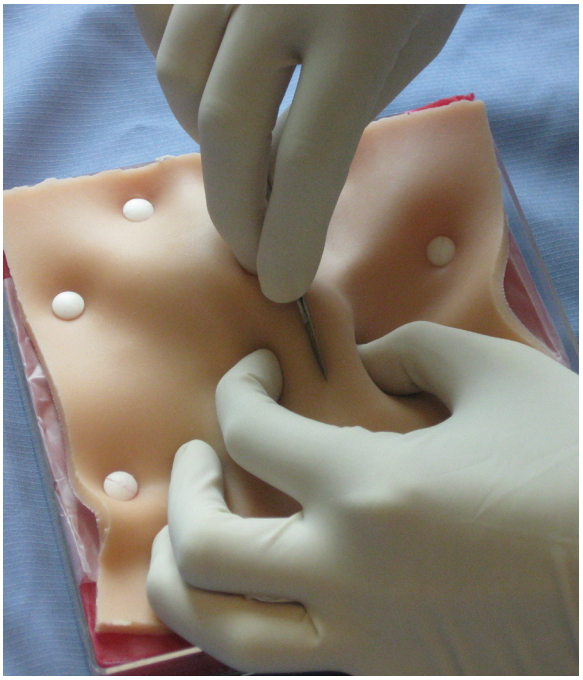

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AAVMC Use of Animals in Veterinary Education Handbook

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AAVMC Use of Animals in Veterinary Education Handbook

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PREFACE

Animals are commonly used in veterinary education to teach fundamental concepts including anatomy, diagnostic imaging, animal behavior, handling, physical examination, and clinical skills. While some animal use may be replaced by alternatives including models or technology, other uses remain important in providing professional-level training for veterinary students.

Veterinary educators are obligated to protect animal welfare during any animal use. Protecting animal and human safety is also of critical importance. Animal use in education is impacted by the ethics and morals held by the people involved in veterinary education—both the educators and the students, and change can and has historically been driven by both groups. Ethics are principles held by a group of people that shape individuals within the group, while morals are individuals' views about what is right and wrong. Ethics and morals are not timeless or universal; they can change over time and differ among institutions and geographic regions.

In 2022, the AAVMC published the *Guidelines for the Use of Animals in Veterinary Education* (AAVMC et al., 2022). The *Guidelines* were created by the Task Force on the Use of Animals in Veterinary Education, a group of veterinary educators selected from nine AAVMC member colleges on three continents, representing disciplines including anatomy; small animal, equine, and food animal clinical skills; and clinical year training. The aim of the *Guidelines* was to provide guidance for AAVMC member schools on how to improve their animal use policies, use of animal alternatives, and transparency. The two-page *Guidelines* provided recommendations for institutions to annually review their animal use, including cadaver use, from sourcing to disposition, ensuring that use is guided by the 4Rs (replacement, reduction, refinement, and respect). The *Guidelines* recommended that alternatives replace non-essential animal use where appropriate and advocated for transparent reporting of animal use information to students, faculty, and staff annually. There was no recommendation for reducing clinical caseload or medically necessary veterinary care.

While the *Guidelines* provided overarching principles and broad recommendations for the use of animals in veterinary education, the short document did not delve into how institutions could implement its recommendations. As the Task Force wrote the *Guidelines*, they conceived of a second, longer document that would explain in more detail how institutions could implement the recommendations laid out in the *Guidelines*. The *AAVMC Use of Animals in Veterinary Education Handbook* is that second, more detailed document, written by authors chosen by the *Task Force* as experts in their fields.

The *Handbook* is divided into two parts. The first part, chapters 1 through 4, is devoted to the use of cadavers and cadaver parts, which may be used in teaching veterinary anatomy, clinical skills, and other disciplines. The second part of the *Handbook*, chapters 5 through 11, discusses the use of live animals, which may be used in many facets of veterinary education. The section of the *Guidelines* relevant to cadavers and live animals are provided before the first and second parts of the *Handbook*, respectively. Readers are encouraged to review the entire two-page *Guidelines* (Appendix 1) prior to reading the *Handbook*.

The Task Force members and the Editors sincerely hope that both the *Guidelines* and the *Handbook* will further contribute to progress in the field of veterinary education, including the promotion of effective animal alternatives and the support of animal welfare, animal ethics, and the safety of veterinary students and the animals with which they learn.

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SECTION 1:
Cadaver Acquisition & Use

AAVMC Guidelines for the Use of Animals in Veterinary Education

Animal use within veterinary education should provide professional level opportunities for students to acquire the knowledge, skills, and attributes necessary to prevent, control, diagnose, and treat medical, surgical, and behavioral conditions in animals in a way that is humane, respectful, and welfare appropriate for all animals used in the educational process.

Animal use should be guided by 4 Rs (replacement, reduction, refinement, and respect) and must be compliant with applicable laws and regulations. Veterinary institutions should critically evaluate all animal use to determine if it is necessary to achieve educational outcomes. Institutions should explore and implement alternatives where appropriate to minimize animal use while maintaining student competence.

Institutions should establish a formal policy for the critical evaluation of animal source and use as part of the educational mission. Institutions should demonstrate transparency by reviewing, presenting, and discussing information about the source and use of all animals, cadaver and live, with students, faculty, and staff at least annually.

Cadaver Acquisition & Use

Institutions using cadavers in teaching should:

1. Implement respectful methods of cadaver acquisition, use, and final disposition appropriate to local context and culture.
2. Implement a policy for auditing and evaluating cadaver use; implementing replacement, reduction, and refinement of use where appropriate and possible; and reporting to the institution's senior veterinary administration at least annually.
    A. Alternative instructional models and technology should be considered where effective to meet learning objectives.
    B. Cadavers should be used strategically, purposefully, and to the fullest extent possible.
3. Responsibly and ethically source their cadavers, when cadaver use is necessary in the veterinary curriculum.
    A. Whenever possible, animals should not be euthanized solely for educational purposes; cadavers used in teaching should be sourced from animals that have died or are euthanized at or nearing the end of their natural and/or productive life.
    B. Willed body donation programs, in which the donation is accompanied by owner consent, can serve as an ethical source of cadavers.
    C. If necessary, cadavers or live animals may be purchased. Institutions should work towards establishing auditing processes to ensure transparency in ethical sourcing.

To cite the *Guidelines*:

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CHAPTER 1: Best Practices for Teaching Veterinary Anatomy in a Contemporary Curriculum

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Introduction

The use of animals, both live and cadaveric, has historically been an integral part of anatomy teaching. However, in line with best ethical practice, as well as the rise of other challenges such as cost, curriculum time, student numbers (versus animal availability), and health and safety regulations (e.g., legally enforced environmental limits for formaldehyde), the place of animals within veterinary anatomy curricula is being more carefully considered. In this chapter we consider how anatomy teaching has evolved in line with changing veterinary curricula, new technologies, and an evolving pedagogical understanding of what makes anatomy teaching effective and relevant. The new opportunities and teaching methods discussed in this chapter open doors for educators to further consider refining the way in which animals are used within anatomy teaching alongside the development and modernization of their curricula.

Anatomy within a traditional veterinary curriculum

Anatomy has long been a cornerstone of veterinary, medical, and allied healthcare courses. It is the foundation for understanding the normal function of animals, and for recognizing the effects of injury, disease processes, or abnormal development. Sound comprehension of topographical relationships is essential for carrying out clinical examinations, interpreting diagnostic images, and for the safe performance of surgical and clinical procedures. Since the early 1900s, anatomy has been taught as a basic science module, setting the foundation for clinical disciplines delivered later in the curriculum (Flexner et al., 1910). Mirroring medical curricula, veterinary anatomy has traditionally occupied extensive time and resources in the curriculum delivering anatomical detail across species. Methods of teaching have traditionally been didactic in style, heavily focused on detailed, descriptive lectures and the comprehensive dissection of cadavers. Many have professed dissection as a key tool in the acquisition of anatomical knowledge, providing students with considerable time on task and exposure to individual variation. Further, the process of dissecting can develop dexterity skills and offer opportunities to develop non-technical skills such as teamwork and time management.

Evolution of curricula: challenges and opportunities for anatomy

Following calls for reform in the 1990s, clinical curricula increasingly have shifted toward outcome-based education (OBE) (Davis, 2003). This focus on the capabilities of the new graduate has seen anatomy repositioned to become more integrated within veterinary curricula. Veterinary anatomy has increasingly become embedded into systems-based modules through horizontal integration with other basic science subjects. Vertical integration of clinical and professional skills into early-year teaching has resulted in a reduction in time allocated to basic science content including anatomy teaching. Consequently, many institutions have reviewed basic science content including anatomy to remove extraneous detail which can overburden students and lead to surface learning approaches.

A clinically integrated curriculum provides opportunities for learning in context, which improves knowledge retention and recall, and facilitates deep approaches to learning. Further, applied anatomical teaching shifts the focus from rote learning of facts such as the origins and insertions of muscles and their function, to problem-solving, such as how a lesion in a particular nerve may affect limb function. OBE, and a focus on clinically relevant anatomy, allows for the integration of clinical skills such as diagnostic imaging, surgical techniques, and physical examination. The inclusion of these clinical skills in practical

teaching has been found to increase intrinsic motivation in veterinary students (Gummery et al., 2018), which is known to promote deep learning approaches. True vertical integration through a spiral curriculum (Harden, 1999) facilitates not just the integration of clinical concepts in early years, but also the opportunity to deepen understanding of anatomical concepts in clinical years, maintaining time spent on anatomy, and promoting knowledge retention through repetition. Planning, delivering, and reviewing an effective integrated curriculum relies on collaboration between basic scientists and clinicians, which ensures both scientific rigor and clinical relevance are maintained.

What anatomy does today's veterinary graduate need to know?

Outcome based veterinary curricula develop and assess essential competencies required for a newly qualified veterinarian (e.g., Day One Competencies, and Entrustable Professional Activities). For anatomy, the specific knowledge needed at Day One is difficult to define due to the highly variable roles and career destinations for graduate veterinarians. Any attempt at identifying required 'core' knowledge needs to consider the differing environments that graduates may eventually work within, including species specialization and work settings such as general or referral practice and non-clinical career paths including academia, government, industry, and others. Recent work has aimed to define a core syllabus for veterinary anatomy (Gummery et al., 2023); nevertheless, this research targeted only the minimum level of knowledge required. This strong foundation of clinically relevant anatomical knowledge would then need to be built upon as graduates gain experience and exposure to a range of cases and clinical problems, thus developing and refining a personal working knowledge of anatomy (Wheble & Channon, 2021). Graduates must be equipped with sufficient information literacy, lifelong learning skills, and a good degree of uncertainty tolerance to enable them to proactively build on their core knowledge when required ('just in time learning'). Failure to do so may result in reduced confidence and resultant changes to the way they carry out clinical work (Wheble & Channon, 2021; Homfray et al., 2022).

When considering how much anatomical knowledge a graduate veterinarian needs, it is over simplistic to consider only knowledge-based learning outcomes, since the manner of use of anatomy knowledge is highly practical and interwoven within clinical and professional activities (Wheble & Channon, 2021; Homfray et al., 2022). Veterinarians use anatomical knowledge during physical examinations, when carrying out and interpreting a broad toolkit of diagnostic imaging including the 'oscopies,' and when performing clinical procedures, surgery, and dentistry. Anatomical knowledge is applied physically and dynamically during such procedures through palpation, observation, and the application of spatial skills and mental imagery; all of these may be necessary to complete a task. Anatomical knowledge is vital for making comparisons, such as evaluating normal versus abnormal, or identifying non-pathological anatomical variation. Correct and familiar use of anatomical terminology is also paramount for successful verbal and written communication with clients and colleagues. For these reasons, the principal concern in modern anatomy education is that core anatomy knowledge be taught in context and in a way that it can be readily applied in clinical practice.

Authentic clinically relevant contexts

The context in which anatomy is taught is critical to improving knowledge retention, highlighting the relevance of the information, and thus motivating students to learn. The use of live animals can provide a highly authentic context for anatomy teaching (see Chapter 5 for more detail) allowing students to link topographical anatomy to clinically relevant skills such as animal handling, clinical examination, and palpation techniques. In some medical schools, the live human has replaced the cadaver entirely (Smith et al., 2022), with students focusing on live topographical anatomy through physical examination, auscultation, and sometimes drawing or painting on live models. These ways of learning mirror the application of clinical anatomy for a medical doctor in early clinical training. The other principle means through which medical doctors in early clinical training see anatomy is via medical imaging; this is also the case for primary care veterinary graduates.

Imaging, especially primary care modalities such as radiography and ultrasound, is an effective and engaging way of teaching veterinary anatomy in a clinically relevant context. Students are motivated and excited by the opportunity to visualize clinical images at an early stage of their curriculum. Teaching anatomy through imaging allows students to develop clinical skills, such as ultrasound 'knobology' and radiographic positioning, in an integrated manner alongside locating anatomical landmarks, palpating, and visualizing anatomical structures. For example, the anatomy of the skeleton can be taught in parallel with fracture healing physiology using a case-based approach and radiographs. The anatomy of the tendons of the equine distal limb can be taught using ultrasound on either cadavers or live animals, allowing students to develop their spatial awareness through exposure to and interpretation of both longitudinal and cross-sectional views. Students value opportunities to develop clinical skills while reinforcing anatomical knowledge simultaneously. Used in combination with more traditional teaching methods, practicing clinical skills provides students with the opportunity to transfer and encapsulate knowledge by applying it to a different context.

Alternative approaches that reduce fidelity/complexity

The cognitive load of students is an important consideration for anatomy educators, with cognitive load theory suggesting that the limited working memory capacity of learners is exceeded

if cognitive load is excessive (Sweller, 1988). Models are an effective tool that can decrease cognitive load through reducing either the fidelity (the degree of exactness compared to the real thing) and/or the complexity of anatomical structures and relationships. Limiting the fidelity and complexity of anatomy learning resources and activities, especially for novice learners, and slowly increasing these as students become better able to process the cognitive demands of more multifaceted and authentic tasks, can allow educators to support students with a level of fidelity/complexity that is appropriate for the stage of their learning (Leppink & Devivier, 2016).

There are an increasingly vast number of both low and high-fidelity anatomical models commercially available for educational use, although low fidelity models are also straightforward for both learners and educators to create themselves. There are many benefits of using models within anatomy teaching. They can enhance visibility of small structures as well as those which classically are very difficult to dissect and/or visualize in cadavers (e.g., structures within the inner ear, or inside the equine hoof capsule). They can focus a learner's attention on a specific isolated region of interest, reducing extraneous cognitive load. Many also offer the potential for interactivity, allowing students to deconstruct and reconstruct, which may help in development of spatial abilities and problem solving as well as general engagement and enjoyment (Preece et al., 2013). It is important to acknowledge that low fidelity models tend not to represent the shape or surface details of structures accurately, but instead are often designed to facilitate understanding of spatial relationships between represented structures. If considering extensive use of models within anatomy curricula, instructors should take care to ensure students are appropriately exposed to both normal and pathological variation, as both are typically not represented in anatomical models. 3D printing now offers educators the opportunity to overcome this issue, with pathologies and a range of normal variation able to be reproduced at low cost.

Promoting active learning

Active learning engages students in higher-order cognitive tasks including problem-solving, applying knowledge, analysis, synthesis, and evaluation (Chan et al., 2020). These types of higher-order skills fundamentally underpin the manner in which anatomy will be used in clinical practice. A range of non-traditional approaches to anatomy teaching exist which aim to promote active learning in several ways.

Creative arts-based approaches can be powerful and effective active learning tools. Drawing promotes development of observation skills, and in tandem with haptic exploration of objects can also be effective in allowing students to explore spatial relationships of structures. It can also help to promote reflective practice, a key professional skill, as students cyclically reflect on the product of their work and adapt as required (Backhouse et al., 2017). Creative approaches can be developed further to enhance student understanding of objects and relationships in three dimensions. Modeling clay can be effective and engaging when used to construct and appreciate complex structures or to conceptualize anatomical planes. Papercraft (e.g., origami embryos) or crafting using common materials such as string or pipe cleaners (e.g., to construct the brachial plexus) are also simple, low resource activities that can support learning in or outside of the classroom. Careful selection of media and use of multiple materials within such activities can enhance and integrate multi-sensory systems during learning (Keenan et al., 2017).

'Gamification' is becoming an increasingly popular way to encourage student learning and self-testing of anatomy in an active and collaborative manner (See, 2020). The principles of gamification, including increasing student motivation through fun and playful learning experiences, can be introduced through a simple low-tech format within and outside of the classroom. Board games, card games, game show-type formats, as well as escape rooms, are becoming commonplace; some are freely or commercially available for educators to access, but mainstream non-scientific games are also easy to adapt to the specific needs of a teaching session. The evidence base behind the effectiveness of gamification is fragmented, principally because of the highly context-dependent nature of different games and the manner in which they are integrated within curricula, although there is some evidence of knowledge gains in students learning through gamified approaches (e.g., Anyanwu, 2014).

Multimodal delivery

To date, there is no consensus as to the best way to teach anatomy, and higher education institutions, including veterinary schools, are seeing an increasingly diverse body of students. A multimodal approach utilizing multiple pedagogical resources offers students more flexibility in how they engage with learning materials. Access to a wide variety of online resources and 3D visualization tools without the need for specific facilities affords opportunities to study or revisit anatomy outside of the classroom or in clinical settings. Further, educators can utilize digital tools to develop learning resources that can be delivered as self-directed, case- or problem-based learning sessions, and delivered asynchronously, or through a blended learning approach such as the flipped classroom. As the digital landscape continues to evolve, and educators see the impact of emerging technologies such as artificial intelligence, a focus on student-centered approaches encourages the independent learning and problem-solving skills required of a veterinary professional.

Despite the digital transformation that has taken place over the last decade, the dissection laboratory still provides many opportunities in anatomy teaching, in particular for the integration of clinical skills. For example, cadavers can be used for multiple purposes, such as to practice ultrasound or injection techniques prior to exploration of the relevant anatomy through dissection. Dissection itself may aid in the development of manual dexterity. Dissection also introduces students to anatomical variation and thus a tolerance for uncertainty

required in the veterinary profession. Implicit learning through a 'hidden curriculum' contributes to the development of veterinary clinicians and can be conveyed through group work with cadavers. The opportunity to ask questions and to engage in conversations regarding the ethical sourcing and use of animals fosters components of professionalism such as compassion, integrity, and encourages respectful behavior. Such skills will be beneficial within clinical environments where graduates need to be prepared to encounter death and euthanasia. Professionalism can also be highlighted further within the dissection room through initiatives such as peer-assisted learning and near-peer teaching, both of which have been found to improve knowledge and skills for both 'tutor' and 'tutee' in the context of anatomy teaching (Nnodim, 1997; Baillie et al., 2009), as well as serving to develop student communication and leadership skills.

Constructive alignment

It is widely accepted that assessment affects student learning, and as such it is important to assess students in a manner that fosters deep learning and encourages the application of knowledge to the clinical context. Traditional methods of anatomy assessment have focused on lower-order, factual learning outcomes that can lead to students adopting surface approaches to learning. Spot tests, in which students identify pinned structures, are one such method that has seen a decline in use largely due to practical reasons, including increasing student numbers and improvement in image quality for use in online alternative assessment formats. Spot tests have also been criticized for testing only recall-level knowledge. Gaining factual knowledge on which to base clinical decisions is an important outcome of a veterinary anatomy curriculum. However, in a constructively aligned curriculum (Biggs, 1996) in which teaching and assessment are closely aligned to intended learning outcomes, anatomy assessment should reflect the manner in which it is taught, and the manner to which it will be applied. Therefore, assessment requiring problem solving and integration (e.g., the explanation and interpretation of clinical signs and detection of abnormalities) moves the focus to higher-order outcomes of Bloom's Taxonomy (Bloom et al., 1956). Further, in a constructively aligned, clinically integrated curriculum, applied anatomy can be assessed as part of practical examinations such as Directly Observed Procedural Skills (DOPS) and Objective Structured Clinical Examinations (OSCE) if anatomy is taught in the context of these practical techniques.

Challenges and future directions

The teaching of anatomy continues to evolve rapidly in this era driven by an increased focus on graduate skills and emerging enabling technologies. For this reason, two key areas of focus must be considered if veterinary anatomy educators are to rise to the opportunities and challenges ahead. The first of these is ensuring an evidence-based approach to anatomy education. There is a growing need to ensure that new teaching approaches, including the applications of technology, are grounded in evidence that demonstrates their effectiveness as educational methods. Such evidence should consider the impact of new approaches on learning gains of both knowledge and skills, and not just measure student satisfaction or perceptions of their learning. It should also consider the broader impact on students (e.g., within a holistic curriculum context), as well as the impact at an institutional level (Clunie et al., 2018). It is critical that emerging ideas and technologies continue to advance our field, with our lens firmly focused on the goal of enhancement of anatomy education.

The second area of consideration is that of faculty training and development. In times of rapid curriculum development and emergent technologies, it is necessary to ensure that faculty are empowered to drive change, as well as deliver that change where needed. A community effort is needed to upskill our educators to deliver modern veterinary anatomy teaching, which likely differs considerably from the education that they once received as students. Part of this faculty development effort should center on educational research and scholarship skills, to allow educators to evaluate their own innovations and teaching practices on an ongoing basis. Further faculty development should consider connecting the educator community in an effort to develop and maintain communities of practice and networks that allow educators to share their evaluations and practices with one another.

Conclusion

In conclusion, anatomy education is at a time of rapid and exciting change. What was once a predictable combination of 'pre-clinical' lectures and extensive cadaveric dissection, is now revitalized, producing opportunities for educators to look beyond the traditional formula and incorporate innovative, creative and effective anatomy teaching approaches throughout the veterinary curriculum and beyond.

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CHAPTER 2: Educational Alternatives for Veterinary Anatomy Teaching

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Introduction

The teaching of anatomy as a cornerstone of health professional education is universal across medicine and veterinary medicine. Whilst the importance of learning anatomy to underpin the scientific principles of these disciplines is not under dispute, for some time there has been debate around the best methodology to teach anatomy (Papa & Vaccarezza, 2013).

Anatomy instruction has traditionally relied on materials such as textbooks, illustrations, models, osteologic preparations, and cadavers, including their dissection. Over the past decade, there has been an increasing emphasis on blended learning, with instruction in the classroom and in online learning environments (Longhurst et al., 2020). This accelerated during the COVID-19 pandemic, when anatomy education saw a huge increase in the use of online and virtual learning platforms and the digitization of learning tools (Bond et al., 2023). In addition to online teaching delivery, alternative educational materials are being used to supplement and, in some areas, replace traditional anatomy learning techniques. With progressive advancement in the industry, new and innovative techniques are developing all the time, such as three-dimensional (3D) printing, radiological reconstruction, augmented reality (AR), and virtual reality (VR) learning environments.

This chapter will discuss the advancement and potential use of educational alternatives for anatomy instruction, defined as anything beyond textbooks, illustrations, osteologic preparations, or the dissection of cadavers. This chapter will also explore what can be learned from human anatomy education, and what educational alternatives used in that realm may be utilized in veterinary anatomy education.

History of the use of educational alternatives in veterinary anatomical teaching

Dissection has been a mainstay in veterinary anatomy education throughout history, and despite attempts to create and offer alternatives, the use of alternatives to cadavers has not always been welcomed. Prior to the late 1800s, wax models dominated adjuvant anatomy instructional materials. These were time-intensive to create, expensive, and relatively fragile, and as such they were not considered a suitable replacement for dissection, so their use was not prevalent in veterinary anatomy instruction. In the late 1800s, the improvement and popularization of papier-mâché models, including veterinary models with dissectible parts by Auzoux of France, started to offer an alternative to dissection (Artificial Anatomy, 2000); however, their use and availability remained limited. In the second half of the 20th century, veterinary anatomy educators began publishing instructional material promoting the creation of three-dimensional (3D) models to enhance instruction but overall there remained a lack of available educational alternatives or usable materials (Sack, 1960; Vaĭnauskas, 1970).

Despite this slow start, recently there has been rapid progression in the creation, availability, and use of veterinary anatomy educational alternatives. These range from low-fidelity constructive modeling materials, to high-fidelity models or simulators, 3D printing, dissection software, augmented and virtual reality, and plastinated specimens. This progression has resulted in an abundance of options for educators, presenting the opportunity and the responsibility to investigate which educational alternative options can best enhance the learning outcomes for their veterinary students.

Modern high-fidelity educational alternatives

High-fidelity models and simulators have increasingly become more commercially available for veterinary educational use. Recent improvements of such high-fidelity models, especially when made to be more anatomically correct (e.g., French, 2018), increases their applicability for veterinary anatomy instruction. A simulator has also been shown to be effective in teaching equine cardiac dissection (Allavena et al., 2017). Another example, the haptic cow, one of the best known high-fidelity veterinary simulators, has been shown not only to support students' learning in an engaging way, but also to allow large numbers of students to learn to recognize the anatomy encountered during transrectal palpation without the use of cadavers or live animals (Kinnison et al., 2009).

Digital or computer-based educational alternatives for veterinary anatomy instruction have also progressed significantly in recent years, particularly the technology used to create 3D reconstructions of anatomical structures. As early as 1991, the creation of digital databases of 3D representations of normal anatomy have been utilized in conjunction with gross dissection to help students better visualize spatial relationships between structures (Snell, 1991). The use of compact discs containing digitized cadaver images was subsequently popularized (Wenthe, 1995). A virtual veterinary anatomy program utilizing specimen photographs, QuickTime Virtual Reality, was developed in the early 2000s and possessed interactive features to help students study the dissection, osteology, and radiology of the canine (Linton, 2005). This program was shown to increase student confidence and efficiency when utilized as an adjunct to dissection.

3D software programs that attempt to mimic dissection have been produced by several companies in recent years (e.g., Biosphera, Sciencein3D, Anatomage) and are commercially available; an open-source virtual reality headset-based program that allows for the addition of learning materials by outside contributors has also been created (DeBose, 2020). These new programs offer advanced capabilities, and concerns of the past regarding programs having a low-fidelity experience or unrealistic imagery have nearly been eliminated.

There have also been advancements in making long-term preservation of cadaveric material more achievable, through significant improvements in techniques such as plastination. Since its development in 1977, plastination has become more widespread, and tissues preserved in this way have long term viability and fewer challenges associated with local storage and use of embalmed cadavers, such as environmental hazards inherent with formaldehyde exposure, cost, specialist staff, and facilities. Institutions using plastinated specimens report they are extensively used and deemed useful by students, although it has been recommended that these be used as adjuncts with other materials (Latorre, 2007). Plastinated specimens have also been shown to be useful in teaching anatomy in the context of learning complex procedural skills, such as endoscopy (Janick, 1997).

The merits of low-fidelity learning resources

It is important while considering alternatives to enhance anatomy learning that educators also consider that not all anatomy teaching adjuncts need to be hi-tech. Low cost, low fidelity models such as using clay, plasticine, paper, or simply schematic drawings, are also important in augmenting anatomy education. Even though these models do not typically accurately represent the detail of real-life anatomy in the same way as high-fidelity models, they have still been shown to offer excellent learning experiences for students and can be particularly helpful for supporting students understanding complex 3D concepts. An example is the use of plasticine layered on natural bone to create a reusable 3D model and provide an alternative to dissection or prosection of cadavers (Saber, 2016).

Limitations of educational alternatives

Despite the benefits listed above, any single educational alternative for veterinary anatomy instruction has limitations that need to be considered when selecting methods to supplement or replace traditional materials. There is still a dearth of material that is veterinary specific, and often human anatomy material is not directly translatable for use. There is also a gap in the amount of material with regards to different species, with small animal options (canine and feline) far outnumbering large animal options (equine, bovine, and porcine) and other non-traditional companion animal species (companion exotics).

With respect to high-fidelity models or simulators, the smaller veterinary market demand results in lower production rates and less stock, so there is commonly a time-lag in ordering and limited availability. Cost is a severe factor as well, with the same smaller market driving prices higher than human anatomy educational alternatives, whether it be for models/simulators or for software, which may require additional expensive hardware. Cadaver based alternatives show promise, and more cost-effective methods of creating plastinated specimens are being established (Zerlotini, 2020), but plastination is still highly labor intensive, requires specialized equipment and facilities, and ultimately still relies on acquiring the initial cadaver for processing, as does plasticine modeling that relies on osteology to create a 3D framework.

Impact must also be weighed for any educational alternative chosen, including how long the material can be utilized and the number of students that can utilize it at one time. The effectiveness of using any educational alternative in achieving learning outcomes must be considered as well. For example, some users may develop motion sickness when using virtual reality headsets (Chang, 2020), making their mandatory use challenging compared to web-based applications that can serve a similar purpose as a dissection supplement or replacement in achieving educational objectives. Selecting educational alternatives that have evidence-based publications supporting

their use is optimal, and many have been evaluated for their use in teaching clinical skills (Noyes, 2022), but there is still a need for more research specifically related to educational alternatives in veterinary anatomy instruction.

Considerations from medical anatomy

As in veterinary medicine, cadaver use had been a mainstay of medical anatomy for centuries (Korf et al., 2008). Many programs continued to use human cadavers as core to their anatomy teaching, to provide students with exposure to real human anatomy including the nuances of anatomical variation. Other benefits to students included exposure to the ethics of using human cadaveric tissue for educational purposes and gaining respect for those who donate their bodies to anatomical education and research. It may also be the first time that students have seen a dead body (Smith et al., 2020).

Although there continues to be support for using cadavers, there has been an overall reduction in the time available for anatomy instruction within medical curricula (Turney, 2007). This has been one of the key drivers for change in anatomy teaching modalities in medical education. There is a growing volume of work and research that suggests that cadavers do not need to be used to achieve sound anatomical learning. As a result, many medical education institutions take a blended approach to teaching medical anatomy, using a variety of techniques, and often utilizing both cadavers and digital learning environments to support their healthcare students' learning (Khalil et al., 2018).

Cadaver use in medical anatomy is dependent on availability from donation programs. It also requires specialized, expensive facilities to store and maintain the bodies, and cost alone can be prohibitive to some institutions. Increasingly, cadavers are reserved for postgraduate surgical training to support teaching of specialist techniques. In recent years, many medical schools have moved away from cadaveric dissection, utilizing prosections and plastinated specimens instead, or have stopped using cadavers completely (McLachlan et al., 2004).

There have also been technological advances in teaching due to greater use of software that supports 3D models, high-tech platforms, videoconferencing, augmented reality (AR) and virtual reality (VR). The quality of software solutions continues to improve, providing medical anatomists with a comprehensive range of realistic 3D models, including anatomical variation, which has led to greater use of digital learning platforms in all aspects of anatomy teaching. Examples include the development of virtual dissection tables and fully immersive experiences via VR headsets. These technologies have been shown to be fun and engaging (Erolin et al., 2019), but do not suit everyone, with some students reporting headaches, dizziness, and vision changes while using a VR headset (Moro et al., 2017). VR and AR also fail to offer the haptic (touch feedback) experience of other teaching modalities, although haptic technology is advancing and may be an interesting area of advancement in the future.

Another example, where a digital platform and videoconferencing can support anatomy teaching, is in delivering a more distributed model to support students at regional campuses (Allsop et al., 2020). It is also worth noting that outside of the classroom, students will often be finding and accessing a wealth of digital anatomy materials for their own self-directed study. These may include resources recommended by their institutions or resources they find through social media or web-based searches (Leung et al., 2020).

Medical students use their anatomical knowledge when examining patients and performing clinical and surgical skills, and when interpreting diagnostic imaging investigations. Imaging in clinical practice has become increasingly digitally delivered and therefore there is a need to teach students how to interpret images using the different modalities as part of their anatomy curriculum. Opportunities to learn using diagnostic imaging technologies range from ultrasound of live patients (live anatomy), utilizing imaging databases to review computerized tomography (CT) and magnetic imaging (MRI) scans, through to creating 3D reconstructions of surgical anatomy that can be 3D printed and manipulated as part of learning or for surgical procedure preparation.

Increased use of educational alternatives within medical anatomy education is not without its challenges. One concern is how to make digital anatomy learning accessible and equitable in its delivery. For example, with large cohorts the use of digital dissection tables can become challenging as these can only support a few students at a time. Digital learning packages are not necessarily low cost, particularly if utilizing the latest version and if institutions need to buy large numbers of licenses. Provision of digital anatomy learning platforms online requires good computing hardware and graphics software, and access to reliable internet connections and electricity. While this may be taken for granted in some regions, these are considerations for others (Allsop et al., 2020). Equally, the use of digital educational alternatives requires upskilling of faculty and support staff and may present challenges when trialing and evaluating techniques at the forefront of technological advancement.

Future advances for anatomy education

So, what will be the next revolution in the development of educational alternatives for anatomy education? Students and educators live in an increasingly digital world, and the use of educational alternatives based on technology are likely to take an increasingly prominent role in the anatomy education of medical doctors, veterinarians, and other healthcare professionals. Educators and students have seen huge advances in digital educational alternatives, and the fidelity of 3D reconstructive software has mitigated some of the reservations about using it.

Modern ways of living, studying, and working will also influence the discipline. The increasing availability of mobile devices and the innovative provision of education through social media, apps, and online video hosting websites including YouTube, Facebook, TikTok, and Instagram are all becoming more common, as the way in which humans communicate also changes (Barry et al., 2015). The use of the social media platform 'x' (formerly known as Twitter) was shown to support student understanding outside the classroom (Hennessey et al., 2016).

Most recently, artificial intelligence (AI) platforms and systems integrations have exploded into being. While it is too early to tell what influence AI may have on the way educators teach and the way students learn, with its potential to influence the scaling, speed, and consistency of working, it seems highly likely that the use of AI in anatomy education will increase (Lazarus, 2022).

Conclusion

With recent accelerations in the development and more widespread availability of alternatives to dissection-based anatomy teaching delivery, combined with increasingly accessible price-points, and reports of increased effectiveness on anatomical skills such as spatial awareness (Guimarães et al., 2019), educators can and must re-evaluate the use of educational alternatives in modern veterinary anatomy instruction. Alongside the challenges with cadaveric acquisition and the evolving ethics surrounding cadaver usage, implementing educational alternatives in veterinary anatomy instruction as a supplement or even replacement to traditional materials can no longer be ignored. The advancement and utilization of educational alternatives for veterinary anatomy instruction has often followed those of human anatomy instruction, so the field can consider advancements in human anatomy instruction for guidance or possible direction.

Fundamentally, while exploring these new potential avenues and methods in medical anatomy education, what must remain paramount is for the student to remain at the center of the educational experience. This means that throughout curriculum design, educators must consider how to integrate and use alternatives, and whether to enhance or replace other anatomy teaching delivery techniques. Educators need to remain mindful that there is unlikely to be a 'one size that fits all' approach, at either the discipline, institution, or individual level.

Educators also bear the responsibility of sharing knowledge and developing educational alternatives with others across geographical and discipline boundaries. This collaboration will maximize the benefits of enhanced learning for students within the discipline of veterinary anatomy.

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CHAPTER 3: Developing, Implementing and Utilizing a Willed Body Program in a Veterinary Curriculum

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Introduction

The eminent philosopher and Nobel laureate Albert Schweitzer is credited with coining the phrase "reverence for life" and developing the underlying idea that all living things have inherent worth (Schweitzer, 1929). He supported the idea that we should respect all life, including that of the innumerable non-human animals with which we share the earth; this ethic has been utilized in veterinary education. The implementation of the "Three R's" principle—Replace, Reduce, and Refine—also takes center stage in the setting of veterinary academia, where instruction and research frequently involve animals. These principles provide a framework for ethical and responsible animal use in scientific endeavors (Ciliberti et al., 2016). Willed body programs (WBP) demonstrate a reverence for life and a reduction in animal use, and they are rooted in the fundamental belief that no animal should undergo euthanasia or harm solely for the sake of veterinary education.

Veterinary WBPs have taken inspiration from the common practice of body donation programs found across human medical schools (Bhattacharjee & Ghosh, 2023; Champney, 2019; Champney et al., 2019). The primary intentions of veterinary WBPs are two-fold: they hope to advocate for the ethical treatment of animals in academic use, and they hope to instill an animal's life with added purpose even after their passing. WBPs can eliminate the need to sacrifice animals solely for teaching, aligning with a more ethical and compassionate approach to education (Samper et al., 2023). A WBP also inherently promotes the values of respect and compassion toward the donated bodies, which may be beloved pets that are altruistically contributed for the sake of education. The hope is that these principles can serve as enduring core values for veterinary students, faculty, and staff within a veterinary college and in the community. Additionally, WBPs actively promote collaboration and partnerships with veterinary professionals and the public, aiming to advance both veterinary education and animal welfare by offering the opportunity for animal donation within the community. These programs allow students to learn with a deeper sense of respect for the animals and their generous donors, fostering a more compassionate and ethical approach to veterinary practice from the outset.

In some settings, willed body programs can supply all curricular use of animals, including procedures in the anatomy laboratory. This chapter will describe the development, implementation, and utilization of a WBP, based on the authors' experiences, and will also include considerations associated with human WBPs. This chapter will also discuss how veterinary institutions can establish similar programs in their unique settings.

Outlining a willed body program (WBP)

Eligible animals

A WBP can accept both companion animals (e.g., canine, feline, lagomorph, avian, reptile, rodent) and large animals (e.g., hoofstock), although large animal acceptance into a program depends on specific curricular needs and brings more logistical constraints related to transportation and storage. All donations can come directly from pet owners or the veterinary community after obtaining the animal owner's written consent. Owner consent is imperative to this process, and owners should be provided additional reading material for any follow-up questions and concerns (Champney et al., 2019). Specific standards must be met for an animal to be accepted into a program. Suggestions include a medically justified reason for euthanasia (related to disease or injury), history proving the specimen is safe for use, body weight (applied primarily to canine specimens), and distance for pick-up.

Only pets who died naturally or were euthanized for medical reasons should be considered eligible, and the decision to euthanize the animal should be a joint one made by both the animal owner and their veterinarian. Animals should not be accepted into a program if there is any concern of disease risk to any individuals handling the specimens. Recommendations for specimens that should be omitted from a WBP include: any specimens that have recently undergone invasive surgery, have an undiagnosed central nervous system disorder, or carry the potential for zoonotic disease transmission. A weight restriction of 27 kilograms (60 pounds) for canine specimens is suggested to prevent physical difficulties in moving or transporting the cadaver by students, technical staff, or faculty, mainly after embalming. A WBP Coordinator may waive this weight restriction based on curricular requirements or needs. Companion animals are accepted within a specific distance radius determined by the institution. Large animals can be accepted from a larger radius if needed, due to difficulty in sourcing these specimens; however, considerations must be taken in terms of the transport, climate control, available storage, and assistance of laboratory staff needed to ensure proper handling and processing of these specimens.

Specimen acquisition and handling

Owners who are interested in donating to a WBP should be provided with a form to collect essential information about the animal and owner. Information should include the animal's name, species, age, weight, gender, and the medical reason for euthanasia or the cause of death. Owner information should include their contact details. This form should be intentionally kept concise to help minimize the emotional burden on the owner during the challenging time after euthanasia or natural death. Completion of the form can be assisted by the veterinarian's office at the time of the appointment so that the program can pick up the deceased animal in a relatively quick time frame.

Upon the animal's death, the owner shall promptly inform the WBP Coordinator, who will then proceed to contact the donor's veterinarian, veterinary clinic, hospital, or practice. Subsequently, arrangements can be made for the transportation of the deceased animal to the school campus. The program should only accept and facilitate the transportation of donations accompanied by fully completed and signed donation forms. Transportation services from private residences should not be considered due to the liability associated with entering a private residence. Should a client express the desire to donate from a location outside the specified donation radius, the donor can choose to personally transport the donation to the institution, contingent upon receiving consent from the WBP Coordinator or their designee. This option will necessitate appropriate consideration of factors such as the time of death, the duration of transportation, and the implementation of suitable temperature controls to ensure the preservation of the cadaver during transit. The WBP Coordinator or their designee has the authority to make exceptions to the specified radius rule for transportation if it is required to fulfill specific course requirements.

Specimen identification (ID) system

Once a donation has been accepted into a WBP and the specimen and their donation form have arrived on campus, it should be assigned a unique ID number. This ID tag will always be kept with the specimen and helps to keep track of the cadaver and any derived parts from initial acceptance to final disposition. A tracking database is also updated for each specimen, their assigned ID number, and all the information included on the program donation form. In addition, the database should include information on the preservation technique, storage location, discipline assignment, date of acceptance, and final disposition. Any other information pertinent to the donation may also be included. The database is maintained electronically and has restrictions for accessibility as personal information regarding donors and the animal's detailed medical information is included.

Storage and embalming of specimens

Cadavers, except those used for fresh necropsy training, should be placed in refrigerated or frozen storage within two hours post-mortem to be considered acceptable. Frozen specimens should be processed or utilized in a timely manner to ensure the tissues are not compromised by extended freezing. Specimens for fresh necropsy follow a different storage process. These donations should have been euthanized within 24 hours of the fresh necropsy and can only be refrigerated prior to use, never frozen. Additionally, fresh necropsy specimens may undergo both histological preparation and histopathology.

Finally, embalming preparation methods for each donation can be determined based on curricular needs and storage availability. If embalming of the cadaver is desired, methods for specimen preparation may include but are not limited to embalming-whole body, chemical fixation by either point injection or immersion, osteologic preparation, freeze-drying, plastination, refrigeration, and/or freezing.

Return policy of remains

Return policies regarding the remains are primarily related to companion animals that are accepted into a WBP. A hypothetical choice experiment demonstrated that the most important attribute increasing dog and cat owners' likelihood to donate their pet to a willed body program was the return of the pet's ashes (Samper et al., 2023). When owners make their donation, they can be presented with options regarding the final disposition of their pet's remains. These can include a return or a non-return option. The return option should entail cremation of the animal's body, where there is individual cremation with ashes returned to the owner. Owners should be informed that the return option can take significant time due to academic use. An age and/or weight restriction can be put in place because younger animals can be fully incinerated and leave no ashes to return. If an owner chooses the non-return option for their pet's remains, the specimen can have indefinite use, and the method of disposition

is determined by the local or state-mandated guidelines. Once a deceased animal is admitted to the WBP, it is suggested that the institution should take on all financial responsibilities associated with the transportation and proper disposal of the remains, including cremation and the return of ashes to the owner.

Memorial service

It is suggested that an annual event is held, dedicated to recognizing and celebrating both the animals involved in the WBP program and their generous owners. The timing of this event should allow students to interact with cadavers before the ceremony, fostering a connection between the donated animals and the people who provided them to support the curriculum. The memorial service can be attended by veterinary students, deans, faculty, staff, and specially invited donors. To honor animals and their families, a slideshow featuring images of the animals that were donated to the program, which are submitted by their owners, can be presented. A eulogy and pictures can also be included in the institution's publications (given owner consent of image use), and donors can receive a copy of the publication as an additional tribute to their selfless contributions.

Advertisement

Both printed media and word-of-mouth marketing strategies are used to promote a WBP. The WBP Coordinator is primarily responsible for providing information pamphlets that are sent to students, faculty, and hospital staff at local veterinary clinics and hospitals. Pamphlets can be provided for display at these local veterinary clinics and hospitals. Institutional alumni can also serve as the primary source of word-of-mouth advertisement.

Academic benefits of a WBP

There are a variety of benefits to a WBP. In the anatomy laboratory, students benefit from exposure to a realistic and diverse range of animal anatomy. Among the same species, such as in the canine and feline, students encounter a variety of breeds, sexes, alteration statuses, ages, and pathologies, allowing them to appreciate the natural anatomical variations that exist. Additionally, students can delve into comparative anatomy across different species, enriching their educational experience. This diversity of specimens enhances the clinical relevance of their learning, enabling veterinary students to better understand the practical applications of anatomy. It helps them connect anatomical structures to clinical procedures, surgical techniques, and disease pathology, thereby making their education more pertinent to their future careers. Furthermore, the varied nature of the specimens necessitates collaborative dissections, promoting teamwork and effective communication among students as they work together to achieve shared educational goals, a skill invaluable for their future practice as veterinarians.

Most animal specimens from a WBP can be used for anatomy instruction. Specimens can also be allocated for clinical skills, pathology instruction, and extracurricular use such as student club activities, pending availability. All specimens utilized should be approved by the WBP's Coordinator.

Student ethics development

Through the experience of working with donated animals, students learn to appreciate the ethical aspects of learning animal anatomy and the importance of respect and compassion for animals, even in death (Zemanova, 2021). By dissecting and studying the cadavers from generous donors, students witness the significance of animals' lives and their role in advancing veterinary knowledge. This firsthand experience cultivates a profound sense of responsibility towards animals, emphasizing the ethical principles of beneficence, non-maleficence, and justice that are at the heart of veterinary practice. This newfound understanding extends beyond the anatomy laboratory setting, as it shapes students' future practice and research. It instills in them a commitment to delivering the highest standard of care, always prioritizing the well-being and dignity of their animal patients. Whether it be in a clinical setting, research laboratory, or in the field, this ethical foundation can influence every facet of their work. It can guide their decision-making, ensuring that they approach cases with empathy, while providing the best possible care. Furthermore, it fuels their dedication to advancing veterinary knowledge and developing innovative solutions that not only improve animal health but also further the cause of humane and compassionate treatment of animals. In essence, working with donated animals not only imparts anatomical knowledge but also cultivates an ethical perspective that profoundly influences the practice of veterinary professionals, reinforcing their commitment to caring for animals with the utmost respect, empathy, and compassion throughout their careers.

Implementation of a WBP at a veterinary school

Implementation of a WBP in veterinary education requires a thoughtful and comprehensive approach. The following summary recommendations are based on the authors' experiences and considerations taken from human willed body programs.

First, it is important to establish a coalition of faculty members dedicated to actively developing and refining policies and procedures to execute a successful WBP. The team must define the institution's stance on the WBP in alignment with a mission statement that establishes general policies for acceptance into the program. Once this foundation is developed, the team should assign a dedicated WBP coordinator to oversee the program long-term.

Next, the plan should then outline all information required for pet owners and specimen acquisition. Advertising material should be accessible in veterinary hospitals that support the WBP. Owners should also be provided with consent forms, communication opportunities, and a timeline for the use of the specimen, and final disposition of the remains. Opportunities that recognize animal owners' generous donations (e.g., annual memorial services) should also be considered, as it allows time for the family to be honored and connects the university with the community. Once a specimen is accepted into the willed body program, it is important to consider transport, storage, and final disposition. For specimens from distant hospitals, appraise how these specimens should be stored before pick-up, and the transport system utilized. Ensure suitable storage, and that each specimen is appropriately identified and tracked throughout their use. Finally, determine the options for the final disposition of the remains per the owner's request, as stated above. Throughout, a varied and dedicated faculty and staff team can streamline the WBP implementation process. This typically includes members of the anatomy teaching team, but it will likely require additional support members.

Challenges to implementing a WPB

In a veterinary institution, creating a WBP that provides most, or all cadavers needed for education will have challenges, dependent on several factors, such as location or population density, financial and time constraints, tissue appearance, and individual animal attributes.

The viability of a WBP is closely tied to the local population density. This can affect the total amount of donated specimens and/or affect the species diversity of specimens that are donated. For example, some small species like avian and reptiles are already less represented in the pet population, so procuring animals of a desired species and quantity can be challenging. Institutions operating in regions that have less population density may have to consider a wider radius for pick-up to achieve an adequate number of donations. Those schools located in urban or suburban areas may see a scarcity of large animal specimens due to complexities related to their acceptance, storage, and maintenance. Conversely, schools located adjacent to rural areas may be able to source adequate large animals but may be limited in their ability to source the number of small animals required for their curricular needs.

There are also financial and time constraints to consider once specimens have been acquired. A WBP has maintenance requirements and storage expenses, and these may exceed those of a program that purchases specimens, if donated specimens must be collected over a longer period of time. Challenges can also occur when specimens must be returned to owners in a specified timeframe, and the time differential from acceptance of the animal to use to return must be accounted for.

Various challenges with tissue appearance can also arise in the anatomy laboratory that can affect the student's learning experience. Thawing frozen cadavers (to use as such) introduces the risk of artifacts, potentially damaging tissues and making it more challenging for students to accurately identify and study anatomical structures. Thawing artifacts can further distort tissues, altering organs' color and texture, and ultimately complicating the educational process. These effects are further discussed in Chapter 4.

Lastly, the attributes of the animals themselves pose additional challenges. Finding canine and feline specimens with intact reproductive systems can be difficult, as a significant portion of animals in the program have undergone alteration. This presents challenges for students trying to visualize the complexities of the reproductive system and its associated anatomical structures. Many of the specimens are also older, showcasing age-related anatomical changes not typically seen in younger animals. Additionally, since all specimens have been euthanized for medically sound reasons, they often exhibit associated pathologies, further altering normal anatomical structures. The program will likely receive animals that are overweight, a common issue in companion canine and feline species. These cases affect the ease of dissection and can reveal anatomical changes in the specimens. Nevertheless, it should be noted that the quality of education provided to the students in the program is minimally affected by these challenges. Measures can be implemented to mitigate these issues, including the use of sexually intact animals as prosections for observation by all students, and collaboration among laboratory groups to facilitate resource and specimen sharing, further reducing the impact of these disadvantages.

Conclusion

The success and expansion of WBPs in some veterinary medical colleges have demonstrated that anatomy and clinical skills instruction is possible while embracing the ethical sourcing of cadavers and the reverence for life. WBPs can provide students with a thorough understanding of animal anatomy that is both realistic and varied. Students are challenged to adapt and learn thoroughly by the incorporation of species diversity, variability within species, typical animal-related changes like age and weight, and potential pathologies. WBPs can improve the learning environment and promote values, principles, and lifelong learning. By allowing students to learn from animal donors, WBPs make an invaluable contribution to the veterinary field, ultimately benefiting animals and the communities they serve.

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CHAPTER 4: Teaching Clinical Skills with Cadaveric Tissue

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Introduction

Clinical skills laboratories can be taught using a variety of methods, including models, cadaveric tissue, and live animals. This chapter will discuss the use of cadaveric tissue in teaching large and small animal clinical skills; and explore the sourcing, use, reuse, and recycling of cadaveric tissue in this setting. Cadaveric tissue can be a valuable tool in teaching clinical skills, and removal of this use in veterinary education would need to be thoroughly considered (Varner et al., 2021). It allows learners to better understand how the body works and how symptoms can manifest, and there has been a decrease in anatomic proficiency and surgical skills in graduating medical students since the decline of cadaver use (Varner et al., 2021). Cadaveric tissue may be fresh, frozen/thawed, or soft embalmed. This chapter will discuss the different types and preservation of cadaveric tissue that are most beneficial to teaching specific clinical skills and how cadaver use compares to using live animals or models for clinical skills training.

The value of cadaveric tissue for teaching clinical skills

While students and educators inherently recognize the value of practicing skills on live animals, not all skills are suitable for students to practice on a live animal. For example, invasive skills or procedures that are not medically necessary are best taught on either a model or cadaveric tissue. Even less invasive procedures are ideally taught on a model before live animal practice to allow students to develop some skill before live animal practice.

Cadaveric tissue is generally less convenient and enjoyable to work with than models or live animals. Where an effective model exists, using it in lieu of cadaveric tissue is preferable. Models can be reused, allowing repetition of skills (Hunt et al., 2022; Varner et al., 2021) and facilitating deliberate practice (Ericsson, 2004); cadaveric tissue typically does not allow this repetition. However, cadaveric tissue may prove superior to models in teaching skills where having realistic tissue layers or a particularly accurate 'feel' to the tissue is important, or where no model presently exists.

Ethically sourcing cadaveric tissue

There are several avenues available for sourcing cadaveric tissues, including a willed body program, animal shelters, abattoirs, renderers, and deceased institutionally owned animals. More information about willed body programs can be found in Chapter 3.

Considerations for using cadaveric tissue for teaching clinical skills

There are some limitations to using cadaveric tissue in teaching clinical skills. Compared to live animals, the lack of circulation and blood flow can make it difficult for students to know if a ligature is too loose, for example, or if their pressure on the skin is excessive enough to cause bruising. In these situations, other methods of checking one's work should be provided by the instructor (e.g., instructor feedback, checking ligature tension with hemostats, etc.) The lack of blood flow, while a limitation,

can also be a benefit; it allows the students to learn under less urgent conditions than when hemorrhage is occurring. This more relaxed laboratory setting allows for improved student learning and performance, as excessive stress is known to inhibit learning (Flinn et al., 2015).

Another limitation of using cadavers to teach clinical skills is that most cadavers will have undergone rigor mortis, which can make it more difficult to put them into specific spaces or positions necessary for teaching certain skills. This difficulty in positioning cadavers can also be a problem when cadavers are frozen for storage and incompletely thawed before a laboratory session.

Postmortem changes also alter the composition of cadaveric tissue, particularly the soft organs or organs with significant bacterial flora such as the gastrointestinal tract. Both fresh and frozen/thawed tissues undergo decomposition, which can create a noxious smell, so good ventilation, the use of disinfectants (e.g., placing tissues in dilute chlorhexidine baths), and/or overnight cooler storage may be necessary if skills laboratories use the tissues for multiple days.

Disposal of cadaveric tissue can also be challenging. There are more disposal options for fresh and frozen/thawed tissue than for preserved tissue. Fresh or frozen/thawed tissue can be transferred to a renderer, composted, or incinerated, but fixed tissue requires incineration for disposal. Disposal fees add costs to clinical skills laboratories taught using cadaveric tissue. It should be noted that state and local guidelines for disposal of cadaveric tissue may vary and should be followed.

A final limitation of using fresh or frozen/thawed cadaveric tissue is the storage space required. These unpreserved tissues must remain cooled between use, requiring a certain amount of infrastructure to be in place for storage (Martinsen & Jukes, 2007).

Preservation of cadaveric tissue for clinical skills teaching

When clinical skills educators choose to teach using cadaveric tissue, they must determine what, if any, preservation will work best for teaching a specific skill in their setting. Educators must consider the task they are teaching to determine whether fresh tissue must be used, whether frozen/thawed will suffice, or whether tissue that is preserved would be optimal.

Fresh cadaveric tissue can be collected from recently euthanized or deceased animals and may be refrigerated prior to use but not frozen/thawed. Educators' choice of fresh tissue is influenced by availability; fresh tissue must be collected very close to the time of the laboratory. Fresh tissue may also be preferred for teaching skills on delicate tissues that can be damaged during the freeze/thaw process. Depending on the extent of use during the laboratory, any remaining fresh tissue may be frozen for subsequent use in other laboratories.

Frozen/thawed cadaveric tissue is collected from euthanized or recently deceased animals and is frozen until being thawed immediately prior to use in the laboratory. Most unpreserved cadaveric tissue used in teaching clinical skills is frozen/thawed, as the tissue can be collected and stored in advance of the laboratory. Any tissue remaining at the end of the laboratory using frozen/thawed tissue may be able to be refrozen and used again in future laboratories.

Preserved tissue can also be used for teaching clinical skills. Formalin-preserved specimens may have limited use in teaching clinical skills, as they can assist students in learning to identify landmarks or tissue layers, but the tissue is stiff and not life-like. Soft embalming offers an alternative to formalin-preserved specimens. These specimens last longer, are more pliable, and the tissue appears more realistic. These specimens have less odor and are without the health and environmental concerns posed by formalin. Specimens may be soft embalmed using methods such as arterial or cavity or both. Some examples of soft embalming agents include mixtures with the predominant ingredient being boric acid or glutaraldehyde (Pasricha et al., 2020).

Soft embalmed tissue can be stored at room temperature without additional preservation, though its lifespan may be increased by storing it in a bath of disinfectant or preservation solution when not in use. Soft embalmed tissue can last for years and be reused in multiple non-invasive laboratories if the use does not destroy the specimen. For example, soft embalmed tissue can generate reasonably accurate ultrasonographic images, in contrast to frozen/thawed cadaveric tissue, where the lack of preservation obscures the identification of organs and structures on ultrasonographic images.

Optimizing the use of cadaveric tissue for teaching specific skills

When educators decide that cadaveric tissue offers a better educational experience than the use of models or live animals, they must consider what the best possible use of cadaver tissue is for each task being taught. This section will describe specific skills and offer suggestions for optimizing the use of cadaveric tissue for teaching those skills based on the authors' experience and available literature.

Teaching surgical skills

A multitude of models have been created to teach various surgical procedures (Hunt et al., 2022). Many surgical procedures can be suitably taught using these models up until the time of live animal practice. However, if there are no models for a particular procedure, and educators are not able to create one, then they may resort to teaching using cadaveric tissue. There are also a few surgical procedures where models have struggled to simulate the tissue accurately, such as gastrointestinal procedures, where the hollow organs and mucosa are difficult to simulate (Hunt et al., 2022; Smeak et al., 1994; Grimes et al., 2019).

The use of cadavers in surgical laboratories can help to fill in gaps where the models are lacking, such as in teaching surgical anatomy and landmarks. Surgical laboratories teaching laparotomy-based procedures typically require a whole cadaver so that landmarks can be observed and tissue layers such as those encountered in median and paramedian incisions can be noted. Cadavers for laparotomy-based procedures, musculoskeletal surgeries, or surgeries involving the skin and subcutaneous tissue may use either fresh or frozen/thawed tissue. When opening the abdomen, care should be used to avoid puncturing the gastrointestinal tract, as this releases noxious odors and bacteria. At the end of a surgical laboratory, the entire cadaver may be reused in future laboratories requiring surgery on a different portion of the body, or the cadaver may be sectioned and its parts saved for use in future labs that only require a single body part (e.g., dental laboratories).

In contrast to the surgical procedures mentioned above, gastrointestinal surgical procedures such as gastrotomy, enterotomy, and resection/anastomosis may be best taught using fresh tissues from abattoirs for same day use. Freezing and thawing can cause the delicate small intestinal tissue to fall apart during suturing. Unfortunately, neither models nor cadaveric tissue can mimic the eversion of the mucosa as it happens in the live patient. Students can use models or cadaveric tissue to practice suturing techniques that address mucosal eversion, but they will not be able to experience that eversion until they practice on a live animal. For tasks such as teaching dental procedures using cadaver heads, the tissue may be less impacted by freezing/thawing, as the results of this process do not negatively impacting the educational experience.

A recent review article noted a lack of large animal surgical models (Hunt et al., 2022), although more are undoubtedly in the process of being created. As a result of a lack of models, large animal surgical procedures are often taught using whole cadavers or cadaver parts of production animals, as these can be sourced from abattoirs or production facilities that cull animals. Students may use cadavers to practice enucleation, umbilical hernia repair, vasectomy, castration, rumenostomy/rumenotomy, abomasopexy, and/or omentopexy. Due to the preponderance of veterinary students entering companion animal practice upon graduation, educators may choose to teach large animal surgical procedures as an elective to reduce the number of cadavers used for this purpose.

Teaching dental procedural skills

Dental laboratories may include instruction and practice of dental cleaning, nerve blocks, diagnostic imaging, and extractions. Commercially available human and veterinary models are available to teach these skills. However, an educator may choose to use fresh or frozen/thawed cadaver heads for use in teaching these procedures. If entire cadavers are obtained, after the heads are used for dental procedures, the remaining portion of the body can be used in laboratories that do not require the use of the head.

Teaching emergency and critical care procedures

Small animal emergency techniques such as thoracocentesis, intubation, nasal cannula placement, urinary catheterization, punch biopsy, excisional biopsy, esophagostomy tube placement, purse string placement, Penrose drain placement, dog ear correction, and stent placement can be taught using models or either fresh or frozen/thawed cadavers. Cadavers used for teaching these techniques can be reused/recycled from previous surgical or dental laboratories, if available.

Commonly taught large animal emergency procedures include skills on the head and neck such as tracheostomy, enucleation, and centesis of the atlanto-occipital space. Skills performed on the limbs such as nerve blocks, arthrocentesis, joint lavage, and foot casting are also commonly taught. Models have been created for some of these procedures, but they can also be taught using fresh or frozen/thawed head/neck and limbs.

Teaching reproductive procedures

There are numerous commercially available models for teaching reproductive procedures, such as palpation per rectum, collection of vaginal cytology, artificial insemination, and cesarean section. Cadaveric tissue may be used alone to teach artificial insemination or uterine biopsy, or it may be used in combination with some of these models (e.g., cadaveric reproductive tracts may be clipped into a model to allow students to practice palpation per rectum). Cadaveric tissue for teaching reproductive procedures may be fresh or frozen/thawed and is typically collected from an abattoir.

Fetotomy is another valuable skill for large animal veterinarians and can be taught using cadaver calves that may have been late-term abortions, stillbirths, have died during the neonatal period, or are sourced from the abattoir. If cadaver calves are also used for other laboratories (e.g., for casting and bandaging), these calves could be reused for teaching fetotomy.

Teaching medical (non-surgical) procedures

There are numerous non-surgical procedures that veterinary students should learn, and models are available for teaching many of these procedures. More information on the use of models in teaching clinical skills can be found in Chapter 7. However, educators may choose to use cadaveric tissue for teaching some of these skills, such as the ones mentioned below.

Dermatological cases are frequently seen in companion animal practice, so teaching dermatological examination and specimen collection techniques is important. Cadaveric skin may be used in the laboratory for teaching techniques such as skin scraping, acetate tape preparation, and skin cytology. Skin tissue may be reused/recycled from previous laboratories that have a minimal impact on the skin (e.g., surgical training, emergency procedures). Other small animal procedures that may be conducive to cadaveric instruction include arthrocentesis; fresh or frozen/thawed tissue will work for this skill.

Cadavers can also be helpful for teaching large animal medical skills where models are insufficient or not available. For example, cadaver calves with fractures created postmortem can be used to teach conservative fracture management, including reduction and radiography to evaluate alignment, casting, and bandaging. These calves may be sourced from abattoirs or deceased institutional animals and may be fresh or frozen/thawed. Other large animals that may utilize cadaveric tissue for teaching include bovine foot skills; these can be taught using fresh or frozen/thawed cadaver feet obtained from the abattoir.

Teaching diagnostic imaging skills

Radiographic and ultrasonographic models exist, although they often do not produce images that are realistic and anatomically accurate. Obtaining and interpreting ultrasonographic images in particular is an important skill for both small and large animal general practitioners. Frozen/thawed tissues have been used to teach this skill in the past but are minimally useful, as water and tissue dynamics change postmortem, and the organs are often not discernable or do not have the correct echotextures. Soft embalmed cadavers or cadaver limbs may be helpful in teaching ultrasonography, as they have less odor, are more realistic in appearance, and are more flexible and able to be manipulated than unpreserved cadavers (Sawhney et al., 2017; Dilly et al., 2017).

Teaching necropsy and diagnostic sample collection

Necropsy and diagnostic sample collection have been identified as day one skills for veterinarians. Necropsy instruction is difficult to perform without the use of cadavers, as identification and evaluation of tissue features is critical to performing this skill. While ideally necropsy instruction is performed using fresh cadavers, frozen/thawed cadavers can be used if insufficient fresh cadavers exist. Often production animals are used, as they can be sourced from local farms where animals have died or are culled. Willed body donation programs can be particularly helpful in procuring small animal cadavers that have some degree of pathology. If sample collection is limited to certain tissues or body parts, the remaining cadaveric tissue may be stored and reused in another laboratory.

Use of models

Models offer an excellent alternative to practicing skills on live animals or cadavers. Where a model is available and effective, the model is frequently the best option for allowing students to repetitively practice instrument and equipment handling skills, learn the steps of each procedure, and work toward competence while receiving specific feedback. Clinical skills teaching models are thoroughly discussed in Chapter 7.

While models are commonly used in clinical skills laboratories worldwide (Dilly et al., 2017; Baillie et al., 2023), there are some tasks where seeing anatomically correct tissue layers is critical (e.g., learning to perform a midline celiotomy), where diagnostic images need to be anatomically accurate (e.g., abdominal ultrasonography), or where tissues are difficult to simulate (e.g., gastrointestinal organs). In these cases, educators can consider using only cadaveric tissue to teach the skill or may start with instruction on a model, followed by a cadaver laboratory that can clarify areas where the model may not be accurate or sufficient (e.g., landmarks or tissue layers).

How can educators impart a respect for animal sacrifice?

Clinical skills educators can and should convey to the learners that cadaveric tissue should be treated with respect, as they are learning only through the animal's ultimate sacrifice. Where possible, educators can drape or cover parts of the cadaver that are not in use in a particular laboratory. Educators may wish to share with their students how the cadaveric tissue they are using has been ethically sourced; this disclosure promotes transparency with learners, which encourages ethical discussions and conscious development of positive attitudes towards animals (Martinsen & Jukes, 2007).

Conclusion

Along with the use of models and live animals, there is a place for the use of cadaveric tissue in teaching small and large animal clinical skills laboratories. Several factors influence whether educators might choose to use fresh, frozen/thawed, or soft embalmed tissue; these include the timely availability of fresh tissue, the possibility of saving frozen/thawed or soft embalmed tissue for subsequent use, and the need for long-term durability or accuracy of diagnostic images produced by soft embalmed tissue. In any case, educators should communicate to students how completing a task on cadaver tissue compares to performing it on a live animal. Educators should seek to ethically source cadaveric tissue and consider transparency with the learners, which may induce more positive attitudes toward the use of cadaveric tissue. Wherever possible, cadaver tissue should be reused or recycled to teach other skills, and students should be encouraged to treat cadaver tissue with respect.

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SECTION 2: Live Animals

AAVMC Guidelines for the Use of Animals in Veterinary Education

Animal use within veterinary education should provide professional level opportunities for students to acquire the knowledge, skills, and attributes necessary to prevent, control, diagnose, and treat medical, surgical, and behavioral conditions in animals in a way that is humane, respectful, and welfare appropriate for all animals used in the educational process.

Animal use should be guided by 4 Rs (replacement, reduction, refinement, and respect) and must be compliant with applicable laws and regulations. Veterinary institutions should critically evaluate all animal use to determine if it is necessary to achieve educational outcomes. Institutions should explore and implement alternatives where appropriate to minimize animal use while maintaining student competence.

Institutions should establish a formal policy for the critical evaluation of animal source and use as part of the educational mission. Institutions should demonstrate transparency by reviewing, presenting, and discussing information about the source and use of all animals, cadaver and live, with students, faculty, and staff at least annually.

Live Animals

Institutions using live animals in teaching should:

1. Implement a policy for reviewing the use of animals in education; identifying alternatives to animal use where appropriate; evaluating the pedagogical merit of animal use both for teaching and assessment of skills critical to meeting the learner's career goals; and reporting to the institution's senior veterinary administration at least annually.
2. Teach tasks and procedures using a clinical skills model or simulation whenever one is available and effective to complement or precede live animal practice, depending on pedagogical circumstance.
    A. Models may include low-fidelity task trainers or models that do not resemble a live animal or may be high-fidelity manikins that realistically portray procedures.
    B. Institutions should develop and evolve a longterm strategy for the increased integration of models into teaching and assessment.
3. Implement a policy for the use of internally owned (i.e., by student, staff, faculty) or client-owned companion animals to reduce the need for on-site colonies for non-invasive skills development. A similar policy should be considered for other species.
4. Implement a policy for the ethical use of externally owned animals (e.g., shelter animals, client-owned animals, animals on farms) for invasive skills development. Proactively work toward reducing invasive procedures to those that have the potential to benefit the health and welfare of the animal.
5. Implement policies that emphasize the safety and welfare of the animal and student throughout the performance of all skills and procedures.
6. Optimally utilize clinical cases to achieve clinical competency. There is no recommendation to reduce caseloads in the clinical setting.

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CHAPTER 5: Using Live Animals to Supplement Teaching of Veterinary Anatomy

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Introduction

Veterinary schools typically include both small and large animal anatomy courses in their foundational curriculum. Courses in veterinary anatomy traditionally use embalmed cadavers as primary teaching models for laboratory study. The use of live animals to enhance the teaching of clinical anatomy was historically included in veterinary anatomy courses, as demonstrated in live animal sections included in popular teaching resources such as Guide to the Dissection of the Dog (Evans & de Lahunta, 2016) and Rooney's Guide to the Dissection of the Horse (Orsini & Sack, 2001). Some schools have maintained live animal palpation exercises as part of their anatomy courses while others have discontinued these exercises or have moved these palpation exercises into other courses. This chapter begins by providing an overview of the current use of live animals to teach veterinary anatomy. It then proceeds to discuss the perceived benefits of supplementing didactic classroom and laboratory learning with live animal palpation opportunities in anatomy courses. Finally, guidelines and considerations for implementation of live animal palpation as part of the veterinary anatomy courses are provided.

Current use

In preparation for writing this chapter, the authors carried out a brief survey of North American veterinary schools to inquire about their use of live animals in teaching anatomy in 2023. An email was sent to the American Association of Veterinary Anatomists (AAVA) listserv and included two questions: 1) Does your school use live animals as part of the small animal veterinary anatomy course? 2) Does your school use live animals as part of the large animal veterinary anatomy course? Additionally, respondents were asked to provide a brief summary as to why live animals were not used if they answered "no" to either of the two questions. The results varied considerably among the 20 schools that responded to this brief communication. Some schools reported the use of both small and large live animals to supplement teaching of anatomy; other schools reported the use of either small or large live animals but not both; and still other schools reported using no live animals. Curriculum revisions and the introduction of clinical skills courses into the early years of the curriculum led to the use of live animals being eliminated entirely from some anatomy courses. Time constraints placed on anatomy courses, high student to faculty ratios, and institutional animal care and use compliance were all suggested as factors for eliminating the use of live animals from the gross anatomy courses.

In order to gain a more international perspective, one of the authors (HD) sent personal emails to anatomists at 12 veterinary schools outside of North America that included questions similar to those sent to the AAVA listserv. Correspondence from 6 veterinary schools suggested that the use of live animals to supplement the teaching of anatomy had considerable variation. Similar to North America, curriculum revisions and the introduction of clinical skills courses into the early years of the curriculum, large class sizes, limited faculty and staff, and institutional animal ethics considerations were all mentioned as factors in the elimination of live animals for teaching in the gross anatomy courses. Other schools continued to use live palpation in the gross anatomy course alongside standalone clinical skills courses. The use of live animals was also reported as a component of a multimodal approach to teaching clinical anatomy later in the curriculum at some schools in combination with, for example, ultrasonography and radiography.

Benefits

Benefits of using live animals to teach anatomy include overcoming cadaveric limitations, parallel learning, repetition, and meeting new graduate outcomes (NGOs).

Overcoming cadaveric limitations

During the embalming process, tissues and organs undergo changes that can distort normal structure, texture, color, flexibility, and location within body cavities. These changes can give the student an unrealistic perspective, especially in the large animal. For example, the neurovascular structures of the equine distal limb are well-studied due to their clinical significance. Although observable through cadaveric dissection, these structures are not necessarily palpable in the cadaver and can challenge students during their clinical year. Using live animals provides students with a realistic tactile experience of vessels and nerves and, in some cases, the ability to visually observe distended veins. Organ topography is another limitation of cadavers. While the specific landmarks used for determining organ location are pedagogically presented during anatomy lectures, there is frequently a distorted representation of organ topography in the embalmed cadaver. Surface features are used to approximate the location of internal organs, and the application of this knowledge can be gained through palpation and auscultation of the live animal. Auscultating live animals can help to overcome the misrepresentation of organ location in the embalmed cadaver and serves as an introduction to patient examination by validating in vivo organ topography. See **link** to table for large animal organ topography.

Parallel learning

By simultaneously coupling the study of cadavers with live animals, students gain perspective on the in vivo location and palpability of relevant landmarks and structures. Weight-bearing, muscle mass, body condition, and movement of the animal can present challenges in locating learned landmarks in the live animal. For example, the popliteal lymph node of the dog or cat is easily identified during dissection; however, palpating the node on the live animal can be quite challenging due to variations in the amount of popliteal fat and size of the node among individuals. Another example would be the medial femorotibial joint compartment in the horse, a common medication injection site. Learning joint injection landmarks on a thawed horse limb that is lying flat on a table does not realistically transpose to a live, weight-bearing horse. This “side-by-side” or parallel study of cadavers and live animals presents a unique opportunity for understanding in vivo anatomy, allowing students to associate cadaveric dissection with the live animal. Students are also thought to learn more effectively when multisensory approaches to teaching are used (Johnson et al., 2012). The use of live animals in the anatomy course provides a unique sensory experience and brings anatomy to life, adding relevance to what is learned in lecture and laboratory studies. See **link** to table with a list of palpable skeletal structures in various species.

Repetition

With some schools implementing comprehensive clinical skills courses using live animals in the foundational years, some educators may view live animal palpation as an unnecessary inclusion in the gross anatomy courses. However, offering opportunities for live animal palpation across multiple courses can provide students with valuable repetition and practice. Repetitive practice acts to strengthen neural connections, forming the basis of learning and memory, and memory retention is most likely to increase with repetitive learning (Zhan et al., 2018). Whether live animal palpation is taught in clinical skills first or in the anatomy course first may not be important; what is critical is that there is collaboration between the clinical skills and anatomy faculty to ensure that courses utilizing palpation should be aligned in their content so that they effectively convey anatomical knowledge and prepare students to perform any tasks they are being asked to do. This collaboration allows the courses to complement each other insofar that the clinical skills course benefits from students already being familiar with landmarks on live animals, while anatomy benefits from the relevance gained by students participating in clinical skills.

New graduate outcomes

Using live animals in coordination with cadavers to teach veterinary anatomy plays a fundamental role in increasing competencies in the new graduate outcomes (NGOs). For example, the use of live animals to supplement teaching of veterinary anatomy addresses the following NGOs:

- Perform complete physical examination on all body systems on common domestic species.
- Describe anatomy relevant to performing local and regional anesthetic blocks.
- Explain anatomical relationships associated with entry-level surgical procedures.
- Describe normal physiologic conditions and anatomical presentations relevant to surgical intervention.
- Locate and describe the regional anatomy relevant to common medical procedures.

Implementation

There are several important considerations when planning the use of live animals in anatomy courses, including methods used, scheduling and facilitation, required number and sourcing of animals, anatomy and clinical faculty collaboration, and student assessment. For a discussion of oversight of use of teaching animals and a discussion on the use of dogs owned by faculty, staff, students, and the institution, see Chapter 8.

Methodology

The Guide to the Dissection of the Dog is commonly used in veterinary anatomy courses and contains approximately 20 "Live Dog" sections throughout to guide exercises in live small animal palpation (Evans & de Lahunta, 2016). Rooney's Guide to the Dissection of the Horse was once a popular resource for use in large animal veterinary anatomy courses, and each of the seven chapters within this guide includes an "Exercises on the Live Animal" section (Orsini & Sack, 2001). Given the diversity in large animal cadaveric procurement and use, anatomy faculty at several veterinary schools have developed their own in-house dissection guides to complement their customized large animal anatomy courses. These guides may include instructions for live animal palpation, listings, or labeled images of palpable structures in their appendices. These may be provided to students as supplemental resources.

Facilitated vs. non-facilitated

Palpation sessions should have a predetermined student to instructor ratio and method of facilitation (structured vs. unstructured). Facilitation refers to the presence or absence of a faculty member for supervision or instruction. The instructor's role may be more structured, such as providing an interactive demonstration and/or direct questioning, or the session may be unstructured, with students responsible for working through a list of anatomical structures independently in the presence of an instructor.

Examples of facilitated palpation activities:

- Provide student groups with paint or another marker that can be used to demarcate palpable landmarks and regions. Groups can then assess other groups on marker placement.
- Group competition (i.e., gaming)
    - Have individual students from each team draw a structure or region from a pool to demonstrate. An instructor or staff member keeps a running score.
    - Have an instructor demonstrate a structure or region and see which team is the first to call it correctly.
- Have faculty initiate group discussions during palpation labs by asking focused questions.
- Have faculty demonstrate relevant palpable structures and regions on osteological specimens and cadavers in the anatomy lab, immediately prior to taking students to live animal palpation.

One instructor can oversee multiple groups of students and palpation animals, but the efficacy of structured facilitated sessions increases with fewer groups overseen by one instructor. Facilitated group sessions require the scheduling of specific times for each group to meet in the presence of an instructor and may need to be done over multiple days depending on the number of groups and the time allotment per group. If facilitated sessions are scheduled during regular class time, members of dissection teams can be appointed to various palpation groups, thus allowing some team members to continue dissection while other members of the team go to palpation practice with their appointed group at their scheduled time. If scheduling instructor-led palpation practice at the veterinary college is not a possibility, pre-recorded videos can be used to provide both visual and auditory instruction so students can practice off-site on their own.

If practice sessions are not instructor-facilitated, students can design their own protocols using provided guidelines and structure lists. Alternatively, students practicing on-site can be provided with a pool of structures from which to draw (e.g., laminated cards), where individuals can take turns demonstrating and discussing selected structures with their group members.

Scheduling and facilitation

Scheduling and facilitation of live animal palpation sessions becomes more challenging as student numbers increase. While there are many challenges in organizing live animal palpation opportunities in high enrollment veterinary anatomy courses, there are some schools that have maintained these valuable activities. The student to faculty/staff ratio; proximity and availability of palpation facilities; and amount, sourcing, and availability of live animals are important considerations when determining whether palpation sessions should be held during or outside of designated class time, whether palpation sessions should be facilitated or non-facilitated, the frequency of palpation sessions, and whether palpation sessions should be optional or mandatory.

During or outside class time

The proximity and availability of palpation facilities are important considerations when determining if palpation sessions should be held during designated class time. At schools where there are large animal stalls and small animal holding cages close to the anatomy laboratory, individual students can freely roam between locations, or student groups can leave the anatomy laboratory, to perform live animal palpation during appointed times. Providing palpation opportunities during designated class time is most beneficial for parallel learning, allowing students to immediately transpose cadaveric learning to the live animal.

If holding live animal palpation sessions during designated class time is not a possibility, the potential for outside of class, or independent, palpation exercises can be considered. Students are likely to have external access to small animals, thus giving instructors the option of requiring or strongly suggesting that students practice off-site using either their own animals or those of friends, neighbors, or colleagues. A major drawback is the possibility of improper practice due to lack of supervision by course instructors. If instructors, tutors, or near peers are willing to volunteer their time, optional "meet at the park" days could be offered when students can bring their dogs to a designated location at a specified time for group practice and feedback.

Requiring or holding outside sessions may be a bit more challenging for large animals. At some schools, students are allowed to independently "check out" university-owned large animals. At some schools, instructors, tutors, or student clubs have volunteered their time and personal large animals to hold scheduled off-site palpation sessions with interested students.

Frequency of palpation sessions

There are several considerations when deciding how many live animal palpation labs to hold each semester. If sessions are mandatory but scheduled outside of class time, the first thing to consider is the suggested amount of student effort hours relative to course credit hours. Additional factors of consideration include whether a designated location needs to be reserved (e.g., laboratory or arena), whether animals need to be reserved (e.g., university-owned animals), whether animals need to be transported to a designated location, any affiliated costs (e.g., of animals and/or transport), and faculty/staff availability (i.e., for facilitated palpation sessions). Based on the authors' experiences, four facilitated on-site live animal palpation sessions per semester (two for small animal and two for large animal) provide sufficient practice for an end of semester assessment on identifying palpable structures. Students are also strongly encouraged to conduct self-directed practice sessions using their own animals.

Mandatory or optional

If students are responsible for procuring their own animals and organizing their own palpation practice sessions, then it is reasonable that these sessions be optional, yet strongly encouraged. Incentive for participation in optional practice sessions is improved if students know they will be assessed. Given the demand on faculty time and facilities, organized, on-site, facilitated sessions should be mandatory in most cases. Students can be given points for attendance and participation or can be required to take a short quiz following the palpation activity.

Required number and sourcing of animals

The total number of live animals required for palpation labs and assessments is dependent upon the student to animal ratio that is most efficient for learning, the number of required laboratory sessions, and the number of students. Ideal student to animal ratios may differ based on the size of the animal and whether sessions are facilitated or not. In general, groups of 4-8 students per dog or 8-12 students per horse or cow are likely safe and efficient for instruction, though these will vary based on learning objectives, instructional techniques, and settings.

Since there are currently no federal laws, regulations, or policies that clearly and specifically address animal care and use protocol involving the use of animals in teaching (Vemulapalli et al., 2017), it is necessary to receive guidance from the institution's animal ethics committee (e.g., Institutional Animal Care and Use Committee, or IACUC) when planning a protocol for live animal use. In alignment with the 4 Rs (replacement, reduction, refinement, and respect) of animal care and use, the minimal number of animals should be used for the desired outcome. To reduce the number of animals used, the practicality of reusing the same animals for multiple student palpation sessions on a given day should be considered if animal comfort can be ensured. External palpation is not considered an invasive procedure, so it should cause minimal distress to the animal if done properly. However, horses or cattle may be restrained in stocks or headgates, which should be limited to a period consistent with their comfort. Likewise, a dog has a limited period during which it would enjoy being handled without a break; after that time, it may resent being restrained and palpated, resulting in decreased animal comfort and a less productive learning experience for the student.

An animal ethics protocol will need to describe the justification and rationale for the use of animals in teaching. There are several questions that the instructor should ponder while completing the animal ethics protocol, such as, "How are the learning objectives of the course related to animal use?"; "Does the course build on animal experiences covered in previous courses?"; "Does this course prepare students for animal use in future (higher level) courses or post-graduate careers?"; and "Is a rationale given for the cumulative use of an individual animal?" (Vemulapalli, Donkin, Lescun et al., 2017). If there is potential for collaboration with another course (e.g., clinical skills or integrative animal medicine), submitting a single animal ethics protocol on behalf of both courses may be a possibility. If relevant content for both courses can be focused within a given palpation session, this would reduce the total number of animals used but would also reduce student opportunity for repetitive practice.

If internally owned animals (i.e., by student, staff, faculty) are to be used on or off-site for teaching purposes, school policy may require that the pet owner fill out and submit a consent form. Holding space for animals may be needed while the animals are not in use, which could potentially be a limiting factor for the number of animals that can be used on-site on a given day.

It is strongly recommended that guidelines for animal handling, use, welfare, and safety, as well as student safety, be provided to all participants.

Anatomy and clinical faculty collaboration

When clinical teaching faculty participate in anatomy, and anatomy teaching faculty participate in clinical courses (e.g., clinical and professional skills, integrated animal care, advanced applied anatomy), consistency of content is reinforced. The amalgamation of content between courses is conducive for implementing critical thinking activities that require the integration of content learned in multiple courses, thus increasing the probability of retention. Faculty collaborations across multiple courses can increase the faculty to student ratio for facilitated activities that require students to transpose their didactic learning to application on the living animal.

Student assessment

At the discretion of the course coordinator and participating course faculty, assessments can be given on-site using live animals, in the classroom synchronously using projected images or video clips demonstrating palpation sites on live animals, or off-site where images or video clips are linked to specific questions in an assessment hosted on a digital assessment platform or learning management software platform. Off-site assessments can be done synchronously, where all students are required to take the assessment at a specified time and location, or asynchronously, where students can choose when and where they will take the assessment within a permitted time span.

If assessments are given on-site using live animals, scheduling of student groups in coordination with course instructors, procurement and transport of animals, and arrangement of location will be necessary. For the on-site live animal assessment, palpable structures and regions can be indicated by the student or by the instructor, or the assessment can be designed to include a mixture of student and instructor demonstration. Instructors can have students randomly draw from a pool of structures or can dictate to each student or student group which structure(s) they should demonstrate for assessment.

Conclusion

Live animal palpation brings multiple benefits to the veterinary anatomy curriculum, including overcoming cadaveric limitations, allowing opportunities for parallel learning, ensuring repetition that is helpful for learning, and assisting students in meeting new graduate outcomes. However, numerous schools have removed live animal palpation from their anatomy curricula for a variety of reasons.

Some veterinary schools have excluded live animal palpation from their anatomy courses with the introduction of clinical skills early in the curriculum. At these schools, the change in curriculum resulted in the transfer of credit hours from the anatomy courses to clinical skills, so anatomists have defaulted to the clinical faculty the responsibility of having students apply what is learned in anatomy to live animals. In these cases, faculty collaboration is necessary to assure the integration of content across courses. Collaborations between anatomy and clinical skills courses offer the benefits of parallel learning, increased faculty to student ratio, and consistency of content. Anatomy and clinical skills faculty can work together to develop live animal palpation activities that are beneficial for both courses and that inspire critical thinking.

Another factor that may have contributed to the loss of live animal palpation activities from veterinary anatomy courses is an increase in class size. While the thought of organizing structured palpation practice sessions in high enrollment programs may seem overwhelming, there are faculty who believe that the use of live animals to teach anatomy is valuable and worth the time and effort necessary for incorporation into their anatomy courses.

There are several options for implementing live animal palpation exercises in veterinary anatomy courses. Faculty can choose whether these activities will be held during or outside of designated class time, will be facilitated or non-facilitated, or will be optional or mandatory. At each school, anatomy course faculty will have to deliberate the benefits and challenges of including live animal palpation laboratories in their courses and how best to do this at their institution.

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CHAPTER 6: Best Practices for Building and Delivering Clinical Skills Curricula Using Live Animals and Alternatives

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Introduction

Competency in veterinary medicine consists of the knowledge, skills, and behaviors required to successfully treat patients. Thus, didactic knowledge alone is insufficient to create a good veterinary practitioner, and clinical skills are an important part of a new graduate's ability to practice veterinary medicine. This chapter will discuss how clinical skills educators can structure, teach, and assess clinical skills with a competency-based veterinary education (CBVE) focus. Clinical skills laboratories (CSLs) use a variety of teaching materials, including models, cadavers, and live animals. This chapter will discuss how to optimize a clinical skills curriculum and will examine the continued role of live animals in teaching clinical skills amid the proliferation of models and alternatives.

How are clinical skills related to Competency-Based Veterinary Education?

Veterinary educators have traditionally promoted students based on their ability to pass knowledge-based examinations. Veterinary education recently has moved towards adopting a competency-based veterinary education (CBVE) model, which consists of three components: a framework of competencies, entrustable professional activities (EPAs), and milestones (Molgaard et al., 2018a, 2018b; Salisbury et al., 2019). Competencies are key tasks that represent most veterinarians' work tasks. Competencies may be classified into multiple domains such as clinical reasoning, communication, or individual animal care. EPAs are broad professional entrustment activities, such as performing surgery. The completion of a single EPA requires successful performance of multiple competencies, such as performing a procedure and post-procedural care, communicating professionally with the veterinary healthcare team, and keeping complete medical records.

The third component of the CBVE model are milestones, or the progress of learners toward independence in performing EPAs. Learners are rated on a scale of novice, advanced beginner, competent, or proficient on the EPA. These are assessed using in-training evaluation reports (ITERs), direct observation of procedural skills (DOPS), or objective structured clinical examinations (OSCEs). ITERs and DOPS are workplace-based assessments that must occur in a "real-world" environment; OSCEs are more commonly used in a pre-clinical CSL environment, although a remediation OSCE may be part of a clinical year improvement plan.

In a true CBVE model, students' progress is based on their skill rather than time spent in rank (i.e., years spent in classes), but implementation challenges schools. CBVE progression decisions are made by a panel or committee, based on many data points from different types of assessments; this is called programmatic assessment (van der Vleuten et al., 2012). Assessments may be formative or summative. They may be at the end of a laboratory or the end of a semester. They may include one or more skills. Most occur in the pre-clinical curriculum, but they may also be part of clinical year rotations or remediation activities.

Programmatic assessment identifies students performing below standard, for whom remediation is required. CSL faculty may play a role in the remediation of students who are struggling on their clinical rotations, as students can attend the CSL to work on the specific competencies in which they have substandard skills. Clinical skills educators should have on-going conversations with clinical rotation faculty and practitioners to understand broadly in which skills the clinical students tend to need improvement, so that the preclinical curriculum can continue to be improved.

What clinical skills should be taught?

Perhaps the most important decision in a clinical skills program is choosing what skills to teach, and there are a variety of methods used to make this decision. One of the simplest is to defer to the judgment of an organization. Lists of "day one" competencies or skills have been published by the American Veterinary Medical Association (2021), the Royal College of Veterinary Surgeons (2020), the North American Veterinary Medical Educational Consortium (2011), and other educational organizations. Additionally, some species-based organizations such as the American Association of Equine Practitioners (2020) and the British Cattle Veterinary Association (2023) have provided skills lists for new graduates or graduates following an internship year, for their species of interest.

Another option is to survey veterinarians in clinical practice, particularly those who recently hired new graduates. A Delphi process, whereby an expert consensus is developed, can provide additional rigor to the survey data generated (e.g., Wood et al., 2023). Another option is to survey recent graduates in clinical practice to find out how prepared they were, and which skills they wish they had learned to perform prior to entering clinical practice.

Often, which skills to teach may be determined in part or full by the agreement of the faculty at the institution. However, this can be subject to change as faculty leave the institution and new faculty join it. Comparison to the clinical skills curricula at several other institutions can be helpful, keeping in mind that institutions vary in their goals, geographic regions, budgets, animal availability, access to models, resources, class size, and schedule.

How can a clinical skills curriculum be designed?

Clinical skills training should start early in students' pre-clinical curriculum to allow students time to acclimate to the CSL, performing their skills repetitively while being observed and assessed, and receiving feedback.

For most clinical skills, there is no research data on learning curves or how many times a student needs to practice a skill to become competent. It is known that repetition is necessary to master complex clinical skills (French et al., 2018), so educators should expect to have to revisit skills multiple times if retention of skills is the aim. Veterinary research also suggests that decay of skills occurs with students' time off from practicing their skills, such as what may occur over a summer off (Hunt et al., 2022). Overall, it is wise to teach fewer skills more thoroughly than to teach many skills once, as they will probably be quickly forgotten. Spaced repetition with an admonishment to practice non-invasive skills during academic breaks may help to limit attrition.

Skills should align with didactic course content whenever possible (e.g., when learning about surgical asepsis, the student should be learning to gown and glove in the clinical skills laboratory); this is called horizontal integration. Skills should be repeated during subsequent semesters to improve retention; this is called vertical integration, or, when the skills are expanded upon each time they are revisited, the spiral curriculum. For a clinical skills curriculum to be effective, it must be taught cumulatively and must be assessed; students should be held accountable for retaining previous skills as they are taught additional skills.

More complicated procedures (e.g., canine ovariohysterectomy) may be taught best as disassembled tasks when they are first presented. If presented all together the first time, the length and complexity of the large procedure may exceed the student's cognitive load. The distribution of disassembled tasks is called backwards design because the educator begins with the end in mind–in this case, the ovariohysterectomy–and works backwards to distribute the component skills into the preceding labs or semesters.

How should sessions be scheduled to maximize retention?

Educators often prefer to schedule fewer sessions with multiple skills per session or schedule sessions back-to-back. In theory, having a break between sessions to sleep and/or exercise allows students to consolidate the skills they have learned, which helps with retention (Boyce et al., 2017; Mang et al., 2013). However, research data on whether there is any measured difference in retention between massed sessions (learning multiple skills close together) and distributed sessions (learning with breaks between sessions) is divided. When reading the research below, note that there is no common definition of what is massed and what is distributed.

The research in veterinary medicine:

- Model ovariohysterectomy: At the 1-week retention test, the weekly instruction group had superior performance to the monthly instruction group. There was no difference between groups at the 5-month retention test (Hunt et al., 2023).
- Basic surgical skills on a model: Immediately after instruction, the spaced instruction group (2 consecutive days) performed better than the massed instruction group (2 consecutive hours). There was no difference between groups 1 day or 3-4 weeks after instruction. Note that both groups did supervised practice sessions 1 and 2 weeks later; this may have mimicked spaced instruction (Banse et al., 2022).

The research in human medicine:

- Microvascular anastomosis on a live rat: The distributed group (weekly) performed better than the massed group (all in 1 day). (Moulton et al., 2006)

These studies collectively suggest that learning skills on consecutive days or on a weekly basis may be optimal and that having multiple laboratory sessions within the same day, especially on similar tasks or topics, is probably not ideal.

How can veterinary faculty improve the teaching of clinical skills?

Several learning theories and educational research govern how clinical skills are learned and retained; these should guide teaching practices.

Clinical skills instruction

The bulk of laboratory time should be spent in hands-on practice, not in instructor lecture or demonstration. Educators can utilize a flipped classroom model, where students study materials prior to coming to the laboratory, so that they are oriented to the task and ready to practice their skills upon arrival. Instructors may provide instructional videos, diagrams or sketches, pictures, booklets, or step-by-step instructions with pictures. Alternatively, some programs may incorporate mini lectures the day prior to a laboratory, providing additional instruction with time to review before the laboratory. Different colleges and students will have varying preferences. Students often prefer live demonstrations, particularly for specific difficult tasks within a skill. Key demonstrations can be recorded and looped on digital screens to play during a laboratory.

Recorded materials can also be beneficial as resources to support students in the laboratory if an instructor is not immediately available should a question arise. For example, if the student brings a tablet or phone to the laboratory session and cannot recall how to perform the last stitch of a suture pattern in the laboratory, the student can watch the instructional video again on their device if there is not an instructor immediately available to answer their question.

Opening the clinical skills laboratory or a separate practice space for after-hour practice time and/or sending models home with students to facilitate at-home practice is also helpful in supporting student learning, assuming adequate instructional resources are also provided. Technology has allowed the use of laminated instructional sheets to be supplemented with QR codes or near-field chips to link electronic material such as digital videos (Kang et al., 2021).

Feedback

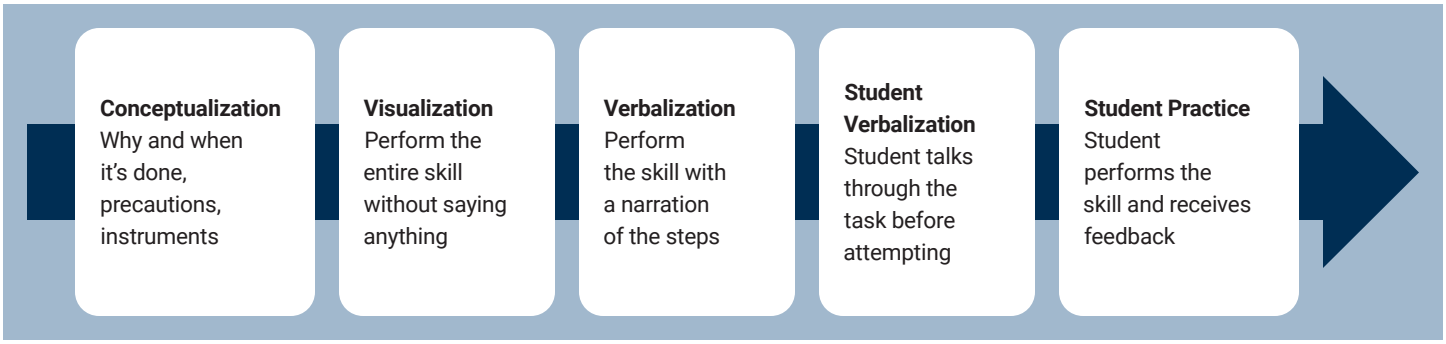
A review in medical education identified feedback on how to improve students' skills as the most important factor affecting learning in simulation-based training (Issenberg et al., 2005). Feedback should be timely, expected, specific, non-judgmental, and descriptive. There must be enough instructors in CSL sessions to provide feedback. Optimal instructor to student ratios in veterinary suturing, for example, were reported at 1:10 with instructional videos provided (Hunt et al., 2021). Suturing in human medical education has be taught at a ratio of 1:4 with learning outcomes reduced at some point between instructional ratios of 1:4 and 1:12 (Dubrowski & MacRae, 2006). Unfortunately, instructional ratio research has not been done for other veterinary clinical skills tasks. Typical instructor ratios suggested for use in veterinary medicine may be 1:10-1:12 for less technical tasks such as physical examination, 1:6-1:8 for fine motor skills such as model ligations, and 1:2-1:6 for live animal surgery.

The ideal instructor should deliver the consensus teaching rather than their own techniques and should have effective feedback skills. They should have a good working knowledge of both the didactic and skills curriculum, so that they are familiar with students' knowledge and anticipated prior experience. They should preserve a low-stress environment in the laboratory, where it is safe to make errors, seek help, and ask questions.

Clinical skills instructors do not have to be specialists. Instructors with recent clinical practice experience can offer the relevance of that practice experience to students. Recent graduates are not very far removed from being learners themselves, which allows them to recall how they learned the same tasks that they are now teaching. Specialists may be too far removed from general practice skills or themselves have not practiced the basic skills being taught for many years.

One clinical skills instructional model is George and Doto's 5-step method (2001). This teaching method reminds instructors to discuss the why and when of a particular clinical skill, to verbalize the steps of the skill, and to require the learner to accurately state the steps before allowing the learner to start practice. These aspects make it a gentle introduction to a skill. It is included here as it is a commonly cited model that may be helpful to newer educators.

Figure 1. George and Doto's 5-step method



How should live animals be used in clinical skills instruction?

Model use in CSLs initially arose from students' request for an alternative to live animal use for invasive procedures. Model use in CSLs has expanded well beyond this to situations where animals are not available, as an alternative to live animal use, as a precursor to enhance skills prior to live animal use, or to simulate procedures not reproducible with healthy animals; thus, they now have a central place in veterinary curricula worldwide.

Models are divided according to their fidelity, or realism, with low-fidelity models and task trainers being the staple in veterinary CSLs (Hunt et al., 2022). The low-fidelity models used in veterinary CSLs cannot reasonably exclude all use of live animals due to their limited features. Instead, models should be considered as preparing students for the best possible live animal use (e.g., getting used to instrumentation, refining technique, etc.). Many clinical skills laboratories use live animals to teach at least some of their clinical skills; according to the 2021 survey by Baillie et al., 46% of existing clinical skills laboratories worldwide reported using live animals (2023).

Live animals are best used in the CSL for teaching skills where animal behavior is fundamental to the task (e.g., restraint, handling, training), where the task cannot be replicated with adequate fidelity by models or cadavers (e.g., a complete physical examination), or for practicing skills where models or cadavers have already been used to teach the task (e.g., castration and ovariohysterectomy on shelter-owned patients after the use of models or cadavers). In all cases, it is important only to use live animals when the safety and welfare of the animals and students can be ensured.

How should clinical skills be assessed?

Assessing clinical skills ensures students will value learning them, and cumulative assessment means students will value retaining their skills. Assessment at predefined points should include both formative and summative assessments. Formative assessment should be performed early and often, as it assists the student to develop better self-assessment skills, set goals, and identify their current skill level. A formative assessment evaluates how a student is learning the material and is generally accompanied by feedback. A summative assessment evaluates how much a student has learned and may include feedback.

Competency-based Veterinary Education (CBVE)

In addition to the competencies created by the AAVMC, individual veterinary schools can also write additional competencies for use in their setting, such as adding a pre-novice level for students at the beginning of their clinical year. Students can be expected to move up the milestone scale (i.e., moving from novice to advanced beginner, etc.) as they move through the veterinary program. At predetermined points in the program, assessment can take place on models, cadavers, or live animals. Students should approach or exceed a competent level by graduation on these assessments. Remediation can be performed if the student is not on track to achieve that minimum competency level.

Rubrics

Valid and reliable rubrics should be used for formative and summative assessments to improve objectivity. This is especially important when performing summative assessments that are used as decision-making points or progression hurdles. Validated rubrics can be adopted without changes from other institutions that have validated the rubrics or can be created and validated using a framework of several of the following: content evidence, response process evidence, internal structure or reliability evidence, relationship with other variables evidence, and/or consequences evidence (American Educational Research Association et al., 1999). If multiple raters are used, rater training should take place, and inter-rater reliability should be measured rather than assumed. Inter-rater reliability poses a major risk to the reliability of a performance assessment (Royal & Hecker, 2016).

Types of rubrics include:

- Checklists are dichotomous (yes/no) task-specific rubrics. These are easier to use for novice raters.
- Component rating scales are task-specific rubrics that are not dichotomous but have a small rating scale (typically 3-4 choices) per line item (see Read et al., 2016 for an example). These are a little more challenging to score, as raters tend to default to a single number choice unless swayed from it.
- Global rating scores (GRS) are not task specific and are therefore easier to develop. They can be more challenging for novice raters to use. Sometimes a single GRS is used, or there can be a series of them for different items. See Objective Structured Assessment of Technical Skills (OSATs), below.
- OSATS are a specific set of GRS designed for scoring human surgical residents. They do not necessarily translate to veterinary students well, as one item is for use of assistants, which often veterinary students do not have (Martin et al., 1997).

Multiple formats can be used within a single assessment. For example, an assessment may use a 10-item checklist, a single 6-point GRS, and record the time to perform the task.

Types of assessments

The most well-known pre-clinical skills examination is the objective structured clinical examination (OSCE). This examination should possess at least 10-20 stations to ensure reliability and should have a different rater for each station. Fewer stations or raters creates low reliability due to sampling error. The examination should be blueprinted to ensure that stations are drawn from various domains (i.e., have content validity). Stations generally have a 10-20 point checklist combined with a single 4-7 point GRS. Raters, who will have previously completed rater training, are encouraged to document comments about student performances, though they provide no verbal feedback during a summative OSCE. Feedback is given during a subsequent feedback session. The examination is timed, and students move through the examination, performing one task per station. Some tasks may involve models, cadavers, live patients (generally with handlers), or simulated clients. Stations may be run in duplicate to increase student throughput.

A standard setting method should be used to determine the cut score for passing the OSCE; some can be done before the OSCE (e.g., the modified Angoff), and some can be done after the OSCE (e.g., borderline regression). Using one of these methods ensures defensibility of results.

Clinical skills can also be assessed on models during formative and summative mini-skills evaluations at the end of laboratory sessions or during surgical skills assessments on models. Additional methods of assessing clinical skills on live patients include directly observed procedures (DOPs), in-training evaluation reports (ITERs), electronic portfolios, and mini clinical evaluation exercises (miniCEX), among others.

Approximately two-thirds of clinical skills laboratories internationally do some formative or summative assessment of skills (Baillie et al., 2023). It is important to do cumulative assessment of clinical skills because otherwise students may not apply adequate effort into learning and retaining these important skills.

Conclusion

Clinical skills are an important part of a new graduate's ability to practice veterinary medicine. This chapter highlighted how clinical skills educators can structure, teach, and assess a clinical skills curriculum with a CBVE focus. In conclusion, becoming competent in clinical skills is all about structured training, good instructors, repetitive practice, rigorous and fair assessment, and effective feedback.

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CHAPTER 7: Using Models as Alternatives to Live Animals

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Introduction

In recent years, there has been a rapid increase in the range of clinical skills models available to veterinary educators (Baillie, 2007; Hunt et al., 2021; Noyes et al., 2021; Braid, 2022) and an expansion of clinical skills laboratories around the world (Baillie et al., 2023). As a result of these advances, veterinary schools are increasingly introducing alternatives to complement teaching and assessment with live animals (AAVMC, 2022) and adopting the concept of 'never the first time on a live animal' (EAEVE, 2023).

Models were introduced in medical education many years ago, with an early example being a manikin for training midwives in France in the 18th century (Gelbart, 1998). The recent expansion in the health professions has been driven by the need to complement bed-side teaching and better prepare trainees and healthcare teams. There is a wide range of models now available, from simple task trainers to high-fidelity simulators, typically in dedicated simulation centers (McGaghie et al., 2010).

Veterinary education has followed medicine's lead and is capitalizing on the many benefits of using models and simulators to support and enhance learning with live animals. Alternatives are not limited to models and simulators, which will be the focus of this chapter, but also include e-learning such as video recordings used in a flipped classroom (see Chapter 6).

Why use models?

There are clear benefits for animal welfare if students are prepared by learning skills on models prior to classes involving live animals. Skill mastery requires deliberate and repeated practice (Ericsson, 2004). When using models, students can have multiple attempts while practicing and perfecting a skill, which may not be ethical or feasible using only live animals. Additionally, models offer a safe, trial and error experience where mistakes carry no serious consequences, which is conducive to learning and has been shown to reduce student anxiety (Langebæk et al., 2012).

There are also benefits for teachers, as using models supports guided instruction with focused feedback. For curriculum leaders, strategic inclusion of model-based teaching will ensure learning is timely, e.g., in preparation for classes with live animals, and standardized for all students, as the achievement of learning outcomes is more manageable. Strategic use of models aligns with the move to competency-based education (AAVMC, 2018), supporting a stepwise approach from simple skills (instrument handling, suturing on a model, surgical preparation in an artificial theater setting), to procedures requiring a combination of skills performed on models (making and closing an abdominal incision, performing an ovariohysterectomy), to performing an entrustable professional activity (EPA) in a clinical setting ('perform a common surgical procedure on a stable patient' (Salisbury et al., 2020)). Basic animal handling skills can be learned on models with students acquiring technical proficiency (e.g., putting a halter on a model cow, a muzzle on a model dog) before handling and restraining a live animal, when students also need to be aware of behavior, safety, and the environment. However, there are certain challenges associated with using models. Models are an approximation for the real task and animal, but they may have shortcomings in their depiction of anatomy or the tactile properties of the task, for example. However, initially learning a skill on a model, and in isolation from some aspects of reality, is beneficial. The student can focus on practicing and then mastering the technique on the model before learning in the more complex clinical setting.

The decisions about which models to use should be informed by, and aligned with the curriculum to support acquisition of the skills students need to learn to achieve program outcomes and graduate competencies. For a particular model, considerations include cost, re-usability (multiple attempts by multiple students), repair and/or replacement, sustainability, and environmental impact. Some simple and cheap models can be provided for students to use at home to support repeated and timely practice (Parkes et al., 2023). Some of the costs associated with investing in models can be mitigated by a reduction in the associated budget needed for the purchase, care, and husbandry requirements of animals. Overall, strategic combinations of models and animals will allow for refinement in the uses of animals for learning.

Clinical skills laboratories

In addition to making or purchasing models, it is crucial to have a dedicated space, such as a clinical skills laboratory or center, for teaching, self-directed learning, and assessment of clinical skills. In veterinary medicine there has been a rapid and recent expansion of clinical skills laboratories (CSLs) worldwide (Dilly et al., 2017; Baillie et al., 2023).

Typically, a CSL consists of one or more large teaching areas that can be repurposed for different classes, room(s) for storage, a room or space for model making and repair, and an office for the CSL team. The CSL may be purpose built or in a refurbished existing building. It should be close to other student facilities for ease of access for taught classes as well as self-directed learning, which is particularly important for the repeated practice required to develop competence. The effective running of a CSL depends on having a dedicated team, which usually includes an academic lead; one or more technicians who may be involved in teaching, setting up and running classes, and developing learning resources (models, videos, instruction booklets); and students, who may be involved in peer teaching.

The CSL will primarily contain models but may be used for live animal classes, particularly with dogs and potentially other species depending on the facility. Some CSLs have spaces for cadaver classes, such as for surgical skills, if the building is suitable for such material.

Consideration needs to be given to funding; initial set up costs for a CSL, whether it is a new build or refurbishment, are often provided by the university or are sometimes supported by grants and philanthropy. In addition, an annual budget is required for model replacement and repair, for consumables, and to support ongoing teaching and assessment. Over time, extra models will be required for new teaching initiatives and expansion due to larger cohorts.

In summary, a CSL is a safe, trial and error environment that is conducive to learning, and provides a venue for repeated and strategic practice, such as before a placement, clinical rotation, or assessment. To fulfil a CSL's potential in supporting student development of clinical skills and competencies at each stage of the curriculum, it is important that classes are formally timetabled into the students' schedules and there is good access to the facility for practice and self-directed learning.

Selecting the most appropriate models

Considerations when using models include the level of realism required, the stage of skill development, how to combine model use effectively with the use of live animals or cadavers, and how new models might be validated. Regardless of which models and simulators are used, training must be developed to align with specific learning outcomes (Noyes et. al., 2021).

Models are often referred to on a scale from low- to high-fidelity. Fidelity can be defined as the degree to which the model or simulator mimics the patient or procedure. Low-fidelity models are less 'realistic' and usually represent simpler skills. High-fidelity models are more 'realistic', representing the appearance and/or feel of the real patient. Models may simulate an entire patient and/or procedure or be a part-task trainer. Part-task trainers replicate part of the animal or an individual skill and are typically used for simple psychomotor skills, like knot tying or venipuncture (Maran & Glavin, 2003). It is important to note that in early training, low-fidelity models can be as effective in developing skills as high-fidelity models (Norman et al., 2012). Low-fidelity models have the advantage of being cheaper and easier to make or purchase and are feasible in more resource-limited settings. For example, the use of a dishtowel for learning suture patterns is as effective as higher fidelity silicone skin (Baillie et al., 2020).

Choosing which model to use, and when, depends on a variety of factors. Educators should have a clear idea of the intended learning outcomes for the model, and which parts of the skill are most important for the student's current stage. Typically, teaching should start with simple, part-task trainers before progressing to models for more complex and advanced procedures. If the ultimate goal is that students complete an entrustable professional activity (EPA), the clinical skills learned on models can be used as building blocks to support progress towards that EPA. For example, the EPA might be to perform a basic surgical procedure. For this, students could use simple, low-fidelity models to train in surgical preparation, making an incision, performing sub-tasks such as ligation, and closing the incision. Students may then progress to a low- or high-fidelity model that allows them to complete a full procedure by combining the sub-tasks they have already learned. Finally, students complete the whole EPA with a live patient in a workplace setting and integrate skills from other domains, such as teamwork, communication, and case management.

In addition to the pedagogical requirements, educators need to consider the budget, available resources, number of models needed for the number of students, and practical aspects such as how to store the model(s), ease and cost of replacing parts, and how to develop supporting materials. It should be noted that it is often possible to build suitable models using locally available and relatively cheap materials.

When working with models, it is also essential to consider how to enable students to progress from using the model, however simple or advanced, to a live animal, and what the benefits of the model are to this process. For example, placing a simple interrupted suture on a silicone skin pad before being exposed to the challenges of being in an operating theatre and closing an incision on an anaesthetized animal, or applying a halter or headcollar to a model horse's head before dealing with situational awareness and analysis of behavior. However, it is also important that the differences are highlighted and training in context is provided, whether using more complex simulations or with live animals in a clinical setting.

It is important that research studies are undertaken to demonstrate the benefits for students of learning on a model i.e., the acquisition of relevant skills, and ideally, showing that the skills transfer to improved performance with live animals. However, model validation studies are not necessarily simple to design and are often time consuming to implement. There are ethical considerations for both the impact on the student and animals, if used during these studies. It is also not sufficient to demonstrate that a model is better than nothing; there should be some form of comparison to the model as a method of teaching. Keep in mind that when developing simple, low-fidelity models in-house e.g., for injection techniques or skin pads for basic suturing skills, it may not be necessary to perform a full validation beyond testing that experienced clinicians consider the model represents the task and is appropriate to use for student learning. Validation studies may highlight areas for improvement or teaching-related issues that have not been anticipated. However, just because a model is not 'perfect' does not mean that it is not useful – simply that any shortcomings or differences must be highlighted to the student.

The body of evidence to support the use of veterinary clinical skills models has grown rapidly over the last 20 years. Published research studies have been reviewed (Hunt et al., 2021; Noyes et al., 2021; Braid, 2022) and collated in an **online repository**. The repository can be filtered by species and skill and is maintained and updated by the 'Veterinary Clinical Skills + Simulation' community.

*Note: For the following sections, the reader is referred to the reviews mentioned above and the **online repository** to find examples of validated models and the associated papers.*

Types of models

Models for core skills

Core skills are transferable psychomotor skills, necessary for day one practice, that may be applicable to multiple species and situations. Models for developing core skills are often lower fidelity and may be made in-house, or at least should have cheap, easily replaceable parts as these models will be used repeatedly. Once core skills are mastered on a generic model, the learning can be applied to similar skills in other species with more of a focus on the differences. Examples include injection techniques (handling sharps, drawing up drugs), surgical preparation, suturing (instrument handling, knot tying and basic suture patterns), laboratory diagnostics, and using applying bandages. Therefore, it can be helpful when developing a new clinical skills program to initially identify the models that will support core skill as many are generalizable across species and applicable to multiple procedures.

Small animal models

Many core skills will be taught in the context of the dog due to the emphasis on this species for many practitioners and the ease of finding both models and dogs for students to learn with. When considering how to reduce and refine live animal use, it is important to integrate safe handling into the clinical skills curriculum. For example, students may start by learning to place a muzzle on a model dog, in addition to classes using gentle handling methods with live animals. The use of a model dog for muzzling allows students to select appropriately sized muzzles and learn how to place them safely, which reduces bite risk and undue stress when subsequently practicing with a live dog.

Some aspects of small animal physical examination may also be started on models, especially those which, while technically non-invasive, can make an animal head shy or stressed due to repeated interactions with novices who may take extra time or use inappropriate technique. For example, if the purpose of a class is to teach students how to handle and focus an ophthalmoscope and how to position themselves safely to examine a live dog, functional models may be created using tools as simple as a modified plastic ball inserted into a soft toy. When proficient in these simple skills, students can then progress to examining a live dog, perhaps in a later session or course as part of a spiral curriculum. Practicing invasive skills should be avoided on the live animal unless clinically indicated.

There is a growing range of more sophisticated small animal models, some home-made and some commercially available, which support skills learning in, for example, anesthesia, resuscitation, surgery (including feline and canine castration and ovariohysterectomy), dentistry, ultrasound, and laparoscopy.

Equine models

Teaching with horses poses certain safety challenges, with a risk of serious injury. These risks are compounded by the nature of some of the skills required; several essential day one equine skills, including nasogastric intubation and rectal examination, are challenging for novices, relatively dangerous for both horse and veterinarian, and relate to life-or-death situations, like diagnosing and managing colic. Common safety issues are also often difficult or impossible to replicate in a model.

The focus for equine models should be on essential skills and day one competencies that are not easily transferable from other species, such as nasogastric intubation or the use of rasps for basic dentistry. This not only avoids repetition in an already overcrowded curriculum but allows a clear focus on species-specific skills and the development of key motor/procedural skills that cannot be developed elsewhere.

Whole horse models can be used to prepare students for animal handling and basic technical skills, such as placing a halter or headcollar, tacking up, or bandaging a leg, before performing the same skill on a horse. Assessing behavior, approaching the animal, and situational awareness need to be combined with the hands-on skill on the live horse. There are some commercially available and/or homemade models for training specific equine clinical skills, including venipuncture, intramuscular injection, perineural analgesia of the lower limb and ocular blocks, abdominocentesis, rectal palpation for colic and reproductive purposes, shoe removal/hoof trimming, and dental floating. However, only a few equine models have been validated.

Farm animal models

The most well documented farm animal models are those used to support skills in rectal palpation for bovine pregnancy diagnosis and fertility examinations. Achieving competence in these skills requires considerable practice. Opportunities for access to enough cattle can be limited, particularly as student numbers increase. There are welfare considerations including the impact on individual cows through repetitive palpation as well as the perceived risk of iatrogenic damage when the procedure is performed by novices. Furthermore, teaching with the live animal is difficult as the instructor cannot see or feel what the student is doing. Hence, it is common to use alternatives to better prepare students to palpate cows. These include postmortem tracts, anatomical models (partial and entire cow), and virtual reality with touch feedback (haptics). Many of these models have been validated as effective for teaching the required skills.

Models cannot totally replace the interaction with live animals for development of handling skills, but there are opportunities to use models to enhance practical teaching. Basic handling skills have been highlighted as important by farm animal practitioners and underpin many day one competencies (Wood et al., 2023). These skills include putting on a halter, using a cattle crush/chute, placing casting ropes on a cow, and turning a sheep; learning such skills can be supported through the use of models. This will be particularly important, given that students from non-farming backgrounds may have limited experience of farm species, or may lack confidence in handling them, and the potential risks during handling to those inexperienced with such species will be higher.

As noted above, many core clinical skills will be taught initially with models designed for other species, particularly canine, and then specific farm animal models can be used to highlight differences. For example, suturing the abdominal wall of a cow (for a cesarean section or displaced abomasum) involves a vertical approach, thicker skin, and large gauge needles and should be learned on bovine models. However, in preparation, the basic skills of instrument handling, knot tying, and suture techniques can be learned first on more generic models.

High-fidelity simulation models exist for some farm animal procedures but come with the associated expense; for example, dystocia simulators for teaching of obstetrics skills and virtual reality haptic simulations. However, when developing learning objectives, educators should have in mind the priority skills required by new graduates entering farm practice; many low-fidelity models will support competence development in the core skills required at graduation such as animal handling, diagnostic sampling, and medicine administration.

Exotic animal models

For more detail about considerations for teaching animal handling and clinical skills for exotic species (also referred to as zoological species and non-traditional companion animals) refer to Chapter 10.

Conclusion

Clinical skills are a crucial part of the competencies students need to develop to be ready for day one in practice. There has been a rapid expansion in the range of veterinary models, home-made and commercial, available to educators to complement learning with live animals. In parallel, many veterinary institutions have a dedicated space, a clinical skills laboratory, for taught classes and self-directed learning. It is anticipated that the range of models, innovations in teaching and evidence-base will continue to grow with associated benefits for veterinary educators, student learning, and animal welfare.

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CHAPTER 8: Use of Small Animals in Preclinical Veterinary Education

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Introduction

The use of live animals in teaching and assessment supports student learning and preparation for careers in the veterinary profession. In preclinical curricula (i.e., prior to final or clinical year), there are many examples for use of institution-owned and faculty-, staff-, and student-owned animals in veterinary education. Typical uses of live animals include instruction in animal handling and clinical skills and assessments e.g., Objective Structured Clinical Examinations (OSCEs). This chapter will highlight existing examples for live animal use in preclinical veterinary education as well as the important factors to consider when incorporating live animals in experiential learning opportunities within the curriculum.

Oversight of the use of live animals in teaching and assessment

Paramount to the inclusion of live animals in preclinical teaching and assessment is the establishment of governance for the welfare and use of these animals. This requires thorough and comprehensive management and intensive oversight, often with the establishment of separate committees and reporting structures to manage the use of the animals in teaching. Laws, regulations, and institutional size will dictate the number of committees necessary and the appropriate reporting structures.

Establishing an overarching institutional animal care and use committee and/or animal ethics committee is important to review and approve animal use and to ensure compliance with all national, regional, local, and institutional regulations. In the U.S., for example, this responsibility falls to the Institutional Animal Care and Use Committee (IACUC). When developing an overarching committee, membership should include a variety of perspectives from scientists, veterinarians, ethicists, behaviorists, and perhaps representatives from the public sector. A second committee is often necessary to manage the granular details for animal use related to teaching goals for specific courses and/or teaching sessions. This committee typically includes faculty and staff directly involved with teaching. The protocols for each session where live animals are to be used should be drafted from this committee and submitted to the institutional level committee e.g., IACUC, for review and approval.

Both committees should have mechanisms to communicate policies and gather feedback from all stakeholders including animal owners. The committees should report to the institution's senior administrative group on an annual to semi-annual basis.

The committee duties, responsibilities, and terms of reference should align with the overarching aim of promoting best practices for the use of animals in veterinary education for teaching and assessments, and specifically involve:

- Providing guidance on when it is appropriate to use animals in the curriculum for animal handling and clinical skills classes, and when alternatives, such as models, could be used.
- Ensuring regulatory compliance for the welfare and use of live animals in teaching and assessment.
- Advising on the operational management of teaching animals, including developing standard operating procedures (SOPs).
- Overseeing the review for approval of new applications to use live animals (e.g., creation of a new course or teaching opportunity).
- Gathering and analyzing data to monitor, review, and report the use of animals in the program.
- Planning for future requirements and sustainability of live animal use (e.g., increased student cohort size or the loss of availability of animals).

What animals may be used in preclinical teaching and assessment?

Although dogs will be the primary focus of this section, many of the approaches described are applicable and generalizable to other species and therefore can easily be adapted and applied. The primary means by which institutions ensure dogs are available for teaching and assessment include dogs owned by faculty, staff, students, and clients, and institutionally owned colonies of dogs, and/or a combination of both. It is important to note that an increasing number of suitable models are available to complement the use of live animals; these may reduce the need for some uses of live animals for teaching (see Chapters 6 and 7).

Dogs owned by faculty, staff, students, and clients

Before a privately-owned dog is used in teaching or assessment, an evaluation should be performed to determine its suitability. This is in the interest of the animal, students, program, and institution. The evaluation should include a behavioral assessment, creation of a record with basic owner information and dog details (e.g., age, microchip number, a photo identification), relevant clinical conditions (e.g., heart murmur, dietary allergies if treats are given), and individual animal considerations when using the dog (e.g., issues when around other dogs). The evaluation of the animal is typically performed during a scheduled appointment with a veterinary nurse or veterinary technician who may be a member of the clinical skills team or member of the committee responsible for developing animal use protocols. For some animals, additional animal evaluation by a qualified behaviorist may be necessary.

If deemed qualified for inclusion in teaching and/or assessment, the dog should then be entered into an electronic teaching register. It is advised to place the dog on a probationary list while feedback is gathered during teaching activities to ensure its suitability for use in teaching. Adaptations to the animal's record should be made as required e.g., if developing a new clinical condition, based on notes from teaching activities. If at any point a dog becomes unsuitable for use, the animal should be removed from the register. Dogs may retire from use as they age or due to health concerns (e.g., development of osteoarthritis).

There will need to be clear expectations established so that owners are aware when dogs will be used in teaching and assessment, and a signed consent form may be required. Additionally, the types of animal handling and clinical skills that can be performed by students will need to be defined. This information needs to be clear and transparent to all involved, including the owners, and oversight will fall under the remit of the relevant animal use committee. It should be noted that utilizing faculty- and staff-owned animals as compared to student-owned animals can be beneficial as animal availability is more consistent and reliable from year-to-year, drop-off and pick-up is more streamlined, and monitoring animal suitability for each class is easier.

Colony dogs owned by the institution

The considerations if an institution decides to obtain, house, and use dogs on a campus for teaching are complicated and lengthy. The following paragraphs outline some of the considerations, which may be prioritized differently based upon needs and resources within individual programs.

Teaching colonies may be established for short or long periods of time based on the needs of the program. Rather than creating long-term dog colonies, some institutions may be able to schedule their canine teaching laboratories to take place during only a few weeks during the semester. These institutions may be able to obtain dogs from a local shelter, house them for a few weeks for use in those laboratories, provide healthcare including desexing surgeries, and then find them homes or move them forward to rescue organizations for re-homing.

Regardless of the duration of the housing, establishing and maintaining a colony involves considerable financial investment and maintenance costs, which includes construction of suitable housing facilities, initial purchase/establishment of the dog colony; per diem for housing, feeding, and daily care; preventative care and wellness; and animal enrichment. Treatment costs associated with acute and chronic illness, isolation facilities, and unforeseen incidentals should also be considered.

Adherence to regulatory factors relevant to regional and national legislation is required. For example, programs planning to establish a colony of dogs in the U.S. must register with the United States Department of Agriculture (USDA). Once registered, programs are required to follow the Animal Welfare Act rules and regulations. Other countries have their own regulations, and international accreditation groups are expanding (e.g., AAALAC International). Regardless of the country, awareness of the relevant laws and regulations is critical to ensure compliance. Many of these regulatory bodies also provide guidelines for forming an institutional animal use oversight committee as well as creating animal housing expectations and veterinary care standards.

Prior to establishing a colony of teaching animals, the decision-making process must include where and how suitable housing can be provided for both short- and long-term holding/housing. While the amount of financial capital expended on building kennels can vary, housing structures must always meet or exceed the guidelines decreed by regulatory agencies. Discussions between the program, institution administration, and interested parties are important in reaching agreement on the best property or building space.

Expectations and considerations for colony animals to participate in the curriculum must be well-defined, and oversight will fall under the remit of the relevant animal use committee. Establishing animal comfort in both colony housing and when used in teaching spaces is important for animal welfare. The dogs participating in teaching and assessment may also require some basic training. It is good practice to develop and maintain socialization and handling training for colony animals. Training may include basic leash manners, voice commands such as sit/stay, and advanced commands based upon needs surrounding the teaching environment.

One advantage of using an institution-owned colony is that it can make scheduling for live animal sessions more efficient. Since the animals are housed onsite, there is less reliance on faculty, staff, students, or owners dropping off and picking up the dog at the scheduled times.

Colony animals are institutionally owned, which may complicate adoption and/or retirement of dogs. Careful consideration for both political and practical concerns should be made with input from administration, faculty, staff, and students. Developing the policy and process for adopting out of the colony or animal retirement is important (e.g., should this be based on time of service, be animal dependent, related to age and/or health?). It is also important to consider and plan for where and how replacement animals will be procured.

Another consideration for institutions with an existing colony, or when deciding whether to establish and/or continue to maintain one, is the pressure that outside entities may place upon programs. This pressure can be intensive, persistent, and pervasive. The institution must take this into consideration and factor in processes for protecting both the animals and the program (e.g., not allowing posting of pictures on social media). Even in instances where all rules, regulations, and governances are followed, there is no guarantee that outside entities will not intervene. This outside pressure can be significant, and many institutions do not keep live companion animals for this reason.

Managing the use of live animals for teaching and assessments

There are several administrative processes required to support the operation of teaching and assessments that involve live animals. The institution, typically via the animal use committee and associated documentation and protocols, needs to define what the animals can be used for. For example, faculty-, staff-, student- and client-owned animals would likely be used only for non-invasive procedures (e.g., animal handling, physical examination, external anatomy palpation, ultrasound). Student-owned animals are not typically utilized for assessment purposes e.g., in OSCEs, as this could create an unfair advantage for the student-owner of the animal.

Planning for the use of animals in the curriculum involves multiple steps and usually starts with information supplied by the course director, who will be responsible for identifying classes requiring live animals and submitting a request, typically through a standardized online form. Ideally, an individual person (e.g., a member of the clinical skills team) should have specific responsibility to oversee and manage the animals for all activities throughout the curriculum.

A mechanism should be in place to schedule the animal's use, for example asking owners for availability or coordinating scheduling of institution-owned animals, and then confirming the date, time, and location of the class. The teaching area should be set up appropriately with a dedicated location to house the animals securely (e.g., kenneling or a collapsible cage). Dogs should be allowed to rest and be provided a water source. When moving or transporting dogs, a 'two leashed' rule is advisable to enhance security and safety of the animals.

Information should be available for all individuals involved in the class about how each dog will be used including overall duration of use during that session, number of times a task or procedure can be performed per session, breaks for a walk, and any special requirements (e.g., dietary, behavioral). This is particularly important during lengthy activities such as a full day OSCE or back-to-back live animal sessions. Additionally, the frequency (weekly, etc.) that an animal can be used should be defined, typically by the animal use committee.

At the time of the teaching activity, it is important to record each animal's use. An online system is a useful way to record and monitor such information, including the identity of the animal through markings or microchip number, details of the activity such as name of course/activity, venue, date, and duration. For faculty- and/or student-owned animals that are registered for work in the program, it may be helpful to attach a 'teaching pet' tag to the collar for ease of identification. There will also need to be a way to collect feedback from the instructors and report any incidents related to animal performance, abnormal or unacceptable behaviors, or other concerns. Overall, the data collected before, during, and after the teaching or assessment activity allows for comprehensive monitoring of the animal's overall use and welfare.

Conclusion

The use of live animals in preclinical teaching and assessment is important for providing veterinary students with hands-on experiences that prepare them for clinical training and careers in veterinary medicine. The inclusion of live animals requires significant forethought, planning, and record-keeping to verify and ensure the welfare of animals used in the program. The use of faculty-, staff-, student-, and client-owned animals, when possible, provides an option that can reduce reliance on institution-owned dog colonies. This chapter provides information that supports the use of live animals in teaching and assessment and provides foundations for the development and management of preclinical educational activities incorporating the use of live animals.

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CHAPTER 9: Use of Large Animals in Preclinical Veterinary Education

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Introduction

Most veterinary curricula include routine training in large animal clinical skills. Core competencies have been published for veterinary graduates entering bovine, ovine, and equine practice (Morin et al., 2002a; Morin et al., 2002b; Hubbell et al., 2008; Luby et al., 2013; Wood et al., 2022). Strong clinical skills remain critical to success in equine and food animal practice; employers expect graduates to have these skills, and many would provide higher starting salaries for graduates with these skills (Thomson et al., 2017). Additionally, non-large animal students should be provided with core clinical skills in their preclinical curriculum as they are less likely to pursue elective rotations to further develop these skills during their clinical year. Large animal clinical skills can be taught using models (see Chapter 7), cadavers (see Chapter 4), or live animals, as described in this chapter.

Two sources of large animal herds exist: university-owned and privately-owned. Historically, veterinary colleges were housed at universities with undergraduate animal science programs, which commonly had teaching and research farms associated with them, although these teaching and research farms varied between colleges. As veterinary colleges are established at universities without these animal science teaching herds, or in urban or urbanizing locations, alternatives to university-owned herds, such as partnering with private farms, have become necessary. These relationships with outside facilities may vary widely depending on the goals of the college and the interests of the owners. Examples of these types of relationships will be provided, and key considerations when establishing and maintaining these partnerships will be explored.

Terminology

This chapter refers to large animals, which are meant to include food animals, livestock, and horses, and to livestock-owning properties, which are meant to include ranches, stables, farms, feedlots, and dairies. Privately-owned farms will be defined as any farm that is not owned by a university or college.

Rationale for using large animals

Educators should follow all animal welfare legislation when planning clinical skills training using large animals. All use of animals, whether university- or privately-owned, requires approval from an animal ethics committee, unless that use is clinically necessary care of the animal. Additionally, the formation of a committee for the use of animals in education can be helpful in reviewing animal use within the college; details about this type of committee can be found in Chapter 8.

University-owned

University-owned large animals can be used for teaching several types of clinical skills procedures. These include:

- Non-invasive procedures such as handling, restraint, physical examinations, and body condition and locomotion scoring;

- Invasive clinical procedures such as disbudding, dehorning, castration, rectal palpation, rectal ultrasound examination, hoof trimming, and venipuncture; and
- Clinical surgical procedures. Training for surgical correction of problems can be performed on naturally occurring cases in university-owned teaching herds, on models, or cadavers. Institutions should proactively work to reduce invasive procedures to those that have the potential to benefit the health and/or welfare of the animals.

Using university-owned large animals to teach clinical skills has several advantages over the use of animals on private farms or ranches. These include:

- Scheduling: Access to individuals and groups of university-owned animals can be scheduled to accommodate the needs of a teaching program, while access to private farms must work around the farm's schedule.
- Animal and time availability: University-owned herds tend to be stable in size, and animals tend to be available daily for the same amount of time. Private farms may have a varying number of animals available daily, as animals are bought, sold, or unavailable. Private farms are on schedules for milking, training, and other events, potentially resulting in less consistent time available for teaching groups of students.
- Animal oversight: Compliance with animal welfare may be easier to ensure on university-owned farms but must also be monitored on private farms. University-owned animals are always under the purview of animal ethics committees' policies and protocols, while privately-owned animals may or may not be governed by these committees. No matter the ownership of animals used for teaching, animal welfare is paramount, so coordination with all stakeholders is a must.

Privately-owned

Using privately-owned large animals to teach clinical skills has several advantages, including:

- Authentic representation of clinical practice: Animal housing and restraint facilities more authentically represent those seen once the student graduates. Facilities may not be ideal for each scenario being taught, but students can learn flexibility and practice safe approaches to complete the necessary tasks. Students are also more likely to encounter a wider range of normal and abnormal animals, including a variety of body conditions, common disease presentations, and animal behavior typical of what students will encounter in their future careers.
- Interaction with private veterinarians: Students are likely to interact with an outside veterinarian utilized by the private farm, observing the typical veterinary-client-patient relationship that exists in private practice but can be difficult to model in referral institutions.
- Access to a larger number of animals: Most privately-owned farms are larger than university-owned herds, providing many more opportunities for students to practice clinical skills without overusing a small herd.

There are opportunities to leverage private farm relationships to teach students with a food animal focus more production medicine skills that often are not emphasized in traditional veterinary curricula (Howard et al., 2009). Using private farms to educate students puts some responsibility on farms to help train new large animal veterinarians. Obtaining their buy-in in the training of these future practitioners can increase the value of graduates from a particular college.

Considerations for using large animals

Animal welfare must be prioritized in all uses of animals for teaching. Each animal should be monitored for behaviors associated with fear, anxiety, distress, discomfort, and/or pain before and during teaching sessions, and faculty must address the issues or remove animals showing these signs and behaviors. Therefore, all teaching faculty must be trained to recognize signs of discomfort and pain in all species they are using for teaching.

Clinical skills training is more convenient if multiple students can practice a skill on one animal. While not a problem for skills such as haltering, restraint, or basic examination, this is problematic for invasive procedures such as venipuncture and transrectal palpation. Animal ethics and animal use committees at different institutions often have varying opinions on the use of individual animals in a single laboratory session (e.g., how many times it is acceptable for one animal to undergo venipuncture in a single session) and over time (i.e., how many days' rest that animal should have between sessions). Published data on how many invasive procedures are possible before animal welfare is threatened are scarce or non-existent and are unlikely to be performed, so these decisions are typically opinion-based rather than data-driven. Educators and ethics committee members should consider and discuss multiple factors when making these decisions, including:

- the invasiveness of the task being performed;
- the potential for the task to cause fear, anxiety, distress, discomfort, pain, and/or medical risk to the animal;
- whether any potential fear, anxiety, distress, discomfort, pain, and/or medical risk to the animal can or should be mitigated using one or more medications (e.g., a sedative or muscle relaxant); and
- the time it would take the animal to recover fully from the effects of the task being practiced and/or any medication administered.

The amount of time animals are restrained in a halter, in a headlock, or in a stock should also be regulated by the animal ethics and animal use committees and be monitored while animals are being used. Animals should be restrained for the

minimal amount of time necessary, and the animal must be released and allowed to walk and rest when needed. Teaching faculty are responsible for monitoring and ensuring the animals' comfort. Teaching sessions should be scheduled so that the number of animals available determines the number of students for each clinical teaching session. This prevents too many students from arriving to practice skills on fewer animals, potentially applying pressure to extend the animals' restraint time.

University-owned animals

University-owned herds operated or managed by colleges and departments outside the veterinary school require Memoranda of Understanding that stipulate access to animals, uses of animals, and costs for use, if applicable. These agreements should include who is responsible for the animals' daily care, faculty responsible for the lab and teaching events, and who to contact if problems occur.

Privately-owned animals

The use of privately-owned animals is associated with additional considerations that are generally not encountered when utilizing university-owned animals; these include location, management of the farm relationship, liability, and logistics.

Location

Colleges of veterinary medicine located in more urban areas are likely to have less access to production facilities. Unfortunately, these are the institutions that may need these connections the most. Their students may be less familiar with large animal facilities prior to veterinary school, and their teaching hospitals typically see fewer of these species. Even colleges in rural areas are unlikely to have access to all the different species of livestock. For those farms that are used, travel will remain a logistical challenge. Travel time to and from a farm may make scheduling these labs difficult due to already full days in the curriculum. Parking for a large number of students may not be readily available at all locations, and therefore, colleges may need to organize transportation for students.

Management of the relationship

Most of these types of arrangements that the authors are familiar with have been built at least initially on relationships between farm owners and individual faculty. Maintaining these relationships requires a significant amount of faculty effort and time. This may involve rearranging teaching activities around an emergency at the farm, addressing student concerns about their perception of the farm, and answering farm staff concerns about student conduct. The faculty will also have to address any negative animal health issues that may arise from a teaching activity. Documenting and rewarding the faculty time dedicated to this effort is challenging in most promotion and tenure processes.

Because these arrangements are often initially built on individual relationships, maintaining the access to the private facility can be difficult when either the faculty member leaves or the farm is sold. This can be particularly painful when significant effort and expense has been expended to develop and maintain the relationship. Some colleges have financially supported improvements in a facility to facilitate teaching, and loss of access to these facilities can be difficult to replace.

Most farms will also maintain a relationship with a primary private practice veterinarian. While there are advantages for students to see this person's relationship with the farm, there are also challenges, as faculty and the primary veterinarian must navigate who is responsible for medical issues at the facility. These responsibilities should be clearly delineated so that the farm staff is certain who is ultimately responsible in various scenarios. Differing approaches between faculty and the primary veterinarian in managing specific conditions could lead to confusion in the students on the farm and the staff. Further, what is the role of veterinary faculty who may be on the farm when an issue arises but the primary veterinarian is not readily available? The faculty could potentially assist in this situation, but their intervention could also negatively impact the veterinarian's income. The faculty would need an appropriate VCPR to do this work, and they may not have this through their teaching activities on the farm.

The issues of liability and safety also should be addressed in both directions prior to entering into an agreement with a private farm. What is the legal and financial liability of a farm in which a student is injured during a lab? What is the legal and financial liability for a college if a student activity leads to the injury or death of an animal or a student's poor biosecurity leads to a disease outbreak?

Facilities

Working in authentic large animal facilities is valuable for students, but private farm facilities may not be suitable to accommodate inexperienced students. Additionally, private farms are rarely designed to manage large numbers of students at once. This becomes a more significant challenge as class sizes continue to increase. Dairies may be more amenable to larger groups of students as numerous cows can be restrained in headlocks at once. On the other hand, beef ranches or feedyards are typically designed to examine only one animal at a time. This may not create an efficient or effective learning environment for large numbers of students. Other aspects of large animal facilities may also inhibit the learning environment including noise and disruptions or distractions caused by normal farm operations (Choi et al., 2014). Given that these facilities are not designed for teaching and that most students are inexperienced, the risk of injury is significant. Close faculty supervision is required to ensure student safety, which is challenging in larger student groups.

Prior to visiting a private farm, significant effort should be spent addressing students' perceptions and expectations.

Many veterinary students have not spent time in large animal agriculture, so they need to understand the expectations of them relative to appropriate behavior and safety. These discussions should also facilitate students' understanding of modern production practices through a transparent description of the rationale behind current approaches. Even after these discussions, there remains a risk to a farm that a student could photograph or video record any number of situations that may occur in a production facility, and when taken out of context, may lead to significant public scrutiny for the farm involved. Given the ubiquity of cell phones, this risk may be difficult to eliminate completely, and unfortunately could disrupt access to a farm if an incident occurred.

Managing biosecurity is an additional hurdle for some private farms, particularly swine and poultry facilities that may require all visitors to shower in and shower out. Most equine and cattle facilities are less stringent, but the risk for introduction of a pathogen is likely greater due to the lax biosecurity. Students are also more likely to have contact with horses or cattle outside of school, and therefore, more likely to bring a potential pathogen onto the private farm. Students can also acquire zoonotic infections on farms. Technology can be used to prepare students for arrival on farms requiring biosecurity measures. For example, students may be able to observe the farm environment in advance using videos, 360-degree videos, or blended learning modalities that allow them to see the environment that they will be entering and prepare for the site-specific biosecurity requirements and facilities and how to use them.

The final, and potentially most difficult, facilities hurdle is institutional and involves the regulatory oversight of teaching animals. As training of veterinary students is typically regulated as biomedical teaching, standards for animal housing exceed those for agricultural teaching and certainly exceed those found in most production facilities. Maintaining private farms at this level is not practical or economical. Therefore, a clear understanding with the inspector of the college's teaching facilities of their view of these types of relationships is crucial prior to entering into this type of partnership.

Proposed framework for working with private farms for preclinical teaching

To address some of the potential issues discussed above, institutions should consider establishing a legal contract to govern the relationship between the college and the private farm; this may be required by an accrediting body. Specifically, the contract should include plans for the frequency of renewal and/or renegotiation of the contract. There should be guidance and timelines for a notice to end the relationship from either side, and specifically how changes in faculty personnel and farm management will affect the relationship. Payment should be explicitly negotiated to consider veterinary services provided to the farm by the college and use of the animals for teaching provided by the farm. Funding for building, improving, and maintaining facilities should be included in the contract, as well as who owns the facilities. Finally, legal liability for the farm for any student injuries, and for the college for any animal injury must be settled prior to the initiation of the collaboration.

Examples of use of privately-owned large animals

Many institutions partner with private farms in a variety of ways. The most common is for clinical teaching, as performing clinical activities is not subject to outside and internal animal use committee oversight. This may be with preclinical students, but the visits are scheduled clinical activities at the farm such as disbudding of dairy calves, pregnancy diagnosis, vaccine administration, or dental floating in horses. Other examples of collaboration include farms raising animals specifically for teaching that are purchased or paid for through a per diem, and several examples of production agriculture tours (Foster et al., 2018).

There are two published examples of significant integration of veterinary colleges and private farms to address dairy teaching. The University of Minnesota College of Veterinary Medicine and Michigan State (MSU) both developed long-term relationships with large dairies near their campuses to address teaching dairy production medicine to students (Fetrow et al., 2015; Fetrow et al., 2020; Herdt et al., 2008). There were several similarities between the two approaches. Funding from the college, allied industries, and the dairies themselves helped support the programs. Specific teaching facilities were built on the farms to support the educational activities, which focused on clinical activities with final (clinical) year students. Both institutions facilitated training of visiting students from outside institutions—MSU through a relationship with the Ontario Veterinary College and Minnesota through a United States Department of Agriculture (USDA) grant shared with multiple institutions. While both have been successful in creating authentic training opportunities for students in dairy production medicine, the ability to integrate these farms into routine pre-clinical teaching remained difficult due to many of the issues cited above. Sustaining these partnerships has also been challenging as faculty and farm ownership has changed, and the MSU program ended in 2021 after a 15-year partnership. The dairy training program at the University of Minnesota continues today but has moved to a different location since its inception.

Other schools have collaborated with local beef producers to provide animal handling facilities in exchange for access to the cattle for routine training in pregnancy diagnosis and animal handling, or have arranged for beef producers to provide summer externships for students. Several veterinary schools have arrangements with local ambulatory equine veterinarians to allow preclinical students to accompany them while providing routine care, which may be subsidized. As these activities are typically not a part of an official course, the sustainability and scalability with larger student numbers remain challenging. As mentioned previously, these visits are largely driven by the relationship between a specific faculty member and animal owners, so the long-term viability of these programs is also an issue.

Conclusion

Large animal clinical skills are essential to include in the veterinary curriculum; these can be taught using university-owned or privately-owned animals. University-owned animals benefit a veterinary teaching program by providing more consistency to scheduling teaching labs and a stable number of animals. Private farms offer access to larger numbers of animals in an authentic environment that mimics a typical veterinary practice experience. Yet, hurdles remain in using private farms for preclinical teaching, including distance from the college, liability for student safety and animal health, maintaining relationships through changes in faculty and farm staffing, and managing oversight by the university and outside entities. Examples of these relationships demonstrate both the benefits and challenges of integrating private herds into the preclinical curriculum. Regardless of the source of teaching animals, the welfare of these animals and the safety of students are paramount and are the responsibilities of the faculty.

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CHAPTER 10: Considerations for Teaching with Zoological and Exotic Species

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Introduction

Zoological companion animals, commonly referred to as exotics, and zoo species encompass thousands of diverse species compared with the handful of domestic species commonly included in most veterinary curricula. Many of these species will rarely be encountered by the typical veterinary practitioner; however, as veterinary care of zoological companion animal, zoo, and wildlife species grows, so does the need for graduate veterinarians comfortable with the basics of handling, restraint, and examination of the more common exotic pet species and those under managed care in zoos and aquaria. According to the 2022 AVMA Pet Ownership and Demographics Sourcebook, 2.7% of US households owned pet fish, 2.5% owned at least one bird (non-poultry), 1.4% owned a reptile, 1.3% owned a gerbil or rodent, and 1.2% owned a rabbit. These numbers may seem low in comparison to other small animal pets, as 45% of US households owned dogs, but they are much greater than other domestic animals such as horses, which are only owned by 0.2% of US households. The need for inclusion of zoo and zoological companion animal species in the veterinary curricula and the expectation for clinical competency of veterinary graduates in birds, reptiles, small mammals, and fish is certainly not new or novel; these recommendations were outlined by the American College of Zoological Medicine (Stoskopf et al., 2001) and discussed in greater detail by taxa in the Journal of Veterinary Medical Education in 2006 (Flammer et al., 2006; Carpenter et al., 2006; Hartman et al., 2006).

Typically, this education begins by exposure to one representative species in a taxonomic group, such as bearded dragons (*Pogona vitticeps*) for reptilian species and/or a domestic chicken (*Gallus gallus domesticus*) for avian species. There are limited available animal models for most of these species, except for some small mammals used in laboratory research, such as rabbits and rodents. This leaves limited to no alternative options to live animals for use in veterinary student education of exotics and zoo species. For the purposes of this chapter, this diverse group of animals has been divided into the following sections: mammals (rabbits and rodents), birds, ectotherms (reptiles, amphibians, fish, and invertebrates), and free-ranging wildlife/non-domestic animals in managed care.

Mammals

As mentioned, rabbits and rodents make up 1.2% and 1.3% of the pets in American households. The rabbit is the most common zoological companion animal species kept after dogs and cats, as fish, birds, and reptiles make up categories that include numerous species. In addition to being the top single species, when estimating 128 million households in the US, this equates to over 1.5 million rabbits. With this data in mind, rabbits and rodents are very likely to be encountered by veterinary students after graduation. Rabbits and rodents have species that represent multiple different orders and suborders, including the order Lagomorpha (rabbits) and multiple suborders of the order Rodentia, including Hystricomorpha (guinea pigs, chinchillas) and Myomorpha (mice, rats, gerbils, and hamsters). The other small mammals that are kept as pets, including ferrets, degus, hedgehogs, and sugar gliders, are outside of the scope of this chapter, but should also be considered when deciding upon opportunities to provide for teaching.

Rabbits and rodents have the most similar anatomy to the typical domestic species covered in veterinary curricula. There is overlap with some species in terms of anatomy and physiology.

For example, the gastrointestinal anatomy of a rabbit, guinea pig, or chinchilla can be compared to horses, with all being hindgut fermenters. Additionally, both hamsters and cows are foregut fermenters. All rodents and rabbits have some amount of anelodont, hypsodont, and aradicular teeth, again similar to horses. Numerous differences also exist, but with the vast similarities between these and domestic species, comparative medicine can be practiced from the onset of veterinary school.

Due to their small size in comparison to most domestic species covered, special handling must be considered to avoid injury. To complicate this further, rabbits and rodents are prey species that may be more impacted by novice learners in comparison to dogs and cats, which are predators and possibly more acclimated to handling. Sedation may be advisable to decrease the stress associated with teaching laboratories and can be accomplished using midazolam in most cases. Voices should be kept low, and breaks should be provided to animals that appear stressed (high respiratory rate, increased body temperature, excessive struggling). Animals should be removed from the laboratory if these signs persist, and the length of time that an animal is actively engaged in the laboratory should be limited to one hour when possible.

Because of these challenges, it is important to consider models that allow learners to practice without time constraints or concern for causing animal distress. Models that are available at this time include common laboratory species, such as rats and mice. These models allow for practice with handling, ear tagging, microchip placement, endotracheal intubation, blood collection from the lateral saphenous and lateral tail veins, injections (subcutaneous, intramuscular, intravenous, intraperitoneal), oral medication administration, oral examination, intravenous catheter placement, and rectal thermometer placement. Limited physical examination procedures may be practiced as well. These will decrease the number of live animals needed, which is both economic for the teaching institution and ideal from an animal welfare perspective.

Rabbits and rodents are often housed in laboratory animal facilities when used for teaching purposes and are often either opportunistically acquired from other studies or purchased solely for teaching purposes. Colonies can be managed using guidelines for laboratory animals by animal ethics committees such as the Institutional Animal Care and Use Committee (IACUC), Association for Assessment and Accreditation of Laboratory Animal Care (AAALAC), and other relevant regulatory agencies. Many of the species represented in this category are regulated by the United States Department of Agriculture (USDA), with the exception of rats of the genus *Rattus*, and mice of the genus *Mus*. This should also be considered when the decision is being made regarding acquiring and maintaining colonies of these species for teaching purposes. Alternatively, animals from rescue groups or client-owned pets may also be utilized. Caution should be used with regards to disease transmission both between animals and from a zoonotic perspective. If using these sources, informational pamphlets and consent forms should be utilized so that caretakers are aware of the risks associated with the animals' participation.

There are numerous zoonotic diseases that are possible to contract from rabbits and rodents. Fortunately, the majority of these are concerns with wild species rather than those commonly kept as pets or as laboratory animal species. Dermatophytosis is a zoonotic disease that may be associated with handling of rabbits and rodents (d'Ovidio & Santoro, 2023). Many can be asymptomatic carriers, and gloves and laboratory coats should be utilized when possible. A non-zoonotic concern associated with handling are allergens from the skin and hair of rabbits and rodents. Personal protective equipment, including face masks, face shields or protective eyewear (less ideal), laboratory coats or gowns, and gloves should be worn by learners with a known allergy. Allergic reactions may be mild, including erythema and pruritus, or may be severe and cause respiratory difficulty.

Avian

Birds, excluding poultry, are kept as pets in 2.5% of all households in the United States, and according to the American Pet Products Association in 2023, as many as 13% of US households now own backyard chickens, which has increased dramatically in the last several years. While specific statistics for veterinary care are not available for these species, one can and should assume that these animals will be presented to a veterinarian at some point in their lifetimes. Ideally, veterinary students should be provided with opportunities to learn basic physical exam skills and clinical techniques for at least one of the 9,000+ avian species during their training.

Avian species have numerous anatomic and physiologic differences from mammal species, which precludes extrapolation from many basic tenets students have learned in mammals, namely restraint, physical examination, and clinical techniques. Most avian species are orders of magnitude smaller in weight and overall size compared with common small mammals used in teaching such as dogs and cats. In addition, most birds have pneumatized bones, a keel, and all are bipedal, none of which are present in domestic mammals. Therefore, they are predisposed to long bone fractures and suffocation due to limiting keel movement secondary to inappropriate manual restraint. Palpation is significantly limited compared with a mammal due to the presence of the large keel covering most of the coelom. Most bird species are also capable of flight, which is a major but often overlooked difference that has significant implications for housing and physical restraint to prevent injury and escape of the bird. It is often impossible to safely spay and neuter most birds; therefore, single sex flocks are often a requirement to prevent reproduction. A comprehensive list of differences between mammals and birds is outside the scope of this chapter; however, the limited examples listed here are meant to reinforce the need for avian specific teaching models and explain how extrapolation from mammals is not often possible or recommended. Extra pre-clinical education relevant to these species should be provided prior to any handling lab to ensure safety and compliance.

The most common avian orders currently used in veterinary curricula are Galliformes (chickens, turkeys, quail), Psittaciformes (parrots), and Columbiformes (pigeons and doves). Some institutions have also incorporated, albeit to a lesser extent, Anseriformes (waterfowl) and birds of prey (hawks, falcons, eagles). Certain bird species (mainly raptors) are covered under the Migratory Bird Treaty Act, and permits are required to house them temporarily or permanently in captivity in the US. In 2023, new welfare regulations for birds not bred for use in research were passed in the US to ensure humane treatment and transportation of birds regulated under the Animal Welfare Act. With the rising popularity of backyard chickens, their comparatively large size for a bird, and the variety of veterinarians (small animal, avian, mixed, and large animal) who are presented with poultry patients compared with other avian species, these birds are frequently used as avian models in veterinary curricula. They are also typically easier and cheaper to source than the other avian orders previously listed.

Avian species are subject to several important diseases that are critical for students to be able to diagnose. Chickens can develop several reportable diseases of high regulatory concern such as avian influenza and exotic Newcastle disease as they are considered a major food producing species in the US. Preventing exposure to wild birds for any captive flocks of birds, regardless of species, is of the utmost importance to reduce the incidence of infectious diseases. Birds of prey can develop pododermatitis if permanently kept in captivity without appropriate husbandry and are also much more dangerous to handle without specific training. Many semi-aquatic avian species, including Anseriformes, also commonly develop pododermatitis if not provided adequate water sources that can be challenging to maintain. Most parrots are highly intelligent and prone to behavioral problems, such as feather destructive behavior, if not provided appropriate enrichment and husbandry. These are also long-lived birds (20+ years); therefore, appropriate plans for long-term care following their use in a teaching flock should be in place prior to their acquisition.

As in other taxa, there are numerous potential human health hazards, including zoonoses, associated with handling and housing birds. The two most notable are Salmonellosis and Chlamydiosis. While infection with non-typhoidal *Salmonella* spp. is most commonly acquired through eating contaminated meat and eggs, it can also be contracted by contact with poultry—in fact, live-poultry associated salmonellosis has increased dramatically over the last ten years. Chlamydiosis, caused by *Chlamydia psittci*, is a reportable zoonotic disease that can be acquired from many avian species, most often parrots and pigeons, and asymptomatic infections in birds are common. A previous outbreak of chlamydiosis, also called psittacosis, was reported in a veterinary teaching hospital associated with a flock of parrots used in practical student labs (Heddema et al., 2006). Appropriate screening and quarantine of birds, prevention of exposure to wild birds, and use of personal protective equipment during student handling labs should mitigate the majority of zoonotic disease transmission.

Ectotherms

Ectotherms include reptiles, amphibians, fish, and invertebrates who rely on environmental temperature to regulate their internal temperature, with a few exceptions to this general rule (ball pythons (*Python regius*) among others). Fish were the third most common pets in the United States after dogs and cats, and more households owned a reptile than a rabbit in 2022. As some of these species are considered common companion animals, there is a need for veterinary teaching about ectotherms. In addition, amphibians such as xenopi and fish such as zebrafish are very common laboratory animals. There is a growing need for teaching about aquatic animals, especially in the expanding aquaculture industry and for public aquaria. Preserving the health of marine invertebrate, such as corals, is a growing concern as ocean acidification and rising temperature have large-scale impact on invertebrate free-ranging populations. Stony coral tissue loss disease and sea star wasting disease are some examples of threats faced by wild marine invertebrates. Veterinarians working in public aquaria or for governmental agencies may need to contribute to conservation efforts and should therefore be trained in this field. Veterinary students may learn about ectotherm medicine through teaching laboratories using a teaching colony or rented individuals from a breeder or pet shop. Common options are teaching colonies of bearded dragons, colubrid snakes, or boid snakes. For invertebrates, it is often not advisable to maintain these species in a teaching colony due to their high sensitivity to environmental conditions. Alternative options may include on-site visits to a zoological institution or field visits using innovating methods such as scuba diving or virtual activities using underwater images. Reef images are available through on-line platforms such as global reef record (http://www.globalreefrecord.org/) or the AGGRA website (https://agrra-data-explorer-oref.hub.arcgis.com/).

Many ectotherm species are considered endangered by the The International Union for Conservation of Nature (IUCN) and are listed in the annexes of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). For instance, 36% of reptile species are classified as threatened by the IUCN. It is therefore critical to use ectotherm species bred in captivity to conduct teaching laboratories and to use these species as surrogates to promote conservation. Of note, some endangered free-ranging populations, such as the axolotl, have been bred extensively in captivity. As these captive populations are not releasable, they may be used for teaching.

In addition to the conservation status, species selected for teaching should not be too sensitive to stress, as it is expected specimens will be handled on a regular basis. An ectotherm colony may be maintained to teach handling, husbandry, anatomy, or more advanced procedures such as venipuncture, anesthesia and/or surgery. Species that are very prone to stress or difficult to handle should be avoided. This includes various species of chameleons, cuttlefish, and fish with fragile scales such as American shad (*Alosa sapidissima*). When choosing a species of lizard for a teaching colony, an important characteristic may

be the occurrence of autotomy and jumping behavior in that particular species. For instance, bearded dragons (*Pogona vitticeps*) are more easily handled than species of lizard performing tail autotomy, such as crested geckos (*Correlophus ciliatus*) or day geckos (*Phelsuma* spp.). Fish that inflate their esophagus in case of stress, such as pufferfish (*Tetraodontidae*) or porcupinefish (*Diodontidae*), should also be avoided. In addition, venomous species of reptiles, amphibians, fish, and invertebrates should be avoided. This includes *Viperidae*, *Elapidae*, *Bufonidae*, rockfish (*Sebastes* spp.), and *Diadema* spp. sea urchins, among many others. When setting a fish, amphibian, or turtle teaching colony, special consideration should be given to filtration systems. These should be set up prior to acquiring the animals and should be monitored following laboratory animal guidelines.

When selecting species included in a teaching colony, other aspects to consider are the ultimate size of adult individuals, their life expectancy, the potential for unwanted reproduction, and their nutritional requirements. For instance, very large tortoise species, such as African spurred tortoises (*Centrochelys sulcata*) should be avoided unless sufficient space is available for adult individuals or a facility/sanctuary is available for retired animals. Some ectothermic species feed on live insects or crustaceans and will refuse to feed on frozen/thawed prey. This is the case of many chameleons, some individual leopard geckos (*Eublepharis macularius*), and some fish such as pipefish. While some individuals may convert to dead prey, facilities housing these species should be equipped to keep live insects if needed. Some snakes are also difficult to convert to dead prey if they have been used to feed on live rodents.

The main zoonotic disease associated with reptile handling is salmonellosis. Many reptile individuals are asymptomatic carriers of *Salmonella* spp., which is transmitted through fecal-oral contact. Thus, an important consideration when housing reptiles is to implement strict hand hygiene practices for the students and caretakers. Preventive measures regarding mycobacteriosis should also be in place for aquatic animals. This zoonosis is typically cutaneous and arises as an opportunistic pathogen if animals or filters are handled with cutaneous wounds or in a context of immunosuppression.

Free-ranging wildlife and non-domestic animals in managed care

As interest in exotic species has increased in the general population, so has training coverage in veterinary school curriculums. In 2001, representatives from 31 American Veterinary Medical Association (AVMA) accredited colleges of veterinary medicine in the United States and Canada, as well as representatives from the American College of Zoological Medicine and its allied professional veterinary organizations, met to develop recommendations for inclusion of zoological medicine in veterinary curricula. Of schools accredited by the AVMA in 2022, more than half offer formalized training in non-domestic animals in managed care or free ranging wild animal species as part of the core or elective curriculum. There is limited data on the efficacy of these training programs, but a recent study demonstrated that veterinary students from University of Nottingham School of Veterinary Medicine and Science (Nottingham, United Kingdom) who underwent a mandatory five day training rotation in partnership with the Twycross Zoo self-reported scores on understanding the work of modern zoos, zoo veterinarians, and affinity toward wildlife conservation changed positively from pre- to post-placement (Liptovszky et al., 2022). This positive change occurred regardless of prior interest or experience but was stronger among individuals with limited prior interest or experience (Liptovszky et al., 2022). It is impossible to prepare veterinary students for the breadth of presentations or disease conditions that are experienced in these species during the veterinary curriculum, but focusing on translational medicine is key to teaching veterinary students how to problem solve when they are presented with these species. Safety is also a key concern that needs to be met when working with free-ranging wildlife and non-domestic animals in managed care.

There are a few collections of captively managed zoo or wildlife species that are maintained for training husbandry and animal care standards, and only one of these collections expressly uses the teaching population for veterinary education. Captive teaching colonies and teaching zoos in the United States are licensed through the USDA (www.aphis.usda.gov) if they maintain mammals or birds; frequently they are also managed under university IACUCs, and some maintain a higher level of accreditation as a member of the AZA (www.AZA.org). There are many North American veterinary schools that have partnerships with local captively managed collections with the veterinary faculty providing supervision of veterinary care and/or with the collection's on-site veterinary staff serving as adjunct faculty in the veterinary curriculum. Because of student training partnerships, establishing a managed training colony or research colony is often not needed to convey these veterinary principles. If a colony needs to be established for a specific purpose, careful species selection is recommended, and the highest standards of animal care and welfare should be maintained (www.AZA.org).

Wildlife rehabilitation centers are another place that veterinary students can receive hands-on training. Depending on local jurisdictions, injured wildlife may be treated by veterinary students under the supervision of veterinary staff. Several veterinary schools maintain wildlife clinics where veterinary care for injured or ill wild species is provided by veterinary students. Abroad training programs have become popular with veterinary students to gain hands-on experience with wildlife species in range countries. Likewise, many zoological parks and aquaria maintain veterinary student externship or preceptor programs to allow students to expand their experience with these species (e.g., AAZV).

Conclusion

Zoo, wildlife, and zoological companion animal species encompass thousands of animals, several of which are growing in popularity as companion animals. With that growing interest, there is also an increased demand for veterinary care of these species. Exposure to common representatives from each major taxa (small companion mammals, birds, reptiles, and ideally fish) in the veterinary curricula is paramount to ensure continued veterinary care for this diverse group of animals. While some rabbit and rodent models are commercially available, this experience is best achieved with live animal physical exam and handling labs. Experience with zoo and wildlife species is often achieved through off site training opportunities in zoological institutions and/or in the field. The inclusion of zoo, wildlife, and zoological companion animal species in all veterinary curricula is strongly encouraged.

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CHAPTER 11: Ethical Considerations in the Use of Animals and Animal Alternatives

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Introduction

Animal use is necessary to teach veterinary students the fundamental knowledge and skills of their profession and ensure competency as they enter practice. With that comes the obligation to recognize the importance of adhering to sound ethical and animal welfare principles (American Veterinary Medical Association, n.d.; Lairmore & Ilkiw, 2015). As societal views about animal use changed over the years, there has been an accompanying refinement for how animals are used for teaching. As discussed in other chapters, the development of alternatives to animal use has allowed veterinary education to continue to evolve, reduced the number of animals used in teaching, and improved the welfare of the animals that are used. Yet there remains discussion about what constitutes best practice as applied to animals used in various courses. These discussions need to include concerns about maintaining student competency, ensuring good welfare for animals used, minimizing the number of animals used, maximizing student safety, and using available animal alternatives when practical. These must also reflect ever changing ethical expectations of society.

Because ethical and moral principles change gradually, it is important for the veterinary profession to continually monitor for and adapt to such changes to remain relevant. Although ethics and morality are often considered to be interchangeable, they actually represent somewhat different concepts (Ethics vs Morals, Diffen, n.d.). Ethics has to do with the principles held by a larger group or culture that become part of what shapes an individual within the group. These reside within a social system such as a religion or community. Morals are the individual's principles that shape their actions and views about what is right or wrong. Ethics provide a set of rules; morals are how the individual decides good or bad within the boundaries of those rules (Ethics vs Morals, dictionary.com, n.d.).

As scientists, veterinarians tend to use ethical frameworks that guide acquisition of new knowledge following established rules that support scientific research. This framework will also be incorporated into their life experiences, education, and thoughts that shape their moral compass. This science-focused background makes appreciation of ethical expectations about animal use somewhat challenging, especially when quantitative data about what constitutes good welfare and defined human obligations to animals are missing (Lund, 2006).

This chapter will discuss what ethical frameworks and moral theories are and why they are important to consider relative to the use of animals and models in veterinary education.

Ethical frameworks

Ethical frameworks provide a system of rules for a group or community that lay down consistent expectations for group members, allowing them to determine which course of action to take that is also consistent with their individual moral beliefs. Three major ethical frameworks—consequentialism, virtue, and deontology—have been defined, each of which includes branches that vary slightly. There are other minor frameworks that will not be discussed here.

The first of the major ethical frameworks is consequentialism, which is also called teleology. This emphasizes the outcome, not the motive, of an action to determine its moral goodness (Beaver & Golab, 2023; Consequentialism, 2022; Sinnott-Armstrong, 2019). The general philosophy came from the hedonic value theory that all human action should be motivated by the pursuit of pleasure and avoidance of pain (Consequentialism, 2022; Sinnott-Armstrong, 2019). Thus, under consequentialism, the rightness of an action will maximize happiness and good (Teleological ethics, n.d.). Subgroups of this ethical framework relate primarily to who is the recipient of the pleasure. It can be self-interest (egoism), "my" group (e.g., family, religion), or all sentient beings (utilitarianism) (Beaver & Golab, 2023; Duignan, 2008; Hinman, 2013). Because only sentient beings matter,

utilitarians who regard animals as sentient–and not all do–must balance human and animal benefits and harms (Sebo, 2023; Utilitarianism, n.d.). Euthanasia is an acceptable outcome to utilitarians for animals living in poor conditions, and it can also be acceptable for animals raised in a well-managed environment when humanely done (Animals Ethics Dilemma, n.d.).

Virtue is the second major ethical framework. The concept of virtue is that people will act morally because the act itself is the right one and is necessary for the person to feel good about what they do (Beaver & Golab, 2023; Hursthouse & Pettigrove, 2018; National Academies of Sciences, Engineering, and Medicine, 2019). This framework is generally associated with a more global view, such as religion, and is responsible for the various religious doctrines about how animals should be treated.

Deontology, the third major ethical framework, relies on rules to distinguish right from wrong and to determine duty and obligation, regardless of the outcome (Beaver & Golab, 2023; Duignan, 2008; Hinman, 2013). This creates a moral obligation to obey and fulfill the rules, such as always telling the truth. There are three major branches within this framework—divine command theory, natural law theory, and animal rights theory. Under the divine command theory, followers would be expected to obey specific religious laws such as worshiping certain types of animals or not eating others. The natural law theory subgroup differentiates humans from animals by emphasizing that humans have the ability to assess actions and then willfully choose a way forward (Gordon, n.d.; Kantian ethics, 2019; Tulloch, 2011; Wilson, n.d.). Even with that distinction, all living subjects are regarded to have inherent value, creating a moral obligation to treat animals well. The fundamental principle of the animal rights theory is that sentient animals have basic interests deserving of recognition and protection because they have moral worth (Wise, 2016). That means they are deserving of equal consideration to humans.

Until recently, an animal's sentience went unrecognized or at least under appreciated. As science began to show that sentience and cognition exist in several animal species, society has shifted its expectations about how the animals should be handled and what should or should not be done to them. This paradigm shift has become the driver of recent expanded discussions about animal welfare (Bayvel et al., 2012).

The moral status of animals

Morality reflects an individual's view of whether an action is right or wrong. Three broad moral theories are recognized (indirect, direct but unequal, and moral equality theories), each encompassing several branches that vary only slightly. The range of moral views about the relationship between humans and animals is extensive, covering extremes from the view of no equivalency, and thus no moral standing for animals, to the other extreme that all species are equal (Beaver & Golab, 2013; Wilson, n.d.). Morality guides how an individual determines right from wrong within the ethical framework that is valued by the community with which the person identifies.

Indirect theories constitute the first of the three moral philosophies. This group of theories does not recognize any degree of equivalency between humans and animals and denies moral status to animals (Wilson, n.d.). Supporting arguments are based on the belief the animals lack consciousness, the ability to reason, and autonomy based on their own desires. Under an indirect theory, it can be argued that animals are no different than an inanimate object, without sentience or cognition. No specific discussion is made about harming animals, but it could be argued that an animal is no different than a piece of furniture or stuffed toy. Indirect theories might still require that no harm be done based on human morality instead (Broom, 2010; Degarazia, 1999; Wilson, n.d.).

The shifting focus of ethical discussions about animal sentience has also driven an increased emphasis on understanding what harm a particular action might do to the animal (Birch, 2018). As a result, the remaining two moral theories—direct but unequal and moral equality—recognize some degree of moral status for animals. This offers some protective value against purposeful harm because the animal's interests matter (Degarazia, 1999). Both of these theories recognize sentience as the important aspect when deciding whether to include or exclude an animal from moral discussions, they just vary in the degree of such status.

Direct but unequal theories grant some moral status to animals but not to a level equal to that granted to humans (Wilson, n.d.). The reasons included for the granting of partial, instead of equivalent, status relate to the animal's inability to respect the rights of others and display moral reciprocity. This separation is supported even for "infants and the senile" because those individuals either had or will have the unique human characteristics (Francis & Norman, 1978). Most people would grant certain rights to animals, such as the right to appropriate food and water, but other "rights" become debatable. Those wanting to grant animals an even higher status will argue that the direct but unequal theories should be considered forms of speciesism, expressing an unspoken prejudice toward animals (Stanford Encyclopedia of Philosophy, 2017; Tulloch, 2011).

The third group of moral theories, moral equality theories, recognizes humans and animals as having equal moral status (Wilson, n.d.). By extension, then, animals should have all the same rights as humans. The assertion is that animals are sentient and thus can experience pain and suffering, and they have physiological and mental capacities similar to people with disabilities and to human infants. Some consider adult animals to also have perception, memory, desire, self-consciousness, and a sense of the future.

Why ethical and moral discussions matter

There are several influencers that affect how a person thinks about and interacts with animals. Probably the most significant of these is previous experience because it is based on cultural ethical norms and learned moral values. As an example, a person learned from a father or grandfather to disbud calves by physically restraining the calf while removing the horn bud. A farmer or rancher is then likely to pass on the same techniques to the next generation. If veterinary educators were trained that way, the implications are even greater. However, if those educators were willing to challenge their moral values and include consideration of calf sentience, they might have tried an anesthetic ring block. When they did, they found it resulted in a less stressful experience for the person doing the disbudding, the person restraining the calf, and the calf. This is just one example of how opinions and procedures change over time. While ethical and moral discussions tend to make veterinarians uncomfortable, they are important to have. It takes challenges to an individual's moral comfort zone to bring necessary change.

Conclusion

As stated by a veterinary colleague, "If the social ethics of animal use change, animal use changes." (Linares, 2023) It is important to acknowledge that incoming veterinary students are representatives of society as a whole. Their willingness to question how and why things are done is the challenge veterinary educators need to rethink their own moral approaches, and involving students in the discussion of changes in animal use can guide both students and educators to a deeper understanding of ethical and moral animal use. Past challenges raised by students have resulted in the increased use of non-animal models such as the use of plastic bone models for teaching fracture repair and realistic models of blood vessels to teach venipuncture. Several other examples have been described in preceding chapters. Today's students are challenging certain teaching models such as whether there might be better ways to teach surgical skills. As ethical and moral paradigms shift, today's educators will continue to search for ways to improve how they teach and assess students while protecting and improving animal welfare.

Veterinary educators continue to innovate how animals and animal alternatives such as models are used in teaching and assessing veterinary students. Such innovations will continue to improve the welfare of teaching animals and improve the safety for both animals and students. This is what the public also expects.

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AAVMC Use of Animals in Veterinary Education Handbook

APPENDIX 1

AAVMC Guidelines for the Use of Animals in Veterinary Education

Animal use within veterinary education should provide professional level opportunities for students to acquire the knowledge, skills, and attributes necessary to prevent, control, diagnose, and treat medical, surgical, and behavioral conditions in animals in a way that is humane, respectful, and welfare appropriate for all animals used in the educational process.

Animal use should be guided by 4 Rs (replacement, reduction, refinement, and respect) and must be compliant with applicable laws and regulations. Veterinary institutions should critically evaluate all animal use to determine if it is necessary to achieve educational outcomes. Institutions should explore and implement alternatives where appropriate to minimize animal use while maintaining student competence.

Institutions should establish a formal policy for the critical evaluation of animal source and use as part of the educational mission. Institutions should demonstrate transparency by reviewing, presenting, and discussing information about the source and use of all animals, cadaver and live, with students, faculty, and staff at least annually.

Cadaver Acquisition & Use

Institutions using cadavers in teaching should:

1. Implement respectful methods of cadaver acquisition, use, and final disposition appropriate to local context and culture.
2. Implement a policy for auditing and evaluating cadaver use; implementing replacement, reduction, and refinement of use where appropriate and possible; and reporting to the institution's senior veterinary administration at least annually.
    A. Alternative instructional models and technology should be considered where effective to meet learning objectives.
    B. Cadavers should be used strategically, purposefully, and to the fullest extent possible.
3. Responsibly and ethically source their cadavers, when cadaver use is necessary in the veterinary curriculum.
    A. Whenever possible, animals should not be euthanized solely for educational purposes; cadavers used in teaching should be sourced from animals that have died or are euthanized at or nearing the end of their natural and/or productive life.
    B. Willed body donation programs, in which the donation is accompanied by owner consent, can serve as an ethical source of cadavers.
    C. If necessary, cadavers or live animals may be purchased. Institutions should work towards establishing auditing processes to ensure transparency in ethical sourcing.

Live Animals

Institutions using live animals in teaching should:

1. Implement a policy for reviewing the use of animals in education; identifying alternatives to animal use where appropriate; evaluating the pedagogical merit of animal use both for teaching and assessment of skills critical to meeting the learner's career goals; and reporting to the institution's senior veterinary administration at least annually.
2. Teach tasks and procedures using a clinical skills model or simulation whenever one is available and effective to complement or precede live animal practice, depending on pedagogical circumstance.
    A. Models may include low-fidelity task trainers or models that do not resemble a live animal or may be high-fidelity manikins that realistically portray procedures.
    B. Institutions should develop and evolve a longterm strategy for the increased integration of models into teaching and assessment.
3. Implement a policy for the use of internally owned (i.e., by student, staff, faculty) or client-owned companion animals to reduce the need for on-site colonies for non-invasive skills development. A similar policy should be considered for other species.
4. Implement a policy for the ethical use of externally owned animals (e.g., shelter animals, client-owned animals, animals on farms) for invasive skills development. Proactively work toward reducing invasive procedures to those that have the potential to benefit the health and welfare of the animal.
5. Implement policies that emphasize the safety and welfare of the animal and student throughout the performance of all skills and procedures.
6. Optimally utilize clinical cases to achieve clinical competency. There is no recommendation to reduce caseloads in the clinical setting.

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