Successful trauma resuscitation at any trauma center requires central, peripheral, or intraosseous catheterization. Peripheral intravenous (PIV) catheterization poses a low risk of complications in almost all patients; however, trauma patients often encounter emergency medical service (EMS) providers in environments or circumstances that necessitate immediate intravenous access and are not always aseptic. Thus, for trauma patients, a prehospital PIV catheter can occasionally lead to significant complications.

PROBLEM DESCRIPTION
Within a period of 5 months, seven of 870 Level I trauma patients were identified with PIV complications during discussion in morning report. Medical record review revealed that these PIV sites appeared to have been started prior to the patient’s hospital arrival. Owing to documentation practices required by our trauma center’s policy, determining when an intravenous catheter was changed after the patient arrived to the emergency department (ED) was difficult. The nursing policy required an intravenous site assessment every shift, and when an intravenous catheter was started in the prehospital setting, it was to be removed within 24 hr. Complexity with the electronic medical record layout was challenging to nursing compliance with documentation, making it difficult to determine when a prehospital PIV catheter was discontinued and which site was utilized for medication administration.

In the hospital nursing orientation education and training program, little emphasis was placed on PIV documentation and adherence to the policy requiring a new site for prehospital PIV within 24 hr of admission. The lack of consistent documentation and development of complications led to the initiation of a quality improvement (QI) project to address these issues.

SETTING
Our Level I academic trauma center is located in a major medical center and admits approximately 7,000 adult burn and pediatric patients annually. The trauma service line of care includes a progressive ED, shock trauma intensive care unit (ICU), and intermediate care unit, a verified burn center, geriatric trauma, and orthopedic trauma units. One of two helicopter services in the area is affiliated with the trauma center and serves a 150-mile radius. Multiple ground EMS agencies provide transportation to the facility from

ABSTRACT
Peripheral intravenous (PIV) catheterization is commonly performed, and its complications are costly, may result in serious health issues, and may adversely affect patient satisfaction. At our large urban Level I trauma center, we identified a cluster of 7 PIV complications from prehospital insertions in a 5-month period. Several of the patients developed noninfectious as well as infectious, limb-threatening complications requiring aggressive operative intervention. A performance improvement project was chartered to identify the cause of PIV complications and review current nursing practice. The FOCUS-Plan Do Check Act methodology was used to measure and improve practice. With implementation of interventions and outcomes monitoring, no PIV complications were reported for the subsequent 39 consecutive months. Our findings have implications for more controlled studies to establish best practice at other Level I trauma centers across the country.

Key Words
Peripheral venous catheterization, Prehospital emergency care, Quality improvement

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various surrounding communities. At our center, motor vehicle crashes are a major category of trauma care provided, second only to patient falls. Assumptions were that prehospital PIV catheters started in a rapid and time-dependent environment were nearly impossible to start aseptically.

**RATIONALE**

Peripheral intravenous complications are costly, may result in serious health issues including operative excision of infected veins and soft tissue as well as increased length of stay, and may adversely affect patient satisfaction. Because of the critical nature of complications resulting in pain, surgical intervention, increased cost, and negative patient experience, this QI project was initiated to address prehospital PIV site documentation, compliance with our policy changing prehospital sites in the ED or upon arrival in the trauma unit, and ongoing site assessment documentation.

**AVAILABLE KNOWLEDGE**

As a result of our concerns and subsequent plans to initiate a QI project, a literature review was completed. Using the electronic databases CINAHL, Ovid, and MEDLINE including the search terms “peripheral venous catheterization,” “prehospital emergency care,” and “quality improvement,” the terms were combined using the Boolean operators “OR” and “AND,” yielding a total of 11 articles published from 1988 to 2015. Our goal was to identify research studies or QI articles discussing the care and prevention of complications from prehospital PIV sites; however, current literature was limited. We found that most hospitals have a policy to change PIV sites every 72–96 hr as recommended by the Centers for Disease Control and Prevention (CDC, 2011). The CDC recommends that intravenous catheters placed in emergency situations to be replaced within 48 hr, but intravenous catheters placed in circumstances where an aseptic technique cannot be provided should be changed “as soon as possible and after no longer than 48 hr” (CDC, 2011).

The literature yields little evidence supporting changing PIV catheters before 72 hr on patients having them inserted while on the trauma scene, nor was there evidence that complications were significantly discipline-related. In a study by Zarate, Mandleco, Wilshaw, and Raver (2008), the phlebitis rate in patients whose PIV catheters were started by an RN in the ED was 2.9% whereas the rates for those started by an intermediate emergency medical technician or paramedic in the prehospital setting were 6.09% and 7.78%, respectively. Nonetheless, the results in this study were not shown to be significant in chi-square analysis (Zarate et al., 2008). To prevent phlebitis and comply with best practice recommendations, many ICUs remove PIV catheters started in the prehospital setting within 24 hr (Zarate et al., 2008).

Lawrence and Lauro (1988) compared PIV complication outcomes between those started within the ED and those initiated prehospital. Although the authors’ results supported changing the PIV catheters upon hospital admission, the study had limitations. One such limitation was the inconsistencies of EMS provider practices. More research is necessary to identify the aspects of the prehospital care setting that increase the risk of complications from field PIV catheterizations in trauma patients (Lawrence & Lauro, 1988).

A QI study by Shreve and Knotts (1999) resulted in a decision tree that suggested restarting a field PIV catheter within 24 hr of admission if the patient had three or more risk factors for complication or was admitted to the ICU. If the patient had fewer than three risk factors or an expected short duration of hospitalization, the site was not changed (Shreve & Knotts, 1999). Findings from a study by Levine et al. (1995) revealed a very low infection rate of 0.12% in noncritical patients who were admitted with PIV catheters started prior to hospital arrival. However, patients admitted to the ICU were excluded from that study, as the hospital policy was to remove PIV catheters once patients arrived in the ICU (Levine et al., 1995).

**MEDICOLEGAL–ETHICAL CONSIDERATIONS**

Clemen et al. (2012) suggested that institutions and textbook resources will continue to have variation in reports of PIV complications until there is sufficient evidence. Until strong evidence is available, hospitals must take into consideration the medicolegal implications of the potential risk of complications and the cost of subsequent lawsuits that far exceed the cost of supplies to change PIV catheter sites and additional patient discomfort (Zarate et al., 2008). The University of Texas institutional review board (IRB) has issued guidance for investigators to determine whether their project is QI. This project is considered QI per HHS Guidelines, and UT Health IRB does not require submission for QI projects to the IRB for review and approval.

**METHODS**

The FOCUS-Plan Do Check Act (PDCA) methodology used for achieving a desirable outcome was chosen as the systematic approach for the QI project (Bader, Palmer, Stalcup, & Shaver, 2005). The components of methodology outlined by Bader et al. (2003) are as follows: (1) Find the process to improve; (2) organize a team that knows the process; (3) clarify what is known or the current process; (4) understand variation; (5) select process improvement interventions; (6) plan and do the interventions; and (7) check the results and act on further issues identified.

Following the FOCUS approach, we began by finding the process to improve: the management of prehospital PIV catheters in trauma patients. We organized a multidisciplinary team of the ED staff and representatives.
from each of the trauma service line units (shock trauma ICU, burn ICU, surgical intermediate care unit, orthopedic trauma unit, and geriatric trauma unit). The team reviewed the trauma center’s current policy and procedures to clarify the existing expectations in the management of a prehospital PIV site.

To understand any variation in practice, a thorough event analysis of each of the seven documented complications was completed (Table 1). The team members reviewed the cases extensively and convened to discuss variations in practice as evidenced in the case reviews. Because of limited vascular access, many of these PIV catheters were in longer than the CDC recommendation of 72–96 hr, making it difficult to attribute the complication due to prehospital insertion over dwell time. Two root causes of complications were revealed: (1) inconsistent, noncompliant documentation of PIV sites, and (2) a failure to change prehospital PIV sites upon arrival or within 24 hr of admission to the ED as stated in our current policy.

In selecting process improvement interventions, the team determined that reeducation of the existing policy was necessary. One cause of variation was the difficulty in evaluating compliance owing to the lack of documentation of when sites were changed and assessed. Second, no procedure was in place for identifying prehospital PIV catheter once the patient was transferred to the next level of care. Finally, in the event caustic medication was administered, the electronic medical record lacked a field for documenting the actual site that was used, which rendered the evaluation of any complication incomplete.

The team discussed additional variations that may exist across the service area that may preclude the standardization of prehospital PIV site management. Owing to the substantial number of EMS companies that transport patients to our trauma center (>60), the team felt it unreasonable to expect standard, aseptic site preparation by EMS providers, given the prehospital difficulties inherent in major trauma cases.

**Plan**

In the first PDCA cycle of our improvement model, we made a plan for improvement and implemented our strategies. Because of the current issues we experienced with prehospital PIV complications, trauma leadership decided to leave the policy as it was. Their recommendation was to add an emphasis on changing the site “as soon as possible” upon arrival to the hospital, and with education to include upon the arrival to the next level of care in the event it was not changed in the ED.

**Do**

The action items outlined in the plan were to be completed as follows:

1. To reach all existing staff members, education was implemented in all trauma service line units during shift huddles. Education included an overview of the complications discovered, a review of the current policy and procedure, nursing documentation requirements including the reason a prehospital site was not changed, and a discussion of the importance of communicating the prehospital PIV status at the time of nursing handoff to another area. Posters were hung in each unit’s lounge areas that included bullet points of policy requirements. Documents explaining all these requirements were added to the new employee orientation packets for all trauma units. This information was discussed with the Unit Preceptor in each area’s new employee orientation.

2. During handoff communication at the time the patient was transferred from the ED to the receiving

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<th>Table 1</th>
<th>Outcomes of Event Analysis</th>
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<tr>
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<td>Oct 2012</td>
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Note. LAC = left antecubital; LFA = left forearm; LUE = left upper extremity; PIV = peripheral intravenous; RAC = right antecubital; RUE = right upper extremity.
unit, nurses from both parties discussed the need to change the site according to the current policy and procedure.

3. Because caustic medications could result in PIV site complications and the site used to administer these medications was not currently being documented, we submitted an improvement recommendation to our Information Systems Department for a design adjustment to the electronic medical record. We requested that the electronic medical record include a drop-down box that listed each of the current intravenous sites, thus allowing the nurse to indicate which site was used during all intravenous medication administration.

4. Four weeks after implementing our strategies, evaluation of effectiveness would be completed via manual, retrospective review of the electronic medical records. The team chose initial monthly monitoring to assess (1) compliance with required documentation of the site change and (2) the number of prehospital PIV-related complications. During that time if a complication was identified, an event analysis would be completed to determine the root cause of the new complication. A paper data collection tool was designed to align with our identified measures, and the trauma performance improvement project manager and designees would collect the data from the electronic medical records. The team decided that 10 randomly selected patients per week for each of the six units would be a monthly total of 240 audits. This would exceed the recommendation our population size according to The Joint Commission (2016). The team of reviewers was identified as RNs on the unit who had instruction on and experience in data collection from our electronic medical record. As deficiencies were identified, the medical records would be reevaluated by a second individual in that particular unit for validation. The team discussed the need to establish a defined target initially and decided that zero complications and 90% or more compliance with documentation were appropriate goals.

5. Quantitative methodology would be used to draw conclusions from the data collected.

RESULTS

Check
Knowing the importance of baseline data to measure improvement, a graph was created to represent the trend of complications as well as the point at which our initial intervention of reeducation was provided (Figure 1). After this initial intervention, the “C,” or “check,” step of the PDCA cycle revealed that 84% of prehospital PIV insertions were changed according to the policy. There was no documentation in the medical record noting the reason for not changing the other 16% of sites.

Act
During the “A,” or “Act,” step, the team met to discuss the results of the current data and recommended the addition of a new intervention. In major trauma patients, the ED staff were to place a red sticker on any PIV site started in the field that could not be changed in the ED. The sticker included documentation of the date and time the prehospital PIV catheter was inserted and the initials of the ED staff member who acknowledged the prehospital

Figure 1. Baseline data.
PIV start. This sticker was a visual reminder to the staff in other trauma service line units that the site needed to be changed as soon as possible or upon arrival to the next level of care (Figure 2).

With the use of the PDCA methodology, variation was anticipated to decrease as each PDCA cycle of additional actions was implemented. After implementation of the red sticker, 1,680 charts were randomly reviewed over the next 6 months and documentation compliance improved from 62% to 95%. This included a total of 240 charts each month × 2, every other month × 2, and quarterly × 3 at which time greater than 90% compliance indicated sustainment at our identified goal. Upon implementation of the red sticker and improved documentation, no further complications from prehospital PIV sites occurred, thus eliminating the need for further actions.

To update the trauma staff, we prepared a monthly graphic report emphasizing the correlation of our interventions to the outcomes. Monthly updates of the findings were shared in all multidisciplinary trauma service line committee meetings and unit staff meetings. Posters describing the improved results were placed in prominent locations in the various trauma units. Since the full implementation of our interventions and improved compliance, we have identified no further complications or need for additional PDCA cycles (Figure 3).

DISCUSSION

Summary

By utilizing our established morbidity and mortality performance improvement process, we rapidly identified a trend in prehospital PIV complications and were able to use the FOCUS-PDCA methodology to initiate interventions to ensure policy compliance, thereby eliminating further complications in our trauma patients. A primary strength of this project was the use of a systematic QI methodology for rapid-cycle improvement and sustainment. A secondary strength was the inclusion of the frontline staff on the project team who could help identify barriers to compliance and develop interventions to immediately get results. Because of our success in reducing complications, our

Figure 2. Red sticker to identify prehospital peripheral intravenous insertions.

Figure 3. Postimplementation data. PIV = peripheral intravenous.

Post-intervention: Correlation of number of complications to compliance with site change
practice continues to include these interventions shown to be best practice in our Level I trauma center.

The impact of the current project on the nursing staff included the additional evaluation of prehospital PIV sites and the task of changing them as soon as possible in the ED or upon the patient arrival to the next level of care. Patients with a prehospital PIV may experience pain, inconvenience, and the dissatisfaction of having it replaced and would incur additional cost for supplies and staff time. However, neglecting to change the PIV catheter can lead to serious complications that not only elicit the aforementioned concerns but also significantly affect health care costs related to extended hospitalization secondary to medical or surgical treatment.

Limitations
Ideally, a comparable control group would allow direct comparisons with and without the intervention, thereby rendering the project more rigorous and the findings more reliable. However, because the interventions were implemented for all patients simultaneously, no comparison group was available. We were not able to obtain the complication rate for all PIV catheters within the trauma population. A lack of knowledge of various EMS protocols for intravenous insertions was also a limitation of this convenience sample.

CONCLUSIONS
On the basis of the findings from our improvement project, a couple of recommendations for trauma centers were identified in consideration for best practice. Centers should explore challenges the electronic medical record could potentially pose to nursing documentation compliance. The chaotic environment in Level I trauma centers also demands tight controls for adequate handoff communication for patient safety. This QI project was beneficial at our organization via the implementation of new strategies to eliminate complications from prehospital PIV sites in major trauma patients. Pending further study results, this project may have the potential to be implemented at other trauma centers. The next steps for our organization include random data collection to evaluate compliance sustainability with site changes and documentation requirements as well as a concurrent review of red sticker use when appropriate.

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KEY POINTS
- Peripheral intravenous complications from prehospital catheters in trauma patients pose high risk for medicolegal implications, increase cost and hospital length of stay, and negatively impact patient satisfaction.
- With the use of a systematic approach to QI, practice evaluation along with added interventions can prevent prehospital PIV complications in Level I trauma centers.

REFERENCES