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Improving resident confidence with a low-cost interventional spine course

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ABSTRACT

Background: Procedure training is highly desired by residents pursuing a career in interventional pain medicine; however, the opportunities for hands-on training may vary amongst residency programs for various reasons.
Objective: To evaluate the change in residents' self-perceive competence after participation in a novel low-cost resident interventional spine course, as well as how resident experience (years of training) influences change over time. This article offers step-by-step details on how to implement a resident interventional spine course.
Methods: Residents completed a pre- and post-course survey in the domains of self-perceived confidence, knowledge, and skills related to interventional spine procedures.
Results: Over five years, 19 individual residents participated in an annual elective interventional spine course (four residents chose to repeat the course during their training, one of which repeated it twice). The dimensions with highest percent improved change included the ability to perform a procedure kit set-up, followed by post-procedure complication management. Residents earlier in their training showed significantly greater improvement in rating their ability to conduct a pre-procedure chart review and addressing post-procedure complications compared to more experienced residents. In addition, resident feedback regarding the course was resoundingly positive. Of the 12 graduated residents, half applied and successfully matched into a pain medicine or sports medicine fellowship.
Conclusion: A low-cost interventional spine course appears to be a practical option to help improve residents' confidence related to various aspects of interventional spine procedures.

1. Introduction

One of the major challenges of medical resident education is providing hands-on experience to develop procedural skills. A 2018 study indicated that the opportunities for procedural training was second only to perceived happiness of the current residents in factors determining the rank order for medical students applying to Physical Medicine and Rehabilitation (PM&R) residency programs [1].

As a part of a multidisciplinary approach, interventional spine procedures have become engrained in both PM&R and anesthesia practice and resident education. These are the two fields that make up the majority of residents applying to pain medicine or interventional spine fellowships. The degree of exposure to spine procedures is variable across different resident training programs. While some residents are given an opportunity to develop these skills, other residents may have limited exposure based on the focus of their training program and access to clinicians that are willing, or able, to introduce these skills.

The goal of this article is to detail the steps to develop, implement, and evaluate a two-night resident interventional spine course. Included are instructions for building a relatively low-cost spine simulator and helpful reference materials. Data from the post-course survey and feedback comments suggests that this type of course is highly valued by residents pursuing a procedural focused fellowship, as well as those just seeking to further their understanding of this patient population.

2. THE spine course

This project was approved by the institutional review board (HUM00217164). The interventional spine course was developed in 2018 and made available to residents between their postgraduate year (PGY) two and four during their three-year PM&R residency. As an advanced specialty program, preliminary year interns were not eligible for the course.

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The two-night elective resident interventional spine course is targeted for PM&R residents interested in pursuing fellowship training in interventional pain medicine. This course offers the opportunity for residents to advance their knowledge and procedural skills related to the management of spine pain. As part of the course, residents complete a pre- and post-written survey (see supplemental digital content). The questions are focused on three aims of the course: 1) confidence, 2) knowledge, and 3) skills. The questions are geared to compare the participants own perception of their degree of improvement within each of these domains upon completing this hands-on and highly interactive educational course. Each question asks residents to rate their proficiency on a 5-point scale, ranging from 1 (low) to 5 (high). In addition, residents are asked what their goals are for the course and their preferred learning style.

2.1. Course preparation

The interventional spine course is scheduled to coincide with the PM&R resident's yearly spine and pain didactics. Residents are emailed the course notification about one month prior and asked to RSVP. Confirmed residents receive a follow-up email with schedule details and suggested pre-course readings [2–6]. Additional course preparation includes: verifying a sufficient number of interventional spine instructors; reserving a lecture room with video projector; collecting reference materials and a spine procedure atlas; printing handouts for the residents and instructors; notifying the fluoroscopic suite staff of the course schedule; ensuring the spine simulator model is in good condition; collecting sterile procedure kits and needles (from excess or damaged stock); arranging food for each night.

2.2. Night one

The course begins with an interventional spine physician providing a 1-h lecture on general practice guidelines for interventional spine procedures. Much of the practice guidelines presented are based on the Spine Interventional Society (SIS) Practice Guidelines for Spinal Diagnostic and Treatment Procedures 2nd Edition, 2013 [7]. To meet residents at their experience level, the lecture is arranged in a framework of a chart review that an interventional spine provider may conduct prior to their procedural day. Four broad categories are presented as potential risk factors that any provider should be aware of prior to performing any interventional spine procedure. The acronym B.I.A.S. was developed to stand for Bleeding, Infection, Allergy, and Sedation. In addition to the SIS guidelines, additional topics include: 2015 and updated 2018 American Society of Regional Anesthesia and Pain Medicine (ASRA) Anticoagulation Guidelines; SIS Emergency Protocols; SIS FactFinders [4–6,8].

Next, residents are divided equally and rotated through three 30-min stations: 1) Patient selection for various spine procedures; 2) Obtaining informed consent and procedure kit preparation; 3) Needle driving skills, radiation safety, fluoroscopic C-arm operation, and introduction to fluoroscopic-guided spine procedures with the spine simulator model. Instructors for each station are interventional spine physicians or fellows. Typically, each station has between one and three residents paired with an instructor. This ratio offers ample opportunity for instructors to tailor the discussion to meet the educational needs of the residents.

2.3. The simulator model

A low-fidelity spine simulation model has been built for hands-on training during the course. Construction of the low-cost spine simulator starts with a standard, flexible, plastic human spine model complete from the occiput to the proximal femur (approximate cost $80–100). No special radiopaque paint or coating is required as most spine models will appear under fluoroscopic x-ray. The flexible metal core and sacroiliac (SI) joint screws have been replaced by string and each disc segment has been glued to make a relatively rigid spine. In addition, drill holes have been made at the lower SI joints and sacral hiatus to simulate these respective injections. A one-inch-thick project foam, from a local fabric store, sits below the spine model with cut outs to accommodate the anterior cervical and lumbar lordotic curves (approximate cost $20). Above the spine model are two layers of foam separated by landscape fabric, which offers a realistic feel of advancing a needle through the fascial plane. Image 1 shows the three layers of foam and spine model placed inside a king-sized pillowcase (approximate total cost less than $150). Fluoroscopic images of the spine simulator demonstrate a realistic view of the total spine and pelvic girdle (Image 2). When driving needles, residents experience the tactile feel of advancing through skin (pillowcase), adipose tissue (foam layer 1), fascial plane (landscaping cloth), muscle (foam layer 2), and finally the spine target. Through the institutional library, residents have access to an on-line image-guided spine procedures atlas that serves as the teaching manual for the simulated procedures [2].

2.4. Night two

With the emphasis in pain management in the field of PM&R, training programs prepare residents for potential related questions on board certification examinations. The second night starts with a round table discussion of board-style questions about spine procedures [9]. Interventional spine physicians lead the discussion and offer real-world prospective to these questions. Next, the residents are again divided into small groups for two 30-min stations: 1) Discussion of sedation and management of complications; 2) Further practice with fluoroscopic-guided spine procedures using the spine simulator model.

Upon completion, residents are asked to complete a post-course survey ranking their newly perceived confidence, knowledge, and skills related to interventional spine procedures. In addition, residents are asked to offer feedback on the strengths and further recommendations for the course.

3. Statistical analysis

Percent change on each survey question was computed by subtracting the pre-course rating from the post-course rating, dividing this result by the pre-course rating, and multiplying by 100. Thus, a positive change on an item reflects an increase in perceived competency within the dimension. The significance of the change in ratings from pre-to post-course was examined using matched-pairs t-tests. In addition, to examine whether change varied as a function of the experience of the resident, independent t-tests were conducted on change scores grouping residents as less experienced (second year) versus more experienced (third and fourth year). Seven residents fell into the less experienced group, while 17 comprised the latter group.

4. Results

A total of 19 different PM&R residents participated in the elective interventional spine course between 2018 and 2022. Three residents opted to repeat the course for a second time and one for all three years during their training. Two residents were missing post-course evaluations due to schedule conflicts, and one resident did not rate three of the items pre- or post-course. Group mean imputation was used for subjects that had missing data. In total, there were 24 pre- and post-course responses.

Pre-and post-course ratings, percent change, and the significance of the change pre-to post-course are presented in Table 1. Ratings of all the course aims significantly increased post-course (p's < 0.001). The largest percent increase was observed for ratings of ability to perform the procedure kit set-up, followed by ratings of ones understanding of how to address post-procedure complications.

Table 2 presents the mean percent change in ratings as a function of resident experience. While there are trends in the data favoring a particular group based on the item rated, younger residents (PGY 2)

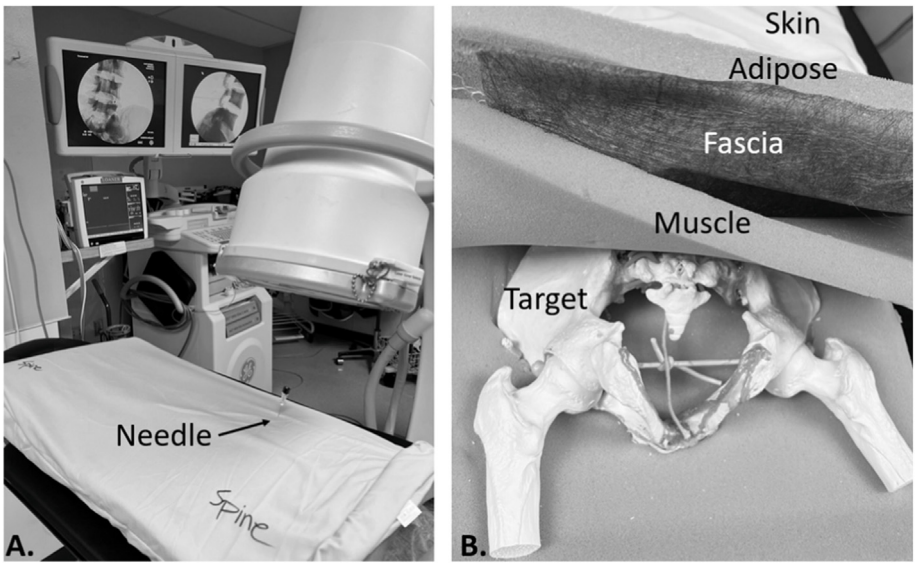

Image 1. The spine simulator as set up for the course (A) and the layers of the simulator model as they correspond to the anatomical structures (B).

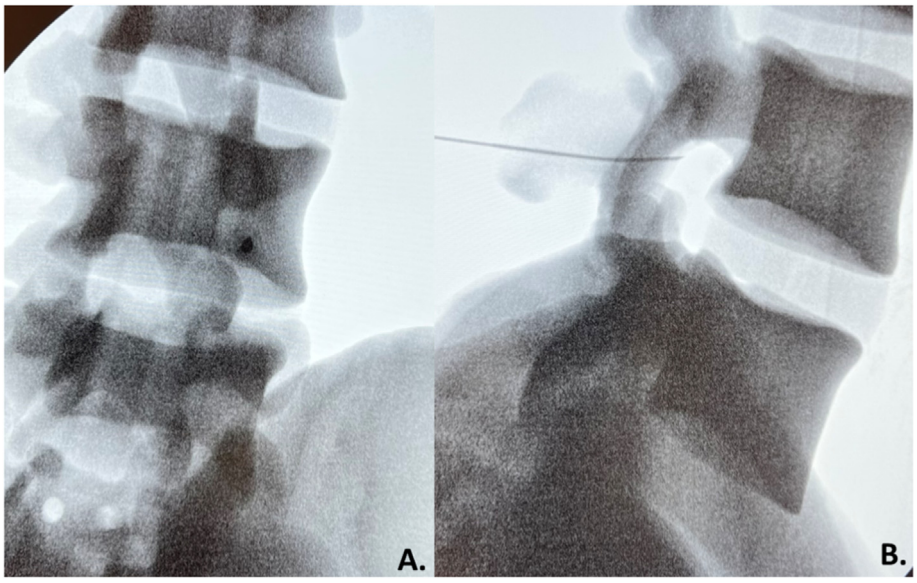

Image 2. Fluoroscope images of a lumbar transforaminal access using the spine simulator in the oblique (A) and lateral (B) views.

showed a significantly greater percent change in ratings pre-to post-course on their perceived ability to perform a pre-procedure chart review ($t = 2.26$, $p = 0.034$) and understanding of how to address post-procedure complications ($t = 4.41$, $p < 0.001$). In general, the trend on all the items was for less experienced residents to show greater percent change, with a few exceptions. Of the residents that participated in the course thus far, 12 have graduated from the PM&R residency with half applying and successfully matching into a fellowship that has an emphasis on procedural skills. Two matched into pain medicine and four into sports medicine.

4.1. Resident feedback

As part of the pre-course survey, the residents were asked to comment on what they were most hoping to accomplish by participating in the course. From a knowledge domain, residents reported a desire to improve in the following areas: patient selection; identification of risk factors; management of complications; and a better understanding of fellowship opportunities. From a hands-on skills domain, residents wanted to practice completing procedures from start to finish; try higher risk cervical procedures; and learn how to operate and optimize images on the fluoroscope C-arm.

Residents also commented that their preferred learning style included: didactic instruction followed by hands-on repetition; self-study with reference materials; board review questions; and instruction from interventional spine physicians.

Upon completion, residents reported the strengths of the course included: freedom to ask questions and make mistakes in a low stress environment; the multi-night event helped reinforce skill development; detailed reviews of spine procedure anatomy and related fluoroscopic images; small groups facilitated individualized education; simulator provided tactile feedback for needle driving skills; interactive board review questions.

Further participant recommendations for the course included: more frequent access to the spine simulator throughout the year; consider making the course a requirement for all PM&R residents prior to their

Table 1
Pre-and post-course ratings on each aim of the course.

Aims of the Course	Mean Pre (SD)	Mean Post (SD)	Mean Percent Change (SD)	T-value	Significance
Overall Confidence:					
Overall Patient Selection	3.04 (1.00)	4.29 (0.67)	52.9 (46.6)	−9.32	<.001
Chart Review	3.39 (0.87)	4.38 (0.69)	33.7 (24.6)	−7.96	<.001
Prep Kit	3.04 (1.23)	3.95 (0.86)	49.1 (58.9)	−4.80	<.001
Perform Procedure	2.46 (0.93)	3.59 (0.82)	65.5 (69.5)	−6.29	<.001
Address Complications	2.38 (0.82)	3.86 (0.90)	75.2 (51.1)	−11.04	<.001
Base of Knowledge:					
Discuss Indications	3.00 (0.83)	3.91 (0.78)	35.4 (30.6)	−6.88	<.001
Discuss Consent	3.63 (0.97)	4.50 (0.64)	30.6 (30.7)	−5.68	<.001
Explain Set Up/ Prep	2.67 (1.17)	3.77 (0.88)	60.9 (62.8)	−6.14	<.001
Identify Targets	2.50 (0.98)	3.77 (0.93)	69.2 (65.6)	−7.88	<.001
Explain Reducing Risks	2.67 (1.13)	3.82 (0.81)	67.1 (72.9)	−6.60	<.001
Hands-on Skills:					
Obtain Informed Consent	3.33 (1.13)	4.36 (0.81)	58.0 (68.4)	−4.78	<.001
Perform Set Up	2.92 (1.21)	4.00 (0.93)	80.9 (87.5)	−5.45	<.001
Perform Basic Skills	2.29 (1.04)	3.50 (0.97)	54.4 (99.7)	−6.13	<.001

Table 2
Mean percent change (SD) on each aim of the course as a function of resident experience.

Aims of the Course	Resident Experience		T-value	Significance
	Year 2	Years 3 and 4		
Overall Confidence:				
Patient Selection	78.6 (61.4)	42.3 (36.1)	1.82	ns
Chart Review	50.0 (25.5)	27.0 (21.5)	2.26	0.034
Prep Kit	77.4 (62.5)	37.4 (55.1)	1.55	ns
Perform Procedure	82.1 (68.8)	58.7 (70.7)	0.74	ns
Address Complications	128.6 (48.8)	53.2 (33.1)	4.41	<.001
Base of Knowledge:				
Discuss Indications	28.6 (20.9)	38.3 (33.9)	−0.70	ns
Discuss Consent	42.9 (18.3)	25.5 (33.7)	1.29	ns
Explain Set Up/Prep	59.5 (34.5)	61.4 (72.3)	−0.07	ns
Identify Targets	71.4 (69.9)	68.3 (66.0)	0.10	ns
Explain Reducing Risks	97.6 (78.4)	54.5 (69.0)	1.34	ns
Hands-on Skills:				
Obtain Informed Consent	81.0 (142.7)	43.5 (78.8)	0.83	ns
Perform Set Up	58.3 (41.7)	60.7 (73.4)	0.01	ns
Perform Basic Skills	60.7 (73.4)	89.2 (93.5)	−0.72	ns

Note: ns = not significant.

spine rotation; making available pre-recorded didactic lectures to allow for increased hands-on time and serve as future reference; consider expanding the simulator instruction to include advanced procedures (pump and stimulator trials).

5. Discussion

Spine and pain education has become an integral part of PM&R and anesthesia resident training. The goal of this article is to outline the steps to develop and implement a resident interventional spine course. The hope is that residency training programs will use this as a framework to develop their own educational programing that meets the needs of their residents.

At this PM&R residency program, residents rotate through two separate months of spine and two separate months of musculoskeletal procedures for a total of four months of procedural focused training spread throughout their three-year PM&R residency. Most residents will have completed one or more of these rotations by the time the spine course is offered in the spring of the year. Beyond the standard rotation schedule, some residents choose to pursue additional procedural training within the department during quasi-elective time. Industry-sponsored events are generally not a part of this residency program. Additional outside spine procedural courses or conferences are generally at the resident's own expense, unless they have grant or scholarship funding. These factors further justify the benefit of offering a formal interventional spine course for residents that are interested in advancing their depth of knowledge and skills.

Residents who participated in the interventional spine course showed significant changes in their perceived competence in all dimensions assessed on the post-course questionnaire. Less experienced residents showed a trend towards gaining greater perceived improvement after completing the course, although this was not universal across all areas assessed. These findings suggest that the course increases residents perceived competency regardless of the years of experience.

The largest percent increase in perceived competence was in procedure kit set-up and addressing post-procedure complications. Sterile kit preparation has some basic principles regardless of the procedure. While residents likely have had prior surgical training in medical school, they may not have been exposed to kit preparation specifically for interventional spine procedures until residency, or a course such as this. Dedicating time to these skills appears to greatly increase resident confidence.

The gains in confidence related to interventional spine complication management may be related to improving the resident's depth of knowledge. In this PM&R program, residents are the first level of coverage for overnight patient calls. Early in the academic year, all residents receive some basic education for covering calls related to interventional spine procedures. By the time this course is offered later in the year, even the least experienced residents have likely received some overnight calls from patients that have recently had an interventional spine procedure. This course likely gives the residents an opportunity to ask more in-depth questions with a better frame of reference for complication management.

The use of simulation models has been a mainstay of instruction for high-risk procedures in a non-threatening learning environment. While some interventional spine procedures are conducted under mild sedation, most are conducted with the patient fully aware of their surroundings in the procedure room. This factor may limit in-depth discussions and hands-on opportunities for residents to learn new procedure skills. The use of simulator models, often referred to as phantoms, have been shown to improve trainee's confidence and reduce radiation exposure for fluoroscopic x-ray-guided procedures [10]. Moreover, exposure to 3D models leads to higher trainee engagement and improved clinical application of anatomical knowledge [11].

Unfortunately, commercially manufactured spine simulation models may be cost prohibitive for some residency programs, especially those in developing countries with lower resources. While higher tech simulators may offer some advantages, lower fidelity simulator models offer the distinct benefit of accessibility and utility while still facilitating the same educational discussion advantages. The low-fidelity model described above offers a rather unique tactile feature. The layer of landscaping cloth between foam provides a realistic feel of advancing a needle through the fascial layer. This model closely simulates the importance of optimal needle placement through the fascia to accurately reach the desired target. Learners can practice repositioning in and out of the fascial layer for optimal needle placement. This is a distinct advantage over many high-fidelity models that use a solid gel-based medium without a simulated fascial layer.

Furthermore, offering a lower fidelity model for simulation may provide an opportunity for repetitive practice providing improved procedural skill and knowledge retention. A 2013 study demonstrated that a lower and higher fidelity simulator were found to be equally effective in an educational training setting [12–14].

While our study chose to evaluate resident self-perceived competence, future studies could expand on the objective measures of resident skill acquisition and compare this to residents that do not take advantage of this type of course. Longitudinal studies could further track performance of the residents as they transition into fellowship training. Courses such as this could help in the development of a standardized spine skills evaluation to be used across several participating training programs.

As competition for medical residencies increases, it is imperative that programs respond to the interest of potential candidates. Procedural training is in high demand and this type of course appears to increase residents' confidence in various aspects of spine procedures. While there is no replacing working with actual patients, the hope is that this course will better prepare residents for their clinical rotations and potentially fellowship training.

6. Conclusion

The resident interventional spine course serves as an example of how high-quality didactics and hands-on training does not necessarily have to be high cost. Residents were able to demonstrate improvements in self-reported confidence, knowledge, and procedural skills, with the greatest improvements seen in the least experienced residents. This type of course could be of great value to any residency programs looking to enhance their resident educational experience or international training programs with limited resources.

Institutional review board

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Author disclosures

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Data availablitiy

The datasets generated during and/or analyzed during the current study are not publicly available but are available from the corresponding author on reasonable request.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.inpm.2022.100151.

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