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Effect of Curriculum Changes on Student Performance During General Surgical Clerkship

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INTRODUCTION: Good clinical knowledge of anatomy, taught in medical school, is necessary for practicing physicians. It is a key feature of performance on the United States Medical Licensing Examination Step 1 score. Student performance on anatomy is also an early indicator of overall medical student performance. Unfortunately, curricular time provided for the teaching of anatomy has declined significantly over the last 30 years, leading to growing concerns that the anatomical knowledge of new medical graduates may not be adequate. Data regarding the impact of these changes to the medical school curriculum are lacking, with studies often being limited in number of medical students or time.

METHODS: This study examined the anatomy knowledge of students on third-year clinical rotations at Tulane University Medical School. Oral examinations were administered at the conclusion of the junior surgical clerkship. Data on performance were collected over a 5-year period from 690 medical students tested in their knowledge of anatomy, and the other basic sciences collectively considered as pathophysiology.

RESULTS: Over the 5-year period, student total scores by year increased in all categories tested. However, during the course of the students' third-year clerkships, the later in the year the students rotated on surgery, the more their scores progressively declined. Unfortunately, this fall was most severe in the knowledge of anatomy.

DISCUSSION: Although it is possible to teach anatomy in increasingly shorter periods of time, such that the students achieve high test scores in the standardized short answer examinations, it is clear that their knowledge, as applied to clinical care, rapidly declines the further they get away from Step 1 studying. Further study is necessary to elucidate the weaknesses in the current basic science curricula as they pertain to anatomy and to devise mechanisms to assure retention of this critical science during clinical rotations and beyond into practice. (J Surg Ed ▮:▮▮▮-▮▮▮. ©2017 Published by Elsevier Inc. on behalf of the Association of Program Directors in Surgery)

KEY WORDS: Clinical anatomy knowledge, Dissection, Multiple-choice examinations, Basic science retention

COMPETENCIES: Medical Knowledge, Practice-Based Learning and Improvement

INTRODUCTION

Anatomical dissection is considered a fundamental cornerstone of medical education in the United States. From the first formal anatomy course in 1745 at the University of Pennsylvania, cadaver dissection grew immensely popular as an educational tool. The scarce supply created a whole industry of procurement, with medical students turning to grave robbing in the 18th and 19th centuries.[1] State legislatures began to enact laws facilitating supply of cadavers to medical schools starting in the 1830s, with laws allowing for unclaimed bodies of people who died in public institutions, hospitals, asylums, and prisons to be used for anatomical dissection.[1] In 1968, the National Conference of the Commissioners on Uniform State Laws approved the Uniform Anatomical Gift Act (UAGA), establishing that an individual's right to donate their body superseded the wishes of any next of kin. Reforms in 1987 standardized the process of body donation in the

TABLE 1. Average Student Scores for Each Year. Data Represent Percent. Total $N = 690$

Year	Anatomy	Pathophysiology
2010	86.1	88.1
2011	84.5	88.5
2012	85.6	88.1
2013	88.0	88.6
2014	87.3	89.2

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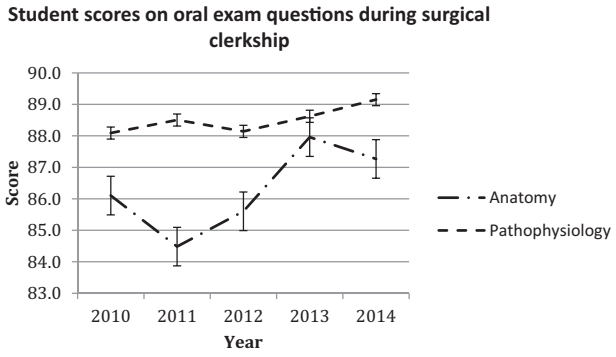

FIGURE 1. Overall average student scores for each year. Data represent percent. –..–, anatomy; – – –, pathophysiology. Bars represent mean ± standard error.

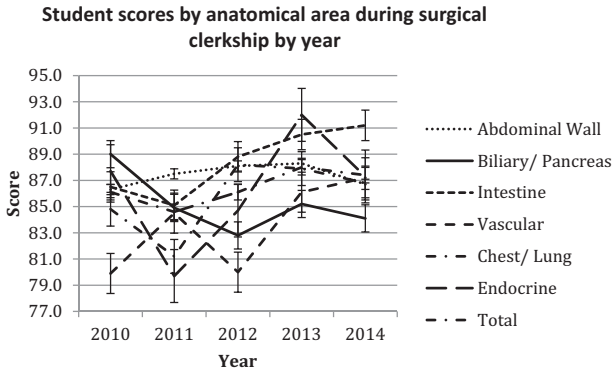

FIGURE 2. Average student scores by anatomical component for each year. Data represent percent. ……, abdominal wall; _____, biliary/pancreas; ————, intestine; __ . __, chest/lung; - - - , endocrine; – . – , total. Bars represent mean ± standard error.

United States, ensuring that human cadaver dissection is available to teach gross anatomy to medical students.

Mastery of anatomy is important to the future career of all physicians. Student performance in this first-year anatomy course, especially in human cadaver dissection, is positively correlated with student outcomes. Contrary to the potential needs of practicing physicians, current changes in curriculum countrywide include decreased hours for anatomy lecture and dissection. While scores on the United States Medical Licensing Examination (USMLE) Step 1 examination have marginally increased over time, concerns have been raised about how well these students are prepared for residency and beyond. Over the 5 years of this study, hours dedicated to teaching anatomy at Tulane University School of Medicine (TUSOM) have consistently decreased, falling from 16 weeks in 2008, 2009, and 2010, to 15 weeks in 2011 and 2012. Hours continued to decrease to 11 weeks in 2013 and 2014, to less than 10 weeks in 2015. This study was conducted to determine the effects of this curriculum change and determine whether the shorter course schedules have been destructive to clinical knowledge.

In this article, we discuss data related to anatomy knowledge collected during students' third-year surgical clerkship at TUSOM. These data represent information from students from the first class of students taught with a changing anatomy curriculum, through 4 subsequent years of progressive reduction in time spent learning anatomy. We looked at the performance of almost 700 students, in six different areas of anatomical knowledge compared to their scores in first-year non-anatomy basic science knowledge and total exam scores during their surgery clerkships.

METHODS

This study includes data from 5 years of student performance during their third-year surgical clerkship. Student performance was partially determined by oral exam scores. Thirty-minute oral exams were administered by faculty one-to-one to all third-year students at the completion of their 8-week clerkship. The technique of administration of the oral examination and the use of the exam book were reviewed with faculty annually to assure consistency. The exams were comprised of 3 multipart questions, each with multiple[4-6] anatomic components, selected from a possible 27 questions contained in a standardized surgical examination book, which was used without change for all 5 years. As a result, students were each tested on a minimum of 12 and often as many as 18 anatomic facts. Students were told at the beginning of the clerkship which 27 topics they were responsible to know and would be tested. These topics were taught during the clerkship using a variety of techniques, including lectures, small group assignments, clinical rounds, problem-based learning, and online material. Each question included anatomy and pathophysiology (overall non-anatomy basic sciences). Required answers were listed in the exam book with designated point values for each answer. Grades for each question component added up to a possible 25 points, for a total of 100 points.

The data consist of 690 students' scores for 5 years, with 6 blocks of clerkship per year. The data were blinded to preserve student anonymity. Anatomy scores were compared to

TABLE 2. Average Student Scores for Each Year for Each Anatomical Area. Data Represent Percent

Year	Abdominal Wall	Biliary/Pancreas	Intestine	Vascular	Chest/Lung	Endocrine	Total
2010	86.3	89.0	86.5	79.9	84.8	87.7	86.1
2011	87.5	84.9	85.1	84.5	81.2	79.7	84.6
2012	88.1	82.8	88.8	80.0	88.2	84.7	86.1
2013	88.3	85.2	90.5	86.1	87.9	92.0	88.0
2014	86.7	84.1	91.2	87.2	86.8	87.3	87.4

first-year non-anatomy basic science scores lumped together and considered as pathophysiology scores and to each student's total as a base performance indicator. Anatomy scores were categorized into the following 6 anatomical areas: abdominal wall and inguinal region, biliary and pancreatic function, small and large intestine, vasculature, chest and lung, and endocrine. Student scores for each question component and for each anatomical area were evaluated over the 5 years to elucidate trends among the data. In addition, scores were evaluated over the course of the surgical clerkship blocks within each year in order to determine if there was knowledge fade with time after USMLE Step 1 examination, which has been administered in the spring of the second medical school year over the 5-year time period. Scores were evaluated over the course of the surgical clerkship blocks within each year.

Students were randomly assigned to the sequence of their junior surgical clerkship blocks by the medical school registrar, so that students interested in surgical careers were evenly distributed throughout the clerkship year. Thus, the changes cannot be ascribed to the timing of specific rotations by students with predetermined career interests.

RESULTS

Over a 5-year period, student total scores increased slightly (Table 1 and Fig. 1). Anatomy and pathophysiology scores also increased, with anatomy increasing at a slightly higher rate.

Student scores for small and large intestine, vasculature, chest and lung, and endocrine increased over the 5-year period, with the biggest increase seen in vasculature (Table 2). Scores for abdominal wall and inguinal region, and biliary and pancreatic function showed slight decreases, with the latter falling at a faster rate (Fig. 2).

Examiners mainly used questions that involved biliary and pancreatic function, although the number of small and large intestine questions used increased over time to match that of biliary and pancreatic function (Table 3). The biggest increase in number of questions asked was in abdominal wall and inguinal region, followed by biliary and pancreatic function. The biggest decrease was seen in endocrine, followed by chest and lung (Fig. 3).

All student scores declined over the course of the year (Table 4). Importantly, the biggest decrease was seen in anatomy scores (Fig. 4). The ANOVA p-value was 7.86E-06, showing statistical significance between student scores for anatomy and pathophysiology. Student scores for anatomical areas showed more variability (Table 5). The biggest increase was in endocrine, followed by vasculature. The biggest decrease over the year was seen in chest and lung. Scores for abdominal wall and inguinal region, and biliary and pancreatic function, declined by similar amounts (Fig. 5).

DISCUSSION

Peterson and colleagues reported that class rank in medical gross anatomy and the score on the comprehensive medical gross anatomy final examination were significantly correlated in the USMLE Step 1 score. In contrast to most of the traditional predictors of performance, both indicators of medical gross anatomy performance were also correlated with passing the USMLE Step 1 at the 0.01 level.[2] Recently, a study of over 500 students at the Mayo Clinic[3] showed that better quality of dissection was associated with higher scores on practice and final practical, written, and National Board of Medical Examiners (NBME) examinations. In this study, Nwachukwu et al[3] also re-confirmed the conclusion of an earlier study by Yeager that it took a non-insignificant amount of time for students to get the maximum benefit from dissection.

Despite the obvious benefits of anatomy class, the amount of time, teaching staff, and hours related to dissection dedicated to teaching anatomy in medical schools has significantly declined over the last 30 years. This reduction in the anatomical curriculum has led to growing concerns among medical educators, clinicians, as well as medical students, that the anatomical knowledge of new medical graduates may not be adequate.[4] In the United Kingdom, for example, a sevenfold increase in claims associated with anatomical errors was submitted to the Medical Defense Union between 1995 and 2002.[5] Oliver Beahrs, an internationally acclaimed surgeon from the Mayo Clinic and the first President of the American Association of Clinical Anatomists puts this more bluntly—"today's residents in surgery are learning their anatomy on sick patients for the first time in the middle of the night: operating

TABLE 3. Question Count for Each Anatomical Area Per Year

Year	Abdominal Wall	Biliary/Pancreas	Intestine	Vascular	Chest/Lung	Endocrine	Total
2010	62	108	93	42	83	27	420
2011	78	101	66	35	76	15	378
2012	80	114	88	27	70	12	399
2013	84	113	96	36	75	15	426
2014	95	110	110	33	79	12	447

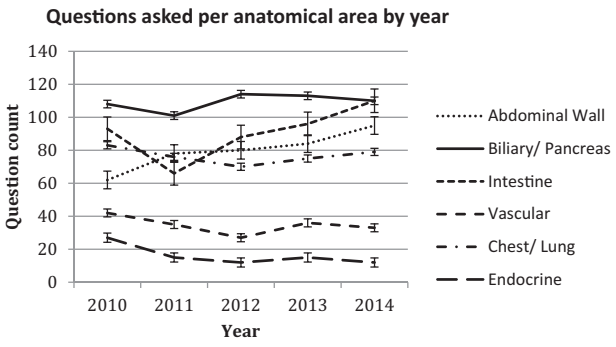

FIGURE 3. Question count for each anatomical component by year. ……, abdominal wall; _____, biliary/pancreas; ————, intestine; - - - , vascular; __ . __, chest/lung; __ __, endocrine. Bars represent mean ± standard error.

without a firm knowledge of anatomy leads to increased mortality and morbidity."[6]

How the changes to the first-year anatomy course impact students' anatomical knowledge is unclear. Jurjus et al[7] demonstrated a significant drop (~50%) in anatomical knowledge in third-year medical students at the beginning of their General Surgery and Obstetrics and Gynecology rotations as compared to their performance as first-year students. Unfortunately, the cohort for this study was comprised of students from a single class at George Washington University Medical School. Although the study was useful for identifying weak areas in retention of knowledge of anatomy, it did not address changing patterns over time. Other studies have evaluated too narrow areas of knowledge of anatomy,[8] anatomy retention between two classes at the same time,[9] or had too few participants to be meaningful.[10]

The current study compared anatomy scores with the remaining basic sciences considered as pathophysiology for a large group of students in sequential years. This allowed for comparison of trends in knowledge of anatomy against a student's total performance, and performance in other basic sciences. In addition, we looked at a breakdown of anatomy scores by subject area during the same time frame. This has also allowed us to determine how much each subject affected the general trends. Unique to this study, data were analyzed for student performance over the course of a total year of surgical clerkships. The fundamental question we were interested in answering was whether the endpoint of anatomy teaching was performance on short answer tests or clinically useful information.

Student total scores on oral examinations improved during their third-year surgical clerkship over the 5-year period 2010–2015. The greatest increase in score was seen in anatomy, contrary to the conclusions of Older[11] and McKeown et al[12], scores for pathophysiology (combined basic sciences) were higher than those for anatomy, attesting to the positive effect of a longer period of education.

TABLE 4. Average Scores by Surgical Clerkship Block. Higher Block Numbers Represent the Progressive Time Course in the Year, With Block 6, the Latest and Thus, Furthest From Step 1. Data Represent Percent

Block	Anatomy	Pathophysiology
1	87.0	89.1
2	86.9	89.6
3	85.8	88.7
4	87.7	90.6
5	86.8	88.2
6	84.3	87.9

The increase in anatomy scores over the 5-year period, despite the decreasing number of hours in lecture and dissection, might possibly be explained by assuming that increased student knowledge derived from independent studies. Since student scores decreased for anatomy over the year, it did not appear that completing other clerkships before surgery helped to reinforce anatomical knowledge. In fact, the data documented exactly the opposite.

Nearly 50% of examination questions came from biliary and pancreatic function and small and large intestine, clearly subjects of high clinical importance. Biliary and pancreatic function scores showed the biggest decline over time, despite being most commonly questioned. The second most commonly questioned area was small and large intestine. In contrast to biliary and pancreatic function, scores increased over time. The gastrointestinal system is clearly considered the most important area of anatomical knowledge for third-year general surgery clerkships. It is difficult to explain this discrepancy. The different student performance in small and large intestine versus biliary and pancreatic function cannot be explained by differences in question count, question usage, or hours dedicated to anatomy lecture and dissection during students' first/basic science year.

Data regarding anatomical area-specific score trends during the third-year clerkships were mixed, with decreases in abdominal wall and inguinal region, biliary and pancreatic function and chest and lung, and increases in

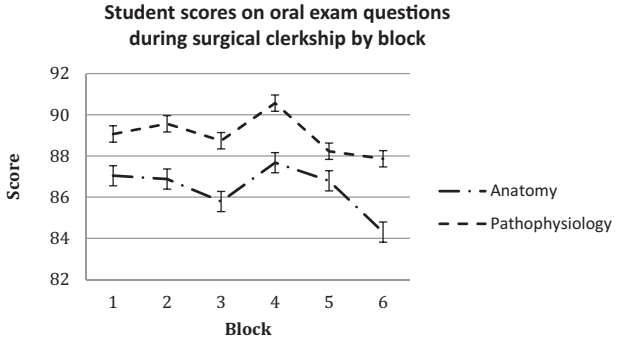

FIGURE 4. Average scores by surgical clerkship block. Data represent percent. __ . __, anatomy; - - -, pathophysiology.Bars represent mean ± standard error.

TABLE 5. Average Scores for Anatomical Component by Clerkship Block. Higher Block Number Represent the Progressive Time Course in the Year, With Block 6, the Latest and Thus, Furthest From Step 1. Data Represent Percent

Block	Abdominal Wall	Biliary/Pancreas	Intestine	Vascular	Chest/Lung	Endocrine	Total
1	89.1	88.7	86.3	80.0	88.9	84.4	87.0
2	89.2	86.0	89.5	81.0	86.2	76.7	86.9
3	85.8	84.3	88.4	83.9	84.5	90.8	85.8
4	90.5	84.6	91.0	85.1	86.1	86.5	87.7
5	86.7	84.1	87.3	89.9	86.3	91.5	86.8
6	83.2	82.7	89.9	84.3	80.5	91.0	84.3

small and large intestine, vasculature, and endocrine. The biggest drop in score was with chest and lung. This decline in knowledge was unexpected, given that other rotations, particularly medicine, during the third-year clerkships should have reinforced knowledge in this area of anatomy.

The reported decrease in knowledge of anatomy among surgical residents over the last several decades[4,6] is concerning. Our data suggests that the brief exposure to anatomy, which is akin to cramming in college, is responsible for the rapid decline in student knowledge of anatomy during their clinical rotations. More research is required to determine how best to rectify this problem. An inter-school comparison of similar data would be another way to determine the effects of curriculum changes related to anatomy. Alternatively, residency programs themselves could take on the burden of bridging the gap. Sharma et al[13] demonstrated that an additional cadaver course during surgical residency results in significant improvements in self-reported operative confidence and competence as assessed by oral examination. Another suggestion is that medical schools delay offering the Step 1 examination until after completion of the junior clerkship years, as has been done in 8 institutions in the United States.[14] This would require further study of anatomy during the clinical years and should presumably eradicate the downward drift in anatomical knowledge during the course of the third-year clerkships.

While this study examined a large group of students over a longer period of time than previous studies, our data are limited to assessing student knowledge based on oral examinations only during third-year surgery rotations. The data did not determine if the decline in student performance in clinical recollection of anatomy was unique to surgery.

CONCLUSIONS

Although student performance during first-year anatomy courses may be correlated to performance on USMLE Step 1,[2,3] our data show that students' knowledge decreased during the year after the Step 1 examination. The biggest decline for all subjects occurred in the blocks following winter recess. Knowledge of anatomy decreased substantially, and this is a matter of serious concern.

This study shows that it is possible to teach anatomy in a shorter period of time than in traditional curriculum such that students do well on USMLE Step 1. However, after that, student knowledge of anatomy sharply declines. To prepare students to function well as physicians, the academic endpoint needs to be clinical performance using anatomy on rotations and beyond, rather than on short answer tests.

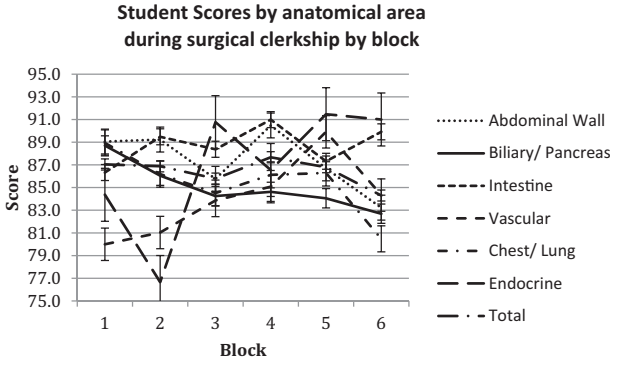

FIGURE 5. Average anatomical component scores by surgical clerkship block. Data represent percent. ……, abdominal wall; _____, biliary/pancreas; — — — —, intestine; - - - , vascular; - . -, chest/lung; __ __, endocrine; __ . __, total. Bars represent mean ± standard error.

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