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CLINICAL PHARMACY RESEARCH REPORT

Implications of the presence of an emergency medicine pharmacist during critical care trauma patient resuscitation

Lynn Lamkin Pharm.D.[1] | Savannah Lindsey Pharm.D.[1] | Kyle Weant Pharm.D., FCCP[2] | Hugh Shoff M.D.[3] | Christina Pinkston M.S.[4]

[1]Department of Pharmacy, University of Louisville Hospital, Louisville, Kentucky

[2]Department of Pharmacy, Medical University of South Carolina, Charleston, South Carolina

[3]University of Louisville School of Medicine, Department of Emergency Medicine, Louisville, Kentucky

[4]School of Public Health and Information Sciences, University of Louisville, Louisville, Kentucky

Correspondence
Lynn Lamkin, Department of Pharmacy, University of Louisville Hospital, 530 S. Jackson Street, Louisville, KY 401202.
Email: lynnla@ulh.org

Purpose: The available literature has shown that the presence of an Emergency Medicine Pharmacist (EMP) is associated with decreased time to medication procurement, a reduction in medication errors, and overall cost avoidance. However, there is limited literature that systematically evaluates the impact of EMPs in the treatment of critically ill trauma patients presenting to the emergency department (ED).

Methods: This study was a retrospective chart review evaluating 1082 adult patients presenting to the critical care area (CCA) of the ED at the University of Louisville Hospital in Louisville, Kentucky for trauma evaluation from July 2014 to December 2014. The study group consisted of patients presenting to the CCA when an EMP was present. Primary outcomes included time to administration of antibiotics, analgesia medication, sedation medication, rapid sequence intubation (RSI), and anticoagulation reversal. Secondary outcomes included time to administration of appropriate antibiotics at an appropriate dose and vaccination administration.

Results: The presence of an EMP was associated with a statistically significant decreased median time from triage to the administration of an analgesic medication (11 minutes [interquartile range (IQR) 8-27] vs 13 minutes [IQR 8.5-20], $P = 0.04$). There was no statistically significant difference in triage time to antibiotic administration, RSI, sedation medication administration, or anticoagulation reversal. Patients in the EMP group were more likely to receive appropriate empiric antibiotics compared with the control group (80.7% vs 52.2%, $P = 0.01$).

Conclusion: The presence of an EMP was associated with decreased time to analgesia medication administration as well as an increased likelihood of the administration of appropriate empiric antibiotics in critically ill trauma patients.

KEYWORDS

pharmacist, resuscitation, trauma

1 | INTRODUCTION

The first descriptions of clinical pharmacy services in the emergency department (ED) occurred in the 1970s with a primary focus on medication distribution.[1] The role of the emergency medicine pharmacist (EMP) has since expanded to involve a variety of services, including direct patient care rounds, medication order review, medication therapy monitoring, and management of high-risk medications as well as participating in procedures, antimicrobial stewardship, medication information, medication procurement and preparation, and resuscitation.[1–17]

The EMP plays a critical role in the care of patients presenting with multiple acute disease states, as demonstrated by the current literature.[2–17] Pharmacists have been shown to decrease the time to percutaneous coronary intervention (PCI) for patients presenting with acute ST elevation myocardial infarction (STEMI), decrease the time to sedation and analgesia following rapid sequence intubation (RSI), facilitate the procurement of health care-associated appropriate antibiotic therapy, and reduce medication discrepancies and errors through medication reconciliation in the ED.

While much evidence exists detailing the impact of EMPs on patient outcomes and cost-avoidance, there is a dearth of studies that

have specifically evaluated their impact on the care of critically ill trauma patients presenting to the ED.[18,19] The purpose of this study was to identify the impact on patient care of the presence of an EMP during a critical care trauma patient resuscitation.

2 | METHODS

2.1 | Setting and patient population

This study was conducted at the University of Louisville Hospital (ULH) ED, a university-affiliated, level one trauma center in Louisville, Kentucky with 38 beds and a four-bed critical care area (CCA) that has approximately 60 000 patient visits per year. In 2014, 5640 patients were admitted directly to the CCA for various indications, including trauma, stroke, cardiac arrest, septic shock, and any other medical condition requiring immediate physician care.

The ED at ULH has had emergency medicine clinical pharmacy specialist services available and physically present in the ED since 2007. These services were expanded in November 2012 to include a total of three full-time EMPs, each with 5 or more years of clinical emergency medicine pharmacy practice experience. The ED is staffed by one of these pharmacists from 0800 to 2200 on weekdays, with every other weekend ED coverage. When the EMP is not present in the ED, pharmacy services to the ED are provided remotely by the inpatient staff pharmacists. Protocols for renal and pharmacokinetic dosing are available and utilized by inpatient staff pharmacists, however, no specific trauma protocols exist for the ED. Pharmacists and nurses in the ED have access to commonly prescribed oral and intravenous medications through the use of automated dispensing cabinets. The services provided by the pharmacists in the ED include drug order entry, dispensing and preparation (via nonsterile clean preparation for immediate use), pharmacokinetic services, drug information services, medication counseling, physician and nursing in-services, and participation in acute patient resuscitations.

The CCA at ULH is a form of quick triage for critical care patients that includes the assessment of an emergency medicine attending physician who makes a decision whether to keep the patient in the CCA or move them to a lower acuity bed in the ED. Patients are brought to the CCA through either direct access from emergency medical services (EMS) or after presenting via private vehicle and are deemed appropriate by a triage nurse. Patients that are kept in the CCA can include, but are not limited to, trauma patients with significant mechanism (eg, hypotensive, death at the scene, and loss of consciousness) or medical patients that are hemodynamically unstable due to respiratory or cardiovascular issues or recent acute stroke symptom onset. Once the decision is made to keep a patient in the CCA, all orders are given verbally by the ED physician and documented on a paper chart by a nurse. The CCA is run as a large interdisciplinary team with an attending physician, one upper level and one lower level medical resident, medical students if on rotation, two nurses (one assigned to procedures and one assigned to documentation), a pharmacist if during EMP designated hours, a radiology technician, a respiratory therapist, a nursing technician, a phlebotomist, and chaplain services among others.

2.2 | Study design

This study was a single-centered, retrospective, cohort chart review of patients presenting to the CCA with a primary diagnosis of trauma. Patients older than 18 years of age presenting to the CCA between July 2014 and December 2014 were evaluated. Patients that were pregnant or incarcerated were excluded from the analysis. Patients presenting to the CCA on weekends and holidays were also excluded due to inconsistent clinical pharmacy services during those times.

The study group consisted of patients who were triaged to the CCA during the time EMP services were consistently available (0800-2159 Monday to Friday). Patients triaged outside of this study period (2200-0759 Monday to Friday) were included in the control group. Pharmacy services during periods when an EMP was not present were provided by pharmacists reviewing medication orders remotely in the hospital's central pharmacy. These services consisted mainly of standard pharmacokinetic and dose adjustment protocols as well as phone consultations by the emergency medicine physicians and nurses on an as needed basis.

2.3 | Data collection and analysis

Investigators utilized the CCA documentation log to identify patients for inclusion in the study. Data collected from this log included the patient identification number and triage time. Further data were obtained from the electronic medical record (EMR) and the pharmacist clinical surveillance system. Nursing documentation during acute resuscitation in the CCA was recorded on paper and later scanned into the EMR. This included diagnosis, vital signs, nursing notes, and a complete record of interventions performed such as procedures (eg, intubation, chest tubes), medications administered, and medication administration times. The CCA paper documentation did not include documentation of pharmacist interventions such as recommendations in medication and dosing changes as all orders in the CCA are verbal physician orders. Data collected from the EMR included demographic data such as age, sex, and race; antibiotic regimen and time of first antibiotic dose; RSI induction agents, time of first RSI medication dose, and time to first dose of sedative medication or start of sedative medication continuous infusion; time of first dose of an analgesic medication; time of first dose of a sedative medication in the absence of RSI; time to administration of an anticoagulant reversal agent and the time to restoration of normal laboratory values; time to tetanus vaccine administration; documentation of patient weight; any other medication administered in the CCA and the time administered; and disposition, including mortality, and CCA discharge. During the time of this study, the only institutional protocol specific to the CCA consisted of a “warfarin reversal protocol” and a standardized “antibiotic dosing protocol”. Appropriateness of anticoagulation reversal and antibiotic dosing was assessed based on these protocols. These parameters were only assessed during the patient's time in the CCA.

Due to the fact that pharmacist interventions are not kept as part of the EMR, patients in the study group were further assessed for pharmacist documentation of interventions made during the CCA encounter. Each of the data points collected was evaluated for a corresponding pharmacist intervention in the pharmacist clinical

surveillance system to ensure gross validity of the data. The protocol for pharmacist documenting interventions on patients presenting to the CCA consists of a quick "CCA event" in the pharmacist clinical surveillance system. Then the pharmacist will leave a quick note of medication events that occurred in the CCA. These events may consist of, but are not limited to, medications obtained, prepared, and dosage recommendations. The pharmacist clinical surveillance system was reviewed for documentation of a "CCA event" on patients presenting in the study group and an intervention was considered if a "CCA event" was documented. The intervention was considered to be a "corresponding pharmacist intervention" if the medication documented in the EMR matched what the pharmacist documented in the clinical surveillance system.

2.4 | Outcome measures

The primary outcomes of interest were triage time to antibiotic administration, triage time to RSI, triage time to analgesic medication administration, triage time to anticoagulation reversal medication administration, and time from RSI to sedation medication administration. Secondary outcomes included: triage time to appropriate antibiotics based on dosing recommendations and existing guidelines, triage time to administration of tetanus vaccination to qualified candidates as determined by the bedside physician, and overall cost avoidance associated with the interventions made by the pharmacist.

The administration of appropriate empiric antibiotic therapy in trauma patients was based on the Eastern Association for the Surgery of Trauma (EAST) guidelines for open fracture prophylaxis.[20] Antibiotics were considered "appropriate" if they met both of the following criteria: preferred antibiotic class per the EAST guidelines for the type of fracture and administered at a dose consistent with the hospital's standardized antibiotic dosing protocol.

2.5 | Statistical analysis

None of the continuous data were normally distributed, and sample size was small for many of the analyses. For this reason, continuous data were described as medians and inter-quartile ranges (IQR), while categorical data were presented as counts and percentages.

Comparisons between the study group and control group were performed with a nonparametric Wilcoxon two-sample test (continuous data) or Fisher's exact test (categorical data). Analyses were performed in SAS version 9.4 (SAS Institute, Cary, North Carolina) with a significance level of $P \leq 0.05$.

3 | RESULTS

3.1 | Patient data

A total of 782 study group patients and 300 control group patients were included in the study. A comparison of baseline demographic data is shown in Table 1. The study group was significantly older (median 47 vs 39 years, $P < 0.001$) and there were significant differences in race between the two groups ($P < 0.001$). There were no other statistically significant differences among patients with respect to baseline demographic data.

TABLE 1 Baseline demographics

Variable	Control group	Study group	*P*-value
Age, years, median (*n*)	39 (300)	47 (782)	<0.001
Weight, kg, median (*n*)	83.6 (291)	84.1 (753)	0.81
Male, *n* (%)	207 (69.0)	515 (65.9)	0.35
Race			<0.001
Caucasian, *n* (%)	212 (70.7)	631 (80.7)	
African-American, *n* (%)	83 (27.7)	131 (16.8)	
Other, *n* (%)	5 (1.7)	20 (2.6)	

Abbreviation: kg, kilogram.

3.2 | Primary outcomes

Results of primary outcome analyses are summarized in Table 2. Similar rates of antibiotic usage were observed between study and control groups (7.3% vs 7.7%, $P = 0.80$). All of the patients in the control group ordered an antibiotic, and 98% of those that ordered an antibiotic in the study group were administered within an hour of triage time, as per hospital quality metric targets. The median time to administration of the first dose of antibiotic was similar between the study and control group (20 minutes [IQR 12-29] vs 18 minutes [IQR 9-27], $P = 0.39$).

Overall, few patients underwent RSI (31 [4%] in the study group vs 12 [4%] in the control group, $P = 0.78$), which was done within a median of 12.5 (IQR 6-18) and 12 (IQR 10-22) minutes of triage, respectively. Medications administered for RSI including preinduction, induction, neuromuscular blockers, and postintubation sedation and analgesia are presented in Table 3. There was no significant difference in the time from RSI to sedation medication administration between the two groups (7.5 [IQR 5-16] vs 8 [IQR 0-10]; $P = 0.50$). There was no statistically significant difference in administration of postintubation sedation following RSI, with 26 patients (84.6%) in the study group receiving postintubation sedation compared with six patients in the control group (50%) ($P = 0.07$). There was also no significant difference in the median time to sedation medication administration following RSI (7.5 minutes in the study group vs 8 minutes in the control group, $P = 0.50$).

There were similar rates of analgesic medication use between the groups (43.1% vs 40.3%, study group vs controls, $P = 0.37$). However, the median time to analgesic medication administration was statistically significantly faster in the study group (11 minutes [IQR 8-17]) compared with the control group (13 minutes [IQR 8.5-20 minutes]; $P = 0.04$). Few patients underwent reversal of an anticoagulant ($n = 2$ for each group) and therefore, statistical tests were not conducted.

3.3 | Secondary outcomes

Secondary outcome results are reported in Table 4. Among patients who received antibiotics, those in the study group were significantly more likely to receive appropriate antibiotics (80.7% vs 52.2%, $P = 0.01$). There was no difference in the rate of tetanus vaccination administration between the two groups, with 160 patients in the

TABLE 2 Primary outcomes

End point	*n* (%) Control group (*n* = 300)	Study group (*n* = 782)	Median (IQR) Control group	Study group	*P* value
Triage to antibiotic administration	23 (7.7)	57 (7.3)	18 (9–27)	20 (12–29)	0.39
Triage to RSI	12 (4)	31 (4)	12 (10–22)	12.5 (6–18)	0.78
RSI to sedation	6 (50)	26 (84)	8 (0–10)	7.5 (5–16)	0.50
Triage to analgesia	121 (40.3)	337 (43.1)	13 (8.5–20)	11 (8–27)	0.04
Triage to anticoagulation reversal[a]	2 (0.67)	2 (0.26)	NA	NA	NA

Abbreviations: IQR, interquartile range; NA, not applicable; RSI = rapid sequence intubation.
[a] No statistical tests performed as *n* = 2 for both groups.

TABLE 3 Rapid sequence intubation agents

Medication used	Control group (*n* = 12)	Study group (*n* = 31)
Preinduction agents		
Lidocaine, *n* (%)	0 (0)	3 (9.7)
Induction agents		
Etomidate, *n* (%)	8 (66.7)	22 (71)
Ketamine, *n* (%)	0 (0)	1 (3.2)
Propofol, *n* (%)	2 (16.7)	4 (12.9)
Midazolam, *n* (%)	2 (16.7)	5 (16.1)
Fentanyl, *n* (%)	3 (25)	2 (6.5)
None, *n* (%)	1 (8.3)	2 (6.5)
Neuromuscular blockers		
Succinylcholine, *n* (%)	9 (75)	23 (74.2)
Rocuronium, *n* (%)	0 (0)	2 (6.5)
None, *n* (%)	3 (25)	7 (22.6)
Postintubation sedation		
Propofol, *n* (%)	8 (66.7)	17 (54.8)
Midazolam, *n* (%)	0 (0)	12 (38.7)
None, *n* (%)	4 (33.3)	5 (16.1)
Postintubation analgesia		
Fentanyl, *n* (%)	4 (33.3)	16 (51.6)
None, *n* (%)	8 (66.7)	15 (48.4)
Postintubation neuromuscular blocker		
Vecuronium, *n* (%)	4 (33.3)	5 (16.1)
Rocuronium, *n* (%)	0 (0)	1 (3.2)

TABLE 4 Secondary end point results

End point	Control (*n* = 300)	Study (*n* = 782)	*P*-value
Appropriate antibiotic use, *n* (%)[a]	12 (52.2)	46 (80.7)	0.01
Tetanus vaccination, *n* (%)	56 (18.7)	160 (20.5)	0.55

[a] Antibiotic therapy was considered appropriate if it was from a guideline-preferred antibiotic class and administered at a dose consistent with the hospital's protocol.

study group (20.5%) and 56 patients in the control group (18.7%) receiving tetanus vaccinations (*P* = 0.55).

The interventions made during the study period were correlated to documentation by the pharmacist to ensure validity of the data. Overall, 690 total interventions occurred during the study period, with 84.3% of those having drug specific comments documented in the pharmacy surveillance system. The most common interventions involved analgesia (337, 48.8%) and sedation (103, 14.9%) (Table 5).

TABLE 5 Correlation of interventions to pharmacist documentation

End point/intervention	Total interventions During study period (*n* = 690)	Corresponding pharmacist Documentation (*n* = 582)
Antibiotics, *n* (%)	57 (8.3)	50 (87.7)
RSI, *n* (%)	31 (4.5)	28 (90.3)
Sedation, *n* (%)	103 (14.9)	90 (87.4)
Analgesia, *n* (%)	337 (48.8)	283 (84)
Anticoagulation reversal, *n* (%)	2 (0.2)	1 (50)
Tetanus vaccination, *n* (%)	160 (23.2)	130 (81.3)

Abbreviation: RSI, rapid sequence intubation.

4 | DISCUSSION

While much evidence exists detailing the impact of EMPs on patient outcomes and cost-savings, limited literature exists to evaluate the pharmacist's effect on critically ill trauma patients presenting to the ED. In this study, the presence of an EMP during the acute resuscitation of critically ill trauma patients was associated with decreased time to analgesic medication administration and more often ensured the administration of appropriate antibiotics at appropriate doses based on available guidelines.

Patients presenting during EMP hours received an analgesic medication on average 2 minutes faster than those presenting outside of EMP hours. Although this difference in time demonstrated statistical significance, it may be argued that this time frame may not be considered clinically significant. These findings are consistent with Montgomery and colleagues who reviewed the pharmacist's impact in acute pain management during trauma resuscitation and identified a four-minute decrease in time to analgesia when a pharmacist was present.[19] This data was utilized to support the addition of a pharmacist as part of a trauma resuscitation team. Another study retrospectively evaluated ED trauma patients who underwent RSI with rocuronium.[7] Primary and secondary outcomes were the time to sedative medication provision and the time to analgesic medication provision, respectively. The presence of an EMP was associated with significantly

decreased time to provision of postintubation sedation medications, but not analgesia. In contrast, our study did find that the presence of an EMP was associated with a statistically significant decrease in time to analgesic medication administration. There was no difference in the current study with regards to the median time to sedation following RSI (9 vs 10 minutes in the control group compared with the study group respectively, $P = 0.37$). However, only a small portion of patients included in the study underwent RSI (31 patients in the study group and 12 patients in the control group) and the study was not powered to detect a difference in this parameter. Most recently, the 2018 Pain, Agitation/Sedation, Delirium, Immobility, and Sleep (PADIS) guidelines discuss the importance of early pain control in preventing delirium.[21] These guidelines also identified trauma patients with a need for emergent surgery to be a patient population at most risk of developing ICU delirium. The new PADIS guidelines support the use of analgesia to prevent delirium and support the role of earlier administration of analgesia in this population. Although our study did not look at patient outcomes based on pharmacist interventions, further research may be aimed at reviewing importance of correlation to time to analgesia in acute trauma resuscitation in comparison to patient outcomes such as pain and delirium.

The majority of interventions made by the EMP were through dosing recommendations, procurement, and preparation of medications at the bedside. This differs from a previous study where therapeutic recommendations were the most common interventions made by the EMP.[9] Our findings suggest that the role of the pharmacist's presence at bedside during the fast-paced, acute resuscitation of trauma patients is to not only provide therapeutic recommendations but to also facilitate the safe and timely delivery of medications. The data demonstrating the significant increase in the provision of optimal antibiotic therapy further shows the diversity of pharmacy interventions that can be provided from physical medication preparation to high-level cognitive services during the acute resuscitation period.

Furthermore, there is a possibility that pharmacists also made additional therapeutic recommendations during the acute resuscitation of these patients, however these may not have been documented. To provide further validation for the presence of the pharmacist for the interventions made during the study time, the documentation of each intervention was assessed. Of the 690 interventions reported in Table 5, 582 had corresponding documentation by the pharmacist. In Table 5, there are 2 interventions for anticoagulant reversal, however, only 1 of the 2 interventions has "corresponding pharmacist documentation." This may be due to the fact that the first of the 2 anticoagulant reversals may have been given after the pharmacist had already documented on the patient and then did not go back and update the clinical pharmacist surveillance system with the changes. Thus, the authors can only validate that a pharmacist was present during 84.3% of the interventions included in the analysis based on documentation. Documentation in a busy ED is a challenge for every practitioner regardless of discipline, therefore, a level of discordance was anticipated.

Several studies have evaluated the effects of an EMP on patient outcomes. A retrospective chart review of adult patients presenting to the ED with health care-associated pneumonia found that patients presenting within the EMP's hours were significantly more likely to receive guideline-appropriate antibiotic therapy.[12] Patients presenting during the EMP's hours also received antibiotics in a shorter amount of time and at more appropriate doses, although these outcomes were not statistically significant.[12] Our study sought to elaborate on these findings and found that patients presenting during the time that an EMP was present were significantly more likely to receive guideline-appropriate antibiotic therapy. The indication for almost all patients in the current study who received antibiotic therapy during their CCA encounter was open fracture prophylaxis; therefore, the appropriateness of empiric antibiotics was based on the EAST guidelines.[20] The most common antibiotics utilized in both groups were cefazolin and tobramycin. Cefazolin dosing was most commonly given as a 2 g dose, as recommended by hospital protocol for patients with an actual body weight greater than 80 kg. Two patients in the study group received clindamycin due to a documented cephalosporin allergy, and no patients in the control group received clindamycin. The median time to antibiotic administration was not statistically different in the current study; however, this might be due in part to the availability of antibiotic therapy located locally in the automated dispensing cabinets.

5 | LIMITATIONS

This study had several limitations, including its retrospective design that limits the ability to control for confounders. Because the EMP was only staffed four out of six weekends during the study period, weekends were excluded from the analysis. This represents a major limitation to our study as weekends typically present a higher volume of trauma patients. In addition, the control group included overnight hours (between 2200 and 0700), which is often a time of minimal staffing in the ED, and thus the difference between the study and control group is confounded by limited resources during the control group's time frame. The utilization of pharmacy students and residents at different points during the study period could have resulted in multiple interventions that otherwise may not have been recorded when a single pharmacist was covering the ED. At the same time, the study time was chosen based on the assumption that a pharmacist was always present, which cannot be verified for the entirety of the study period. However, interventions made during the study period were compared with interventions documented by the pharmacist to verify pharmacist presence. Conversely, the EMP may have stayed late and made interventions on patients in the control group, but the clinical pharmacist surveillance system was not reviewed for the control patients. Also, time clocks were not reviewed for the clinical pharmacist to confirm or deny the presence of a pharmacist during the hours defined in the methods.

The study population was a convenience sample and thus power was not calculated. Although the overall study population was robust and consisted of over 1000 patients, individual subgroups were small and likely not powered to detect a statistical difference between the study and control group. Clinical outcome data points relied completely on accurate documentation by the trauma nurse and the EMP. There is the possibility of human error in documentation in the

fast-paced setting of acute trauma resuscitation which could confound our results.

6 | CONCLUSION

The presence of an EMP during critical trauma patient resuscitation was associated with statistically significantly decreased time to analgesia medication administration and a significantly increased probability of appropriate antibiotic therapy. Further research in this area is necessary to further elucidate the role of EMPs in the management of this complex patient population that can present with a variety of pharmacotherapy needs.

CONFLICTS OF INTEREST

The authors have no conflicts of interest to declare.

ORCID

Lynn Lamkin https://orcid.org/0000-0003-3419-2728
Kyle Weant https://orcid.org/0000-0003-0835-7955

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