

# CONTRAST EXTRAVASATION AS A COMPLICATION OF EMERGENCY NURSE-PERFORMED ULTRASOUND-GUIDED PERIPHERAL INTRAVENOUS CATHETER PLACEMENT



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## Contribution to Emergency Nursing Practice

- The current literature on ultrasound-guided peripheral vascular access techniques indicates that this skill is being adopted into emergency nursing practice, but little is known regarding the rate of contrast extravasation (CE) for this procedure as it pertains to emergency nursing practice.
- This article contributes research findings that ultrasound-guided peripheral intravenous (USGPIV) catheter placement has a similar CE rate when performed by emergency nurses and emergency physicians.
- The key implication for emergency nursing practice found in this article is that USGPIV catheter placement can be performed safely by emergency nurses who have appropriate training.

## Abstract

**Introduction:** Vascular access procedures are among the most commonly performed procedures in the emergency department. The objective of the current study was to compare the contrast extravasation rate for ultrasound-guided peripheral

intravenous (USGPIV) catheter placement by emergency nurses with peripheral intravenous catheters placed by standard landmark techniques.

**Methods:** A retrospective chart review of all ED patients at our urban tertiary-care institution who underwent contrasted computed tomography examination and suffered contrast extravasation events was performed. A logbook of all ED patients who underwent USGPIV placement and an institution-wide electronic patient safety incident-reporting system was reviewed for all contrast extravasation events between May 2014, and February 2017. Data were analyzed using descriptive statistics, Student *t*-tests for continuous data, and  $\chi^2$  or Fisher's exact test for categorical data.

**Results:** One thousand five hundred USGPIV catheters were placed by 27 emergency nurses. Contrast material was administered 29,508 times, and, of these, 291 were administered via USGPIV placement. There were 74 peripheral IV lines with documented contrast extravasations (0.25%) as reported in the safety-event database; 12 (4.1%) were from the USGPIV population, and 62 (0.21%) occurred in the standard landmark technique population. Relative risk of contrast extravasation events with USGPIV placement was 19.4 (95% confidence interval [CI], 10.6-35.6), and the absolute risk difference was 3.9% (95% CI 1.6%-6.2%).

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**Discussion:** USGPIV placement by trained emergency nurses has higher rates of contrast extravasation than with standard landmark technique placement.

**Key words:** Contrast extravasation; Procedure; Safety; Ultrasound; Vascular access

## Introduction

Vascular-access procedures are among the most commonly performed procedures in the emergency department. Previously identified risk factors for difficult vascular access (DVA) include diabetes mellitus (DM), intravenous drug abuse (IVDA), sickle cell disease (SCD), obesity, and clinical assessment of peripheral vein accessibility by experts.<sup>1,2</sup> Very often, when peripheral vascular access cannot be obtained by ED technicians or nursing staff, physicians are called upon to obtain intravenous access. Ultrasound (US) has become a commonly used tool to assist emergency physicians (EPs) placing PIV catheters. Given the frequency with which patients with DVA are encountered, many emergency departments have developed programs to train emergency nurses and technicians in point-of-care ultrasound (POCUS)-assisted PIV-access procedures.<sup>3</sup>

Although US-guided PIV (USGPIV) catheter insertions have led to reductions in central venous catheter (CVC) placements,<sup>4</sup> they are not without risk. Among the risks associated with USGPIV insertion are increased rates of contrast extravasation (CE) in patients undergoing contrast-enhanced computed tomography (CT) studies, with rates approximately 10 times that of patients undergoing standard PIV catheter placement (3.6% vs 0.3%).<sup>5</sup> Potential explanations for this phenomenon include poor vessel integrity; increased depth of target vein (often related to obesity); and inadequate length of the PIV catheter, given the depth of the vessels that are used.<sup>6</sup> To our knowledge, no study of CE using nurse-placed USGPIV catheters has been performed. The objective of the current study was to describe the CE rate for USGPIV placement by trained emergency nurses and to identify vessel or patient characteristics associated with a greater likelihood of CE events occurring with USGPIV placement.

## Methods

### STUDY DESIGN AND SETTING

This was a secondary analysis of institutional data. We performed a retrospective chart review of all ED patients at our urban tertiary-care institution (approximately 50,000 visits annually) who underwent contrasted CT examination and suffered CE events. This study was submitted to, and received an exemption by, the Institutional Review Board.

### DATA SOURCE

The data source was the online reporting system (MIDAS) that is used to document all patient safety events including CE. All patients who undergo USGPIV catheter placement by nursing staff are entered into a logbook that is maintained by nursing leadership for training and quality-assurance purposes. The institution has an online reporting system that is used to document all patient-safety events (MIDAS) including CE. When a CE occurs, a CT technician in the department of radiology is responsible for reporting the event. We queried our electronic patient-safety incident-reporting system for all CE events between May 2014, and February 2017. We developed a data-collection tool for the study, and study team members, who were blinded to the study hypothesis, were trained in data-abstraction techniques from both the incident-reporting system and the USGPIV logbook. Patients identified as having CE events subsequently had their electronic medical records reviewed for demographic data and other characteristics relating to PIV catheter placement and DVA.

### EMERGENCY NURSE USGPIV INSERTION TRAINING

Since 2014, the emergency department has had a nursing-led program, training emergency nurses in USGPIV insertion. The program was conceived and managed by 2 members of the study team (A.K. and R.W.). Emergency nurses interested in participating in the program attended a 60-minute didactic session and a 60-minute hands-on practical session, where they practice the technique on the Branched 4 Vessel Ultrasound Training Block Model (CAE Healthcare, Sarasota, FL). Upon completion of this training program, emergency nurses were required to complete 10 supervised USGPIV procedures on ED patients. Supervision was performed by 1 of the program managers (A.K., R.W.), 1 of the designated program super-users, or any EP credentialed in the USGPIV procedure. A super-user was defined as any emergency nurse who had performed at least 100 USGPIV procedures. Each supervised USGPIV procedure required a checklist to be completed by the supervising nurse or EP. Once the trainee RN had completed all 10 supervised USGPIV insertions and submitted the appropriate documentation (the 10 signed checklists) to the program managers, they were then able to begin performing USGPIV procedures independently in the emergency department.

## DATA ANALYSIS

Data were analyzed using descriptive statistics, Student *t*-test for continuous data, and Fisher's exact test for categorical data, when appropriate. Analysis was conducted using RStudio (Integrated Development for RStudio, Inc, Boston, MA, version 1.1.383). Regression analysis to identify potential predictors of CE events in the USGPV procedure group was not performed, given the low number of outcome events in this group.

## Results

### MAIN FINDINGS: CE RATE FOR NURSE PLACEMENT OF USGPV CATHETERS

During the 33-month study period, 1,500 USGPV catheters were placed by 27 emergency nurses. Contrast material was administered 29,508 times, and 291 of them were administered via USGPVs. There were 74 peripheral IV lines placed by emergency nurses with documented cases of CEs (0.25%), as reported in MIDAS, of which 12 (4.1%) were from the USGPV population and 62 (0.21%) from the SIV population. Relative risk of CE events with USGPV was 19.4 (95% CI, 10.6-35.6), and the absolute risk difference was 3.9% (95% CI, 1.6%-6.2%) (Table).

### OTHER FINDINGS: FACTORS ASSOCIATED WITH CE EVENTS

There were no significant differences in mean body mass index (BMI) or age between the USGPV and SIV groups (BMI 29.31 vs 29.52,  $t = 0.09$ ,  $P = 0.93$  and 51.92 vs 59.97 years,  $t = 1.62$ ,  $P = 0.11$ , respectively). Of the reported CEs, 72.98% occurred in female patients, 75% ( $n = 9$ ) in the USGPV group, and 67% ( $n = 42$ ) in the SIV group ( $P = 0.74$  for the difference). There was no significant difference in proportion of CT angiograms between the USGPV and SIV groups: 67% ( $n = 48$ ) of total CEs, 6 in USGPV group, and 42 in standard IV group,  $P = 0.32$  for the difference. The proportion of patients with end-stage renal disease (ESRD) was also similar in both groups: USGPV 16% ( $n = 2$ ) vs 17% ( $n = 11$ ),  $P = 1.0$ .

More patients in the USGPV group had histories of IVDA ( $n = 2$ , 16%) compared with the SIV group ( $n = 0$ , 0%),  $P = 0.02$ . In the USGPV group, there were 6 IV lines in forearms, 5 in upper arms, and 1 in antecubital fossa (AC) compared with 24 forearms, 5 upper arms, 28 AC, 4 wrists/hands, and 1 shoulder in the SIV group.

For locations of IV lines in both groups, overall comparison of proportions of IV line by site was statistically significant ( $P = 0.003$ ); however, after using the Holm adjustment for multiple comparisons, no significant differences were found in pairwise proportions. In the USGPV group, there were 5 18-g and 7 20-g IV lines compared with 49 20-g, 5 18-g, 7 22-g, and 1 24-g IV lines; the difference between proportions of 18-g and 20-g IV lines was significant ( $P = 0.013$ ); 22-g and 24-g IV lines were excluded from this analysis.

## Discussion

This study is the first of its kind, to our knowledge, to describe CE rates in an ED population undergoing USGPV placement by emergency nurses. The unique nature of our data-collection methods (using the logbook that all emergency nurse-placed USGPV catheters are entered into, as well as the hospital's safety incident-reporting system, which tracks all CE events) allowed us to capture a comprehensive representation of CE events in the emergency department. The overall rate of CE for our study population (both USGPV and standard PIV cannulation) is similar to previous studies<sup>5,7</sup> and thus helps to improve the generalizability of our findings, given the single-center study that we conducted.

Among the more unexpected findings in our study was the failure to detect patient- or vessel-related features that identified patients at higher risk for suffering CE events, such as obesity and ESRD. Typically, obesity results in USGPV catheters being inserted into vessels that are at increased depth from the skin surface, which would be expected to confer a greater risk of CE, given that less of the catheter is actually inside the vessel and is, instead, residing in the soft tissue. Previous research, consisting of secondary analysis of a prospectively gathered USGPV database, has indicated that vessel depth is inversely associated with catheter survivability.<sup>8</sup> However, we did not find a significant difference in rates of CE for USGPV insertions based on location; this could be due to small sample size or absence of true between-site differences. Although the small number of CE events in the USGPV group precludes definitive conclusions, future studies in this domain should perform analyses of CE rates for USGPV insertions that are placed into vessels at varying target depths (with the depth prospectively recorded at the time of catheter insertion) to explore this interesting finding further.

An additional finding worth mentioning is that the rate of CE for emergency nurse-placed USGPV catheters in our

TABLE

**Contrast extravasation and intravenous characteristics of ultrasound and standard groups**

	Total (%)	USGIV (%)	SIV (%)		Relative risk* (CI)	Absolute risk* (CI)
Contrast extra-vasation events	74 (0.25)	12 (4.1)	62 (0.21)		19.4 % (10.6-35.6)	3.9% (1.6-6.2)
IV location		USGIV	SIV	Difference <sup>‡</sup>		
Antecubital fossa		1	28	NS		
Forearm		6	24	NS		
Upper arm		5	5	NS		
Wrist/hand <sup>†</sup>		0	4	–		
Shoulder <sup>†</sup>		0	1	–		
IV gauge		USGIV	SIV	Difference		
18		5	5	NS		
20		7	49	NS		
22 <sup>†</sup>		0	7	–		
24 <sup>†</sup>		0	1	–		

CI, confidence interval 95%; NS, not significant; SIV, IV placed using landmark technique; USGIV, ultrasound-guided IV

\* Referent is SIV group

<sup>†</sup> Excluded from between-group analysis

<sup>‡</sup> Pairwise comparisons using Holm adjustment for multiple comparisons

study is similar to that for EP-performed USGPIV placements in the current literature. A study design similar to our own has shown that the USGPIV CE rate, when placed by EPs, was 3.6%,<sup>5</sup> compared with 4.1% in the current study. Future investigations into USGPIV insertion may wish to use a study design in which patients would be randomized to undergo either emergency nurse-placed or EP-placed USGPIV catheters.

### Limitations

The major limitation of the current study is the small number of CE events in the USGPIV group, limiting the ability to explore the effect of patient and IV characteristics on CE risk; 12 CE events were believed to be too few to perform a meaningful logistic regression to identify predictor adverse outcomes. Larger multicenter registries are needed to further explore these relationships. Other limitations include lack of data relating to operator experience, the lack of data regarding depth of target vessel (as mentioned above), and the lack of outcome data related to the CE events. Although the relative risk of CE was significantly higher in the USGPIV group, the absolute risk was much smaller, given the low incidence of these events, and it could very well be true that the USGPIV CE outcomes were less hazardous to patients who suffered them compared with CE outcomes that occurred in the SIV patients. This important patient-

related outcome should be the outcome of interest in future studies in this area.

### Implications for Emergency Nurses

The results of this study should assuage concerns relating to the safety of emergency nurse-placed USGPIV catheters as it pertains to the likelihood of CE. Once an adequate training program has been established, the likelihood of CE for any given USGPIV catheter placed by an appropriately trained emergency nurse is likely to be more strongly tied to patient-related factors rather than operator factors. More proximal upper-extremity veins (ie, basilic and brachial veins) are known to have higher rates of CE, and attempts should be made to encourage placement of USGPIV catheters into the more distal forearm veins.

### Conclusions

USGPIV catheter placement by trained emergency nurses were found to have CE rate of 4.1%, a number that is comparable with USGPIV placement by EPs (3.6%). Incidence of CEs was not affected by target vessel locations or patient characteristics, but the study may have been insufficiently powered to detect such differences. It would be wise to collect vessel depth, operator characteristics, and patient-

related data prospectively for future studies in this area to draw more definitive conclusions.

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Study conception and design: Favot, Gallien, Ehrman; acquisition of data: Malik, Kasten, Wells, and Ehrman; analysis and interpretation of data: Favot, Gallien, Malik, and Ehrman; drafting of manuscript: Favot and Malik; and critical revision of manuscript: Ehrman.

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