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Best teaching practices in anatomy education: A critical review

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ABSTRACT

In this report we review the range of teaching resources and strategies used in anatomy education with the aim of coming up with suggestions about the best teaching practices in this area. There is much debate about suitable methods of delivering anatomical knowledge. Competent clinicians, particularly surgeons, need a deep understanding of anatomy for safe clinical procedures. However, because students have had very limited exposure to anatomy during clinical training, there is a concern that medical students are ill-prepared in anatomy when entering clerkships and residency programs. Therefore, developing effective modalities for teaching anatomy is essential to safe medical practice. Cadaver-based instruction has survived as the main instructional tool for hundreds of years, however, there are differing views on whether full cadaver dissection is still appropriate for a modern undergraduate training. The limitations on curricular time, trained anatomy faculty and resources for gross anatomy courses in integrated or/and system-based curricula, have led many medical schools to abandon costly and time-consuming dissection-based instruction in favour of alternative methods of instruction including prosection, medical imaging, living anatomy and multimedia resources. To date, no single teaching tool has been found to meet curriculum requirements. The best way to teach modern anatomy is by combining multiple pedagogical resources to complement one another, students appear to learn more effectively when multimodal and system-based approaches are integrated. Our review suggests that certain professions would have more benefit from certain educational methods or strategies than others. Full body dissection would be best reserved for medical students, especially those with surgical career intentions, while teaching based on prosections and plastination is more suitable for dental, pharmacy and allied health science students. There is a need to direct future research towards evaluation of the suitability of the new teaching methodologies in new curricula and student perceptions of integrated and multimodal teaching paradigms, and the ability of these to satisfy learning outcomes.

1. Introduction

Anatomy is considered one of the cornerstones of medical curricula and it is on that clinicians develop their clinical skills. A deep understanding of anatomy is fundamental for safe clinical practice, particularly in the discipline of surgery (Turney, 2007). The teaching of human anatomy, like that of any course, requires constant revision and analysis to determine the teaching tools and approaches that best suit the learning process (Moxham and Plaisant, 2007). In recent times, there has been a reduction in traditional, cadaver-based, anatomy teaching, in some cases driven by a shift towards an integrated and/or system-based curriculum (Drake et al., 2009; Tibrewal, 2006). Religious belief, cost and time factors have also played a role in this reduction. This is supported by reports that the amount of time devoted to anatomy teaching is not adequate (Lockwood and Roberts, 2007; Drake et al., 2009).

There has been a steady increase in medico-legal litigation for surgical malpractice (Goodwin, 2000). In the UK, between 1995 and 2000, there was a 7-fold increase in claims associated with anatomical incompetence submitted to the Medical Defence Union; 32% of these claims against general and vascular surgeons, and many citing "damage to underlying structures" (Ellis, 2002). Cahill and colleagues showed that a significant number out of the 80,000 avoidable deaths per year in the US may be due to anatomical errors as well as doctor incompetence (Cahill et al., 2000). In spite of a report that less than one-third of new residents in surgery have adequate anatomical knowledge (Cottam, 1999), numerous medical schools continue to reduce the teaching time devoted for teaching anatomy and the knowledge of anatomy amongst undergraduate

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and graduate (medical and dental) students is in decline (Smith and Mathias, 2011; Moxham and Plaisant, 2007).

Many previous publications have examined anatomy curricula, may be more than any other aspect of the medical curricula *e.g.* pharmacology, biology, biochemistry or physiology (Pabst, 2009). Brenner et al. describe six categories of teaching tools: (i) dissection by students, (ii) inspection of prosected specimens, (iii) didactic teaching, (iv) use of models, (v) computer-based learning (CBL) and (vi) teaching of living and radiological anatomy (Brenner et al., 2003). In light of the changes in anatomy curriculum, several studies have explored anatomists' and students' attitudes towards different teaching modalities (Kerby et al., 2011; Azer and Eizenberg, 2007; Patel and Moxham, 2006). We critically review the literature for evidence relating to the current status of anatomical education from the perspectives of anatomists, clinicians, and students, with the aim of coming up with recommendations for best teaching practice in anatomy education.

2. Discussion

2.1. Cadaver dissection

Dissection has been the primary anatomy teaching method for over 400 years (Azer and Eizenberg, 2007). Learning using dissection of human cadavers has advantages that are not easy to quantify such as; enhancing active and deep learning, preparing students for clinical practice, preparing students for encounters with death, practice of manual skills and for understanding the relationship between patients' symptoms and pathology (Azer and Eizenberg, 2007; Fruhstorfer et al., 2011). It also contributes to the development of medical professionalism, including teamwork competency, stress coping strategies and empathy (Bockers et al., 2010). Unlike plastination, dissections using cadavers provide a feeling of surprise at the identification of anatomical variations (Korf et al., 2008), show more variations and finer details, and preserve texture to a level close to those of living body which allow students to feel as if they are in the operating theatre (Mcbride and Drake, 2015). There is no doubt that cadaver dissection plays an integral role in the process of producing future doctors (Netterstrom and Kayser, 2008). Therefore, some believe that dissection courses are still indispensable for learners to achieve anatomical knowledge (Korf et al., 2008).

Many anatomists still favour the use of dissection over other teaching tools. Patel and Moxham (2006) found that majority of the anatomists interviewed (69%) selected dissection, followed by prosections as the most appropriate teaching method. Kerby et al. (2011) concluded that dissection courses were viewed by both anatomists and students as most "fit for purpose" in meeting learning outcomes, but no single teaching tool met all aspects of the curriculum. (Davis et al., 2014) explored anatomists' and medical students' perceptions towards anatomy teaching resources, both anatomists and students strongly favoured using cadaver dissection in anatomy teaching. Similarly, medical students at the Ulm University Faculty of Medicine highly rated using cadaver dissection as a teaching tool (Bockers et al., 2010).

On the other hand, there has been a debate about whether full cadaver dissection is still suitable for modern undergraduate education (Korf et al., 2008). Using cadavers for dissection has been considered costly, time-consuming and outdated (Aziz et al., 2002). Dissection courses are no longer used as the principle method of teaching in a significant number of UK, US, and Australian medical schools (Drake et al., 2009; Sugand et al., 2010; Craig et al., 2010). Full body dissection has been replaced with prosection-based courses in combination with other modalities to teach anatomy (Fruhstorfer et al., 2011; Rizzolo and Stewart, 2006; Sugand et al., 2010). De-emphasizing dissection courses in anatomy curricula has been driven by the move from a regional-based to system-based approach, reduction of time allocated for dissection in already crowded curricula and high costs associated with maintaining mortuary and dissection labs, health concerns related to the exposure to formalin fumes, and ethical and medico-legal issues surrounding their continued use (McLachlan, 2004; McMenamin et al., 2014; Sugand et al., 2010). Only a small number of medical students may need dissection, those that will become surgeons upon graduation (Leung et al., 2006).

2.2. Prosections

A prosection is an already dissected, sometimes plastinated specimen. Cadaver prosections were an essential part of teaching anatomy in the Middle Ages and early Renaissance (Enke, 2005). With a contraction of the time devoted to gross anatomy in an integrated curriculum and decreasing numbers of donated bodies, many programs have moved from full body dissection to prosections; this reduces the number of contact hours while allowing learners the exposure to structures that they might otherwise spend hours trying to find (Dinsmore et al., 1999). Because some structures like the heart and large vessels are located deep in the thorax and abdomen, dissecting such structures region by region or layer by layer is impossible. Therefore, dissection does not fit appropriately into a system-based approach, here anatomy is better taught using prosections rather than the regional approach of dissection (Leung et al., 2006). Within Australian and New Zealand medical schools, despite the availability of cadavers due to an increasing number of donated bodies, no anatomy program is wholly dissection-based (Craig et al., 2010). A recent survey of Australian and New Zealand medical schools, showed that 19 Australian and New Zealand medical schools use a systemic, integrated, case-based learning curriculum for which prosection was the method most consistently used for teaching gross anatomy (Craig et al., 2010).

Prosections offer a number of advantages; prosection-based courses are flexible, contextual and time-efficient as structures and their relations are easily observed, and fewer cadavers are needed as more than one student cohort can use the prosections (Nnodim, 1990; Dinsmore et al., 1999; Pather, 2015). Medical students learning from prosected materials may be able to identify or view more anatomical variations in several specimens, than students who dissect cadavers (Topp, 2004). Despite these advantages, preparation of prosected specimens is time-consuming and requires ample skilled personnel to create multiple prosections of each body region. A previous report showed no significant differences in outcomes between students learning anatomy from dissection and those learning it from examining prosected cadavers (Yeager, 1996). Recent studies show that students favour learning from prosections over dissection (Nnodim, 1990; Dinsmore et al., 1999). Some anatomists believe that prosection can replace full body dissection in teaching gross anatomy (Mclachlan and Regan De Bere, 2004).

2.3. Plastination

Plastination can be considered simply a specialized way of preserving prosections but it does have some limitations such as shrinkage, loss of texture, natural tissue colour and fine details. In addition, there are health and safety concerns associated with the large amounts of flammable chemicals used in preparation of plastinated specimens. Plastination was first developed by Gunther von Hagens at the Anatomical Institute of Heidelberg University in 1977 and, since its development, plastination has become one of the best techniques for the preservation of the human body (Von

Hagens et al., 1987). Many anatomists favour plastinated specimens over simply formalin fixed material, because they are odourless, allow convenient storage, and ease of handling (Latorre et al., 2007; Jones and Whitaker, 2009; Fruhstorfer et al., 2011). Plastination is considered relatively cost-effective due to the "semi-permanence" of the plastinated specimens – prosections only have to be made once every ten years or so instead of every few years; storage costs are lower as refrigeration and fume extraction are not required (Latorre et al., 2007); and plastination can be carried out using low cost equipment which is readily available in most Anatomy departments (O'sullivan and Mitchell, 1995). Previous studies showed that plastinated specimens were deemed useful by students and accommodated student needs at various levels (Latorre et al., 2007; Fruhstorfer et al., 2011). Even though plastination has numerous advantages, plastination shows the most common variations, in time, plastinated sections lose their novel character and eventually students master the exposed variations by heart (Korf et al., 2008).

2.4. Computer based learning (CBL)

With recent advances in technology, reductions in teaching time, increasing class size and increasing costs of cadaver-based instruction, CBL resources are increasingly used in anatomy curricula to foster student learning (Tam et al., 2010; Azer and Eizenberg, 2007). Its use augments anatomy teaching, enhances independent learning, problem solving, and provides flexibility (Trelease, 2002). Although, there is no clear proof that CBL alone is better approach than traditional teaching methods (Mcnulty et al., 2004; Khot et al., 2013), evidence shows that learning anatomy using CBL can enhance learning by supplementing rather than replacing the traditional teaching methods (Tam et al., 2010; Durosaro et al., 2008). Students still prefer traditional methods such as dissection, prosection, lectures and textbooks over CBL resources (Azer and Eizenberg, 2007; Kerby et al., 2011; Davis et al., 2014). Similarly many anatomists believe that cadaver-based instruction is still a prerequisite for optimal training even with the use of CBL resources (Aziz et al., 2002; Tam et al., 2010).

Most CBL resources have focused on the development of 3D representations of anatomical structures and there has been research into its use in medical education (Drake et al., 2009; Tam et al., 2010). Virtual reality (VR) allows students to visualize, dissect and to interact with simulated objects in artificial 3D space (Trelease, 2002). The usefulness and cost-effectiveness of VR programs have been well acknowledged in anatomy teaching, students' attitudes have also been positive towards the use of virtual anatomy (McNulty et al., 2009; Rizzolo and Stewart, 2006). Over the last few decades, large-scale anatomical data sets have been developed that are being used all over the world as a resource for human anatomy applications such as the Visible Human Project and the Chinese Visible Human dataset (Spitzer and Whitlock, 1998; Zhang et al., 2004). Recently, Anatomage tables have been used in health sciences at Curtin University to replace human cadavers (Fyfe et al., 2013). The Anatomage table is a virtual 3D dissection platform, with a multi-touch screen that provides a life-size "iPad-like" experience that uses digital images in an interactive way to explore the anatomy of the whole body (Fyfe et al., 2013). The BioDigital Human and Zygote Body are examples of 3D visualization, interactive web-based programs that use WebGL technology, based on the Open Graphics Library for Embedded Systems 2.0, which provides a programmatic interface for 3D graphics (Kelc, 2012; Qualter et al., 2011). The 3D visualization technology allows students to explore a whole human body, toggling various systems and explaining clinical topics. Second Life is another example of VR, developed by Linden Lab in 2003. It introduces a unique extension to online learning, as students are not only able to explore the content but also allow interactions between users as they view the same content in the same virtual room (Richardson et al., 2011).

Oculus rift and similar 3D visualization "goggles" have tremendous implications for medical training and instruction purposes. The user wears the Oculus Rift "head mounted display" and holds hand controllers which allow him/her to create a tour or virtually fly through the human body. Oculus rift also enables students to learn using their motor skills and hand movement in a virtual environment where they are required to perform a mixed set of simple and complex tasks (Mathur, 2015). Augmented reality (AR) is another emerging tool, the novel aspect of AR is to combine the view of the real environment with additional virtual content (Kamphuis et al., 2014). AR differs from virtual reality in that it integrates computer-generated objects into the real world to enhance the user's perception of reality (Hugues et al., 2011). AR "provides a window through which the physical world can be seen and for the virtual components to become visible in this window, as an augmentation to reality" (Kamphuis et al., 2014). It has uses in anatomy education in that as it can create an illusion allowing display of anatomical structures on the user's body, it could also be useful to visualize more complex anatomy (Thomas et al., 2010). Haptic (touch) technology is another virtual simulation technology that has been increasingly used in human and veterinary clinical training and is particularly useful for simulating examinations that rely on the sense of touch (Kinnison et al., 2009). Haptic adds both tactile and force feedback to VR and provides a life-like feel of internal anatomy (Kinnison et al., 2009).

3D printing or rapid prototyping is a rapidly expanding technology with great promise for teaching anatomy; surgical planning; creating implantable prosthetics; and biological tissue engineering (Gibson et al., 2010). The principle of this technology is to use 3D computer-aided design (CAD) for the reconstruction of 3D physical models through a process of adding layer upon layer of materials (Gibson et al., 2010). With additive fabrication, the machine reads in data from a CAD drawing and lays down successive layers of liquid, powder, or the sheet material, and in this way builds up the model from a series of cross sections (Gibson et al., 2010). This technology is able to produce highly accurate models, at a low cost and in less time, useful for anatomy education purposes to enhance visuospatial and 3D understanding of structures and relationships (McMenamin et al., 2014). Recently, a group at the Monash University led by Professor Paul McMenamin put together laser hand-held scanners, MRI imaging and CT scans to create a 3D Printed Anatomy Series. The kit contains no human tissue, yet it provides all the major parts of the body required to teach anatomy of the limbs, chest, abdomen, head and neck. A recent pilot study done by McMenamin and colleagues suggest that this innovation offers certain benefits to anatomy learning and supports their use and ongoing evaluation as supplements to cadaver-based instruction (Lim et al., 2015).

Supporters for the use of cadavers argue that only dissection can provide tactile manipulation of tissue, 3D interaction and engagement of multiple senses, VR tools do not offer these advantages. Use of cadavers is also thought to enhance understanding and retention of spatial information and relationships (Rizzolo and Stewart, 2006; Dehoff et al., 2011). In addition, the software's navigation and the plentiful options of the VR programs may hinder student cognitive function and, as a result, impair student learning. Although AR and 3D printing can offer visual and tactile representations of anatomy, they cannot reproduce all of the sensations that cadaveric dissection can. Opponents of cadaveric dissection, argue that CBL and VR resources present significant advantages over the reality of a cadaver as they provide the opportunity to learn gross anatomy without requiring storage, ventilation infrastructure or embalming. VR provides students more autonomy in choosing different views and angles, offers portability, longevity, standardization, and

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diversity that is not possible with a cadaver (Spitzer and Whitlock, 1998).

2.5. Medical imaging

The use of medical imaging in anatomy education provides *in vivo* visualization of anatomical structure and physiology as well as insight into pathological processes (Gunderman and Wilson, 2005). With the advent of computed tomography (CT), magnetic resonance imaging (MRI) and ultrasound, it has become possible to display highly detailed images of internal anatomy in two-dimensions and 3D reconstructions (Gunderman and Wilson, 2005). As a result of the explosion in information technology, medical schools have been required to integrate imaging techniques into their medical curricula (Gregory et al., 2009). Integration of medical images into anatomy curricula offers students the ability to apply basic anatomical knowledge to the interpretation of two-dimensional sectional CT and MRI scans and to correlate clinical relevance with anatomical knowledge (Lufler et al., 2010; Miles, 2005). Medical imaging is considered a valuable addition to dissection-based instruction as it can promote better understanding of anatomical spatial relationships, enhance the efficiency of students' dissection time and increas their interest in gross anatomy (Pabst et al., 2005; Reeves et al., 2004).

Medical imaging cannot substitute for the benefits of conventional dissection (Gunderman and Wilson, 2005; Howe et al., 2004; Aziz et al., 2002), it has important limitations as a stand-alone approach (Howe et al., 2004; Aziz et al., 2002). Numerous anatomical structures with complex courses are difficult to view adequately with current imaging modalities; dissection also provides an appreciation of the "feel" of tissues which cannot be achieved by medical imaging (Miles, 2005). Inspecting medical images also introduces a level of abstraction compared to the face-to-face experience with the human cadaver (Gunderman and Wilson, 2005). By denying students the opportunity to dissect, "the immediacy of the mortality of cadavers and patients is likely to be dissolved" (Gunderman and Wilson, 2005).

2.6. Living anatomy

Artists and art historians have always shown a great interest in the living body (Griksaitis et al., 2011). Living anatomy has advantages over cadavers in that cadavers' colour, texture, and smell are not like real life, and they cannot be palpated, auscultated, or usefully asked to change position (McLachlan, 2004). Living anatomy can be taught to the students using peer physical examination (PPE), ultrasound and body painting. PPE involves students physically examining each other (Rees et al., 2004). Students are willing to participate in PPE, although there is discomfort or opposition to examining sensitive areas of the body (Rees et al., 2005). Nevertheless, PPE has been found to be more beneficial than the use of life models (Metcalf et al., 1982). PPE provides students an opportunity to safely practice and master clinical skills prior to the patient encounter as well as development of empathy and improving communication skills (Patten, 2007; Wearn and Bhoopatkar, 2006). It is also considered cost-effective as there are no additional cost requirements for transportation of patients or fees for standard model patients (Wearn and Bhoopatkar, 2006). Alternatively, the use of professionals or simulated patients (SP) for teaching physical examination skills has been widely used in medical education (Wanggren et al., 2005). The use of SP for teaching examinations of certain parts of body such as the pelvic region and breast has the potential to address ethical concerns, reduce anxiety, avoid embarrassment, improve student performance and provide valuable feedback to the student (Wanggren et al., 2005).

Ultrasound is used more often in modern anatomical education, it can act as an useful adjunct when added to the traditional methods used teach gross anatomy (Brown et al., 2012). Ultrasound permits *in vivo* visualization of body structures in two-dimensions and enables learners to gain anatomical knowledge in a clinically relevant context (Ivanusic et al., 2010). However, there is lack of working knowledge of ultrasound amongst medical students and new doctors due to a lack of formal teaching in ultrasound use (Brown et al., 2012). Therefore, there has been a call from clinical tutors for integrating ultrasound into anatomy curricula (Bahner et al., 2012). Body painting in anatomy education refers to painting internal structures on the surface of the body using marker pens or wax crayons (McMenamin, 2008).

It has been described as an active and tactile learning modality facilitating learning surface anatomy and underlying anatomy in large class settings (Op Den Akker et al., 2002). Besides being enjoyable and interactive, body painting enhances retention and recall of anatomical knowledge (Finn and McLachlan, 2009). McMenamin highly recommended the use of body painting as an adjunct resource to teach surface anatomy and clinical skills (McMenamin, 2008). Body painting is considered relatively cost-effective as painting materials are readily available at relatively low cost, and large numbers of students can be simultaneously engaged in painting while requiring less staff time and physical resources (Finn, 2015).

Despite the apparent benefits of body painting and PPE in anatomy education, several studies have identified that more sensitive issues such as gender, religious beliefs and location of body region to be examined, may influence students' willingness to examine their peers and be examined (Reid et al., 2012; Rees et al., 2009). In Islamic states, cultural sensitivities and religious issues may constrain doing PPE and body painting even between the same genders. A survey conducted by O'Neill and colleagues among medical students from multi-ethnic groups in Manchester University showed that their religion was given as a reason against performing PPE particularly among Muslim female students (O'Neill et al., 1998). Another survey done at the Faculty of Health Sciences in United Arab Emirates University regarding the attitudes of interns and senior medical students towards clinical skills labs concluded that the majority of female students were not comfortable with PPE (Das et al., 1998).

2.7. Lecture-based teaching

Since the sixteenth century, formal lectures and dissection have remained a key part of any anatomy course along with cadaver dissection (Vázquez et al., 2007), however this approach has been criticized by many as an ineffective, outdated and passive form of learning (Nandi et al., 2000; Pawlina and Lachman, 2004). Transformation of all aspects of the medical curriculum, including classroom instruction has been driven by pedagogy (the move to a system-based and vertically approach integrated) and resources (large classes, less teaching staff, limited funding and a crowded curriculum). One promising alternative teaching strategy is blended learning. Blended learning is the integration of traditional face-to-face and online instructional methods (Graham, 2006). The flipped or inverted classroom is a blended learning model, an educational approach that reverses the traditional lecture and homework elements of a course (Lage et al., 2000). This model of teaching has become particularly attractive because of the availability of internet resources including audio and video on any subject. It can make use of social media (YouTube, blogs, wikis, iTunes U or podcasts) and other Web 2.0 tools, to connect tutors to the students. The blended learning model has the potential to facilitate active learning and improve academic performance while avoiding issues that are associated with non-attendance-based teaching (Pereira et al., 2007). However, this learning model is heavily dependent on students preparing outside of class, therefore there is a concern that students may fail to engage with the assigned pre-class or in-class activities. There is also an increased workload involved in preparing the course materials.

2.8. Integrated curricula

Within traditional undergraduate medical curricula, the preclinical/first years usually concentrate on basic science and subsequent years on clinical sciences and clinical training, therefore, students had very limited exposure to anatomy during clinical training. This mode of teaching has led to a frequent criticism by clinical tutors due to a lack of relevant anatomical knowledge among the new medical graduates (Evans and Watt, 2005). This led to concerns that anatomical knowledge amongst newly qualified doctors may be at a level where patient safety could be compromised. Reforms within medical education have led to efforts to develop vertically integrated curricula (Lie, 1995). With this, clinical sciences are introduced in the early years while continued attention is paid to anatomy and other basic sciences in the later years of the curriculum (Bergman et al., 2011). In this process, specific areas of anatomical knowledge can be prioritized such that only anatomy relevant to the general practitioner will be taught to all students in the preclinical years, and trainees with surgical or other specialized interests who need advanced knowledge of anatomy will receive it later in the clinical years and residency programs (Brooks et al., 2015).

Evans and Watt (2005) described how students at the Brighton and Sussex Medical School in the UK return to the dissection room during specialist rotations to study the anatomy relevant to their discipline. This can ensure that core anatomical knowledge is gained at the most appropriate level relative to a student's clinical experience (Evans and Watt, 2005). The vertical integration throughout the entire curriculum helps graduates to put together the learned facts so as to get the whole picture and adopt a holistic approach while treating a patient or planning a health care strategy (Malik and Malik, 2011). This will make the importance and relevance of basic science knowledge more evident and will motivate the students to achieve deeper learning and understanding of both basic science knowledge and clinical medicine (Dahle et al., 2002). Early patient contact from the first year helps students to develop communication skills, to realize the importance of doctor-patient interaction and the effect of illness on the individual person (Dahle et al., 2002).

Despite calls for teaching anatomy throughout the entire curriculum, vertical integration within curricula is often unidirectional. Clinical sciences are easily integrated in the preclinical years, however, it is far less common for basic sciences to be taught in the later years of the curriculum (Bergman et al., 2011). In addition, vertical integration of anatomy across clinical and preclinical years needs a lot of time and work in planning, organization and execution. The faculty members and administrators have to be actively involved and enthusiastic and have to cooperate beyond departmental borders (Dahle et al., 2002). The reduction in the number of contact hours allocated to gross anatomy in integrated curricula are thought to have led to insufficient anatomical knowledge amongst students and junior doctors (Fraher and Evans, 2009). There is also a considerable concern that students will concentrate on clinical aspects and abandon the basic sciences in an integrated curriculum, therefore, it is claimed that students no longer gain a coherent and overall picture of the anatomy of the whole body (Bergman et al., 2011).

2.9. System-based curricula

Since the early 20th century, gross anatomy has been taught as a stand-alone course during the first preclinical year along with other courses such as histology, physiology and biochemistry (Drake et al., 2009). A single anatomical region contains structures with varied characteristics, functions and relationships that belong to different systems, and are taught in different courses (Arslan, 2014). This proved to be problematic as students had difficulty mastering large amounts of disjointed information taught in within a region-based curriculum (Brooks et al., 2015). The curricular paradigm in preclinical medical education has seen a region-based, discipline-based curricula transformed to system-based, interdisciplinary curricula which integrates normal structure, normal function and pathophysiology of disease (Muller et al., 2008). Within a system-based curriculum, learners can master materials with one system as a foundation to the subsequent systems much easier than if they pursued a region-based approach. As the learner moves further forward, the relationships, functional significance and clinical correlations of structures that belong to different systems are discussed and consecutively revisited several times (Arslan, 2014). A system-based approach enhances long-term retention of acquired knowledge and thus reduces the need for massed and crammed repetition (Arslan, 2014). With this, learners can retain factual information more easily and relate anatomical knowledge to their medical practice.

3. Conclusion

The debate continues on how to teach anatomy in the most effective way. Although dissection of cadavers has remained the gold standard for learning anatomical knowledge for hundreds of years, it is considered outdated, costly, time-consuming and a potentially hazardous approach. The transition from standalone anatomy courses into integrated and system-based curricula, and the reduction of teaching staff, resources and contact teaching hours have led many Western institutions to adopt cost effective, less time consuming and up-to-date teaching alternatives such as plastination, CBL, medical imaging and blended learning. To optimize efficient learner time management and maximize future surgical competencies, retention of anatomical knowledge and enhance academic success, we think that the following teaching practices should be incorporated into the educational paradigm:

- Certain educational methods fit certain professions better than others, Because acquiring anatomical skills is essential to perform safe surgical procedures, full body dissection best fits medical trainees (particularly those with surgical career intentions) during specialist rotations and residency programs (Evans and Watt, 2005; Leung et al., 2006).
- Allied health schools (and some medical schools) have neither the money nor time in the curriculum to do dissection or support full dissection labs with a mortuary. Such students also do not need advanced knowledge of anatomy to achieve the required learning outcomes (Mclachlan and Regan De Bere, 2004). Therefore, plastination seems the best fit for dental, nurse and allied health science students as the principle teaching method to substitute for dissection.
- Decrease reliance upon the regional approach of dissection-based instruction in favour of prosections whenever possible. Adoption of more prosections or plastination would help the transition to system-based anatomy curricula (Leung et al., 2006).
- Vertical integration of anatomy throughout medical curricula at appropriate stages in the clinical training and residency program

particularly for those who need it most such as trainees with surgical career intentions (Evans and Watt, 2005).

- To date, no single teaching tool has been found to achieve all curriculum requirements (Kerby et al., 2011). The best way to teach modern anatomy is by combining multiple pedagogical resources (plastination, CBL, living anatomy, medical imaging) to complement one another, students appear to profit most when diverse and system- based modalities are integrated. The use of a multimodal paradigm in teaching anatomy has received support from other anatomists (Biasutto et al., 2006; Rizzolo et al., 2010).

The impact of new curricular reforms on the retention of anatomical knowledge and future surgical competencies is still unclear. A shift away from the traditional regional approach towards integrated, system-based and multimodal teaching paradigms requires further research to evaluate the suitability and student perceptions of, different teaching modalities, and the ability of these to meet learning outcomes.

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