“Anatomy and Imaging”: 10 Years of Experience with an Interdisciplinary Teaching Project in Preclinical Medical Education – From an Elective to a Curricular Course

„Anatomie und Bildgebung“: 10 Jahre Erfahrung mit einem interdisziplinären Lehrprojekt im vorklinischen Medizinstudium – vom Wahlkurs zum curricularen Kurs

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Key words
- education
- anatomy
- teaching of anatomy
- radiologic anatomy
- preclinical curriculum

Abstract

Purpose: Presentation of an interdisciplinary, interactive, tutor-based preclinical teaching project called “Anatomy and Imaging”.

Materials and Methods: Experience report, analysis of evaluation results and selective literature review.

Results: From 2001 to 2012, 618 students took the basic course (4 periods per week throughout the semester) and 316 took the advanced course (2 periods per week). We reviewed 557 (return rate 90.1%) and 292 (92.4%) completed evaluation forms of the basic and the advanced course. Results showed overall high satisfaction with the courses (1.33 and 1.56, respectively, on a 5-point Likert scale). The recognizability of the relevance of the course content for medical training, the promotion of the interest in medicine and the quality of the student tutors were evaluated especially positively.

Conclusion: The “Anatomy and Imaging” teaching project is a successful concept for integrating medical imaging into the preclinical stage of medical education. The course was offered as part of the curriculum in 2013 for the first time. “Anatomy in mortuis” and “Anatomia in vivo” are not regarded as rivaling entities in the delivery of knowledge, but as complementary methods.

Key points:
- The course introduces preclinical students to radiology.
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Zusammenfassung

Ziel: Vorstellung des interdisziplinären, interaktiven, tutorengestützten, vorklinischen Lehrprojektes „Anatomie und Bildgebung“.

Material und Methoden: Erfahrungsbericht, Auswertung der Evaluationsergebnisse sowie selektive Literaturrecherche.

Ergebnisse: Zwischen 2001 und 2012 besuchten 618 Studierende den Grundkurs (4 Semesterwochenstunden) und 316 den Aufbaukurs (2 Semesterwochenstunden). Zur Auswertung lagen 557 (Rücklaufquote 90,1%) bzw. 292 (92,4%) vollständig ausgefüllte Evaluationsbogen vor. Die Gesamtbewertung der Kurse war gut bis sehr gut (1,33 bzw. 1,56 auf einer 5-stufigen Likert-Skala). Positiv beurteilt wurden insbesondere die Erkennbarkeit der Relevanz der Kursinhalte für die ärztliche Ausbildung, die Förderung des Interesses an der Medizin sowie die Qualität der studentischen Turoren.

Introduction

Human anatomy is the basis for almost all clinical action. This fact is highlighted by a survey of 318 medical students, 94% of whom regard the course of gross anatomy as relevant [1]. Specialists before final board examination feel that anatomy is the most important preclinical subject for later work [2].

However, the anatomical knowledge of students entering the clinical stage of medical education is often classified as poor for safe clinical practice. Conventional anatomy courses seem to prepare students inadequately for their clinical tasks [3]. Even students themselves do not feel properly trained [4, 5].

In an article published in 2012, it was yet again demanded for safe clinical practice. Conventional anatomy courses seem to be the most effective teaching procedure [19]. The present medical faculty has a 30-year record of delivering the traditional dissection course with visual methods. The present medical faculty has a 30-year record of delivering the traditional dissection course with visual methods.

The purpose of this course is to deepen knowledge within a clinical context and to provide first contact with medical imaging. The purpose of this course is to deepen knowledge within a clinical context and to provide first contact with medical imaging. We report our experiences and the course evaluations over the last 10 years.

Materials and Methods

The course is organized into a basic and an advanced course, lasting a semester each. The maximum number of participants per semester was limited to 30 students. The course structure and syllabus are shown in Table 2.

Basic course

Management of the course came under the responsibility of the Institute of Anatomy. Staff from the Institute of Clinical

Table 2 Structure and content of the basic and advanced course (as in 2012).

<table>
<thead>
<tr>
<th>one-year course</th>
<th>lessons, group size, content</th>
</tr>
</thead>
<tbody>
<tr>
<td>part 1: basic course</td>
<td></td>
</tr>
<tr>
<td>X-ray and CT-anatomy</td>
<td>12 course entities, 10 participants/group</td>
</tr>
<tr>
<td>part 2: advanced course</td>
<td></td>
</tr>
<tr>
<td>ultrasound anatomy</td>
<td>12 course entities, 5 participants/group</td>
</tr>
<tr>
<td>clinical lectures</td>
<td>8 lessons</td>
</tr>
<tr>
<td>examination</td>
<td>written (multiple choice) practical (objective structured clinical examination)</td>
</tr>
<tr>
<td>part a: technique</td>
<td>systems of chest X-ray systems of skeletal radiology</td>
</tr>
<tr>
<td>part b: applications</td>
<td>brain hemorrhage stroke</td>
</tr>
<tr>
<td>part c: synoptic cases</td>
<td>management of trauma thoracic pain</td>
</tr>
<tr>
<td>part d: lectures</td>
<td>mammography pediatric radiology</td>
</tr>
</tbody>
</table>


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Radiology as well as medical lecturers from other fields were involved in medical lectures.

Participants and entry requirements
The basic course was aimed at preclinical students upon their completion of the gross anatomy course. On account of the students’ keen interest, the passing of an entrance exam was a prerequisite for participation. The top thirty students among approximately sixty applicants were admitted to the course.

Course structure
Classes on X-ray anatomy, ultrasound and clinical lectures took place weekly for one hour in each subject, either in small groups or in an assembly (total attendance 4 periods per week throughout the semester).

X-ray and CT anatomy
Initially, an introduction to the systematics of image viewing and analysis was given. Every group study unit (10 students) began with a discussion of a normal X-ray for the purpose of identifying and demonstrating known anatomic structures. Subsequently, two students examined a clinical case. In addition to the X-rays, the anamnesis and cause of referral were made available for this purpose. As a rule, pathologies were chosen in such a way that they could be derived from knowledge of normal anatomy (i.e., distal radial fracture, lobar pneumonia, hemorrhage of the subarachnoid). Following this, one student from each of the teams was required to present the case to the group. Attention was particularly drawn to the observance of systematic image analysis as the core competence to be learned. Every student was required to demonstrate at least one case per lesson.

Ultrasound anatomy
Sonographic anatomy was instructed in small groups of five students in order to achieve a longer active exercise session for learning practical skills. Firstly, technical fundamentals of sonography were conveyed during two introductory lectures. Secondly, the students examined each other in turn. Specific standard planes, in which anatomical structures were to be identified and indicated, had to be reproduced.

Anatomy of the Living
Until 2003, “Anatomy of the Living” was a fixed component of the course and was concerned with the anatomical identification of anatomical ‘landmarks’ on the living. In a second step, fundamental clinical examination methods were conveyed. The students again examined each other in turn. Due to the introduction of a clinical examination course in the preclinical phase in 2003, this part of the course was omitted.

Clinical lectures
Lectures by experienced clinicians complemented the concept of education to demonstrate the relevance of imaging (Table 2).

Advanced course
The advanced course “Anatomy and Imaging” was for students who had successfully completed the basic course. It took place once a week in small groups of ten participants (2 periods per week throughout the semester). Management of the course was now under the responsibility of the Department of Clinical Radiology. As in the basic course, the syllabus and the personnel were matched with lecturers from the Institute of Anatomy.

Course structure
Initially, the students began with a discussion of essential radiological techniques and the consolidation of the systematics of image analysis. For instance, the Seldinger puncture technique could be tried out on a model. Afterwards, clinical cases (e.g. stroke management) were independently processed by the students under the guidance of one of the student tutors. The emphasis was on the systematic image analysis and on the exact anatomical relationships of the results (e.g. the attribution of the ischemic brain area to the supplying artery and the resulting clinical deficits). In addition, true synoptic cases were treated interactively in the course of which the students could self-reliantly collect an anamnesis and clinical data, as well as arrange for various imaging procedures. Also, the justifying medical indication for the examination was retraced (Table 2).

In the sonography course, the previously obtained skills could be intensified on real patients. The patients had already expressed their approval for the examination to be carried out by the students. The focus of the course was again based on a systematic line of action concerning the survey of the case history, as well as the physical and sonographic examination.

Tutors and lecturers
The periods of study in the basic and advanced courses were given by student tutors from clinical semesters under the supervision of medical lecturers. Prerequisites for becoming a tutor were a successful participation in the course itself in addition to a top mark in the preliminary medical examination. Further conditions were teaching experience as a tutor in the gross anatomy course and completion of a four-week clinical elective in the Department of Clinical Radiology. Before each course session, a preliminary discussion was held between the medical heads of the course and the student tutors. The majority of the tutors were available for several semesters.

Script
An extensive script covering relevant anatomical and clinical information as well as checklists for systematic reporting were made available in print and/or online for both courses, enabling students to prepare before and after.

Final examination
The basic and the advanced course each finished with a multiple choice exam, covering the content of every lesson. For the basic course, a practical test in the form of an OSCE (objective structured clinical examination) with stations for X-ray/CT and sonographic anatomy took place. Special attention was given to the observance of systematic reporting and to the correct description of the anatomic structures as well as to an adequate behavior towards the test person. The grading was carried out by the student tutors in accordance with a previously stipulated standardized pattern.
Within the framework of the final examinations, the students were required to evaluate each course. The evaluation form had been kept constant over the entire period of the last 10 years (Table 3). We used a 5-point Likert scale (1: fully agree, 5: do not agree). After every semester, a discussion about the course evaluation took place between lecturers and tutors for future improvement.

### Evaluation

#### Part 1: X-ray and CT-anatomy
- The course was well organized.  
  - fully agree: 1, 2, 3, 4, 5  
- The material was structured clearly.  
  - fully agree: 1, 2, 3, 4, 5  
- The selection of topics was good.  
  - fully agree: 1, 2, 3, 4, 5  
- The instructors and tutors communicated the material appropriately.  
  - fully agree: 1, 2, 3, 4, 5

#### Part 2: Ultrasound anatomy
- The course was well organized.  
  - fully agree: 1, 2, 3, 4, 5  
- The material was structured clearly.  
  - fully agree: 1, 2, 3, 4, 5  
- The selection of topics was good.  
  - fully agree: 1, 2, 3, 4, 5  
- Training time was sufficient.  
  - fully agree: 1, 2, 3, 4, 5  
- The instructors and tutors communicated the material appropriately.  
  - fully agree: 1, 2, 3, 4, 5

#### Part 3: Clinical lectures
- The course was well organized.  
  - fully agree: 1, 2, 3, 4, 5  
- The selection of topics was good.  
  - fully agree: 1, 2, 3, 4, 5  
- The instructors and tutors communicated the material appropriately.  
  - fully agree: 1, 2, 3, 4, 5

#### Part 4: "Anatomy and Imaging" in total
- The choice of media was adequate.  
  - fully agree: 1, 2, 3, 4, 5  
- The script provided a good working basis.  
  - fully agree: 1, 2, 3, 4, 5  
- The course contributed to my learning process.  
  - fully agree: 1, 2, 3, 4, 5  
- Relevance for medical education was evident.  
  - fully agree: 1, 2, 3, 4, 5  
- The course enhanced my interest in medicine.  
  - fully agree: 1, 2, 3, 4, 5  
- I am satisfied with the course.  
  - fully agree: 1, 2, 3, 4, 5  
- Expenditure of time spent was too high:  
  - appropriate:  1, 2, 3, 4, 5  
- The course level was too high:  
  - appropriate:  1, 2, 3, 4, 5

**Table 3** Questions on the evaluation form in the basic course.

### Results

#### Participants

During the period from 2001 to 2012, 618 students (311 males and 307 females) enrolled in the basic course “Anatomy and Imaging”, and 614 (99.4%) attended the complete course and took the final examination. The majority of the students were in the third preclinical semester when they started the basic course. 316 students (149 males, 167 females) attended the subsequent advanced course.

#### Evaluation results

Of the 618 participants of the basic course, 557 completed assessment forms were available (90% of the total). Of the
316 participants of the advanced course, 292 of the assessment forms could be evaluated (92% of the total). The results are displayed in Fig. 1 – 3. On a 5-point Likert scale (1 = fully agree; 5 = do not agree), the statement “the relevance for medical education was evident” received the highest rating of 1.17 (basic course) and 1.24 (advanced course). The statement “the script provided a good working base” received the lowest rating (1.53 for the basic course; 2.58 for the advanced course). The quality of the tutors was rated with 1.42 and 1.51, respectively. The

![Fig. 1](image1)  
**Fig. 1** Evaluation results for basic course for A X-ray and CT-Ultrasound anatomy, B sonographic anatomy, C clinical lectures, D total assessment 5-point Likert scale (1: fully agree, 5: do not agree).

![Fig. 2](image2)  
**Fig. 2** Evaluation results for advanced course 5-point Likert scale (1: fully agree, 5: do not agree).
summarizing statement “I am satisfied with the course” received the rating 1.33 and 1.56 respectively on a ten-year average.

Discussion

The increase in medical knowledge confronts teaching in medical faculties with new challenges [20]. With the introduction of the new Licensing Regulations for Physicians (Approbationsordnung of 27/6/2002) in 2003, basic medical training in Germany was faced with new demands. These included a stronger link between preclinical theory and clinical knowledge, a stronger interdisciplinary, subject-focused learning method as well as new forms of examination and continuous evaluation of the teaching system [21]. Thereby anatomy teaching is also a hot topic of discussion. Various concepts have been developed in order to improve the quality [16].

A recent article once again called for the modernization of anatomy teaching at German faculties, demanding a closer liaison with clinical subjects. Dissecting exercises were questioned. One should focus on the anatomy of the living [9].

The use of imaging processes to improve visualization of anatomical relationships is a recommended possibility to obtain anatomical knowledge and to connect preclinical with clinical subject matter [22]. A simultaneous application of dissection, radiological film material, clinical cases and the achieving of clinical skills lead to a significant improvement of the understanding of anatomy [23, 24]. According to a survey, 80% of students would welcome the introduction of imaging courses within the framework of teaching anatomy [16]. Also, the introduction of sonography courses has led to positive experiences with high rates of acceptance among students and a positive influence on the interest of anatomical knowledge [17 – 19].

The transmission of information into long-term memory and the rapid recall in a clinical situation depend crucially on the conditions under which the information was learned. Chiefly, active involvement, a connection with present knowledge, the obtaining of knowledge in similar situations like the recalling of knowledge, clear clinical relevance and a high rate of repetition are favorable to learning [4]. “Anatomy and Imaging” as a bridging course between preclinical and clinical semesters achieved the outlined goals by providing students with the means of repetition after their successful completion of the gross anatomy course, with facts and clinical radiological cases in a problem-oriented setting. It is well known that the interactive form of a course as well as practical applications support the learning process [25]. The success of this concept is reflected in the results of the evaluation. The students of the basic and advanced courses rated almost all the statements with 1 to 2. With a participation of over 90%, this can be considered representative. The clinical relevance of the obtained correlation was noticeable, as the very good correlation results with 1.17 and 1.24, respectively, demonstrate.

Only the presented learning material of the advanced course was graded with 2.58. The reasons for this most likely were the lack of illustration of the individual cases of the patients in the sonography lessons, and the omission of the synoptic cases in the third part of the course. These synoptic cases had been left out on purpose, so that the correct diagnosis could not be anticipated.

The course level was considered appropriate by almost all the students (more than 95%). The amount of time used in the basic course was considered too much by 15% of the students. This could be explained by the fact that in the early years only half of the time spent in the course was recognized for the performance certificate. From 2006 onwards, the course was finally recognized as an elective course with graded certificates of 4 periods per week during the semester.

In addition, the question of efficacy of a preclinical imaging course for further education must be discussed. A total of two-thirds of all graduates at seven German medical faculties feel badly prepared for their clinical work. Interpreting X-rays already ranks fifth among all deficiencies [26]. Taking a chest X-ray course as an example, the primary benefit lay less in the memorization of facts but rather in the alleviation of later repetition and intensification of the material from previous experiences [27]. Furthermore, a systematic analysis of a chest X-ray in an early study phase has the potential to create a reliable basis for the later daily working routine [28].

Because of its vital clinical significance, special emphasis was placed on the chest X-ray in our course as well. Conveying a systematic and reliable method for image interpretation was especially important.

“Anatomy and Imaging” is set up as a small group study in order to encourage active and practical work for students. A much discussed problem of this teaching method is the large amount of workload and use of personnel which leads to excessive costs and as a rule can hardly be carried out by qualified medical people.

A solution to the problem – in spite of uttered reservations [29] – could be the use of specially trained student tutors under the supervision of qualified medical personnel. Comparing professional and student tutors by questioning participants of a pharmacology course, it became evident that neither specialized competence nor teaching experience had any significant influence on the students’ results in the written final examinations [30]. Positive experiences were also reported regarding the student tutor system in the area of ultrasound courses [17, 18].

In the above course, the quality of the tutors was assessed by the participants with 1.42 and 1.51, respectively. This shows the high acceptance of tutors in small group study. It must be noted that the tutors also expressed satisfaction with the demanding requirements which resulted in the fact that the majority stayed for many further semesters.

It was also advantageous for the medical tutors. Maximum flexibility with respect to time planning was reached because of prearranged meetings with the well-trained student tutors. A meeting between instructors and tutors together at the end of the semester has proven to be very helpful. Evaluation results were assessed together and the following course was planned.

A difficulty of problem-oriented learning is that students can develop a special interest in the clinical background and then neglect their achieved basic knowledge [4]. An important task for the tutors of “Anatomy and Imaging” therefore was to maintain a systematic priority with image analysis and image interpretation. The total positive resonance and the high number of applicants for the limited number of places indicated that an enlargement of the course concept would be desirable. For that reason, the basic course of “Anatomy and Imaging” was enlarged as a block course for the winter semester 2012/2013 for a complete semester cohort, with 98 voluntary applications.

Following a decision by the local medical faculty, the course “Anatomy and Imaging” is now, since 2013, part of the curriculum for the third preclinical semester as a “seminar with clinical reference”.

For radiology, the chance exists that students could be brought closer to this subject already in the preclinical stage and to develop an early interest in imaging.

- The implementation of modern clinical imaging techniques into the preclinical phase of medical studies represents a successful concept.
- „Anatomy and Imaging“ in undergraduate medical education creates a win-win situation: For the students to achieve relevant anatomical knowledge in a clinical context; for the radiologists to prime future clinicians for their field.

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**Literatur**
