Original Article

1st Attempt Success Rate of Ultrasound-Guided Peripheral IV Access of Emergency Medical Services Health Care Providers on the Pre-Hospital Simulation Model

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Background: Ultrasound guided peripheral intravenous access (USGPIV) has derived benefits for the Emergency and Pre-hospital Management. However, no studies have yet been conducted that have focused upon Emergency Medical Services (EMS) personnel in Thailand.

Objective: To introduce USGPIV cannulation to the health care providers of Emergency Medical Services and to examine the success rates of the first attempts at PIV cannulation.

Materials and Methods: This prospective observational study was conducted with 49 EMS providers in August 2020. All respondents had been participants in a USGPIV workshop. Afterwards, the participants' skills were evaluated in a Pre-hospital simulation model, which was conducted in a moving ambulance. The data, which was recorded, noted the number of attempts required to successfully obtain USGPIV access, as well as the participants' opinions about using ultrasound in this procedure.

Results: Among the 49 participants, the first attempt success rate was found to be at 57.14%. The participants' genders, their years of work experience, their experience of performing PIV with real patients, and the categories of the Emergency Medical Services health care providers were determined not to be factors that had contributed to the success rate of the first attempts at USGPIV. Our study demonstrated a "High" level of satisfaction with regard to performing USGPIV with this ultrasound device (4 out of 5). However, the participants noted that some elements of the environment in the ambulance may have affected the success rate of performing this procedure.

Conclusion: In this study, the success rate of the first attempts was found to be lower than in other studies. However, in regard to this simulation, implementing this procedure represents the first step towards assisting Thai EMS personnel to perform ultrasound procedures.

Keywords: Ultrasound, Peripheral IV cannulation, Emergency medicine, Emergency medical services, Emergency medical personnel

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Peripheral intravenous (PIV) cannulation is a routine procedure carried out in the Emergency Department. However, pre-hospital PIV attempts are uncommon and represent only 2% of emergent responses[1]. The issue of pre-hospital venous cannulation is still being debated because this procedure can lead to delays in transporting some patients to the hospital[2-5]. Difficult IV access can occur among those individuals, who are morbidly obese, have a history of IV drug use, suffer from hypovolemia, are pediatric patients, and/or who have a chronic illness. All of these can delay the cannulation time by up to 50%[6-7]. Among the pediatric population, success rates are significantly associated with a patient's age, and the lowest success rates have been found in those 2 years of age and younger[1]. The failure rate of the first cannulation attempt was discovered to be up to 67%[8]. Ultrasound-Guided Peripheral Intravenous (USGPIV) cannulation has been developed to improve the overall success rate of this procedure[9]. In Thailand, this is a novel technology for Emergency Medical Services (EMS) health care providers. In this particular field, a lack of studies still remains. The aim of this study was to answer the research question by introducing USGPIV cannulation to the Emergency Medical Services health care providers and by examining the success rate of their attempts at PIV cannulation.

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Materials and Methods

Study design

This was a prospective, single-center, descriptive study carried out in a tertiary university hospital in Thailand. Ethics approval was provided by the Ethics Committee for Human Research of Khon Kaen University, and the study

was registered with the Thai Clinical Trials Registry (HE631350).

Participants

In August 2020, EMS providers at the Emergency Department at the Faculty of Medicine of Khon Kaen University were enrolled in this study by using convenience sampling. None of the participants had had any previous knowledge or experience with USGPIV access. No monetary incentives were provided for participation, and prior to enrollment, written informed consent was obtained from each participant.

Sample size calculation

In order to estimate the proportion of a population with specified absolute precision, the sample size for analysis was determined based on a study by Van Loon[10]. We hypothesized a prevalence of 0.8525, an absolute precision of 0.1, and a standard normal value of 1.96. The power analysis was determined using an alpha of 0.05. Hence, it was determined that a total of at least 49 subjects would be required.

Study protocol

We conducted this study at the Emergency Medical Services of Srinagarind Hospital. At the beginning of the study, all volunteer EMS providers participated in a USGPIV placement workshop, which consisted of a 30-minute didactic session and a 30-minute hands-on session. This workshop was taught by an Emergency Physician, who is a specialist in the field of Emergency Ultrasound. The participants were taught the following: 1) probe orientation, 2) image optimization using depth and gain, 3) upper extremity venous anatomy, 4) the use of vascular ultrasound to identify the appropriate vein, 5) the transverse approach, and 6) the dynamic technique using a simulation model (in which the operator holds the US probe with their non-dominant hand and the needle in their dominant hand while visualizing the needle tip entering the vein).

The simulation model was created based on a study by Chao[11]. The phantom was created using gelatin powder, fiber powder, and a latex tube. Moreover, the quality of the phantom, which was examined prior to the study, was determined to provide an adequate sonographic view and to be able to sustain multiple punctures.

After the training period, the participants' skills were evaluated by the Emergency Physician, who had taught the workshop, and by an examiner, who had had no previous associations with the participants. The data was recorded as the number of attempts needed to successfully obtain USGPIV access, as well as the time required to complete the procedure. Following the study, the participants completed a questionnaire (based on a 5-point Likert scale) regarding their opinions about the aspects of the feasibility of the ultrasound machine. Moreover, an open question was utilized for the purpose of assessing any problems that the participants might have encountered while performing the procedure in the ambulance.

The primary outcome of this study was the success rate of the participants' first-attempts to gain USGPIV access in the Pre-hospital-Simulation Model in which the participants were required to perform the USGPIV on the phantom in a moving ambulance, which was traveling at a speed of 80 km/hr.

Ultrasound equipment

This study was conducted using the SONIMAGE MX1 (KONICA MINOLTA, JAPAN). All images were obtained in B mode, and no color Doppler was used. The transducer was set to the vascular image pre-set. In addition, the simple needle visualization (SNV) technology was utilized. (Figure 1). The SNV features can be used to adjust the sensitivity of the needle visualization depending upon the type of tissue. On the ultrasound screen, the needle is seen as 'blue'.

Statistical analysis

The quantitative data was presented as means $\pm$ standard deviations and the qualitative data as proportions and percentages. The Kolmogorov-Smirnov test was utilized to analyze the time and number of attempts that were required to obtain a successful USGPIV access. Logistic regression was also used to analyze the factors, which were associated with the success rate of first attempts at USGPIV. A two-tailed $p<0.05$ was considered to be statistically significant. All of the data analysis was performed using Stata version 10.1 (Statacorp, College Station, TX).

Results

A total of 49 health care providers from Emergency

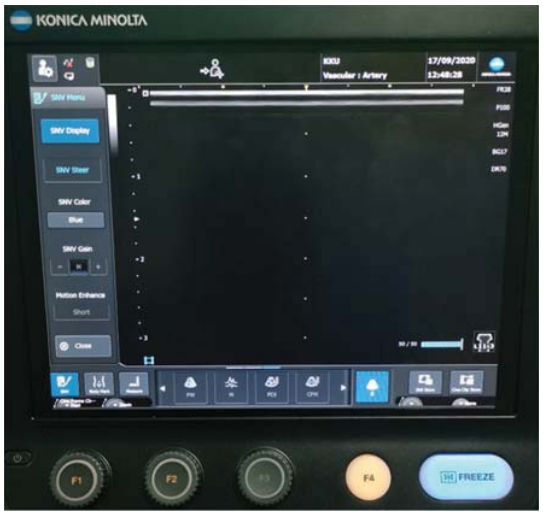

Figure 1. Simple Needle Visualization (SNV) Technology in SONIMAGE MX1.

Medical Services participated in this study. The average age of the participants was 33.09±7.06 years, and 57.14% (n = 28) were male. The average years of work experience of the health care provider practitioners was 8.02 years. Moreover, 65.30% of the participants had previously performed peripheral intravenous access on real patients. The Emergency Medical Services health care providers were categorized into three groups, and the majority of the participants were Emergency Nurse Practitioners, who had had previous ambulance work experience (Table 1).

The success rate for the first-attempts had been 57.14% (95% CI 0.428, 0.715), while the maximum number of attempts to perform this procedure had been recorded at 4 attempts (Table 2). The mean time required to complete the procedure had been 23.34 sec, with a minimum and maximum of 6 seconds and 57 seconds, respectively.

Furthermore, it was found that gender, working experience, experience of performing PIV on real patients, and the categories to which the Emergency Medical Services health care providers belonged had not been the factors, which had been associated with the success rate of the first attempts at USGPIV (Table 3).

Table 1. The characteristics of the participants

Items	Numbers (%)
Age (years), mean ± SD	33.09±7.06
Gender	
Male	28 (57.14)
Work experience (years)	
1 to 5	19 (38.78)
5 to 10	18 (36.73)
>10	12 (24.49)
Experience of performing PIV with real patients	
Yes	32 (65.30)
Categories of emergency medical services health care providers	
Emergency medical technicians (EMT's)	17 (34.69)
Advanced emergency medical technicians (AEMT's)	2 (4.08)
Emergency nurse practitioners (ENP's)	30 (61.22)

Table 2. The numbers of attempts required to complete the procedure (frequency)

Numbers of attempts	Frequency (%)	95% CI
1	28 (57.14)	0.428, 0.715
2	11 (37.93)	0.103, 0.346
3	4 (8.16)	0.002, 0.161
4	6 (12.24)	0.027, 0.218

Regarding the questionnaire survey, the response rate was 100%. In regard to the aspects of the feasibility of the ultrasound machine, the quality of the images, and the feasibility of the SNV technology, most of the participants had rated the experience with a high score of more than 4 points (with 4 being "Satisfied") (Table 4).

When answering the open question, the participants indicated that the obstacles that they had encountered when attempting to perform this procedure while in the ambulance had been as follows: 1) the vibration created by the moving ambulance; 2) the limited area in which to perform the procedure; 3) the insufficient lighting inside of the ambulance; 4) difficult patients, such as agitated patients and pediatric patients; and 5) the EMS personnel's lack of familiarity with using ultrasound equipment.

Discussion

The main primary outcome in this study was to identify the success rate of the first attempt at USGPIV by EMS personnel. Several studies have demonstrated that the rate had been found to range from 50 to 86% of all dispatches[10-12]. However, this study showed that the rate of success for the first attempts had been 57.14%. Among the groups, the success rate had been 100% among the AEMT's, 60% among the ENP's, and 47.06% among the EMT's. For this study, the categories of Emergency Medical Services health care providers were divided following the EMS Thailand[13]. However, these were not the factors, which had been associated with the first attempt success rate of USGPIV. Furthermore, these findings stands in contrast to

Table 3. The factors associated with the 1st attempt success rate

Factors	Odd ratio	*p*-value
Gender: male	1.40	0.56
Work experience (years)		
5 to 10	1.14	0.76
>10	0.72	0.53
Experience in performing PIV with real patients: yes	1.88	0.30
The categories of emergency medical services health care providers	1.88	0.30

Table 4. The mean questionnaire scores for each item (n = 49)

Item	Scores mean	Scores min	Scores max
Feasibility of the ultrasound machine	4	3	5
Quality of the images	4.37	2	5
Feasibility of the SNV mode	4.33	2	5

results from a study by Prottengeier[8], in which it was found that the skill of venous cannulation was well-established among Paramedics. In a study by Duran-Gehring[14], the overall success rate of the attempts performed by ED technicians had been 0.970 (95% CI 0.956, 0.983), which was higher than was found in our study. In our opinion, EMT's had gotten the lowest success rate for first attempts because they had never performed peripheral intravenous access on real patients given that their job descriptions are limited under Thai law, which states that only Advanced Emergency Medical Technicians (AEMT's) and Paramedics are allowed to perform this procedure. The majority of the participants (71.4%), who successfully accomplished USGPIV on the first attempt, had had previous experience in obtaining PIV access on real patients. However, this was not found to be statistically significant. In terms of work experience, most of the participants, who had achieved success on their first attempts at USGPIV had had 1 to 5 years and 5 to 10 years of experience. This was, in fact, consistent with findings from a study by Yalcinil[15], who found that nurses, who had less than 2 years of professional experience, had failed on their first attempt at PIV (OR 3.45, 95% CI 2.00, 5.97, $p<0.001$).

Regarding the 'feasibility of the ultrasound machine', another interesting finding was that the participants had scored all aspects at a "High" level. However, based on the open question, some participants may not have been familiar with the ultrasound machine at first, which may have resulted in them being uncomfortable about performing USGPIV despite the fact that they were knowledgeable about this procedure. Because of this, we do not recommend using USGPIV as a substitute for traditional PIV with novice EMS personnel.

Most of the studies, which have demonstrated the benefits of USGPIV, have been conducted in high-income countries[16-18]. This study, however, was conducted in a low-middle income country. Nonetheless, it was found that, even in this setting, USGPIV is practical and effective. In the near future, it may be used to help EMS personnel in remote areas.

One strength of our research lies in the fact that this has been the first study to demonstrate the effectiveness of USGPIV for EMS personnel. However, this study also has some limitations[19-23]. Firstly, this was a single-center study, which limits the generalizability of the results. Secondly, before and after training, the ultrasound skills of the participants were compared. Therefore, the effectiveness of the USGPIV training from this workshop remains unclear. Thirdly, this study was solely carried out in a simulated environment. As a result, it cannot be considered to represent the true success rate of this procedure when it is carried out with real patients.

Conclusion

In this study, it was revealed that the success rate for the first-attempts at USGPIV had been lower than other studies. This was due to the fact that the participants had been novices to the technique and had also been unfamiliar with the ultrasound machine. However, this simulation represents a first step in implementing this procedure for Thai EMS personnel in order to assist them to perform ultrasound procedures.

What is already known on this topic?

In the past decades, Point of Care Ultrasound (POCUS) has played an important role in many aspects of pre-hospital management. The feasibility of pre-hospital POCUS, changes in patient management induced by POCUS and education of providers. However, the POCUS in pre-hospital care in Thailand is the novice technique for EMS personnel.

What this study adds?

From this study, it was revealed that EMS personnel had been able to perform USGPIV after participating in a short training. Yet, when compared to other studies, the success rate was found to be lower.

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Conflicts of interest

The authors declare no conflict of interest.

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