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ORIGINAL RESEARCH

## Evaluation and Analysis of Fellow Learning and Education Curriculum in a Regional Anesthesiology and Acute Pain Medicine Fellowship: A Prospective, Observational Pilot Study

MACIEJ Z. KLOSOWSKI, MD

NICHOLAS J. SCHOTT, MD

### INTRODUCTION

Regional anesthesiology and acute pain medicine (RAAPM) has been an integral component of resident education in anesthesiology residencies throughout this country for the last several decades. Starting in 2017, the Accreditation Council for Graduate Medical Education (ACGME) officially recognized and accredited RAAPM as a fellowship subspecialty of anesthesiology.<sup>1</sup> Since that recent time, several programs have been accredited and several curriculums have been developed to meet the ACGME's medical knowledge requirements. Although the ACGME will periodically review a program and its educational curriculum, there is a paucity of literature investigating how effective or efficient these didactic curriculums are in delivering the core required medical knowledge. Formally, no studies assessing the *best* or *ideal* organization of an educational didactic curriculum for RAAPM have been published. Furthermore, it is important to note that there is no formal exam that has been mandated following fellowship completion in RAAPM.

To address this gap in the literature, a prospective observational study of the RAAPM fellowship at UPMC (University of Pittsburgh Medical Center) was conducted from 2020-2021. As part of the existing curriculum, fellows are administered an 89-question, multiple-choice examination at orientation and again at 4 months and 8 months into

their fellowship year. This prospective, observational pilot study comprised a secondary analysis of the fellows' answers to elucidate how quickly fellows learn the core ACGME-required medical knowledge for RAAPM. We hypothesized that there is a time point where a *plateau* of a learning curve plot occurs during the fellowship year. Furthermore, the study aimed to use the data to evaluate the existing educational didactic curriculum and determine if any modifications or improvements are needed.

### MATERIALS AND METHODS

Approval for a secondary analysis study was granted by the Institutional Review Board at the University of Pittsburgh (#STUDY20040023). The UPMC RAAPM fellowship is one the largest ACGME-accredited fellowships in the United States. At this institution, 15 fellows are typically accepted per academic year. During their fellowship year, fellows typically attend 1 mandatory lecture per week in addition to 1 problem-based learning didactic and 1 grand rounds lecture per month. The didactic lecture topics are typically presented by one of the RAAPM faculty determined the year prior. Problem-based learning didactic topics and grand rounds are RAAPM-specific and lead by one of the RAAPM faculty members as well. In addition to these classroom lectures, fellows also participate in a hands-on workshop early in the academic year, in addition to a hands-on cadaver lab dissection. At graduation, fellows will have typically performed 700 to 1100 peripheral nerve

blocks at 9 different hospitals or health care settings. All fellows work at each of the 9 sites, however some may spend an extra month at one of the larger call-taking sites compared to the others. Majority of the fellows start the academic year in July while the remainder of the class start in August.

As part of the existing educational curriculum, an 89-question, multiple-choice examination was created using questions and answers provided by the American Society of Regional Anesthesia and Pain Medicine fellowship portal.<sup>2</sup> This open-source multiple choice exam was created by various RAAPM faculty throughout the country and edited by members of the society. This was the first time this multiple-choice examination was administered to the UPMC RAAPM fellows. The quizzes were printed and administered during protected time in place of a scheduled lecture in the lecture classroom and proctored by the fellowship program coordinator. Afterward, the examinations were graded by the fellowship program coordinator. To ensure that the multiple-choice examination was a valid tool to assess the fellows' medical knowledge, each question was mapped out to a specific mandatory medical knowledge requirement as determined by the ACGME (Table 1 and Table 2). The same exam was administered on orientation day and at 4 months and then 8 months into the fellowship year. After completion of the final examination at 8 months, each fellow's

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answers were collected in an anonymous and deidentified manner. Regarding statistical analysis, the cumulative average score for the orientation, 4-month, and 8-month examinations were calculated using Microsoft Excel (Microsoft, Redmond, Washington). The standard deviation of the averages of all the fellows for the orientation, 4-month, and 8-month examinations were also calculated using Microsoft Excel.

The inclusion criterion for this study was fellows who completed all 3 examinations. The exclusion criterion was fellows who did not complete all 3 exams (due to illness, maternity leave, etc). The primary outcome of this secondary analysis was individual fellows' average score on each examination. A secondary outcome was analysis of individual topics as mandated by the ACGME. This was achieved by mapping each individual examination question to specific medical knowledge topics that fellows are required to learn in an ACGME-approved RAAPM fellowship. This was then used to identify which topics were commonly answered correct or incorrectly.

## RESULTS

Fifteen fellows were included in this study. The fellowship class represents a diverse group of trainees from around the country. In this class, 3 fellows completed their residency training at the same institution of the RAAPM fellowship. Demographics otherwise were diverse with varying training institutions from around the country representing a broad background of anesthesiology residency training. Fellows got averages of 64% ( $n = 15$  SD  $\pm 7.4$ ), 74% ( $n = 15$  SD  $\pm 9.8$ ), and 79% ( $n = 15$  SD  $\pm 12.2$ ) correct responses on the orientation, 4-month, and 8-month examinations, respectively (Figures 1 and 2). All 15 fellows of the RAAPM class completed the orientation, 4-month, and 8-month examinations. An analysis of each individual ACGME-mandated medical knowledge requirement revealed that the topic with the lowest percent of correct responses (defined as less than 33% of fellows answering correctly) for the orientation exam and 4-month exam were lower extremity nerve blocks, truncal blocks, and neuraxial anesthesia. No topics

had less than 33% correct responses on the 8-month exam except for 1 question regarding identification of a lower extremity nerve block location based on an ultrasonographic image. Questions with 100% correct response rates across all 3 exams focused on local anesthetic pharmacology as well as systemic opioid pharmacology. All fellows in the RAAPM class completed all 3 examinations, and none were excluded from the study.

## DISCUSSION

The aim of this study was to elucidate how quickly RAAPM fellows learn the core medical knowledge topics as required by the ACGME. The results of this study demonstrate that there is significant improvement from orientation to 4 months into the fellowship. The improvement continues to 8 months, albeit to a lesser degree (74% correct average vs 79% correct average). Comparing the 4-month to the 8-month scores, a *plateau* appears to have been reached, as there was only a 5% increase in the average score compared to a 10% average increase in scores from orientation to 4 months into the fellowship year. This suggests that the greatest amount of learning tends to occur in the first half of the fellowship year and that there may be a *plateau* of learning for RAAPM fellows (Figure 2). A final, fourth exam was considered around the time of graduation. However, because we reviewed the exam with our fellows for educational purposes, a fourth exam was not given.

A review of the currently available literature revealed that extensive research has been conducted on the evaluation of knowledge acquisition as a function of a curriculum. Some of these studies looked at the impact of forming a new curriculum and comparing it to an older, preexisting one and determining whether there was increased knowledge acquisition via a multiple-choice test.<sup>3-5</sup> These studies were able to demonstrate an increase in knowledge acquisition by demonstrating improved pre vs post multiple choice examination scores. Other studies evaluated the impact of introducing a new curriculum or restructuring an existing didactic schedule and evaluating their respective impacts on knowledge acquisition via an analysis of a nationally administered in-training examination.<sup>6,7</sup>

In addition to these studies, other investigators have researched the impact of how a curriculum is delivered and its effect on knowledge acquisition. Examples include an analysis of whether a *flipped-classroom* approach to adult education improves knowledge acquisition or whether an interactive case-based module compared to a traditional textbook module has any impact on knowledge acquisition.<sup>8,9</sup>

All the aforementioned studies involved modifications of curriculums or how the curriculum was delivered, but it is also important to examine what factors can affect knowledge acquisition. McDonald et al retrospectively evaluated the association of knowledge acquisition with different factors such as conference attendance or self-directed daily reading of an electronic educational resource.<sup>10</sup> Some of their interesting conclusions were that 20 minutes of self-directed daily reading of an educational electronic program such as UpToDate could increase in-training examination (ITE) scores by the same magnitude as an entire year of residency training.

These studies show that knowledge acquisition has been extensively studied as a function of an educational curriculum; however, fewer studies have investigated the association of knowledge acquisition as a function of medical training or experience. A cross-sectional study by Williams et al evaluated medical students' acquisition of diagnostic pattern recognition and clinical data interpretation abilities as a function of 0, 1, 2, and 3 years of medical education.<sup>11</sup> Researchers found an upward growth of these abilities that leveled off in year 3. This study shows that it is possible to evaluate knowledge acquisition longitudinally as a function of time.

Further supporting this claim, a study by Zhou et al published in 2018 specifically looked at the rate of knowledge acquisition for anesthesiology residents as a function of the newly introduced staged examinations for primary certification.<sup>12</sup> These researchers found an accelerated rate of knowledge acquisition over time after the introduction of the BASIC examination as compared to when the BASIC and advanced examinations were combined and

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administered after completion of residency. Although this study showed a temporal association of learning, the populations in question were anesthesiology residents and not fellows.

Upon evaluating each individual topic in this study, it was apparent that lower extremity nerve blocks, truncal blocks, and neuraxial anesthesia seemed to be a common area of knowledge deficiency in our study population in the beginning of the fellowship year. This may be related to the fact that according to the educational didactic schedule, these topics are covered later in the year. One question regarding ultrasound image interpretation for a common adductor block was answered correctly by <33% fellows. Upon reviewing the question and answer, this was likely due to open interpretation of at which level the image was obtained and not because this is a rare block. This is perhaps one of the most common blocks performed in this fellowship. A lack of expertise in these regional anesthesia topics is likely why a resident would seek a RAAPM fellowship.

The core didactic curriculum was based on encouraging a growing experience and competence in the subspecialty. Core, science, and lecture-based sessions were implemented early in the academic year. As the curriculum advanced, more medical literature sessions and problem-based learning discussions were added to the curriculum. These latter categories were intended to emphasize and apply knowledge obtained toward expertise in practice as opposed to learning new, unseen topics. This was based on the ACGME Milestones approach to fellow education.<sup>13</sup> It is also important to note that no changes in the curriculum were made during this study given the results were not analyzed until after the examinations were administered. The results of this study would be used to implement changes in the future didactic curriculum. It may also be interesting to study the effect of a daily multiple-choice question sent to each fellow and its impact on knowledge retention and acquisition.

Although this study did demonstrate a *plateau* of learning for RAAPM fellows, the study had several limitations. First, this study used the same multiple choice

examination questions for each time point in the fellowship. This significantly increases the chance that recall bias may have an effect on the results of the later examinations. Furthermore, these are *open access* questions that are available online (answers however are not readily available) where a fellow could theoretically review the exam at some point. A possible solution to this limitation in future studies would be developing a multiple-choice question bank with enough questions so that each topic would be covered for all examinations without repetition. A second limitation is the relatively small sample size and diverse pool of fellows with various anesthesia training backgrounds. Although the UPMC RAAPM fellowship is one of the largest programs in the country, to truly determine if 4 months is the time point when fellows reach a *plateau* of learning, this study would need to be repeated for several other programs to increase the sample size as well as pool data annually. Given our limited sample size of 15 fellows each year, we plan to continually collect the data and see if there is a plateauing effect of the subsequent classes. This could be combined into a pooled data set. This may introduce bias as the curricula adapts annually based on gaps of knowledge which may vary from class to class. Orientation test scores may be able to be assessed, yet 4-month and 8-month data may be inaccurate when pooled. Additionally, introducing the exam to other ACGME accredited programs with similar requirements could give more data, especially for baseline knowledge.

Given that there is no standardized RAAPM curriculum, multiple choice question bank, or formal examination, it forces individual fellowship programs to formalize their own curricula, which requires a significant time and monetary commitment. This relatively easy assessment tool can be used to modify future didactic curriculums. For example, in this fellowship, topics such as truncal blocks, lower extremity blocks, and neuraxial anesthesia can be given earlier in the academic year and less time can be spent on local anesthetic pharmacology and systemic opioids. Some topics are learned in residency, and more advanced topics should be given more attention. Other programs may use this study method to identify areas, if any, that are lacking in their educational didactic curriculum.

We hope that other programs will be able to provide a more efficient and effective didactic educational curriculum tailored specifically to their program's weaknesses and strengths by using a similar approach to evaluate the quality of their current didactic educational curriculum. Furthermore, this method could also be applied to non-ACGME RAAPM fellowship programs and even anesthesiology residency programs to improve their overall didactic curriculums.

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**Maciej Z. Klosowski** is a 2020-2021 Regional Anesthesiology and Acute Pain Medicine fellow in the Department of Anesthesiology and Perioperative Medicine, University of Pittsburgh Medical Center, Pittsburgh, PA. **Nicholas J. Schott** is an Assistant Professor and Site Director in the Division of Acute Pain and Regional Anesthesia, University of Pittsburgh Medical Center Magee-Womens Hospital and also a Program Director for the Regional Anesthesiology and Acute Pain Medicine Fellowship, Department of Anesthesiology and Perioperative Medicine, University of Pittsburgh Medical Center, Pittsburgh, PA.

**Corresponding author:** Nicholas J. Schott, MD, UPMC Department of Anesthesiology and Perioperative Medicine, Kaufmann Medical Building, 3471 Fifth Avenue, Suite 402, Pittsburgh, PA 15213. Telephone (412) 692-4572, Fax: (412) 692-4572

**Email address:** Nicholas J. Schott: [schottnj@upmc.edu](mailto:schottnj@upmc.edu)

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#### Abstract

**Background:** Since 2017, several regional anesthesiology and acute pain medicine fellowship programs throughout the country have developed various educational didactic curriculums to address the core medical knowledge requirements as set by the Accreditation Council for Graduate Medical Education. Given the paucity of existing literature regarding the medical knowledge acquisition of regional anesthesiology and acute pain medicine fellows, this study aimed to determine how quickly these fellows learn during their fellowship year, with a secondary aim of analyzing a new educational didactic curriculum in its goal of delivering the required medical knowledge.

**Methods:** An 89-question, multiple-choice examination was administered to the 2020-2021 regional anesthesiology and acute pain medicine fellows at the University of Pittsburgh Medical Center during orientation and again at 4 months and 8 months into the fellowship. A secondary analysis of anonymous deidentified answers was completed.

**Results:** Fellows averaged 64%, 74%, and 79% correct responses on the orientation, 4-month, and 8-month exams, respectively. An analysis of the orientation exam revealed that the most commonly incorrect answers stemmed from topics including lower extremity nerve blocks, truncal blocks, and neuraxial anesthesia. The 4-month exam showed overall marked improvement; however, truncal blocks remained the most missed topic. Topics with 100% correct response rates in all examinations were local anesthetic pharmacology and systemic opioids.

**Conclusions:** The results of this study indicate that a large portion of learning occurs during the first 4 months of the fellowship and slows thereafter. Using this simple form of fellowship evaluation, changes to an educational didactic curriculum can be implemented to reach medical knowledge goals more effectively and efficiently as required by the Accreditation Council for Graduate Medical Education.

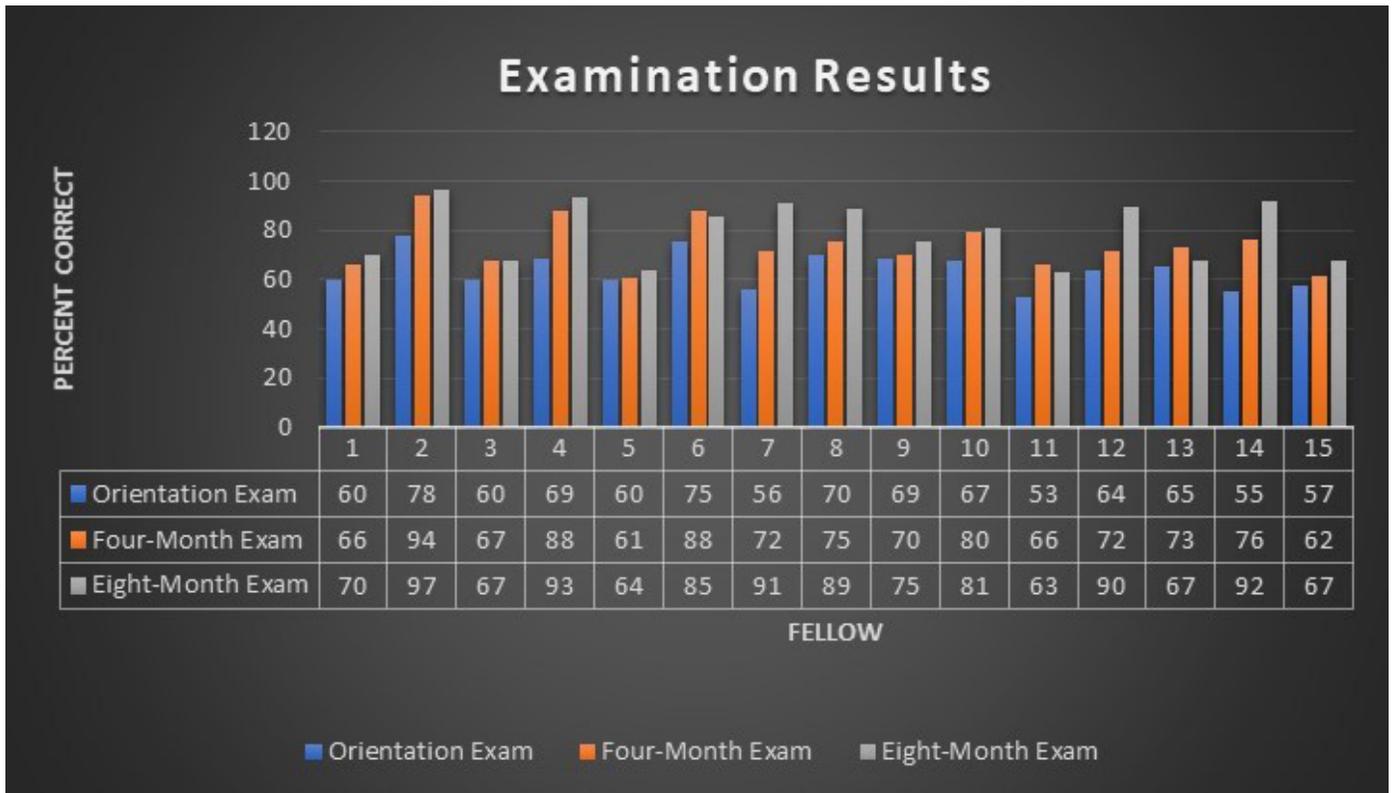
**Keywords:** Fellowships, curriculum, medical education, anesthesiology, regional anesthesiology, acute pain medicine

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# Figures

Figure 1. Percent correct response for each examination for each individual fellow.

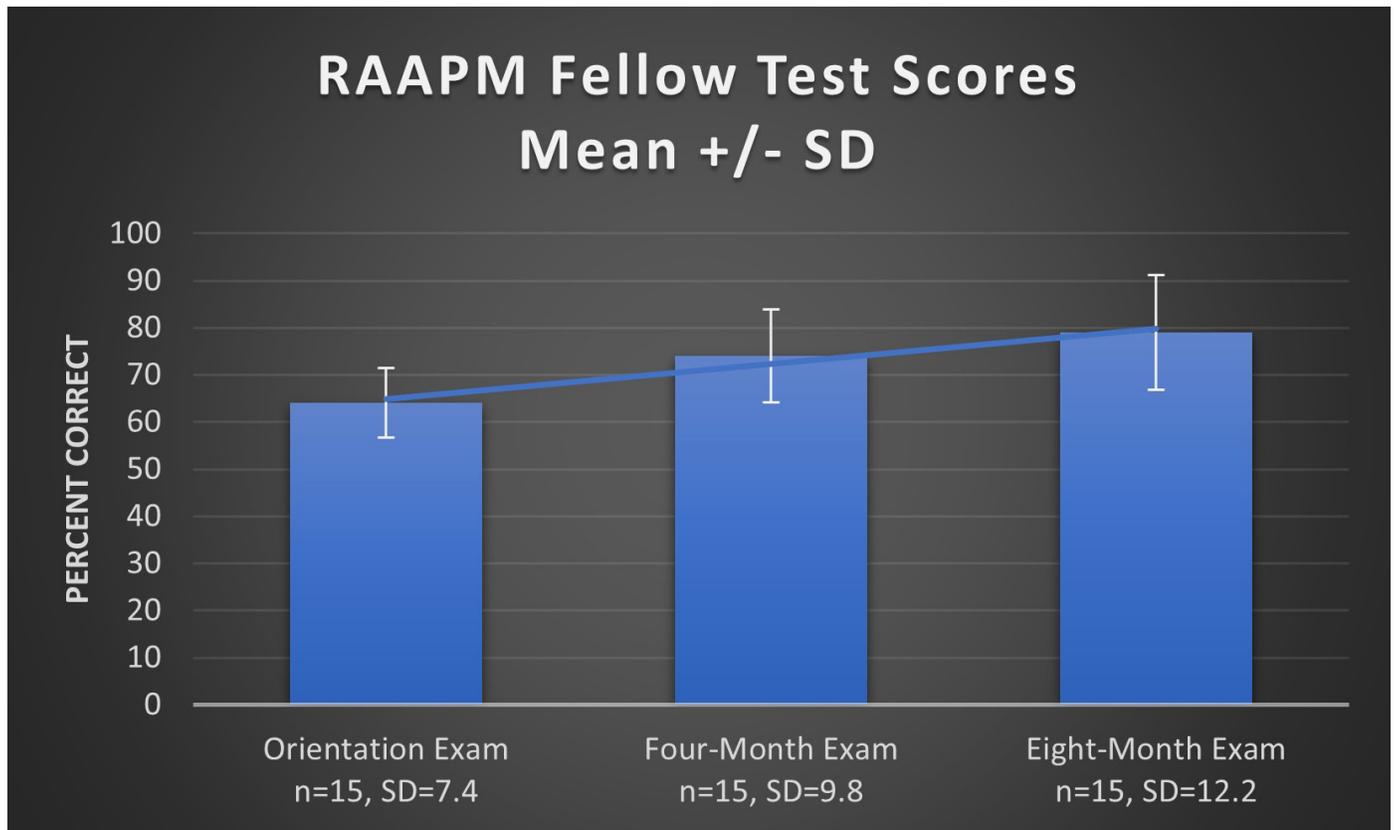


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## Figures continued

Figure 2. Correct response percentages with standard deviations for all fellows for the orientation exam, 4-month exam, and 8-month exam.



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## Tables

**Table 1.** General Medical Knowledge Topic Requirements per the ACGME Requirements for Graduate Medical Education in Regional Anesthesiology and Acute Pain Medicine.<sup>14</sup>

<b>Fellows must demonstrate knowledge of anatomy and clinical pharmacology including:</b>
Central Neuraxial and Peripheral Nerve Anatomy
Local Anesthetic Pharmacology
Neuraxial Opioids
Systemic Opioids
Non-Opioid Analgesia
<b>Fellows must demonstrate knowledge of regional anesthesia techniques, including:</b>
Nerve Localization Techniques
Spinal Anesthesia
Epidural Anesthesia (Lumbar and Thoracic)
Upper Extremity Nerve Blocks
Lower Extremity Nerve Blocks
Truncal Blocks
Intravenous Regional Anesthesia
Complications of Regional Anesthesia and Acute Pain Medicine

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## Tables continued

**Table 2.** Mapping of each individual multiple choice examination question to specific medical knowledge topics as required by the ACGME.

Question	Topic
1	Central Neuraxial Nerve Anatomy, Complications
2	Local Anesthetic Pharmacology
3	Local Anesthetic Pharmacology
4	Local Anesthetic Pharmacology
5	Local Anesthetic Pharmacology
6	Local Anesthetic Pharmacology, Complications
7	Complications
8	Spinal Anesthesia, Complications
9	Spinal Anesthesia, Complications
10	Spinal Anesthesia, Complications
11	Local Anesthetic Pharmacology
12	Neuraxial Opioids
13	Neuraxial Opioids
14	Neuraxial Opioids
15	Systemic Opioids, Chronic Pain
16	Systemic Opioids, Chronic Pain
17	Systemic Opioids, Chronic Pain
18	Systemic Opioids, Chronic Pain
19	Systemic Opioids
20	Nonopioid Analgesics
21	Nonopioid Analgesics
22	Nonopioid Analgesics
23	Nonopioid Analgesics
24	Nonopioid Analgesics
25	Nerve Localization Techniques
26	Nerve Localization Techniques
27	Ultrasound - Not Medical Knowledge Requirement
28	Spinal Anesthesia, Local Anesthetic Pharmacology
29	Epidural Anesthesia, Complications
30	Epidural Anesthesia, Complications
31	Epidural Anesthesia
32	Truncal Block
33	Epidural Anesthesia

Question	Topic
34	Epidural Anesthesia
35	Spinal Anesthesia, Complications
36	Spinal, Epidural
37	Upper Extremity Nerve Block
38	Upper Extremity Nerve Block, Complications
39	Nonopioid Analgesics
40	Lower Extremity Nerve Block
41	Lower Extremity Nerve Block
42	Lower Extremity Nerve Block
43	Lower Extremity Nerve Block
44	Lower Extremity Nerve Block
45	Lower Extremity Nerve Block, Nerve Localization Techniques
46	Lower Extremity Nerve Block
47	Lower Extremity Nerve Block
48	Truncal Block
49	Truncal Block
50	Truncal Block
51	Truncal Block
52	Truncal Block
53	Truncal Block
54	Truncal Block
55	Truncal Block
56	Intravenous Regional Anesthesia
57	Epidural, Complications
58	Complications
59	Complications
60	Spinal Anesthesia
61	Lower Extremity Nerve Block, Complications
62	Complications
63	Lower Extremity Nerve Block, Complications
64	Upper Extremity Nerve Block, Complications
65	Complications
66	Epidural Anesthesia

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## Tables continued

**Table 2 cont.** Mapping of each individual multiple choice examination question to specific medical knowledge topics as required by the ACGME.

Question	Topic
67	Complications
68	Ultrasound - Not a Medical Knowledge Topic Requirement
69	Neuraxial Opioids
70	Lower Extremity Nerve Block
71	Complications
72	Lower Extremity Nerve Block
73	Truncal Block
74	Chronic Pain, Complications
75	Local Anesthetic Pharmacology, Complications
76	Complications
77	Spinal Anesthesia, Epidural Anesthesia
78	Truncal Block
79	Complications
80	Lower Extremity Nerve Block
81	Systemic Opioids, Complications
82	Lower Extremity Nerve Block, Peripheral Nerve Anatomy
83	Epidural Anesthesia
84	Complications
85	Truncal Block
86	Local Anesthetic Pharmacology
87	Nerve Localization Techniques
88	Epidural Anesthesia
89	Chronic Pain