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Teaching anatomical terminology: effective learning strategies in medical education

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Abstract

All healthcare professionals have to master the extensive anatomical terminology, which is an indispensable tool in communication. The *Terminologia Anatomica*, formerly known as *Nomina Anatomica*, is a particularly useful tool for effective communication among anatomists and specialists beyond the field, both within a medical context and the broader scientific discourse. The inaugural edition of the Terminologia Anatomica, which was issued in 1998 by the Federative Committee on Anatomical Terminology, gained widespread international recognition. Nevertheless, many authors believe that precise definitions and valid names for the parts and segments of the anatomical structures that are clinically and didactically useful should be incorporated in future editions of anatomical nomenclature. Thus, refining and extending the Terminologia Anatomica remains a challenging task for future generations of anatomists. Simultaneously, the intricate nature of anatomical nomenclature poses a major challenge, as learning, remembering, and understanding the complex terminology is a difficult task, especially for first-year medical students and newcomers to the field, emphasizing the need to simplify the anatomical language. The purpose of this article is to explore specific strategies designed to elevate the educational experience of medical students as they endeavor to master human gross anatomy and its terminology.

Running title: anatomical terminology in medical education

Keywords: anatomical nomenclature, anatomical terminology, anatomy teaching, clinical anatomy, human anatomy, medical terminology

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Introduction

Proficiency in medical terminology is a fundamental requirement for all healthcare professionals, essential not only in the execution of clinical duties, but also in their ongoing academic pursuits [1-4]. Within the field of anatomy, the acquisition and adept use of anatomical terminology is paramount, laying the groundwork for a thorough understanding of human anatomy and contributing to the overall competence of medical professionals, scholars, researchers, and authors [5-7]. In this context, anatomical accuracy and terminological precision are equally crucial for effective communication and precise navigation within the intricacies of the human body [8-11].

However, the acquisition, understanding, and retention of the specialized, copious, and occasionally idiosyncratic anatomical names pose a significant challenge to many learners [7]. Therefore, it is important to simplify anatomical nomenclature [10-13]. It should be stressed that the occurrence of any mistakes and inconsistencies in the application of medical terminology is likely to give rise to confusion, thereby hindering the learning process or contributing to errors in clinical practice [14-17].

Drawing upon our experience as researchers and educators, we offer selected strategies to enrich the educational experience of first-year medical students and their instructors. These methods are meticulously designed to support medical students in their pursuit of mastering the intricate details of human anatomy and the extensive anatomical terminology.

The role of reliable sources: textbooks, atlases, and tutorials

Gaining insights into the intricacies of the human body requires an unwavering commitment to consulting only the most meticulous, conscientious, validated, and esteemed sources [18-21]. Unfortunately, many students resort to unreliable sources, a practice that might be precarious. The utilization of well-established anatomical textbooks and atlases, endorsed by generations of medical professionals, is indeed essential in the learning process. These resources, possessing a unique blend of beauty and wisdom, should be regarded as cultural treasures. To cultivate a comprehensive understanding of human gross anatomy, all students should consider these faithful texts as exemplars, guiding them through the intricacies of this field.

Interactive technology and (virtual) cadaver dissection

Human anatomy is a cornerstone of medical education. It is crucial to acknowledge the rich tradition and importance of cadaveric dissection in the field of human anatomy. Cadaver dissection is often considered one of the best methods of studying the complexity and variability of human anatomy, as it allows medical students to appreciate the spatial relationships among gross anatomical structures [22-26]. While this modality dates back to the ancient times, and it has been perceived as obsolete in today's medical training [27], it remains essential, as the spatial awareness is fundamental in developing a good understanding of the human body. Moreover, for aspiring surgeons, cadaveric studies might be a gateway to honing surgical skills. The tactile experience of dissecting tissues and organs prepares surgeons for the intricacies of live surgeries, fostering a level of comfort and confidence. Furthermore, radiologists and other clinicians who have undergone cadaveric dissections often exhibit enhanced diagnostic proficiency, as they can easily visualize anatomical structures and their variations.

However, recent advancements in interactive technology have paved the way for 3D exploration of the human body. For instance, virtual anatomy software, augmented reality, and virtual reality applications provide medical students with interactive platforms to dissect, manipulate, and understand anatomy. These new technologies bring anatomy to life, allowing students to navigate the complexities of the human body in ways previously unimaginable. In this context, virtual cadaver dissection is a digital frontier. Digital cadaver resources and online dissection platforms have redefined the traditional cadaver dissection experience. High-resolution images and videos of cadaveric specimens enable anatomy students to dissect without the need for a physical lab. Accessibility and flexibility are key advantages, as students can engage in dissection exercises remotely, at their own pace, and with repeatable precision. While anatomy teachers and clinical instructors need to be professional, competent, and charismatic, all learners must be sufficiently engaged to maintain their focus on learning. Therefore, the use of active methods is likely to promote more consistent engagement for learners of all styles.

The benefits of this revolution are manifold. Interactive technology and virtual cadaver dissection provide an excellent learning environ-

ment. Educators can customize learning paths to cater to diverse student needs, fostering engagement and motivation. The time and cost efficiencies associated with virtual methods democratize access to quality anatomy education. The convergence of interactive technology and virtual cadaver dissection has ushered in a new era, offering students unprecedented opportunities for immersive and dynamic learning experiences. In the evolving landscape of medical education, cadaver dissection remains an irreplaceable cornerstone. Beyond its role in teaching, cadaveric studies and pictures and empower students with a profound appreciation for the complexity and the beauty of the human body. Despite technological advancements, this exploration affirms that the cadaveric experience continues to be the golden standard in anatomical education.

Clinical integration and case-based learning

Clinical anatomy serves as the foundation of medical knowledge. Understanding human anatomy is a preliminary step, but its true essence is revealed when integrated into the clinical realm. Clinical integration transforms this theoretical knowledge into dynamic entities, illustrating their relevance to medical practice. Through this lens, medical students not only grasp the intricacies of form but also discern the functional implications in health and disease. In this context, case-based learning emerges as a powerful tool, weaving clinical scenarios into the fabric of anatomical education. By presenting anatomy students with real-world cases, anatomy educators and clinical instructors can nurture problem-solving skills and they can cultivate a holistic understanding of medicine. Each case is a narrative, guiding students through the application of anatomical principles in the art of diagnosing and treating patients.

In the contemporary world, technology serves as an invaluable ally. Virtual dissections, interactive simulations, and 3D models enhance case-based learning, offering medical students realistic encounters with clinical scenarios. Indeed, technology augments traditional methods, providing a dynamic and accessible platform for exploring the human body and its complexity. While integrating clinical aspects into anatomy education is indispensable, challenges still exist. For instance, striking a balance between the depth of anatomical knowledge and clinical application, ensuring that all cases are realistic and relevant, and addressing diverse learning styles are ongoing considerations. Active engagement, collaboration, and the continuous refinement of methodologies are the strategies that can help overcome these challenges. In summary, nurturing a generation of clinicians adept at translating anatomical insights into clinical acumen perpetuates a legacy of comprehensive medical education.

The role of active learning

Compelling evidence supports the idea that individuals learn more effectively when actively engaged in meaningful activities, such as discussing, debating, and drawing anatomical structures, creating anatomical models, completing writing exercises, participating in cadaver dissections, or engaging in educational gaming [28-31]. The incorporation of simulated clinical scenarios, like virtual patient encounters or anatomy-based simulations, empowers students to apply their anatomical knowledge within a simulated healthcare setting. This type of learning is instrumental in bridging the gap between theoretical anatomy and clinical practice. Active learning plays an important role in the study of human anatomy. Rather than passively absorbing information, active methods immerse students in the learning process, promoting a deeper understanding, retention, and practical application of anatomical knowledge. These approaches not only enhance student engagement but also cultivate critical thinking skills, contributing to a more comprehensive medical education.

The role of mnemonics in anatomy education

The use of mnemonics, i.e. memory aids or techniques designed to facilitate the recall of information, can be a valuable and effective teaching tool when introducing first-year medical students to human anatomy. In anatomy, several types of mnemonics, including acronyms (name mnemonics), acrostic mnemonics, image mnemonics, and visualization mnemonics, are frequently employed (**Tab. 1**).

Considering that human anatomy involves a vast amount of detailed information, including the names of bones, muscles, nerves, vessels, and other structures (parts, segments, spatial relationships etc.), these methods provide an organized way to condense complex information into easily memorable patterns. These tools can help students associate structures with memorable phrases, aiding in the quick recall of the most crucial information during examinations or clinical scenarios. Furthermore, mnemonics add an element of creativity and fun to the learning process, making it more enjoyable and fostering a positive attitude toward learning anatomy. It is noteworthy that using mnemonics

TABLE 1 The most common mnemonics that are frequently utilized in anatomy courses for first-year medical students, facilitating comprehensive retention and application of anatomical knowledge

MNEMONIC	EXPLANATION
Some lovers try positions that they can't handle	From lateral to medial, the proximal row of the carpal bones consists of the scaphoid, lunate, triquetrum, and pisiform, whereas the distal row comprises the trapezium, trapezoid, capitate, and hamate
Some anatomists like freaking out poor medical students	The external carotid artery gives off the following branches: the superior thyroid, ascending pharyngeal, lingual, facial, occipital, posterior auricular, maxillary, and superficial temporal arteries
DAMI – MDPB – PAIDS	There are three segments of the maxillary artery, i.e., the mandibular, pterygoid, and pterygopalatine segments, giving off the following branches: the deep auricular (D), anterior tympanic (A), middle meningeal (M), inferior alveolar (I), masseteric (M), deep temporal (D), pterygoid (P), buccal (B), posterior superior alveolar (P), artery of pterygoid canal (A), infraorbital (I), descending palatine (D), and sphenopalatine (S) arteries
ROS	From anterior to posterior, the openings located at the base of the greater wing of the sphenoid bone are: the foramen rotundum (R), foramen ovale (O), and foramen spinosum (S)
SCALP	The scalp is composed of five layers, namely the skin, connective tissue, aponeurosis (*galea aponeurotica*), loose connective tissue, and pericranium
Two zebras borrowed my car	After leaving the stylomastoid foramen, the facial nerve (CN VII) gives off the posterior auricular nerve, the digastric and stylohyoid branches and the following terminal (motor) branches for the facial muscles: the temporal, zygomatic, buccal, marginal mandibular, and cervical branches
COPS	There are four main parasympathetic ganglia in the head, namely the ciliary ganglion (C), the otic ganglion (O), the pterygopalatine ganglion (P), and submandibular ganglion (S). Additionally, the sublingual ganglion may be present
NAVY	The common carotid artery, the internal jugular vein, and the vagus nerve (CN X) form the neurovascular bundle of the neck that is wrapped by the carotid sheath
P – F – P – F (Pass, fail, pass, fail)	The superficial layer of the anterior group of the forearm muscles consists of the following four muscles: the pronator teres (P), flexor carpi radialis (F), palmaris longus (P), and flexor carpi ulnaris (F)
AFO + Add	The thenar muscles include the abductor pollicis brevis, the flexor pollicis brevis, and the opponens pollicis muscle (all innervated by the median nerve), while the adductor pollicis lies deep in the palm and is innervated by the ulnar nerve
Remember to drink cold beverages!	The main parts of the brachial plexus, from medial to lateral, are five roots, three trunks, six divisions, three cords, and several branches
½ LOAF	The median nerve supplies the muscles of the anterior compartment of the forearm, excluding the flexor carpi ulnaris and the medial part of the flexor digitorum profundus. After passing through the carpal tunnel, this nerve innervates the two lateral lumbricals, the opponens pollicis, the abductor pollicis brevis, and the flexor pollicis brevis
VAN	In the intercostal space, the neurovascular bundle comprises the intercostal vein, artery, and nerve, arranged from superior to inferior
C3, 4, and 5 keep the diaphragm alive	The diaphragm is innervated by the phrenic nerve, which arises from the C3, C4, and C5 spinal nerves
VAU	The renal veins lie anterior to the renal arteries, whereas the ureter (renal pelvis) lies posteriorly in the renal hilum
The over-under-over-under rule	The ureter follows a course that involves passing over the genitofemoral nerve, crossing under the testicular or ovaric vessels, traversing over the iliac vessels, and then passing under the ductus deferens in men or the uterine artery in women. At the base of the broad ligament of the uterus, it lies laterally to the cervix uteri, penetrates into the space between the vagina and the bladder, and finally pierces the wall of the bladder in an oblique direction
The F-AB-ER muscle	The sartorius (tailor's muscle) flexes (F), abducts (Ab), and laterally (externally) rotates (Er) the thigh. At the knee, it flexes the leg, and when the knee is flexed, this muscle medially rotates the shin
NAVEL	From lateral to medial, the sequence of structures in the femoral triangle are the femoral nerve (N), femoral artery (A), and femoral vein (V). The lymphatics (L) lie medially
PIMP	From medial to lateral, the floor of the femoral triangle is composed of several muscles, including the pectineus (P), the iliacus (I), and the psoas major (MP)
Say grace before tea	The sartorius, gracilis, and semitendinosus muscles converge on the medial aspect of the tibial tuberosity, forming the pes anserinus
NEVA or NiVeA	From superficial to deep, the structures in the popliteal fossa are: the tibial and common fibular nerves (N), the popliteal vein (V), and the popliteal artery (A)
Tom drives a very nice Honda	From anteromedial to posterolateral, the components of the tarsal tunnel are as follows: the tibialis posterior muscle (T, tendon), the flexor digitorum longus (D, tendon), the posterior tibial artery and vein, the tibial nerve, and the flexor hallucis longus (H, tendon)

every now and then during anatomy classes can significantly enhance the learning experience by simplifying complex information, aiding in retention, promoting engagement, and facilitating the transition to clinical practice.

The beauty of the human body: visualizing through drawing

The act of conceptualizing and illustrating anatomical structures is a highly effective strategy in the realm of anatomy education. These methods facilitate the visualization of three-dimensional structures, demanding active engagement and interaction with the subject matter. This hands-on approach enhances the learning experience, surpassing the efficacy of passive learning modalities and augmenting the retention of information. Moreover, the creation of visual representations of various anatomical structures play a pivotal role in fortifying memory retention. It is worth noting that within the purview of the medical profession, where conveying complex information to both patients and colleagues is routine, the cultivation of drawing skills might not only enhance creativity, but can also bolster receptivity, cooperativity, amenability, and the adept articulation of complex concepts. The generation of realistic illustrations depicting the anatomical structures propels learners to contemplate the function, location, and interconnections of distinct anatomical elements, thereby fostering a more profound understanding of human anatomy.

Conclusions

Human anatomy is arguably one of the oldest medical disciplines with a rich history, distinct tradition, and specialized terminology. Precision in the usage of anatomical nomenclature is paramount to ward off any potential error or confusion. A reliance on reputable sources, such as well-established anatomical handbooks and atlases, is deemed indispensable in the pursuit of accurate knowledge. Traditional cadaver dissection remains instrumental, providing a tactile experience that is crucial for grasping spatial relationships. Embracing modern strides, including virtual cadaver dissection and 3D exploration, opens the gateway to immersive learning experiences. The amalgamation of case-based learning with cutting-edge technology not only fosters problem-solving skills but also deepens the understanding of modern medicine. Furthermore, active learning methods, such as engaging in discussions, debates, and virtual patient encounters, serve as dynamic bridges connection theory to practice. These novel teaching methods and learning strategies heighten student engagement and help cultivate critical thinking.

Ethical approval
The study did not require the approval of the local Ethics Committee.

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Conflict of interest
The authors declare no conflict of interest.

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