Section: Medical Education and Technology

Review Article

INTEGRATION OF ARTIFICIAL INTELLIGENCE IN ANATOMICAL SCIENCES: A NARRATIVE REVIEW

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ABSTRACT

Anatomical sciences are transforming a paradigm shift of the traditional cadaveric dissection to image-centered and data-based methods. Artificial intelligence (AI) has proved itself as a potent instrument to medical imaging, three-dimensional models of the human organs and organs interpretation. The objective of this narrative review is to provide an overview of the existing uses of AI in anatomical sciences, focusing on radiological anatomy, morphometric analysis, surgical practice, and medical education. A literature review was performed based on the studies that reflect clinical and educational implementation of AI and deep learning methods in anatomy. AI algorithms are found to be very precise in the field of segmentation of organs in computed tomography and magnetic resonance, automated evaluation of skeletal and soft-tissues structure, and interactive learning environments. These strategies minimize observer variability, enhance efficiency in the workflow as well as spatial understanding among the students. Artificial intelligence is not a substitute to traditional anatomical techniques: it should be viewed as an addition to anatomical knowledge. Ethical regulation should drive the future introduction of AI in anatomy to achieve responsible and fair use.

Keywords: Artificial intelligence artificial intelligence, anatomical education, radiological anatomy, deep learning, morphometry.

INTRODUCTION

Medical language is structural and is present in human anatomy. This experience had been acquired over generations via cadaveric dissection and printed atlases. These procedures are simple, and they do not best deal with the gigantic anatomical disparities which exist in living patients. The imaging and digital information has become an increasing foundation of health care of the modern world and demands the new interpretation approach.

AI offers the possibility to assess complex structural data that are not can be assessed manually and at a large scale. Algorithms can recognize organs, vessels and the tiniest differences by being trained on thousands of examples. It has given rise to the concept of personalized or precision anatomy, where clinical decisions are drawn based on morphology of the patients, rather than idealized norms.[1,2]

The present review describes how AI is changing the big fields of the anatomical sciences, which encompass radiology, research, surgery, and education, and contains restrictions and ethical issues.

2. Classical Observation to Computational Anatomy: Classical anatomy was based on descriptive observation. The measurements were calculated manually and analyzed based on personal experience. Digital imaging had formed huge stores of structural information but deriving meaningful information about the images was tedious.

Machine learning algorithms transform raw pixels into structured anatomical maps. In contrast to software with rules, the current deep-learning frameworks construct their internal expression of shape and texture. This will enable the objective study of variability across populations and age groups and in the long run anatomy will have become a quantitative field of study.

3. Radiological anatomy Applications

1. Automated Segmentation: Segmentation is the definition of organs and tissues in imaging studies.

Convolutional neural networks are currently able to accomplish this task with the accuracy of experts. Reporting time has been reduced greatly using automated delineation of brain nuclei, abdominal organs and pelvic floor muscles.[5,6]

2. Three-Dimensional Reconstruction: AI helps to create 3D representations of specific patients based on CT or MRI cuts. These models can be useful in planning cardiac, orthopedic, and neurosurgical surgeries to identify the relationship between lesions and the surrounding structures prior to surgery.[7]

3. Quantitative Morphometry: Lengths, angles, and volumes can be automatically computed by algorithm and allow massive research on normal and variant anatomy. Predictive tools assist in predicting the vascular or skeletal differences that can affect the risk of surgery.[8,9]

4. Role in Surgical/Clinical practice: Robotic platforms are becoming more and more aware of AI to identify landmarks in minimally invasive procedures. Live action instructions minimize unintentional harm and aid more secure navigation.[10] Augmentation with AR, enables the doctor to see concealed structures imposed on the operating table.[12]

At the microscopic scale, deep learning has helped in recognition of muscle fibers, pathological patterns in histology sections, encouraging more engagement between anatomy and pathology.[15]

5. Anatomical Education Transformation

I. Learning Systems that are Smart: In studying through fixed pictures, students find it difficult to grasp three-dimensional relationships. The AIs-assisted platforms generate adaptive modules that will react to the performance of the learners by providing hints and corrective feedbacks.[3]

II. Virtual and Augmented Reality: Using AI and VR/AR together to simulate the dissection does not require cadavers. Haptic equipment is tactile and software identifies structures in real time as the learner navigates.

III. Evaluation and Standardization: The NLP tools help in standard anatomical words and automated scoring of student works. These technologies help in objective and scalable scoring.[17]

IV. Synthetic Data Generation: The lack of annotated images is an impediment to the training of algorithms. Synthetic anatomy Generative models have been able to generate realistic synthetic anatomy and extend datasets without compromising confidentiality, especially in rare variants.

6. Ethical and Practical Problems: However, there are a number of concerns, including:

I. Data bias: The models that are trained on small populations might fail to work equally across ethnic groups.[11]

II. Transparency: Deep network decision pathways are quite often hard to understand.

III. Educational balance: Too much use of automation would undermine the traditional observational skills.[18]

IV. Consent and privacy: The use of cadaveric and patient image must have firm control.[11]

Integration requires interaction among anatomists, clinicians, and data scientists so that it can be done responsibly.

7. Future Perspectives: Whole-body automated mapping and integrating genomic data with structural data and AI-assisted cadaver laboratories are expected to transform the standards of reference of the next generation.

CONCLUSION

Anatomy is being transformed by the use of Artificial Intelligence in the practice and teaching of anatomy.[19]

It supplements classical approaches by allowing objective analysis and immersive visualization and allows personalized patient care. The success of its long-term implementation will be subject to careful adoption at the expense of its ethical security.

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