

The Effectiveness of Peripheral Intravenous Cannulation Using Ultrasonography Compared with Conventional Method in Patient with Unpalpable Vein Access

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Abstract:

Background: Peripheral intravenous access is the most frequent procedure of action in emergency department installations. The installation of peripheral venous by conventional methods often fails in patients with unpalpable veins, although performed by trained medical personnel. There is a need for peripheral venous cannulation innovation with greater success rate, one of them using ultrasound.

Objective: comparing the effectiveness (number of attempts, time, cost) as well as the emerging complications in obtaining peripheral intravenous access between conventional and ultrasound methods in patients with unpalpable venous access.

Method: a true clinical experimental study with a single blinded post test only control group design approach on 40 samples of the study at the Saiful Anwar Hospital's Emergency Room to compare the effectiveness (number of attempts, time, costs) and complications arising from peripheral intravenous cannulation methods.

Results: The cannulation using ultrasound was more effective than conventional peripheral venous cannulation ($p < 0.05$) but with higher cost ($p < 0.05$)

Conclusion: Peripheral venous cannulation with ultrasound guidance is more effective, has fewer side effect but more expensive than the conventional method

Keywords: peripheral vein, ultrasound, conventional, vascular access

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I. Introduction

Peripheral intravenous access, the most frequently performed procedure in emergency room (ER) across the USA, refers to peripheral intravenous access installation to inject medicine or intravenous liquid (Fields, et al., 2014). In certain cases, medical staffs spend longer time to install the peripheral intravenous access for example, patients with obesity, chronic kidney failure or ones who have just finished their chemotherapy. There are also a group of people whose peripheral veins are not as much palpable or visible (Au, et al., 2012). The most ideal solution for such condition is to increase the rate of successful peripheral venous access installation, which avoids CVC installation. Bedside ultrasound (USG) is able to identify the vein that is hard to be found using the naked eyes or palpitation by dynamically guiding peripheral venous access cannulation significantly. However, there is not any report describing the effect of peripheral venous access using USG (Weiner, Geldard & Mittnacht, 2013).

Several studies showed debates concerning effectiveness of peripheral venous access installation using USG in terms of duration, accuracy and amount of man-labor compared to conventional methods making the topic interesting to analyze. It is interesting to conduct the study in hospitals in Indonesia, more particularly Saiful Anwar Hospital in Malang in which, based on the researchers' observation, the level of peripheral venous cannulation using conventional method in the peripheral intravenous cannulation procedure in the patients whose veins are not as palpable is high, even though the ones performing the procedure are well-experienced nurses or medical doctors. Innovations with higher success rate and accuracy are needed; one of them is using ultrasound.

II. Method

2.1. Patients

The total samples were 40 patients with P2 triage who were divided randomly into two cannulation methods, conventional method and ultrasound.

2.2. Design

Clinical true experimental study using clinical post test only control group design single blinded approach was conducted to compare effectiveness (man-labor, duration and cost) as well as complication that occurred between ultrasound and conventional method to get peripheral venous access in patients whose veins were not palpable. It had been approved by the Ethical Commission of Saiful Anwar hospital in Malang and was conducted in the ER of Saiful Anwar hospital between April and July, 2017. The inclusion criteria were patients who were above 18 years old, needed intravenous access, and had impalpable veins due to at least one of these three conditions, chemotherapy, chronic kidney failure, BMI > 30kg/m²). The exclusion criteria involved unstable patients (those suffering from airway, breathing and/or circulation disorder) or the patients who required central venous access or were unwilling to participate in the study. The operators of both methods were at least the 5th-semester residence of the Department of Emergency Medication. Conventional method for peripheral venous access is visual method and palpation of the vein of which antecubital will be injected after being tourniquet. On the other hand, peripheral venous access using ultrasound is using GE Vivid E ultrasound with vascular probe (7.5 – 10 MHz). Once cannulation was successfully conducted, an individual took note on how much injection was needed, how much time and cost were spent as well as whether or not there was complication such as swelling, redness or pain.

2.3 Data Collection and Data Analysis

The data were in the form of frequency of injection needed to perform peripheral venous cannulation as there is not any maximum injection due to standardized clinical practice. Time spent for peripheral venous access referred to how much time (seconds) needed for venocath needle to get through patient's skin for the first time and the ultrasound had been turned on (tourniquet and all equipment for infuse procedure had been prepared previously). Effort referred to number of peripheral intravenous cannula needed for successful peripheral venous access cannulation without any complication. Cost referred to how much money being spent to carry out successful peripheral venous access cannulation without any complication. Complication referred to occurrence of one or more of the following symptoms, pain, artery impingement or swelling after venocath injection.

2.4 Data Analysis

Statistical significance was evaluated using 95% level of significance. The efforts, time, cost and complication were represented in the form of average score \pm SD, maximum-minimum scores. Odd ratio was particularly represented complication.

III. Findings

Table 1. Characteristics of the Subjects and Reason for Impalpable Venous Access based on Groups

	Conventional Method	Ultrasound	p-value	
Total Sample	20	20		
Sex				
Male	11	55%	13	65%
Female	9	45%	7	35%
Age (year)				
Mean (SD)	52.60	10.43	47.70	11.20
Median	54		45	
Range	31-75		32-68	
Reason				
Chronic Kidney Failure	16	80%	16	80%
Cancer	4	20%	4	20%

There was not any significant difference between sex, age and reason for impalpable veins between the methods ($p > 0.05$) and therefore, the samples were distributed evenly.

Table 2. Data Analysis Results on the Number of Injections, Time, Cost and Complication based on Groups

	Conventional Method	Ultrasound	p-value
Total Sample	20	20	
Peripheral Venous Access Installation in One Trial			

Yes					
No	4		17		0.000
	16		3		OR = 22.667
Number of Injection					
Mean (SD)	2.15	0.88	1.15	0.37	
Median	2		1		0.000
Average	1-4		1-2		
Time (second)					
Mean (SD)	182.40	59.50	163.9	104.75	
Median	159.5		141		0.000
Average	144-348		37-415		
Cost (rupiah)					
Mean (SD)	68215	12338.8	304115	5165.5	
Median	66100		302000		0.000
Average	52000-94300		302000-316100		
Complication					
No complication	4		17		
Hematoma	14		3		0.000
Artery Impingement	2		-		
Neural Impingement	-		-		

3.1 Successful Rate on the First Trial

Using ultrasound, peripheral venous access was installed on the first trial to 17 patients (85%) while using the conventional method, the peripheral venous access was installed on the first trial to only 4 patients (20%). There was significant different ($p < 0.05$) between the successful rate of the peripheral intravenous cannulation on the first trial using ultrasound and that using the conventional method.

3.2 Number of Injection between Methods

Conventional method required twice more injections than the conventional one. The average injection for the conventional group was 2.15 and that for the ultrasound group was 1.15 ($p < 0.05$).

3.3 Cost of Peripheral Intravenous Cannulation between Methods

The peripheral intravenous cannulation using ultrasound for the patients whose veins are impalpable was up to four times more expensive than doing so with the conventional method (average score of 304.115 versus 68.215) ($p < 0.05$).

3.4 Complication between the Two Methods

The conventional method had higher complication rate compared to ultrasound. The conventional method resulted in 16 cases of complication (14 cases of hematoma and 2 cases of artery impingement), while ultrasound only caused 3 complications (3 cases of hematoma). There was significant influence between ($p < 0.05$) the methods for peripheral venous access installation and complication (hematoma or artery impingement) with OR = 22.7 (CI 95% 4.4 – 117.5). It meant conventional method for peripheral venous access for patients with impalpable peripheral veins caused 22.7 more complications than the ultrasound.

VI. Discussions and Limitation

After the first report on the successful implementation of ultrasound for vascular access in 1984, intravenous cannulation using ultrasound has developed rapidly, with the average procedures of 150 – 200 million procedures per year in the USA (Gottlieb, 2017).

Patient's condition more particularly how palpable their veins are play significant role in vascular access. Obesity, chronic disease such as kidney failure, cancer and frequent injection to the blood vessels, drug users who is using injection and vasculopathy are several reasons why patient's veins are impalpable (Ismailoglu, 2015). Repeated injections to patients with the risk factors stated above obviously spend significant time and resource in the ER. Hospitals currently have used ultrasound as a tool for peripheral venous access. Ultrasound guideline for peripheral venous cannulation procedure has showed high successful rate, fewer complications and less time (Bauman, 2009). In line with Bauman, Gottlieb, et.al., in their study, found out that the rate of successful peripheral venous cannulation using ultrasound was 80% and thus, reduce central venous catheter installation (Gottlieb, 2017). Based on Bauman, et.al's study, the percentage of successful peripheral venous access on the first trial for the patients whose veins are impalpable using ultrasound is 80.5% (33 out of 41 subjects) whereas that using the conventional method is 44.1% (15 out of 34 patients) (Bauman, 2009). Chinnock, et.al's percentage is 83%, and Gregg, et.al's is 71%. (Chinnock, 2007; Gregg, 2010)

The number of injections is twice higher in the conventional group (average of 2.15) than the ultrasound group (average of 1.15). It is in line with Bauman and Brannam, et.al that the average injections using ultrasound is far fewer than the conventional method (1.6 versus 3.6, each) (Bauman, 2009). In addition a study

conducted by Constantino, et al in 2005 revealed that the average injection in ultrasound method is 1.7 and the conventional method is 3.7 (Constantino, 2005)

In terms of statistics, ultrasound significantly reduces the number of injection as during cannulation procedure, operator is able to visualize clearly the tip of cannul needle, targeted peripheral venous blood vessel in one trial and the procedure is conducted in dynamic, real – time manner allowing accurate peripheral venous access cannulation. In this study, there are 3 (three) samples injected twice due to losing visualization of the cannule needle tip during the cannulation using ultrasound. Even though cannule needle tip and veins blood vessels are displayed on the same screen or despite of well-experienced operators, the ultrasound in mode B can only described a two-dimensional image (Reusz, 2015).

The peripheral venous access installations in the samples whose venous access are impalpable using ultrasound guide requires less time for vascular access compared to the conventional method (average time of 163 versus 182, $p < 0.05$). It is in accordance to Mills, et al that the average time needed for peripheral venous cannulation using ultrasound guide is between 2 and 4 minutes (Miles, 2012)

Peripheral venous access installation using ultrasound is four times more expensive than the conventional method (average score of 304,115 versus 68,215). Cost for peripheral access cannulation procedure involves intravenous feeding service, intravenous feeding equipment, certain medical instruments, dressing and other equipments such as cotton and alcohol. The installation using ultrasound is less affordable than the conventional method as the cost for ultrasound alone is pretty high (Rp 250,000.00) according to the guideline for ultrasound cost in the ER of Saiful Anwar Hospital, Malang.

The finding corroborates to Tan, et al that the cost for ultrasound is CNY 2,225.98 compared to CNY 1,632.28 as the cost for the conventional method ($p < 0.001$) (Tan, 2016). The cost of ultrasound in this study is lower than that stated in Tan, et al as this study used venocath instead of PICC as the peripheral venous access cannulation. The researchers did not use PICC as the peripheral venous access cannulation since it is not available in Saiful Anwar Hospital ER pharmacy. The conventional method caused more frequent complications, 16 samples (80%), while the ultrasound only causes complications in 4 samples (20%). It is in line with Tan, et al in which patients treated with ultrasound suffered from fewer complications than the conventional method (2.8% versus 38.3%). Tan, et al's study involved larger samples, 144 patients in ultrasound group and 175 patients in conventional group. As the result, the percentage of complication between their study and this study is different (Tan, 2016)

Using the conventional method for peripheral venous access for the samples with impalpable peripheral veins causes 22.7 times higher complications compared to the ultrasound. In this study, the most frequent complication is hematoma (17 cases or 47%) followed artery impingement (2 cases or 5%). It is in line with Dargin's study in which the percentage of hematoma is 32% and that of artery impingement is between 1 and 4%. (Dargin, 2010). The limitation of the study is it is conducted in one hospital with limited samples. Therefore, it is suggested that future researches conduct similar study in several hospitals and involve larger samples. In this study, the cost referred to the amount of money spent when the patients were taken care of in Saiful Anwar Hospital Malang ER; the researchers did not involve other cost for taking care of further complication such as phlebitis or DVT (Deep Vein Thrombosis) the inpatients may suffer from after the peripheral intravenous cannule installation. The complications may result in higher cost and cause significant difference between both methods. Factors related to blood vessel such as diameter and intravenous blood vessel that becomes peripheral intravenous cannulation target are excluded in this study although they may possibly influence successful installation of peripheral intravenous cannulation using ultrasound.

V. Conclusion

Ultrasound is a more effective method (in terms of number of injection, time and complication) than conventional method for peripheral intravenous access in patients with impalpable veins. However, ultrasound is less cost-effective than the conventional method.

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