Anatomy teaching: ghosts of the past, present and future

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> 'Ghost of the Future,' he exclaimed, 'I fear you more than any spectre I have seen. But as I know your purpose is to do me good, and as I hope to live to be another man from what I was, I am prepared to bear you company, and do it with a thankful heart. Will you not speak to me?'
> Ebenezer Scrooge (Charles Dickens, *A Christmas Carol)*

INTRODUCTION Anatomy teaching has perhaps the longest history of any component of formalised medical education. In this article we briefly consider the history of dissection, but also review the neglected topic of the history of the use of living anatomy.

CURRENT DEBATES The current debates about the advantages and disadvantages of cadavers, prosection versus dissection, and the use of living anatomy and radiology instead of cadavers are discussed.

THE FUTURE Future prospects are considered, along with some of the factors that might inhibit change.

KEYWORDS anatomy/*history/education; teaching/*history; dissection/*history; cadavers; history, 17th century; history, 18th century; history, 19th century; history, 20th century.

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INTRODUCTION

Anatomy is widely appreciated as being among the most significant components of medical education and the study of anatomy through the dissected cadaver is viewed as the uniquely defining feature of medical courses. However, it may be that we are now entering a time of paradigm shift, aided by new understandings and new technologies, and, as in all such times, views are held strongly and expressed emotionally.

While the history of dissection has been well studied, less attention has been paid to the use of the living body in anatomy teaching. In this article, we briefly review the use of the cadaver and make an initial contribution to the history of living anatomy. Then we review the debates on the value of dissection and prosection, and on the use of the cadaver as opposed to the study of the living body and medical imaging. Finally, we consider possible futures: in evaluation of teaching methods; in the use of imaging and simulation techniques, and in the use of the arts in aiding anatomical understanding.

THE HISTORY OF DISSECTION

Cadaveric dissection has been the paradigm of anatomy teaching since the Renaissance, and the defining experience of medical teaching since the 16th and 17th centuries.[1,2] Subsequently, cadaveric dissection featured regularly in medical training, although often in an informal, semi-official manner. In the UK and elsewhere, private anatomy schools flourished alongside hospital-based professional courses. In 1822, however, the Royal College of Surgeons determined that it would no longer accept summer courses as a qualification for entry to the college diploma. This began to inhibit the

Overview

What is already known on this subject

The study of anatomy is recognised as being among the most significant components of medical education.

What this study adds

This paper reviews the use of the cadaver and the history of living anatomy. It considers the value of dissection, prosection and the use of the cadaver, as opposed to the study of the living body and medical imaging. It evaluates the use of imaging, simulation techniques and the use of art in aiding anatomical understanding.

Suggestions for further research

Further evidence is needed to define which method of anatomy teaching leads to the most effective clinicians and if the choice of method affects student selection.

activities of private medical schools and the 1832 Anatomy Act reinforced this process. Stricter regulation of the methods by which bodies could be obtained worked in favour of hospital-based anatomy schools, which could use the bodies of their own deceased patients (often as a *quid pro quo* for free treatment while alive). This marked a key transition from the 'apprenticeship model' of medical training (often limited to one-to-one instruction) to a professional training model in which students were taught in larger groups by individuals for whom teaching was among the main purposes of their employment.

A useful distinction can be drawn between the *observation* of dissection (which was a mainstay of Renaissance teaching, through the 'anatomy theatre') and active dissection by students themselves. The so-called 'Paris method' of giving each student his or her own cadaver was influential in the UK due to the numbers of students who travelled abroad for part of their medical training. Gradually, dissection came to be seen as the modern way and observation was relegated to a second class activity.

A more profound psychological shift may also have taken place at this time, when there was a shift from the indeterminateness of traditional medicine (folk medicine) towards the formalisation and professionalisation of (literally) conventional medicine; that is, the practice of medicine moved away from the personal, idiosyncratic and patient-focused view of the past to the standardised, diseased-focused world of the Rationalist future. In the very uncertain world of medicine in the late 18th and early 19th centuries, where no organised or rational bases for diagnosis or treatment existed, it must have been a great comfort to turn (literally) to a body of anatomical knowledge which was regular, standardised and capable of shared and agreed observation by everyone working in the field.

The move towards dissection may have been further reinforced by the growing sense of the creation of a professional monopoly. The observation of dissection in the anatomy theatre could be open to everyone, male and female, medical practitioner and layperson alike. Dissection, on the other hand, was not open to everyone and women were not permitted to take part in anatomy classes. Along with the increasing professionalisation of medicine in the early 19th century went a distinct masculinisation.

Dissection has thus been encultured into medical education such that it has become an almost universal expectation of medical courses. More recently, Dyer and Thorndike[3] suggested that anatomy's status as a science has diminished as it is no longer considered to be a research-led discipline. There is much debate over the nature of science. A more conventional definition of science centres on the formation of a scientific hypothesis, which may be proved or disproved, and is qualified by statements of conditional probability. John Pickstone[4] presented a rather different philosophy on the nature of science, suggesting that science, medicine and technology should be defined as an integrated enterprise of knowing and acting defined through four 'ways of knowing': extracting meaning; collecting and classifying data; analysing, and experimenting. It is probably true that the early anatomists founded their study of anatomy on the scientific method of data collection (direct observation of the body structures), followed by hypothetical explanation and further observational testing of the hypothesis. Today, the discovery of new gross structures is unlikely, except perhaps in the field of neuroanatomy, and this has contributed to anatomy's altered status as a science. It seems that disciplines such as histology and embryology, which evolved from anatomy, have superseded

it in terms of research status and popularity.[3] The anatomical body described in textbooks is presented as objective reality, as a series of common observations in a structure which is simultaneously simple enough to understand and complex enough to be a lifetime study. This reality can be studied and appreciated by everyone as part of a common experience.

THE HISTORY OF LIVING ANATOMY

In contrast to the well described and documented history of anatomy teaching using the cadaver, the history of teaching anatomy through the study of the living body has, as far as we know, been neglected. The living body was and is, of course, of major interest to artists, and art history may provide an access route for this subject. Johann Zoffany painted 'Dr William Hunter lecturing at the Royal Academy' some time around 1775 (Fig. 1). This shows Hunter demonstrating the rotation of the scapula on a living male model, with a skeleton and a sculpture showing muscle groups available nearby. Sallé's painting 'The anatomy class at the École des Beaux Arts', exhibited in 1888, shows an eminent anatomist, Professor Mathias-Marie Duval, carrying out a demonstration on a living male model in front of a class of students (Fig. 2). The teacher is holding the model's right arm at the wrist and upper arm in a slightly pronated position, and seems to be occluding the basilic vein. A scapula and arm bones, articulated as a unit, are in front of him on the table, and have plainly been recently used in the demonstration. Duval was a clinician and anatomist and presumably used living anatomy in his medical teaching. However, academic literature documenting the uses of living anatomy is scarce. In 1931, the anatomist David Waterston published *Anatomy in the Living Model*,[5] in which he indicated: 'It is now several years since the study of the living model was introduced into anatomy schools as a means of supplementing the training in anatomy obtained by the dissection of the cadaver.' This suggests that it had not taken place before that time in UK medical schools at least. Waterston also quoted the General Medical Council (GMC) as having recently recommended that 'the demonstration of structure and function in the living' should

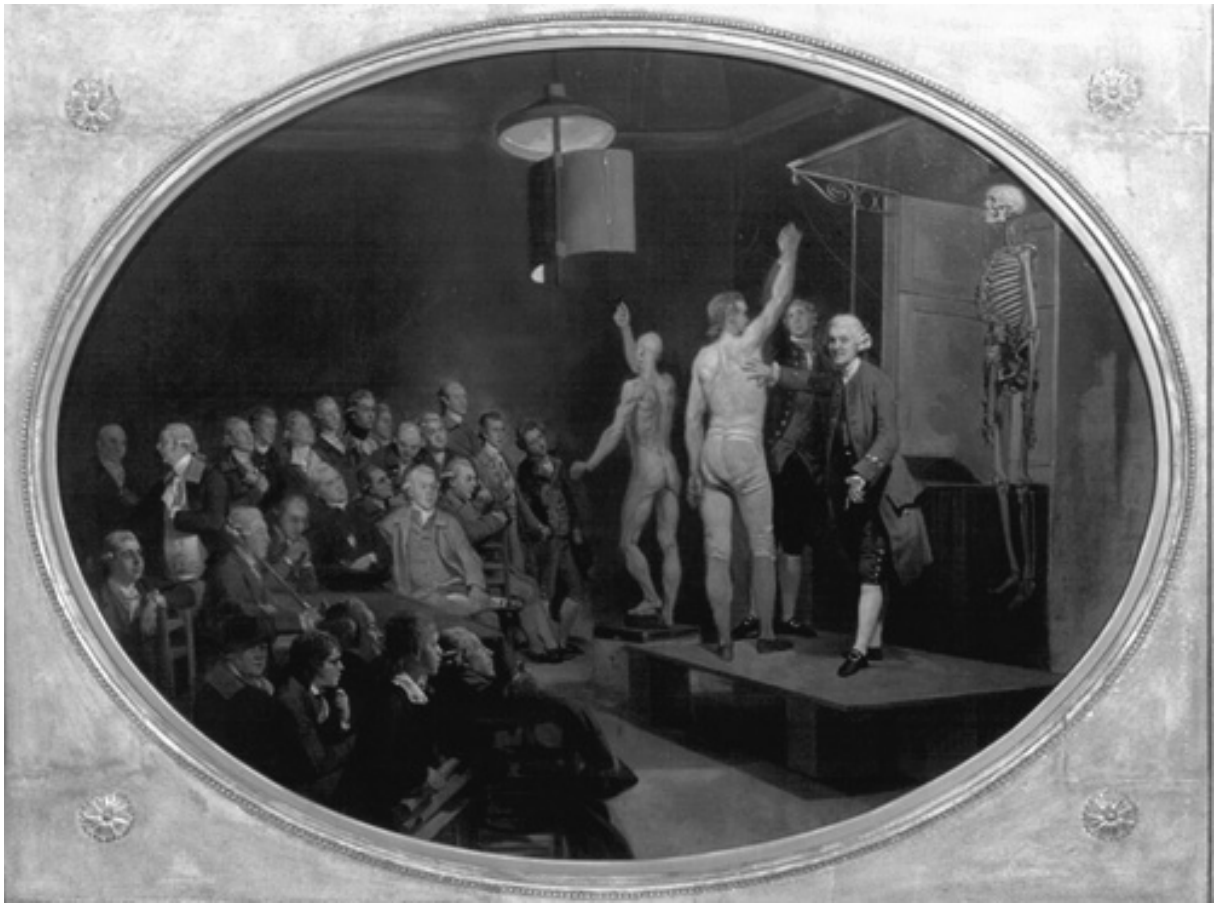

Figure 1 *Dr William Hunter lecturing at the Royal Academy.* J Zoffany. With permission of the Royal College of Physicians.

Figure 2 *The Anatomy Class at the École des Beaux-Arts.* F Sallé. With permission of the Art Gallery of New South Wales.

form an integral part of medical students' professional training.[5] However, the GMC itself appears to have no record of this recommendation, due to the incompleteness of its records. In 1947, RD Lockhart (Regius Professor of Anatomy at Aberdeen), published *Living Anatomy*,[6] which went into a second edition in 1949, and included the sound advice: 'Keep your eye on the body, especially the living body, is the first principle in anatomy'. The photographic illustrations, both male and female, are of Lockhart's own students, which must have posed some challenges at that time and location.

In 1968, Barrows and colleagues[7] recommended the use of life models in anatomy teaching, commenting that 'during the anatomy course, the students gradually develop an objective but respectful attitude towards the cadaver. Paradoxically medical students do not seem to enter the clinical arena with the same objectivity concerning the disrobed human body.' Their work was cited as the inspiration for the programme of living anatomy introduced at the University of Arizona College of Medicine by Stillman and colleagues in 1978.[8] The authors concluded that 'live models were rated superior to using cadavers, especially in demonstrating superficial anatomy and landmarks'. Both Barrows et al. and Stillman et al. preferred the use of professional life models to peer-examination. By contrast, in 1982 Metcalf and colleagues[9] proposed that peer-examination was more valuable than the use of life models, and introduced a living anatomy course in which compulsory peer-examination, including breast and internal examinations, was practised in mixed sex pairings. These authors and others[10] refer to studies as an introduction to the physical examination, as well as a way of studying anatomy per se. Currently, the Anatomical Society of Great Britain and Ireland[11] and the American Association of Clinical Anatomists[12] continually reiterate the necessity for identifying structures in the living throughout their 'benchmark' core curriculum. However, studies of anatomy teaching methods frequently omit living anatomy as a study component.[13,14]

In more recent times, attention has focused on student views on participation in peer-examination.[15–19] These studies have generally concluded

that students were willing to take part in peer examination, although there were reservations around particular sensitive areas of the body. A variety of factors, including age, ethnicity, religious background and body image, proved influential for individual students. Equally, there are a number of significant cultural problems with regard to participation in peer examination.

THE DEBATES

Methods of teaching anatomy are briefly reviewed in the Appendix. However, there are a number of active debates currently taking place in medical education on anatomy teaching methods, two of which are summarised below. Proponents of the use of electronic representations of the body have also joined the debate; however, there seems to be a widespread consensus that these resources are currently inadequate to be anything other than a support to anatomy learning by other means.

Advantages and disadvantages of dissection

Advantages

The majority of published papers on anatomy teaching strongly recommend the use of dissection. Proponents of dissection generally identify a range of benefits that may spring from dissection.[3,20–24] These benefits mostly fall into three domains: knowledge acquisition and integration; skills, and attitudes.

Benefits identified in the first domain include: development of cognitive anatomical knowledge and its specific vocabulary; appreciation of three-dimensional relationships and anatomical variability; establishing a system for classifying tissues; laying the foundations for the study of other disciplines where knowledge of structure is essential (e.g. physiology, microbiology and pharmacology); participating in cadaver/patient-centred computer-assisted learning, and peer-group learning.

Skill-based benefits include developing fine motor control and a touch-mediated perception of the cadaver/patient and developing competence in diagnostic imaging and training for the medical specialties.

Finally, attitudinal benefits include establishing the primacy of the patient; promoting professionalism through a direct encounter with the cadaver, and promoting attitudes conducive to team working.

More recently, medical students have cited an appreciation of the historical significance of dissection and the development of respect for the physical body as additional reasons to learn anatomy through dissection.[25]

Disadvantages

Some hold the belief that there are several important negative factors associated with studying anatomy via dissection, which again fall into three domains: those concerning the emotional impact of dissection; health and safety issues for those handling cadaveric material, and, lastly, the practicalities and cost of using cadavers.

In contrast to the reports that dissection may promote a sympathetic understanding of death, some studies have reported dissection as causing extreme anxiety and emotional disturbances in some students[26–31] and, at the other end of the spectrum, levels of desensitisation which may result in an undesirable detachment from death.[26,32] Others have suggested that the cadaver has little clinical relevance,[33] perhaps due to its appearance (colour and texture), lack of mobility and smell.[34]

There are significant health and safety implications central to the use of cadavers, which include exposure to embalming fluid chemicals and/or inadequately preserved human material and infectious diseases such as transmissible spongiform encephalopathies, human immunodeficiency virus, tuberculosis and hepatitis.[35] In addition, there are legal requirements; for example, in the UK these relate to the Human Tissues Act and the Anatomy Act.

There are also practical problems associated with dissection such as the difficulties in acquiring cadavers, the cost of transporting, maintaining and disposing of cadavers, the shortage of qualified anatomists and the large amount of time required for study by dissection. Procurement of cadaveric material, for example, is proving increasingly difficult and occasionally fraught with tensions. Since 2001, there has been a 10% reduction in the number of bodies accepted by Her Majesty's Inspector of Anatomy (HMIA) for anatomical studies (from about 670 in 2001 to 600 in 2004/05; personal communication, HMIA). In part this is due to a reduction in the numbers of potential donors available following health and safety directives which do not permit donors diagnosed with mild dementia to be accepted. It is also likely that the public perception of anatomy has been tarnished by the recent scandals at Alderhay

and Bristol, and perhaps by Gunther Von Hagen's controversial Body Worlds Exhibition and public autopsy, which received a mixed response from the general public. These factors, coupled with rising student numbers across the UK, including the establishment of eight new medical schools, have all contributed to a reduction in the amount of cadaveric material available for anatomical study. Shortages of cadavers lead to high student:cadaver ratios, which must inevitably detract from the value of dissection as a useful learning activity.

Discussion

Despite the arguments in favour of dissection, often by anatomists who are self-professed enthusiasts for their subject and who have studied anatomy themselves by dissection, many anatomy departments worldwide have adopted prosections as their primary learning resource. The drivers for this change have been the need to maximise the use of increasingly scarce resources (cadavers and teaching staff), limited teaching time and most importantly, to achieve improvements in outcomes for students in terms of examination results and long term recall of anatomical knowledge.[30,36–38] Thus, there is recognition amongst anatomy teachers that dissection may not be the best means by which students can acquire and retain anatomical knowledge and to date, no studies have demonstrated that longterm retention of anatomical knowledge is an outcome of dissection.

The benefits of learning anatomy through dissection are undeniable for some students, in particular for those who report that dissection enables the mental mapping of the body's three-dimensional internal structure,[25,39,40] but some of the other reported benefits are also fostered elsewhere in medical curricula.

Today, the cadaver is often not the first patient that the student encounters as some students meet patients in the first week of their studies, and it is fair to suggest that the first patient encounter is best achieved with a real patient in a clinical setting or in the simulated environment of a clinical skills laboratory. Similarly, the response of many UK medical schools to the recommendations of the GMC (*Tomorrow's Doctors*[41] *and Good Medical Practice*[42]) has meant that there are more opportunities in medical curricula for fostering team working skills and promoting an understanding of death.

It may be true that dissection allows for the inculcation of the scientific method which is the basis of diagnostic medicine,[24] but given the loss of status of anatomy as a science, it seems more likely that the greatest value of dissection is in the active learning process and the self-discovery that occur during learning, rather than inculcation of the scientific method. Evidence-based medicine (EBM) and evidence-based practice (EBP), now integral components of many medical curricula, are likely to be more useful vehicles for espousing the inculcation of the scientific method.

Developing a touch-mediated perception of the body and motor skills may also be fostered in a clinical skills environment where students palpate, percuss and auscultate the living body. In fact, given the high student:cadaver ratios reported in some studies,[13,37] it is unlikely that many students dissect enough to allow any extensive development of these skills.

Cadavers versus living anatomy and imaging

Anatomy is most commonly encountered by medical practitioners in the form of living anatomy on the one hand, and medical imaging on the other.[43] It would seem to be authentic to argue that these means therefore are how anatomy ought to be taught.[44] Indeed, Biggs' theory of 'constructive alignment'[45] would advocate that learning activities and resources should be 'constructively aligned' to assessment. In a profession such as medicine, the assessment of a competent clinician is ultimately about his or her ability to diagnose and treat patients effectively; this interpretation would therefore argue that the learning resources and activities employed to achieve this outcome should be centred around patients and, with respect to anatomy, would advocate the use of living subjects rather than cadavers.

Potential advantages and disadvantages of living anatomy and imaging

Imaging technology and its application in clinical medicine have advanced enormously in recent years. A recent innovation, which has been explored particularly in the field of neurosurgery, employs the use of real-time intraoperative magnetic resonance imaging (IMRI). This technology, although costly, enables improved visualisation of soft tissues and the observation of tissue changes in real time as surgery proceeds.[46,47] Imaging technology has and will continue to become less expensive, easier to interpret and more widely available. Small portable ultrasound scanners, for instance, are already available and can be used in a new range of settings from emergency medicine in the field to primary care in local and community settings. These devices can be used in

undergraduate teaching, both in terms of their diagnostic function as a clinical skill, and as a way of viewing anatomy in the classroom. This has been attempted on a number of occasions,[48–52] but there are a number of difficulties which have been inadequately addressed. These include the potential safety hazards arising from repeated scanning of individuals for teaching purposes, the obtaining of informed consent from participants, and the possible discovery of conditions requiring further investigation. Internal live three-dimensional reconstructions, both of ultrasound images and MRI scans, are currently in clinical use and may feed into teaching practice, especially where cadavers are unavailable or not used.

Simulation has contributed to the safety of procedures in a number of high-risk industries.[53] It is likely that this will be used increasingly in medical education,[54] not only for exploring clinical skills, but also for providing an apparently authentic introduction to the importance of anatomy in certain procedures. Such simulations can employ manikins with increasingly sophisticated responses, or virtual reality approaches that can include haptic feedback. Already, a number of laparoscopic trainers are available which would be invaluable in aiding the importance of anatomy, but their cost is currently prohibitive. Computerised simulations of anatomy and the body are also available, of course, but the consensus among anatomy teachers seems to be that these are not yet of sufficient quality or development in terms of pedagogic principles to be a substitute for the dead or living body.

Discussion

Historically, the primary purpose of dissection and the use of the cadaver has always been to gain understanding of the living body. In clinical practice, however, doctors are virtually always required to deal with the living body, and study of the corpse is largely confined to various kinds of pathologists. Study of the chemically preserved cadaver is even less common in medical practice. It is therefore fair to ask if this primary purpose can be better achieved through other means in undergraduate medical courses.

Student, public and medical professional responses to the suggestion that the dissection or study of the preserved human cadaver might be reduced in medical teaching is overwhelmingly one of diminishment and regret.[20,55,56] Indeed, responses to a new medical school's decision to employ the use of living anatomy and imaging in favour of cadaveric anatomy were generally hostile. *The Times* ran an article entitled 'Medical School consigns cadavers to history',[57] which contained comments such as 'training is being dumbed down' and 'There is no place for squeamishness in medical education', *and* a generally traditionalist slant: '...for centuries the dissection of a corpse has been an essential learning aid … as well as a rite of passage … however, students at the school will not dissect a single corpse'. The references to the value of history are interesting, as medical practice generally values change and improvement. An equivalent use of terms during discussion of, say, blood-letting, is implausible. Channel 4 publicity material, in association with a documentary series on Professor von Hagens, posed the question in the following terms: 'Would you mind if your doctor has had no real, practical experience of human anatomy?'[58] Here, interestingly, real anatomy is explicitly equated with the dead rather than the living body.

On occasion the debate has been inadequately represented. For instance, rather than engaging in discussion of the value of living anatomy and imaging versus dissection, it has been asserted that 'all the anatomical teaching is carried out using plastic models'.[58] Motives may also be misrepresented. For instance, one critic wrote: 'Reading between the lines, the decision to do this seems to have been made for reasons of expense and resources',[59] although the original article to which the writer referred explicitly stated that the authors were 'primarily concerned that our programme produces clinicians who are capable of using their understanding of anatomy in the management of clinical problems', and 'It is not intended to imply that alternatives to cadavers are intrinsically less expensive'.[44] Indeed, teaching that relies heavily on medical imaging and consultant radiologist teaching is more expensive than the cadaveric alternative. A third tactic is a straightforward dismissal of the non-cadaveric approach as being not worthy of engagement in argument; for instance: 'the educational justifications simply do not exist'.[59]

Plainly, the response to the suggestion that working with cadavers may not be an essential part of medical training has been emotive. Perhaps we can attribute such strongly and emotionally expressed views to the paradigm shift currently underway.

It may be possible that the nature of dissection, with its cultural and physical challenges in handling and disaggregating the dead human body, may indeed have promoted the sense of a rite of passage, in the phrase so revealingly used by *The Times*. Such rites are typically unpleasant, sometimes even painful, and

serve the function of binding together the initiates, while at the same time excluding those who have not passed through the ritual.

A more generalised anxiety may also underlie the responses. Anatomists currently feel that their subject is under threat,[3,55] with diminishing resources and decreasing numbers of qualified teachers. A move away from cadaveric dissection may be misinterpreted as a downgrading of the importance of anatomy itself as a component of medical training. Nothing is further from the truth; human structure remains an extremely significant part of the knowledge base of students. The question is rather about what kind of anatomy it should be. It is in anatomical understanding that dissection must base its firmest defence. However, anatomical knowledge *per se* is not the goal of medical education: this, rather, is to produce good doctors.

THE FUTURE

The single most desirable improvement in anatomy teaching would probably be in the field of evaluation. The question we must answer concerns which method of teaching about the structure of the body produces the most effective clinicians. Sadly, evidence of this kind is almost entirely lacking, due in part to the difficulty of carrying out such studies and in part to the lack of a sufficiently wide range of approaches in the past which would enable comparisons to be made. To date, evaluation studies have frequently been of the 'show and tell' kind – 'this is what we do in our institution'.

It is no longer acceptable to publish student satisfaction studies, which are often poorly designed, with inadequate separation of the role of teacher and investigator. Such studies are merely likely to support the prejudices of teachers in either direction. It is essential to attempt to identify measurable outcomes, employing both qualitative and quantitative approaches, and to have some means of comparison between different methods of instruction through comparisons between different co-operating institutions. Such an approach is feasible.[60] However, the larger question concerns which method of instruction produces better doctors, and this is less amenable to easy resolution. Experimental power would be gained if institutions could be categorised along an axis of intervention, where, for instance, greater or lesser participation in dissection or interactivity of anatomy learning is identified. This would aid in the construction of a dose–response curve for the processes under study. However, only in time will the comparative merits of different approaches become evident. This won't happen for at least 10 years after a particular approach is initiated. As any new teaching method requires time to be developed, we may find that the first year or even first two years of a new approach are not representative, and perhaps the research period should be extended accordingly. It is perennially difficult in medical education to determine the clinical outcomes of a teaching intervention, and to measure these in clinical practice. Surrogate measures that have been used include dropout rates, time to membership of professional bodies, time to promotion, views of colleagues and patients, and numbers of complaints.

Another relevant area of research would concern the range of disciplines entered into by students who have undergone different educational interventions during their undergraduate careers. It would be interesting if lack of exposure to cadaveric dissection in the undergraduate course made students less (or more!) likely to undertake careers in surgery. Concomitantly, it would be of interest to explore whether students were more or less likely to select courses featuring different methods of instruction.

The use of arts and humanities in medical teaching is likely to add a further dimension to the agenda (see Appendix). 'Desensitisation' is not necessarily of intrinsic value in the practice of medicine. It is the ability to carry out medical practice effectively, despite the emotional difficulties involved, which is the desired outcome, and greater insight may be a better approach to this than decreased sensitivity.

Another fruitful area for exploration will be that of interprofessional working. In some professions allied to medicine, such as nursing, the experience of anatomy has often been rather limited. In others, such as physiotherapy, students gain a profound understanding of human anatomy in practice, probably as a result of their experiences in extensive peer examination and living anatomy during the course of the programme. There is also scope for co-operation between undergraduate and postgraduate students, including those engaged in professional development, which is likely to be beneficial to both.

Just as dealing with cadavers is a profound event, working with the living body has high emotional impact. It may even become an equivalent rite of passage to that of dissection. It is common to witness new students placing their hands on the living human body for the first time, and becoming speechless, deaf

and blind in immediate consequence. This is because they may never have deliberately placed their hands on another adult human, to whom they are not related, other than in a sexual context. It is inspiring to watch their development towards professionalism over the course of an academic year.

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APPENDIX

Approaches to anatomy learning

Dissection

Dissection describes the experience of students who are assigned cadavers that they dissect, usually in teams and with the guidance of a tutor. In the past, students at many medical schools were able to dissect every region of the body. This is becoming less

common, and where dissection still takes place, it often does so for selected regions only, or as part of an optional activity such as a special study module or student-selected component.

Prosection

In prosection, the materials are dissected in advance by a professional anatomist, and studied by the students as relevant. Prosections may suffer wear and tear in normal use, and their long term employment may be at odds with the desire of families for the return and disposal of remains. A particular version of prosection is plastination, where the material is impregnated with stable polymers that enable it to be handled safely at room temperature.

Living anatomy

Living anatomy may include palpation, percussion, auscultation and study of musculoskeletal movements, as well as marking surface reflections of underlying structures. Surveys of student learning in anatomy often neglect living anatomy as a category and therefore information on its use is incomplete.

Living anatomy may be conducted either with the use of life models or through peer examination. Willingness to participate in peer examination depends upon an interaction of cultural and demographic factors, including sex, age, past history, ethnicity and religious beliefs. In some paramedical disciplines (such as physiotherapy), participation in peer examination may be compulsory.

Life models are paid to take part in living anatomy, and should be distinguished from simulated patients and patient examination. Their use has been recommended in several publications (see text) but anecdotal evidence suggests this still remains unusual.

Medical imaging

Medical imaging includes X-rays and computerised axial tomography, MRIs, ultrasounds and other approaches to imaging. Modern technology offers the opportunity to provide three-dimensional reconstructions of individual patients and this is now being used clinically. Since the discovery of X-rays, they has been used intermittently in medical teaching, despite the fact that it is one of the two major modalities by which clinicians experience anatomy in practice. There are good arguments for a very significant input by radiologists into the development of the curriculum, as well as its delivery. It would not be inappropriate if 50% of student time was spent on medical imaging so that students were able to build up an understanding of the strengths and weaknesses of each of the different individual approaches and learn how to interpret the anatomy as viewed through these very distinct modalities, which give a very different experience to that of dissection and prosection of cadavers.

Animal models

A common feature in anatomy teaching has been the use of fresh animal materials such as lungs, hearts and eyeballs. These are valuable in demonstrating structures in their unpreserved state, and may be used to demonstrate the effect of inflation on lungs, for instance. Fresh eyeballs may be dissected to reveal the fluid components that are lost on preservation.

Learning through arts and humanities

There is some evidence that learning through arts and humanities can have a significant impact on students' understanding of the body.[61–63] One risk of using cadavers is that it may objectify the body and lead to it being viewed in an overly detached manner. Re-engaging with the arts and humanities' view of the human body has the potential of offering a more rounded perspective. Activities such as life drawing and modelling, accompanied by reflective discussions, have the potential to offer a significant advance in students' understanding of their perceptions of the body.

Michael Sappol's web-site 'Dream Anatomy'[64] exhibits a comprehensive selection of anatomical images of historical and artistic significance from the 1500s to date and comments upon the changing artistic representation of cadaveric anatomy during that period. The use of body projection within art and science also deserves a mention here. Krzysztof Jurecki[65] comments upon the 'shocking, fearful and hideous imagery' created in Dariusz Gorczyca's photographic exhibition 'Camera Anatomica', where images of anatomical structures were projected onto the body of a young woman and photographed. In stark contrast, this concept has been successfully used to enable students to learn surface anatomy, locating gross anatomical structures found in cadaveric anatomy on the surface of a living individual.