

Original Contribution: Defining an Ultrasound-Guided Regional Anesthesia Curriculum for Emergency Medicine

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14 **Abstract**

15

16 Objectives: Ultrasound-guided regional anesthesia (UGRA) can be a powerful tool in the
17 treatment of painful conditions commonly encountered in emergency medicine (EM) practice.
18 UGRA can benefit patients while avoiding the risks of procedural sedation and opioid-based
19 systemic analgesia. Despite these advantages, many EM trainees do not receive focused
20 education in UGRA and there is no published curriculum specifically for EM physicians. The
21 objective of this study was to identify the components of a UGRA curriculum for EM physicians.
22 Methods: A list of potential curriculum elements was developed through an extensive literature
23 review. An expert panel was convened that included 13 ultrasound faculty members from 12
24 institutions, and from a variety of practice environments and diverse geographical regions. The
25 panel voted on curriculum elements through two rounds of a modified Delphi process.
26 Results: The panelists voted on 178 total elements, 110 background knowledge elements and 68
27 individual UGRA techniques. A high level of agreement was achieved for 65 background
28 knowledge elements from the categories: benefits to providers and patients, indications,
29 contraindications, risks, ultrasound skills, procedural skills, sterile technique, local anesthetics,
30 and educational resources. Ten UGRA techniques achieved consensus: interscalene brachial

31 plexus, supraclavicular brachial plexus, radial nerve, median nerve, ulnar nerve, serratus anterior
32 plane, fascia iliaca, femoral nerve, popliteal sciatic nerve, and posterior tibial nerve blocks.
33 Conclusions: The defined curriculum represents ultrasound expert opinion on a curriculum for
34 training practicing emergency medicine physicians. This curriculum can be used to guide the
35 development and implementation of more robust UGRA education for both residents and
36 independent providers.

37 **Introduction**

38
39 The management of pain is a cornerstone of emergency medicine (EM) practice.¹
40 Ultrasound-guided regional anesthesia (UGRA) encompasses a variety of procedures that can
41 effectively alleviate pain without use of oral, intravenous, or intramuscular pharmacotherapies
42 such as opiate medications.² UGRA utilizes real-time ultrasound guidance to assist anesthetic
43 medication injection near peripheral nerve or associated facial planes to provide sensory
44 blockade.³ In addition to pain management, there are a number of potential advantages to using
45 UGRA in the Emergency Department (ED). Utilizing UGRA in place of opioid-based systemic
46 analgesia avoids the potentially dangerous side effects of opioid medications, particularly in
47 geriatrics patients and those with previous substance use issues.² For example, the femoral nerve
48 and fascia iliaca blocks, both well studied ED UGRA techniques, reduce complications and
49 improve long-term functional outcomes for elderly hip fracture patients when compared to
50 systemic opioid-based treatment.⁴ UGRA can also provide a more timely and less resource
51 intensive alternative to procedural sedation.⁵ Nerve blocks provide effective pain control for a
52 variety of painful procedures including fracture and dislocation reductions.^{6,7,8}

53 Despite the many potential benefits of UGRA, there is substantial variation in the
54 utilization of these techniques in EM. While most academic emergency departments report
55 performing UGRA, there is high variability in the frequency of use, quality assurances processes,
56 and credentialing processes.⁹ In addition, the education provided to EM physicians in these
57 techniques is highly variable. In a recent survey of EM residency programs, nearly all program
58 directors believed UGRA was necessary for all EM physicians to learn.⁹ The Accreditation
59 Council of Graduate Medical Education lists regional anesthesia performance as a core
60 emergency medicine resident competency in the 'Anesthesia and Acute Pain Management'
61 milestone.¹⁰ However, only 53% of programs reported providing UGRA specific education to

62 their residents.¹¹ There are online learning resources, textbooks, and review articles available on
63 UGRA use by EM physicians, however there is no published UGRA curriculum to meet this
64 need. There is also no recommended knowledge base or set of nerve block techniques
65 specifically defined for EM physicians.

66 The purpose of this study is to define the expert recommended components of an UGRA
67 curriculum that represents ideal knowledge and skills for all practicing EM physicians.

68 **Methods**

69

70 A literature review was performed with the assistance of a librarian and a list of specific
71 UGRA concepts and techniques was assembled. This included items from published peer-
72 reviewed manuscripts and textbooks in Emergency Medicine and Anesthesia literature.¹²⁻²⁶
73 Online resources and resources that were not subject to peer-review were not reviewed for
74 possible curriculum elements. A multi-institutional expert panel of 13 emergency medicine
75 physicians with advanced ultrasound training was assembled via a convenience sample. Of the
76 panelists, 11 were ultrasound fellowship trained, 6 were ultrasound directors at their institutions
77 and 4 were ultrasound fellowship program directors. The panel was formed with consideration
78 for geographic diversity with 3 panelists from the east, 4 from the midwest region, 3 from the
79 south, and 3 from the west. Panelist demographics are described in **Table 1**.

80 We then used a modified Delphi technique to build consensus on core UGRA curriculum
81 elements. The research team included two ultrasound fellowship trained experts and an
82 educational expert with extensive modified Delphi experience to help with methodology and
83 obtaining validity evidence. This educational expert assisted with data collection but was not a
84 participant during any round of the Delphi process.

85 The Delphi technique is a well-established theory-driven educational method that uses
86 expert opinion to build agreement.^{27,28} A questionnaire with the full list of UGRA techniques
87 was sent out to the expert panel via the QualtricsTM online survey platform. This platform is able
88 to receive and track distinct information from individual respondents and confidentially store
89 data. This study was reviewed by the IRB and granted exempt status.

90 In the first round of the modified Delphi, participants were presented with each of the
91 UGRA items and rated them on a scale of how important knowledge of this skill or topic would
92 be for EM physicians at all levels of training to learn regardless of place of practice (i.e.

93 community or academic site). Items were rated on a five-point Likert scale following standard
94 modified Delphi technique (1 = absolutely do not include/not important; 2 = not very important;
95 3= kind of important; 4 = important; 5= definitely include or very important).

96 After the initial round, the research team pulled the results from Qualtrics™ and
97 generated a detailed report that was sent back to each participant, which included the
98 participant's score as well as the group's mean score, standard deviation and level of agreement
99 for each item. Levels of Agreement were assessed for each item based on a method described by
100 de Loe to analyze modified Delphi results.^{29,30} When using this methodology, a high level of
101 agreement occurs when >80% of responses fall on two contiguous points on the 5-point scale,
102 medium level of agreement occurs at 70%-80%, and low level of agreement occurs when there is
103 less than 70%. Following this standard, we rated items as high agreement when >80% of
104 responses were either a 4 or 5, medium agreement when 70-79.99% of responses were either a 4
105 or 5, and low agreement if less than 70% of responses were either a 4 or a 5.

106 Following the first round, results were distributed to each participant as noted above, and
107 the expert panel met to discuss the results of the first round. Members of the panel were allowed
108 to ask questions of other members to explain their scores and ask clarifications about questions.
109 Different viewpoints were shared, and we emphasized discussion on the items with medium
110 agreement and low agreement with high means as these items had potential to achieve high
111 agreement for consensus after the second round.

112 Following the meeting, we then distributed the questionnaire to the expert panel for the
113 second round of the modified Delphi process. The expert panel responded again to the
114 questionnaire via Qualtrics. The data was analyzed using the de Loe method described above to
115 assess mean, standard deviation, and level of agreement, and provided the results to the expert
116 panel during a second meeting. All topics that had a high-level of agreement after the second
117 round were included in the final curriculum. The items that did not achieve high agreement after
118 the second round were excluded from the final curriculum table.

119 **Results**

120
121 The initial list of 178 curriculum elements consisted of 110 background knowledge
122 elements and 68 individual UGRA techniques. The background knowledge elements were
123 categorized by our research team into the following sections: benefits to providers, benefits to

124 patients, risks of UGRA procedures, indications for UGRA procedures, contraindications for
125 UGRA procedures, ultrasound knowledge and skills, equipment and materials, local anesthetics,
126 procedural knowledge, sterile technique, educational resources, and institutional factors. The
127 UGRA technique elements were divided into 4 categories by anatomic region, head/neck, upper
128 extremity, thoracic/lumbar/abdominal, and lower extremity.

129 All of our expert panelists voted in the first round. 117 items achieved low agreement for
130 inclusion in a final curriculum, 17 achieved medium agreement, and 44 had high agreement.
131 These results are available in Supplementary Table 1. During the discussion after the first round,
132 5 elements were revised based on participant comments for clarity from round 1 group
133 discussion, which included compartment syndrome, soft tissue infection, informed consent, local
134 anesthetics, and visualization of needle tip. We also provided the opportunity to add additional
135 items that the expert panel felt might be missing and important to include in a UGRA
136 curriculum. None were added.

137 All panelists then voted in the second round. After the second round of voting, 75 items
138 achieved a high level of agreement for inclusion in UGRA curriculum, 9 items had medium
139 agreement, and 94 had low agreement (results available in Supplementary Table 1). The
140 consensus list of 75 UGRA elements for inclusion in the curriculum is shown in **Table 2**.
141 Consensus was achieved by the expert panel on 65 background knowledge and 10 UGRA
142 technique elements. At least one element from each background category section, and each
143 regional category was included on the final list, with the exception of the “institutional factors”
144 section and the “head/neck” UGRA technique category.

145 **Discussion**

146
147 The expert panel came to consensus on 65 background items and 10 UGRA techniques
148 for a UGRA curriculum. During our panel discussions after each round, many important ideas
149 emerged pertinent to this final list. Importantly, the panel clarified that the inclusion of an
150 element in the final curriculum did not imply the relative importance of that element to others or
151 how much time that element should take to teach in the curriculum. For example, while hand
152 hygiene is a critical and necessary step prior to initiating a procedure, the amount of time spent
153 on teaching this may not be as substantial as time spent on learning and practicing one of the
154 UGRA techniques. Panelists also agreed that learners may enter into the curriculum with

155 previous knowledge of one or more of the elements and may not need additional instruction in
156 those areas. For example, identification of different types of tissues using ultrasound.
157 Additionally, there are items that were not included in the curriculum that panelists discussed as
158 important prerequisites to enter into a UGRA curriculum. For example, the ability to track a
159 needle using ultrasound is considered a prerequisite and was not included on our list as a skill
160 that would be taught in this curriculum.

161 After the second round was complete the expert panelists assembled again to discuss
162 results. It was noted that the consensus list contained far more background knowledge elements
163 than UGRA techniques (65 compared to 10 respectively). The group again emphasized that the
164 list did not prescribe the relative importance of each element, but rather that learners should have
165 knowledge of each of these elements at the time they would complete a curriculum in UGRA.
166 While there is heavy emphasis on background knowledge, this is appropriate given the
167 introductory nature of the proposed curriculum. Additionally, building a foundational knowledge
168 of UGRA could be applied to a wide array of UGRA techniques not included on the consensus
169 list for this curriculum. Despite only 10 of 60 UGRA techniques being included in the consensus
170 list, more techniques could be added to a curriculum without a need to add additional
171 background knowledge elements, and this provides the groundwork for the development of more
172 advanced UGRA courses in the future.

173 There were some items that were absent from the final list due to less than high level of
174 agreement despite having a high mean. For example, the “Vascular injury and bleeding” element
175 from the “Risks of UGRA procedures” was omitted from the final consensus list despite having a
176 mean of 4.08. Upon discussion with the panelists, it was felt that elements elsewhere, like
177 “Recognizing appearance of blood vessels” in the “Ultrasound Knowledge and Skills”
178 subsection provided sufficient emphasis to address this topic. Similarly, “Billing for UGRA
179 Procedures” in the “Procedural knowledge” subsection had a mean of 3.85 but did not make the
180 consensus list. Panelists noted that the “Documentation requirements” element from the same
181 subsection was included and this was sufficient. The “Sterile field” element from the “Sterile
182 technique” subsection was also not included despite a mean of 3.92. There was substantial
183 disagreement among the panelists that a sterile field including a sterile drape should be used for
184 every UGRA procedure. None of the elements in the “Institutional factors” subsection made the
185 consensus list, although the “Interdepartmental politics” element scored a mean of 3.85. Several

186 panelists felt that this section contained elements outside the scope of an introductory
187 curriculum. There were no elements in the “UGRA techniques” section that scored above a mean
188 of 3.80 and were not included in the consensus list.

189 Future work could develop new curricula to expand on the list of UGRA procedures. A
190 list of UGRA procedures could be selected after completion of an introductory curriculum and
191 adapted to an institution depending on the needs of the patients at that institution. In this way, a
192 learner could progress through more advanced training by adding additional UGRA techniques.
193 After implementation, learner outcomes such as assessment of procedural competency and
194 development of a procedural competency assessment tool would be useful for measuring the
195 success of the course. Additional work could also measure patient outcomes such as the number
196 of patients who undergo blocks after the training curriculum is implemented, and then measure
197 perceived pain as well as potentially the reduction of opiate use. Ideally, provider comfort and
198 competency would be assessed as well as patient reported efficacy of the procedure and patient
199 safety data.

200 **Limitations**

201

202 Despite a thorough search of the literature with the help of a librarian, the list of
203 curriculum elements voted on by the panel may not have been exhaustive. We did not include
204 sources such as online blogs that sometimes have novel techniques that could be useful for this
205 course. We attempted to mitigate this by giving panelists the opportunity to suggest additions to
206 the list during the round 1 discussion.

207 There are also inherent limitations to the use of a Delphi panel with regard to bias. We
208 attempted to ensure the panel was composed of a large number of individuals from diverse
209 geographic locations, practice environments, and roles within their institutions to allow for
210 diverse opinions. However, the opinions of our panel may not be representative of all EM
211 physicians in the United States given they have may have different levels of experience with
212 UGRA. Further, our panel consisted of ultrasound faculty members and did not include trainees,
213 program directors, department chairs, or others who may have interest in the training of their
214 faculty and residents.

215 This study represents an initial determination of curriculum elements for introductory
216 instruction in UGRA for EM physicians. Our list requires further validation and feasibility

217 testing, possibly through development of individual training curricula as well as input from
218 learners. The curriculum elements were intended for learners at all levels of experience in
219 UGRA, however may need adjustments for an optimal training experience at a particular level of
220 experience.

221 There may be barriers to implementation of a curriculum containing these elements
222 depending on individual practice environments. There may be limitations on the types of UGRA
223 procedures performed in the ED based on EM physician privileges, EM experience with these
224 techniques, or institutional guidelines. Emergency department and hospital leadership may not be
225 supportive of all UGRA procedures in this curriculum being performed by EM physicians. But,
226 having an established training program in UGRA with a record of safety may aid in expanding
227 the scope of practice in these scenarios.

228 **Conclusions**

229

230 This study found consensus support by point-of-care ultrasound experts for the
231 components of a curriculum in UGRA for EM physicians. This list emphasized the importance
232 of background knowledge elements to build a strong foundation of knowledge in UGRA.
233 Implementation of a curriculum containing these elements would place patient safety at the
234 forefront and may have additional benefits such as reduction of opiate use. The consensus list
235 includes 10 UGRA techniques most likely to be useful to EM practice. The findings of our study
236 can be used by training programs to develop curricula that meet the needs of EM physicians as
237 well as other providers at all levels of experience with UGRA. These elements can serve as a
238 guide for each institution to tailor their curriculum to match their practice environment and
239 ensure their patients receive the many benefits of UGRA.

240

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Author

Table 1: Expert Panelist Demographics

	Female	Male		
Gender	7	6		
	Mean	Range		
Years of Faculty Experience	8	1 - 18		
	Academic	Community	County	Multi-Site
Practice Type	8	1	3	1
	East	Midwest	South	West
Geographic Region	3	4	3	3

Table 2: Consensus Curriculum Elements

Author Manuscript

I. Background Knowledge
1. Patient Benefits
<ul style="list-style-type: none"> a. Decrease opioid medication use b. Avoid risks of opioid pain medications c. Avoid risks of procedural sedation d. Pain relief e. Decrease disease complications like pneumonia
2. Provider Benefits
<ul style="list-style-type: none"> a. Relieving pain for patient b. Develop needle tracking skills
3. Risks
<ul style="list-style-type: none"> a. Intravascular injection b. Intraneural injection c. Allergy to anesthetic d. Phrenic nerve blockade e. Importance of continuous monitoring f. Recognize signs of local anesthetic systemic toxicity g. Management of local anesthetic systemic toxicity h. Indications for use of Intralipid i. Dosing of Intralipid
4. Indications
<ul style="list-style-type: none"> a. Fracture and Dislocation Reduction b. Laceration Repair c. Facilitation of procedures d. Pain control
5. Contraindications
<ul style="list-style-type: none"> a. Abnormal neurovascular examination b. Risk of compartment syndrome

<ul style="list-style-type: none"> c. History of allergy to local anesthetics d. Presence of soft tissue infection
6. Local Anesthetics
<ul style="list-style-type: none"> a. Weight based dosing b. Calculation of maximum allowable dose c. Pediatric specific dosing d. Properties of ropivacaine e. Properties of bupivacaine f. Properties of lidocaine g. Use of epinephrine
7. Sterile Technique
<ul style="list-style-type: none"> a. Skin sterilization b. Use of sterile gloves c. Use of ultrasound probe cover
8. Ultrasound Skills
<ul style="list-style-type: none"> a. Probe selection b. Depth c. Gain d. Appearance of nerve tissue e. Appearance of muscle tissue f. Appearance of adipose tissue g. Appearance of blood vessels h. Appearance of fascial planes i. Anisotropy j. Reverberation artifact k. Probe manipulation l. In and out of plane needle tracking techniques m. Hydrodissection technique
9. Procedural Skills

<ul style="list-style-type: none"> a. Identification of anatomical structures b. Optimal patient positioning c. Informed consent process d. Discussion with consultants e. Documentation of complete neurovascular examination f. Placing patient on continuous monitoring g. Needle trajectory h. Knowing the risk and severity of complications i. Knowing how to manage complications j. Performing repeat neurovascular examination after procedure k. Knowing documentation requirements
10. Educational Resources
<ul style="list-style-type: none"> a. Organizational guidelines b. Landmark studies c. Use of phantoms
II. Ultrasound Guided Regional Anesthesia Techniques
1. Upper Extremity
<ul style="list-style-type: none"> a. Interscalene brachial plexus block b. Supraclavicular brachial plexus block c. Radial nerve block at the level of the forearm d. Median nerve block at the level of the forearm e. Ulnar nerve block at the level of the forearm
2. Thoracic, Lumbar, and Abdominal
<ul style="list-style-type: none"> a. Serratus anterior plane block
3. Lower Extremity
<ul style="list-style-type: none"> a. Fascia iliaca plane block b. Femoral nerve block c. Popliteal sciatic nerve block d. Posterior tibial nerve block