Longevity and Complication Rates of Ultrasound Guided Versus Traditional Peripheral Intravenous Catheters in a Pediatric Emergency Department

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Abstract

Background: *Ultrasound-guided peripheral intravenous lines are frequently used in patients with difficult access. We have previously reported on the longevity and complication rates of ultrasound-guided peripheral intravenous lines, but there are limited data comparing outcomes of ultrasound-guided peripheral intravenous lines to traditionally placed peripheral intravenous lines in children. The aim of this study was to compare the longevity and complication rates of ultrasound-guided peripheral intravenous lines to traditionally placed intravenous lines in a pediatric population.*

Methods: *This study analyzed 300 ultrasound-guided peripheral intravenous lines and 552 traditionally placed intravenous lines using patient records to determine the reason and timing for intravenous line removal. A* t*-test was used to compare overall mean survival times, and a log-rank test was used to compare Kaplan-Meier survival curves. Complication rates were compared using a chi-squared test.*

Results: *The survival times of ultrasound-guided peripheral intravenous lines (mean = 73 hours, SD = 68 hours) were significantly longer than those of traditionally placed intravenous lines (mean = 38 hours, SD = 29.4 hours),* $t(559) = 8.51$, $P < .0001$. *Kaplan-Meier survival analysis yielded a median ultrasound-guided peripheral intravenous line survival time of 143 hours (IQR = 68-246) and a median traditionally placed intravenous line survival time of 100 hours (IQR = 65-106) with a significant difference between the 2 survival curves by the log-rank test. There was also no significant difference in complication rates between ultrasound-guided peripheral intravenous lines (34.8%) compared to traditionally placed intravenous lines (31.8%),* $x^2(1, N = 517) = 0.465$, $P = .50$.

Conclusions: *Our data suggests that ultrasound-guided peripheral intravenous lines are a viable option for children, including those with a history of difficult access. Survival times were longer for ultrasound-guided peripheral intravenous lines versus traditionally placed intravenous lines, and complication rates of the ultrasound-guided peripheral intravenous lines and traditionally placed intravenous lines were similar.*

Keywords: *ultrasound, intravenous access, pediatrics, emergency care*

Background

Problem Description

A current challenge in emergency departments (EDs) is obtaining peripheral intravenous (IV) access. Placing peripheral IVs with ultrasound guidance has emerged as a way to decrease the number of needlesticks. The placement of peripheral IVs in children is particularly difficult due to decreased patient compliance during placement and the smaller size of veins. Because multiple failed attempts at IV placement can be particularly distressing for children and their parents, a variety of techniques have been used to aid in the visualization of peripheral veins, including local warming of IV site and more advanced technologies such as transillumination, near-infrared lighting, and ultrasound.[1] Some emergency departments have instituted teams of nurses and doctors that are IV specialists to maximize IV insertion success rates.[2]

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Available Knowledge

To determine whether IVs placed with real-time ultrasound visualization leads to fewer failed IV attempts, previous clinical studies have compared success rates of traditionally placed peripheral IVs (TPIVs) to ultrasound-guided peripheral IVs (USGPIVs). In 2012, a randomized controlled trial (RCT) was conducted comparing USGPIVs to TPIVs in children under 3 years of age with difficult venous access. In the study, USGPIVs had a significantly lower median time to cannulation and median number of punctures in addition to a higher success rate at first cannulation.[3] A 2009 study performed a RCT of children under 10 years of age in a pediatric ED who required IV access and had either 2 previous unsuccessful traditional attempts at IV placement or a history of difficult access. The patients were randomized to undergo IV placement by either continued traditional attempts or with live ultrasound visualization. The USGPIVs required less overall time to place, fewer attempts at placement, and fewer needle redirections than TPIVs.[4]

We previously analyzed USGPIV attempts in a pediatric ED to determine the success rate, longevity, and complications of USGPIVs. The complications of USGPIVs were similar to those commonly reported for TPIVs, including unintentional dislodgement, infiltration, occlusion, and phlebitis. In terms of the longevity, the study found that the Kaplan-Meier median survival time of USGPIVs was 143 hours (6 days).[5] Previous studies in adults have shown poor durability of USGPIVs. Some attribute the poor durability to ultrasound assistance allowing cannulation of deeper and smaller vessels; however, there are limited data on the outcomes of USGPIVs directly compared to TPIVs.[6-8]

Rationale and Specific Aims

As demonstrated by previous studies, ultrasound guidance is both an efficient and effective aid for IV placement especially in patients with difficult access. Determining whether USGPIVs have higher complication rates and poorer durability compared to TPIVs will affect the feasibility of using ultrasound in pediatric EDs to place IVs. The specific aim of this study was to directly compare the longevity and complication rates of USGPIVs to TPIVs in a pediatric ED.

Methods

Context and Intervention

The study took place in an urban tertiary-care teaching hospital with a pediatric ED that sees approximately 97,000 patients per year. A high percentage of the patients have chronic illnesses and have issues with IV access. For patients that have had a history of difficult access or had failed IV attempts via the traditional approach, ultrasound is often used to facilitate IV placement.

From August 2013 to April 2014, a formalized training program for USGPIVs took place in the ED for nurses and physicians as part of a hospital-wide difficult access initiative. ED practitioners placing USGPIVs included nurses, pediatric and emergency medicine (EM) residents, pediatric emergency medicine (PEM) fellows, and PEM attendings. The EM residents, PEM fellows, and PEM attendings all completed a rotation in emergency bedside ultrasound before being authorized to place USGPIVs. The nurses and pediatric residents underwent a 4-hour course that had both a didactic component and hands-on training. Any USGPIVs placed during this 4-hour training period were also included in the data set.

Methods and Measures

This study analyzed data from a data set collected as part of an initial quality improvement project and was deemed exempt by the hospital's institutional review board. For each USGPIV placed from August 2013 to April 2014 as part of the training program detailed earlier, the practitioner placing the IV was asked to complete a form documenting why the IV was placed, if traditional IV access was attempted along with the number of TPIV attempts, and the number of USGPIV attempts along with whether or not the USGPIV was successfully placed. The reasons for USGPIV placement included history of difficult IV access, multiple failed TPIV attempts, patient or family request, and teaching purposes. The form included identifying patient information to track the USGPIVs in the electronic health record (EHR). All USGPIVs that were placed by an ED clinician participating in the training program were eligible for inclusion in the study. Two providers (A.E.C., A.M.V.) performed the follow-up in the EHR for all of the USGPIVs that were placed in the study. Removal reason, complications of the IV, and time from IV placement to removal was extracted from the EHR.

The USGPIVs were placed via the dynamic method in the short axis. The provider decided both the placement site and catheter size (gauge and length); options included traditional length 24-, 22-, 20-, or 18-gauge IVs or the longer 45-mm length (22-g) or 48-mm length (20-g) catheters.

The same data was obtained for TPIVs placed during the same time period through the EHR. The EHR was examined for a random selection of patients each month with diagnoses that made them likely to receive an IV during their ED visit. These diagnoses included sickle cell disease, diabetes, febrile neonates, and vomiting/dehydration. Providers had the same options for placement site and catheter size of the TPIVs as they did for the USGPIVs.

Analysis

The statistical analyses performed in this study were performed using Stata version 13.1. The survival times of the USGPIVs and the TPIVs placed were calculated based on the time placed and time removed as documented in the EHR. Overall mean survival times of the USGPIVs and the TPIVs were compared with a *t*-test. A Kaplan-Meier survival analysis was performed censoring for IVs removed because they were no longer needed or had incomplete follow-up records. A log-rank test was used to compare the Kaplan-Meier survival curves. The percentage of IVs removed due to a complication was determined, and a chi-squared test was used to compare the complication rates of the USGPIVs versus TPIVs.

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