 70%-90% of patients with acute disease require IV access during hospitalization.⁴ Installation of IV access is required for infants in the intensive care unit for parenteral nutrition, prescribed IV medication, prolonged antibiotics, administration of blood products, or intravenous contrast for diagnostic procedure.^{5,6}

The insertion of a peripheral IV is a painful procedure, and it often requires multiple attempts.⁷ Installing peripheral IV access required more than four attempts in as much as 23% of children and 9% of adults.⁸ The average time needed for peripheral intravenous insertion is 2.5 to 25 minutes, and difficult IV access might need 30 to 60 minutes.⁹

The impact of this invasive procedure is a change of vital signs and changes to SPO₂, PaO₂, PaCO₂, and pH. In addition, there are changes in infant behavior, such as crying, facial expressions, and body movements.¹⁰ An observational study of pediatric patient in an Emergency Department (ED) who needed multiple IV attempts experienced an increase in pain to 51 mm Visual Analog Scale (VAS). Patients who underwent one IV attempt experienced an increase of only 25 mm VAS.¹¹ Multiple insertions may also delay treatment for 120 minutes as much 5% of the time and for 15 minutes as much 23%.¹² This is work time that nurses lose, it affects client satisfaction, and it raises the cost of treatment.¹³ A prospective observational study found that 28% of children who needed IV

access required more than three attempts at insertion. There was an increase in costs between \$69 and over \$125 in children who required three or more attempts at IV access.¹⁴ However, similar study for neonates is not available. The objectives of this study were to measure the correlation of multiple insertions of peripheral intravenous catheters with infants' pain, heart and respiratory rates, body temperature, oxygen saturation, duration of crying, delayed treatment, and increase in the cost of care.

Materials and Methods

Study Design

This was an analytical study with a cross-sectional design. The selection of subjects used a consecutive sampling method with a sample size of 216 respondents, all of whom were low-birth-weight infants who had intravenous access.

Setting

This research was conducted at a referral center hospital in Jakarta with the consideration of a "high-volume" of births of low-birth-weight infants—as many as 86.7% from live births in 2019. Research activities were carried out for eight months from April 2020 to December 2020.

Participants

The number of samples in this study was 216. The calculation of the size of the research sample used the formula for numerical-numerical correlative analytic research with an alpha value of 5%, a beta value of 10%, and a minimum correlation coefficient of 0.2, based on the clinical judgment of the researchers, which is considered sufficient to describe the minimal relationship to each outcome in the study. These calculations showed that the minimum sample was 211 participants. The inclusion criteria in this study were LBW < 2500 grams, infants who were planned for peripheral IV access and whose parents allowed them to participate in the study. The exclusion criterion was severe clinical deterioration. The method of collecting research data was direct observations of the research subjects according to the inclusion criteria.

Variables

Number of Attempts: The number of attempts made by a nurse to acquire IV access, measured from the first insertion until a peripheral IV was successfully established.⁹

Pain: Pain is an unpleasant sensory and emotional experience from actual or potential tissue damage.¹⁵ Pain was assessed using a valid pain assessment format for neonates undergoing painful procedures, namely the Neonatal Infant Pain Scale (NIPS). The indicators included facial expressions, crying, breathing patterns, hand movements, leg movements, and awareness. The NIPS assessment format has been carried out by instrument validation at the national referral hospital in Indonesia. This instrument has been validated with concurrent validity ($r=0.53-0.84$) and interrater reliability >0.92 .¹⁶

Physiological indicators: Changes in heart rate, respiratory rate, oxygen saturation, and body temperature from normal limits. The assessment of the indicator should be recorded prior to insertion, during the procedure, and after the procedure.

Duration of infant crying: This was the length of time that audible crying persisted during the procedure. This indicator can be gauged in minutes or seconds.¹⁷ It was measured from the first insertion until peripheral IV was successfully established.

Delayed treatment: This means that patients received therapy at a time later than scheduled.¹⁸ It included both medicine and fluid therapy. Delayed treatment was calculated from the time the therapy was scheduled until therapy was given to the patient.

Duration of insertion: This is the time from the first insertion until intravenous access is successfully established.¹²

High cost of care: This is the increase in the overall cost of having peripheral intravenous access successfully installed by the nurse with multiple insertions.¹⁴

Procedure

Data collection was carried out by assessing the infants who met the inclusion criteria as they were treated in the perinatology room and requesting informed consent from the person in charge of the infant (usually the parents). If the infant's parents did not allow the infant to be the respondent, then no observation was made on the infant. If the infant's parents were willing to allow the infant to be the respondent, then observation continued. All infants who were respondents were observed when peripheral intravenous access was being established. All observations were recorded on observation sheets, and demographic data from medical records were added.

Statistical method

Spearman bivariate analysis was used to determine the relationships between multiple insertions to establish peripheral intravenous access and increased pain, increased heart rate, increased respiratory rate, decreased body temperature, decreased oxygen saturation, duration of infant crying, delayed treatment, duration of insertion, and high cost of care.

Results

Table 1 shows that the largest proportion of infants were those with a gestation age of 32-36 weeks (as much as 54.2%) and a birth weight of 1500-2499 grams (61.1%). The number of infants who are male and female is the same, namely as many as 108.

Table 2 shows that there is a significant relationship between multiple insertions during peripheral intravenous access and increased pain, increased heart rate, increased respiratory rate, decreased body temperature, decreased oxygen saturation, duration of infant crying, delayed treatment, duration of insertion, and high cost of care.

Table 1. Characteristics of respondents at perinatology of Cipto Mangunkusumo and Fatmawati Hospital in May-December 2020 (n=216).

Variable	n	%
Gestational Age		
<28 weeks (extremely preterm)	26	12.0
28-31 weeks (very preterm)	47	21.8
32-36 weeks (low and moderate preterm)	117	54.2
37-41 weeks (at term)	26	12.0
Birth Weight		
<1000 grams (ELBW)	29	13.4
1000-1499 grams (VLBW)	55	25.5
1500-2499 grams (LBW)	132	61.1
Sex		
Male	108	50.0
Female	108	50.0

ELBW, Extremely Low Birth Weight; VLBW, Very Low Birth Weight; LBW, Low Birth Weight.

Discussion

Increased pain

This study showed a significant positive correlation between multiple insertions during peripheral intravenous access and an increase in pain. These results aimed to provide a representation of the pain experienced by LBW infants during repeated efforts to establish peripheral intravenous access. The data show that multiple insertions led to an increase in pain scores of 1-7 points. This is in accordance with a study by Cameron *et al.* (2007) who stated that pain scores in VLBW infants increased significantly after painful procedures.¹⁹

A study of 30 neonates who were punctured found that 96.6% had a score of 7 and 3.3% had a score of 6.²⁰ A cross-sectional observational study of 729 ER patients who experienced multiple insertions during intravenous access found that the subjects experienced an increase in pain to 51 mm VAS (pain level). This is compared to patients who underwent one insertion, which caused 25 mm VAS.¹¹ Donia and Tolba had results similar to those of this study. They explained that infants who underwent painful procedures had an average pain score of 5 points.²¹

Increased heart rate

This study showed a significant relationship between multiple insertions during peripheral intravenous access and increases in heart rates. The results are in accordance with the systematic reviews conducted by Johnston *et al.* They also found an increase in heart rate in infants undergoing painful procedures.¹⁷ The heart rate in infants undergoing a painful procedure was 157-173 beats per minute. This is in line with a study of 107 neonates who underwent painful procedures. Their heart rates were counted in the first 5 minutes, and the result was an increase in heart rate after being punctured.²² Another study of VLBW infants found that there was an increase in heart rate of 13.6 beats per minute after the infants were given a painful stimulus.²³ Donia and Tolba had results similar to those of this study. They explained that infants who undergo painful procedures experience an increase in heart rate of up to 17 beats per minute.²¹

Increased respiratory rate

This study showed a significant relationship between multiple insertions during peripheral intravenous access and an increase in respiratory frequency. Installing peripheral intravenous access

with multiple insertions causes pain to the infant. The physiological responses to pain include an increase in heart rate, changes in breathing patterns, and changes in behavior such as crying. The results of this analysis are in accordance with other systematic reviews that concluded that pain affects respiration by increasing its flow, frequency, and volume.²⁴

Decreased oxygen saturation

This study showed a significant relationship between multiple insertions during peripheral intravenous access and decreased oxygen saturation. These results are in accordance with the systematic reviews conducted by Johnston *et al.* They found that there was a decrease in oxygen saturation in infants undergoing painful procedures. Oxygen saturation under such conditions is between 82% and 94%.¹⁷ This is in line with a study of 107 neonates who underwent painful procedures. Oxygen saturation was calculated in the first 5 minutes, and the result was a decrease in oxygen saturation between the first minute and the fifth minute from the puncture procedure begun.²² Donia and Tolba had similar results, they found a decrease in oxygen saturation by an average of 4%.²¹

Decreased body temperature

This study indicated there was a significant relationship between multiple insertions during peripheral intravenous access and a decrease in body temperature. The procedure for gaining peripheral intravenous access begins by opening the incubator door. This affects the temperature in the incubator, which can lower the infant's body temperature. The results of this analysis are in line with research that found that the average temperature of infants before and after blood collection in an open incubator declined by 0.36°C.²⁵

Duration of infant crying

This study found a significant relationship between multiple insertions on peripheral intravenous access insertion and the increase duration of infant crying. The results of this analysis are in line with a study conducted on 107 neonates who underwent painful procedures for 5 minutes. The results showed that the duration of the crying of the infant who was punctured was 2-5 minutes.²²

Delayed treatment

This study found a significant positive relationship of moderate strength between multiple insertions during peripheral intra-

Table 2. Analysis of the correlation between multiple insertions during peripheral intravenous access and increased pain, increased heart rate, increased respiratory rate, decreased body temperature, decreased oxygen saturation, duration of infant crying, delayed treatment, duration of insertion, and high cost of care in the Perinatology Department in May-December 2020 (n=216).

Variable	Number of attempts		
	r	r ²	p
Increased pain	0.358	0.128	<0.001
Increased heart rate	0.561	0.314	<0.001
Increased respiratory rate	0.545	0.297	<0.001
Decreased oxygen saturation	-0.446	0.198	<0.001
Decreased body temperature	-0.487	0.237	<0.001
Duration of infant crying	0.794	0.630	<0.001
Delayed treatment	0.546	0.298	<0.001
Duration of insertion	0.836	0.698	<0.001
High cost of care	0.815	0.664	<0.001

venous access and delayed treatment. The findings had a probability value of 0.001 (p -value<0.05) and a correlation coefficient of 0.546. Installation of peripheral intravenous access with several insertions takes more time, resulting in delayed therapy. These are in accordance with another study that found that multiple insertions increased treatment costs, delayed the provision of therapy, and required long insertion times.²⁶

Duration of insertion

This study found a significant positive relationship between multiple insertions during peripheral intravenous access and the duration of insertion. These results are consistent with those from studies conducted with adult patients who underwent multiple insertions during peripheral intravenous access. The insertion time was longer as the number of cannulation insertion attempts rose. The insertion time increased to 19.1 minutes when eight insertions were needed to achieve intravenous access.²⁷

High cost of care

This study found a significant relationship between multiple insertions during peripheral intravenous access and increases in the cost of care. These results are in accordance with those from a study that explained that gaining peripheral intravenous access with multiple insertions required more than one cannula. This led to an increase in treatment costs because multiple intravenous catheters were needed.^{9,14} This is in line with research conducted by Kuensting and Walsh, who concluded that multiple attempts to gain peripheral intravenous access led to delays in treatment and increased costs because they required additional time, used more equipment, and required special intervention when peripheral intravenous access was not successfully installed.^{28, 29}

This is in line with studies of adult patients who experienced multiple attempts at insertions to gain peripheral intravenous access. The cost increased as the number of attempts rose. The cost for successfully inserting the IV on the first attempts was approximately 9.32€ lower, but the cost rises sharply to 65.34 € when five attempts are required.²⁷

Limitations

Some limitations should be considered when interpreting the results of this study. First, the cross-sectional study design will affect interpretation because it is based only on a correlation between multiple attempts to establish IV access, so that causal effect could not be drawn. Further research using a longitudinal study should be considered to address this issue. Second, our study was conducted only at a top national referral hospital. That might affect the generalizability to other settings with different levels and/or different characteristics of nurse staff and newborns. Future studies should consider a multi-center research design setting with a larger sample size.

Conclusions

The impact of multiple insertions during peripheral intravenous access includes increased pain, increased heart rate, increased respiratory rate, decreased body temperature, decreased oxygen saturation, extended duration of infant crying, delayed treatment, extended duration of insertion, and a high cost of care. Nurses are needed to arrange specific preventive measures to reduce the number of peripheral catheter insertions to avert several negative impacts on very low birth weight infants.

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