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REVIEW ARTICLE

Anatomical Knowledge of Graduates of Integrated Medical Curriculum Schools: A Real Challenge to Health Care System

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ABSTRACT

Background: There is no doubt that anatomy is a keystone in medical education. Its understanding is vital for each health care practitioner to perform safe medical practice. Anatomy is a solid knowledge requires imagination, and memorization then proceeds to applying its knowledge to different clinical situation. Traditionally, anatomy is taught by didactic lectures and practical cadaveric dissection.

This review ultimately aims to summarize the main findings of the effective curriculum and teaching strategies of the human anatomy as a basic science in integrated medical education.

Methods: A narrative review of all the relevant papers discussing anatomical curricula in undergraduate medical education was conducted.

Conclusion: The actual benefit of new curricular modifications on the preservation of anatomical knowledge and future surgical experiences is still doubtful. The change from the old-style regional program towards integrated, system-based and multimodal methods of education needs more researches to assess suitability, undergraduates' ability to achieve learning outcomes.

Key words: Anatomy teaching; Undergraduate medical curriculum; cadaveric dissection..



INTRODUCTION

Anatomy is a keystone of medical education. Its understanding is essential to patient care [1]. It has a significant role for success of healthcare system and provides an important base to understand and manage various pathological procedures [2]. It has a great value for any practitioner performing an invasive procedure on a patient; completes crisis techniques; inspects radiological imaging; performs a physical evaluation on a patient; attributes a patient to another specialist; or clarifies a technique to a patient. Anatomy is essential for surgeons in particular. A capable and effective surgeon must be a perfect anatomist by mastering anatomy at the start of medical education and commanding refreshing it during surgical training [3]. Anatomical varieties related to congenital anomalies are often common and are of clinical significance so the learning of embryology is required [4]. As right on time as the sixteenth century, anatomy was instructed by dissection [5]. As introducing dissection to methods of teaching improves levels of anatomical knowledge so dissection needs to stay a key part of the

educational program related to other showing modalities, for example, radiological anatomy and innovative technology [6]. Cadaver dissection and/or examination of prosected material is the base of anatomy learning [7]. We conduct this review for proof identifying with the current status of anatomical sharing in integrated curricula from the perspectives of anatomists, clinicians and undergraduates with the appropriate suggestions to arrive at the best in instructing of anatomy. So, more efficient use of new technology and teaching methods in anatomy should allow a better teaching and understanding towards overcoming this crisis. Integration of newer teaching modalities and modern technology will encourage interest and retention of anatomical knowledge and its clinical relevance. So, this review ultimately aims to summarize the main findings of the effective curriculum and teaching strategies of the human anatomy as a basic science in integrated medical education.

METHODS

We performed an online comprehensive search at multiple search engines for the literature articles dealing with anatomical knowledge in the

traditional as well as in the integrated undergraduate medical curricula introduced recently in our medical college and all over our country. The literatures available in English only were considered. The collected literatures were carefully revised to include only which is reliable. The keywords used for this search were anatomical knowledge, anatomy curricular reform, cadaveric dissection teaching methods and assessment of

anatomy. All the included literature was considered to be the most relevant to anatomical knowledge and how it could be enhanced among graduates of integrated undergraduate medical curricula. These data have been analyzed in association with our own practical thoughts. As shown in table (1) which summarizes the data collected from literature.

Table (1): Summary of data collected from literature.

No	Author (s)	Title	Year	Source	Findings
	Bergman EM, Verheijen IWH, Scherpbier AJJA, van der Vleuten CPM, de Bruin ABH	Influences on anatomical knowledge: The complete arguments.	2014	Clinical Anatomy journal	Anatomy is a keystone of medical education. Its understanding is essential to patient care
	Caswell FR, Venkatesh A, Denison AR.	Twelve tips for enhancing anatomy teaching and learning using radiology	2015	Medical Teacher journal	Anatomy has a significant role for success of healthcare system and provides an important base to understand and manage various pathological procedures
	Singh R, Tubbs R, Gupta K, Singh M, Jones D, Kumar R	Is the decline of human anatomy hazardous to medical education/profession? —A review.	2015	Surgical and Radiological Anatomy journal	A capable and effective surgeon must be a perfect anatomist by mastering anatomy at the start of medical education and commanding refreshing it during surgical training
	Kumar R, Singh R	Model pedagogy of human anatomy in medical education	2016	Surgical and Radiological Anatomy journal	Anatomical varieties related to congenital anomalies are often common and are of clinical significance so the learning of embryology is required
	Jordan D, Griffin M, Phillips B, Hindocha S, Elgawad A.	Teaching Anatomy; Dissecting its Delivery in Medical Education.	2016	Open Medicine Journal	As right on time as the sixteenth century, anatomy was instructed by dissection
	Farey JE, Bui DT, Townsend D, Sureshkumar P, Carr S, Roberts C	Predictors of confidence in anatomy knowledge for work as a junior doctor: A national survey of Australian medical students	2018	BMC Medical Education journal	As introducing dissection to methods of teaching improves levels of anatomical knowledge so dissection needs to stay a key part of the educational program related to other showing modalities, for example, radiological anatomy and innovative technology

No	Author (s)	Title	Year	Source	Findings
	Stabile I.	The Teaching of the Anatomical Sciences Eur	2015	Journal of Anatomy	Cadaver dissection and/or examination of prosected material is the base of anatomy learning
	Rodrigues M, Da A, Longarito S, Ferreira MA, Sousa N.	PhD Program in Medicine The Challenge of Integration of Neuroanatomy in Medical Education	2018	PhD thesis	The way anatomy has been approached over the centuries has evolved, reflecting the changes occurring in medicine and society
	Vieira JE, Silva LFF da, Baracat EC.	Medical education at the University of São Paulo Medical School.	2015	Clinics	Medical institutions are obliged to choose the most essential of the available knowledge as it is impossible to cover all these knowledge
	Arja S.	Immunotherapy Research Journal Editorial Undergraduate Medical Education and Curricula	2017	Immuno-therapy Research	In this reform different models of curricula are designed including the oldest traditional discipline-based curriculum, organ-based curriculum and problem-based learning curriculum.
	Hulail M.	Medical Education: Historical Backward, Current Trends and Challenges.	2018	Zagazig University Medical Journal	Some medical schools use two types of combined curricula as organ-based curriculum and problem-based learning
	Blackstock U, Munson J, Szyld D	Bedside ultrasound curriculum for medical students: Report of a blended learning curriculum implementation and validation	2015	Journal of Clinical Ultrasound	The changes in the curriculum and correspondingly methods of teaching have a negative impact on anatomy teaching with a consequent reduction in the time dedicated to its teaching with fewer lectures compared with the traditional curriculum
	Gonzalo JD, Chang A, Wolpaw DR.	New Educator Roles for Health Systems Science: Implications of New Physician Competencies for U.S. Medical School Faculty	2019	Academic Medicine	Moreover, the curriculum reform introduces new subjects such as healthcare delivery systems and professionalism with consequent decline of time allocated to basic sciences including anatomy
	Leveritt S, McKnight G, Edwards K, Pratten M, Merrick D	What anatomy is clinically useful and when should we be teaching it?	2016	Anatomical Sciences Education	The weakening of anatomical knowledge of today's medical undergraduates might lead to medical mistakes
	Ellis H.	Medico-legal Litigation and its Links with Surgical Anatomy	2002	Surgery (Oxford)	Ellis was an assessor in second part of the Membership of the Royal College of Surgeon's stated that "I have surprised to find candidates do not know how to locate the ureter, or others that have little idea of surface anatomy to insert a chest drain and some of the candidates in practical surgical anatomy are

No	Author (s)	Title	Year	Source	Findings
					seeing a real anatomical specimen for the first time”
	Buja LM.	Medical education today: All that glitters is not gold	2019	BMC Medical Education	A strong curriculum in the basic medical science is a necessity to the development of future generations of physician-scientists
	Yogesh M, S V, M J S, C S.	Integration of problem based learning with conventional teaching for understanding anatomy among first year medical students.	2013	International journal of health sciences and research	The problem-based learning (PBL) method was designed as an alternative to the traditional teaching and becomes popular in medical education
	Gogalniceanu P, Palman J, Madani H, Sheena Y, Birch W, Paraskeva P, et al.	Traditional undergraduate anatomy education – a contemporary taboo? ANZ Journal of Surgery	2010	ANZ Journal of Surgery	The anatomy topics that cannot be covered through PBL discussions must be taught through lectures
	Vorstenbosch MATM, Kooloos JGM, Bolhuis SM, Laan RFJM	An investigation of anatomical competence in junior medical doctors.	2016	Anatomical Sciences Education	The knowledge of anatomy is uncertain, deficient and below an acceptable standard required for safe medical practice
	Watmough SD, O’Sullivan H, Taylor DCM	Graduates from a reformed undergraduate medical curriculum based on Tomorrow’s Doctorsevaluate the effectiveness of their curriculum 6 years after graduation through interviews.	2010	BMC Medical Education	Students from PBL wish a more organized educational teaching method to get more knowledge in basic science
	Alexandrov Missankov A, Ivanova Missankova K	Does the Traditional Teaching Component of The Hybrid Curriculum Improve the PBL Component, In the Teaching of Anatomy?	2015	International Journal of Health Sciences & Research	Anatomical sciences are better taught either by the traditional method or by the hybrid curriculum involving the traditional and the PBL methods as the two components complement each other.
	Smith CF, Martinez-Álvarez C, McHanwell S.	The context of learning anatomy: does it make a difference?	2014	Journal of Anatomy	The students have to do effort considerably to memorize anatomical expressions, recognize arrangements and then relate information to clinical training
	Eisenstein A, Vaisman L,	Integration of Basic Science and	2014	Academic Medicine	Many medical schools have preserved a gross anatomy stand-

No	Author (s)	Title	Year	Source	Findings
	Johnston-Cox H, Gallan A, Shaffer K, Vaughan D, et al.	Clinical Medicine: The Innovative Approach of the Cadaver Biopsy Project at the Boston University School of Medicine.			alone course in the old-style design and struggled the integration of anatomy with other basic science disciplines
	Smith CF, McManus B	The integrated anatomy practical paper: A robust assessment method for anatomy education today	2015	Anatomical Sciences Education	The anatomical society (UK) through rigorous analysis of current curricula recommended an anatomy syllabus detailing the knowledge the students should attain prior to graduation to ensure safe and effective internship practice.
	Brooks WS, Woodley KTCP, Jackson JR, Hoesley CJ.	Integration of gross anatomy in an organ system-based medical curriculum: Strategies and challenges.	2015	Anatomical Sciences Education	In 2007 the University Of Alabama School Of Medicine in United States implied a syllabus for gross anatomy and embryology taught through a combination of didactic talks, team-based learning activities, and cadaveric dissection and radiological anatomy workshops
	Bergman EM.	Discussing dissection in anatomy education	2015	Perspectives on medical education	In this approach the topics are revisited throughout the course, at increasing levels of difficulty to increase the competence level of the students
	Kerby J, Shukur ZN, Shalhoub J.	The relationships between learning outcomes and methods of teaching anatomy as perceived by medical students.	2011	Clinical Anatomy	Current teaching methods of anatomy include traditional lecture, cadaveric dissection, anatomical models, radiological images and Computer assisted learning (CAL), Problem based learning (PBL)
	Sara K, Notebaert A.	The Value of Traditional Lecture in Medical Gross Anatomy: Student Perceptions and Performance.	2019	HAPS Educator	Traditional talks are still the main core of medical education and are the major method of learning, as they permit teaching many subjects in an ordered mode to a large number of students
	Brennan A, Sharma A, Munguia P	Diversity of online behaviours associated with physical attendance in lectures	2019	Journal of Learning Analytics	Students have reported that lectures provide exam guidance and big picture concepts and highlight important ideas
	Sbayeh A, Qaedi Choo MA, Quane KA, Finucane P, McGrath D, O'Flynn S, et al.	Relevance of anatomy to medical education and clinical practice: perspectives of	2016	Perspectives on Medical Education	On a cross-sectional, questionnaire-based study found that lectures and laboratory cadaveric dissection are the main preferred methods for learning and

No	Author (s)	Title	Year	Source	Findings
		medical students, clinicians, and educators.			teaching anatomy among all the sharing students
	Houser J, Kondrashov P.	Gross Anatomy Education Today: The Integration of Traditional and Innovative Methodologies	2018	Missouri medicine	Cadaveric dissection integrates knowledge from didactic lectures with practice, improves practical skills, encourages small group learning, fosters teamwork ability and promotes professionalism and respect for the human body
		Anatomage Table the Future of Anatomical Education and More	2018		The use of Virtual Dissection technology seems to have a promising role in future educational training
	Kurt E, Yurdakul SE, Ataç A	An Overview of the Technologies Used for Anatomy Education in Terms of Medical History.	2013	Procedia - Social and Behavioral Sciences	Computer assisted learning (CAL) can't replace the knowledgeable, educational and emotional experience presented to medical students by cadaveric dissection and even prosection
	Songur A, Gulsari Y, Gonul Y, Turamanlar O.	The Need of Vertical Integration of Anatomy Education in Medical Schools.	2018	EC Dental Science	Radiological anatomy teaching is a beneficial method for the students in their future careers and correlates the basic anatomy with the clinical skills.
	Tian Y, Xiao W, Li C, Liu Y, Qin M, Wu Y, et al.	Virtual microscopy system at Chinese medical university: An assisted teaching platform for promoting active learning and problem-solving skills.	2014	BMC Medical Education.	Enhancement of assessment develops knowledge of students and strengthens the learning of anatomy. The assessment facilitates learning of students.
	Shamkuwar S, Mokhasi V.	STUDENTS PERCEPTION ON INTERNAL ASSESSMENT IN ANATOMY.	2019	International Journal of Anatomy and Research	Another type the spotter test is to ask the students to identify the marked structure and its function, nerve or blood supply and/or its relations
	Yaqinuddin A, Zafar M, Ikram MF, Ganguly P.	What is an objective structured practical examination in anatomy?	2013	Anatomical Sciences Education	However oral forms of assessment have also been out of control because of examiner bias and reliability issues



Figure 1: Diagram shows the different teaching methods in anatomy.

DISCUSSION

Human anatomy has always been considered a fundamental basis for raising the building of medical knowledge. However, the way anatomy has been approached over the centuries has evolved, reflecting the changes occurring in medicine and society [8].

In the last quarter of the last century, there was an explosion of knowledge in the biomedical sciences which become broad and diverse. Medical institutions are obliged to choose the most essential of the available knowledge as it is impossible to cover all these knowledge [9].

In this reform different models of curricula are designed including the oldest traditional discipline-based curriculum, organ-based curriculum and problem-based learning curriculum. Some medical schools use two types of combined curricula as organ-based curriculum and problem-based learning [10], [11]. The changes in the curriculum and correspondingly methods of teaching have a negative impact on anatomy teaching with a consequent reduction in the time dedicated to its teaching with fewer lectures compared with the traditional curriculum [12]. Moreover, the curriculum reform introduces new subjects such as healthcare delivery systems and professionalism with consequent decline of time allocated to basic sciences including anatomy [13].

The difficulty in implanting system-based approach for teaching anatomy results from the fact that organization of the different systems not coincide with the regional approach making it problematic to teach the important relations of different organs and systems. For example, dealing with a stab wound in the neck may involve multiple

systems as cardiovascular, nervous or musculoskeletal systems [7]. By its very nature, curricular integration disrupts the topographical relationships of body regions. As concerning this point the authors observed from the actual application of the newly established integrated system-based approach that the skills of broad imagination and recognition of different organs relations specially which are anatomically highly related to each other but system – based are in separate modules as (heart and lungs) and (spleen and stomach). In this concern, it is suggested to add a vertical module (vertical integration) by the end of the basic sciences semesters concerned with applying relations of different anatomical regions with their clinical application and correlation. Moreover, the solid knowledge of anatomy would be delivered using ordinary methods (didactic lecture/dissection) and the recent approaches can be used only as additional tools for rapid memorization [3]. The declined anatomical knowledge among the undergraduates in recent years for any curriculum is attributed to absence of a main program for anatomy, reduced use of dissection as a teaching means. The weakening of anatomical knowledge of today's medical undergraduates might lead to medical mistakes [14]. Ellis was an assessor in second part of the Membership of the Royal College of Surgeon's stated that "I have surprised to find candidates do not know how to locate the ureter, or others that have little idea of surface anatomy to insert a chest drain and some of the candidates in practical surgical anatomy are seeing a real anatomical specimen for the first time" [15]. Learning and acquiring perfect clinical skills and evidence-based

medicine will not happen effectively without a good knowledge of biomedical science which is studied in medical education to under graduates at the primary two-years as movement from a beginner to a medical expert must be built on a solid knowledge in biomedical science. Furthermore, there are several years to master the required clinical skills. Hence a strong curriculum in the basic medical science is a necessity to the development of future generations of physician-scientists [16].

The problem-based learning (PBL) method was designed as an alternative to the traditional teaching and becomes popular in medical education. It is supposed to encourage self-directed learning, gives chance to undergraduates to learn by using thinking rather than memorization of facts and aids them to become life-long learners and promotes their skills of problem solving which is vital for practicing clinician [17]. Many medical schools around the world designed their curricula on PBL method [2]. Furthermore, the students should acquire basic anatomy knowledge firstly before the actual PBL tutorials start as they can use deep and critical thinking talents when they are aware to all the basic facts. Moreover, the anatomy topics that cannot be covered through PBL discussions must be taught through lectures [18]. Graduates of medical programs using PBL have shortages in their basic knowledge, especially in anatomy compared with the other teaching methods. Their knowledge of anatomy is uncertain, deficient and below an acceptable standard required for safe medical practice [19]. Students from PBL wish a more organized educational teaching method to get more knowledge in basic science [20].

Anatomical sciences are better taught either by the traditional method or by the hybrid curriculum involving the traditional and the PBL methods as the two components complement each other. A more structured didactic teaching approach and cadaveric dissection are to be applied in undergraduate medical curriculum to enhance the students to gain anatomical knowledge required for their future practice [21]. This comes in agreement with authors' experience that the most recommended method of undergraduate anatomical sciences teaching is the hybrid/blended method to be able to get the greatest benefit from each teaching method.

Suitable anatomy syllabus is necessary to prepare skilled tomorrow's doctors. The anatomy must be taught by well qualified and experienced anatomy teachers in a proper time [4]. The students have to do effort considerably to memorize anatomical expressions, recognize arrangements and then relate information to clinical training [22]. On this

context many medical schools have preserved a gross anatomy stand-alone course in the old-style design and struggled the integration of anatomy with other basic science disciplines [23]. We don't support this strategy, anatomical science as a basic discipline needs to be integrated with other basic disciplines to give the greatest benefit to the medical students and to avoid repetition of subjects overlapped in other disciplines which is time and effort consuming for both the students and the instructors. The anatomical society (UK) through rigorous analysis of current curricula recommended an anatomy syllabus detailing the knowledge the students should attain prior to graduation to ensure safe and effective internship practice. This syllabus includes anatomical terminology and details of various body regions [24]. In 2007 the University Of Alabama School Of Medicine in United States implied a syllabus for gross anatomy and embryology taught through a combination of didactic talks, team-based learning activities, and cadaveric dissection and radiological anatomy workshops [25]. This method is highly effective and attracting to both the student and facilitator. The use of spiral curriculum is suggested to enhance retention of anatomical knowledge. In this approach the topics are revisited throughout the course, at increasing levels of difficulty to increase the competence level of the students [26]. This also may be with good outcome as it will encourage the students to do their best and be interested and more engaged in the educational process.

As shown in figure [1], current teaching methods of anatomy include traditional lecture, cadaveric dissection, anatomical models, radiological images and Computer assisted learning (CAL), Problem based learning (PBL) [27]. Traditional talks are still the main core of medical education and are the major method of learning, as they permit teaching many subjects in an ordered mode to a large number of students [28]. Students have reported that lectures provide exam guidance and big picture concepts and highlight important ideas [29]. On a cross-sectional, questionnaire-based study found that lectures and laboratory cadaveric dissection are the main preferred methods for learning and teaching anatomy among all the sharing students [30]. The dissection room is the best place for teaching of anatomy [1]. The cadaver is the first patient a medical student encountered and it is the most important tool for teaching gross anatomy by either dissection or prosection. Cadaveric dissection integrates knowledge from didactic lectures with practice, improves practical skills, encourages small group learning, fosters teamwork ability and promotes professionalism and respect for the human body. It helps the medical students

to realize the three-dimensional relations of all organs and structures [31] At this regards, it is believed that cadaveric dissection is highly valuable and presents an unique experience that can't be provided by any other tool although it consumes a long time and may affects students' emotions. The major challenge is the difficulty of its obtaining with lack of well qualified anatomists with the harmful formaldehyde effects which has been documented in many researches.

Moreover, teaching/ learning of practical anatomy with Anatomage; a virtual dissection table, could be included as a teaching tool in medical undergraduate curriculum to facilitate 3D visualization of structures and their relations. It enhances class room experience of learners. The Anatomage table improves understanding of complex anatomical structures, their special relationship and helps training of manual skills and hand-eye coordination. The use of Virtual Dissection technology seems to have a promising role in future educational training [32]

Computer assisted learning (CAL) can't replace the knowledgeable, educational and emotional experience presented to medical students by cadaveric dissection and even prosection[33]. With the advancement of technology, computer-based anatomy programs become available as useful tools in enhancing learning of practical anatomy adopted by many medical institutes and surgical training curricula. The student can revisit and access teaching material when needed. Use of technology in learning promotes more interaction within the classroom [2]. It is observed that CAL play a very important role as an aiding tool that helps all other tools to reach more and more successful points which, by the end, improves the final outcomes of the educational process and can't be neglected nowadays after technology evolution all over the world.

Radiological anatomy teaching is a beneficial method for the students in their future careers and correlates the basic anatomy with the clinical skills. It should become a core component of anatomy curriculum. Radiologists can share in teaching anatomy because of their appropriate clinical experience and anatomical knowledge. Clinicians from other specialties can also contribute to anatomy teaching for by underlining the clinical correlation with anatomy [34].

Enhancement of assessment develops knowledge of students and strengthens the learning of anatomy. The assessment facilitates learning of students. The methods of assessment include different forms such as short or long essay questions, short answer questions, multiple choice questions, extended match questions, the spotter practical examination [35]. Practical assessments

usually include spotter tests that contain a number of wet specimens of dissected cadavers and radiological images. The students are asked to identify the marked structures in the included specimen [24]. Another type the spotter test is to ask the students to identify the marked structure and its function, nerve or blood supply and/or its relations [36].

Oral assessment helps to evaluate attitude and professionalism, practical skills and ability of problem solving [24]. However oral forms of assessment have also been out of control because of examiner bias and reliability issues [37]. It can be used as a part of an objective structured clinical examination (OSCE), which exams the use of anatomical knowledge to patients or as an objective structured practical examination (OSPE) where a number of clinical cases are presented to students along with a problem that requires the use of anatomy [37]. Oral assessments must be restricted to formative assessments only better applied at the small group teaching or practical sessions to promote team work ability among the students as it happens in our medical institute. If it will be used for summative assessment, it is recommended to keep the oral assessment with implementation of firm rules for its application keeping fairness between all students.

CONCLUSIONS

Anatomical science as a basic discipline needs to be integrated with other basic disciplines to give the greatest benefit to the medical students and to avoid repetition of subjects overlapped in other disciplines which is time and effort consuming for both the students and the instructors. It is suggested to add a vertical module (vertical integration) by the end of the basic sciences semesters concerned with applying relations of different anatomical regions with their clinical application and correlation, many teaching varieties can play an important role for better delivery of the knowledge as problem based learning; radiological anatomy and computer assisted learning, which are to be used as accessory tools to enhance retention of knowledge not as sole methods of teaching anatomy. Powerful assessments have to be established to promote anatomical knowledge retention.

RECOMMENDATIONS

We recommend that medical schools considering full integration of gross anatomy and embryology:

- (1) Carefully consider the sequencing of organ system modules.
- (2) Able to do an engagement of the anatomical details in clinical application.
- (3) Provide additional electives (vertical integration) to third- and fourth-year students.
- (4) Integrate radiology with anatomical education.

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