Implementation of an Ultrasound-Guided Regional Anesthesia Program in the Emergency Department of a Community Teaching Hospital

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Study objective: We sought to initiate an emergency department (ED)–based ultrasound-guided regional anesthesia (UGRA) program in our community teaching hospital system. Here, we present our development process and protocol. We also sought to assess the types, indications, and associated adverse event rates for the UGRA procedures in this study.

Methods: We conducted a retrospective analysis of prospectively collected quality assurance data from a case series of patients who underwent an UGRA procedure in the ED. In August 2020, we developed an UGRA program for our community teaching hospital and its 2 affiliated freestanding EDs. For quality assurance purposes, we tracked all UGRA procedures performed in the ED, and we specifically assessed adverse events using structured follow-up. We subsequently obtained approval from our institutional review board to perform chart reviews of the patients in our dataset to abstract additional data and formally perform a research study. We determined the frequency with which different UGRA procedures were performed, and we calculated the adverse event rate.

Results: Between August 24, 2020, and July 15, 2022, a total of 18 different sonographers performed and documented 229 UGRA procedures on 206 unique patients. This included 28 different types of procedures. Follow-up after disposition was successful in 82.0% of patients. In 2 cases, the patient reported no pain relief at all from the procedure, but no patients reported complications related to the procedure.

Conclusion: We successfully initiated a robust ED-based UGRA program in our community teaching hospital system. Among patients with successful follow-up, no adverse events were identified. [Ann Emerg Med. 2023;■:1-10.]

Please see page XX for the Editor's Capsule Summary of this article.

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SEE EDITORIAL, P. XX.

INTRODUCTION

Although regional anesthesia has traditionally fallen under the purview of anesthesiologists, some emergency physicians have been performing ultrasound-guided regional anesthesia (UGRA) since 2007.[1] UGRA has been shown to improve safety, quality of anesthesia, and physician confidence as compared with regional anesthesia procedures without ultrasound.[2-5] Over time, the scope and use of UGRA techniques in the emergency department (ED) have grown. The effectiveness of UGRA in the ED has been demonstrated for numerous applications, including managing pain from hip fractures and clavicle fractures and providing anesthesia for procedures such as shoulder dislocation reductions, abscess drainage, and tube thoracostomy.[6-11] Moreover, the American College of Emergency Physicians (ACEP) released a policy statement in 2021[12] stating that ultrasound-guided nerve blocks are "not only within the scope of the practice of emergency physicians, but represent a core component of a multimodal pathway to control pain for patients in the ED."[7]

Despite the numerous applications of UGRA and the support from ACEP, some academic EDs do not perform UGRA at all, and among those that do, there is substantial variation in training and use.[3] Some of the barriers to entry are not only related to equipment and exposure to UGRA techniques, but also in knowing how to implement a robust regional anesthesia program in a facility that is not familiar with this practice. One additional factor that is undoubtedly affecting widespread adoption is a lack of data regarding the safety of regional anesthesia techniques utilized in the ED. A recent publication highlighting an ongoing systematic review of adverse events related to

Editor's Capsule Summary

What is already known on this topic

Ultrasound-guided regional anesthesia (UGRA) is increasingly used by emergency physicians.

What question this study addressed

Does a structured UGRA program change safe deployment of this analgesic adjunct?

What this study adds to our knowledge

A 2-year assessment of a community hospital system–structured UGRA program was associated with a very high rate of successful regional anesthesia in the absence of complications.

How this is relevant to clinical practice

Development of a formal UGRA program could allow institutions to facilitate use and track performance.

Research we would like to see

What procedures are routinely associated with high success and low complications, and which procedures are associated with lower success rates or more complications?

ultrasound-guided regional anesthesia speaks to this point.[13]

Therefore, a more formalized process for establishing an UGRA program in the ED is needed. In 2020, we established a structured UGRA program in our community-academic hospital system to replace the independent physician practice model. In this manuscript, we report how we established this program, and we present our preliminary data with regards to use and adverse events.

METHODS

Study Design and Setting

In August 2020, we implemented an ED-based, UGRA program in our hospital system, and we prospectively collected data from all patients who underwent UGRA in the ED for quality assurance purposes. We then decided to use these data for research purposes. We obtained approval from our hospital's institutional review board, and then performed a retrospective chart review to obtain additional data from each patient who had undergone UGRA in the ED. We followed Strengthening the Reporting of Observational Studies in Epidemiology guidelines.

Our hospital is a community teaching hospital located in Miami Beach, Florida, USA. The main hospital has an annual ED volume of approximately 60,000 visits, hosting a 3-year emergency medicine residency program (7 residents per year) and a 1-year advanced emergency medicine ultrasound fellowship (2 fellows per year) that started in July 2021. Our hospital system also has 2 associated freestanding EDs. No residents work in the freestanding EDs. However, the fellows do, and there is compliance with the UGRA program across all EDs in this study. During the study period, we had a total of 21 emergency medicine residents, 2 advanced emergency medicine ultrasound fellows, and 25 full-time emergency medicine attendings. Nurse practitioners and physician assistants were not included in our analysis as they do not typically perform UGRA in the EDs in our hospital system.

Development Steps for the UGRA Program

Our efforts to initiate an UGRA program were led primarily by the ED ultrasound faculty. At the time of implementation, we had 3 ultrasound faculty members who had completed advanced emergency medicine ultrasound fellowships and had experience with UGRA. When we developed our UGRA program, we coordinated with the following departments: orthopedics, anesthesiology, and pharmacy. Orthopedics officially signed off on our departmental protocol (see Appendix E1, available at http://www.annemergmed.com) for ED-based UGRA. The pharmacy assisted with the development of dosing guidelines and stocking of the required anesthetics and lipid emulsion kits in the automated dispensing systems in each of our 3 EDs. Anesthesiology assisted with the general education of UGRA techniques by allowing advanced emergency medicine ultrasound fellows to rotate with their procedural teams and obtain additional exposure to UGRA.

To standardize the department's approach to UGRA use and to coordinate optimal patient care between departments, we developed a departmental guideline for UGRA. The protocol was developed by the lead ultrasound faculty and signed off by the ED chair as well as the division head of orthopedics. The protocol contained general recommendations about indications, anesthetic dosing, local anesthetic systemic toxicity management, and techniques (Appendix E1, available at http://www.annemergmed.com).

Emergency physicians at our institution were already credentialed for regional anesthesia procedures under general privileges. At the time of this study, application-specific ultrasound credentialing was in effect. UGRA was considered to be within the general category of ultrasound-guided procedures. Physicians were credentialed for UGRA

once they had demonstrated proficiency through procedural ultrasound either by performing 20 scans in that application that were saved and had undergone quality assurance review by our ultrasound division or by having a procedure list from a previous institution demonstrating proficiency in procedural ultrasound. Our internal ED clinical ultrasound policy also requires 5 ultrasound-specific continuing medical education credits every 2 years (credentialing period) to maintain clinical ultrasound privileges.

On initiation of the UGRA program and during data collection for this study, our main ED campus had 3 SonoSite X-porte systems available. Among the 3 systems, there were 3 high-frequency linear ultrasound probes (2 13-6 MHz, 25-mm footprint and one 15-6 MHz, 50-mm footprint footprint) and 2 curvilinear ultrasound probes (5-1 MHz, 60-mm footprint) that were available for UGRA. One freestanding ED had a SonoSite X-porte system with the same 25-mm footprint linear probe and a 5-1 MHz, 60-mm footprint curvilinear probe. The other freestanding ED had a SonoSite Edge-II with a 13-6 MHz, 25-mm footprint linear probe and a 5-1 MHz, 60-mm curvilinear probe.

Prior to the development of the UGRA program, our ED had already established a successful diagnostic point-of-care ultrasound program. Images/clips saved on the modality from all ED-based point-of-care ultrasound machines are stored in Qpath (Telexy Healthcare, Maple Ridge, BC, Canada) regardless of whether the physician completes a diagnostic worksheet. Once a physician completes and signs a diagnostic worksheet for the ultrasound study in Qpath, the images are linked to our electronic medical record picture archiving and communication system for viewing by any provider accessing the patient's medical records, and a corresponding report is generated in the patient's electronic medical record. Similarly, all the UGRA procedures performed, regardless of whether a physician completed Qpath, had representative images stored in Qpath. The UGRA scan consisted of a preprocedural anatomy scan, needle guidance (most commonly in-plane), and postprocedural scan.

In addition to the ultrasound machines listed above, starting our UGRA required some other equipment. For ease of access, we created a "block cart" with all the necessary equipment for UGRA procedures. One block cart was located in each of the 3 ED sites in this study. Special equipment we found useful to stock included the following (additional details are provided in Appendix E2, available at http://www.annemergmed.com):

- 20-gauge Tuohy spinal needles
- Sonoplex regional anesthesia needles with attached intravenous tubing
- Syringes (10 mL and 20 mL)
- Normal saline solution bags of 50 to 100 mL volume to use for hydrodissection and volume
- 3-mL intravenous connecting tubing (short length)
- Small adhesive protective barriers
- Chlorhexidine swabs
- 25 and 27 gauge 1.5-inch needles

Tuohy needles were suggested for use by novice users and/or during UGRA procedures that are near vasculature structures (for example, the retroclavicular approach to the infraclavicular region [RAPTIR] nerve blocks). Sonoplex regional anesthesia needles were suggested for use if a steep angle of insonation would make it difficult to visualize the needle. Otherwise, most blocks were performed with spinal needles or standard injection needles of various gauges depending on the block location. The nonspecialized needles were already available in the ED.

Our available anesthetic options were primarily 0.5% bupivacaine, 0.25% bupivacaine, 1% lidocaine with and without epinephrine, and 2% lidocaine with and without epinephrine. Chloroprocaine could be available at the main campus from the hospital pharmacy. The leadership team coordinated with the pharmacy to ensure that the primary anesthetics would be available in the automated dispensing machines at each ED barring any shortages. Additionally, a lipid emulsion kit was made available at each ED location. Details on local anesthetic systemic toxicity and its management were included within our protocol (Appendix E1).

Selection of Participants

Patients in one of our 3 EDs of any age who consented to UGRA for any indication were tracked initially for quality assurance purposes and later could have been included in our study. Patients of all ages were included and were chosen for eligibility by the treating physician, who then either performed the UGRA procedure or requested assistance from any other emergency physician present who was more familiar with the technique. All patients evaluated in the study had written and/or verbal consent for the procedure documented in the electronic medical record procedure note as is standard policy for any nonemergency procedure performed in our ED. Both admitted and discharged patients were included in the analysis. Only patients who refused UGRA were excluded from analysis as they were not included in the quality assurance data set.

Interventions

We considered UGRA procedures to be any of the following procedures performed under direct ultrasound guidance: nerve blocks (nerve, nerve bundle, or plane blocks), hematoma blocks, intra-articular injections, and bursal injections. We only tracked and reported UGRA procedures that were conducted within the ED and performed by emergency physicians of any training level (including residents, fellows, or attendings). The physician performing the procedure chose the anesthetic type and volume at their discretion, although recommendations were listed in the protocol.

Measurements

Initially, data were prospectively collected for quality assurance purposes. Subsequently, after institutional review board approval, we conducted a retrospective analysis of these data during the period from August 24, 2020, to July 15, 2022. For quality assurance purposes, the physician who performed the procedure recorded the following data for each UGRA procedure: type of procedure, date and time the procedure was performed, indication, anesthetic type, short-term complications (while in the ED), and disposition. Per institutional protocol (Appendix E1), patients who received injections near vasculature or who received a high volume of anesthesia were supposed to be placed on a cardiac monitor for at least 60 minutes of observation in the ED after procedure. This allowed a time period to assess for short-term complications. Additionally, the physician who performed the procedure called the patient by phone 24 to 72 hours after the procedure to ask them if they had any persistent weakness or numbness (that might indicate neuropraxia) or if they had any other concerning symptoms (that might indicate another complication). If the patient did not answer, a chart review was performed using Epic (Epic Systems Corporation) immediately after the unsuccessful phone call and then again at least one month later. Epic's Care Everywhere was used to search for medical encounters within our hospital system as well as in other hospital systems that participate in Care Everywhere. All nurse and physician documentation in Epic was reviewed for one month following the UGRA procedure to look for evidence of complications from the UGRA procedure. If documentation from an admission or follow-up outpatient visit was present and there was no mention of a symptom that could indicate a complication, the patient was considered to have not experienced a complication. If the patient did not answer the phone call and had no viewable medical encounters in Epic for the next month, follow-up was considered unsuccessful. All of this data collection occurred for quality assurance purposes, and data were kept on a password-protected Microsoft Excel (version 16.75) spreadsheet.

After making the decision to use our data for research purposes and achieving institutional review board approval, a single research assistant performed an additional chart review on all patients to obtain demographic data (age and gender), body mass index (BMI), and time of ED disposition and to confirm the follow-ups in which the phone call was unsuccessful. This research assistant has experience conducting chart review studies and received specific training for this study described below. The investigators created a data dictionary that defined the variables and described where to find them in Epic. The principal investigator met with the research assistant before data abstraction began, and they reviewed the data dictionary. New columns for age, gender, race, ethnicity, and BMI were added to the existing Excel spreadsheet (from the quality assurance data), and the research assistant directly input the values into that spreadsheet. Additionally, the research assistant performed a chart review to assess for complications on all patients for whom the attempt at direct contact through a phone call was unsuccessful. As described in the Results section, there were 67 patients for whom attempts at direct contact were unsuccessful. However, in 48 of those cases, the treating physician thought there was chart review evidence that there were no complications. The research assistant reviewed the documentation in Epic's Care Everywhere for each of these 67 patients to try to confirm the presence of absence of complications from the UGRA procedure as previously assessed by the physician who performed the procedure. The patient could be categorized as having had a complication, not having had a complication, or being lost to follow-up. The principal investigator and the research assistant reviewed the first 10 patients together, and they had an additional meeting to discuss any uncertainties in the chart review process about halfway through the chart review portion of the data collection. Ultimately, the research assistant agreed that, based on chart review, there were no complications in the 48 patients as reported by the physicians who performed the procedure. However, the research assistant identified one additional patient who initially was categorized as lost to follow-up but had documentation in Care Everywhere that provided evidence against any complication. This case was adjudicated by the principal investigator, and they deemed the research assistant to be correct that chart review evidence suggested no complication. Overall, the free-marginal kappa for chart review assessment of complications was 0.98 (95% confidence interval 0.93 to 1.00).

Outcomes

The primary goal of this study was to report the user, types, and frequency of UGRA procedures performed in the ED after implementing an ED-based UGRA program. Our primary safety outcome was the incidence of major complications, including local anesthetic systemic toxicity and neuropraxia, which we defined as persistent weakness or numbness at the time of follow-up. Minor complications, such as bleeding or injection site pain, were not recorded. Secondarily, we determined the percentage of regional anesthesia procedures that failed (did not result in pain relief, according to the patient).

Analysis

We compiled data in Microsoft Excel (version 16.60, Microsoft, Redmond, WA) and analyzed it in R Studio (version 2022.02.2). We report only descriptive data.

RESULTS

Between August 24, 2020, and July 15, 2022, a total of 18 different sonographers performed and documented 229 ultrasound-guided regional anesthesia procedures on 206 unique patients. Two different UGRA procedures were performed on 21 patients, and 3 different UGRA procedures were performed on 2 patients. The 18 sonographers included 3 advanced emergency medicine ultrasound fellowship-trained attendings (141 regional anesthesia procedures), 2 advanced emergency medicine ultrasound fellows (61 regional anesthesia procedures), one sports medicine fellowship-trained emergency medicine attending (2 regional anesthesia procedures), 3 other emergency medicine attendings (4 regional anesthesia procedures), and 9 emergency medicine residents (21 regional anesthesia procedures).

Patient age ranged from 14 to 99 years old with a median age of 51 years (interquartile range (IQR) 35 to 73). In total, 120 (58.3%) identified as female, and 86 (41.7%) identified as male. The median body mass index was 25.8 (22.5 to 29.1). After the regional anesthesia procedures, 159 were discharged from the ED, 46 were admitted, and one was transferred to a different facility.

There were 5 cases in which the type of anesthetic used was not documented. Among the 224 cases in which the anesthetic type was documented, 98 (43.8%) were performed with bupivacaine (only), and 54 (24.1%) were performed with lidocaine (only). In 72 (32.2%) of those cases, the procedure was performed with a combination of lidocaine and bupivacaine. The most used anesthetic (with concentration) was 0.5% bupivacaine (without epinephrine), which was used in 78 (34.8%) of the procedures in which an anesthetic was documented.

The most common clinical scenario for which patients received an UGRA procedure was an orthopedic injury. Of the 229 UGRA procedures performed in this study, 157 (68.6%) were done to help manage a patient who had sustained an orthopedic injury, either for pain control or for procedural anesthesia. In total, 96 UGRA procedures (41.9%) were performed purely for pain control, whereas 133 (58.1%) were for procedural anesthesia.

The 5 most performed techniques in our study were the RAPTIR brachial plexus block (31 times, 13.5%), the ulnar nerve block (28 times, 12.2%), interscalene brachial plexus block (27 times, 11.8%), median nerve block (22 times, 9.6%), and the erector spinae plane block (19 times, 8.3%). The Table shows the number of times each technique was performed and the associated indications.

Regarding adverse events and procedure failures, there were 2 cases in which the regional anesthesia procedure provided no relief. Of these 2 failures, one was a RAPTIR nerve block for analgesia in the setting of an elbow dislocation, and the other a subacromial bursal injection for analgesia in the setting of acute on chronic shoulder pain. There were no cases of local anesthetic systemic toxicity during the study period. The median time of observation for short-term complications (from injection until ED disposition) was 2 hours 20 minutes (IQR 1 hour 16 minutes to 3 hours 36 minutes). For the 229 procedures tracked, the time from injection to ED disposition was more than 60 minutes in 191 (83.4%) of cases. The time from injection to disposition was less than 60 minutes in 38 cases (16.6%) and less than 30 minutes in 4 cases (1.7%). Subsequent follow-up after ED disposition was successful for 169 (82.0%) of the 206 patients. Follow-up was obtained through phone call 24 to 72 hours after the procedure in 120 patients and through chart review in 49 patients. There were no cases of neuropraxia, and no other adverse events were noted.

LIMITATIONS

There were several limitations to this study. First, most UGRA procedures were performed by either ultrasound fellows or ultrasound fellowship-trained physicians, and just 3 (advanced emergency medicine ultrasound fellowship-trained) physicians performed about 63% of the UGRA procedures. Additionally, as this was not a randomized trial, our findings were likely influenced by selection bias in that UGRA procedures may have been selectively performed on patients in whom adverse events were thought to be less likely to occur. These issues may

Table. The types and numbers of regional anesthesia procedures performed along with the reasons why they were performed and complications.

Regional Anesthesia Procedure	No. (%)	Indications	Complications
RAPTIR	31 (13.5%)	Elbow, forearm, wrist, and hand fracture/dislocation reduction; arm abscess drainage; arm pain	1 case with no pain relief
Ulnar nerve block	28 (12.2%)	Hand pain, hand laceration repair, hand fracture/dislocation reduction	None
Interscalene brachial plexus block	27 (11.8%)	Proximal humerus fracture pain, humerus fracture splinting, shoulder dislocation reduction	None
Median nerve block	22 (9.6%)	Hand pain; abscess drainage; hand laceration repair; wrist and hand fracture/dislocation reduction	None
Erector spinae plane block	19 (8.3%)	Abdominal pain, back pain, rib fracture pain	None
Fascia iliaca block	17 (7.4%)	Hip fracture pain	None
Distal sciatic nerve block	16 (7.0%)	Shin laceration repair, ankle and foot fracture pain, ankle fracture reduction, abscess drainage	None
Radial nerve block	13 (5.7%)	Hand laceration repair, hand and wrist fracture/dislocation reduction	None
Serratus anterior plane block	11 (4.8%)	Rib fracture pain, chest wall pain, chest tube insertion	None
Posterior tibial nerve block	6 (2.6%)	Foreign body removal from foot, dorsal foot laceration repair, foot pain, abscess drainage	None
Superficial cervical plexus block	5 (2.2%)	Neck pain, internal jugular vein catheter insertion, clavicle fracture pain	None
TAP block	5 (2.2%)	Abdominal pain, abdominal wall abscess drainage	None
Hematoma block	4 (1.7%)	Wrist fracture reduction	None
Adductor canal nerve block	3 (1.3%)	Shin laceration repair, ankle fracture reduction, pain from patella fracture	None
Glenohumeral injection	3 (1.3%)	Shoulder dislocation reduction, shoulder pain	None
PENG block	3 (1.3%)	Pelvic fracture pain	None
Supraclavicular nerve block	3 (1.3%)	Wrist fracture reduction, humerus fracture reduction	None
Clavipectoral fascial plane block	2 (0.9%)	Clavicle fracture pain	None
Knee injection	2 (0.9%)	Knee pain	None
PEC nerve II block	2 (0.9%)	Drainage of axillary abscess	None
SI joint block	2 (0.9%)	Sciatica	None
Subacromial block	1 (0.4%)	Shoulder pain	1 case with no pain relief
Common peroneal nerve block	1 (0.4%)	Laceration on dorsum of foot	None
Ilioinguinal nerve block	1 (0.4%)	Drainage of abscess	None
Intercostal nerve block	1 (0.4%)	Rib fracture pain	None
Transgluteal sciatic nerve block	1 (0.4%)	Distal femur fracture pain	None

PEC, pectorialis; *PENG*, pericapsular nerve group; *SI*, sacroiliac; *TAP*, transversus abdominis plane.

limit the generalizability of our findings to other EDs. Another significant limitation involves the process of our assessment for adverse events. Because our data were initially recorded for quality assurance purposes, the physician who recorded complications was the same as the one who performed the procedure, which may have led to

an underreporting of adverse events. Also, the callback window of 24 to 72 hours may not have captured all adverse events, and we did not formally assess for adverse events except local anesthetic systemic toxicity and neuropraxia. Given the rarity of local anesthetic systemic toxicity, a much larger study would be needed to estimate its incidence.[14,15] Additionally, 18% of patients were lost to follow-up, thus it is uncertain whether adverse events occurred in this group. Nonetheless, no formal complaints or legal actions have occurred because of ED-based UGRA since its formal implementation in our hospital system. Lastly, other analgesics administered in the ED may have confounded our results, eg, in patients who concurrently received opiates in addition to regional anesthesia.

DISCUSSION

Our work demonstrates that it is feasible to implement UGRA in a community teaching hospital. We demonstrate that there are a variety of indications and UGRA techniques that can be utilized in the ED, and that no immediate cases of local anesthetic systemic toxicity, neuropraxia, or other adverse events were identified within the limitations of our chart review and patient call back methods.

Among the 26 types of UGRA procedures performed in our dataset, the 5 most frequently used UGRA procedures, in order, consisted of the RAPTIR, ulnar nerve block, interscalene nerve block, median nerve block, and erector spinae plane block. In total, 28.8% of the UGRA techniques performed in this sampling were brachial plexus nerve blocks, whereas forearm blocks comprised another 27.5%, anesthesia of the lower extremity comprised 20.8%, and truncal blocks represented 15.3% of the total. Our data agree with published recommendations regarding the UGRA procedure types that should be included in emergency medicine trainee curriculums.[16,17]

It is worth mentioning that there will likely be some deviation from our study results compared with other institutions. Notably, fascia iliaca blocks, which have been studied extensively and are recommended for hip fractures, were not in the top 5 procedures in our study.[18,19] Although we had the support of most of the orthopedists at our facility, some orthopedists on call during the study period were not amenable to having patients receive nerve blocks for femoral neck fractures. This undoubtedly skewed our data regarding admission and the proportion of lower extremity UGRA procedures that might be representative at other institutions. Secondly, the RAPTIR nerve block was used frequently in this study as a means for reducing difficult distal radius fractures. We recognize that the RAPTIR nerve block is a more complicated technique that may not be broadly adopted. However, the authors believe similar techniques, such as the supraclavicular nerve block, may be used at a frequency similar to that noted for the RAPTIR technique in this study.

From our experience and the existing literature, there are several key steps to developing an ED-based UGRA program.[3] These include having a local expert(s), interdepartmental coordination, the availability of appropriate equipment/medications, the means of capturing UGRA procedures in the electronic medical record/image review library, the development of an ED-based UGRA protocol, and department education on UGRA. We had 3 local experts (ultrasound fellowship-trained emergency physicians) lead this initiative. They brought experience and helped overcome cited issues with starting an UGRA program, including procedural expertise and interdepartmental politics.[20,21] We agree with literature that advocates the benefits of promoting the UGRA program in various departments that have overlapping interests.[20,22] Interdepartmental coordination is particularly important for admitted patients, as continued care for the patients may include additional or continuous regional anesthesia and the administration of local anesthetics. Clear documentation in the electronic medical record citing the amount and type of anesthetic used as well as the location and time of administration of UGRA are critical to optimal and safe patient care. Most patients who received UGRA procedures in our analysis were discharged from the ED (77.2% discharged, 22.3% admitted). A higher percentage of patients may be admitted at trauma centers, which we do not have in our hospital system. However, this would likely only increase the need for a robust ED-based pain program and interdepartmental cooperation.

To facilitate ease of use, we established regional anesthesia carts at each ED location that were stocked with the desired equipment, as recommended by other institutions.[23] Each of the departments in our study had ultrasound machines with linear and curvilinear probes and used the same mechanism for capturing ultrasound imaging of the UGRA procedure. As previously mentioned, lipid emulsion kits were available in each of the EDs in this study. Based on the implementation of this system, we suggest working with the information technology department to generate a lipid emulsion order set for quick access in the rare case of local anesthetic systemic toxicity and to conduct yearly staff training.

Local anesthetic systemic toxicity is a rare but potentially fatal complication of UGRA that results from excessive systemic uptake of local anesthetic, where high

concentrations in the cardiac and central nervous system result in cardiovascular or neurologic deterioration.[24] Symptoms of local anesthetic systemic toxicity can range from mild (such as perioral paresthesia) to devastating (seizure or cardiac arrest).[25] The use of ultrasound greatly reduces the incidence of local anesthetic systemic toxicity by allowing physicians to avoid direct intravascular injection of anesthetic.[2] Based on large databases, current estimates of the incidence of local anesthetic systemic toxicity with peripheral nerve blocks are at 0.1% to 0.18%.[14,15] Given the number of patients in our retrospective analysis, we did not expect to find any cases of local anesthetic systemic toxicity and indeed did not. It is important to recognize that larger volume blocks, such as those used in fascial plane blocks, are more likely to lead to local anesthetic systemic toxicity, we educated all physicians who performed blocks beforehand on which types were more likely to lead to local anesthetic systemic toxicity, and this fact is emphasized to learners in our system.[23] The vast majority of cases of local anesthetic systemic toxicity occur shortly after injection of the local anesthetic, so our institutional protocol recommends at least 60 minutes of observation with cardiac monitoring for large volume blocks or those near vasculature.[26] This was not strictly followed in our sample of patients, but was done in most cases. The optimal time for observation after an ED-performed UGRA procedure remains uncertain.

As mentioned, we generated a department protocol (Appendix E1) that included clinical situations that were considered high risk, suggested management pathways for pain management, information pertaining to the management of local anesthetic systemic toxicity, and indication recommendations for most UGRA procedures performed in our institution. After this framework was established, the authors then frequently educated the residents, fellows, and clinical faculty in our ED on the use of UGRA. Our education models were based on the collective experience of the ultrasound faculty as well as other expert opinions on UGRA curriculums that have been discussed in the literature.[16] This focused knowledge and experience is a benefit for the implementation of an UGRA as other literature has demonstrated the use of UGRA particularly at training programs.[3]

It is important to discuss the pros and cons of UGRA when educating about regional anesthesia. We support a multimodal pain management approach and do not advocate solely for the use of UGRA techniques to control pain.[21] Rather, we advocated for UGRA as part of the multimodal approach to pain management in our department. We do not have an institutional definition of multimodal pain management, but departmentally adhere to the commonly used context of multimodal pain management being the use of, or consideration to use, more than one pharmacologic class of analgesic and more than one means of application (for example, intramuscular, intravenous, oral, local infiltration or UGRA) as clinically indicated.[27] All nerve blocks in our institution's EDs are performed using a weight-based limit as a maximum, but we adhere to amounts shown to be effective and will use less anesthetic if possible.[26,28] Epinephrine was the only additive utilized in the blocks analyzed over this period and was preferred as an additional means of identifying intravascular injection.[29] Often, the combination of lidocaine with epinephrine was made with 0.5% bupivacaine as bupivacaine with epinephrine was not readily available at our institution. Bupivacaine was utilized as our long-acting agent due to availability, but there are well-documented benefits to considering the use of ropivacaine if it is institutionally available.[30]

It is also important to highlight the known risks of regional anesthesia (nerve injury, local anesthetic systemic toxicity, arrhythmia, and infection) as well as the importance of proper post block management.[31] If admitted, the type of nerve block performed should be listed clearly on the chart and ideally on the affected limb using a surgical marker. The expected length of action of the chosen anesthetic should be discussed with the patient, as well as return precautions if discharged. Discharged patients should receive a sling or crutches as appropriate. For our protocol, we implemented a callback/chart review policy for UGRA procedures performed in the ED. From this callback/chart review data, we demonstrated safety and efficacy for the UGRA procedures performed in our institution during the study period. Based on the departmental call back and chart review policy, we successfully followed up on 82% of the UGRA procedures performed during the analysis period.

During the study period, there were only 2 cases of inadequate analgesia. Of these UGRA procedures, only one involved an ultrasound-guided nerve block (RAPTIR). For both cases, we believe there are explanations for why there was failure to achieve analgesia. As part of the internal image review policy of our ultrasound fellowship, all UGRA procedures are reviewed for quality assurance. When this case was reviewed, the needle tip was noted to be below the posterior cord and outside of the intended fascial plane that is critical to successful nerve blockade when performing the RAPTIR technique. In the case of the subacromial bursal injection, it is very likely that there was an additional injury to the rotator cuff or labrum that would not have been relieved by a subacromial bursal injection. Block failures are an inherent risk to any UGRA

procedure, but the internal review process helps identify errors and improve technique. Regarding safety, no complications based on the mechanisms used in the study were reported. Although there are limitations to chart review and nonblinded patient call backs, this initial step demonstrates the feasibility and relative safety of an ED-based UGRA program.

In conclusion, an analysis of our initial case series of patients demonstrates that UGRA can be used in the ED to control pain or provide anesthesia for procedures performed for a large variety of clinical conditions. In rare cases, the procedure did not provide any anesthesia. However, among patients with successful follow-up, no cases of neuropraxia or local anesthetic systemic toxicity were identified. We believe that the steps taken to implement an ED-based UGRA protocol as part of a multimodal approach to acute pain management can be utilized by other institutions. Further prospective and multicenter studies demonstrating the utility and safety of ED-based UGRA is warranted.

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Author contributions: RAF and MAN conceived the study. RAF, MAN, DK, and TZ designed the study. RAF, MAN, DK, MS, RMD, and TZ collected the data. RAF, TZ, and DAF supervised the conduct of the study and data collection. RAF, MAN, RMD, and TZ managed the data, including quality control. TZ provided statistical advice on study design and analyzed the data. RAF, MS, MAN, and TZ drafted the manuscript, and all authors contributed substantially to its revision. RAF takes responsibility for the paper as a whole.

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