

Teaching of Anatomy: Dissecting Dissection in Veterinary and Medical Education from a Historical Perspective through to Today

Poučevanje anatomije: seciranje potrebe po sekciji v veterinarskem in medicinskem izobraževanju z zgodovinskega vidika do danes

Key words

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As veterinary and human medicine education evolves, instructors can now incorporate a range of innovative anatomy tools, from low-fidelity models to high-fidelity simulators, 3D printing, dissection software, and augmented/virtual reality. However, cadaveric dissection in line with ethical animal use, guided by the 4Rs: replacement, reduction, refinement, and responsibility; still remains an important and critical teaching strategy. Dissection is the methodical isolation of the various parts of the cadaver to study their physical characteristics (colour, consistency, weight, dimensions, shape), location, and structure, as well as their irrigation and innervation. It enables a deeper understanding of anatomical structures through practical work. As a synonym of anatomy, dissection remains the main method to study, understand and research the body in veterinary and human medicine education. Students learn the key skills and core knowledge necessary for subsequent clinical work, including clinical examination, necropsies, and surgery. They also acquire the manual dexterity, pre-surgical techniques, and confidence vital for their future work. This paper investigates the advantages and disadvantages of using dissection and explores the contemporary, and often complimentary, methods used to teach anatomy. We should clarify that this discussion is about the dissection of

Z razvojem izobraževanja na področju veterinarske in humane medicine imajo asistenti in profesorji anatomije na voljo vedno več inovativnih orodij za poučevanje anatomije, od osnovnih modelov in naprednih simulatorjev do 3D-tiska, programske opreme za virtualno sekcijo ter navidežno in obogateno resničnost. Kljub tem napredkom pa disekcija kadavrov – izvedena v skladu z načeli etične uporabe živali, ki jih opredeljuje načelo 4R: zamenjava, zmanjšanje, izboljšanje in odgovornost – ostaja ključna in nepogrešljiva metoda poučevanja. Disekcija omogoča metodično preučevanje struktur telesa, vključno s preučevanjem njegovih fizičnih lastnosti, kot so barva, konsistenca, teža, mere, oblika in lokacija. Poleg tega razkriva njegovo strukturo, ožiljenost in inervacijo ter s tem omogoča poglobljeno razumevanje anatomske strukture skozi praktično delo. Ta praktični pristop študentom ponuja poglobljeno razumevanje anatomske značilnosti in razvija veščine, ki so nujne za nadaljnje klinično delo, skupaj s preiskavami, obdukcijami in kirurškimi posegi. Poleg tega disekcija prispeva k razvoju ročnih spretnosti, predkirurških tehnik in samozavesti, ki so bistvene za prihodnjo poklicno pot študentov. Članek analizira prednosti in izzive disekcije ter raziskuje sodobne, pogosto neinvazivne alternative za poučevanje anatomije. Pomembno je poudariti, da se razprava osredotoča na seciranje kadavrov in s tem povezane etične vidike, ne pa na

cadavers (including the associated ethical considerations), rather than the largely outdated practice of vivisection.

The history of dissection, in teaching and researching anatomy and medicine, spans millennia. In ancient Mesopotamia, often called the 'oldest known cradle of civilization', rudimentary animal dissections were performed and observations were made from human wounds, these helped form words for internal anatomical structures such as blood vessels (1). Mesopotamian clay liver models dating back to 2000 BC still survive today (2). We also know that in ancient Egypt (circa 3000 BC), embalmers had developed detailed knowledge of human anatomy, but this was initially more for religious than medical purposes (3). There is no doubt that by 1850 BC this work had accumulated into rigorous medical and scientific knowledge regarding anatomy, surgery, medicine, disease and healing. Much knowledge was gained during this time about the cardiovascular and reproductive systems, the brain, and even tumours (3). This work continued and Aristotle (384–322 BCE) and Erasistratus (304–258 BCE) were known to be dissecting animals to understand anatomy and physiology (4). Systematic human dissection was also recorded to be in use in the 3rd century BC by the Greek anatomists Herophilus and Erasistratus in Alexandria (Egypt) (5). Dissection has gone through many complex cultural taboos, during these times animal dissection was often permitted, with Greek anatomists and physicians such as Hippocrates (460–370 BCE) and Galen (129–216 CE) gaining anatomical knowledge through this practice (6, 7). During the Medieval period in Europe dissection was culturally taboo however Islamic physician Avicenna (980–1037 CE) from Persia, and Al-Zahrawi (936–1013 CE) an Arab surgeon, amongst others continued to add to the wealth of knowledge known about the body during the 'Golden Age of Islam' (8, 9). During the 14th–17th centuries, there was a resurgence of acceptance in the practice of dissection in Europe, yet the centuries to follow had several times of turmoil due to religious beliefs, laws and unethical practices (10). Despite this, dissection was one of the primary methods to teach anatomy (11, 12).

Detailed and meticulous dissection requires patience and time, as well as the motivation and knowledge necessary to perform it, and is therefore a rigorous and active method of study. Animals are three-dimensional beings, and it is in dissection that students build up their ideas and mental images of the structures of the animal body, a process that is carried out gradually with experience. Another objective of dissection is to introduce the concept of biological, specific, and interspecific variability. In anatomy, variability is a constant, there are variations between individuals, and those caused by age, physiological state, sex, breed, disease, injury, and other factors. An additional benefit of anatomical dissection in teaching is that cadavers can also be reused in many cases for other uses. These may include using components towards research projects both at undergraduate levels and beyond – another method of teaching widely used to support anatomical teaching (13). The

vivisekcijo, ki je v današnjem času že večinoma opuščena praksa.

Disekcija kot metoda za preučevanje anatomije in medicine ima večtisočletno zgodovino. V starodavni Mezopotamiji, poznani kot »zibelka civilizacije«, so izvajali preproste disekcije živali in opazovali človeške rane, kar je privedlo do prvega oblikovanja terminologije za notranje anatomske strukture, vključno s krvnimi žilami (1). Ohranjeni glineni modeli jeter iz Mezopotamije, ki datirajo v leto 2000 pr. n. št., pričajo o zgodnjih prizadevanjih za razumevanje anatomije in so se ohranili do danes (2). V starem Egiptu (približno 3000 pr. n. št.) so balzamerji razvili podrobno znanje o človeški anatomiji, ki je bilo sprva povezano z verskimi obredi. Do leta 1850 pr. n. št. je to znanje postalo pomemben del medicinskega in znanstvenega razumevanja anatomije, kirurgije, bolezni in zdravljenja. Takrat so že poznali osnovne koncepte kardiovaskularnega in reproduktivnega sistema, možganov ter celo tumorjev (3). Zgodovinski zapisi kažejo, da sta Aristotel (384–322 pr. n. št.) in Erasistrat (304–258 pr. n. št.) secirala živali za razumevanje anatomije in fiziologije (4). V 3. stoletju pr. n. št. sta grška anatomata Herofil in Erasistrat v Aleksandriji izvajala sistematično disekcijo človeških trupel (5). Čeprav je disekcija pogosto naletela na kulturne in verske tabuje, je bil njen pomen v raziskovanju anatomije neizpodbiten. V grški tradiciji so zdravniki, kot sta Hipokrat (460–370 pr. n. št.) in Galen (129–216 n. št.), anatomska spoznanja pridobivali predvsem z disekcijo živali (6, 7). Medtem ko so disekcijo v srednjeveški Evropi kulturno in versko zavračali, sta islamska učenjaka Avicenna (980–1037 n. št.) in Al-Zahrawi (936–1013 n. št.) v »zlato dobi islama« znatno prispevala k razvoju anatomskega znanja (8, 9). V obdobju renesanse, od 14. do 17. stoletja, je disekcija ponovno postala sprejeta v Evropi, čeprav so verska prepričanja, zakonske omejitve in etični pomisleki še dolgo vplivali na njeno izvajanje (10). Kljub zgodovinskim izzivom je disekcija vse do danes ostala ena ključnih metod poučevanja anatomije, saj je temelj za razumevanje človeškega telesa in njegovo raziskovanje (11, 12).

Natančna izvedba disekcije zahteva potrpežljivost, čas, motivacijo in ustrezno znanje, kar jo uvršča med temeljite, dosledne in aktivne metode študija. Živali so tridimenzionalna bitja, zato študentje skozi proces disekcije postopoma gradijo svoje miselne podobe in razumevanje struktur živalskega telesa, kar je proces, ki se razvija z izkušnjami. Disekcija ima tudi pomembno vlogo pri uvajanju koncepta biološke, specifične in medvrstne raznolikosti. V anatomiji je spremenljivost stalnica, ker so anatomske razlike prisotne tako med posamezniki, po drugi strani pa jih povzročajo dejavniki, kot so starost, spol, pasma, fiziološko stanje, bolezni, poškodbe in drugi. Dodatna prednost anatomske disekcije kot metode pri poučevanju je njena vsestranskost, saj je kadavre mogoče pogosto uporabiti tudi za druge namene, na primer pri raziskovalnih projektih na dodiplomski ali podiplomski ravni (13). Poleg tega omogočajo pripravo vsebin za dodatna učna orodja, kot so fotografije, rentgenski posnetki, računalniška tomografija (CT), ultrazvok, magnetna

cadavers used for dissection may be used (before or after) to create opportunities for creating content for complementary teaching tools. For example, taking photographs, conducting X-rays, computed tomography (CT), ultrasound, and magnetic resonance imaging (MRI) scans, creating prosections (observation of dissection or prepared preparations), developing models including 3D printing, and making histology and histopathology slides (14). These in turn can be used to develop multimedia, virtual and physical museums and in addition to content for reference textbooks and research papers and student assignments. The cadavers used in dissection also often provide valuable opportunities to help create images and tissues in preparation for student practical examinations to test knowledge gained. Although many of these tools are relatively new, we know models for example, as well as dissection, have been used for centuries. Anna Morandi Manzolini (1714-74) was selling her wax models based upon her dissections throughout the world (15). Ultimately, these tools can be used alongside dissection to create a more clinically integrated curriculum, which has proved to be a popular with learners (16-18).

Dissection involves the meticulous work of removing the connective tissue that surrounds the various structures and organs and involves gradually uncovering the structures that make up each region of the body and their relationships, all of which are lost with virtual anatomy or the use of anatomical models. Some may argue that this approach takes more time, with less time often given when teaching using non-dissection techniques (19). Another relevant topic acquired in the dissection room is the varied interactions with the student. Educators in the dissection room teach students how to communicate effectively, access information, interact with their peers and learn teamwork, which may additionally help students manage the stress of college/university, especially in the early years. These interactions may also provide enjoyable collaboration times for students, and provides a hands-on approach to learning anatomy (20). It should be noted that integrated teaching using prosections and other teaching tools can also be teacher led and include collaborative and teacher-learner interaction time. For example, in a spiral curriculum investigating both dissection and prosection teaching, alongside clinical skills, students overwhelmingly valued and enjoyed both dissection and prosection learning (20, 21). Importantly these students also reported motivation to learn anatomy in this system and appreciated linking clinical aspects to anatomical learning.

Given the benefits and long history of anatomical dissection for medical and scientific courses (22), what are the challenges facing anatomists in the use of this technique? Many universities and colleges, and of course our students and the public, consider the ethics behind using cadavers. Universities choose to invest time and money into collecting cadavers in the most ethical manner, with all required permits and with owner consent. This may be via body donation programmes or via local clinics, shelters, zoos and

resonanca (MR), pripravo histoloških ali histopatoloških preparatov, prosekcijo (opazovanje disekcije ali že pripravljenih preparatov) in tudi razvoj modelov za 3D-tiskanje (14). Hkrati so materiali uporabni še za izdelavo multimedijskih, virtualnih in klasičnih muzejev ter služijo kot dopolnitev referenčnim učbenikom, raziskovalnim nalogam in študentskim projektom. Kadavri, uporabljeni pri disekciji, so pogosto ključni za pripravo praktičnih delov študentskih izpitov, saj nudijo priložnosti za ustvarjanje slikovnega gradiva in tkiv ter kot taki služijo za preverjanje pridobljenega znanja. Medtem ko so sodobna učna orodja relativno nova, je uporaba modelov, prav tako kot sekcije, v anatomiji dolgotrajna tradicija. Na primer, Anna Morandi Manzolini (1714–1774) je ustvarjala in prodajala natančne voščene anatomske modele, izdelane na podlagi svojih disekcij, kar je pripomoglo k razvoju poučevanja anatomije po vsem svetu (15). Sodobno poučevanje anatomije vse bolj vključuje uporabo različnih učnih orodij v kombinaciji z disekcijo, kar omogoča razvoj kurikulumu predmeta in tako dodatno vključuje še klinični pomen poznavanja anatomije. Pristop, ki povezuje praktično delo z razumevanjem kliničnih primerov, je med študenti izjemno priljubljen in se je izkazal za zelo učinkovitega pri krepitevi znanja in veščin, za katere želimo, da jih študenti osvojijo (16–18).

Disekcija zahteva natančno odstranjevanje vezivnega tkiva, ki obdaja različne strukture in organe, ter omogoča postopno odkrivanje anatomske strukture in njihovih medsebojnih povezav. Te ključne informacije se pri uporabi virtualne anatomije ali anatomskega modela pogosto izgubijo. Čeprav nekateri trdijo, da poučevanje z alternativnimi metodami brez disekcije zahteva manj časa, je pri teh tehnikah pogosto zanemarjena poglobljena obravnava anatomskega odnosa med strukturami (19). Poleg spoznavanja anatomske strukture disekcija omogoča raznolike interakcije med študenti in predavatelji. V sekciji se študenti naučijo učinkovite komunikacije, dostopanja do informacij in sodelovanja z vrstniki, timskega dela, kar jim lahko pomaga pri obvladovanju stresa, zlasti v zgodnjih letih študija. Te interakcije ponujajo tudi priložnost za prijetnejše sodelovanje in praktičen pristop k učenju anatomije (20). Celostno poučevanje, ki vključuje disekcijo, prosekcije in druge učne metode, ustvarja prostor za sodelovanje in interakcijo med učitelji in študenti. Na primer, t. i. spiralni kurikulum, ki združuje disekcijo, prosekcije in osnove osvajanja kliničnih veščin, je med študenti izjemno cenjen. Študenti poročajo o večji motivaciji za učenje anatomije, saj pristop učinkovito povezuje anatomske izobraževanje s kliničnimi primeri (20, 21). Disekcija tako ostaja nepogrešljivo orodje za poglobljeno razumevanje anatomije, ker ponuja ne le tehnične in klinične veščine, temveč tudi pomembne izkušnje sodelovanja, komunikacije in praktičnega učenja.

Kaj so številni izzivi kljub dolgi tradiciji in mnogoterim prednostim anatomske disekcije za medicinska in znanstvena izobraževanja (22), s katerimi se anatomici soočamo pri uporabi te tehnike? Eden ključnih izzivov, s katerim se sooča veliko univerz in fakultet, je obravnava etičnosti uporabe kadavrov, kar vključuje spoštovanje do lastnikov, ki svoje živali darujejo,

farmers. This ensures animals are not bred or euthanised specifically for dissection. It also helps students, and the public, understand that ethical routes are used to procure cadavers. These ethical considerations are often discussed openly with students and accreditation boards, and cadaver use policies are often formed following consultations with stakeholders. It is also widely recognised that anatomical dissection can be expensive. It takes academic and technical time to prepare specimens, teach the classes, prepare examinations and manage the specimens. Naturally there is also a cost to the specialist equipment and space needed to conduct these classes (including chemicals, refrigeration, tables, lighting, instruments, room ventilation, health and safety consumables and equipment, owning appropriate transport). It should be noted that alternative methods of teaching also require time, teachers and money, but possible at a lower cost due to their reuse and sharing of multimedia resources between universities. Increasingly health and safety laws and local rules look at the use of chemicals such as commonly used fixatives. Monitoring and adhering to these regulations, and adapting to new regulations, can require specialist equipment, time, changes in practice and complexities in finding appropriate chemicals. Implementing these all have cost and time implications of course, but also require the skills to navigate new laws and regulations. These regulations are all designed to maximise health and safety of all technicians, academics and of course students, in addition to any others potentially impacted such as housekeeping staff. Frequently universities provide occupational health to support staff frequently working in these areas too. It should also be noted that whilst students often report the value of dissection classes and may benefit from time working together and with teachers, this learning style may in itself be stressful for some students (23). While students may find anatomical dissection challenging, there is limited research comparing their experiences in clinical situations when dissection has not been part of their university training.

Dissection of cadavers has been used in human and veterinary medical education since the 16th century and was documented to be in use for research well before this (14, 24, 25). However, since the 1980's, some universities reduced or even ceased using this form of teaching (10, 26). Interestingly, many of the medical schools that ceased dissection reinstated it following research into decreasing pedagogical skills and a negative impact on surgical skills resulting in reduced patient safety (10, 27-29). Others increased the levels of dissection teaching in postgraduate courses to compensate for reductions at an undergraduate level (29, 30), but notably this was reported in human medicine. This difference is essential as veterinary medicine graduates do not enter a period of compulsory supervised post-graduate study, therefore these vital skills must be achieved within the undergraduate curriculum. Many schools offering modern curricula have integrated dissection within clinical contexts and settings, and have added complimentary techniques, as opposed to anatomy and

in transparentnost pri pridobivanju vzorcev. Univerze vlagajo čas in sredstva v zagotavljanje, da so kadavri pridobljeni na etičen način, z vsemi dovoljenji in izrecnim soglasjem lastnika. Takšna darovanja kadavrov ter sodelovanje z lokalnimi klinikami, zavetišči, živalskimi vrtovi in kmeti zagotavljajo, da živali niso vzrejene ali evtanazirane izključno za disekcijo. Take etične prakse študentom in javnosti pomagajo razumeti pomen odgovornega pridobivanja kadavrov, hkrati pa so pogosto predmet odprtih razprav z različnimi komisijami, akreditacijskimi odbori in drugimi zainteresiranimi stranmi. Oblikujejo se politike uporabe kadavrov, ki temeljijo na posvetovanjih in transparentnosti. Številne univerze in visoke šole ter seveda naši študenti in javnost upoštevajo etičnost uporabe kadavrov. Drug pomemben izziv so visoki stroški anatomske disekcije. Priprava vzorcev, organizacija predavanj, praktičnih vaj in izpitov zahtevata znaten akademski in tehnični čas. Prav tako so potrebne finance, povezane z nabavo specializirane opreme in infrastrukture, vključno s kemikalijami, hlajenjem, razsvetljavo, mizami, orodji, prezračevalnimi sistemi in varnostno opremo. Poleg tega zakonodaja o zdravju in varnosti, skupaj z lokalnimi predpisi, ureja uporabo fiksativov, kar lahko povzroči dodatne stroške in potrebo po prilagoditvah v praksi. Prilagajanje tem regulacijam zahteva čas, opremo in spretnosti, vendar so ti predpisi namenjeni zagotavljanju zdravja in varnosti za vse vpletene – od tehnikov in asistentov, profesorjev do študentov in drugega sodelujočega podpornega osebja. Mnogo univerz zagotavlja tudi dodatno zdravstveno podporo osebju, ki redno dela v takšnih okoljih. Kljub številnim prednostim disekcije nekateri študenti poročajo, da je ta metoda učenja lahko stresna (23). Čeprav se študentom anatomska disekcija včasih zdi zahtevna, obstaja le malo raziskav, ki bi primerjale njihove izkušnje v klinični praksi z izkušnjami tistih, ki med univerzitetnim izobraževanjem niso opravljali disekcije.

Disekcija kadavrov se v humani in veterinarski medicinski izobrazbi uporablja že od 16. stoletja, njena uporaba v raziskovalne namene pa je dokumentirana že veliko prej (14, 24, 25). Vendar pa so v osemdesetih letih prejšnjega stoletja nekatere univerze zmanjšale ali celo prenehale uporabljati to obliko poučevanja (10, 26). Zanimivo je, da so številne medicinske šole, ki so opustile to metodo, ponovno uvedle disekcijo po ugotovitvah raziskav, ki so pokazale negativne posledice za poznavanje anatomije in kasneje za sposobnost izvajanja kirurških postopkov, saj je pomanjkanje praktičnih veščin vplivalo na varnost pacientov (10, 27–29). Nekatere institucije so povečale obseg poučevanja z uporabo disekcije na ravni poddiplomskega izobraževanja, da bi nadomestile zmanjšan obseg na ravni dodiplomskega izobraževanja (29, 30). Ta pristop je bil pogostejši v humani medicini, kjer diplomanti po zaključenem dodiplomskem izobraževanju vsotopajo v obvezna obdobja nadzorovanega poddiplomskega študija. Veterinarska medicina pa tega ne predvideva, zato morajo študenti ključne veščine pridobiti že med dodiplomskim študijem. Sodobni učni načrti vključujejo disekcije v kliničnem kontekstu in jih dopolnjujejo s tehnološko podprtimi metodami, namesto da bi bila anatomija s sekcijo samostojen predmet (28, 31, 32). Poleg disekcije obstajajo številna

dissection being standalone subjects (28, 31, 32). There are many tools used to compliment dissection based anatomical learning. In cases where universities have ceased dissection these will, or would have been, the only resources available to students. Prosections or plastinated products are final products, where the dissection work has already been done usually by academic or technical staff or on occasion by students themselves. Non tissue models of organs/systems/cells, formalin fixed tissues and models originally derived from animal tissues such as corrosion casts and preserved tissue sections are also commonly used in teaching and share many features common to prosections and plastinated samples. When using technological resources and multimedia resources, such as different types of virtual anatomy software (even further from reality from prosections), many are based on images, videos or scans (such as MRI, computed tomography, X-ray). In some cases, these are based on a single animal, from one species, which may be considered the same or worse than using plastinated preparations given the lack of specimen variation. As time passes, many of the resources are increasing the variety of animals used in their resources though.

These types of anatomical models, or methods of learning anatomy, do not generally enable the experience of hands-on dissecting by the student. By removing the connective tissue surrounding the organs, all structures are immediately exposed to the learner. When using the non-dissection teaching tools mentioned, there is no dissection or discovery of structures, this may provide less appreciation of anatomical variability for the learner. The student does not learn key pre-surgical skills such as working with scalpels, cutting tissue or a experiencing the emotions related to working with a cadaver. The structures are often presented to the student in non-dissection-based methods, rather than a true exploration of structures as is often the case in dissection learning. In dissection there are usually no answers readily available as to the name of each structure. In contrast, and both a strength and a weakness, other learning tools such as videos, books, models, online tools, virtual reality, augmented reality and others, may provide labelled structures. Although dissection costs are generally relatively large, a great deal of expertise and time is also often required to create these non-dissection teaching tools, and frequently some of the cost is covered by reusing cadaver material from anatomical dissection. Some non-dissection techniques still require the use of chemicals and time from experts (e.g. plastination). Other non-dissection techniques may need investments in appropriate software and accompanying hardware devices such as headsets for virtual reality, or the purchase of a virtual reality dissection 'anatomy table' (33).

Many of these non-dissection tools will have been developed over many years and despite some disadvantages, their benefits are vast. Indeed, the authors of this article have been involved in creating many learning tools for their students, and those further afield, to compliment dissection

orodja, ki podpirajo učenje anatomije. V primerih, ko so univerze opustile disekcijo, so ta orodja pogosto postala ali pa bodo postala edini vir, ki je na voljo študentom. Prosekcije in plastinirani preparati so končni izdelki, pri katerih je disekcijo izvedlo strokovno osebje ali včasih študentje sami. Pri poučevanju se pogosto uporabljajo tudi netkivni modeli organov/sistemov/celic, tkiv, fiksiranih s formalinom, in modeli, prvotno pridobljeni iz živalskih tkiv, kot so korozijski odlitki in ohranjeni deli tkiva. Ti imajo veliko skupnih značilnosti s prosekcijami in plastiniranimi vzorci. Tehnološki viri, kot so programske opreme za virtualno anatomijo, ponujajo dodatne možnosti. Te platforme temeljijo na slikah, video-posnetkih ali skeniranju, kot so MR, CT in rentgenske slike. Vendar pa so takšni viri v nekaterih primerih omejeni na eno samo živalsko vrsto, kar se lahko šteje za enako ali slabše od uporabe plastiniranih preparatov glede na pomanjkanje vzorcev različnih živalskih vrst. Sčasoma se pri mnogih virih povečuje raznolikost živali, ki se uporabljajo. Postopoma se sicer povečuje število vrst, ki so vključene v te vire, vendar ti pogosto ostajajo dopolnilna orodja, ki ne morejo v celoti nadomestiti praktičnih izkušenj disekcije.

Alternativne metode učenja anatomije, kot so modeli ali multimedijaska orodja, študentom običajno ne omogočajo praktične izkušnje seciranja. Pri uporabi teh pristopov so vezivna tkiva, ki obdajajo organe, že odstranjena, kar pomeni, da so vse strukture takoj izpostavljene študentu. Tak način študija onemogoča proces postopnega odkrivanja anatomskih struktur, ki je osnova disekcije, zato lahko študent manj ceni anatomsko variabilnost. Poleg tega študentje pri teh metodah ne pridobijo ključnih predkliničnih veščin, povezanih s kirurgijo, kot je natančno delo s skalpelom, pravilno rezanje tkiva ali obvladovanje čustev, povezanih z delom s kadavri. Pri alternativnih metodah so strukture običajno predstavljene kot že prepoznane in označene, kar lahko omeji sposobnost študentov za samostojno raziskovanje in identifikacijo anatomskih struktur. Nasprotno je pri disekciji pogosto potrebno aktivno raziskovanje, saj odgovori, kot so imena posameznih struktur, niso takoj na voljo. To spodbuja bolj poglobljeno učenje in razumevanje anatomije. Čeprav so stroški izvajanja disekcije pogosto visoki, tudi ustvarjanje učnih orodij brez disekcije zahteva ogromno strokovnega znanja in časa. Paradoksalno je, da se veliko teh virov še vedno opira na material iz disekcije, kar vključuje pripravo vzorcev za plastinacijo ali druge tehnike. Nekatere metode brez seciranja, kot je plastinacija, prav tako zahtevajo uporabo kemikalij in dodatnega strokovnega časa. Poleg tega so za naprednejše tehnike brez disekcije, kot so virtualna resničnost (VR), obogatena resničnost (AR) ali uporaba anatomske mize za navidezno seciranje, potrebne visoke finančne naložbe v programsko in strojno opremo. To vključuje tudi nakup očal VR ali drugih naprav, kar lahko predstavlja dodatno finančno obremenitev (33).

Kljub določenim omejitvam imajo alternativna učna orodja brez disekcije številne prednosti in velik potencial za nadaljnji razvoj. Avtorji tega članka so bili dejavni pri ustvarjanju takšnih orodij, ki dopolnjujejo učne ure disekcije, tako za

lessons. Appropriate laboratory spaces are required to create models and prosections, as are chemicals, waste disposal and technician and academic time, but this is usually on smaller scale than compared to dissection classes, and specimens often last longer and digital assets can be used indefinitely (if they are updated and supported by the correct technology). Increasingly, 3D methods are emerging which add to the user experience when learning anatomy. These resources may be accessible outside of the dissection room, are easy to provide to students without staff interaction, can be less expensive, and indeed many are developed by anatomists themselves. As these tools advance, they are frequently adding more specimens and combining information from a variety of sources. This may give the learner access to species they may not encounter regularly in person, for example more exotic species. These tools are widely accepted, enjoyed, and appreciated by students and educators alike but are not seen by them as a replacement for cadaver dissection (33-36).

Anatomy has always been taught by dissection, but nowadays the frequently reported reduction in experienced teaching staff, reductions in anatomy teaching time, and difficulties in obtaining cadavers have reduced in some cases reduced the availability of dissection (26). There is an alarming trend away from time spent in dissection with little evidence-based research on the overall impact on learning and skills, both as a student and during later careers (26). Research into learner outcomes tends to be based on whether anatomical structures can be named by learners in examinations (for example following dissection vs. non-dissection-based teaching), and not on other key skills potentially gained such as confidence and surgical competence. This is true for all types of learning at undergraduate level and is a known limitation in researching long term skills and knowledge related to any of these teaching and learning tools.

Some research into dissection based learning versus digital learning indicated better retention of information and more student satisfaction when learning through dissection, whilst other studies show better outcomes following dissection based teaching (37). The abandonment of dissection in some areas may have reduced anatomical knowledge or skills, but this reduction may take many decades to observe and is complex to quantify. Research in human medicine has shown the complexities involved in removing dissection, which ultimately meant an increase in postgraduate levels or reinstating dissection in undergraduate studies. In human medicine the longer term outcomes of reduced dissection or temporary removal of dissection (usually reinstated following problems in later or clinical years) has taught our profession many valuable lessons, especially in terms of information and skills lost when dissection is not utilised (28). At the same time, people have been noting a noticeable reduction in the number of qualified instructors and therefore researchers (10). Decision makers working in disciplines far away from anatomy may not understand the

lastne študente kot za širšo strokovno javnost. Za izdelavo teh modelov in sekcij so potrebni laboratorijski prostori, kemikalije, tehnični in akademski čas ter ustrezno odstranjevanje odpadkov. Vendar so te zahteve pogosto manj obsežne v primerjavi z zahtevami fakultet, ki pri študiju vključujejo disekcijo. Ustvarjeni preparati so dolgotrajni, digitalna sredstva na drugi strani pa omogočajo praktično neomejeno uporabo, če so ustrezno posodobljena in podprta s primerno tehnologijo. Sodobne 3D-metode so vse bolj vključene v poučevanje anatomije, saj izboljšujejo uporabniško izkušnjo in ponujajo nove možnosti za učenje. Prednosti teh virov so v njihovi dostopnosti izven učilnic, enostavni distribuciji brez potrebe po sodelovanju osebja in pogosto nižjih stroških. Veliko takšnih orodij anatomi razvijejo sami, kar omogoča prilagoditev potrebam posameznih študentov in programov. Napredovanje teh tehnologij prinaša vključevanje več primerkov in združevanje informacij iz različnih virov, kar omogoča dostop do vrst, s katerimi se študentje redkeje srečujejo v praksi, kot so na primer bolj eksotične vrste. Taka raznolikost povečuje vrednost učnih orodij, saj študentje pridobijo širši vpogled v anatomske razlike. Študentje in učitelji ta orodja splošno sprejemajo, uživajo v njihovi uporabi in jih cenijo, vendar jih večina ne dojema kot nadomestek za disekcijo trupel, temveč kot dopolnilo h klasični metodi učenja s pomočjo disekcije (33–36).

Disekcija je tradicionalno veljala za temelj poučevanja anatomije, vendar se sodobni izobraževalni sistemi pogosto soočajo z izzivi, kot so pomanjkanje izkušenega učiteljskega osebja, skrajševanje časa, namenjenega anatomiji, in težave pri pridobivanju kadavrov, kar je v številnih primerih privedlo do zmanjšane razpoložljivosti disekcije (26). Pojavlja se še skrb vzbujajoč trend skrajševanja časa, namenjenega disekciji, pri čemer primanjkuje raziskav, ki bi temeljile na dokazih in bi celovito analizirale vpliv skrajšanja na učenje ter razvoj ključnih veščin, tako med študijem kot v kasnejši karieri (26). Študije pogosto ocenjujejo učne rezultate na podlagi sposobnosti študentov, da na izpitih prepoznajo in poimenujejo anatomske strukture, vendar redko vključujejo oceno drugih ključnih veščin, pridobljenih z disekcijo, kot sta samozavest in spretnost dela s skalpelom in pinceto. Ta omejitev je značilna za vse vrste dodiplomskega izobraževanja in opozarja na potrebo po boljšem raziskovanju dolgoročnih vplivov različnih metod poučevanja na znanje in veščine, ki jih študenti pridobijo. Razumevanje teh učinkov bi lahko pomembno prispevalo k izboljšanju učnih načrtov in oblikovanju učinkovitejšega poučevanja anatomije.

Raziskave primerjave disekcije in digitalnega učenja nakazujejo, da učenje, ki temelji na disekciji, pogosto prinaša boljše ohranjanje informacij in večje zadovoljstvo študentov. Nekatere študije poročajo tudi o boljših rezultatih po poučevanju z uporabo disekcije (37). Kljub temu lahko opustitev disekcije na nekaterih področjih vodi do zmanjšanja osnovnega anatomskega znanja ali praktičnih spretnosti, čeprav lahko traja desetletja, da se te spremembe v celoti razkrijejo in kvantificirajo. V humani medicini so posledice zmanjšane uporabe disekcije ali njenega

importance of dissection, especially if they are not anatomists, but it is recognised that one concern they may have relates to the economics of this teaching method.

Although technological resources and anatomical models are very useful and enhance and complement the learning experience, we believe that they cannot fully replace dissection in the veterinary and human anatomy teaching. Gummery and coauthors (21) highlighted perceptions of students in later years, and those of recent graduates, who emphasised the importance of the skills and techniques they learnt in dissection. Although anatomy is traditionally considered a basic science, anatomical learning, including dissection, increasingly integrates and links clinical techniques and skills, especially in spiral and vertically integrated curricula. Clinical (or applied) anatomy is often described as the practical application of anatomical knowledge to diagnosis and treatment. Veterinary medicine curricula are increasingly teaching clinical anatomy. The American Association of Clinical Anatomists defines clinical anatomy as "anatomy in all its aspects - gross, histologic, developmental and neurologic as applied to clinical practice, the application of anatomic principles to the solution of clinical problems and/or the application of clinical observations to expand anatomic knowledge" (38). Meanwhile the World Association of Veterinary Anatomists (WAVA) promotes and represents veterinary anatomy, by "encouraging research, promoting the use of modern teaching methods and better knowledge of anatomy in applied science, and encouraging the exchange of information" (39).

Together, curriculum revisions, introduction of novel innovative techniques, and the introduction of clinical skills courses in the early years have led to reduction and even elimination of animal cadaver dissection from some anatomy courses. We believe that modern teaching methods need not shy away from well-established techniques such as dissection. Instead, they should integrate the valuable skills and information gained from dissection with other complementary anatomical learning techniques. This can be done in a clinically relevant manner within thoughtfully designed curricula, incorporating blended learning opportunities that enhance learner motivation and engagement.

začasnega umika pogosto zahtevale povečanje podiplomskih programov ali ponovno uvedbo disekcije v dodiplomske kurikule. Dolgoročni rezultati so razkrili izgube v znanju in spretnostih, ki so pomembno vplivale na klinično prakso, kar je prineslo dragocene lekcije za anatomsko izobraževanje (28). Hkrati pa se soočamo še z opaznim upadom števila usposobljenih inštruktorjev, kar negativno vpliva tudi na raziskovalno dejavnost na področju anatomije (10). Odločevalci, ki niso specializirani za anatomijo, pogosto ne razumejo ključnega pomena disekcije, kar je še posebej očitno, ko gre za presojo ekonomičnosti te metode poučevanja. Vendar je treba priznati, da disekcija prinaša nenadomestljive pedagoške in klinične koristi, ki jih alternativne metode ne morejo v celoti posnemati.

Čeprav so tehnološki viri in anatomske modeli izjemno koristni ter pomembno prispevajo k izboljšanju in dopolnjevanju učnega procesa, menimo, da ne morejo povsem nadomestiti disekcije kot temeljne metode pri poučevanju veterinarske in humane anatomije. Gummery in sod. (21) so poudarili perspektive študentov višjih letnikov in nedavnih diplomantov, ki so izpostavili pomen poznavanja tehnik in spretnosti, pridobljenih z disekcijo. Tradicionalno je bila anatomija obravnavana kot temeljna znanost, vendar se anatomske učenje, vključno z disekcijo, vedno bolj prepleta s kliničnimi tehnikami in praktičnimi veščinami. To je še posebej opazno v spiralnih in vertikalno integriranih učnih načrtih, kjer klinična anatomija predstavlja povezavo med teoretičnim znanjem in njegovo praktično uporabo. Klinična anatomija, opredeljena kot praktična uporaba anatomskega znanja pri diagnozi in zdravljenju, pridobiva vse večji pomen v veterinarskih učnih načrtih. Ameriško združenje kliničnih anatomov jo opisuje kot interdisciplinarno področje, ki združuje različne vidike anatomije, kot so makroskopska, mikroskopska, razvojna in nevrološka anatomija, ter njihovo uporabo v klinični praksi (38). Svetovno združenje veterinarskih anatomov (WAVA; iz angl. *World Association of Veterinary Anatomists*) pa promovira veterinarsko anatomijo z raziskavami, sodobnimi učnimi metodami in širjenjem znanja, da bi izboljšali razumevanje anatomije kot uporabne znanosti (39). Združevanje disekcije in dopolnilnih učnih orodij je zato ključno za ohranjanje visokih standardov izobraževanja in pripravo študentov na praktične izzive v kliničnem okolju.

Spremembe kurikuluma, uvedba inovativnih tehnik in vključitev poučevanja kliničnih veščin v zgodnjih letih študija so privedle do zmanjšanja ali celo opustitve seciranja živalskih kadavrov v nekaterih anatomske programih. Vendar menimo, da sodobne učne metode ne bi smele izključevati dobro uveljavljenih tehnik, kot je sekcija. Nasprotno, k dragocenim veščinam in znanju, pridobljenem z disekcijo, je treba vključiti še druge komplementarne anatomske učne pristope. To lahko dosežemo na klinično relevanten način z oblikovanjem premišljenih kurikuluma, ki združujejo različne učne metode in spodbujajo motivacijo ter aktivno sodelovanje študentov.

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