

# IMPROVED RESIDENTS' KNOWLEDGE AFTER AN ADVANCED REGIONAL ANESTHESIA EDUCATION PROGRAM

VICENTE GARCIA-TOMAS\*, DEBORAH SCHWENDEL\*,  
JEAN-PIERRE P. OUANES\*\*, SARAH HALL\*  
AND MARIE N. HANNA\*

## Abstract

**Background:** Although residents in anesthesia are confident in performing neuraxial anesthesia, many are not confident in performing peripheral nerve blocks. The purpose of this study was to evaluate the effectiveness of a structured regional anesthesia teaching program in a large academic medical center.

**Methods:** Residents participated in regional anesthesia didactics that took place in a unique resident education program scheduled during two fully protected teaching days a month. The curriculum included hands-on cadaver workshops in the anatomy lab, hands-on ultrasound workshops, hands-on nerve stimulator and surface anatomy workshops, and simulator sessions related to complications of regional anesthesia. Before beginning the formal regional anesthesia teaching program, residents completed a pretest composed of 25 multiple choice questions (MCQ) and a three-section observed standardized clinical examination (OSCE). Seven months later, approximately 1 month after completion of the regional anesthesia curriculum, the residents were evaluated again with the exact same tests. Pretest and post-test results for both the MCQ and the OSCE were compared by using a paired t-test for statistical means.

**Results:** Post-test results were significantly improved ( $P < 0.05$ ) across all clinical anesthesia (CA) years and for both the MCQ and OSCE examinations. Post-test results were also significantly improved ( $P < 0.05$ ) across all CA years for each of the three sections of the OSCE.

**Conclusion:** The formal regional anesthesia teaching program developed by the departmental faculty was effective in improving resident knowledge.

**Conflict of Interest:** None.

---

\* MD.

\*\* DO.

Affiliation: Department of Anesthesiology and Critical Care Medicine, the Johns Hopkins University School of Medicine, Baltimore, Maryland.

**Corresponding author:** Dr. Marie N. Hanna. Associate Professor, Department of Anesthesiology, Johns Hopkins University 600 N. Wolfe Street, Carnegie 280, Baltimore, MD 21287. Tel: (410) 955-5608, Fax: (410) 614-1796. E-mail: mhanna9@jhmi.edu

## Introduction

As the need for adequate postoperative pain control has increased tremendously in the past few decades, the need to incorporate regional anesthesia as part of multimodal analgesia has become a necessity<sup>1-3</sup>. Consequently, regional anesthesia training has been identified as an area for improvement in resident education<sup>4</sup>. The paradigm in anesthesia medical education has evolved from an apprenticeship model to a competency-based training model. Recently, recommendations for education and training in ultrasound-guided regional anesthesia (UGRA) were established through a joint committee effort of the American Society of Regional Anesthesia and the European Society of Regional Anesthesia<sup>5</sup>.

The Accreditation Council for Graduate Medical Education (ACGME) has established a set of core competencies to promote the training of capable physician specialists that includes the minimum number of regional anesthesia procedures required to graduate from a residency training program<sup>6</sup>. In recognition of these needs, many anesthesia training programs are improving their teaching modules in regional anesthesia and acute pain management<sup>7-9</sup>.

Our institution's educational curriculum has evolved from a traditional to an interactive model that incorporates the six ACGME core competencies. Traditional teaching took the form of didactic lectures in regional anesthesia and one anatomy workshop every year. Starting in August 2009, we began to divide our residents into small groups, or colleges, that meet during two protected academic days per month in a program termed "college days." Interactive teaching during college days includes simulation sessions; hands-on workshops; small learning groups; quality improvement projects; oral and written board exam practice; journal clubs; and training sessions in ethics, business, communications, fatigue-impairment, and conflict resolution. The Division of Regional Anesthesia and Pain Management redesigned its educational program to an interactive advanced regional anesthesia program (ARAP) based on the ACGME core competencies and incorporated the program into the residents' college days. The instructors tested its utility on a cohort of residents using a

validated tool to measure the residents' knowledge in regional anesthesia and pain medicine before and after the curriculum change. Skills and knowledge were tested by an objective, structured clinical examination (OSCE). OSCEs used in the published medical literature have been well validated<sup>10-14</sup>.

We have demonstrated previously that a short, structured regional anesthesia course given to fourth-year medical students improves their knowledge and skills in regional anesthesia and pain management<sup>15</sup>. Similar education efforts through ARAP are required to improve anesthesia residents' knowledge and skills in regional anesthesia and postoperative pain management. The purpose of this study was to evaluate whether an ARAP that uses innovative and interactive methods improves anesthesia residents' knowledge and skills in regional anesthesia and postoperative pain management as compared to the previous traditional teaching method.

## Methods

Institutional review board (IRB) exemption was obtained before initiation of the study. Anesthesiologists at Johns Hopkins developed an advanced regional anesthesia education program that was based on the ACGME core competencies and included interactive modalities. The revised regional anesthesia teaching program was conducted over a 6-month period as part of the residents' college program. Before the beginning of the ARAP, all residents answered multiple-choice questions (MCQs; Fig. 1) and an OSCE (Fig. 2). The OSCE was given by four regional anesthesia faculty members and graded independently. The tests were repeated 7 months later, 1 month after completion of the regional anesthesia teaching program. The content of the questions and OSCE was developed by a group of regional anesthesiologists and agreed upon by consensus. The ARAP was taught to all residents [clinical anesthesia year 1 (CA1), CA2, and CA3] and consisted of: 1) Hands-on anatomy workshops with three stations that demonstrated relevant structures of brachial, lumbar, and sacral plexus. 2) UGRA stations where all residents practiced scanning the upper and lower extremity blocks on live models. 3) Simulation sessions that used high-fidelity mannequins on which

residents practiced different regional anesthesia complication scenarios, such as seizure and cardiac arrest resulting from local anesthetic toxicity and high spinal and postoperative nerve injury. After the scenarios, regional anesthesia faculty provided detailed debriefing. 4) Oral board preparation sessions and nontraditional classroom teaching that used Jeopardy game-show formats and problem-based learning sessions. 5) Journal club sessions in which residents and faculty discussed recent literature and controversies in the field of regional anesthesia and pain management. 6) Problem-based learning or evidence-based practice projects in which residents worked in small groups to identify defects in clinical practice and implement improvement projects (including regional anesthesia and pain management). Before the institution of the college days program, regional anesthesia was taught by a traditional approach that consisted of didactic and Web-based lectures and one anatomy lab workshop per year at which attendance was limited by clinical commitments.

To evaluate the effectiveness of the ARAP, we administered a post-test to the residents that consisted of the same 25 MCQs (Fig. 1) and OSCE (Fig. 2) as those given before the start of the program. The MCQs tested the same concepts as those of the pretest. The OSCE used a patient with significant comorbidities who was scheduled for shoulder arthroplasty. The OSCE was divided into three sections. The first section (OSCE A; questions 1-6) evaluated residents' choices of anesthesia and analgesia and assessed their knowledge of potential regional anesthesia complications. The second section (OSCE B; questions 7A-7F) evaluated residents' knowledge of regional anesthesia techniques, anatomic landmarks, elicited motor response, and local anesthetic choices. In this section the residents were also evaluated on their speed and confidence. The third section (OSCE C; questions 8-11) evaluated residents' knowledge in postoperative pain management and ability to manage postoperative challenges.

In addition, statistical means for pretest and post-test results for each section of the OSCE (A, B, and C) were compared by using a two-tailed paired t-test for dependent samples. Results were also analyzed by level of training. A *P*-value < 0.05 was considered significant for all analyses.

Fig. 1  
Multiple-choice questions.

---

Date: \_\_\_\_\_ CA= \_\_\_\_\_

Resident Name: \_\_\_\_\_

Regional Anesthesia Multiple Choice Questions

**A) Choose the best Answer:**

- Which of the following approaches to the sciatic nerve will most reliably block the posterior aspect of the Thigh?
  - The anterior approach
  - Subgluteal approach
  - Labatt approach
  - Popliteal approach
- For femoral nerve block the end point motor stimulation is?
  - Sartorius muscle contraction
  - Vastus lateralis contraction
  - Vastus medialis contraction
  - Quadriceps muscle contraction
  - Biceps femoris contraction
- ASRA consensus for therapeutic BID dose LMWH?
  - Contraindicate the use of interscalene indwelling catheters
  - Contraindicate the use of femoral indwelling catheters
  - All (A&B)
  - None of the above
- 65 year old male s/p prostatectomy under spinal anesthesia. Next day c/o of severe low back pain radiating down his legs. What is the most likely reason?
  - TNS( Transient neuropathy)
  - Residual motor block
  - Epidural hematoma
  - Epidural abscess
- What is your management if patients referred to in Q=4 have no other symptoms besides Back pain and legs pain?
  - Order an MRI
  - Obtain neurology consultation
  - Order non steroidal anti-inflammatory
  - Order Gabapentine
- Site of action of IVRA( intravenous regional anesthesia)
  - At the nerve axon
  - At the distal Nociceptors
  - By retrograde diffusion of local anesthetics
  - By perfusing the vasa nervorum
- Drug of choice for IVRA (intravenous regional anesthesia)?
  - 1% mepivacaine with epinephrine 1/200k
  - 1% chlorprocaine
  - 0.5% lidocaine with epinephrine 1/200k

- d. 0.5% lidocaine
8. Common complication of Lumbar Plexus block
- Seizure
  - Retroperitoneal hematoma
  - Neuraxial block
  - Psoas abscess
9. Anatomical Landmarks for femoral nerve block are except
- Femoral artery
  - Anterior superior iliac spine
  - Inguinal ligament
  - Quadriceps femoris
  - Inguinal crease
10. Absolute contraindication of infraclavicular block?
- Severe COPD
  - Contralateral hoarseness
  - Ipsilateral congenital Horner syndrome
  - All of the above
  - None of the above
11. Nerve commonly missed in interscalene block
- Median
  - Ulnar
  - Radial
  - Musculocutaneous
12. Reason for adding epinephrine to LA. For nerve blocks
- To prolong the duration of analgesia
  - To detect IV injection
  - To promote density of a block
  - To reduce LA plasma concentration.
  - All of the above
13. Removal of epidural in a patient on BID doses of LMWH
- 12hs after last dose of LMWH.
  - 22hs after last dose of LMWH
  - 28hs after last dose of LMWH
  - 3 days after last dose of LMWH
- K- Type questions:**  
**A ( 1, 2, 3). B (1, 3).C (2, 4).D (4).E (1, 2, 3, 4)**
14. Surgical anesthesia of the ankle could be provided by more than one of the following?
- Blocking the sciatic nerve at the popliteal region
  - Blocking the femoral nerve at the inguinal region
  - Blocking the Saphenous nerve
  - Ankle block
15. Block for surgical anesthesia in ORIF of RT wrist?
- RT interscalene block
  - LT supraclavicular block
  - Rt postcervical block
  - Rt infraclavicular block
16. Common side effects of interscalene block?
- Recurrent laryngeal nerve block
  - Pneumothorax
  - Hemidiaphragmatic paralysis
  - Intravascular injection
17. Nerves commonly missed in Axillary block
- Median nerve
  - Intercostals T1-T2
  - Axillary nerve
  - Musculocutaneous nerve
18. Ropivacaine compared to bupivacaine
- Chemically similar to Bupivacaine
  - Less motor block than Bupivacaine
  - Less cardio toxicity than Bupivacaine
  - Shorter onset than Bupivacaine
19. Peripheral nerve catheters for postoperative pain
- Induction could be with short or long acting LA
  - Maintenance with low conc LA ( 0.2% Ropi)
  - No need to add epinephrine
  - Use multimodal analgesia
20. Subgluteal approach of the sciatic
- Used for below knee procedures
  - Used for thigh procedures
  - Used for Achilles tendon repair procedure
  - Calf muscle contraction when used Nerve Stimulator.
21. Anatomy of Popliteal Sciatic nerve
- The nerve is in the popliteal fossa
  - It consists of 2 separate nerve trunks
  - Division of the nerve 50-100mm above the popliteal crease
  - Peroneal division is larger than Tibial division
22. Only sensory nerves
- Saphenous
  - Lat nerve of the thigh
  - Sural
  - Obturator
23. Combined spinal epidural can be done
- At T10 level
  - In hemiplegic patient
  - On patients taking Ticlid (Ticlopidine)
  - On patients taking aspirin
24. Methadone
- Acts on different receptors than morphine
  - Acts at the NMDA receptors
  - Acts at alpha-2 receptors
  - Available in a long acting IV form.
25. Treatment of PDPH (post dural puncture headache)
- Hydration
  - Epidural blood patch
  - Caffeine
  - Narcotics
-

Fig. 2

Objective structured clinical examination (OSCE).

Date: CA= \_\_\_\_\_ Residents name: \_\_\_\_\_

**Regional Anesthesia and Acute Pain Management OSCE**

**Case**

A 74 year old male 280 lbs (BMI=40) with past medical history of HTN and obstructive sleep apnea scheduled for RT shoulder arthroplasty. Patient and family are concerned about postoperative pain control. Labs are within normal limits. EKG showed sinus rhythm with right bundle branch block. Patient is taking (HCTZ, propranolol and MVI)

1. **What type of anesthetic would you offer to this patient?**

a. G/A - ET tube	5 points	
b. Nerve catheter	5 points	
c. Nerve catheter + G/A	10 points	Max = 10 points
  
2. **Will you use regional anesthesia for this case?**

a. Yes	5 points	
b. No	0 points	Max = 5 points
  
3. **What type of regional anesthesia?**

a. Interscalene catheter	5 points	
b. Brachial plexus catheter	5 points	
c. Brachial plexus block	0 points	Max = 5 points
  
4. **Will you do Brachial Plexus analgesia above or below Clavicle?**

a. Above	5 points	
b. Below	0 points	Max=5 points
  
5. **What are the complications of brachial plexus blocks?**

a. Vascular puncture	2 points	
b. Epidural or intrathecal injections	2 points	
c. Pneumothorax	2 points	
d. Hoarseness (recurrent laryngeal nerve block)	2 points	
e. Ptosis(Horner Syndrome)	2 points	
f. Phrenic nerve paralysis	2 points	Max = 10 points
  
6. **Is there any advantage in placing an interscalene catheter vs. single shot in this case?**

a. Yes	5 points	
b. No	0 points	
c. Why	5 points	Max = 10 points
  
7. **You decide to do an US post interscalene catheter for post operative pain control. Can you position the patient, and show me the landmark?**
  - 7A
  - Patient Position and Sedation**

a. Lateral or semi lateral	2 points	
b. Minimal sedation or 1 mg versed	3 points	Max = 5 points
  - 7B
  - Anatomical Landmarks for NS**

a. Posterior border of sternocleidomastoid	2 points	
b. Interscalene groove between the anterior and middle scalene muscles	2 points	
c. Cricoid cartilage at C6	2 points	Max = 5 points
  - 7C
  - Appropriate NS response**

a. Deltoid muscle contraction (axillary nerve)		
b. Anterior component of arm (musculocutaneous nerve)	2 points	
c. Posterior component of arm (radial nerve)	2 points	
  
- d.
  - 7D
  - Confidence and speed**

a. Confident and fast	5 points	
b. Confident and slow	2 points	
c. Hesitant	0 points	Max = 5 points
  - 7E
  - What type of LA, Conc and Volume will you use as a bolus in this case?**

a. 10 - 30 cc of 0.2% Ropivacaine, 0.25% Bupivacaine, 1% Lidocaine, or 1% Mepivacaine	5 points	
b. Any high conc LA	0 points	Max = 5 points

<b>7F</b>		
<b>What type of LA, Conc and rate will you order for this patient interscalene catheter?</b>		
a. 0.2% Ropivacaine 6/4/20 or 8/3/20	5 points	
b. Any other	0 points	Max = 5 points
<b>8. Does this patient need a monitored bed postoperatively?</b>		
a. Yes	2 points	
b. No	0 points	
c. Why	3 points	Max = 5 points
<b>9. Patient is comfortable in the ICU but complains of hoarseness of his voice. What is the reason for hoarseness?</b>		
a. Recurrent laryngeal nerve block	5 points	Max = 5 points
<b>10. What is the treatment of hoarseness in this situation?</b>		
a. Reassurance	5 points	Max = 5 points
<b>11. Next morning surgeons asked you to remove the catheter so they can start the patient on lovenox (enoxaparin) 40 mg SC. BID. Will you remove the catheter?</b>		
a. Yes	0 points	
b. No	5 points	
c. Why	5 points	Max = 10 points
		<b>Total Points = 100</b>

OSCE A= Questions 1-6

OSCE B= Questions 7A-7F

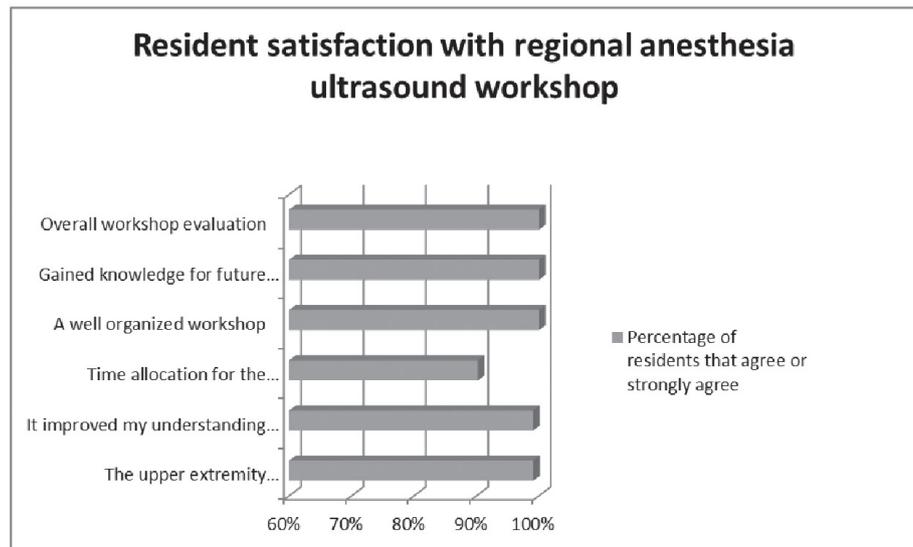
OSCE C= Questions 8-11

All testing materials were identical for the pretest and post-test, except that the post-test included five additional MCQs to further evaluate the residents' pain management knowledge (MCQ 26-30). These extra questions were not included in the statistical analysis. Only residents who completed both pre- and post-tests were included in the analyses.

Additionally, the residents anonymously

evaluated the anatomy and ultrasound workshops (Fig. 3). Responses to questions relating to both workshops were gathered by an ordinal data rating scale. The survey queried the residents about the value of the workshops to anesthesia training, anatomy knowledge, and future practice and about the quality, organization, and overall usefulness of both sessions. Residents were asked to pick from five responses that ranged from strongly disagree to strongly agree.

*Fig. 3*  
Residents' evaluation of the ultrasound (A) and anatomy (B) workshops.



### Statistical analysis

All statistical analyses were performed by using statistical functions included in Excel 2010 (Microsoft, Redmond, WA). Statistical means for pretest and post-test results (for both the multiple choice test and OSCE) were compared by using a paired t-test for dependent samples. Results were analyzed by level of training.

### Results

Of 75 residents in the program, 56 completed the study (CA1=19/25, CA2=22/25, and CA3=15/25), representing nearly 75% (56/75) of our residency program. Post-test results were significantly improved ( $P < 0.001$ ) across all CA years and for both the multiple-choice test and OSCE (Table 1). Table 3 in the manuscript (*Curriculum Development for an Advanced Regional Anesthesia Education Program: One Institution's Experience from Apprenticeship to Comprehensive Teaching*) shows the pretest and post-test means for the MCQ and OSCE evaluations with the associated  $P$ -values by CA training years. Baseline values, as evidenced by pretest scores, were higher with increasing years of training. The difference between pretest and post-test values was significantly different across all training levels. Further examination of the different sections of the OSCE showed that post-test results were also significantly improved ( $P < 0.001$ ) across all CA years for each section of the OSCE (Table 1).

For the eight-question survey, we collected 168 responses from the CA-1 class, 145 from CA-2, and 124 from CA-3. Residents' evaluations for the anatomy and ultrasound workshops are shown in Figure 3. Over 90% of residents agreed or strongly agreed to all positive survey questions except for one. Only 78% of residents thought that time allotted for the anatomy lab workshop was adequate.

### Discussion

The ARAP, which consisted of interactive and nontraditional classroom teaching, significantly improved anesthesiology resident understanding and

Table 1  
Summary of Pretest and Posttest Means Broken Down  
by OSCE Section and CA-Year

OSCE Section	OSCE Pretest Mean (95% CI)	OSCE Posttest Mean (95% CI)	$P$
OSCE (A)			
Questions 1-6			
CA1	18.53 (4.34)	36.11 (3.29)	<0.001
CA2	27.82 (2.61)	42.77 (1.68)	<0.001
CA3	29.60 (3.52)	43.47 (1.44)	<0.001
OSCE (B)			
Questions 7A-7F			
CA1	7.68 (1.16)	16.58 (2.58)	<0.001
CA2	10.14 (2.31)	21.50 (1.84)	<0.001
CA3	12.13 (2.68)	21.87 (2.27)	<0.001
OSCE (C)			
Questions 8-11			
CA1	5.00 (2.07)	17.05 (2.17)	<0.001
CA2	10.14 (2.63)	26.05 (1.95)	<0.001
CA3	15.53 (2.08)	28.27 (1.12)	<0.001

CA1, clinical anesthesia year 1; CA2, clinical anesthesia year 2; CA3, clinical anesthesia year 3; OSCE, objective structured clinical examination.

knowledge in regional anesthesia and postoperative pain management. All residents performed better in the post-program multiple choice test and OSCE than they did on the pretests. All residents performed significantly better in all OSCE sections after the ARAP program than they had at baseline. These results might help to evaluate the interactive teaching of the ARAP and to identify areas of improvement in the teaching program.

Advancement in regional anesthesia and acute pain medicine will be highly dependent on the quality of regional anesthesia training over the next decade. In recognition of these needs and their implications, many anesthesia training programs, including ours, have developed structured regional anesthesia education that focuses on graduating residents who are competent in regional anesthesia and pain management. A group of experts in regional anesthesia, along with other experts in simulation, audiovisual technology, and anatomy, developed and organized the ARAP for our

residents. The use of multimedia, simulation, and hands-on applied anatomy provides excellent realism for improved training and teaching purposes<sup>16,17</sup>.

In this study, we used multiple choice and OSCE pretests and post-tests as measuring tools to evaluate the residents' knowledge gain in the program. The OSCE, which was first described by Harden et al.<sup>18</sup>, has become a widely used and accepted method to evaluate clinical competence in various fields<sup>15,19</sup>. The reliability and validity of the OSCE test has been well documented. It provides information about a student's "clinical abilities that is not available through traditional testing"<sup>20</sup>. Based on these studies, we felt that using an OSCE would accurately evaluate the clinical knowledge that the residents have gained through the ARAP.

All residents performed better in all parts of the post-program OSCE (Table 1) than they did in the pre-test. Even CA-2 and CA-3 residents (all previously exposed to traditional regional anesthesia teaching methods) had statistically significant gains in knowledge. Differences between pretest and post-test scores in all OSCE sections were significant ( $P < 0.001$ ) across all CA years and included improved knowledge in OSCE A (regional anesthesia choices and complications), OSCE B (hands-on techniques and confidence), and OSCE C (postoperative pain management and challenges). These results reflect the effectiveness of our novel teaching curriculum.

We excluded residents who were unable to complete both the pretest and post-test. Fewer senior residents (CA3) completed the post-test than residents in other classes. This difference probably resulted from CA3 residents being more likely than others to be away for activities such as job/fellowship interviews and rotations at off-site locations.

In addition to the increased knowledge demonstrated by the significant improvements in post-test scores, the unique educational modalities of the hands-on workshops were well received. Over 90% of residents agreed or strongly agreed to nearly all positive survey questions. Only 78% of residents thought that time allotted for the anatomy lab workshop was adequate. Additionally, residents have requested that the workshops be repeated periodically; some have requested to expand time allocated to cadaver

dissections in the future.

One limitation of this study was that we measured improved knowledge and skills only through MCQs and an OSCE; we did not measure improved clinical outcome and number of blocks successfully performed by residents. Additionally, the specific OSCE that we used in this study was not validated. All four examiners did not evaluate the residents, and we did not assess variability between graders. Another limitation is that we used the same OSCE and MCQs for the pretest and post-test. Although the two tests were 7 months apart, this practice could limit the conclusion we can make about the effectiveness of the ARAP. However, the magnitude of the scoring differences between the pretest and post-test was so large that it is unlikely to be the result of residents recalling the answers from the pretest questions. Finally, the post-test was performed shortly after completion of the ARAP, so we do not have data on how well the information is incorporated.

Using a control group in this study composed of residents who would not attend the multiple hands-on workshops (cadaver workshops, ultrasound workshops, nerve stimulator and surface anatomy workshops) and simulator sessions would potentially put these residents at a disadvantage. We considered it best to have all residents in our training program receive the additional training in regional anesthesia.

An obstacle we faced in implementing this teaching module was that the program required a substantial commitment from the Division of Regional Anesthesia, which has only a limited number of faculty members. Hence, finding enough individuals to cover clinical duties and participate in teaching was extremely difficult. Instituting the program requires the faculty to be flexible and willing to incorporate new interactive teaching techniques. As the program is further developed, we hope to demonstrate levels of validity, reliability, and usability by other residency programs.

In summary, our findings suggest that incorporation of didactic and interactive teaching, such as hands-on cadaver workshops, live-model ultrasound workshops, simulation scenarios, and board preparation sessions, is a more effective instructional method than the traditional teaching modality. We believe that focused college days have a unique potential to substantially

improve residents' base knowledge and technical skills in multiple clinical specialties in anesthesia as well as in other medical fields. We also believe that interactive

teaching methods may be associated with clinical excellence and better learning outcomes in any clinical discipline.

## References

1. DUNCAN CM, HALL LK, WARNER DO, HEBL JR: The economic implications of a multimodal analgesic regimen for patients undergoing major orthopedic surgery: a comparative study of direct costs. *Reg Anesth Pain Med*; 2009, 34:301-7.
2. ELVIR-LAZO OL, WHITE PF: The role of multimodal analgesia in pain management after ambulatory surgery. *Curr Opin Anaesthesiol*; 2010, 23:697-703.
3. YASTER M: Multimodal analgesia in children. *Eur J Anaesthesiol*; 2010, 27:851-7.
4. TAN JS, CHIN KJ, CHAN VW: Developing a training program for peripheral nerve blockade: the "nuts and bolts". *Int Anesthesiol Clin*; 2010, 48:1-11.
5. SITES BD, MACFARLANE AJ, SITES VR, NARAGHI AM, CHAN VW, ANTONAKAKIS JG, SINGH M, BRULL R: Clinical sonopathology for the regional anesthesiologist: part I: vascular and neural. *Reg Anesth Pain Med*; 2010, 35:272-80.
6. Accreditation Council for Graduate Medical Education: Anesthesiology Program Requirements, effective July 1, 2007. Internet 2009; [http://www.acgme.org/acwebsite/trc\\_040/040\\_prIndex.asp](http://www.acgme.org/acwebsite/trc_040/040_prIndex.asp)
7. NEAL JM, KOPACZ DJ, LIGUORI GA, BECKMAN JD, HARGETT MJ: The training and careers of regional anesthesia fellows-1983-2002. *Reg Anesth Pain Med*; 2005, 30:226-32.
8. SMITH HM, KOPP SL, JACOB AK, TORSHER LC, HEBL JR: Designing and implementing a comprehensive learner-centered regional anesthesia curriculum. *Reg Anesth Pain Med*; 2009, 34:88-94.
9. MARTIN G, LINEBERGER CK, MACLEOD DB, EL-MOALEM HE, BRESLIN DS, HARDMAN D, D'ERCOLE F: A new teaching model for resident training in regional anesthesia. *Anesth Analg*; 2002, 95:1423-7, table.
10. HARDEN RM, GLEESON FA: Assessment of clinical competence using an objective structured clinical examination (OSCE). *Med Educ*; 1979, 13:41-54.
11. WALTERS K, OSBORN D, RAVEN P: The development, validity and reliability of a multimodality objective structured clinical examination in psychiatry. *Med Educ*; 2005, 39:292-8.
12. NEWBLE D: Techniques for measuring clinical competence: objective structured clinical examinations. *Med Educ*; 2004, 38:199-203.
13. PANDYA JS, BHAGWAT SM, KINI SL: Evaluation of clinical skills for first-year surgical residents using orientation programme and objective structured clinical evaluation as a tool of assessment. *J Postgrad Med*; 2010, 56:297-300.
14. SLOAN DA, PLYMALE MA, DONNELLY MB, SCHWARTZ RW, EDWARDS MJ, BLAND KI: Enhancing the clinical skills of surgical residents through structured cancer education. *Ann Surg*; 2004, 239:561-6.
15. HANNA MN, DONNELLY MB, MONTGOMERY CL, SLOAN PA: Perioperative pain management education: a short structured regional anesthesia course compared with traditional teaching among medical students. *Reg Anesth Pain Med*; 2005, 30:523-8.
16. BOET S, BOULD MD, SCHAEFFER R, FISCHHOF S, STOJEBAN N, NAIK VN, DIEMUNSCH P: Learning fiberoptic intubation with a virtual computer program transfers to 'hands on' improvement. *Eur J Anaesthesiol*; 2010, 27:31-5.
17. TUNUGUNTALA R, RODRIGUEZ O, RUIZ JG, QADRI SS, MINTZER MJ, VAN ZUILEN MH, ROOS BA: Computer-based animations and static graphics as medical student aids in learning home safety assessment: a randomized controlled trial. *Med Teach*; 2008, 30:815-7.
18. HARDEN RM, STEVENSON M, DOWNIE WW, WILSON GM: Assessment of clinical competence using objective structured examination. *Br Med J*; 1975, 1:447-51.
19. SLOAN PA, PLYMALE MA, JOHNSON M, VANDERVEER B, LAFOUNTAIN P, SLOAN DA: Cancer pain management skills among medical students: the development of a Cancer Pain Objective Structured Clinical Examination. *J Pain Symptom Manage*; 2001, 21:298-306.
20. SLOAN PA, DONNELLY MB, SCHWARTZ RW, SLOAN DA: Cancer pain assessment and management by housestaff. *Pain*; 1996, 67:475-81.

