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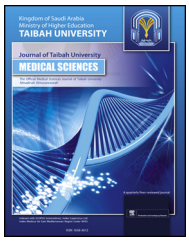

Original Article

Clinical students' reflections on the preclinical anatomy learning experience

Syarifah A. Syed Abd Halim, MMedSci (Anat), MB BCh [a,b],
Muhamad Saiful B. Yusoff, MD, MSc, PhD [b],
Mohamad N. Yaman, MBChB, MMEd, PhD (Medical Education) [c],
Shazrina Ahmad Razali, MD, MSc (Medical Education) [d],
Tg Fatimah M. Tengku Muda, MD, MSc [e],
Ramiza Ramza Ramli, MBBS, M.MED (ORL-HNS) [f],
Fairrul Kadir, MD, Master of Medicine [g] and Siti N.H. Hadie, MD, MSc, PhD [h,*]

[a] *Department of Anatomy, Faculty of Medicine, Universiti Kebangsaan Malaysia, Kuala Lumpur, Malaysia*
[b] *Department of Medical Education, School of Medical Sciences, Health Campus, Universiti Sains Malaysia, Kota Bharu, Kelantan, Malaysia*
[c] *Department of Medical Education, Faculty of Medicine, Universiti Kebangsaan Malaysia, Kuala Lumpur, Malaysia*
[d] *Medical Education Unit, Faculty Medicine and Health Sciences, Universiti Malaysia Sarawak, Kota Samarahan, Sarawak, Malaysia*
[e] *Anatomy unit, School of Basic Medical Sciences, Faculty of Medicine, Universiti Sultan Zainal Abidin, Medical Campus, Kuala Terengganu, Terengganu, Malaysia*
[f] *Department of Otorhinolaryngology, School of Medical Sciences, Health Campus, Universiti Sains Malaysia, Kota Bharu, Kelantan, Malaysia*
[g] *Department of Emergency Department, Faculty of Medicine and Health Sciences, Universiti Malaysia Sabah, Kota Kinabalu, Sabah, Malaysia*
[h] *Department of Anatomy, School of Medical Sciences, Health Campus, Universiti Sains Malaysia, Kota Bharu, Kelantan, Malaysia*

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المخلص

أهداف البحث: علم التشريح هو ركيزة أساسية من أركان المعرفة الطبية التي تربط المعرفة بالعلوم الطبية الأساسية والممارسة السريرية. ومع ذلك ، فقد أدت المناهج الطبية الحديثة المتكاملة إلى تقليل محتوى تدريس علم التشريح، ولم يعد يتم إجراء تشريح الجثة. وبالتالي، من المتوقع أن يكون خريجو الطب الذين يفتقرون إلى معرفة التشريح غير مجهزين بشكل كاف لممارسة سريرية آمنة. هدفت هذه الدراسة إلى استكشاف تجارب طلاب السنة السريرية في تعلم علم التشريح خلال المرحلة قبل السريرية في كليات الطب الماليزية. كما عكست كيف أن تدريبهم على التشريح قبل السريري قد أعدهم لسنواتهم السريرية.

طرق البحث: لذلك ، تم إجراء دراسة الظواهر النوعية باستخدام أسلوب المناقشة الجماعية المركزة مع 30 طالبا في السنة النهائية من أربع جامعات عامة. تم إجراء أربع جلسات نقاش جماعية مركزة، وتم نسخ ردودهم وتحويلها إلى أشكال إلكترونية. تم تحليل النصوص بشكل موضوعي باستخدام برنامج "أطلس.تي".

النتائج: أنتج ترميز الدورة الأولى لتحليل النص 157 رمزا مفتوحا استنادا إلى العبارات المستخدمة من قبل المشاركين. أنتجت دورة التشفير اللاحقة 16 رمزا محوريا - مجموعات من الأكواد المفتوحة ذات الميزات المتشابهة. خلال دورة الترميز النهائية، تم تصنيف المحتوى والعلاقات المتبادلة بين الرموز المحورية إلى ستة أكواد مختارة: (1) تجربة تعلم علم التشريح قبل السريري، (2) محتوى علم التشريح والتدريس، (3) الكفاءة المتعلقة بالتشريح، (4) الأهمية لمعرفة علم التشريح للممارسة السريرية، (5) أهمية التعرض المبكر للتشريح السريري التطبيقي، و (6) اقتراحات لتعليم علم التشريح في المستقبل.

الاستنتاجات: عكست الموضوعات الستة التي تم تحديدها في هذه الدراسة تصورات الطلاب عن تجربة تعلم علم التشريح والتحديات التي واجهوها خلال

* Corresponding address: Department of Anatomy, School of Medical Sciences, Health Campus, Universiti Sains Malaysia, Kubang Kerian, 16150, Kota Bharu, Kelantan, Malaysia
E-mail: snurma@usm.my (S.N.H. Hadie)

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السنوات ما قبل السريرية، وآرائهم حول معرفة علم التشريح والمهارات ذات الصلة وظيفيا خلال السنوات السريرية. رددت ردودهم أيضا الحاجة إلى تحسين تدريس علم التشريح والتعلم، مؤكدين على أهمية التكامل والتطبيق السريري المبكر.

الكلمات المفتاحية: منهج علم التشريح؛ الكفاءة المتعلقة بالتشريح؛ علم التشريح التطبيقي؛ الكفاءة المعرفية؛ الكفاءة الحركية؛ التعليم الجامعي.

Abstract

Objectives: Anatomy is a fundamental pillar of medical knowledge that bridges basic medical science knowledge and clinical practice. However, integrated modern medical curricula have reduced the anatomy teaching content, and cadaveric dissection is no longer conducted. Medical graduates who lack anatomy knowledge are anticipated to be inadequately equipped for safe clinical practice. This study was aimed at exploring clinical year students' experiences regarding their anatomy learning during the preclinical phase in Malaysian medical schools. The findings reflect how the students' preclinical anatomy training prepared them for their clinical years of study.

Methods: A qualitative phenomenology study using the focus group discussion method was conducted on 30 final-year students from four public universities. Four focus group discussion sessions were conducted, and students' responses were transcribed and converted to electronic formats. The transcripts were analyzed thematically with ATLAS.ti software.

Results: The first-cycle coding of the text analysis generated 157 open codes based on the phrases used by the participants. The subsequent coding cycle produced 16 axial codes—groups of open codes with similar features. During the final coding cycle, the content and interrelations between the axial codes were categorized into six codes: (1) preclinical anatomy learning experience, (2) anatomy content and teaching, (3) anatomy-related competency, (4) the importance of anatomy knowledge in clinical practice, (5) the importance of early exposure to applied clinical anatomy, and (6) suggestions for future anatomy education.

Conclusions: The six identified themes reflected students' perceptions of their anatomy learning experience, the challenges that they faced during their preclinical years, and their opinions regarding the anatomy knowledge and skills that are functionally relevant during the clinical years. Their responses also echoed the need to improve anatomy teaching and learning, thereby emphasizing the importance of early clinical integration and application.

Keywords: Anatomy curriculum; Anatomy-related competency; Clinically applied anatomy; Cognitive competency; Psychomotor competency; Undergraduate education

Introduction

Anatomy is an important basic science subject that serves as the foundation of medical knowledge. Given that anatomy content underpins the concepts of body functions, pathological conditions, diseases, physical examinations, and clinical procedures,[1,2] having adequate anatomy knowledge is critical for medical graduates.[3] Studies have shown that anatomy courses have successfully promoted medical students' development of professional behaviors and competencies pertinent to clinical practice.[4–7] Furthermore, the acquisition of core knowledge and skills related to anatomy is crucial to ensure safe clinical practice, because inadequate anatomy competency is associated with medicolegal litigation.[8–10]

Anatomy, the oldest medical subject, has substantially evolved in terms of content, teaching methods, and learning tools. In the modern medical curriculum, cadaveric dissection has become less feasible to teach in some medical schools, because it is costly and time-consuming.[11,12] With advances in medical education research and practice, new educational principles and teaching methods have been introduced to meet needs in anatomy education, including the use of horizontal and vertical integration of anatomy syllabi[13]; use of problem-based, team-based, and case-based learning,[14–16] use of interactive multimedia and virtual reality simulations[17]; and incorporation of active learning pedagogies, such as body painting and interactive lectures.[18,19] All multimodal teaching methods in anatomy have been argued to be are equally effective.[20] Indeed, the unprecedented COVID-19 pandemic has disrupted normal face-to-face teaching, which is crucial for the development of psychomotor skills and affective learning in anatomy.[21,22]

In Malaysia, the anatomy curriculum in many universities uses integrated, student-centered, and problem-based learning (PBL).[23] Students enrolled in Malaysian medical schools complete a foundation course in science (e.g., A-level, matriculation, and Malaysian Higher School Certificate) and therefore have basic knowledge of science. In general, anatomy is taught during the first two years (of five or six year medical programs), and anatomy knowledge is horizontally integrated with other preclinical subjects (e.g., physiology, biochemistry, and pathology). In contrast, vertical integration of anatomy knowledge is achieved through PBL and clinical skills laboratory sessions: preclinical students apply their anatomy knowledge during PBL discussions and while performing procedures on mannequins. Before the COVID-19 pandemic, anatomy in Malaysian medical schools was taught primarily through didactic or interactive lectures,[24–26] and practical sessions using prosected cadaveric specimens and anatomy models.[22] In view of the integrated nature of the medical curriculum and shortages of cadavers, most public medical schools in Malaysia were unable to accommodate cadaveric dissection as a teaching method in the undergraduate anatomy syllabus. Instead, cadaveric dissection was reserved mainly for demonstration purposes, clinical skills workshops, and postgraduate training. Furthermore, the use of digital anatomy software and applications has markedly increased since the enforcement of remote learning in the COVID-19 pandemic.[21,22,27,28] Because of

financial constraints, anatomy teaching in Malaysia is slightly behind that in Western countries regarding the use of virtual and augmented reality simulation.

Nonetheless, a pressing need exists to design a positive anatomy learning environment in Malaysia to ensure optimal learning.[29] Although the anatomy curriculum in Malaysia is integrated, medical students appear to have difficulty in applying their anatomy knowledge in their clinical years. The intrinsically complex nature of anatomy may impose a high cognitive load on students, thus posing difficulties in recalling and applying knowledge.[30] Hence, this study was designed to uncover gaps in the current anatomy curriculum associated with anatomy core competency to support safe clinical practice from the perspectives of clinical year students. By exploring the clinical year students' experiences during their clinical training, this study sought to answer the following specific research questions: (1) How has anatomy learning during the preclinical phase influenced students' clinical practice? (2) How did the students use their anatomy knowledge and skills in their clinical practice? The students' responses were expected to reflect how their preclinical anatomy training had prepared them for clinical attachment. The findings also provide preliminary insights that may help anatomy educators address the gaps in current anatomy curricula and redesign a more clinically relevant anatomy curriculum that can prepare preclinical year students for clinical training.

Materials and Methods

Study design and ethical considerations

We conducted a qualitative phenomenology study by using a focus group discussion (FGD) method that explored clinical year students' anatomy learning experiences during the preclinical phase of their studies. Because of the ongoing COVID-19 pandemic, the FGD was conducted through an online platform by using Cisco's Webex teleconferencing application. Four FGD sessions were conducted to achieve saturation of responses; no new information emerged from the participants by the end of the fourth FGD session. Before each session, written consent was obtained from each participant through the Google Forms platform. This study was approved by the Human Research Ethics Committee of USM, with approval code USM/JEPeM/19040257.

Participants

A total of 30 final-year students from four public medical schools in Malaysia—Universiti Sains Malaysia (USM), Universiti Sultan Zainal Abidin (UniSZA), Universiti Malaysia Sabah (UMS), and Universiti Malaysia Sarawak (UNIMAS)—were recruited for this study. To ensure smooth discussion among the participants, each FGD session was attended by students from the same institution. Sessions 1 and 3 were attended by eight participants each, and sessions 2 and 4 were attended by seven participants each. Although some variations in anatomy curricula existed across the four institutions, all institutions used integrated system-based curricula in which anatomy was taught in the first 2 years of the medical degree program, and was integrated with other basic science subjects and clinically applied content. The teaching methods were similar: anatomy was taught through lectures, practical examinations, tutorials, and PBL sessions. Likewise, similar learning resources were used before the COVID-19 pandemic, namely, standard anatomy textbooks and atlases, plastic anatomy models, cadaveric specimens, and histological slides. All participants had completed anatomy courses during their preclinical studies and had passed the final examinations for the preclinical phase before their clinical attachment. The selection of final-year medical students was based on their having undergone all major clinical postings during their preclinical years. Therefore, we expected that the students would be able to reflect on the importance of anatomy knowledge during clinical training.

Number of participants

In view of purposive sampling, the number of participants required for this study was guided by the saturation principle.[31] The recommended sample size for phenomenological studies using FGD ranges from 7 to 89 participants.[31–33] Saturation occurs when the data collection does not provide any new information regarding the investigated issue, and similar instances are repeatedly encountered.[34] To assess the saturation of data, each FGD session was transcribed and analyzed by using the thematic analysis approach within 1 week after the session had ended. This effort was aimed at identifying new, unique themes that contributed to the interpretation of the results. The process was repeated for subsequent FGD sessions until no further unique themes emerged. The saturation of responses in this study was achieved after the fourth FGD session, which involved 30 preclinical-year medical students.

Sampling technique

Purposive sampling was applied to recruit participants from the universities on the basis of their exposure to the preclinical and clinical phases of undergraduate medical training. These variables were considered to ensure a good representation of experience at different levels of undergraduate medical training.

Focus group discussion sessions

All FGD sessions were moderated by the second author (MSBY), who had extensive experience in conducting FGD sessions. Each FGD session consisted of eight to ten participants and was conducted in English. To ensure the anonymity of the participants and facilitate group discussion, each participant was assigned a letter. Each session began with a brief introduction by the moderator, who introduced himself and the research team and explained the aims and expectations of the studies. The general rules of the FGD were emphasized to prevent interruption and miscommunication during the discussion session. Verbal consent for audio recording was obtained, and the participants were requested to introduce themselves with the letters assigned to them whenever they wanted to speak.

A semi-structured FGD protocol was used to guide the moderator for the session. The moderator initiated the

discussion by asking the students to complete the sentence: "The anatomy teaching and learning during my preclinical years was …" The subsequent discussion was moderated according to the participants' responses to the trigger. At the end of each session, the moderator summarized the important points from the sessions, and the participants were allowed to make additional remarks on the summary. The moderator thanked the participants for their cooperation and discussed his willingness to share the findings of the analysis with the participants. All FGD sessions lasted for 90 min on average, and each session was recorded with the record function of the Webex teleconferencing application. The recordings were converted into YouTube videos that were made available only to the research team members. Throughout the FGD sessions, the fourth (SAR), fifth (TFM), and last (SNH) authors observed and documented the non-verbal reactions among participants to capture any agreement or disagreement and interactions that might influence the findings of the thematic analysis.

Thematic analysis

Thematic analysis was conducted on the FGD transcripts with the method proposed by Saldana.[50] To ensure the trustworthiness of the FGD data, the analysis was independently conducted by three researchers—the seventh author (RRR), the eighth author (FM), and the last author (SNH). The participants' responses were transcribed manually by the first (SA) and third authors (MNY), and the transcripts were converted into electronic formats by using ATLAS.ti software, version 22 (Scientific Software Development, GmbH, Berlin, Germany). The text analysis tool in the ATLAS.ti software was used to perform the first-cycle coding—known as open code (OC)—wherein the transcripts were categorized into smaller codes based on the phrases used by the participants. Second-cycle coding involved grouping OCs with similar features and connections under one common category, known as the axial code (AC). At that stage, the OC framework was explored to identify any connections, overlaps, or duplicates.

During the final cycle of coding, the researchers explored the content and interrelations between the ACs and categorized them into several common codes, known as select codes (SC). Throughout the coding process, the researchers made notes of patterns and categories, which were subsequently used for comparison and triangulation during the data analysis to increase the credibility and transferability of the data.[35,36]

Results

The analysis generated six SCs (i.e., themes) comprising 16 ACs (i.e., subthemes) and 157 OCs (i.e., elements). The six themes were (1) preclinical anatomy learning experience, (2) anatomy content and teaching, (3) anatomy-related competency, (4) the importance of anatomy knowledge in clinical practice, (5) the importance of early exposure to clinically applied anatomy, and (6) suggestions for future anatomy education. The themes, subthemes, and elements are summarized in Table 1.

Theme 1: Preclinical anatomy learning experience

In general, the students shared their positive and negative learning experiences during their preclinical anatomy learning experiences. One student described her excitement when real cadaveric specimens were used in learning anatomy:

> *"During my preclinical anatomy classes, I admit that I was a bit stressed because we need to remember a lot of structures. However, I felt excited when learning with cadaveric specimens, because we can visualize what we learn on the real human body."* (Student B, University 1)

One student expressed his disappointment with having limited opportunities to apply anatomy knowledge and skills during his preclinical years. Consequently, he felt that he was learning anatomy only for the purpose of examination.

> *"But most of our clinical skill laboratory sessions were held during the second year of our studies. To be honest, not everyone had the chance to perform the physical examination or clinical skills on the mannequin. It was a different thing when we learned anatomy theory because we didn't learn applied anatomy. I felt like I was learning for the sake of the exam."* (Student H, University 3)

During the preclinical year, most students acquire their knowledge and skills in anatomy through rote learning. One student described how rote learning had resulted in poor knowledge retention; therefore, she had difficulty in applying the knowledge during her clinical years.

> *"When I first entered the clinical years, it was quite hard for me because at that time I just realized that I only memorized the anatomy information during my clinical years. I wasn't able to apply the knowledge, and most of the time, I forgot my anatomy."* (Student D, University 1)

Nevertheless, some students indicated that early clinical integration, the use of PBL, and the use of animation in anatomy instruction facilitated their understanding of anatomy. One student expressed her relief in being able to integrate anatomy knowledge into PBL sessions during the preclinical phase.

> *"Learning anatomy was never easy, but luckily, we had PBL sessions where we could discuss the significance of every part of organs and integrate it with various aspects. From there, we could learn the significance of anatomy knowledge, especially related to diseases."* (Student C, University 4)

Beyond learning through cadaveric specimens and PBL sessions, the students learned anatomy through didactic lectures, models, textbooks, and atlases. Nevertheless, one student raised concerns regarding the anatomical structures encountered in real patients during clinical years, which appeared different from what she had learned from textbooks, atlases, and cadaveric specimens.

> *"When we were in the operation theater, the surgeon would ask, what layer is this? What structure is this? I could not*

Table 1: Themes, subthemes, and elements generated from the focus group discussion sessions.

Theme (Select code)	Subtheme (Axial code)	Elements (Open codes)
Theme 1: Preclinical anatomy learning experience	Positive learning experience	Easier to understand anatomy when studied on the human body
		Good knowledge retention and recall
		Good learning environment during pre-clinical years
		Learning anatomy during pre-clinical years was fun
		Positive experience and good environment stimulate anatomy knowledge recall
		Positive learning experience during the pre-clinical years
	Poor learning experience	Difficulty in memorizing anatomical structures
		Emphasis on kinesthetic learning
		Limited cadaveric dissection section
		Limited number of anatomy models
		Limited opportunity for cadaveric dissection
		Limited opportunity to apply anatomy knowledge or skills during the preclinical years
		Lack of visual stimulus during anatomy teaching
		No intrinsic motivation to learn anatomy
		Poor retention of anatomy knowledge
		Students learn anatomy for the sake of the exam
	Learning methods practiced by students	Anatomy is learned through memorization
		Animation improves understanding of anatomical structures
		Application of anatomy knowledge in the clinical context
		Clinical application introduced during anatomy lectures
		Learning of anatomy during preclinical years through memorization
		Observing procedures strengthens anatomy knowledge
		PBL is a good way to understand the clinical value of anatomy knowledge
		Peer discussion promotes understanding of anatomy
		Preclinical year students learn anatomy through observation
	Difficulty faced during anatomy learning	Difficulty in applying anatomy knowledge during clinical practice
		Difficulty in applying anatomy knowledge in clinical years
		Difficulty in integrating anatomy knowledge vertically and horizontally
		Difficulty in learning anatomy through didactic lectures
		Difficulty in memorizing anatomical structures
		Difficulty in recalling anatomy knowledge during clinical years
		Difficulty in visualizing anatomical structures in 3D because teaching during preclinical years was in 2D
		Learning anatomy is challenging for novices
		Limited cadaveric dissection section
		Limited number of anatomy models
		Limited opportunity for cadaveric dissection
		Limited opportunity to apply anatomy knowledge or skills during the preclinical years
		No intrinsic motivation to learn anatomy
		Preclinical year students struggle to learn anatomy
		Unable to relate anatomy knowledge to clinical practice during clinical years
		Unable to remember anatomical knowledge during the clinical years
		Unequally weighted anatomy content
		Students learn anatomy for the sake of the exam
Theme 2: Anatomy content and teaching	Anatomy content and syllabus	Anatomy input during the preclinical year is mainly cognitive

(*continued on next page*)

Table 1 (*continued*)

Theme (Select code)	Subtheme (Axial code)	Elements (Open codes)
		Anatomy lectures are dry and difficult to understand
		Neuroanatomy is a difficult subject
		The anatomy subject is cognitively challenging
		The anatomy subject is content heavy
		Lymphatic drainage is an important aspect of anatomy with high clinical relevance
		Massive anatomy input
		The medical curricula in institutions influence anatomy teaching during preclinical years
	Anatomy teaching methods and tools	Anatomical structures on living participants appear different from those in atlases or textbooks
		Anatomy during preclinical years was taught through lectures and practical sessions
		Anatomy practicals were taught by using anatomy models
		Anatomy practicals were taught by using cadaveric specimens and anatomy models
		Anatomy was didactically taught through lectures
		Institution provides useful resources in anatomy
		Learning materials during preclinical anatomy learning aided in anatomy revision during clinical years
		Learning by using anatomy specimens promotes knowledge retention and recall
		Models and specimens facilitate identification of structures
		Practical sessions were conducted through cadaveric dissections and use of anatomy models
		Preclinical year students learned anatomy from textbooks and lecture slides
		Preclinical year students visited an anatomy museum to learn anatomy specimens
		Students visited an anatomy museum to learn anatomy
		Teaching resources were outdated
		The use of anatomy models facilitates students learning
		Video improves the visualization of anatomical structures
		Worked examples in preclinical anatomy teaching assist in knowledge retention
	Students' perception of anatomy teaching	Anatomy knowledge learned during preclinical years is inadequate for clinical practice
		Anatomy lecturers are dedicated
		Anatomy should be taught by using multimodal approaches
		Anatomy taught with visual modalities promotes knowledge retention
		Anatomy teaching facilitates students' understanding
		Anatomy teaching lacks clinical relevance
		Anatomy teaching was systematic and organized during the preclinical year
		Anatomy teaching was boring
		Clinical applications were introduced during anatomy lectures
		Clinically applied anatomy during the preclinical year is not comprehensive
		A lack of kinesthetic learning exists during anatomy teaching
		Role of lecturers in emphasizing important anatomy content
		Some anatomy knowledge is difficult to apply during clinical years
	Perceived benefits of anatomy teaching	Anatomy notes and resources are systematic and facilitate understanding

Table 1 (*continued*)

Theme (Select code)	Subtheme (Axial code)	Elements (Open codes)
		Anatomy practical sessions aid in understanding of anatomy
		Assessment-based teaching in anatomy improves students' understanding
		Neuroanatomy knowledge is important to locate sources of pathology/abnormality
	Students' perception of anatomy practical	Anatomy teaching lacks clinical relevance
		Anatomy teaching was systematic and organized during the preclinical year
		Anatomy teaching was boring
		Cadaveric dissection facilitates understanding of anatomy
		Hands on anatomy practicals increase understanding of anatomy
		Cadaveric dissection was ineffective (too many students per group, lack of hands-on activities, and excessively long sessions)
		Learning anatomy during preclinical years was through memorization
		More hands-on activities during anatomy learning are required
Theme 3: Anatomy related competency	Anatomy cognitive competency	Blood circulation and lymphatic drainage
		Blood supply of organs (especially the heart and brain) and other anatomical structures such as muscles, bone, and fascia.
		Differentiation between arteries and veins
		Differentiation of the concepts of dermatomes and cutaneous innervations
		Innervation of muscles and organs (somatic and autonomic innervation)
		Brachial plexus and its branches
		Surface anatomy of the thorax and abdomen
		Layers of skin including hypodermis
		Abdominal wall and inguinal region
		Anatomical features of organs (gastrointestinal, respiratory, cardiovascular, genitourinary, and reproductive systems, including the female perineum)
		Anatomy of the cerebrum and spinal cord
		Spinothalamic and corticospinal tracts (to locate sources of abnormality)
	Clinical skills	Blood collection and peripheral venous canulation
		Urinary catheterization (male and female bladder catheterization)
		Performing rectal examination
		Performing tracheal intubation
		Placement of ECG chest leads
		Intramuscular injection
		Insertion of chest tube
		Identifying normal placenta
Theme 4: Importance of anatomy knowledge for clinical practice	Importance of gross anatomy knowledge	Anatomy knowledge aids in understanding the pathophysiology of diseases
		Learning anatomy stimulates curiosity and interest
		Anatomy knowledge facilitates diagnosis
		Radiological anatomy improves students' understanding of anatomy and medical knowledge
		Understanding the blood supply helps determine patient prognosis
		Anatomy knowledge aids in clinical management of patients
		Anatomy knowledge increases students' appreciation of clinical findings
		Anatomy knowledge is important for history taking
		Anatomy knowledge is important for conducting clinical procedures

(*continued on next page*)

Table 1 (*continued*)

Theme (Select code)	Subtheme (Axial code)	Elements (Open codes)
		Anatomy knowledge is important for physical examination
		Anatomy knowledge is important for safe clinical practice
		Anatomy knowledge is important to conduct clinical procedures
		Anatomy knowledge is important to interpret radiological images
		Anatomy knowledge is important to rule out differential diagnoses
		Neuroanatomy knowledge is important to locate sources of pathology/abnormality
		Understanding the blood supply helps determines patient prognosis
	Importance of surface anatomy knowledge	Surface anatomy improves clinical correlation of anatomy knowledge
		Surface anatomy is important during clinical practice
		Surface anatomy is important for performing physical examination
		Surface anatomy is important for performing clinical procedures
		Surface anatomy links anatomy knowledge to physical examination and procedural skills
		Surface anatomy prevents complication of procedural knowledge
Theme 5: Importance of early exposure to clinically applied anatomy	Benefits of clinical application during preclinical anatomy learning	Clinical application during learning stimulates interest
		Clinical application facilitates understanding of anatomical structures
		Clinical application improves appreciation of anatomy knowledge
		Clinical application facilitates memorization of anatomical structures
		Clinical correlation strengthens understanding of anatomy
		Clinical exposure promotes experiential learning in anatomy
		Integration of anatomy knowledge with other basic science subjects facilitates understanding of anatomy
		Interpreting radiographic images stimulates 3D visualization of anatomical structures
		High application of anatomy in surgical posting
		High application of anatomy knowledge in orthopedic posting
		Integration of anatomy and clinical knowledge helps students learn in clinical years
		Physical examination stimulates appreciation of anatomical structures
Theme 6: Suggestions for future improvement	Multimodal teaching and learning	Hands-on learning activity using anatomy models and cadaveric specimens
		Three-dimensional anatomy software stimulates visualization of anatomical structures
		Video improves visualization of anatomical structures
		Learning anatomy through a radiological modality
		Surface anatomy knowledge must be applied on people with different features (e.g., obese, thin)
		Worked examples in preclinical anatomy teaching aid in knowledge retention
		Anatomy is easier to understand when studied on the human body
		Learning anatomy is small groups is effective
	Longitudinal anatomy curriculum	The clinical relevance of anatomy knowledge should be made explicit during the preclinical years
		Anatomy is revisited during the clinical years

recall which was what. It looked different from the pictures in the slides, textbooks, and atlases. So when I entered the clinical years, I learned a lot more." (Student I, University 3)

Furthermore, the students addressed several challenges that they faced when learning anatomy during their preclinical years, including difficulty in recalling, integrating, and applying anatomy knowledge, as well as limited opportunities for cadaveric dissection. One student described the difficulty in visualizing anatomical structures in 3D, because anatomy was mainly taught in 2D during the preclinical years.

"Sometimes I felt bored during the anatomy classes because I couldn't imagine the structures in 3D form. Most of the diagrams were in 2D, either in the lectures or in the books, and at that time, we did not have the opportunity to learn using anatomy software."

Theme 2: Anatomy content and teaching

In general, the students described anatomy as a dry, content-driven, and cognitively challenging subject. One student described how she struggled to acquire knowledge of anatomy, which she believed had been substantial compressed during her preclinical years.

"For me, learning anatomy during the preclinical years was difficult, as there was a lot to learn. Everything was compressed within one year. When we entered the second year, we learned mostly pharmacology and pathophysiology. It was difficult for me to connect the dots between anatomy and these subjects. Even though we had a clinical skills lab every week, it was difficult to incorporate what we had learned in anatomy into physical examinations of the patient." (Student F, University 4)

The students' responses describing anatomy teaching at their institutions were heterogeneous. One student recalled that the anatomy classes were delivered didactically, were boring, and lacked clinical relevance.

"I wish to cut down some of the boring lectures. I think most of the students would prefer to study the details on their own. What is in the lecture can be found in the textbook. I think we can replace these boring lectures with some interesting activities or use learning software. I also felt that the lectures did not emphasize the clinical application, which can actually make the lectures more interesting." (Student G, University 4)

One student described her experience in learning anatomy with various tools, which she believed had facilitated her comprehension of the subject.

"I remembered during my preclinical years, there was an anatomy lecturer who used several methods when teaching us, such as drawing and learning through YouTube video. I remembered learning from a YouTube video that the lecturers suggested. It was very easy to understand, and when I entered her class, the knowledge that I learned in the video helped me to understand the class." (Student A, University 1)

Theme 3: Anatomy-related competency

Two types of anatomy-related competencies were perceived by the students: cognitive and clinical. The three main cognitive competencies highlighted several times by the students were musculoskeletal anatomy, dermatomes, and arterial and venous circulation. For clinical skills, the students emphasized the need to master blood-collection procedures, venous cannulation, and urinary catheterization.

A student described how she perceived the importance of musculoskeletal anatomy during her clinical posting, although musculoskeletal anatomy was cognitively challenging:

"Musculoskeletal anatomy is quite important even though I found it very annoying as there are many muscles to be remembered. However, these structures are vital for upper limb and lower limb examinations, especially during my orthopedic posting, because we are required to evaluate their innervation thoroughly to understand any lesions." (Student F, University 3)

A student described how she encountered the need to apply anatomy knowledge associated with blood supply in almost all her clinical postings:

"Every system is important, but for me personally, the most important is the circulatory system. We need to learn about the entire arterial and venous circulation as well as the blood supply of the brain, heart, and other organs. Not to forget, we also need to know the entire lymphatic system. I think we encountered this topic during each posting. Blood supply is a concept that we must know, by hook or crook, as it has clinical importance." (Student J, University 4)

A student described her learning experience in inserting a venous cannula for the first time and relating her experience to her surface anatomy knowledge.

"When I first did the branula insertion, I was puzzled why I didn't manage to get the blood withdrawn. During my preclinical year, I didn't think about how deep the vein would be from the skin. So, when I inserted the branula, it was too deep to the point it reached the muscle. That was why blood did not flow out. I didn't know why, but I couldn't recall how superficial the vein was, even though I was able to see it. From that very first time, I realized that every time I do the branula insertion, I must know my anatomy so that the needle wouldn't pass from one side of the vein to the other into the muscles. It was an eye-opening moment for me." (Student B, University 3)

One student described his embarrassment at being unable to differentiate between the female urethral orifice and the vaginal opening during his obstetrics and gynecology posting, which had resulted in a failed urinary catheterization.

"It was a very shameful moment because it was in the OT, and the specialist and medical officers were observing me while I was trying to insert the urinary catheter. I was really confused. Where is the urethra? I can only see one opening

into which I attempted to insert the catheter. But then the specialist gave me a stern look and asked me, 'Why did you insert the CBD into the vagina?' Then I realized that I had mistakenly identified the urethra, and it was a vaginal orifice! Even since then, I have realized that what we see in the atlas does not look the same in the real-life patient, unless our minds know what we are seeing." (Student C, University 1)

Theme 4: Importance of anatomy knowledge in clinical practice

In general, the students described anatomy as a difficult subject with high clinical relevance. Several students discussed how they applied anatomy knowledge during history taking, performing physical examinations, ruling out differential diagnoses, performing clinical procedures, and managing patients.

"Even though studying anatomy is quite hard for me, I still think that it is important. Based on my experience, I mainly applied my anatomy knowledge when performing a physical examination, such as placing my stethoscope at an auscultation point. I also used anatomy knowledge to rule out differential diagnoses. For example, if patients present with abdominal pain, I need to understand the location of the organs and their relationships with surrounding structures. So when we understand our anatomy well, it is easier to identify the differential diagnosis." (Student G, University 2)

"For a hernia case, before doing any radiological intervention, we can diagnose whether it's direct or indirect hernia based on a simple deep ring occlusion test. Another example is differentiating between thyroid and thyroglossal cysts. Hmm … to diagnose a tension pneumothorax with hyper-resonance and tracheal deviation." (Student A, University 3)

"If I revised my anatomy before studying the disease, it helped me to understand the pathophysiology of the disease and help me to plan the management of the patient." (Student E, University 1)

One student described how anatomy knowledge forms the foundation of procedural skills and is important for safe clinical practice.

"For me, not knowing anatomy is like you are going into a dark cave without bringing any light, and you don't know how you are going to get out from there, and you don't know about any danger that you may encounter. That's why anatomy is very important for safe clinical practice. You shouldn't be a doctor if you don't know your anatomy." (Student D, University 4)

Theme 5: Importance of early exposure to clinically applied anatomy

Most students felt that early clinical exposure could have enhanced their understanding of anatomy as preclinical-year students. One student expressed her disappointment at not having the opportunity to apply anatomy knowledge in a clinical context during her preclinical phase:

"I remembered what it was like to revise my anatomy during the preclinical years. It was much easier during the clinical years than when I was in the preclinical phase, because I knew how to apply the knowledge. To me, it was not a good experience. My anatomy experience during preclinical years wasn't as, umm, I would say, wasn't as important as it was in clinical years." (Student H, University 4)

Another student expressed his thoughts on how early clinical exposure could improve the appreciation of anatomy knowledge:

"I think what is more important is the clinical relevance. For example, when we learn the anatomy of the hand, we should be introduced straight away to carpal tunnel syndrome and its signs and symptoms. If we can relate our knowledge straight away, we would be able to appreciate the anatomical structures better." (Student I, University 2)

Theme 6: Suggestions for future anatomy education

To support belief in clinical application and integrated anatomy instruction, one student suggested a multimodal teaching approach by sharing her experience as an exchange student in a medical school abroad.

"When I was an exchange student in the Philippines, we learned through various methods. For example, when we're about to learn [about] the liver, we started with just a lecture related to the anatomy and physiology of the liver, and then we performed an ultrasound on our friends to learn about what the liver looks like in an ultrasound. Then, we went to the dissection hall to perform the cadaveric dissection. For me, it was like a dream came true. I could understand the anatomy, and I know what a real liver looks like in a cadaver and ultrasound image." (Student E, University 3)

Two students suggested that more hands-on activities should be incorporated into anatomy teaching, for example, learning by using cadaveric specimens or living anatomy:

"I would say having more hands-on activities would be great, like learning through anatomy models and conducting a cadaveric dissection at the same time. Then we can compare what we have learned using these tools." (Student H, University 1)

"I think maybe we can also learn using real or simulated patients during our clinical years so that we can look and feel for the anatomical landmark on a living person. We were allowed to see real patients only when we entered the third year. I think it was a bit late, as we tend to forget our anatomy. Besides, anatomy in patients looked and felt different when we compared it with what we learned from cadavers and atlases." (Student B, University 4)

One student suggested that anatomy should be revisited during the clinical years or taught throughout the medical candidature period.

"I think we shouldn't be learning anatomy within two years. It should be throughout the entire five years as a medical

student. I think this experience would expose us to different kinds of teaching and experiences, and we can see how anatomy plays a huge role in clinical practice." (Student A, University 4)

Several students emphasized the need to use virtual reality software or applications to stimulate 3D visualization.

"We should use 3D anatomy software. To all the anatomists who will be reading this discussion, please help us by using software in your teaching, or at least as additional material that can help the students learn. I'm pretty sure that there is a lot of software or applications, so maybe the anatomists can decide which is suitable or needed for learning. I think students can understand and imagine better." (Student G, University 3)

"There is this app called 3D anatomy, which I think is quite useful because it allows us to visualize the vessels, muscles, and bones clearly. Maybe we can encourage future juniors to use the app more during their learning so that they can understand and visualize the anatomy of the body." (Student F, University 2)

Discussion

This study identified several important pieces of information associated with preclinical anatomy education in Malaysia from the perspective of final-year medical students. Given that these students had undergone all major clinical postings, their responses provided a clear indication of how their preclinical anatomy learning experiences influenced their learning during the clinical attachments. The six themes identified in this study reflected students' perceptions of their anatomy learning experience, the challenges that they faced during the preclinical years, and their opinions on the anatomy knowledge and skills that are functionally relevant during the clinical years. Their responses also echoed the need to improve anatomy teaching and learning, emphasizing the importance of early clinical integration and application.

This study indicated that, although the students had some positive experiences during preclinical anatomy learning, they described challenges faced during the preclinical phase. Difficulty in memorizing content, a lack of opportunity to apply their knowledge, and limited exposure to cadaveric dissection were the major challenges highlighted by the students. That is, the students perceived anatomy as a difficult subject and preferred a more vertically integrated anatomy curriculum, but with a concomitant opportunity for cadaveric dissection. Indeed, the perception of anatomy as a difficult subject aligns with the findings of previous studies reporting students' views on the complex nature of anatomy.[37,38] Hence, anatomy is argued to be an intrinsically difficult subject that imposes a high cognitive load on students. However, the students in this study felt that the anatomy content they learned during the preclinical phase of their medical studies was excessively detailed and that some portions were not necessary for clinical practice. This sentiment was echoed by many anatomy educators, given that anatomy is a unique subject that is rich in facts, new terminologies, and complex diagrams, which require the use of 3D visualization, along with drawing connections between several different areas of study.[24,37,39] Hence, several anatomy educators worldwide have attempted to construct a core anatomy curriculum outlining the minimum anatomy knowledge required for medical students to be able to provide demonstrations upon graduation.[40–45] Likewise, in Malaysia, ongoing research is aimed at identifying the anatomy-related competencies required for safe clinical practice, which could subsequently lead to the formation of a national anatomy syllabus for the Malaysian medical undergraduate curriculum.

Interestingly, this study identified several pertinent aspects of anatomy knowledge and skills that are important for clinical practice. Although anatomy is a content-heavy subject, not all anatomy details are functionally important. In general, the students emphasized the importance of knowing only important parts of the organs in the gastrointestinal, cardiovascular, pulmonary, genitourinary, and nervous systems to practice during their clinical attachment. More importantly, the students perceived that understanding the surface anatomy; arterial, venous, and lymphatic circulation; dermatomes; and innervations of organs and muscles had high relevance in a clinical context, because this content was frequently encountered during their clinical postings. For instance, surface anatomy enables students to inspect and palpate anatomical structures, particularly those of the musculoskeletal system, which are commonly encountered during physical examinations and clinical procedures.[17] Furthermore, placing electrocardiogram leads on a patient's chest—which was highlighted by the students as a commonly conducted procedure during an emergency posting—requires students to use their surface anatomy knowledge to identify ribs and intercostal spaces. Similarly, junior physicians have rated studying the circulatory system and dermatomes, which are often less emphasized during the preclinical years, as having high importance.[2] The students indicated that this knowledge is required for them to draw blood, perform intravenous cannulation, and identify peripheral nerve lesions. Therefore, to produce competent graduates capable of safe clinical practice, exploration of anatomy-related core competency elements is essential to decrease the gap between knowledge and expectations in the anatomy curriculum.

Despite the integrated nature of the preclinical curricula in Malaysia, the students in this study were concerned about the limited opportunity to apply their anatomy knowledge during their preclinical years. Although a vertically integrated anatomy syllabus provides clinical relevance for students to make sense of dry, content-driven anatomy teaching, hands-on learning activities in which they could apply their anatomy knowledge were lacking. The practical sessions were limited to identifying anatomical structures by using cadaveric specimens and anatomy models, with minimal exposure to radiological modality and procedural skills.[22] These modalities might arguably be best taught in clinical skills laboratory training or during the early phase of clinical training; however, previous studies have reported that introducing basic radiological and clinical procedures in teaching anatomy strengthens anatomy knowledge, enhances radiological and clinical skills, and improves students' perceptions of the value of learning anatomy.[27,46] Hence, to enable the integration of clinical application into

the preclinical anatomy curriculum, anatomists must be willing to sacrifice anatomical details and design an instructional blueprint that integrates relevant anatomical concepts with clinical application.[60] Indeed, ongoing efforts among Malaysian anatomists are aimed at the integration of anatomy teaching with clinical practice.[30,47,48]

Beyond early clinical integration and incorporation of the core competencies of anatomy in the preclinical anatomy syllabus, the students also offered suggestions for how to improve anatomy teaching and learning. These suggestions comprised teaching anatomy longitudinally throughout the medical program; increasing kinesthetic learning opportunities, through cadaveric-based teaching or living anatomy; and using virtual reality software to promote 3D visualization and mental imagery of anatomical structures. Indeed, these suggestions are aligned with findings from previous studies describing the effectiveness of revisiting anatomy knowledge in enhancing knowledge retention[49]; efficacy of cadaveric-based teaching and living anatomy in promoting hands-on active learning and development of professional behaviors[50,51]; and effectiveness of virtual reality in enhancing students' anatomy knowledge.[52] Anatomy knowledge should arguably be revisited during clinical postings, particularly in orthopedics, surgery, and obstetrics and gynecology.[53,54] Unfortunately, limited opportunities exist for anatomy lecturers in Malaysian medical schools to contribute during the clinical years, given the tight schedule of the clinical postings. Nevertheless, the use of virtual reality and digital instruction in the anatomy curricula in Malaysia has substantially increased since the COVID-19 pandemic, and anatomy educators in Malaysia are moving toward redesigning a future-proof anatomy curriculum that is adaptable to change.[22,55] Although formal cadaveric dissection training is not feasible in the current anatomy curricula in Malaysian medical schools, anatomy educators in Malaysia have been conducting research to provide evidence-based methods with benefits comparable to those of cadaveric dissection, such as learning living anatomy through a work-based environment or through body painting.[47,56]

Indeed, anatomy curricula can be made maximally effective by balancing content details with important core knowledge for safe clinical practice, as well as incorporating multimodal teaching that emphasizes kinesthetic and affective learning value.[2] Overall, the students' rationale for highlighting important core knowledge is aligned with their thoughts on how anatomy knowledge could affect their learning and future careers. They believe that having pertinent anatomy knowledge, including radiological and surface anatomy, is important for decreasing patients' morbidity and mortality.[57] However, little agreement exists regarding core anatomy competency among various educational stakeholders. Moreover, whether anatomy is sufficiently taught to medical students for safe clinical practice, and the extent to which medical students apply their anatomy knowledge during clinical training, remain unclear.

Limitations

The study findings reflect students' perceptions regarding their anatomy learning experience and the challenges that they faced during the preclinical year, elaborating on the core anatomy knowledge necessary for the clinical years. Unfortunately, this study was unable to identify students' perceptions of professionalism and etiquette during the anatomy teaching and learning modules in their preclinical years. Exposure to professionalism early in the medical curriculum years provides many opportunities to prepare students as they progress to the clinical years, because medical practitioners with positive professional attitudes are required in modern healthcare settings.[58]

Another aspect of medical education addressed in this study is how the assessment of the anatomy module during the preclinical years affects students' learning during the next 3 years in the clinical clerkship phase. The breadth and depth of anatomy and its clinical relevance have not been thoroughly investigated in relation to their assessment during preclinical years.

This study included students from four public universities in Malaysia, which had similar medical curricula settings. In future studies, recruiting medical students from private medical schools—particularly schools that collaborate with overseas medical schools—and medical schools in other countries should be beneficial. Such studies might better generalize students' perceptions of the teaching and learning of anatomy, and indicate more ways to improve in both national and international settings.

Finally, this study explored only the perceptions of medical students in their clinical years. Exploration of the elements of anatomy-related competencies must include feedback not only from medical students but also from preclinical and clinical lecturers, as well as practitioners who perform clinical skills on a daily basis. In fact, perceptions regarding the relevance of anatomy education to medicine and clinical practice differ among students, medical practitioners, and anatomy educators.[57,59] Hence, incorporating input from all stakeholders is critical to ensure the validity and generalizability of the data.

Conclusion

The study identified six main themes presented by clinical-year students regarding their personal experiences in applying anatomy knowledge during their clinical training. The six themes—1) preclinical anatomy teaching experience, 2) anatomy content and teaching, 3) anatomy-related competency, 4) the importance of anatomy knowledge in clinical practice, 5) the importance of early exposure to clinically applied anatomy, and 6) suggestions for future anatomy education—highlight the real situations encountered in teaching of anatomy curricula during preclinical years in Malaysian medical schools. Although this study focused on Malaysian clinical year students' reflections on how they applied anatomy knowledge in their clinical practice, the findings may provide an understanding of the anatomy core competency necessary for safe clinical practice, which is expected to be similar across countries. The studies emphasized the importance of the integration of anatomy knowledge into the medical curriculum, which requires alignment of the anatomy syllabus with clinical correlation. Nevertheless, further research exploring the experience of medical practitioners and the opinions of anatomy lecturers regarding

anatomy-related competency would be beneficial for data triangulation and thus increase accuracy in determining which competencies are important for safe clinical practice.

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Conflict of interest

The authors have no conflict of interest to declare.

Ethical approval

This study received ethical approval from the Human Research Ethics Committee USM (USM/JEPeM/19040257). The date of ethical approval is 2nd March 2022.

Authors contributions

SASAH conducted and provided research materials, analyzed data, and prepared the first draft. MSBY and MNY conducted and provided research materials, collected and analyzed data, and prepared the first draft. SAR, TFM, and SNH designed the study, conducted and provided research materials, collected, analyzed and interpreted data, and prepared the first and final draft of the article. RRR and FR analyzed and interpreted data, and prepared the first and final draft of the article. All authors have critically reviewed and approved the final draft and are responsible for the content and similarity index of the manuscript.

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