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Teaching Anatomy Through Imaging: Single-Centre Retrospective Analysis from NOVA Medical School Between 2012 and 2020

Ensino de Anatomia em Colaboração com a Radiologia no Mestrado Integrado de Medicina: Análise Retrospectiva na NOVA Medical School entre 2012 e 2020

Tiago Bilhim[1], Diogo Casal[2], Rui Mateus Marques[1], Diogo Pais[3]

[1]Professor, Radiology Department, NOVA Medical School, Lisbon, Portugal
[2]Professor, Anatomy Department, NOVA Medical School, Lisbon, Portugal
[3]Professor, Director of Anatomy Department, NOVA Medical School, Lisbon, Portugal

Address

Tiago Bilhim
Radiology Department
NOVA Medical School
Campo Mártires da Pátria, 130
1169-056, Lisboa, Portugal
e-mail: tiagobilhim@hotmail.com

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Abstract

The main challenges for teaching anatomy and radiology for undergraduate medical students rely on the limited available time and large volume of information. To face these challenges, many medical schools have merged anatomy and radiology teaching. Clinical and imaging anatomy is a course created for undergraduate medical students of the second year, second semester, from the NOVA medical school, run by the imaging and anatomy departments. A retrospective analysis of this course was performed from 2012/2013 through 2019/2020, using the student's questionnaires at the end of each semester. More than 90% of students found that the allotted time for this course was adequate and that the information provided was important for the future medical practice. The overall satisfaction rate with the theoretical and practical teaching was greater than 75%. The mean global satisfaction with the course was superior to 75%. Based on the student's responses, over 85% reported that the radiological anatomy teaching was well accomplished. However, the teaching of anatomy and radiology should be revisited during the last, clinical years of the undergraduate medicine course.

Keywords

Teaching; Anatomy; Radiology; Medical; Students, Medicine; University.

Resumo

Os principais desafios ao ensino de anatomia e radiologia no mestrado integrado de medicina (MIM) prendem-se com o tempo limitado e o enorme volume de informação. Para fazer face as estas limitações, as reformas do MIM levaram a que o ensino de anatomia e radiologia fosse fundido em muitas faculdades de medicina. Na NOVA medical school, o ensino de anatomia clínica e radiológica foi estruturado numa unidade curricular denominada de imagiologia e anatomia clínicas (IAC), no 2º ano, 2º semestre, assegurada pelos departamentos de anatomia e radiologia. A análise do ensino da UC de IAC desde a sua implementação em 2012/2013 até 2019/2020 foi feita com base nas respostas dos alunos aos questionários implementados de acordo com o procedimento para a análise semestral do funcionamento do ciclo de estudos da NOVA. Mais de 90% dos alunos inquiridos considerou que o tempo alocado à IAC (UC semestral de 72 horas) é adequado e que os temas versados são importantes para o futuro do médico. Globalmente, a taxa de satisfação com o ensino teórico e prático da IAC foi superior a 75%, e a satisfação global com a UC foi em média superior a 75%. O ensino de anatomia radiológica foi bem sucedido em mais de 85% dos alunos inquiridos. Contudo, o ensino de anatomia e radiologia nesta UC não é suficiente para os alunos do MIM, sendo necessário o reforço do ensino, com UCs dedicadas ao ensino de anatomia e radiologia clínica nos últimos anos do MIM.

Palavras-chave

Ensino; Anatomia; Radiologia; Medicina; Estudantes; Médicos.

Challenges of Teaching Anatomy to Medical Students

The main challenges faced when teaching modern anatomy rely on the vast amount of information needed to be learned in face of the progressive reduction of dedicated anatomy teaching time over the last decades at medical universities. These challenges highlight the importance of optimizing the limited amount of time to teach and learn the essential and clinically relevant anatomy. Defining the essential or ground base anatomy concepts is also a matter of debate. More so, varied teaching methods to overcome these challenges have been proposed.[1-15] Three different dimensions of learning have been identified: deep, superficial and strategic.[1,3,15] Deep retention on knowledge relies on continued study with multiple resources and complementary information that allows consolidation of concepts and integration of information leading to long-lasting retention of knowledge. Superficial learning is based on memorization of concepts in a random and isolated manner, without integration and linkage of ideas, leading to short-lasting retention of knowledge. Strategic learning relies on evaluation-driven retention of knowledge.[1-7,15] The first contact that medical students have with anatomy teaching could be a superficial one, to be consolidated in the following years. This sequential teaching of anatomy through the different years of medical school using different approaches and perspectives would allow a retention of knowledge, with integration of more

information.[2,8,15] This continued teaching of anatomy throughout medical school years would allow a more efficient learning with a vertical approach top-down, revisiting anatomy in the clinical years.[1-11,15] This vertical teaching of anatomy would be based on different approaches: descriptive anatomy in the initial year, clinical and radiological anatomy in the second year, topographic and dissection anatomy in the last clinical years of medical school to foster deep acquisition of knowledge.[4,5] The best way to teach anatomy is based on multiple teaching resources as dissected specimens, cadaveric dissection, 3D plastic models, radiological anatomy, and digital platforms (Figure 1). The goal of this study was to describe the performance of a newly created curricular unit called clinical and imaging anatomy to second year medical students to complement the anatomical teaching of basic anatomy taught during the first year of medical school.

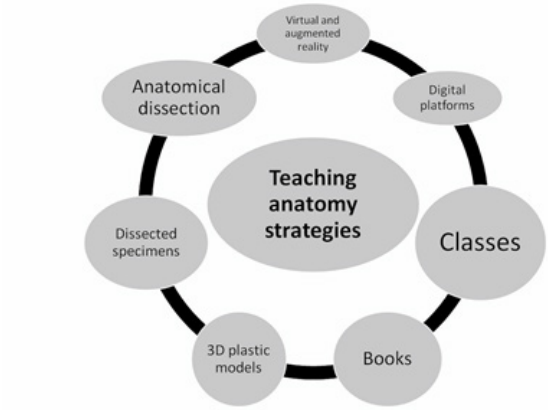

Figure 1 – Strategies for teaching anatomy.

Teaching of Anatomy and Radiology at NOVA Medical School throughout the Years

Before the curriculum reform of the medicine course established in 2011/2012 at NOVA medical school, anatomy was taught during the first two years of medical school with two curricular units spanning over the whole year (four semesters) with a total of 336 hours.[2] Teaching methodology was based on descriptive and systematized anatomy, with 2 sessions (on in each year) of two weeks dedicated to cadaveric dissection. During each year, anatomy was taught over a period of 28 weeks. In each week, there were two theoretical classes of 50 minutes and two practical classes of 110 minutes. Since the curriculum reform put into place in 2011/2012, anatomy has been taught differently at NOVA medical school:

- Descriptive and systematized anatomy of bones and joints, muscles, organs, cardiovascular and nervous system of the whole body: curricular unit of anatomy taught during the first year, first semester, 13 ECTS (European Credit Transfer System), 112 hours – taught by the Anatomy Department.
- Anatomy of the central nervous system, curricular unit of fundamentals of neurosciences during the second year, first semester, 8 ECTS, 29 hours – 9 hours dedicated to anatomy taught by the Anatomy department.
- Clinical and radiological anatomy, curricular unit of clinical and imaging anatomy (whole human body except central nervous system taught previously), second year, second semester, 8 ECTS, 72 hours – teaching integrated between the anatomy and radiology departments.
- Optional curricular units – cadaveric dissection of the trunk during first year, second semester and cadaveric dissection of the head and neck, back and limbs, second year, second semester, each curricular unit with 30 ECTS and 30 hours – taught by the anatomy department.

To face the time constraints for anatomy teaching at NOVA medical school, a new teaching approach and format was adopted, using different modalities of teaching, different teachers with different backgrounds, at different timepoints during the first two years of medical school. Radiology and anatomy teaching were merged in the second year of medical school, to enhance the anatomical concepts introduced during the curricular unit of anatomy during the first semester of the first year. The use of radiology to enhance anatomy teaching has been thoroughly described in medical schools throughout the world.[1,4,12-23] The European Society of Radiology has suggested a specific curriculum to optimize teaching of anatomy and radiology during the initial years of medical school.[24-26]

The curriculum reform of the medicine course established in 2011/2012 at NOVA medical school also led to the extinction of a curricular unit of radiology taught during the fourth year of medical school. Since then, teaching of radiology at NOVA medical school is only mandatory during the curricular unit of clinical and imaging anatomy (second year, second semester), focusing on introducing imaging techniques, image interpretation and radiological anatomy. This could be viewed as insufficient, given the fundamental role of radiology in modern medicine, to diagnose, triage, guide therapeutical decisions and prognostic considerations. At present, the first module of radiology teaching, suggested by the European Society of Radiology,[26] is provided at NOVA medical School with the curricular unit of clinical and imaging anatomy. However, the second module of radiology teaching suggested by the European Society of Radiology, focusing on the different pathologies is not structured at NOVA medical school. There is a limited cooperation of radiology teaching with the curricular unit of medicine during the third year of medical school and an optional curricular unit of clinical radiology taught at the fourth year, second semester of medical school.

Organization of the Curricular Unit Clinical and Imaging Anatomy, Second Year, Second Semester, NOVA Medical School

The teaching staff comprises three different departments: anatomy, radiology and neuro-radiology. Radiology and neuro-radiology professors are hired specialized consultants and residents. Anatomy professors comprise a variety of different physicians with multiple medical specialities, including specialized consultants and residents. Imaging with radiologists and neuro-radiologists comprises 2/3 of the whole curricular time (48 hours), whereas anatomy comprises the remainder 1/3 (24 hours), totaling to 72 hours for direct contact teaching, with 32 hours of theoretical classes and 40 hours of practical classes spanning over 14 weeks (Table 1).

As recommended by the European Society of Radiology (ESR), all theoretical and practical classes were pre-recorded and available before the actual class date,[26] allowing students to prepare all class contents beforehand. This allowed time optimization, using the time with the teaching staff for questions and discussion over the study contents, increasing the interaction between teachers and students.[26] This approach was very well received among students. All

Table 1 – Overall organization of the curricular unit clinical and imaging anatomy along the second semester of the second year of the NOVA medical school.

Organization of the curricular unit clinical and imaging anatomy	
1st week	Anatomy theoretical classes: introduction to clinical anatomy; clinical anatomy of the thorax, heart and breast. Radiology theoretical classes: introduction to imaging, basic physic principles for medical imaging; image interpretation; nuclear medicine; vascular imaging; imaging of the thorax, heart and breast.
2nd week	Anatomy theoretical classes: clinical anatomy of the abdomen. Radiology practical classes: introduction to imaging, basic physic principles for medical imaging; image interpretation I.
3rd week	Radiology theoretical classes: imaging of the abdomen. Radiology practical classes: introduction to imaging, basic physic principles for medical imaging; image interpretation II. Anatomy practical classes: clinical anatomy of the thorax, heart and breast.
4th week	Anatomy theoretical classes: clinical anatomy of the pelvis and perineum. Anatomy practical classes: clinical anatomy of the abdomen. Radiology practical classes: imaging of the thorax, heart and breast.
5th week	Radiology theoretical classes: imaging of pelvis and perineum. Radiology practical classes: imaging of the abdomen. Anatomy practical classes: clinical anatomy of the pelvis and perineum.
6th week	Anatomy and radiology theoretical classes: head and neck. Radiology practical classes: imaging of the pelvis and perineum.
7th week	Anatomy and radiology theoretical classes: vertebral column, cranial nerves, sense organs Radiology practical classes: intermediate evaluation with group assignments. Anatomy practical classes: clinical anatomy of the head and neck.
8th week	Anatomy theoretical classes: clinical anatomy of the upper limb. Radiology practical classes: vertebral column, cranial nerves, sense organs I.
9th week	Radiology theoretical classes: imaging of the upper limb. Radiology practical classes: vertebral column, cranial nerves, sense organs II. Anatomy practical classes: clinical anatomy of the upper limb.
10th week	Anatomy theoretical classes: clinical anatomy of the lower limb. Radiology practical classes: imaging of the upper limb.
11th week	Radiology theoretical classes: imaging of the lower limb. Anatomy practical classes: clinical anatomy of the lower limb. Radiology practical classes: visit to the radiology department.
12th week	Radiology theoretical classes: emergency imaging. Radiology practical classes: imaging of the lower limb.
13th week	Radiology theoretical classes: pediatric and pregnancy imaging . Anatomy practical classes: student evaluation through labeling of anatomical structures. Radiology practical classes: emergency imaging.
14th week	Radiology practical classes: student evaluation through labeling of anatomical structures with imaging techniques.

study contents were based on the recommended book references,[27-30] digital platforms[31-33] and specific contents for more detailed concepts.[34-42] Student evaluation was divided into practical evaluation (50%) and final written exam (50%). Practical evaluation was divided into 3 parts: a group assignment (30%); written test of anatomy (35%) and radiology (35%). The group assignment was based on literature research covering specific clinical scenarios where radiological anatomy was relevant. This group assignment was presented during the 7th week of classes. The written tests were performed during the 13th (anatomy) and 14th (radiology) weeks of classes, where students had to label anatomical and radiological images. The final written exam comprised 80 multiple choice questions.

Performance of the Curricular Unit Clinical and Imaging Anatomy, NOVA Medical School between 2012-2020 and Improvement Strategies

The analysis on the performance of the curricular unit clinical and imaging anatomy was performed since its creation in 2012/2013 until 2019/2020, based on the student´s responses to institutional questionnaires (REIT. DGQ.PR.04) from NOVA University. Institutional review board approval was obtained (115/2021/CEFCM) for the publication of these results. The questionnaires evaluated the student´s perspectives on the organization, structure and performance of the curricular unit (form NMS.CP.FOR.04/ NMS.GQ.PR.04). The mean proportion of students responding to the questionnaires was 28% (mean of 80/288 students responded), which is above the designated threshold of 20% to be considered representative (NMS.CP.PR.01.01). The performance of the curricular unit was based on the comprehension of study subjects, goal completion, adequate teaching methodologies and resources, teaching methods, individual progression over the semester, and overall satisfaction (Table 2). Multiple organizational components had to be improved since 2012 to enhance the academic performance of the curricular unit. The greatest challenge was related to the coordination between anatomy and radiology departments. In the initial years, 25% of students responded that the organization of the curricular unit could be improved. This led to a strategic and combined effort of coordination between teaching staff and departments that led to consistently improved outcomes since 2016. The remainder evaluated parameters were well rated, with 5%-15% of students considering that the program, contents, curricular unit duration, articulation with other curricular units, teaching methods and resources, study references, and interest of study contents needed to be improved. The vast majority of students considered the duration of the

Table 2 – Student evaluation on the performance of the curricular unit clinical and imaging anatomy from 2012-2020.

Year	Number of responses	Unserstanding of study contents	Goals completion	Useful methods	Useful resources	Information on evaluation	Complying with evaluation	Progress evaluation	Overall satisfaction with curricular unit
2012/2013	90	53.34%	47.78%	37.77%	47.78%	58.89%	65.56%	43.34%	35.56%
2013/2014	59	77.96%	77.96%	59.31%	61.01%	76.27%	77.96%	42.37%	62.71%
2014/2015	75	92.00%	86.67%	82.67%	85.33%	96.01%	90.67%	48.00%	81.33%
2015/2016	76	68.42%	68.42%	52.63%	74.99%	81.58%	51.32%	57.89%	50.00%
2016/2017	73	91.79%	89.05%	68.50%	80.83%	93.16%	80.83%	45.21%	68.50%
2017/2018	104	93.27%	88.46%	82.68%	86.54%	98.07%	97.12%	48.09%	81.73%
2018/2019	91	93.41%	90.11%	74.73%	87.91%	100.00%	97.80%	63.74%	76.93%
2019/2020	74	91.89%	94.60%	82.43%	90.54%	100.00%	95.95%	85.14%	82.43%
Mean	80.25	82.76%	80.38%	67.59%	76.87%	88.00%	82.15%	54.22%	67.40%

curricular unit adequate (93.06%) and agreed that the study contents were relevant for future medical practice (95.14%). During the last four years it was possible to consistently achieve study contents comprehension rates above 90% and goal completion rates above 85% (Table 2). During the year 2019/2020, the mean student's satisfaction rate was 4.4 (scale of 0 worse to 6 best), which was considered adequate by the institutional quality department.

The academic performance of the curricular unit is presented in Table 3. The number of registered students varied between 275 – 305 and the final mean scores between 15 and 16 on a scale from 0-20. The global fail rate was inferior to 10%. These aspects were considered adequate by the institutional quality department. According to regulation NMS.CP.PR.01.01, a curricular unit is considered adequate when the fail rate is < 25%. The class attendance rate improved with the "blended-learning" (combined online and onsite lectures and classes), with an increase in attendance to theoretical classes that were available online. Overall, the mean satisfaction rate with the theoretical and practical courses was 84% (Table 3), also considered adequate by the institutional quality department.

memorization without comprehension. Methods to teach more and better anatomy and radiology, using less time are reviewed. The specific example of the curricular unit clinical and imaging anatomy from NOVA medical school is reviewed from 2012 – 2020, highlighting the performance of teaching anatomy through imaging. Over 90% of students considered the teaching time adequate (72 hours) and that the study contents were relevant for the future medical role. The global satisfaction rate with the curricular unit and teaching classes was > 75%. Teaching anatomy through imaging was considered well succeeded by > 85% of students. To achieve these performances, a better coordination was required between radiology and anatomy departments. Basic anatomy and radiology concepts were acquired by second year medical students. However, anatomy and radiology teaching need to be further developed during the last clinical years of medical school to enhance learning and understanding of key anatomical and radiological concepts. Also, the importance of imaging within modern medicine, needs to be reflected in the last years of medical school, with dedicated time to teach clinical radiology.

Table 3 – Academic performance of medical students after completion of the curricular unit clinical and imaging anatomy from 2012-2020.

Year	Registered students (n)	Mean final score (0-20)	Fail rate	Attendance < 50%	Attendance 50% - 75%	Attendance > 75%	Satisfaction with theoretical classes	Satisfaction with practical classes
2012/2013	281	14.65	4.98%	23.38%	22.08%	54.55%	n/a	n/a
2013/2014	280	14.86	8.21%	15.10%	20.75%	64.15%	n/a	n/a
2014/2015	275	15.51	6.55%	5.80%	18.84%	75.36%	n/a	n/a
2015/2016	284	15.02	8.80%	9.21%	10.53%	60.53%	n/a	n/a
2016/2017	300	14.72	8.33%	5.48%	12.33%	75.34%	93.15%	80.83%
2017/2018	279	15.41	10.04%	25.00%	24.04%	50.96%	82.69%	94.23%
2018/2019	299	15.76	7.36%	12.09%	20.88%	67.03%	78.02%	87.91%
2019/2020	305	16.29	6.56%	8.10%	14.90%	77.00%	83.8%	74.32%
Mean	288	15.28	7.60%	13.02%	18.04%	65.62%	84.42%	84.32%

Conclusion

Increasing the efficiency of anatomy and radiology teaching for medical students, considering existing time restraints, might be achievable through different approaches and using a vertical method of teaching throughout the medical school years. Such teaching will potentiate deep acquisition of knowledge, allowing a better understanding and retention of study concepts, minimizing superficial learning based on

Ethical disclosures / Divulgações Éticas

Conflicts of interest: The authors have no conflicts of interest to declare.
Conflitos de interesse: Os autores declaram não possuir conflitos de interesse.
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Suporte financeiro: O presente trabalho não foi suportado por nenhum subsídio ou bolsa.
Confidentiality of data: The authors declare that they have followed the protocols of their work center on the publication of data from patients.
Confidencialidade dos dados: Os autores declaram ter seguido os protocolos do seu centro de trabalho acerca da publicação dos dados de doentes.
Protection of human and animal subjects: The authors declare that the procedures followed were in accordance with the regulations of the relevant clinical research ethics committee and with those of the Code of Ethics of the World Medical Association (Declaration of Helsinki).
Protecção de pessoas e animais: Os autores declaram que os procedimentos seguidos estavam de acordo com os regulamentos estabelecidos pelos responsáveis da Comissão de Investigação Clínica e Ética e de acordo com a Declaração de Helsínquia da Associação Médica Mundial.

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