Review

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Cadaver Dissection Is Obsolete in Medical Training! A Misinterpreted Notion

Ismail Memon

Basic Sciences Department, College of Science and Health Professions, King Saud bin Abdulaziz University for Health Sciences, Riyadh, Kingdom of Saudi Arabia

Significance of the Study

- Since the inception of the modern medical curriculum, anatomy teaching and cadaver dissection (CD) have been diluted or reallocated in medical training. Anatomists, surgeons, and medical educationists have published different opinions on the status of CD. This review presents the status of CD in traditional and modern curricula, undergraduate and postgraduate medical education, surgical training, and elective courses. It also provides information on the relevance of CD to medical training. This can help stakeholders to include anatomy and CD in a justified manner in medical training.

Keywords
Anatomy teaching · Medical curriculum · Cadaver dissection · Surgery training

Abstract
Cadaver dissection (CD) is considered a tool for studying the structural details of the human body. Lately, conflicting opinions regarding the utility of this modality in medical training have been published in medical literature. This review of the literature examines the status of anatomy teaching with CD in traditional, modern, and postgraduate medical training across the world. Literature published in the English language on topics related to CD in the past 3 decades was scrutinized using different search engines. About 200 full texts were reviewed. We describe how medical schools have continued to include CD in anatomy teaching in the traditional or modified form. Medical schools that stopped or decreased CD have learnt from their experiences, and have restarted it in modified forms by integrating it vertically with medical training. In addition, CD activities have increased in postgraduate anatomy courses, surgery training, and voluntary/optional CD programs. CD, when integrated vertically, still has a part to play in medical training in modified ways. This overview may help curriculum designers to place CD in medical curricula and training programs in a justified manner.

Introduction

Cadaver dissection (CD) started in 300 BC [1] and by the 15th century, it was considered a tool for studying the structural details of the human body. The first documented CD by a medical student was performed in the 16th

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E-Mail karger@karger.com
www.karger.com/mpp

Ismail Memon
Basic Sciences Department, College of Science and Health Professions
King Saud bin Abdulaziz University for Health Sciences
Mail Code 3124, PO Box 3660, Riyadh 1148 (Kingdom of Saudi Arabia)
E-Mail ismail.memon@gmail.com

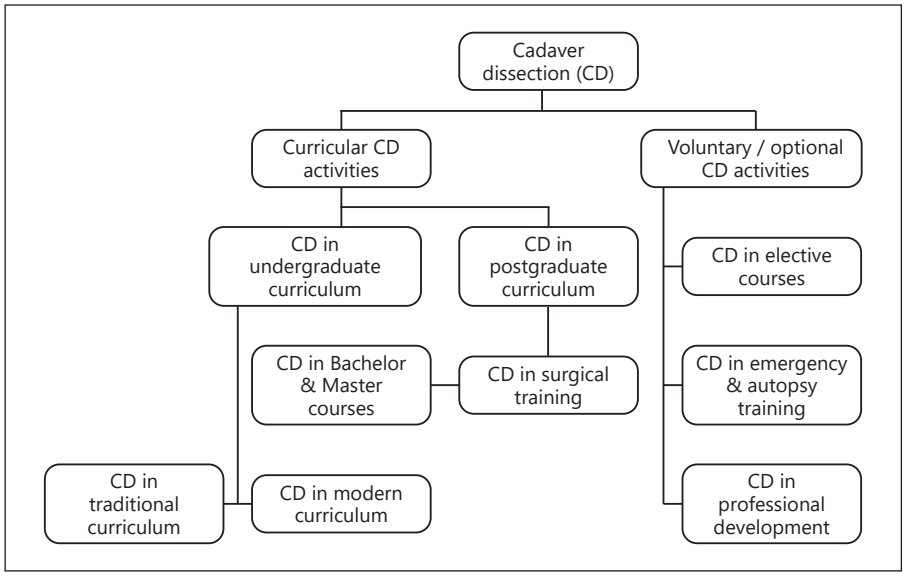

Fig. 1. Organogram illustrating the status of cadaver dissection in the curriculum and as voluntary/optional activities.

century and by the 18th century, it had become an essential component of medical education [2]. CD remained an integral part of the undergraduate medical curriculum until 2–3 decades ago and was mostly carried out in the initial years of medical training [2]. A revolution then started in the medical curriculum, aimed at decreasing expenses, removing redundancies, and making it more clinical [3]. In modernized versions of the curriculum, anatomy became the most compromised of the basic medical science subjects. This was particularly true for CD, which was reduced substantially, limited to prosections, or removed completely [4]. Conflicting opinions in favor of/against CD have been reported in the literature [5, 6]. The aim of this review is to determine the status of CD at different stages of medical training from the undergraduate to the postgraduate level. Placement, reallocation, and the importance of CD at curricular and voluntary/optional levels are also discussed. Briefly, in current medical curricula, traditional CD has been reduced but is still practiced in modified forms which we explain in this article.

Literature Search

This is a narrative overview. Published literature in English on relevant topics was searched on PubMed, Google Scholar, Ancestry, Ingentaconnect, ResearchGate, and FreeFullPDF. The following key words, either individually or in combination, were used for the search: "human cadaver dissection," "traditional and modern anatomy curriculum," "anatomy teaching," "anatomy practical lab," "cadaver dissection in surgery training and post-graduation courses," "elective and special courses of cadaver dissection," and "training workshops on cadaver dissection." Studies concerning anatomy teaching with CD in the medical curriculum and as a voluntary/optional activity, published in 1990–2017, were included. After screening the abstracts, about 200 articles were found to be relevant to our review and their full texts were read. Studies on the same topics published in other languages were excluded. The main ideas from the selected papers were extracted and are discussed here. I also share my personal and anecdotal experiences from colleagues. The status of CD in the medical curriculum and as voluntary/optional (VOCD) activities is illustrated as an organogram in Figure 1.

Current State of CD in Medical Training

CD in the Traditional Undergraduate Curriculum

In the traditional undergraduate medical curriculum, teaching anatomy with CD remains important to many students [7], and so CD has therefore continued as a significant part of anatomy teaching over the last 4 centuries. Recently, in the past 2–3 decades, several medical schools have reduced or stopped dissection in undergraduate teaching [8]. Despite this, published literature from different continents has shown that CD is still practiced in

Table 1. Examples of institutions that include cadaver dissection in the traditional undergraduate medical curriculum

Institution	Country	Reference
University of Nairobi	Kenya	[12]
Methodist University	Kenya	[12]
Ambrose Alli University	Nigeria	[10]
University of Gondar	Ethiopia	[11, 14]
Mount Sinai School of Medicine	USA	[13]
St. George's Medical School	Grenada	[14]
National University of Cordoba	Argentina	[5]
University of Toronto	Canada	[18]
McGill University	Canada	[18]
University of British Columbia	Canada	[18]
University of Saskatchewan[1]	Canada	[18]
Santosh Medical College	India	[19, 20]
University of Sri Jayewardenepura	Sri Lanka	[21]
Dhaka Medical College (and others)	Bangladesh	[22]
Nanjing Medical University	China	[23]
Seoul National University College of Medicine	Korea	[24]
Naresuan University	Thailand	[25]
Islamabad Medical and Dental College, Abbottabad Northern Institute of Medical Sciences, and others	Pakistan	[26, 27]
Jundi Shapour University of Medical Sciences	Iran	[31, 32]
College of Medicine, King Saud University, Riyadh	Saudi Arabia	[29]
Fukushima Medical University	Japan	[32]
Guy's, King's, and St. Thomas' School of Biomedical Science	UK	[33]
University of Leicester[1]	UK	[15]
University of East Anglia[1]	UK	[3]
Brighton and Sussex Medical School	UK	[15]
School of Medicine and Medical Science[1]	Ireland	[35]
Otto von Guericke University Magdeburg	Germany	[36]
Graz Medical School	Austria	[38]
University of the Witwatersrand, Johannesburg	South Africa	[38]

[1] Optional cadaver dissection.

the undergraduate curriculum, albeit in modified and integrated forms.

Today, Africa and the USA are the leading geographic areas in which medical schools offer CD. In Africa, 90% of medical schools [9–12], and also in North and South America, a large majority [5, 13–15] offer CD in their undergraduate curricula. A survey involving 65 medical schools in the USA indicated the inclusion of dissection in most anatomy teaching programs [16, 17]. In Canada, several medical schools have retained mandatory dissection in their undergraduate medical curriculum; the University of Saskatchewan offers optional dissection to interested students [18].

In Asia, data regarding CD are not available from most of the medical schools. However, the literature shows that, in India [19, 20], Sri Lanka [21], Bangladesh [22], China [23], Korea [24], and Thailand [25], many medical schools continue teaching anatomy assisted by CD. I have worked at an Anatomy Faculty in Pakistan for >15 years in the public and private sectors. Anecdotal evidence suggests that the majority of medical schools, particularly in the public sector, have continued with the traditional curriculum and use prosections and plastic models in anatomy laboratory teaching, but that only some of them offer CD [26, 27]. Some medical schools in Saudi Arabia [28, 29], Iran [30, 31], and Japan [32] also use CD in anatomy teaching.

In European countries, traditional CD is not overwhelmingly used. Nonetheless, well-known medical schools in the UK [14, 33], Ireland [34], France [35], and

Table 2. Examples of institutions that include cadaver dissection (CD) in the modern undergraduate medical curriculum, in bachelors, diploma, masters courses, and in surgical training programs

CD activity	Institution	Country	Reference
Modern undergraduate curriculum	University of Melbourne	Australia	[7]
	Universities of Otago and Auckland	New Zeeland	[38]
	Alfaisal University	Saudi Arabia	[28]
	New York University	USA	[41]
	University of California (San Francisco and Davis)[1]	USA	[41]
	University of Hawaii[1]	USA	[42]
	University of Washington[1]	USA	[42]
Bachelors, diploma, and masters	Cardiff University (BSc)	UK	[50]
	University of Dundee	UK	[48]
	University of Otago	New Zealand	[47]
	The Wayne State University USA (MSc)	USA	[49]
	University of Nairobi	Kenya	[49]
Surgical training	Wolfson Surgical Skills Centre	UK	[73]
	The Royal College of Surgeons	UK	[56]
	The Newcastle-upon-Tyne Hospitals	UK	[55]
	Otago School of Medical Sciences	New Zealand	[66]
	Universities of Sydney and Melbourne	Australia	[58]
	Clinical Training and Evaluation Centre	Australia	[59]
	The University of Western Australia	Australia	[59]

[1] Restarted dissection.

Germany [36] offer CD in anatomy teaching. The University of East Anglia, UK [3], and many medical schools in Australia offer optional dissection [37]. The details of some of the institutions continuing with CD in their traditional curriculum are given in Table 1.

A recent report by subject experts from Austria, Brazil, Colombia, India, New Zealand, Nigeria, Spain, South Africa, the USA, and Uruguay, confirms the presence of CD in different forms and formats in undergraduate curricula in their institutions [38]. Thus, collective data indicate that CD in the undergraduate curriculum has continued in many institutions across the world.

CD in the Modern Undergraduate Curriculum

Several institutions around the world have introduced modern integrated curricula by introducing problem-based learning (PBL), case-based learning (CBL), team-based learning (TBL), and other computer-assisted teaching methods along with CD in undergraduate anatomy teaching [6, 28, 39, 40]. The medical curriculum is not static. It takes many years for changes to be incorporated into the curriculum, and even more to decide if their outcomes are beneficial. For instance, some medical schools either reduced or abolished CD, but feedback from faculty and students, and concerns raised by surgeons, resulted in its reintegration into the clinical context and modern teaching methods [40–42]. Recent studies also recommend integrating CD into the modern curriculum [43], but some medical schools offer CD to students only when they are in their clinical rotation/internship [44]. In addition, CD is found to be beneficial in integrated teaching approaches for histopathology training [45]. Details of institutions conducting anatomy teaching with CD in the modern curriculum are given in Table 2.

CD in Diploma and Masters Programs

Medical graduates can further continue their careers on either a teaching or a clinical track. In teaching careers, graduates can pursue diploma, masters, MPhil, or PhD programs, while on the clinical side, they can pursue residency training in surgery or medicine. It is noteworthy that where there has been a lack of CD in undergraduate medical education, it has been compensated for in postgraduate training. Such training methods are practiced in Europe, Australia, New Zealand, the USA, and Africa, where medical schools strengthen the anatomical skills of their students in postgraduate programs using CD [46–50]. Anecdotally, in Pakistan, CD is offered in programs

such as MPhil in Anatomy. Details of the above are presented in Table 2.

CD in Surgical Training

Highlighting the need for CD, Oliver Beahrs, a surgeon of international repute and the first President of the American Association of Clinical Anatomists, asserted: "... today's residents in surgery are learning their anatomy on sick patients for the first time in the middle of the night: operating without a firm knowledge of anatomy leads to increased mortality and morbidity" [51]. During the succeeding years, Ellis [52], Pawlina and Lachman [53], Regenbogen et al. [54], Holland et al. [55], and many other surgeons, anatomists, and medical educationalists also raised this issue and emphasized the significance of CD in medical and surgical training. In order to overcome these deficiencies, many institutions in the UK [55, 56], New Zealand [57], Australia [58, 59], and the USA [60, 61] have recommended and/or included additional dissection programs of specific body parts in their surgical residency programs. Details of the institutions offering CD in surgery training are given in Table 2.

Voluntary/Optional CD

VOCD refers to CD activities which are not necessary for passing examinations or qualifying with a degree, and if someone practices CD in extracurricular sessions, it is not credited in his/her course work. To fulfill the need for CD amongst interested students, many institutions offer extra CD courses. These training sessions provide opportunities for hands-on practice to dissect the specific regions/parts of the body and learn emergency procedures. VOCD training activities, such as CD in elective courses, in the learning of emergency and autopsy procedures, and in continuous professional development sessions, are optional and not actually a part of the curriculum.

CD in Elective Courses

Accepting the significance of dissection, Warwick University in the UK created an anatomy exchange program with St. George's University, Grenada, which was a voluntary activity [14]. In 2011, the Sydney Medical School, Australia, reintroduced a 7-week elective whole-body CD course [46]. Medical schools in Australia, New Zealand, Kuwait, and Saudi Arabia have also started CD as a voluntary activity [62–64]. Ohio State University in the USA has implemented elective programs with interactive CD for medical students in different surgical specialties [65]. Charles University in Prague, Czech Republic, uses cadavers for teaching practical endoscopic methods to undergraduate and postgraduate students [66]. I would like to note that Aga Khan University in Pakistan offered intermittent elective CD courses during the summer vacations in 2003–2011. Details are given in Table 3.

CD in the Learning of Emergency and Autopsy Procedures

Emergency clinical procedures such as lumbar puncture, cricothyrotomy, paracentesis, gastric lavage, and venesection require a detailed knowledge of human anatomy; CD and demonstrations provide an ideal opportunity to learn such skills [67]. In this context, the University of California, USA, in addition to its online training, uses hands-on practice with unembalmed cadavers for teaching emergency procedures [68]. Autopsy is a pathological dissection procedure of medicolegal importance. In order to learn and keep updated about anatomy and dissection skills over time, it is essential for medical students and practicing physicians to acquire autopsy skills [69]. During autopsies, trainees avail the opportunity of dissecting mostly fresh and unembalmed bodies [70]. In Japan, dissection of the human body is allowed only under special circumstances, such as medicolegal autopsies or for teaching in medical colleges. The anatomy departments of most universities in Japan provide the facilities for comedical training schools to observe CD as they acknowledge the importance of dissection [71]. Details are depicted in Table 3.

CD in Continuous Professional Development Sessions

Following the need and importance of CD in the subspecialties of surgery, radiology, and clinical practice, various institutions have started specialty-specific training courses on cadavers. These courses are in addition to their routine curricular residency training and conducted under the supervision of experts, providing a valuable opportunity for learning particular procedures and techniques. In this regard, many institutions arrange voluntary courses on CD for teaching modified surgical skills [72–76]. I note here that the neurosurgery, orthopedic surgery, and otolaryngology sections of the Surgery Department of Aga Khan University and many other institutions in Pakistan conduct specialty-specific training courses on cadavers. In Germany, a new "Theatrum anatomicum," similar to the ancient anatomical theatre provides an opportunity for learning anatomy and difficult surgical procedures outside the operating room by making use of cadavers [77]. In addition, many medical training centers conduct CD workshops in order to develop

Table 3. Examples of institutions that include cadaver dissection (CD) in elective courses, emergency and autopsy training, and continuous professional development programs

CD activity	Institution	Country	Reference
Elective courses	Warwick University	UK	[14]
	St. George's University, Grenada	Grenada	[14]
	Charles University in Prague	Czech Republic	[66]
	Sydney Medical School	Australia	[46]
	Medical Schools	New Zealand	[62]
	Kuwait University	Kuwait	[63]
	Al Faisal University	Saudi Arabia	[64]
	The Ohio State University	USA	[65]
	Aga Khan University	Pakistan	this study[1]
Emergency and autopsy training	University of California	USA	[64]
Continuous professional development	European Academy of Facial Plastic Surgery, Amsterdam	The Netherlands	[72]
	"Theatrum anatomicum"	Germany	[77]
	Wolfson Surgical Skill Centre	UK	[73]
	Centre of Anatomy and Cell Biology, Medical University Vienna	Austria	[75]
	Duke Division of Plastic, Maxillofacial, and Oral Surgery, and Docent LLC, Atlanta	USA	[90]
	Surgery Department of Aga Khan University	Pakistan	this study[1]

[1] As yet unpublished observations by the author.

new surgical procedures [78, 79]. The institutions conducting specialty-specific training courses on cadavers are shown in Table 3.

Discussion

This article presents the status of anatomy teaching with CD as parts of both the medical curriculum and VOCD. Curricular activity is categorized under both undergraduate and postgraduate curricula. Undergraduate anatomy teaching with CD is discussed as a part of traditional and modern curricula. In postgraduate programs, CD is discussed in the diploma, masters, and surgery training programs. Outside the curriculum, CD is presented in elective courses, the learning of emergency and autopsy procedures, and continuous professional development.

The literature indicates that many schools around the word have retained CD as part of anatomy teaching in their traditional undergraduate medical curricula. Some medical schools have integrated it vertically and/or with other basic science subjects. Some other medical schools offer optional dissection to interested students. Although the modern undergraduate medical curriculum started with cutting down on detailed anatomy teaching and CD, the literature cited here shows that CD has either been continued or restarted with the PBL, CBL, and TBL methods of teaching. For modern teaching methods, CD has been integrated within the clinical context and aided by radiological images. Around the world, CD is also practiced in postgraduate programs (surgery training, diploma, bachelors, and masters in anatomy, etc.).

Deficiencies in physical examination skills and surgical procedures as well as the lack of anatomical knowledge for interpreting radiological images tempted experts to start dissection programs outside the curriculum. The published literature also shows that CD has been practiced in VOCD programs, such as elective dissection courses, learning emergency and autopsy procedures, and continuous professional development sessions.

Anatomy teaching with CD used to be a major component of the first 2 years of the undergraduate curriculum. As it is a time-consuming activity, other basic science subjects were compromised. This situation compelled the stakeholders to voice their concerns and

demand a balanced allocation of time for the basic science subjects in the medical curriculum. However, the outcomes were different. Instead of a balanced reallocation of basic science subjects, several, but not all, medical schools reduced the time allocated for anatomy teaching. Simultaneously, they omitted or significantly condensed CD [80]. Within the span of approximately 2 decades, gaps in anatomical knowledge amongst graduating students became evident. General medical practitioners graduating from this era were found to be lacking in skills for performing simple medical procedures, which jeopardized the safety of patients [81]. This undesirable impact gave rise to new strategies which brought CD back, in conjunction with innovative teaching methods, and reallocated it in medical training [70].

As highlighted in the subsections "CD in the Traditional Curriculum" and "CD in the Modern Integrated Curriculum," a significant number of medical schools in the USA, Africa, and others around the world have continued with CD in their traditional, modern integrated, and hybrid undergraduate curricula. I agree with Inuwa et al. [82] that traditional and modern curricula can be taught together, instead of discarding the traditional methods of anatomy teaching. Additionally, many other techniques like radiographs, cadaver computed tomography (CT) scans, magnetic resonance imaging (MRI), ultrasound [44, 83, 84], computer media, CD ROM [20], and computer-aided holographic models [85] have been added to CD in anatomy teaching. These modifications, with some exceptions [86], have enhanced 3-dimensional perception and the understanding of the human body, thus moving closer to safe medical practice. I also agree with Yammine [61], Alyafi et al. [39], and Turney [87] that traditional methods, such as dissection and prosections, can meet many of the objectives of the PBL approach, like developing reasoning skills and learning, in a relevant context.

On the academic side, the shortage of anatomy teachers experienced in CD skills has increased [80, 88]. Thus, the teaching of anatomy by unskilled teachers has created a vicious cycle of producing more anatomy teachers and clinicians who are, however, less equipped with dissection and procedural skills [8, 16, 42, 87, 89]. To compensate for these deficiencies, diploma, bachelors, and masters courses in anatomy and/or basic sciences with CD have been recommended and introduced [59, 90]. Such programs have certainly helped in producing better anatomy teachers who can train medical students to be competent enough to cope with the needs of general medical practice and surgery training [91, 92]. This scenario emphasizes the importance of continuing anatomy teaching with CD in medical training. However, CD has partly shifted from the undergraduate to the postgraduate level.

On the clinical side, abandoning CD had a negative effect on the competency of future surgeons, ultimately compromising the safety of patients. This impelled surgeons and anatomists to raise their concerns and vouch for CD in medical training. They could not convince medical educationalists to resume CD the way it is practiced in the traditional curriculum, but they were able to incorporate it in surgical training programs. Furthermore, reallocation of CD at advanced levels, in conjunction with various modalities of radiology, imaging, cadaver CT slices, and modern electronic and digital techniques, enhanced the spectrum of CD in diagnosis and treatment [44, 57, 93, 94]. The reorganization of CD from undergraduate teaching to surgical training programs has reinforced its validity in medical education.

In many countries of the world, it is within the scope of general medical practitioners employed in the public sector to conduct general medical procedures and perform autopsies. A sound knowledge of gross anatomy and dissection skills is essential for carrying out medical emergency procedures and autopsies. The importance and necessity of CD has thus continued to grow. Different institutions have added dissection at different levels in their undergraduate and postgraduate curricula, but the need for CD is undisputed. Therefore, in addition to reallocation of CD in the medical curricula, VOCD is also introduced into elective courses, the learning of emergency and autopsy procedures, and specialty-specific workshops (Table 3).

Many medical graduates continue their professional careers as general practitioners, some specialize in surgery- or medicine-allied fields, and the rest adopt teaching as a career. It is a common anecdotal argument that graduates who do not become surgeons or anatomy teachers do not need extensive dissection skills. However, in today's medical world, the subspecialties in intervention medicine, such as cardiology, gastroenterology, nephrology, and pulmonology, require a good knowledge of the human body for safe procedural practice. At the very least, a sound knowledge of anatomy would behove practitioners to understand patients' symptoms and relate them to the organs involved. This entire situation indicates that CD has actually not been abolished but rather integrated vertically in the undergraduate and postgraduate medical curricula, and is strengthened by the clinical scenario, radiology, and digital and other modern tools.

Limitations

This review does not include any numerical data or statistical analysis, which could have strengthened its value and importance. Secondly, the inclusion of additional literature in other languages would have broadened the spectrum of the article.

Conclusion

Medical practitioners, surgeons, anatomy teachers, and researchers in the anatomical field cannot avoid CD if they wish to become competent professionals. They need CD skills to assist them in performing safe and satisfactory practices during their professional careers. Thus, it is not reasonable to conclude that CD is obsolete in medical training. I support the contention of Ghosh [95] that anatomy including CD should be incorporated vertically, in a reasonable manner, into medical education at the undergraduate and postgraduate levels as well as in internships, along with other modern teaching strategies.

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