TEACHING THE ANATOMY OF ONCOLOGY: EVALUATING THE IMPACT OF A DEDICATED ONCOANATOMY COURSE

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Purpose: Anatomic considerations are often critical in multidisciplinary cancer care. We developed an anatomy-focused educational program for radiation oncology residents integrating cadaver dissection into the didactic review of diagnostic, surgical, radiologic, and treatment planning, and herein assess its efficacy.

Methods and Materials: Monthly, anatomic-site based educational modules were designed and implemented during the 2008–2009 academic year at Duke University Medical Center. Ten radiation oncology residents participated in these modules consisting of a 1-hour didactic introduction followed by a 1-hour session in the gross anatomy lab with cadavers prepared by trained anatomists. Pretests and posttests were given for six modules, and post-module feedback surveys were distributed. Additional review questions testing knowledge from prior sessions were integrated into the later testing to evaluate knowledge retention. Paired analyses of pretests and posttests were performed by Wilcoxon signed-rank test.

Results: Ninety tests were collected and scored with 35 evaluable pretest and posttest pairs for six site-specific sessions. Posttests had significantly higher scores (median percentage correct 66% vs. 85%, p < 0.001). Of 47 evaluable paired pretest and review questions given 1–3 months after the intervention, correct responses rates were significantly higher for the later (59% vs. 86%, p = 0.008). Resident course satisfaction was high, with a median rating of 9 of 10 (IQR 8-9); with 1 being “less effective than most educational interventions” and 10 being “more effective than most educational interventions.”

Conclusions: An integrated oncoanatomy course is associated with improved scores on post-intervention tests, sustained knowledge retention, and high resident satisfaction.

INTRODUCTION

Gross anatomy has been part of a long-standing tradition in medical education. However, hours devoted to teaching anatomy have been declining (1–3). Up to 71% of residency directors report that incoming residents either require a refresher anatomy course or are “seriously lacking in anatomic knowledge” (1).

Radiation oncologists require an intimate understanding of anatomy, in the diagnosis and staging of disease via physical, radiologic, and pathologic examinations, and in the appropriate selection of therapies (4). An intimate knowledge of anatomy must be cultivated to further one’s expertise in the field. However, reviewing gross anatomy via cadaver dissections is not a traditional part of the radiation oncology residency. This is in contrast to many surgical subspecialties; for example, cadaver lab experience is a required by the Accreditation Council for Graduate Medical Education for all otolaryngology residency programs (5–9).

The “oncoanatomy” course at the Duke University Medical Center was designed in 2005 to address this need (10). The course goal was to reintegrate the often-forgotten gross anatomic relationships (usually learned in the first year of medical school) with relevant oncologic problems. We herein assess the educational impact of this initiative.

METHODS AND MATERIALS

Course description

The “oncoanatomy” course at Duke is based on monthly modules addressing a specific body region or tumor site where anatomic relationships are particularly pertinent to radiation oncologists (10). This analysis is limited to the 2008–2009 academic year for modules listed in Table 1. Module subjects were determined by the chief
Table 1. Oncoanatomy modules 2008-2009

Pancreatic cancer
Gastric cancer
Cancer in the mediastinum (including nodal metastases, thymoma, lymphoma, and germ cell tumors)
Nasopharyngeal cancer
Lymph node drainage patterns for cancers of the head and neck
Prostate cancer
Cervical cancer
Base of skull tumors
Laryngeal cancer
Retroperitoneal sarcoma
Pancoast (superior sulcus) tumors

in gross anatomy). Appropriate resources for the anatomic lab session are then obtained and organized by the anatomists.
Existing cadavers and anatomic models from the medical school gross anatomy course are used in the current phase of the project. The individual modules have been opened to residents and faculty from other disciplines as relevant to their interest, but the radiation oncology department is the primary instigator and beneficiary of the course. Costs for 50% full-time equivalent of an anatomist and 60% full-time equivalent of the residency coordinator are provided by an Innovations Grant from the Duke University School of Medicine department of Graduate Medical Education (W.R.L., P.I.).

Each module consists of two 1-hour sessions. The first hour is a clinically oriented presentation by our residents and faculty that is similar to our conventional educational conferences. This typically includes reviewing a patient case and the relevant radiographic anatomy. Time is devoted to defining critical normal tissues on the treatment planning images (i.e., image segmentation), an important factor during radiation treatment field design. The second session begins with a brief, 10-min introduction by the anatomists that includes review of anatomic diagrams and an orientation to up to
four prosection stations. The large group is then divided into smaller
groups of five to six attendees each. These small groups proceed to
rotate through each prosection station, for a 10- to 15-min informal
discussion and exploration of the prosected cadaver, guided by the
anatomist who prepared the specimen. Station topics are site specific
and vary with the module. For example, for the Base of Skull mod-
ule, stations included views of a dry skull, the cranial fossae from
a superior view, and an inferolateral view of the jugular foramen
(Fig. 1). Radiologic imaging is available at the stations via computer
monitors to assist in the synthesis of the gross anatomy with the
radiographs. For each session, the anatomists and the radiation
oncology residents and attendings coordinate their presentations to
define the key issues to be discussed.

To assess the utility of this educational intervention, the following
aims and assessment tools were defined.

A. Aim #1: To assess the immediate educational impact of the
modules. Short, 10–15 question tests were administered within 24
h before a module, and within 24 h after module completion. The
pretest and posttest covered the same material, with small alterations
to the question subject and answer selection. Questions included
“boards-style” multiple choice questions, segmentation of radio-
graphic images of critical tissues, and radiation field design.

It was explicitly communicated to the residents that performance
on these tests would only be used for evaluation of the course, not
for evaluation of their performance within the residency program.
Pretests and posttests for each module were scored by one investiga-
tor (J.C.) at the same sitting to maximize scoring consistency.

B. Aim #2: to assess knowledge retention. After the first two
modules, the pretests and posttests for the latter modules were mod-
fied to include review questions addressing material presented in
prior modules completed 1–3 months earlier. The format of these
questions was identical to that described under Aim #1.

C. Aim #3: to assess the resident satisfaction with the course.
Anonymous web-based surveys were distributed to the residents
at the time of the posttest for the skull base module, which occurred
eighth in the series of 11 modules for the academic year. Participants
were asked to rate the oncoanatomy course as a whole in comparison
to other educational interventions in the Duke residency training
program. A scale of 1–10 was used, with 10 being superior to
most interventions, 5 being equivalent to the average intervention,
1 being inferior to most interventions. Participants were also asked
to rate the educational effectiveness of each portion of the oncoanat-
omy module, differentiating between the clinical didactic compo-
nent, the radiology review component, and the anatomy lab
component. A 1–10 rating scale was used; 10 being highest educa-
tional utility, 5 being of moderate utility, and 1 being of no utility.

Statistics
Paired sample analysis compared pretest versus posttest perfor-
mance (aim #1), as well as pretest versus review question perfor-
mance (aim #2) using the Wilcoxon signed-rank test (11). Tests
were paired by resident (e.g., posttest from resident 1 was compared
with pretest from resident 1). Tests that did not have a corresponding
pair were excluded from the analysis (e.g., if resident 2 completed
Fig. 2. Example questions for multiple choice “boards-style” questions, segmenting exercises, and field design questions
for various modules of the Duke Oncoanatomy course.
a pretest but not a posttest for a given module, that pretest was excluded). All $p$ values are given for two-tailed tests. All statistical analyses were performed in SPSS v17.0 (Chicago, IL).

RESULTS

Aim #1: to assess the immediate educational impact of the modules

Ninety pretests and posttests were evaluable from ten residents from six completed modules. Of the residents, six were postgraduate year (PGY)-2, two were PGY-3, one was PGY-4, and one was PGY-5. The median number of tests per resident was 10 (interquartile range [IQR] 8–10). Thirty-nine paired pretests and posttests were evaluable, with a median of four test pairs per resident (IQR 4–4). The median pretest score was 66% (IQR 53–82%) vs. a posttest median of 85% (IQR 71–94%), $p < 0.001$ for difference by paired analysis (Fig. 3). For the “boards style” multiple choice questions, the pretest median was 71% (IQR 41–100%) vs. the posttest median of 84% (71–100%), $p < 0.001$. For the image segmentation and field design questions, the pretest median score was 62% (IQR 38–77%) vs. the posttest median of 78% (IQR 67–100%), $p < 0.001$.

Upper level residents (PGY 3-5; years 2–4 of radiation oncology training) performed better on pretests overall (median score for PGY-2 residents 59% [IQR 40–74%], vs. upper level median of 73% [IQR 58–86%], $p = 0.03$), but not on posttests (median PGY-2 score 83.3% [IQR 69–92%], vs. upper level median 84.6% [IQR 73–100%], $p = 0.34$). The differences were largest in the pretest board-style questions (PGY-2 median 50% [IQR 34–81%] vs. upper level median 81% [IQR 50–100%], $p = 0.04$), with smaller differences in the pretest segmentation and field design exercises (PGY-2 median 59% [IQR 28–73%] vs. upper level median 66.7% [IQR 47–92%], $p = 0.15$). Both higher level residents and lower residents showed improved performance after the oncoanatomy modules, statistically significant for all comparisons except for boards style questions for the higher level residents (Fig. 4).

Aim #2: to assess knowledge retention

Eight multiple choice review questions were introduced into the testing in the latter four modules; each of these questions was identical to a question on a pretest for a prior module. Individual resident performance on the review question was compared to their performance on the pretest between 1 to 3 months prior. Forty-seven pretest and review question pairs were evaluable. Thirty of the pairs were obtained 1 month after module completion, 10 pairs were 2 months after, and 7 were 3 months after. Performance on review questions was improved compared with pretest performance; percent correct on all review questions was 86% vs. pretest percent correct was 59%, $p = 0.008$ by paired analysis. There was no difference between the performance on the review questions and the corresponding immediate posttest questions (percent correct was 84% for postest, 86% for review, $p = 1.0$ for paired comparisons).

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**Fig. 3.** Boxplots of scores from pretest and posttests. The box outlines the upper and lower quartiles, the horizontal line inside the box is the median, and the whiskers represent the range; Outliers are noted by points outside of the whiskers.
Though the number of evaluable tests at 3 months after intervention were limited, performance remained significantly better on review versus the matched pretest (1/7 correct in pretest, 5/7 correct in review 3 months after intervention, \( p = 0.046 \)).

**Aim #3: to assess the resident satisfaction with the course**

Ten anonymous web surveys were distributed at the time of the eighth module (base of skull), and all were returned (response rate 100%). The results are collated in Fig. 5. High resident satisfaction was seen in all module components with a median evaluation of 10 of 10 for each of the three components. The median evaluation for the whole course was 9 of 10 (IQR 8–9).

**DISCUSSION**

This study demonstrates that integrating the gross anatomy lab into a coherent oncoanatomy course is a useful educational intervention, as measured on objective tests. We also demonstrate that the knowledge gained during these interventions is maintained for at least 3 months.

Oncology practice requires an in depth understanding of anatomy, for the diagnosis and staging of disease via physical, radiologic, and pathologic examinations, and for the appropriate selection of therapies. For the surgical and radiation oncologist, a detailed knowledge of the regional anatomy and the patterns of spread of cancer are critical to appropriately address both macroscopic and microscopic extent of disease. For the surgeon, anatomy influences the selection of dissection plane, resection extent, and either biopsy or resection of lymph node drainage basins. For the radiation oncologist, anatomy influences the sequence of treatment (preoperative vs. postoperative treatment), the selection of treatment modality (teletherapy, brachytherapy, intraoperative therapy, and particle therapy), and the design of treatment volumes and doses.

In addition, with increasing survivorship, particular attention must be paid to the relationship of normal tissues within treatment fields, and the potential morbidity of treatments (12–14). In the case of local regional treatments such as surgery and radiation therapy, the normal tissue often establishes the limit to which the macroscopic and microscopic disease can be treated.

An elective oncologic-anatomy course for first-year medical students was previously described by Hansen et al. at the University of Rochester (15). Their course was designed to introduce clinical relevance to medical students during their training in gross anatomy. In some respects, the current study is an inverted form of the Rochester format. We return residents in clinical oncology to the gross anatomy lab to reinforce the
three-dimensional relationships learned 5–9 years previously, now particularly relevant to their postgraduate training.

A randomized trial of the integration of cadaver dissection into the obstetrics and gynecology residency program was reported in 1995 (6). In this small trial, 13 first- and second-year obstetrics and gynecology residents were randomly assigned to 2- to 3-h dissection sessions with a female cadaver or the same amount of protected self-study time with provided anatomical references. The dissection group performed significantly better on posttests than the control group, with an improvement of 56.7% compared with a 20% improvement in controls ($p < 0.001$).

There have been several recent studies looking at optimal methods of improving image segmentation and field design skills among residents in radiation oncology. A study from Memorial Sloan-Kettering demonstrated improved head and neck target delineation among 11 residents after a dedicated seminar series in combination with a hands-on image segmentation session (16). Investigators at Princess Margaret Hospital conducted a small randomized trial of a single image segmentation educational intervention in prostate and normal anatomy delineation in 31 participants (17). The participants receiving the image segmentation intervention became more confident with their image segmentation skill. However, the control group and intervention group had similar improvements in pretest vs. posttest scoring. Tai et al. found a significant improvement in target delineation of the cervical esophagus after specific training in an uncontrolled cohort of 12 radiation oncologists (18). They were also able to show that the uniformity achieved by training was maintained 1–2 months after intervention.

The development of consensus atlases and protocols has been shown to improve consistency in image segmentation in the setting of prostate bed treatment and gynecologic brachytherapy planning (19, 20). The Radiation Therapy Oncology Group has developed consensus contouring atlases in anorectal, gynecologic, head-and-neck, prostate, and breast cancer, with a goal to standardize volume delineation (21). The challenge facing residency programs, then, is how to optimally train residents to accurately reproduce these volumes. We believe that integrating experiences in the cadaver lab with didactic teaching methods will prove useful to this goal, and is the subject of future research.

We acknowledge that our analysis has several potential shortcomings. First, the importance of the anatomy lab component of this initiative is unclear as we have not performed similar pretests and posttests for other didactic educational conferences. Nevertheless, comments and evaluations from the residents suggest that the gross anatomy lab is of high utility. Second, the number of residents involved is modest. Even so, the findings were fairly similar across our residents. Further, our study is a reasonable size when compared with other studies of educational initiatives in oncology education. Third, the follow-up remains relatively short in the evaluation for knowledge retention at 3 months. That stated, there are few reports of resident educational interventions with any evaluation of retention (22–25). Moreover, we intend to pursue longer follow-up of this course in the coming years. Finally, the three-point scale used in evaluation of segmentation and field design is coarse. A more refined quantitative method of segmentation analysis is being developed for future research to address this.

**CONCLUSION**

An integrated oncoanatomy course is a useful educational intervention based on objective testing, sustained knowledge retention, and high attendee satisfaction.
REFERENCES