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CLINICAL ANATOMY WILEY

Anatomy of the physical examination: A small group learning approach for increasing engagement and learning in a medical gross anatomy course

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Abstract

The ability to perform and interpret the physical examination requires an understanding of human anatomy and how to apply that content in the clinical setting. Previous work has shown that students understand and retain information more effectively when they are actively engaged in the learning process and it is clearly linked to other coursework and their future needs. We developed a series of learning activities, based on the general physical examination, designed to enhance engagement and encourage durable learning of anatomical principles that are important in performing and interpreting the physical examination. Activities were designed for use in small group settings with faculty supervision and input as needed. We describe these activities and provide comments from students regarding the perceived value of these learning activities. Students reported that the applied anatomy learning activities were engaging and aided in their learning of human anatomy. Additionally, students appreciated the connection between the applied anatomy activities and the skills being learned in concurrent coursework focusing on the physical examination. We observed that applied human anatomy exercises modeled after components of the general physical examination and embedded in an anatomy course enhanced student engagement and helped students appreciate the importance of anatomical principles. We note that sensitivity to and acceptance of personal preferences and religious matters must be shown when using learning activities that involve close physical interactions to teach anatomical topics.

KEYWORDS
anatomy, medical education, self-directed learning

1 | INTRODUCTION

An essential skill in the evaluation and management of patients is the ability to perform and interpret the findings elicited during the physical examination. The knowledge required to correctly perform and properly interpret examination findings include familiarity with anatomical relationships among various structures and tissues and an adequate understanding of the physiological principles associated with individual body systems. Not uncommonly, these topics are considered in formal course work included in the early years of the medical curriculum. Knowledge of this material is typically presumed to have been acquired prior to or concurrent with instruction in how to perform and interpret the general physical examination. Bickley and Szilagy (2003) state "We assume that our student readers have had

basic courses in human anatomy and physiology" thereby making clear the important relationship between these basic sciences and the physical examination. Seidel et al. (2003) include a brief review of pertinent anatomy and physiology as a preface to each of the body system chapters in their textbook on the physical examination.

Not surprisingly as students progress and advance into the more clinical or practice oriented phases of the curriculum, many discover that the anatomical knowledge they possess is somewhat different from the kind they need when evaluating patients. What many students encounter is difficulty in applying the anatomical facts and principles previously learned in the classroom and dissection laboratory. This difficulty often becomes evident in the clerkship years when students work with and learn from living persons, including both standardized patients and actual patients.

In an effort to help overcome this difficulty, we developed a series of classroom-based learning activities based on techniques used in the physical examination that we incorporated into our first year human anatomy. Our goal was to develop specific activities that would help students learn and retain principles of human anatomy as they are encountered in living persons. Previous investigators (Boon et al., 2002) found that a clinical anatomy practicum involving inspection, palpation, percussion and auscultation methods gave students a better understanding of the anatomical basis of the clinical examination. Other investigators (Diaz & Woolley, 2015) have described multidisciplinary approaches to teaching anatomy, however these were not specifically toward anatomical principles that would be helpful in performing the physical exam.

In this descriptive report, student responses to a Likert question included on our End of Block survey asking about the extent to which these activities enhanced their learning of anatomy are presented. In addition to describing how we integrated these activities into our anatomy course, we call attention to the importance of addressing student preferences and concerns when using learning activities that involve clinically forms of physical contact commonly used in the physical examination.

2 | MATERIALS AND METHODS

2.1 | Description of class activities and support materials

We developed a series of seven, student-centered learning activities, modeled after components the general physical examination that highlight anatomical relationships and physiological processes that are important when eliciting and interpreting data collected during the general physical examination. The activities are structured around individual body regions so as to be easily integrated into a regionally organized anatomy course. Individual session activities are listed in Table 1. Students engage in these exercises in small groups of 6–7, using each other as subjects. Class sessions are moderated by faculty who ensure that the focus of the activities remains on the anatomy being applied and not on the physical examination techniques being utilized. The overall objective of these exercises is to focus learning human anatomy as it is encountered in living subjects.

TABLE 1 Applied human anatomy learning activities

Limbs and back
1. Shoulder girdle and upper limb
2. Hip and lower limb
3. Back
Thorax
4. Thoracic wall
5. Lungs and pleura
6. Heart
Abdomen
7. Abdominal wall

A description of individual activities are included in a laboratory manual made available at the beginning of the course. Specific activities include palpation, percussion and auscultation as well as other commonly performed techniques such as determining strength of limb muscles, evaluating range of motion, palpating pulses, and auscultating heart and lung sounds. Other non-clinical activities are included such as using a skin pencil to mark the location of the pleural reflections and fissures of the lung on the chest wall, the position on the anterior chest wall for auscultating each of the four heart valves and the vertical and horizontal lines that define the quadrants of the abdominal wall. For some activities such as "Evaluate the strength of shoulder abduction," space is provided in the laboratory manual for the student to "Document your observations using appropriate terminology" and to respond to one or more associated question(s) such as "What muscles are important in shoulder abduction?" or "What nerves provide motor innervation to the muscles that flex the elbow?" or "How does the scapula move during shoulder abduction?" Students are informed that questions such as these may be included on the summative examination. Students are also reminded that these are the types of questions they might be asked by a resident or attending physician while on a particular clerkship or elective rotation.

The laboratory guide for these sessions also includes for each activity (1) a list of measurable session objectives, (2) a list of pages of suggested reading from the recommended textbook for the course, (3) a description of the several, individual activities the students are asked to perform during the laboratory session, and (4) a bank of anatomy focused, fill in the blank questions that students may complete either in preparation for each activity or as a form of self-assessment after completing an activity (Nolan, 2003). The laboratory guide is posted electronically on our educational platform and is also provided in hard copy for students who wish to document their findings when performing the activities in class and for responding to the related short answer, fill in the blank questions. Table 2 includes a sample applied anatomy activity on the thorax.

The exercises are designed as group activities, intended for small numbers of students working together. Each work group should ideally consist of four to six students, preferably mixed with regard to

TABLE 2 Thorax

Objectives
1. Describe and identify by palpation in a living subject the major bony and soft tissue landmarks of the thorax.
2. Describe and using a skin pencil mark on a living subject the several "vertical lines" used to subdivide the thorax into definable regions.
Application exercises
A. Inspection and Palpation
With the subject seated comfortably facing toward you:
1. Inspect the sternum
a. Is the body of the sternum flat or is it indented (pectus excavatum) or protruded (pectus carinatum)?
2. Palpate the suprasternal (jugular) notch and the sternoclavicular joints.
b. What vertebral body would be crossed by a horizontal line extending posteriorly from the suprasternal notch?
3. Palpate the sternomanubrial joint (sternal angle or angle of Louis).
c. What vertebral body would be crossed by a horizontal line extending posteriorly from the sternomanubrial joint?
d. What rib attaches to the sternum at the sternal angle?
4. Palpate xiphoid process and xiphisternal joint.
a. What vertebral body would be crossed by a horizontal line extending posteriorly from the xiphisternal joint?
b. Which ribs attach to the sternum by way of their own, individual costal cartilage (i.e. vertebrosternal ribs)?
c. Which ribs attach to the sternum by way of a common costal cartilage (i.e. vertebrochondral ribs)?
5. Palpate the inferior margin of the costal cartilages starting at the xiphoid process and moving laterally.
a. Which ribs attach only to the vertebral column (i.e. vertebral ribs)?
With the subject comfortably facing away from you:
6. Inspect the vertebral column with respect to its position in the sagittal plane.
a. Is the convexity of the thoracic spine directed anteriorly or posteriorly?
b. What term is used to refer to an increase in the curvature of the thoracic spine in the sagittal plane?
7. Inspect the vertebral column with respect to its position in the coronal plane.
a. Is the thoracic spine straight or do you see a curvature?
b. If you see a curvature, is the convexity directed toward the right or left side
c. What term is used to refer to curvature of the spine in the coronal plane?
8. Palpate the spinous process of C7 (vertebra prominens). (Note: sometimes the spinous process of T1 is prominent to palpation also).
9. Palpate the supraspinous ligament from C7 to the sacrum, pressing hard enough to identify the thoracic and lumbar spinous processes.
10. With the subject sitting upright and the hands resting lightly on the thighs, palpate the vertebral border of the scapula from the superior angle to the inferior angle.
a. What rib lies immediately deep to the superior angle of the scapula?
b. What rib lies immediately deep to the inferior angle of the scapula?
B. Landmarks
1. The location of clinically important structures within the thorax is frequently described in relation to several vertical "lines" that subdivide the thoracic wall into definable regions. With the subject sitting upright and comfortable, identify and use a skin pencil to mark the following "lines" on the thorax:
a. midsternal line
b. midclavicular line
c. anterior axillary line
d. midaxillary line
e. posterior axillary line
f. midscapular line
g. midspinal line

body size, shape, age, sex, and race. The intent of building diversity within the work group is to permit students to gain familiarity with as wide a variety of human anatomy as class enrollment will permit. Students are instructed to dress in comfortable clothing that does not prohibit visualization or palpation of important anatomical landmarks and structures. Each applied anatomy laboratory session is scheduled

TABLE 3 Summary of student responses to a Likert question on the end of block evaluation

	"The applied anatomy sessions enhanced my learning of anatomy"						
	NA	SD	D	N	A	SA	#
Block I AY2014-2015	0	1	2	6	21	12	42
Block II AY2014-2015	0	0	0	5	27	10	42
Block III AY2014-2015	0	2	0	2	26	12	42
Block I AY2015-2016	0	3	7	4	20	8	42
Block II AY2015-2016	0	2	7	8	22	3	42
Block III AY2015-2016	0	2	4	7	23	5	41
Block I AY2016-2017	0	2	5	6	19	10	42
Block II AY2016-2017	0	1	8	2	24	7	42
Block III AY2016-2017	0	2	2	8	24	6	42

Abbreviations: A, agree; D-disagree; NA, not applicable; N, neutral; SA, strongly agree; SD, strongly disagree; #, number of respondents.

for 50 min during which time faculty are present to provide guidance and answer questions as they arise.

When appropriate, each student in the work group is encouraged perform each of the activities and to take a turn as the subject for each exercise performed by each of the other members of the group. Clearly, the greatest benefit is achieved when each student performs each exercise on all other members of the group. In this way variations in anatomical structure that exist within the group can be identified, compared and discussed in relation to a student's developing concept of human anatomy in its various shapes and forms. However, it is important to emphasize at the beginning of each session that students who do not feel comfortable with any of the activities may decline for any reason and without question to participate without penalty of any sort.

2.2 | Implementation within the course

Anatomy instruction at our institution is embedded within each of four, 8 week Blocks of a systems-based curriculum during the first academic year. The learning activities described here are included in the first three instructional Blocks: limbs and back, thorax, and abdomen. Head and neck anatomy is considered in a fourth Block which includes medical neuroscience.

Anatomy instruction formats include traditional lectures, cadaver dissection labs, imaging sessions, recommended readings, formative feedback sessions and the applied anatomy laboratory sessions described here. Approximately 28 h per Block are used for anatomy instruction for a total of 112 h per year, 2 h of which during each Block are used for formal formative assessments (practice exams). Students work together to perform the exercises, document their findings in the laboratory manual or online and complete the short answer, fill in the blank questions associated with each activity. Four faculty, all of whom are clinicians, one of whom is also an anatomist, are present to guide students in performing the activities, answer questions and to encourage discussion among the students focusing specifically on the principles of anatomy and physiology under study. With time, students begin to become familiar and comfortable with the processes of inspection, palpation and auscultation as a means of learning anatomy. They begin to acquire skill in the acquisition and documentation of reliable data by these means and develop a sense of respect and sensitivity for their subjects when engaging in these close personal learning activities.

Student feedback regarding the effectiveness of the applied anatomy learning activities was obtained by means of a Likert question included on the standardized, institutionally administered End of Block survey: "The applied anatomy sessions enhanced my learning of anatomy."

This work was reviewed and approved (IRB #19-1032) by the Institutional Review Board of the Virginia Polytechnic Institute & State University (Virginia Tech).

3 | RESULTS

3.1 | Feedback from the students

Forty-two students responded to the survey question: "The applied anatomy sessions enhanced my learning of anatomy" during each of three Blocks for three successive academic years with the exception of Block III in academic year 2015–2016 in which only 41 responses were obtained. The mean number of students over a 3 year period either agreeing or strongly agreeing with the survey question that the applied anatomy sessions enhanced their learning of anatomy was 30 (71%) for Block I, 31 (74%) for Block II and 32 (75%) for Block III (Table 3).

3.2 | Feedback from the faculty

Our anatomy teaching faculty include four core faculty who participate in all three Blocks and who participated in the applied anatomy laboratory sessions. Several additional faculty with specialty clinical training in subject matter related to a particular Block participated in

the cadaver dissection laboratory sessions. Because of the clinically related nature of these activities, faculty enthusiasm for the applied anatomy sessions was high. They enjoy teaching in a manner that emphasizes anatomy that is important in clinical practice and appreciate the opportunity to bring their clinical experiences into the teaching environment.

4 | DISCUSSION

The teaching of human anatomy has an important place in the education and training of physicians and other health care professionals. Methods used to teach anatomy vary widely and include traditional faculty lectures (Drake et al., 2009; Heylings, 2002) peer teaching and team based approaches (Krych et al., 2005; Nieder et al., 2005; Nnodim, 1997) and problem based learning strategies (Prince et al., 2003; Ranson et al., 2017). Courses frequently incorporate cadaver dissection (Dinsmore et al., 1999; Ellis, 2001; Granger, 2004; Gregory & Cole, 2002; Johnson, 2002; Jones, 1997; Korf et al., 2008; McWhorter & Forester, 2004; Nnodim, 1990; Rizzolo, 2002; Wilson et al., 2011; Winkelmann, 2007; Yeager, 1996) and may include anatomy as encountered using imaging techniques including plain film radiographs (Ganske et al., 2006; Gunderman & Wilson, 2005; Lanier & Kaude, 1993), CT and MRI images (Erkomen et al., 1990; Erkomen et al., 1992; McLachlan, 2004), virtual anatomy images (Codd & Choudhury, 2011; Garg et al., 1999; Nicholson et al., 2006; Shaffer, 2004) and most recently, ultrasound generated images (Brown et al., 2012; Dreher et al., 2014; Jurjus et al., 2014; So et al., 2017; Sweetman et al., 2013). Less frequently used are approaches that emphasize anatomy as it is encountered in living subjects and most of these focus on surface anatomy (Agarwall et al., 2006; Azer, 2011; Boon et al., 2002). In addition to traditional anatomy courses and courses in which anatomy is integrated together with other basic sciences, anatomy has been taught in courses primarily focused on the acquisition of clinical skills (Dangerfield et al., 2000; Dusseau et al., 2008). We have taken the reverse approach and employ selected clinical methods to teach human anatomy.

In conversations with our clinical colleagues we found that some students who performed well in our preclinical anatomy course had difficulty utilizing that information in clinical settings. The fact that students could correctly answer multiple choice questions and provide short descriptions of anatomical structures and relationships of the thyroid gland, did not mean that they could identify the thyroid gland by palpation in a living individual. Similarly, students who could recognize each lobe and fissure of the lungs were frequently unable to properly position the stethoscope to auscultate a particular lobe of the lung. In an effort to better prepare our students for the expectations of the clerkship years, we created learning activities in which anatomy might be learned in ways that would be useful in the clinic. We believe it is important to help students appreciate the importance and necessity of being able to apply principles of anatomy and physiology in living individuals. The applied anatomy activities described here, utilizing their peers as subjects, can serve to begin that process and in addition can help students develop sensitivity for the patients who they will be examining.

The incorporation of the applied anatomy learning activities into our curriculum has made the learning of anatomy more engaging and interesting for our students. These learning activities serve as a bridge, demonstrating the linkage between basic science content and its application in the general physical examination. We found over several years that most students either agree or strongly agree that the applied anatomy sessions enhanced their learning of anatomy.

4.1 | Some lessons learned

The placement of specific activities within a Block or section of a course is an important consideration. A session in which students draw and use anatomical landmarks to delineate the six or nine regions of the abdominal wall or to mark landmarks on the thorax such as the midsternal, midclavicular, anterior axillary, midaxillary, posterior axillary, and scapular lines should be scheduled early in the Block, before the contents of the abdomen or thorax are studied or dissected. Other activities such as marking and auscultating the valves of the heart or the fissures and boundaries of the lungs should be scheduled after the anatomy and physiology of the heart or lungs has been considered. For sessions involving the limbs and back, we have found it best to schedule these learning sessions in parallel with or slightly after topics such as the attachments, innervation or actions of muscles or muscle groups have been addressed. In this way, students have some preliminary understanding of the anatomical structures being palpated and studied.

It is important to communicate with faculty who teach in other courses in the curriculum that focus on clinical skills to ensure that students receive consistent and non-conflicting instruction and feedback during various class sessions. For example, what regions of the chest may be auscultated when evaluating each lobe of the lung or what position to place the subject in when evaluating and discussing the anatomy organization of a particular muscle stretch reflex should be discussed and agreed upon in advance. We have observed how sometimes minor differences in understanding or practice among the faculty such as what spinal roots mediate the triceps reflex, where to palpate to detect the PMI (point of maximal impulse) or what vertebra marks the level of the transtubercular line can inadvertently undermine the credibility of both groups of faculty.

In addition to learning about human anatomy in these sessions, students also begin to acquire basic competency with selected diagnostic tools such as the stethoscope. We have found that it is important to make clear that skill in the use of diagnostic tools is not the primary intent of these activities. Rather, the use of these tools and activities are intended to help learn about the underlying anatomy and physiology being studied.

It is important to recognize and respect that some students for personal, religious or other reasons, particularly during the early years of training as health care professionals, may feel ill at ease or hesitant

to participate in learning activities that involve palpation or exposing certain body parts. These concerns should be recognized and addressed promptly and effectively with appropriate accommodations that will permit all students to benefit from these class sessions. Some students enter the program with previous experience in health care settings and oftentimes these students will take the lead in helping their peers become more comfortable with these activities. Faculty play an important role in monitoring and facilitating engagement during class sessions.

5 | CONCLUSIONS

The ability to efficiently and effectively perform the physical examination and to reliably interpret the elicited findings relies heavily on a solid understanding on the anatomical structure and organization of different body regions. We developed small group learning activities structured around specific components of the general physical examination for use in our human anatomy course. The specific objective was to develop a teaching approach that increased engagement and enhanced learning in clinically relevant ways. The learning activities we developed for our course focused on the anatomical structures and relationships being considered rather than on the techniques being used. The overall intent in developing these activities was to help students become familiar with anatomy as it is encountered in living subjects.

The classroom activities described here emphasize the close relationship between anatomy and the physical examination. Survey data from students supported our belief that these learning activities enhanced both engagement and learning. In addition, we found faculty enthusiasm to be high because of the clinically related nature of these activities. While increased engagement in the learning process was a major objective of this effort, we emphasize that teaching approaches that involve physical contact, while clinically relevant in nature, must be utilized with caution and sensitivity, acknowledging personal, religious and social preferences that might influence comfort or willingness to participate.

CONFLICT OF INTEREST

None of the authors has any conflict of interest regarding the content of this article.

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