

What Use is Anatomy in First Opinion Small Animal Veterinary Practice? A Qualitative Study

Roisin Wheble,¹ Sarah Beth Channon ^{2*}

¹Laurels Veterinary Centre, Bromley, United Kingdom

²Department of Comparative Biomedical Sciences, The Royal Veterinary College, London, United Kingdom

Despite the uncontested importance of anatomy as one of the foundational aspects of undergraduate veterinary programs, there is still limited information available as to what anatomy knowledge is most important for the graduate veterinarian in their daily clinical work. The aim of this study was therefore to gain a deeper understanding of the role that anatomy plays in first opinion small animal veterinary practice. Using ethnographic methodologies, the authors aimed to collect rich qualitative data to answer the question “How do first opinion veterinarians use anatomy knowledge in their day-to-day clinical practice?” Detailed observations and semi-structured interviews were conducted with five veterinarians working within a single small animal first opinion practice in the United Kingdom. Thematic analysis was undertaken, identifying five main themes: Importance; Uncertainty; Continuous learning; Comparative and dynamic anatomy; and Communication and language. Anatomy was found to be interwoven within all aspects of clinical practice; however, veterinarians were uncertain in their anatomy knowledge. This impacted their confidence and how they carried out their work. Veterinarians described continually learning and refreshing their anatomy knowledge in order to effectively undertake their role, highlighting the importance of teaching information literacy skills within anatomy curricula. An interrelationship between anatomy use, psychomotor, and professional skills was also highlighted. Based on these findings, recommendations were made for veterinary anatomy curriculum development. This study provides an in-depth view within a single site small animal general practice setting: further work is required to assess the transferability of these findings to other areas of veterinary practice. *Anat Sci Educ* 0: 1–12. © 2020 The Authors. Anatomical Sciences Education published by Wiley Periodicals LLC on behalf of American Association for Anatomy.

Key words: Veterinary anatomy education; undergraduate education; health professions education; veterinary practice; basic sciences; authentic learning; inquiry-based learning; professionalism

*Correspondence to: Dr. Sarah Beth Channon, Department of Comparative Biomedical Sciences, Royal Veterinary College, Royal College Street, London NW1 0TU, United Kingdom. E-mail: schannon@rvc.ac.uk

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INTRODUCTION

Anatomy is one of the foundational aspects of medical and veterinary education, and often deemed one of the most important (Cottam, 1999; McLachlan and Patten, 2006; Sugand et al., 2010). This is undoubtedly in part due to its palpable relevance for surgery (Cottam, 1999; Estai and Bunt, 2016), though the relevance of anatomy for all aspects of healthcare has been widely discussed (e.g., Dangerfield et al., 2000; Turney, 2007; Sugand et al., 2010; Phillips et al., 2013; Sweetman et al., 2013).

A Decline in Anatomical Knowledge?

Over the last 30 years, following the publication of several key documents from a number of regulatory bodies (Pritchard, 1988; GMC, 1993; RCVS, 2001; GMC, 2003,

2009), medical and veterinary curricula have been extensively modernized and reformed on an international scale. These reforms, driven by a desire to enhance clinical and professional skills-based training (Harden et al., 1997; McHarg and Kay, 2008; Jaarsma et al., 2009) have led to pressures on the time available for teaching basic sciences within curricula (Heylings, 2002; Drake et al., 2009; Sugand et al., 2010; Bergman et al., 2011). Prior to, during, and since this period of modernization, debate has raged about whether medical and veterinary graduates are competent in anatomy (Monkhouse, 1992; Prince et al., 2005; Ahmed et al., 2010; Sugand et al., 2010; Bagley et al., 2011; Bergman et al., 2011, 2014). Central to this debate are the differing opinions of how much anatomical knowledge is required to allow the safe and efficient practice of medicine.

Much of the evidence provided for a decline in the anatomical knowledge of medical and veterinary graduates is based on surveys of the perceptions of clinical students and new graduates on their level of preparation for the clinical environment. Across a range of knowledge areas and skill-sets, new graduates self-report varying levels of preparedness for clinical practice (Dean et al., 2003; Jaarsma et al., 2008). Clinical students tend to report widespread low levels of confidence in their anatomical knowledge (Custers and Ten Cate, 2002; Prince et al., 2003; Bergman et al., 2008). Though, where medical graduates have been asked about their anatomical knowledge, the majority (77%) felt they had learned enough anatomy to practice competently (Smith and Mathias, 2011). Equally, anatomy did not feature among the top four areas of deficiency as identified by graduates of both traditional and innovative veterinary curricula (Jaarsma et al., 2008).

Where evidence for a decline in anatomy knowledge of graduates is based on the opinions of more senior, and inherently specialist clinicians, it is apparent that some feel that the current anatomical education of students is inadequate (Cottam, 1999; Waterston and Stewart, 2005). There are difficulties however with relying on expert views of competence. A range of experts have been shown to hold markedly different individual views on the appropriate standard of anatomical knowledge for a fourth-year medical student (Prince et al., 2005)—indicating that the ability to appropriately define and assess outcomes of anatomy education in graduates is compounded by lack of agreement in what students need to know (Bergman et al., 2008).

Specialists versus Generalists, and the “Expert” Viewpoint

The number of specialists and specialties in medicine has never been greater (Dalen et al., 2017), and even though in decline, primary care is still the most popular destination for graduates (Jeffe et al., 2010; Svirko et al., 2013). This trend is mirrored in the veterinary profession, with 92% of the workforce in primary care (first opinion) practice (Buzzeo et al., 2014). In the United States (US) and the United Kingdom (UK), the regulatory bodies of the veterinary profession require graduates to be omni-competent across a range of common species (RCVS, 2014; AAVMC, 2018). Graduates exit into a wide range of species-specific, or mixed species careers; however, the vast majority work within “small animal” general practice settings (53.6% in the UK; Buzzeo et al., 2014). Traditionally, clinical veterinary training has taken place within university-owned,

referral (second opinion) teaching hospitals (May, 2015), taught by specialist clinicians. The need to enhance the primary-care relevance of learning opportunities for veterinary students has only relatively recently been emphasized (Halliwell, 2006; Stone et al., 2012; May, 2015). Given the diversity of specialties abound within university teaching hospital settings, it is not surprising that the range of expert views on what core knowledge students and graduates need to possess is disparate (Koens et al., 2006). The high expectations of clinicians, the stark discrepancy in expert viewpoints, coupled with the required omni-competence of graduates alerts anatomists to the need to develop clear and realistic guidelines on the level of anatomical knowledge required by newly qualified veterinary students.

Defining an Anatomy Curriculum

Great efforts have been made in medical education to define core learning outcomes for anatomy (McHanwell et al., 2007; Smith et al., 2016a,b). These studies, employing Delphi methodologies, are increasingly widespread within various anatomical disciplines (e.g., Moxham et al., 2015; Connolly et al., 2018; Finn et al., 2018) and have culminated in well-utilized impactful core anatomy curricula (Smith et al., 2018). While the core curricula developed for medicine are highly valuable, at present they only attend to knowledge-based content and, perhaps intentionally, neglect the contribution of anatomy education for wider skills development. They are also limited by the nature of the Delphi methodology which relies on expert views, making the outputs of such work highly sensitive to the choice of panel members, and who is deemed to be an “expert” (McKenna, 1994; Yousuf, 2007; Humphrey-Murto et al., 2017).

Progress on similar curricula in veterinary education has been limited to date, in part due to the need to consider multiple species. Since educators do not yet have a full grasp of what the key anatomical learning outcomes for undergraduate veterinary curricula should be, studies are required to explore how anatomical knowledge and skills are utilized in clinical practice. This study aimed to use an exploratory approach in order to begin to build an evidence base to underpin anatomy curriculum development in veterinary education. The primary goal was to gain a deeper understanding of the role that anatomy plays in first opinion veterinary clinical practice. Using ethnographic methodologies, the authors aimed to collect rich qualitative data to answer the question “How do first opinion veterinarians use anatomy knowledge in their day-to-day clinical practice?”.

MATERIALS AND METHODS

The establishment and veterinarians that participated in this study have been anonymized and consented to the use of their data for publication. The project received ethical approval from the Royal Veterinary College’s Social Sciences Research Ethical Review Board (Ref: URN SR2017-1122).

Selection of Veterinarians

Observations and structured interviews of veterinarians were carried out within one independent single branch first opinion small animal practice in the UK. The practice was chosen for practical reasons (proximity, ease of access for daily travel and willingness to accommodate the authors), as

well as for its characteristic features, which were felt to be as representative as possible of a range of possible practice types (small-medium-sized practice; located in a medium-sized town—rather than highly rural or urban; not part of a larger corporate structure). The practice had one part-time and five full-time employed veterinarians. All five full-time veterinarians consented to participate in the study. The part-time employee was not included in the study due to the more highly specialist nature of her role within the practice. The veterinarians studied were diverse, in terms of sex, ethnic, and cultural background, and level of experience. Some, but not all, clinicians had worked in other practices prior to starting their current position. The veterinarians were graduates from five different veterinary schools (four within the UK and Ireland, and one from elsewhere in Europe) and had different specialties within the profession (Table 1).

Data Collection

Data collection for this study was ethnographic in its approach. The author, a final-year veterinary student, spent three weeks within the veterinary practice during 2017. During the first two weeks, each of the five veterinarians were observed for two (non-consecutive) days. These days were chosen such that each individual was observed across their main duties: consultations, surgery, and inpatient work. During the third week of the study, semi-structured interviews were conducted with each of the veterinarians. The areas explored by these interviews included the perceptions of veterinarians' anatomy knowledge, and details of how they used anatomy in their current role. A structured proforma was used by the investigator to guide the interview (Supporting Information Appendix 1); however follow-up and probing questions of an individual nature were also used to explore participant experiences in depth. For example, the interviews were also used to clarify any observations from the previous weeks. This clarification was important to understand the veterinarians' underlying rationale for procedures and surgeries that they were doing, and gauge how their anatomy knowledge impacted their practice. Interviews varied in length, however, were a maximum of 30 minutes in duration. Field notes were handwritten then word processed. Notes included details of the case (including species, body systems/structures involved, condition, procedures undertaken, examination), quotes or paraphrases of veterinarians' comments

Table 1.

Profiles of the Five Veterinary Practitioners that Participated in this Study

Veterinarian	Sex	Experience (in years)	Speciality
V1	Female	>20	Feline medicine and surgery
V2	Male	10-20	Internal medicine and ultrasound
V3	Female	10-20	Surgery and laboratory diagnostics
V4	Female	<10	Feline medicine
V5	Female	<10	Internal medicine

and case discussions, and descriptions of clinician's actions. Example field notes can be found in Table 2. Videos were taken during surgeries, then reviewed and field notes made, as for standard observations. Interviews were recorded by voice recorder, model Evida L69 (Evida Corp., Salt Lake City, UT), then transcribed. Video data also underwent transcription for further analysis.

Data Analysis

A thematic analysis of the qualitative data, by a grounded theory approach (Glaser and Strauss, 1967; Lingard et al., 2008), was conducted to identify themes across the whole data set, including the field notes, video and interview transcripts. Initial coding was carried out independently by the authors, with subsequent comparisons and refinements (coding, categorizing, adjusting, reflecting) made throughout the iterative process. Subthemes and themes were then decided and agreed upon by both authors. Following this, themes were considered in the context of current theory and practice in anatomy education. A simple quantitative analysis of the observational data was carried out to determine the range and number of different types of tasks observed, and the range and frequency of body systems examined/discussed/treated.

RESULTS

In total, 86 hours of observations and interviews were conducted and analyzed. Observations reflected the normal day-to-day tasks of the veterinarians at this practice (Fig. 1). Veterinarians were most frequently observed conducting consultations (consults; N = 81), which included first opinion consults (43%), discharge consults (2%), rechecks (25%), and vaccination consults (30%). Procedures observed included (not exclusively) nerve blocks, intubation, urinary catheterization, intravenous catheterization, fine needle aspiration, blood sampling, foreign body removal, and aural examination. Surgeries observed included dental surgeries, castration, laparotomy, spay, and dew claw amputation. The body system most frequently coded in observations was the digestive system (N = 76), followed by the cardiovascular system (N = 72; Fig. 1).

Five main themes were identified within the data. These were Importance; Uncertainty; Continuous learning; Comparative and dynamic anatomy; Communication and language. A summary of these themes and subthemes is provided in Figure 2. Each theme and its subthemes will be explored in detail in the subsequent section.

Importance

A very clear theme within the data was the acknowledgment of the importance of anatomy knowledge for first opinion veterinary practice. Veterinarians were clear that they use anatomy knowledge every day in every aspect of their job. This was supported by the extensive observations of anatomy use by the researcher (Table 2). Examples of how anatomy was used (as noted from both interviews and observations) were carrying out a physical examination, performing clinical techniques and procedures, surgery, dentistry, and undertaking and interpreting diagnostic imaging.

“You're more acutely aware of how important anatomy is when you're doing surgery.... [and then there are] new

Table 2.

Example Data from Case Observations.

Body System	Veterinarian Actions	Comments/Quotes	Outcome
Observation number: 6; Participant: V1; Overview: Forelimb dew claw amputation dog			
MSk	Induction of IV, cephalic vein ; Directed VN on area to clip ; felt for vein by moving finger over surface of leg ; Intubated - [VN holding mouth open] visualised throat and opening to trachea, flipped soft palate up and placed tube in trachea. Subcutaneous injections antibiotics and NSAIDs;	Swelling following ripped nail and subsequent infection. Dew claw attached by bone so required bone cutters, V1 preferred to cut through bone rather than joint - as would produce joint fluid and create swelling “there’s a blood vessel under the dew claw but I could not tell you the name of it. I just know not to cut it. Did I know it was there the first time I did the surgery? No. It’s knowledge through osmosis. No fat here so almost like doing two intradermal layers - one lower down and one right at skin edge, lower one takes some of the strain off of the top layer ” I asked which joint went through: “ through 2nd-3rd interphalangeal joint ”. V1 unsure of name but knew bones it was between but not their names (called them 2nd and 3rd when actually proximal and middle), is actually the proximal interphalangeal joint. Ultimately could perform the surgery and knew which part of the bone to go through	Successful surgery
Observation number: 15; Participant: V3; Overview: Dog collapse			
Multiple; Primary – renal, CVRS	Examination - palpated abdomen, lymph nodes, spine, check teeth and gums; neuro work up - paw placement ; temperature check; heart and lung field auscultation ; Subsequent ultrasound and radiographs of abdomen and thorax ; insert IV catheter.		Diagnosis of bladder mass and heart murmur.
Observation number: 34; Participant: V4; Overview: Dog vaccination			
N/A	Heart / lung auscultation ; Checked teeth and gums , CRT and moistness, eyes and ears ; Palpated abdomen, sub-mandibular, prescapular and popliteal lymph nodes ; Subcutaneous injection for vaccination.	“I can hear a little heart murmur today. Her lungs sound fine” Asked process for dog abdominal palpation: “dog abdomen, I just start at the front, I feel the edge of the liver, then the spleen, I can hardly ever feel the kidneys ” “ I feel for any masses...I feel the bladder ”	
Observation number: 72; Participant: V2; Overview: Dog with prostate/ bone cancer			
Renal, MSk	Prostate examination – rectally with finger ; Palpation of forelimbs elbow to carpus, range of motion of joints. Looked up on VIN about asymmetric enlargement.	“ prostate is a completely normal shape now , we call it benign prostatic hyperplasia” “it felt like it was more on one side... they’re usually more symmetrical...it felt very unilateral ” “it’s an acute flare up” [whilst looking at right leg and said that left is usually worse]	

A total of 113 cases were observed. Anatomically relevant aspects (as determined by the investigator) are in bold. CRT, capillary refill time; CVRS, cardiovascular system; IV, intravenous; MSk, musculoskeletal system; NSAID, non-steroidal anti-inflammatory drugs; V, veterinarian; VIN, Veterinary Information Network; VN, veterinary nurse.

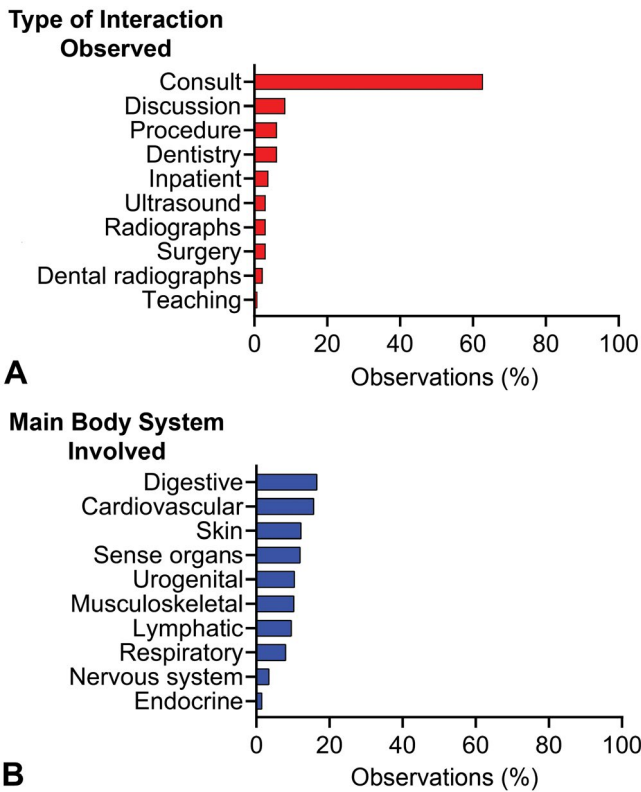


Figure 1.

Breakdown of study observations. A, breakdown by type of clinical activity observed and B, by the body system involved. Proportion of the total number of observations is provided in percentages.

imaging techniques and modalities and then having that foundational knowledge of anatomy suddenly becomes really relevant and important” [V2; Interview transcript]

“Some of it [anatomy] is just ingrained in the brain, so it is automatic or instinctive” [V1; Interview transcript]

“I use it in every single consult and also, of course, every single time I do surgery. You want your markers to know where to make your incision. You need to know which organs should be where”. [V4; Interview transcript]

Veterinarians considered anatomy knowledge to be important for verbally communicating with colleagues, writing clinical notes, and teaching veterinary placement students or more junior colleagues. These latter aspects overlap to some extent with the theme of communication and language and will be discussed in more depth in that section.

Veterinarians were reflective, but not critical, of the preparation that their previous anatomy teaching had provided them for their current role. Rather than blame the teaching or curriculum for any deficiencies, they focused on their own motivation to learn as an undergraduate student, and the early timing of anatomy teaching within many veterinary curricula:

“...when I was a student, I thought it was a little bit boring to learn all the names of all the different bits of bone.” [V4; interview transcript]

“It’s hard when you don’t have a foundation to appreciate the importance of anatomy in day to day general practitioner life” [V3; interview transcript]

“I think when you’re starting off... you don’t have a framework to reference it to, so something where you’re looking for problems or assessing it in a logical or clinical way, it’s hard to link the two together to what you’re going to be doing in the future” [V3; interview transcript]

Uncertainty

This theme arose from the multiple occasions whereby veterinarians were uncertain or lacked confidence in their anatomy knowledge. These instances occurred when individuals were uncertain of the correct terminology or, for example while doing dentistry, surgery or diagnostic imaging. When questioned, veterinarians often did know the anatomy of the structures they were dealing with but focused on the detail they did not know, or specific terminology that was lacking (the subtheme of terminology will be discussed further in a later theme).

“look at that little artery pumping away there” [V1; Case 26; observation of exploratory laparotomy]

“VS4 didn’t know numbers of teeth but looked at chart to get numbers for notes” [Case 104; V4; cat dental observation notes]

“through 2nd-3rd interphalangeal joint”. [V1; Case 6; When questioned about site of dew claw amputation V1 was unable to name the proximal interphalangeal joint].

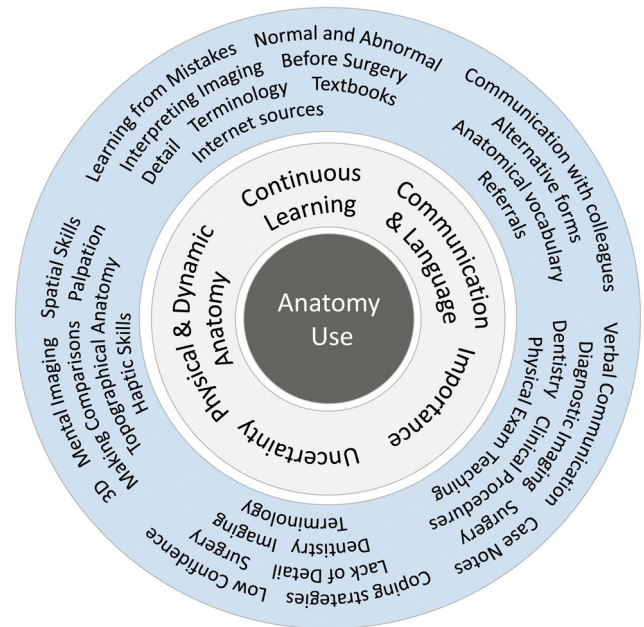


Figure 2.

Themes and subthemes found within the dataset (observations and interviews). Themes are within the inner circle with associated subthemes in the surrounding outer circle.

When veterinarians reported uncertainty in their anatomy knowledge, this impacted their confidence, working practices, how they chose to approach cases, and even their referral decisions. Veterinarians used a variety of different coping strategies to deal with uncertainty. One such strategy was avoidance. One individual commented on how lack of anatomy knowledge affected his career; feeling that this made him more cautious.

“Probably when I’m getting into things where I don’t know the anatomy, I’m probably more likely to refer them or get someone else to do the procedure because of that gap” [V2; interview transcript]

“I’d probably do more [dental] nerve blocks if I had the anatomy knowledge” [V2; Case 82; case discussion with V1]

“I’m probably more just being really careful and slow, whereas I could be probably more confident” [V2; interview transcript]

Other coping mechanisms included teamwork and problem solving. Veterinarians worked through their uncertainties with colleagues, and used problem-solving strategies where required, especially when interpreting diagnostic images:

“That’s the hyoid apparatus. What’s that triangular structure?...”. [V5; Case 14; X-ray of inpatient dog with pain of unknown origin - team discussion of radiographic findings. VS1 and VS3 checked textbook and realized radiograph was normal]

“you’ve got enteric contents, then you’ve got black, white, black, white, which is bowel wall...” [V2; Case 26; cat with dysphagia - discussion of ultrasound findings with V4 to determine location of gut-associated soft tissue mass]

Clinicians also referred to developing a working knowledge of anatomy and carrying out further research as the need arose (this latter subtheme will be explored further in Continuous Learning).

“Realistically, am I going to know every single nerve, muscle, vessel that I encounter? No” [V3; interview transcript]

“I think as you get more experienced, you probably develop techniques and learn the anatomy that you need to learn to get you through different situations” [V2; interview transcript]

Continuous Learning

Veterinarians described that they were continually improving their anatomy knowledge and learned using a variety of resources whenever required. This may be to get supplementary detail on a structure or region, prior to surgery, to check whether a finding was (ab)normal, to look up correct terminology, or as a guide when interpreting imaging.

“The number of times I’ve had to go back to a textbook or to look something up. If I’m unsure about something, I know where to look or to try and make sure I’m correct with the phrases or the terms that I’m using” [V3; interview transcript]

“I think [looking things up] is important because that’s continuous learning and, like I said, I don’t think anyone can be fully aware or know all of the anatomical terms” [V3; interview transcript]

“I sometimes have to get the books out to know which muscles are where in the neck or something like that” [V4; interview transcript]

Veterinarians also referred to “knowledge by osmosis” and learning from mistakes as key drivers of their anatomy knowledge.

“There’s a blood vessel under the dew claw but I could not tell you the name of it. Did I know it was there the first time I did the surgery? No. It’s knowledge through osmosis” [V1; Case 6; observation of dew claw removal]

One individual however found referring to other resources difficult and as a result this impacted his ability to improve his anatomy “on the job”:

“Sometimes when I have looked at resources that I’ve had, which is usually textbooks, I find that they’ve not always been easy for me to get the information I need really quickly...You look up anatomy and it takes time.” [V2; interview transcript]

“I probably qualified and thought, “I’ll do that a lot,” but I would say that I probably don’t do it as much as I should.” [V2; interview transcript]

Physical and Dynamic Anatomy

Veterinarians highlighted that the ability to use their anatomy knowledge to make physical comparisons between structures (for example, comparing left and right bilateral structures or making comparisons between normal and abnormal) was important. They recognized the need for appropriate skills to map change in an animal’s anatomy—between visits, or between static and active assessments (such as during a lameness examination).

“the one on the right feels smaller than the one on the left and they were equally big” [V4; Case 33; Dog for blood sample with history of lymph adenomegaly; comparing size of popliteal lymph nodes with last visit]

“I’ll have a feel of his kidneys...the right one is a bit smaller than his left” [V4; Case 63; examination of a feline inpatient]

Veterinarians felt that a good understanding of topographical anatomy was critical to successful physical examination and described making use of mental imagery as they applied their anatomy to practical situations:

“When you do abdominal palpation, whether that lump is a kidney or whether that lump is a lump... You need to know which organs should be where” [V4; interview transcript]

“you’re able to look back and try and form an image or a picture in your head” [V3; interview transcript]

“It’s all feeding into how your fingers and hands are working, how you’re mentally envisaging what you’re

trying to do with your imaging or whatever. It's usually more physical things" [V2; interview transcript]

"So, I'm trying to get my three-dimensional picture as I'm palpating, and I'll actually use my hand in a different position as I'm palpating" [V3; interview transcript]

Veterinarians had a personal technique/process for palpation, physical examination, and making comparisons. Despite reference to the importance of anatomy knowledge for these processes, they identified experience, as well as knowledge, as important for development of good physical examination skills.

"I think these are things I've learned over time, so I'll get a feel for where I think usually things are in my order of palpation and then I feel that there's something a little bit off or off-center....." [V3; interview transcript]

Communication and Language

Communication and language was a strong theme within the data. Not only were veterinarians frequently required to verbally communicate using anatomical vocabulary, but they highlighted major deficiencies in their use of anatomical language. They felt this was detrimental to effective communication with colleagues.

"If you want to explain something so that your colleague understands it, you need to know the names of everything" [V4; interview transcript]

"In terms of our general understanding and chat between us, I think we understand each other, but if we were asking opinions from another practice or from another referral center, then the terminology that we use, I don't think that's going to be enough to get across what we're asking for." [V3; interview transcript]

"In terms of having a standardized way of communicating with your colleagues or with the nurses or even with students or other practitioners, I think it's important to have at least a general working understanding of the names [of structures]." [V3; interview transcript]

"if you stick to medical speak, theoretically you should all know what we're talking about as opposed to lay or descriptive terms which might be one thing to one person and something quite different to another" [V1; interview transcript]

They frequently used alternative communication forms as a coping strategy, such as colloquial language, alternative shared vocabulary, drawing diagrams or making hand gestures.

"I took out the two big back ones but not the little vestigial one at the back" [Case 81; dental extraction handover between V2 and V1]

"there's the tail, there's the anus and it's really sharply demarcated" [V1, while drawing shape with hands]

"so it's the anal sac" [V5]

"no, it's more here" [V1 gestures]

"ah, so more ventral" [V5]

[V1 and V5; Case 27; VS1 describing mass location on dog to VS5]

"so do you know what the wall looks like?" [V2]

"there's quite a big vessel...artery and vein here..." [V1 draws a picture of the tumor] "well I had the round tube of..." [V1]

"duodenum" [V2 prompts V1]

"...then you got to the stomach bit" [V1]

"so it's the proximal duodenum and pylorus" [V2]

[V1 and V2; Case 26; description of gastrointestinal tract anatomy and route of transit during case discussion of celiotomy from previous day]

DISCUSSION

The major findings of this study can be summarized in three parts: (1) anatomy is critically important within much of a first opinion veterinarian's day-to-day job, but some veterinarians are uncertain in their anatomy knowledge, which impacts their confidence and work; (2) veterinarians are continually learning and refreshing their anatomy knowledge in order to effectively undertake their role; (3) there is a clear and important inter-relationship between psychomotor and professional skills (such as observational, haptic, spatial, and communication skills) and anatomy use in first opinion veterinary practice.

The Importance and Impact of Anatomy Knowledge

The high importance given to anatomy by the veterinarians in this study echoes the opinions of medical students (Moxham and Plaisant, 2007; Bergman et al., 2013), veterinary students (Gummery et al., 2017), and doctors themselves (Fitzgerald et al., 2008). While previously doctors have stated that anatomical knowledge is more critical for surgery than medicine (Böckers et al., 2010; Estai and Bunt, 2016), the clinicians participating in this study did not take that view. They felt that anatomy was utilized in every aspect of their role within first opinion veterinary practice, and this view was corroborated by observational data.

Despite its perceived importance, many of the veterinarians observed and interviewed were uncertain in their anatomy knowledge at times. Uncertainty is an accepted and intrinsic part of the medical and veterinary profession, taking many forms including the uncertainty that surrounds diagnosis, treatment, teachers, clients as well as uncertainty related to knowledge (Light, 1979). Uncertainty related to knowledge may be avoidable in many instances; however, individuals will rarely be able to master all available knowledge. Additionally, professional knowledge is indeterminate in nature, with inherent omissions and ambiguities (Fox, 1957). Some uncertainties may even relate to the inability of the individual to distinguish their own inability to master the knowledge from deficits within the body of knowledge itself (Light, 1979).

Uncertainty changed the way veterinarians dealt with clinical cases, making them less likely to undertake a procedure themselves and more likely to refer a case to a specialist. This is interesting since one of the coping strategies for uncertainty observed by Light (1979), was specialization by clinicians, seeking to reduce the body of knowledge that they must master. Individuals described as "intolerant of uncertainty" have also been identified as less likely to practice in primary care or resource-limited settings (Merrill et al.,

1994; Wayne et al., 2011). It seems that perhaps by choosing to work in first opinion practice the participants in this study have found themselves in an environment which requires extensive breadth and depth of anatomical knowledge, making some degree of avoidable as well as unavoidable uncertainty an inevitability. If this is the case, educators may wish to consider approaches to help students intending on entering general practice learn to navigate this uncertainty prior to beginning a professional career. Small group discussions, especially those including elements of professionalism, and reflective writing assignments, are good avenues for stimulating reflection on issues surrounding ambiguity and uncertainty (Wayne et al., 2011). Within anatomy specifically, developing an appreciation of anatomical variation is widely considered important (Willan and Humpherson, 1999; Sprunger, 2008) in order to equip the clinician for variations encountered in their professional careers. The implicit outcomes of teaching variation might contribute to developing a student's ability to cope with understanding the limits of both anatomical knowledge and their own knowledge, and in learning to deal with the unknown.

Lifelong Anatomy Learning

Veterinarians in this study emphasized that learning and reviewing anatomy was a continual process. They achieved this by using text and web-based resources to supplement their existing knowledge, and by engaging in learning through discussions with their veterinary team. Looking up anatomical details during their future career is an expectation of veterinary students (Gummery et al., 2017), while the development of skills in undergraduates to allow "just in time" learning in the workplace has been well described (May and Silva-Fletcher, 2015). Information literacy skills are increasingly important in a modern information-rich society with an ever-expanding knowledge continuum, yet some of the major documented stressors for veterinarians are related to continuous learning and their ability to sustain their knowledge and technical skills (Gardner and Hini, 2006). These difficulties were reflected in this study, with some veterinarians describing avoidance behaviors due to their inadequate skills in information search and retrieval. Other studies of veterinary students have also highlighted inadequacies in the information-seeking abilities in undergraduates (Elnoor et al., 2017).

Veterinarians in the current study described that having a familiar or favorite anatomy resource made them more inclined to look up information. Encouraging veterinary students to explore multiple and diverse resources during their anatomy learning could familiarize students with resources they may use later in the clinic, and potentially reduce their anxiety when utilizing new information sources. Curricula which maximize the opportunities for students to engage in information seeking are likely to benefit development of such skills (Mastenbroek, 2017). Both problem-based (PBL) (Marshall et al., 1993; Schilling et al., 1995; Dodd, 2007) and more broadly, inquiry-based learning approaches (Chaplin, 2003; Lee, 2011; Bentley et al., 2015; Anstey, 2017) are considered effective in promoting development of information literacy skills through active and independent investigative activities.

Veterinarians referred to "knowledge by osmosis" and learning from their mistakes as they described how they continually learn and evolve their anatomical understanding.

This aligns with experiential learning theory (Kolb and Fry, 1975), and with the idea that reflecting on a concrete event or experience, such as making a clinical error, can lead to improved conceptual understanding. Considering the apparent opportunities and requirements for experiential learning of anatomy in the general practice environment observed in this study, allowing undergraduates to make and learn from mistakes in "safe" anatomy education settings may be helpful preparation for clinical practice. It is difficult to predict or even control the specific authentic learning events that might occur within the clinical workplace but preparing undergraduate students for those experiences when they occur is paramount (Wilkinson, 2017). There are plentiful novel and effective examples of incorporation of experiential learning within anatomy education (Finn and McLachlan, 2010; Bergman et al., 2013; Diaz and Woolley, 2015; Halliday et al., 2015; Backhouse et al., 2017), but traditional approaches such as dissection are also highly experiential (McWhorter and Forester, 2004; Korf et al., 2008; Sugand et al., 2010; Kerby et al., 2011).

Anatomy, Psychomotor, and Professional Skills: Inseparable Parts of the Clinician's "Toolkit"

The process of carrying out a clinical examination is highly complex. It involves acquisition of real-time visual and haptic information, the creation of mental representations of that information, and comparison of these with the clinician's inherent knowledge base and mental models of the clinically normal animal. This multifaceted skill requires clinicians to be equipped with well-developed observational, haptic, and spatial abilities as well as a strong grounding in topographical and "spatial" anatomy. This was central to the theme of "physical and dynamic anatomy" that was identified in this study. Veterinarians frequently referred to the use of mental imagery, and topographical and three-dimensional anatomy knowledge in allowing them to perform a clinical examination. Use of multiple senses by the clinician in this way has been previously reported (Hirschauer, 1991), in describing how surgeons reconstruct their abstract representation of anatomy within a patient's body. Hirschauer perceives anatomical knowledge and surgical experience to be engaged in a "permanent cross-fading of experience and representation" (Hirschauer, 1991), echoing the experiences described by veterinarians in this study.

Mental imagery has been shown to significantly improve the acquisition and execution of technical skills (Epstein, 1980; Driskell et al., 1994; Bohan et al., 1999), has been implicated as important in surgical skills development (Bathalon et al., 2005; Arora et al., 2011) as well as in the development of palpation skills (Esteves and Spence, 2013). Similarly, spatial ability, its importance, and its apparent malleability as a trait (Baenninger and Newcombe, 1989; Hoyek et al., 2009; Lufler et al., 2012) have been widely discussed within the anatomy education literature (e.g., Garg et al., 2001, 2002; Guillot et al., 2007; Hegarty et al., 2008; Lufler et al., 2012; Vorstenbosch et al., 2013; Nguyen et al., 2014; Sweeney et al., 2014; Berney et al., 2015; Delisser and Carwardine, 2017; Gutierrez et al., 2017; Loftus et al., 2017). Given the indication in the current study that haptic and spatial skills are integral to the application of anatomical knowledge in clinical practice, recent efforts within anatomy education to advance development of such skills (e.g., Hegarty et al., 2008; Gutierrez et al., 2017; Roach et al., 2018;

Bogomolova et al., 2020) appear to be well grounded and conceived.

One of the most surprising outcomes of this study was the apparent inadequacy of veterinarians in their ability to communicate using basic anatomical language. Veterinarians were deficient in their ability to name structures, in part attributed to the difficulties retaining such detailed knowledge; however, they also lacked the ability to utilize basic directional and descriptive terms. This is somewhat of an irony, given that one cause of the recent reduction in anatomy teaching within universities was the need to make space for professional skills development such as communication (Cooke et al., 2010; Drake, 2014). Communication skills teaching in veterinary curricula has to date focused heavily on communication with the client (Radford et al., 2003; Latham and Morris, 2007; Hamood et al., 2014; Mossop et al., 2015); however, the current study highlights an apparent requirement for explicit teaching of communication with other members of the veterinary team, using appropriate technical language. It might be that integrating professional skills development opportunities within anatomy teaching, rather than addressing them in isolation, may be optimal for achieving this. Interdisciplinary integration is increasingly considered important for the teaching of professional skills within medical curricula (Lachman and Pawlina, 2006; Pawlina, 2006; Pawlina et al., 2006; Louw et al., 2009; Bandiera et al., 2018) and there are growing numbers of examples of effective use of such integration within anatomy teaching (Swartz, 2006; Gregory et al., 2009; Shapiro et al., 2009; Wilkerson et al., 2009; Johnson et al., 2012).

Students often refer to learning anatomy as akin to learning a new language (Wilhelmsson et al., 2010), and there is an argument for supporting it as such. There have been calls for a bespoke course in medical terminology in the early years of undergraduate curricula (Louw et al., 2009); however, Gibbons (2014) suggests that it is problematic to consider a learner as proficient in a language without considering the context in which the language will ultimately be used. This has resonance within anatomy teaching with context being described as critical to the ability of students to effectively apply their knowledge within a clinic setting (Bergman et al., 2008; Fincher et al., 2009; Lazarus et al., 2012). It may be that deficiencies in anatomical language seen in clinicians in this study could be avoided through supporting students to develop their foundational understanding of anatomical terminology and language within a clinically relevant context, and through supporting and enforcing appropriate language use within the later clinical curriculum.

Limitations of the Study

The limitations of this study align with those of many qualitative research projects. First and foremost, the population of veterinarians studied was necessarily small, in order to appropriately observe and analyze the actions and opinions of individuals in depth. The research was conducted within a single veterinary practice and so generalizability of this research beyond this site and small population is not guaranteed; however, the authors were careful to choose a practice that was as representative of small animal first opinion veterinary practice as possible, and to observe and interview a mixed and representative demographic of veterinarians. Further, it is unlikely that the results of this study would

necessarily generalize to equine or farm animal practice, or indeed referral level practice; therefore, further work is required to understand the specific requirements and nature of diverse graduate destinations.

Another limitation is bias. This includes any bias of the study participants, who for example may possess conformation bias in relation to their experiences of anatomy in the past and present. It also includes the inherent bias of the authors, which may have influenced the observations taken, and subsequent thematic analysis. Bias was minimized via dual coding of the data during analysis, however, is an inherent limitation of qualitative research, in particular ethnographic research (Magnier et al., 2014). This is not frequently considered problematic, so long as the authors are aware of any intrinsic bias that they may carry. The observer and interviewer during this study was a final-year veterinary student. It was necessary for the researcher to be familiar with veterinary anatomy in order to appropriately make judgments on what was considered to be of interest to the study. There was also benefit to the observer and main author of being a student, in that for many experts, competence is unconscious (Howell, 1982); being inexperienced within this context therefore allowed the author to encourage veterinary practitioners to verbalize and elaborate where required, as well as avoid professional bias in analysis and interpretation of the observations.

Recommendations

It is notable that, though the authors set out to explore the use of anatomy knowledge in first opinion veterinary practice, few of these recommendations involve knowledge itself as a construct. The most striking outcome of this research centers on the interrelated nature of anatomy knowledge and its ultimate application within a clinical setting. Effective application seemed to require the veterinarian to be equipped with an integrated skillset (professional, psychomotor, reflective practice, literacy) as well as a strong foundational knowledge of anatomy. Based on this principle, but bounded by the limitations of this study, the authors make some proposed recommendations for development and enhancement of anatomy curricula on Veterinary Medicine programs. Some of these recommendations align with already well-established teaching philosophies in medical and veterinary schools, while others offer a fresh view. The authors acknowledge fully that more research is required to definitively determine the impact of any proposed developments on preparing learners for veterinary clinical practice.

- **Students studying anatomy should at times be allowed to feel uncertain.** Students can be encouraged, as part of their curriculum, to independently discover anatomy in a self-directed and exploratory manner. Anatomical variation can be emphasized to enhance student exposure to ambiguous knowledge.
- **Developing information literacy skills should be a desired outcome of anatomy curricula.** Anatomy teaching can directly provide students with opportunities for inquiry-based learning in order to teach students to recognize and navigate both familiar and unfamiliar anatomy reference resources.
- **Anatomy learning should be experiential and provide authentic learning opportunities.** Clinically relevant, and practical teaching methodologies can provide students with opportunities to learn anatomy within an appropriate

context (aiding future retrieval and the ability to build on past experiences) and within an environment where they can (safely) learn from mistakes. Pawlina and Drake (2016) provide an excellent review of authentic learning as it applies to anatomy education.

- **Anatomy teaching should integrate knowledge acquisition with development of key practical and psychomotor skills.** Students can be actively encouraged to create and utilize mental models of anatomical structures, and to interact in a tactile manner with specimens or live animals as preparation for the requirements of clinical practice. Development of observational and haptic skills as well as visuospatial reasoning could therefore be considered as explicit aims of anatomy curricula.
- **Anatomy knowledge and professional skills should be developed in an integrated manner.** Opportunities exist to encourage students to verbally communicate routinely with teaching staff, clinicians, and other students using anatomical language and terminology. Verbal communication skills could be developed through group work tasks (O'Connell and Pascoe, 2004; Thompson et al., 2007; Vasan et al., 2011), oral presentations (Chollet et al., 2009; Halliday et al., 2015), peer or near-peer teaching (Hall et al., 2013, 2014), or inter-professional learning (Herrmann et al., 2015; Thistlethwaite, 2015).

CONCLUSIONS

This study aimed to investigate how anatomy knowledge was used by clinicians working within primary care small animal veterinary practice. Through detailed qualitative observations and interviews of veterinarians, the authors established that anatomy was critical in all aspects of small animal first opinion clinical practice; however, some veterinarians were uncertain in their anatomy knowledge. This impacted their confidence and how they carried out their work. Veterinarians described continually learning and refreshing their anatomy knowledge in order to effectively undertake their duties, and the role of anatomy curricula in teaching information literacy skills is discussed. Finally, these data demonstrate integration of psychomotor and professional skills with anatomy use within first opinion veterinary practice. The integration of these vital areas could potentially be further enhanced within anatomy curricula. The authors' recommendations should be considered in the light of the limitations of this qualitative study, and the need for further exploratory research in other areas of the veterinary profession, such as farm animal and equine specialties.

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NOTES ON CONTRIBUTORS

ROISIN WHEBLE, B.Vet.Med. M.R.C.V.S., is a veterinary practitioner at Laurels Veterinary Centre, a private small animal first opinion veterinary practice in Bromley, Kent in the South East of the UK. At the time of this study, she was a final-year veterinary medicine student at the Royal Veterinary College in London, UK.

SARAH BETH CHANNON, B.Sc., M.Sc., Ph.D., F.H.E.A., is a senior lecturer in veterinary anatomy in the Department of Comparative Biomedical Sciences at the Royal Veterinary College, London, UK. She teaches anatomy and integrated basic sciences to veterinary medicine students and leads the second year of the BVetMed program. Her research centers on developing an evidence-based approach to anatomy teaching methods, innovations, and curriculum design.

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