BMUS

ECVDI European College of Veterinary Diagnostic Imaging

Small Animal Veterinary Guidelines for Professional Ultrasound Practice

Produced by the British Medical Ultrasound Society

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Foreword:

The importance of ultrasound in the world of human medicine is widely acknowledged and training, competence and professional accountability of its users is carefully monitored.
It is our pleasure to introduce the **Small Animal Veterinary Guidelines for Professional Ultrasound Practice** and we hope that the creation and subsequent use of this document will help to raise the standards of diagnostic ultrasound provision in small animal veterinary medicine and will support best practice, thereby protecting patients, clients, and ultrasound users across the industry.

The format and structure of these guidelines are based around those used in the world of human medical diagnostic ultrasound and are designed to underpin good practice rather than be prescriptive

We are most grateful to the (United Kingdom) Society and College of Radiographers (SCoR) and the British Medical Ultrasound Society (BMUS) for allowing us to use their seminal document 'Guidelines for Professional Ultrasound Practice' (6th edition. December 2021[1]) as a template for the **Small Animal Veterinary Guidelines for Professional Ultrasound Practice.**

The original comprehensive, collaborative document, produced by the SCoR and BMUS covers all aspects of human medical ultrasound and is based on the original text 'Guidelines for Professional Working Practice' first published by the United Kingdom Association of Sonographers in 1993,

Rationale

This document has been written to provide evidence based, good practice guidelines and benchmark standards to those 'non veterinarian' ultrasound practitioners working in small animal medicine; specifically, registered veterinary nurses wishing to support their veterinary colleagues through diversification and ultrasound practitioners/technicians who hold a formal, universally recognised qualification in human diagnostic ultrasound and who wish to expand their scope of practice to include small animal ultrasound.

This document is not intended to encourage any professional to work outside their scope of practice. At the time of writing, the diagnosing of conditions remains solely within the remit of registered veterinary clinician [2] [3] [4].

That said, the document will be of considerable use to both veterinarians and employers as it helps to inform the standards expected of those professionals undertaking small animal ultrasound when working collaboratively with colleagues in the best interests of the animals in their care.

It is hoped that, as there are currently no nationally or internationally agreed protocols or expected standards of practice (that the authors are aware of) for ultrasound examinations in small animal care, these guidelines will act as a basis for service providers when creating their own examination protocols.

These Guidelines, which are not prescriptive, are made available to be used as recommendations for good practice. The examination-specific section, including guidelines and common clinical scenarios (refer to sections 3 and 4) have been compiled by the British Medical Ultrasound Society Professional Standards team (BMUS Clinical Veterinary Ultrasound Group) and is presented as examples of best practice.

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[1] https://www.bmus.org/policies-statements-guidelines/professional-guidance/guidance-pages/guidelines-for-professional-ultrasound-practice/
[2] European Veterinary Code of Conduct, Federation of Veterinarians of Europe. https://fve.org
[3] The American Veterinary Medical Association (AVMA) Model Veterinary Practice Act (MVPA). https://AVMA.org
[4] Royal College of Veterinary Surgeons. https://rcvs.org

They have been included so that veterinary departments can use them as a basis to generate their own examination protocols when there are no nationally agreed ones available.

There are also sections giving general guidance and advice, including reporting and audit.
Hyperlinks have been extensively used within the text to give access to the many relevant documents already published on a wide range of topics by organisations other than the SCoR and BMUS.

Definitions

There can be overlap between the terms 'Standards', 'Guidelines' and 'Protocols' and this can cause confusion. For the purposes of this document, the definitions used below are the same as those in the 2014 Royal College of Radiologists (RCR) and Society and College of Radiographers (SCoR) document[5].

Standard:
'A required or agreed level of quality or attainment. A standard is a way of ensuring optimum levels of care or service delivery. Standards promote the likelihood of an ultrasound examination being delivered safely and effectively, are clear about what needs to be done to comply, are informed by an evidence base and are effectively measurable'.

Guideline:
'A general rule, principle, or piece of advice. Guidelines provide recommendations on how ultrasound examinations should be performed and are based on best available evidence. They help ultrasound practitioners in their work, but they do not replace their knowledge and skills'.

Protocol:
'An agreement, preferably based on research, between practitioners to ensure the delivery of high-quality standardised ultrasound examinations.

Patient:
The animal undergoing care.

Client:
The owner presenting the animal for care

Department:
The veterinary establishment where animal care is given

Veterinary nurse/technician/technologist/technician specialist/animal health technician:
In some countries, the title of veterinary nurse is protected and is recognised in law but in others, it is not, and, in those countries/states, anyone can call themselves a veterinary nurse.

We use the term veterinary nurse to describe a person who has undergone training and holds a formal qualification recognised in the country in which they are working. They should be statutorily registered if this is possible in the country/state in which they work**.** The UK was the first to recognise 'vet nurse' as a title in the 1960s and this was followed by Australia, New Zealand, and Europe

An ultrasound operator/sonographer:
A generic term used for someone who uses ultrasound equipment but who does not hold an ultrasound qualification obtained through formal training in an institution recognised in the country/state in which they practice. As 'sonographer' is not a protected role title (in the way veterinary clinician and in some countries/states veterinary nurse is), many vets and vet nurses using ultrasound call themselves

[5] https://www.rcr.ac.uk/publication/standards-provision-ultrasound-service

sonographers and can do so even if they have not had formal competency-based training and obtained a recognised qualification. This use of the term sonographer also occurs in human healthcare.

An ultrasound practitioner/technician/tech:
A person who has undergone formal competency-based training in ultrasound and gained a graduate or post graduate qualification from a recognised training provider. An ultrasound practitioner/technician/tech will have had both theoretical and practical training and will have passed both written and clinical competency examinations to gain their award.

Regular audit of competency forms part of an ultrasound practitioner's work.
Depending on the country in which they practise, an ultrasound practitioner should be statutorily registered, if possible, for example in the UK, most ultrasound practitioners are registered with the Health and Care Professionals Council (HCPC) under their primary degree as Radiographers.

In the UK, an ultrasound practitioner working in the human world, writes reports which often include diagnoses and recommendations for onward referral or further imaging but in veterinary health this can only be done by veterinary clinicians.

Veterinarian/veterinary surgeon/veterinary physician/veterinary clinician/vet
A person trained to provide medical care to animals. The qualification (degree) obtained must be from an educational institution approved by and recognised in the country (in some countries the state) in which they are registered to practise.
Only those with a recognised qualification are entitled to use the title as it is protected in law.[6]

An imaging specialist/veterinary radiologist
To be deemed to be an 'Imaging Specialist', an individual must have achieved a postgraduate qualification (to Diploma level as a minimum) in veterinary imaging.

The European College of Veterinary Diagnostic Imaging (ECVDI) requires its members to be 'encouraging research and other contributions to knowledge relating to diagnostic imaging, and promoting communication and dissemination of this knowledge'[7]

Members of the American College of Veterinary Radiologists (ACVR) 'undergo rigorous postgraduate (after Veterinary College) training' and the mission statement of the ACVR is 'to promote excellence in patient care by providing leadership, innovation, and education in veterinary diagnostic imaging and radiation oncology''[8]

For the purpose of this document and to avoid confusion, the term 'ultrasound practitioner' will be used to encompass those with post graduate qualifications in ultrasound i.e., veterinary imaging specialists and practitioners from human medicine working in veterinary medicine.

The term 'ultrasound operator' will be used to describe those who have not undertaken formal training leading to a post graduate qualification in ultrasound but who using ultrasound in their practice to support enhanced care e.g., veterinary clinicians or veterinary nurses performing scans which their veterinary colleagues can then use to formulate diagnoses.

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[6] European Veterinary Code of Conduct, Federation of Veterinarians of Europe. https://fve.org
The American Veterinary Medical Association (AVMA) Model Veterinary Practice Act (MVPA). https://AVMA.org
Royal College of Veterinary Surgeons. https://rcvs.org
[7] https://www.ecvdi.org/about-us/who-we-are/ecvdi-constitution
[8] https://acvr.org/

It is the nature of any document whether published in hard or soft copy that it can very quickly become out of date. It is the intention of BMUS that this document will be regularly updated but it is the responsibility of the ultrasound practitioner/operator to ensure that they research and apply the most up to date evidence in association with the contents of this document.

At the time of publication (6th edition, December 2021, all hyperlinks have been checked and are complete).

Please report any broken links to the following contact addresses: https://www.sor.org/contact-us or https://www.bmus.org/contact-us/

Comments and feedback are also very welcome and will guide us in the further development of these guidelines.

Section 1: Introduction:

The use of ultrasound in companion animal care is widespread with the majority of first opinion or general practice providers having access to an ultrasound machine. Vet nurses are experienced animal care professionals and with the right training and support in the use of ultrasound, are ideally placed to help their veterinary colleagues provide the best possible, evidence-based care to their patients. Whilst ultrasound practitioners working in the human world may not be used to scanning companion animals their knowledge and ability to 'drive' the ultrasound machine means that they can move across and work in animal health with the right training.

These guidelines have been written to support vet nurses and ultrasound practitioners with a human health background; two very different professions, each with their own specific learning needs to make them competent in performing ultrasound in small animal care.
Although the guidelines are not aimed directly at veterinary clinicians, the information included will be very useful if they are looking to improve their own skills.

Guidelines and standards have been an important aspect in ensuring the safe and competent use of ultrasound in human healthcare and adapting those tried and tested methods to small animal care will improve the standards of ultrasound service provision.

There are some aspects of the guidelines which will seem to be more relevant in human health, but the authors have included them because the world is ever changing and what seems irrelevant in animal care now could become the accepted norm in a few years.

Whilst litigation in veterinary care is not even close to the level in human health, it is increasing so anything we can do to 'future proof' and protect veterinary staff from the distress of possible litigation can only be a good thing.

Ultrasound is considered safe because it does not use ionising radiation but as it is the most operator dependent imaging modality, it is essential that it is only used by those who:

- Know how to use the ultrasound system controls to optimise the image, recognise artefact, and manipulate the equipment and their technique to mitigate the risk of misdiagnosis.
- Have sufficient training/experience to recognise normal anatomical structures and differentiate between normal and pathological appearances on ultrasound
- Understand the limitations of ultrasound and recognise its place in the patient pathway.
- Follow protocols which include a methodical technique to ensure the information obtained from the procedure is accurate and reproducible.
- Know and accept their own limitations and are willing to seek help and advice as necessary, i.e., do not work outside their scope of practice
- Hold appropriate professional indemnity insurance or obtain this by virtue of their employment.

Ideally, anyone performing ultrasound scans to assist in the diagnosis of conditions and therefore affect patient treatment should be involved in regular audit and should provide evidence of relevant CPD (as is the case in human medicine).

Section 2: Governance and safety

Diagnosis of pathological conditions in animals can only be made by a veterinary clinician or imaging specialist[9] [10] [11]

This means that other professionals using ultrasound may provide information to aid a veterinary practitioner in making their diagnosis but are not permitted to 'diagnose' conditions themselves.

2.1; Code of professional conduct

Around the world, both veterinary clinicians and veterinary nurses/technicians must abide by the veterinarian code of conduct in their country of work and this code will make clear the responsibility of the professional to the patient, the client (and the wider public), the profession and their colleagues. If they can be statutorily registered, they must be aware of and follow the Code of Professional responsibilities of registrants.
Healthcare (human) professionals who also work in animal care should apply the code of conduct across all aspects of their service provision.

The BMUS guidelines on which this document is based lists 10 points to which those performing diagnostic medical ultrasound in the UK must adhere. All are essential components, but the following relate equally to veterinary ultrasound provision.
Note that where the BMUS document uses the term operator, this has been changed to operator/practitioner and client/owners has been included alongside patient carers

- Ultrasound operators/practitioners must be committed to the provision of a quality ultrasound service having due regard for the legislation and established codes of practice related to health care provision to minimise risk to patients, patients' carers/clients/owners and other professionals.

- Ultrasound operators/practitioners must identify limitations in their practice and request training and support to meet their perceived needs.

- Ultrasound operators/practitioners will take all reasonable opportunity to maintain and improve their knowledge and professional competency and support that of their peers and students. This is in keeping with the code of conduct of most healthcare professionals in both human and animal care.

- Ultrasound operators/practitioners have a duty of care to work collaboratively and in co-operation with the multi-disciplinary health care team in the interests of their patients and patients' carers/owners.

- Ultrasound operators/practitioners must act at all times in such a manner as to justify public trust and confidence, to uphold and enhance the reputation of their profession and to serve the public interest.

- Ultrasound operators/practitioners must ensure that unethical conduct and any circumstances where patients and others are at risk are reported to the appropriate authority.

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[9] European Veterinary Code of Conduct, Federation of Veterinarians of Europe. https://fve.org
[10] The American Veterinary Medical Association (AVMA) Model Veterinary Practice Act (MVPA). https://AVMA.org
[11] Royal College of Veterinary Surgeons. https://rcvs.org

- Ultrasound operators/practitioners who are held accountable in another area of health care must relate this code to others that govern their practice.

2.2; Professional indemnity Insurance

All those using ultrasound must ensure that their professional activities are covered by professional indemnity insurance or equivalent (ideally by holding both organisational and personal indemnity). If they are employed, this will likely be included as part of their contract of employment. Those who are self-employed should ensure they have adequate cover to protect both the public and themselves. Naturally different countries and states will have differing requirements and individuals will need to ensure that they meet those requirements.

2.3; Safety of medical ultrasound

The safe use of ultrasound does not only relate to the competency of the operator/practitioner and users must be mindful of the potential hazards of ultrasound as an imaging modality.

There are societies dedicated to the promotion of the delivery of safe and effective ultrasound services around the world and the following are examples where readers can obtain more information about this:

The British Medical Ultrasound Society (BMUS)[12]
European Federation of Societies for Ultrasound in Medicine and Biology (EFSUMB)[13]
The American Institute of Ultrasound in Medicine (AIUM)[14]
Australasian Society for Ultrasound in Medicine (ASUM)[15]
World Federation of Ultrasound in Medicine and Biology (WFUMB)[16]
Information from BMUS and WFUMB are given below.

BMUS "Statement on the safe use, and potential hazards of diagnostic ultrasound" states that '*Ultrasound is now accepted as being of considerable diagnostic value. There is no evidence that diagnostic ultrasound has produced any harm to patients in the time it has been in regular use in medical practice. However, the acoustic output of modern equipment is generally much greater than that of the early equipment and, in view of the continuing progress in equipment design and applications, outputs may be expected to continue to be subject to change. Also, investigations into the possibility of subtle or transient effects are still at an early stage. Consequently, diagnostic ultrasound can only be considered safe if used prudently*'.[17]

The statement from WFUMB
'Diagnostic ultrasound has been widely used in clinical medicine for many years with no proven deleterious effects. However, investigations into the possibility of subtle or transient effects are still at an early stage. Biological effects (such as localized pulmonary capillary bleeding) have been reported in ***mammalian systems*** *at diagnostically relevant exposure, but the clinical significance of such effects is not yet known. Consequently, diagnostic ultrasound can only be considered safe if used prudently.*

[12] https://www.bmus.org/static/uploads/resources/2020_Guidelines_for_Professional_Ultrasound_Practice.pdf
[13] https://www.bmus.org/static/uploads/resources/2020_Guidelines_for_Professional_Ultrasound_Practice.pdf
[14] https://www.aium.org/officialstatements/34
[15] https://www.asum.com.au/standards-of-practice/safety/
[16] https://wfumb.info/2019/04/15/echoes-2-2-2-2-2-2-2-2-2-2-2-2-2-2-2-2-2-2-2-2-2-2-2-2-2/
[17] British Medical Ultrasound Society (2012). Statement on the safe use, and potential hazards of diagnostic ultrasound available at: https://www.bmus.org/static/uploads/resources/STATEMENT_ON_THE_SAFE_USE_AND_POTENTIAL_HAZARDS_OF_DIAGNOSTIC_ULTRASOUND.pdf [Accessed August 14, 2019]

***Ultrasound examinations should only be performed by competent personnel who are trained and updated in safety matters**. It is also important that ultrasound devices are appropriately maintained'.*

Although these statements relate to human medicine, the need for safe and prudent use (by suitably trained and competent professionals with appropriate equipment) in all mammalian species is clear.

It is the responsibility of the operator/practitioner to be aware of, and apply, the current safety standards and regulations in their country of work. As nurses and practitioners will be performing examinations at the request of the veterinary clinician with responsibility for the care of the animal, the need for the scan (i.e., the risk vs benefit) will have already been determined by the clinician.**'**

2.4; Training events

Where ultrasound training is undertaken on 'well' animals e.g., using pets belonging to teaching staff or attendees, written informed consent should be obtained from the pet owner who understands the process in place to support onward referral should an abnormality be detected.

See appendix 1: Document example for obtaining consent to scan a pet during a training event

2.5; Medico-legal issues

The place of work should have a written set of protocols that describes the range of ultrasound examinations undertaken. The protocols should detail the ultrasound examinations, how the findings are to be presented and the image archiving expectations.
Having these in place will ensure that the person performing the scan and the vet requesting it and subsequently forming a diagnosis, both understand the remit of the scan.
Protocol detail should be such that a new staff member with appropriate ultrasound competencies having read them, could undertake the scan and comment on the findings in the manner expected by the department.

Protocols should be evidence based and reviewed and (where necessary) updated regularly and their review date should be included in their content. Superseded versions should be kept on file permanently in case of medico legal requests.

The following guidance should be considered:

- Ultrasound practitioners/operators should be aware that they are accountable for their professional actions
- A competent ultrasound practitioner/operator is one who works to the standards defined by the guidelines of their place of work, the code of conduct of their professional body and when appropriate their regulatory body.
- The standard of care provided by a competent ultrasound practitioner/operator is that which the majority of similar individuals would provide and/or which a significant body of similar individuals would provide in similar and contemporaneous circumstances.
- When a client consents to an ultrasound examination for their animal, they have the right to expect it to be performed and reported by a competent ultrasound operator/practitioner and as part of the consent process, the client should be made aware of the role of the person performing the ultrasound scan, to avoid any confusion.
- Although it is the requesting veterinary clinician who will formulate the diagnosis and decide on the treatment of a patient, it is essential that the report/findings are written with the

understanding that at some point, in some countries, a client can request a copy of it as it (along with any images/video recordings) is part of the patient's care record

- Images that accompany an ultrasound examination should evidence the assumption that the necessary standard of care has been delivered.
- All images must be capable of being attributed to the correct examination and should include the patient identifier(s) and examination date and time.
- Advice on the ideal requisite for the storage of images undertaken during an abdominal ultrasound examination can be found in section4 of this document respectively.

While undertaking any ultrasound examination and working in accordance with locally agreed practice, all ultrasound practitioners/operators should consider the following adapted advice prior to undertaking each ultrasound examination:

- Correctly identify the patient using the following information: the pet's name, client's name and address, age of the pet, species, and breed.
- Obtain sufficient verbal and/or written information from the referring vet to undertake the correct ultrasound examination (Refer to section 3.3 Overview of ultrasound examination procedures). Aside from an emergency, it is expected that a request for an ultrasound scan be in written/digital format and include the clinical details and results of any other diagnostics as a minimum.
- Be able to discuss the relative risks and benefits of the examination with the client; explain the scanning procedure, patient preparation requirements and any technical limitations. *
- Obtain valid, informed consent from the client being mindful of their capacity to understand. *
- Be aware of any individual patient's special needs such as injury, mobility or breathing issues prior to scanning in a specific patient position.
- Ensure the proper care and maintenance of equipment and not use damaged equipment or equipment that is not fit for purpose.
- Be professional throughout the examination to ensure that the examination is carried out to a competent standard.
- Interpret and communicate the findings appropriately and in a timely fashion to the referring clinician
- Ensure appropriate arrangements have been made for further care before the conclusion of the examination

* It is likely that in the majority cases these points would be addressed by the referring vet rather than the nurse or practitioner who is to perform the examination.

2.6; Duty of candour

- All healthcare and veterinary professionals have a responsibility to act in an ethical, open, and transparent way, particularly when things go wrong. Ultrasound practitioners/operators should be aware of the requirements of their code of conduct and professional indemnity insurer if asked to make any statements regarding patient care, complaints, and claims; these requirements may differ from state to state and country to country.
- Details of the expectations of veterinary professionals can be found in the constitutions and codes of professional conduct of the various bodies to which vets and vet nurses belong in their country of work.

Section 2.7; Patient and client records – images and reports

In addition to a comprehensive ultrasound scan report, we recommend the archiving of well optimised and correctly annotated images as part of the patient record as these are an extremely useful adjunct to ongoing treatment and are particularly valuable if a rescan is required whether for follow up comparison or to facilitate interventional procedures.
Individual countries (in some cases groups of countries such as the European Union) will have their own data protection laws and whilst these laws may not relate directly to the animal undergoing care, they will almost certainly apply to the privacy of the pet owner, and these must be considered when archiving care records or sharing images (such as often seen on social media outlets).
The data protection requirements of each country are out of the scope of these guidelines but will likely have the following expectations that information is:

- used fairly, lawfully, and transparently
- used for specified, explicit purposes
- used in a way that is adequate, relevant, and limited to only what is necessary
- accurate and, where necessary, kept up to date
- kept for no longer than is necessary
- handled in a way that ensures appropriate security, including protection against unlawful or unauthorised processing, access, loss, destruction, or damage

Ultrasound images should be stored in DICOM format and in a secure manner on a local hard drive or a picture archiving and communication system (PACS). Reliance on the storage of images on an ultrasound system hard drive should be avoided (particularly on portable ultrasound equipment), as images can be lost if not archived regularly and the processing speed and functionality of the equipment may be affected if image storage capacity is reached. Where there were difficulties obtaining images as per departmental protocol, these should be noted within the patient's report (Refer to section 3.4.2; Report writing)

Although there are no international legal parameters governing the length of time that veterinary ultrasound images should be retained, it is recommended that consideration is given to the legal proviso whereby most civil claims have a maximum limitation period of six years plus one year so it would be sensible to retain records (including any diagnostic test results and images) for 7 years as a minimum. However, professional indemnity providers may have specific requirements around retention of records (and related ultrasound images) so individuals should check with their provider and local governing professional agency and ensure they comply.

Patient records should be completed as close to the time of treatment or action and be clear and factual. Anything relating to the patient wellbeing during the examination should be documented, this may include adverse events or the site of needle biopsy and the name of the vet performing the procedure. The names and designation of anyone involved directly in the care of the patient during the examination should be documented.
Veterinary professionals are frequently required to give copies of clinical notes, (including copies of scan images) to a client on request and in these circumstances, it is essential that there is no breach of personal data belonging to any other client or animal.

2.8; Clinical governance

Professionals involved in animal care (whether statutorily registered or not) understand the importance of clinical governance in all aspects of their practice and for this reason the authors considered not including this section in the document. It was decided however that it would be a useful inclusion because although

ultrasound is such an operator dependent modality there are 'non-clinical' features of good service provision which the practitioner may be unable to directly influence such as the infrastructure and workforce. Having these points in the guidelines could be useful should the practitioner/operator need support from colleagues and/or management in ensuring optimum service delivery.

The infrastructure must be such that:

- roles, responsibilities, and lines of accountability are clearly defined.
- policies, standards, and procedures are shared, and adherence to them is monitored through audit.
- equipment is fit for purpose and undergoes regular service/planned preventative maintenance, which includes a documented process of Quality Assurance (QA) parameters.
- the room in which non-emergency ultrasound scans are performed is suitable e.g., subdued lighting, variable height ultrasound systems, examination tables and chairs and appropriate space to allow for safe working.
- images and reports can be uploaded onto the patient record and/or an appropriate secure data base.
- sharing of knowledge is encouraged.
- there is learning from mistakes in a no blame culture

2.9; Core standards

All veterinary care providers must adhere to the core standards outlined in their country (and state) to ensure that care delivered meets the levels expected/required.
In the UK, these are clearly presented in the Royal College of Veterinary Surgeons (RCVS) voluntary 'Practice Standards Scheme'[18]. An overview of The Practice Standards Scheme for Small Animal veterinary establishments in the UK can be accessed using this link.

The basic requirements or 'Core standards' are those which the RCVS expects all practices to achieve as a minimum, whether they are seeking accreditation through the Practice Standards Scheme or not because these core standards are based around the Code of Conduct.

Within the core standards are specific modules for both clinical governance and diagnostic imaging and whilst the following are UK requirements, they will be broadly the same worldwide and vets and vet nurses should make sure they are aware of the standards expected in their country of work.

The clinical governance standards require evidence of:

- Reflection on clinical effectiveness
- continual improvement of professional practice
- protocols
- audit
- significant event review processes

The diagnostic imaging standards require:

- Reports and quality diagnostic images to be archived in the patient record

[18] https://www.rcvs.org.uk/setting-standards/practice-standards-scheme/an-overview-of-the-practice-standards-scheme/

2.10; Audit

Audit of clinical practice is at the heart of clinical governance and is an essential component of clinical practice and accountability.

The purpose of an audit is to improve patient care and outcomes and prior to starting the audit process, it is essential to include and engage with all grades of staff who are to be included.

An audit does not discriminate, and staff must understand that they will all be measured by the same criteria, irrespective of experience or profession.

Introducing an audit without first meeting with staff to explain the benefits, rationale and process could cause ill feeling or disquiet, particularly in those who have been scanning for a long time

All the relevant staff must be made aware of the audit process and understand the reason for it:

- to improve patient care
- identify noncompliance and
- determine any support/training needs

An audit programme does not need to be complicated to be effective, but it does need to:

- be appropriate
- be explicit in its objectives
- be measurable through a suitable audit method
- enable change

Using the criteria above, a simple ultrasound audit in general practice could be:

- **Appropriate**
  All staff performing ultrasound scans should only do so if they are appropriately trained and working within their scope of practice and understand what is required of them. Standardisation helps to reduce the likelihood of pathology not being detected, maintain quality, and engender confidence for both staff and clients
- **Explicit**
  To make sure that the required images as detailed in a scan protocol have been taken and all have been archived in the appropriate patient's record
- **Be measurable**
  Using these guidelines, a protocol can be written which details minimum images to be archived and the correct plane to be used during organ measurements
- **Enable change**
  Where there is noncompliance, action can be taken. This may be discussion with one member of staff who requires support in training or if multiple staff are involved, a change or review of the overall process.

Staff must also understand how and when their audit results will be shared and how beneficial being a part of an audit is to both their own professional development and improving standards and therefore care of the patient. Audit review can be included as continued professional development (CPD). (Refer to section 2.11; Continuing professional development)

The British Medical Ultrasound Society (BMUS) have devised a universal 'peer review audit tool'[19] that can be used to evaluate the referral, the image quality and report. While this tool may not be suitable for all audit programmes, it can be used as a starting point from which in-house ultrasound audit tools can be developed to meet local needs.
Audits can be used to inform practice and as part of CPD.

2.11; Continuing professional development (CPD)/Continuing education (CE)

The importance of CPD/CE cannot be stressed enough. The requirement to reflect on one's practice and seek to improve is mandatory across most professional bodies.
To remain on a professional register, there is a requirement to evidence the CPD/CE undertaken, reflect on practice, determine training needs and act on them.

In the UK, vets and vet nurses are required to undertake regular CPD which is relevant to their practice and consequently, veterinary surgeons must undertake and document 35 hours and veterinary nurses 15 hours of relevant CPD per annum. From January 2022, the documentation of CPD must include a reflective component[20].

The UK is not alone – vets and vet nurses are required to continually enhance their knowledge as part of their professional roles and a testament to this is the huge amount of CPD/CE available online.

The strategic plan of the American Veterinary Medicine Association (AMVA) has five priorities, one of which is to 'Enhance professional development and Lifelong learning' and although the level and type of CPD/CE varies from country to country; in some it is only considered valid if it has formal accreditation but in others, it can simply be a case of watching a video.

We advise caution when watching on line videos or webinars or following people on social media as not everyone on these platforms will be properly trained and could well be sharing poor practice. Partaking in poor quality CPD/CE is worse than CPD/CE which is irrelevant. For CPD/CE to be worthwhile it must be accurate, relevant and provide value for money.

Veterinary imaging specialists must also evidence their CPD/CE and to be retained on the specialist register are required to demonstrate how they support others in achieving their own CPD goals and training needs.

Documentation of learning activities (whether formal or informal) is essential and this documentation and/or reflection should, ideally be done as soon after the activity to re-enforce the learning
The majority of the professional bodies worldwide will have online portals for recording CPD/CE and indeed many will be available as apps on mobile/cell phones and tablets.

The Royal College of Veterinary Surgeons (1CPD)[21] and the Society and College of Radiographers (CPD Now)[22] both have an online portal available for their members to record continuing professional development

[19] BMUS (2014) Peer Review Audit Tool (for non-obstetric diagnostic medical ultrasound patients)
[20] https://www.rcvs.org.uk/lifelong-learning/continuing-professional-development-cpd/
[21] https://www.rcvs.org.uk/lifelong-learning/continuing-professional-development-cpd/access-1cpd/
[22] https://www.sor.org/learning/cpd/cpd-now

2.12; Transducer and equipment cleaning and disinfection

Good infection prevention and control processes are essential to safe ultrasound examinations, and it is important to follow departmental protocols but also individual manufacturer's instructions when cleaning machines – in particular, transducers and built-in ultrasound system filters.

Although infection prevention and control (IPC) is everyone's job, it is often included as part of a vet nurse role.

Ultrasound equipment providers should be able to supply their customers with a list of safe cleaning materials which will protect both the patients and their equipment. This information is often available on-line for each ultrasound system make and model.

The common practice of using alcohol spirit as a routine ultrasound coupling fluid can cause irreparable damage to the delicate rubberised probe surfaces and may render associated equipment warranties invalid. Repeated use of alcohol spirit on an unprotected transducer can lead to the rubber/plastic surface membrane perishing and potential electrical safety issues.

Cleaning and disinfection processes will be different for different procedures, so it is essential that staff understand their role in infection prevention and control. It can be useful to have cleaning checklists as an 'aide memoire' sited adjacent to the ultrasound machine and indeed, a room specific, written 'cleaning log' (which includes patient ID) completed – this can be particularly useful when invasive procedures are performed under ultrasound control in the event a patient acquires an infection, and an event review is necessary.

Having a cleaning schedule which reminds everyone what should be done after each patient, daily, weekly, and monthly is a good idea.

In emergency situations, where the clipping of fur will cause unnecessary delays to treatment, an ultrasound probe cover or gel-filled clinical glove can be used to protect the transducer from any potential damage (and body fluids), should the fur need to be parted and alcohol applied to obtain good probe-skin contact and a diagnostic image.

Hand hygiene (soap and water or alcohol gel) and the use of appropriate personal protective equipment (PPE) should be demonstrated before and after any patient contact.
The examination table on which the patient lies during the scan should be protected prior to the patient arrival and cleaned immediately after and in accordance with the departmental requirements.

The British Medical Ultrasound Society also has the following advice in its latest edition of the Guidelines for Professional Ultrasound Practice (Section 2.5);

'*All ultrasound transducer probes should be cleaned immediately after a scan to remove all organic residues and body fluids. This involves removal of the used probe cover (if used), wiping off the gel followed by thorough cleaning with probe compatible cleaning agents as per probe manufacturer's instructions.*

Ultrasound probes should then undergo appropriate disinfection or sterilisation. All critical probes (probes contacting sterile tissues or blood) should be preferably sterilised, but if sterilisation is not possible, they should be minimally high level disinfected and used with a sterile sheath/probe cover. All semi-critical probes (both semi-invasive probes contacting mucous membranes and non-invasive probes contacting non-intact/broken skin) should be high level disinfected either manually or with automated systems. High level disinfection is still required when using a probe cover/sheath as these can have micro-perforations or can break. All non-critical probes contacting only intact skin may be low level disinfected.

Only probe manufacturer recommended, and probe compatible disinfection products should be used to avoid any damage to the probe. After reprocessing the probes should be stored to prevent recontamination'

2.13; Equipment quality control and quality assurance

When an ultrasound machine is first installed, it is important that a clinical applications specialist from the relevant ultrasound company works with an experienced ultrasound practitioner to ensure that 'pre-sets' based on the expected case mix are created and saved. These base line pre-sets can then be adapted for each patient to maximise diagnostic potential.

It is also important to ensure ongoing preventative maintenance cover when buying a machine and this should be carried out annually, as part of regular quality assurance (QA) testing

Ultrasound equipment is delicate, and the probes are very easily damaged if not looked after. Probes should always be cleaned after use and stored in the probe holders. Cables must not be allowed to trail on the floor or twisted and when an examination is completed, they should be put away, either on the ultrasound cart or in the box in which they are stored.

As mentioned in section 2.12, the routine use of alcohol as a coupling solution is not recommended, although it may be used initially to degrease the skin prior to the application of water-soluble ultrasound gel. Alcohol may be required as a coupling fluid for sterile interventional procedures and critical care patients but only when a suitable probe cover has been applied.

Alcohol solutions as coupling agents are flammable and electrical conductors and should be avoided for cases where defibrillation might be necessary.

Repetitive use of alcohol at the point of patient-probe contact has been known to cause drying or cracking of the delicate rubberised transducer surface and lead to irreparable damage and compromised electrical safety and regular inappropriate use may render any manufacturer warranty null and void.

It is important that all users appreciate the importance of their own involvement in caring for and maintaining equipment and in reporting any perceived issues with image quality etc.
It is good practice for departments to have a formalised method of reporting any issues so that both colleagues and engineers understand when and how often a problem has arisen.

Section 3; The Ultrasound Examination

This section includes examination-specific guidelines and common clinical scenarios. They have been compiled by diagnostic sonographers proficient at undertaking small animal veterinary abdominal ultrasound examinations, veterinary specialists (veterinary specialist diagnostic imagers) with a specific interest in ultrasound, along with BMUS representatives.
Guidelines or links to information on the vetting and justifying of ultrasound requests, reporting and audit are also included.

These Guidelines are not prescriptive but aim to support the standardisation of clinical ultrasound practice and help create and benchmark best practice principles.
The Guidelines do not and cannot cover all elements of an ultrasound examination.

3.1; Vetting of ultrasound requests

Introduction
An ultrasound practitioner may receive requests from many different sources including internal and external referring vets.

Providers should make clear within their local requesting protocols who may request an ultrasound examination. In the main, this will be restricted to a fully qualified and appropriately registered veterinary clinician.

A fully completed ultrasound request in either paper or electronic format will normally be required for every examination undertaken.

Ultrasound scans may be performed by different staff groups, in a variety of locations and clinical settings, both in and out of normal working hours. It is essential that ultrasound service providers consider the scheduling of appointments to ensure that the *right scan is performed in the right place, by the right person and at the right time* and that other requisite staff such as anaesthetists and/or veterinary nurses are also available.

Aim of vetting ultrasound requests:

- To ensure that ultrasound scans are justified, there is sufficient clinical information and that the correct scan has been arranged with the correct patient preparation.
- To ensure that clinically urgent requests are undertaken in a timely and prioritised manner.
- To ensure that the scans are undertaken by the right person, in the right place and at the right time.
- To ensure that the referral is competed correctly with patient and client demographics to ensure compliance with individual practice / organisation policies.

Attempts should be made to review any previous imaging of the patient and whenever this is not possible (previous imaging performed at a different practice/clinic for example), document in the ultrasound report the reason for this as this may contribute towards the overall clinical significance of any subsequent ultrasound findings.

Where there are numerous patients in an ultrasound session, for example in a veterinary specialist centre, there must be a process of allowing for changes to the list in the event of an extra emergency scan. Rigid adherence to an appointment system is not in keeping with the ‘right scan at the right time’ philosophy.

3.2; Justification of ultrasound requests

Principles

Although ultrasound is an excellent imaging modality for a wide range of abdominal diseases, it is not an appropriate first line test for some e.g., suspected occult malignancy and as such, a request should be justified by the referring clinician.

Requests for imaging must:

- include the clinical question(s) to which the referrer is seeking an answer
- contain any findings from the clinical history, physical examination, and relevant laboratory investigations to support the suspected diagnosis(es).
- state any suspected diagnoses
- not use general terms such as “pain, query cause” or “query pathology”

Where the referral does not include sufficient information to justify the request, clarification should be sought from the referrer. There should be a process of monitoring returned requests to ensure that the examination is not delayed unduly, and the referral is not ‘lost in the system’.

There may be occasions where an ultrasound scan is not the most appropriate examination based on the clinical or laboratory findings and in these cases, both the referrer and/or the client should be advised; an example of this might be when the body conformation or patient condition renders the patient not suitable for ultrasound and CT would be a more suitable method of imaging.

3.3; Overview of ultrasound examination procedures

The ultrasound practitioner should be aware of locally agreed standards of practice and current guidelines of other professional bodies and organisations.
The following points should be considered for all ultrasound examinations:

- The patient is correctly identified by name of patient (pet name), pet-owner/client’s surname and the practice/hospital unique patient identification number.
- The role of the ultrasound examination is understood in the clinical context for the patient and the correct examination has been requested with sufficient clinical details.
- Case notes and results of any previous investigations are reviewed prior to examination (assuming they can be accessed).
- The client is aware of the limitations and potential risks of the procedure.
- The possible need to extend the ultrasound examination, and/or proceed to additional ultrasound-guided or other appropriate imaging techniques, is included in the consent process.
- The client is aware of which member of staff (and their designation) will be undertaking the procedure (this may not always be possible, but the consent process should include an element of explanation so that the client is not misled into believing that the person obtaining consent will be the person performing the scan).
- Valid, informed consent is obtained from the client and documented (per practice protocols).
- The patient is suitably prepared for the examination prior to the scan e.g., clipped, sedated etc.

- A systematic scanning approach is used, including extra modifications if required.
- Representative images are kept and archived in the patient record.
- The required aftercare of the patient is available.
- An appropriate report is written including ultrasound appearances, differential diagnoses if appropriate and the actions in the event that the examination is incomplete.
- Appropriate national and local health and safety regulations including infection control are applied.

3.4; Recommendations for producing an ultrasound report

Whilst there are no veterinary ultrasound report writing guidelines, a great deal has been documented in the world of human medicine and the documents listed are relevant in any diagnostic ultrasound scenario.

To minimise the possibility of error in producing a report for the wrong patient, it is essential that the report author cross-checks the unique patient identification with the date and type of ultrasound examination performed prior to reporting any given ultrasound case.

When considering ultrasound report writing, the following documents are useful to consider:

- RCR/SCoR (2014) "*Standards for the provision of an ultrasound service*" section 5
- The Royal College of Radiologists (2015) "position statement on recording the identity of healthcare professionals who report ultrasound examinations"[23]
- BMUS (2017) "reporting of ultrasound imaging. BMUS position statement" \

3.4.1; General comments

In the UK and many other countries, neither sonographers nor veterinary nurses are permitted to 'diagnose' conditions or pathology by ultrasound. The diagnosis can only be made by a veterinary clinician/veterinarian

An example of a report 'template' is included in appendix 2

- The ultrasound report should be written and issued by the ultrasound practitioner undertaking the ultrasound scan and viewed as an integral part of the whole clinical examination. The report author should be aware of his/her limitations and consequently seek advice of colleagues when necessary.
- The report should be written as soon as possible after the examination has been completed.
- The name and status of the ultrasound practitioner should be recorded on the report. Where applicable it is good practice to include the statutory regulatory body and registration number of report author.
- The report author should take responsibility for the accuracy of the report, ensure that it is communicated to the appropriate personnel and archived in the patient record as per departmental/practice protocol.

[23] https://www.rcr.ac.uk/posts/position-statement-recording-identity-healthcare-professionals-who-report-imaging

- The report author should be aware at all times of the implications of the contents of the report to the patient and act in accordance with any agreed local guidelines, policies, and procedures.

The essential steps for production of an ultrasound report listed below, are in essence, taken and adapted from RCR (2018) "Standards for interpretation and reporting of imaging investigations". Although the RCR guidelines relate to human medicine, the basic premise is the same and as such cross seamlessly into animal medicine.

1. **Understanding clinical information**

   Sufficient clinical information should be provided (either in the patient notes or in the formal referral) by the referring veterinary practitioner. The ultrasound practitioner must understand the referring clinician's information, request, and aim of the scan so that they are able to write a clinically useful and relevant report. The diagnostic importance of the report in the clinical management of the patient should be understood.

2. **Technical knowledge**

   Ultrasound is an operator-dependent technique, and the diagnostic quality of the images is very dependent upon the skills of the operator. The ultrasound practitioner must be able to reflect critically upon the image quality and appraise the impact on diagnostic accuracy. Where images are sub-optimal (e.g., dyspnoeic patient, increased patient adiposity, deep-chested conformation of a patient etc), the ultrasound practitioner should decide/discuss with the referrer (or more senior imaging staff if this is an option) whether the patient requires a recall, repeat scan or alternative form of imaging. It is recommended that any technical limitations of a scan are clearly recorded in the report.

3. **Observation**

   Observations may be sub-classified as:
   - normal findings.
   - abnormal findings: expected or unexpected.
   - equivocal findings: may be normal or abnormal.
   - normal variants.

TOP TIP: It is recommended that a systematic approach to image scrutiny be used for both live and post-scan analysis to ensure that the **L**ocation, **E**chotexture, **M**easurements, **O**utline, **N**umber and **S**ize of any findings are considered (Acronym **LEMONS**).

4. **Analysis**

   Detailed critical analysis of the images should be undertaken, recognising when an appearance deviates from 'normal' and commenting upon this.
   Examples:
   are the findings abnormal and do they directly relate to the clinical question or are they considered incidental findings?
   are the appearances simply normal age-related changes?

5. **Medical interpretation**

The Royal College of Radiologists (2018) states that "a clinically relevant opinion encompasses all the known factors about the patient, as well as the imaging findings".
Veterinarians issuing reports will have an extensive veterinary knowledge enabling them to reach a diagnosis or a series of ranked differential diagnoses on which clinical decisions can be made. Vet nurses/technicians/operators/ultrasound practitioners are not permitted to formulate diagnoses in their report because they do not have the wider knowledge that a veterinarian has.

Whosoever performs and subsequently reports on the ultrasound scan it is essential that there are governance procedures in place to ensure that the individual possesses the requisite knowledge, skills, and competence to do so without detriment to the patient outcome.

6. **Advice**

Report templates (see appendix 2) should incorporate a free text component where conversations/comments at the time of the scan and between whom can be documented.

7. **Communication with the referrer**

For vet nurses/techs/ultrasound practitioners, it is likely that the referring vet will be on site and communication of findings will be immediate.

In the case of specialist referral hospitals, there needs to be an effective mechanism in place to ensure timely, secure dissemination of the ultrasound report between the hospital clinician and the referring vet and/or client. RCR (2016) "Standards for the communication of radiological reports and fail-safe alert mechanisms"[24]

Ideally a report should be issued in line with Royal College of Radiologists' recommendations (RCR 2016; RCR 2018[25]) and should provide information which relates to the original clinical question, including expected and unexpected findings and likely clinical relevance.

8. **Taking appropriate action**

The report author has a duty of care to the patient to ensure that when immediate or urgent action is required that this information is delivered to the referring veterinarian promptly. Any such urgent communication(s) should be recorded in the report. (RCR 2016)

9. **Communication with the pet owner / client**

Report authors should remember that pet owners/client can request a copy of the ultrasound report from the patient care record so should ensure that the report is correct and does not include any irrelevant information.
Where a non-veterinarian performs the ultrasound scan, it is usually outside their remit to discuss the findings with a client directly.

3.4.2; Report content

[24] https://www.rcr.ac.uk/publication/standards-communication-radiological-reports-and-fail-safe-alert-notification
[25] https://www.rcr.ac.uk/publication/standards-interpretation-and-reporting-imaging-investigations-second-edition

It is recommended that an ultrasound report be divided into the following sections:

- **Type of examination requested and performed (completed by the referring vet)**

  The type of ultrasound examination performed should be stated at the top of the report to ensure there is a true record.
  Examples may be:

  - *Focal Ultrasound Assessment of the Urinary Tract*
  - *Abdominal Ultrasound Survey*

- **Summary of clinical details**

  It is often helpful to record an overview of key clinical history and findings at the start of the report. This will assist in setting the report in its true clinical context.
  In cases where the clinical question on the referral is ambiguous, clarification should be sought from the referring vet.

- **Descriptive element**

  It can be helpful to include a description of the observations and findings to include analysis of the **L**ocation, **E**chotexture, **M**easurements, **O**utline, **N**umber and **S**hape (**LEMONS**)of the structures examined.
  For example:

  "A well-defined mass measuring 52 x 46 x 36mm and which is predominantly hyperechoic with internal mixed echoes is present within the head of spleen. The lesion is hyper-vascular on Doppler application''.

  Any difficulties encountered during the scan must be noted, together with their impact on diagnostic accuracy.
  For example:

  "Only limited intercostal views of the liver obtained due to deep-chested conformation of the patient. However, where seen, the liver appears to be regular in size and normal in echotexture".

- **Conclusion**

  The standard use of a conclusion is good practice and should include an interpretation of the observed examination findings whenever possible and in line with The Veterinary Surgeons Act 1966 (used in the UK – other countries will have their own requirements). It is important to appreciate that ultrasound appearances are often non-specific and as such, a definitive diagnosis cannot and should not be made based on ultrasound alone.

- **Recommendations for further investigations / management**

  Include any recommendations for relevant further investigation (e.g. blood tests, radiography, CT, MRI, drainage, FNA etc) dependent upon level of clinical specialist training/ experience, local department guidelines, available resources and individual scope of practice.

- **Identification of the author and contributors**

  The name, position, profession, and qualifications of the person performing and interpreting the ultrasound examination should be documented, along with the name of anyone from whom advice or support has been sought. It is good practice to state the report author's post-nominal

qualifications and for non-veterinary qualified ultrasound practitioners their statutory professional registration number. The specific action or advice of any secondary veterinary diagnostic imaging specialist involvement should also be documented.
e.g., 'Images *and report reviewed by ****** insert name (e.g., ECVDI Specialist) and agrees with the above interpretation" or* 'Images *and report reviewed by ****** insert name (e.g., ECVDI Specialist) and CT scan with a view to core biopsy is advised"*

- **Identification of trainees**

  Details of any trainees undertaking the scan and the name of the person supervising the training

- **Other staff present**

  The name and professional capacity of any staff directly caring for the patient during the examination should be documented

- **Consent**

  The person obtaining consent for fine needle aspiration (FNA) or ultrasound-guided intervention gained from the client prior to the procedure should document this in the patient file. Evidence of any ultrasound-related intervention which occurred during the scan episode should be documented on the ultrasound report, along with the name and designation of those undertaking the interventional procedure and whether any complications occurred immediately after.

- **Additional Relevant Information**

  Any further information which may affect current or future investigations should be included. For instance, "care taken when handling patient due to known arthritis"

3.4.3; Report style

1. Reports should be clear unambiguous and written in plain language. The use of abbreviations is not recommended to avoid confusion.
2. Use of a standard reporting template is recommended to help support consistency and a systematic reporting method.
3. Report conclusions should be written in plain language.
4. Reports should address the clinical question (along with any other findings) to enable the veterinarian to formulate their diagnosis, particularly if the examination has been extended based on findings.
5. Any limitations or difficulties which affect the quality and integrity of the examination should be stated and if an organ or structure has not been fully examined/assessed, the reason(s) should be indicated.

For example:

   a. *"The left limb of the pancreas is obscured by bowel gas and sub-optimal views obtained. No obvious large peri-pancreatic mass evident."*
   b. *"The stomach is moderately gas filled/ empty and contracted at time of scan, therefore sub-optimal visualisation of the dorsal gastric wall".*

6. Diagrams may be useful in describing the findings to the referring clinician (examples: suspected portosystemic shunt pathways, foreign body localisation) - a standard diagrammatic template may be helpful as an adjunct to the written report.
7. Any actions recommended or actioned should be documented in the report.

For example:

   a. *"Complex appearances of the gallbladder are most likely to represent a gallbladder mucocoele. Considering the moderate volume of peri-cholecystic free abdominal fluid and full clinical picture, specialist soft-tissue surgical referral is advised."*
   b. *In view of the findings, case discussed with ******, Diagnostic Imaging Specialist at ******* referral centre and the veterinary practice manager".*

8. If second opinions or advice have been sought and given, or if other personnel have scanned the patient, their status, actions, and opinions should be stated.

For example:

   a. *"Case discussed with ****** insert name, who agreed with findings and report."*
   b. *"Patient also scanned by ******* insert name, who agrees with the findings and report".*

In conclusion, a good report is a report that answers the clinical question. Good reporting avoids confusion, clearly identifies the findings, and gives a correct interpretation in a clear and unambiguous format.

Ultimately, good reporting equates to good communication skills and, in the clinical context, will avoid error and potential harm to the patient.

See appendix 2: Example of an abdominal ultrasound report template for editing

Section 4.0; Abdominal ultrasound examinations

4.1; General principles

It is recommended by the authors of this document that a thorough, systematic ultrasound assessment of the abdominal organs and structures as listed in the abdominal ultrasound report template (appendix 3) is undertaken for all routine abdominal ultrasound requests. This will provide the ultrasound practitioners with a more comprehensive appreciation of ultrasound findings and associated clinical significance than if conducting a focal or target scan (when significant pathology elsewhere could be missed).

In certain situations, for example in an emergency or when determining response to treatment or when comparison views are required, a targeted approach to scanning a body system or organ/structure is appropriate particularly when a full abdominal survey has been undertaken previously.

If targeted ultrasound has been performed, this should be documented within the report and the structures which have been examined be clear.

Where possible, previous imaging and reports should be reviewed, prior to any ultrasound scan (document in the ultrasound report if they are unavailable).

All abdominal organs and structures should be examined in two planes i.e., longitudinal (long axis) section (LS) and transverse (short axis) section (TS), with additional views as required, for example where pathology is demonstrated. Given that organs are 3 dimensional and without access to specialist 3D ultrasound equipment, it is the responsibility of person performing the scan to ensure that the organ or structure is assessed in its entirety (sagittal, dorsal and transverse planes).

Representative images of normality and any pathology are stored as the dynamic assessment progresses, and these should reflect the report content and vice versa.

The abdominal ultrasound examination is a clinical examination and any tenderness or guarding noted during the scan should be considered as a potential indicator for underlying abnormality and, if present should be stated in the report. If possible, try to determine if the pain/tenderness is organ-specific or diffuse. The absence of tenderness should also be documented e.g., when focal disease such as pancreatitis is clinically suspected (If the patient is anaesthetised, there may not be any guarding or response to pressure0

During the examination the ultrasound operator should demonstrate:

- normal anatomy/variants of abdominal organs and structures in at least two planes. This should include assessment of size, outline, and ultrasound characteristics
- relative echogenicity of abdominal organs
- pathological findings including focal and diffuse processes and associated haemodynamic findings (pre- and post-operative assessments)
- the presence of any intra-abdominal fluid, focal fluid collections, peritoneal or retroperitoneal fat or masses
- where clinically relevant: vascular anatomy including position, course, and lumen of relevant vessels (haemodynamic observations including the presence/absence of flow, its direction, velocity, and Doppler waveform).

Most transducers are ‘multifrequency’ and if only one probe is available, the ultrasound practitioner should always choose the highest frequency which provides the required depth of beam penetration. How this is done depends on the equipment but on many modern machines, there may just be ‘Gen’ (general - i.e., middle of the range of frequencies available), ‘Res’ (resolution – highest frequency in the range) or Pen (penetration - lowest of the range of frequencies) available.

As a rule, the smaller the patient, the higher the frequency used but never be afraid of trying different probes if they are available. Take care when using linear transducers as whilst these are generally higher frequency, they often have a larger footprint and that makes it easier to lose contact with the patient skin surface preventing visualisation of the peripheral structures on the image.

For large and/or obese patients, it may be that CT, if available, is the better choice as even with the lowest frequency transducers the practitioner may not be able to see deep enough into the patient (particularly in deep chested dogs). It is also important to consider the fact that the operator/practitioner is at increased risk of developing a work related musculo-skeletal disorder when scanning larger patients because of the need to apply greater pressure with the transducer.

4.2; Patient preparation

It is advisable that the patient fasts for ideally a minimum of 8 hours prior to an abdominal ultrasound examination (except for water to drink) to facilitate a thorough examination of the gastrointestinal and biliary structures. Fasting will help to reduce the visual interference of gastric contents and gas and the gallbladder is more likely to be visualized if it is in a non-contracted state.

It is generally accepted that the ventral aspect of the patient's abdominal fur is clipped using a fine clipper blade to expose a scan area. This scan area would normally extend from a couple of rib spaces cranial to the costal arch and towards the inguinal borders caudally across both sides of the abdomen. The purpose of the clip is to remove air from within the fur, preventing sound transmission and provide a smooth probe to skin contact surface for probe manoeuvre once acoustic gel has been applied. Loss of probe contact will compromise image quality and diagnostic potential. Patients with short or fine hair may not require clipping providing that the hair can be sufficiently moistened with ultrasound coupling gel to expel any trapped air.

When dealing with critically ill patients, there may be insufficient time to clip fur so in those cases, we recommend parting the fur at the designated scan sites prior to applying coupling fluid/gel. Aside from the need to protect the probe surface, application of a probe cover is advised, from an infection control perspective, as contamination by body fluid is often a possibility.

4.3; Patient scan position

Small animals undergoing abdominal ultrasound examinations can be scanned in a variety of positions dependent on their clinical presentation and the preference of the ultrasound practitioner. Whilst there is no right or wrong position, the ability of the ultrasound practitioner to navigate the abdomen and undertake a thorough assessment of the structures depends not only on their own competence but on the position, clinical condition, and body habitus of the patient. The ability of the operator to adapt their technique will increase the likelihood of a comprehensive scan being performed. The authors prefer to use the right recumbency position with the knowledge that patient position can be altered if/when necessary.

Altering the patient position, graded compression and ballottement are all techniques which can be utilised when difficulties arise, and visualisation is impaired or, when there is the suspicion of ultrasound artefacts mimicking pathology. Certain disorders of the peritoneal space will require repositioning of the patient to confirm or support a diagnosis, such as free air or free abdominal fluid which are gravity dependent.

On occasion it may be necessary to perform an abdominal ultrasound examination with a patient in the sternal position for example if the patient requires a focal scan for intervention. If breathing difficulties

require this adapted approach, it will pose a challenge in accessing the full range of abdominal structures and this should be acknowledged within the report.

It is important to appreciate the presence of any underlying conditions or injuries when positioning a patient, adapting the systematic approach to the abdominal survey accordingly.

4.4; Ultrasound examination of the liver

The liver is a large organ and complete examination in either the right lateral or dorsal recumbency may require right lateral, subcostal, and intercostal probe access, supplemented by repeating views in the left lateral dependency if necessary to cover the entire organ.

Longitudinal and short axis views of the liver should be obtained using a thorough, systematic, and comprehensive approach to ensure that the lobes, sub lobes and processes are all assessed.

When imaging the liver, it is important to appreciate and document the subjective impression of liver size, the reflectivity, parenchymal echotexture, and surface regularity.

TOP TIP: Take care not to confuse cranial splenic parenchymal tissue in deep-chested dogs or large quantities of falciform fat with liver parenchyma

Size
Use of formal liver measurements is difficult considering the variety of sizes between different species, breeds, and conformations. The right lobe of liver is normally in contact with the cranial pole of the right kidney and should. Early/mild enlargement can sometimes be identified by the blunting of the free caudal edge of the liver lobes and as enlargement of the organ progresses, an experienced operator will detect increased caudal extension of the liver, both clinically and on ultrasound.

Echotexture
In general, normal liver is minimally hyperechoic or isoechoic compared to the normal renal cortex, but should be hypoechoic to the splenic parenchyma. Where abnormality is suspected, or diffuse liver disease is the clinical indication for the scan, then an additional split screen comparison image of liver/kidney and spleen/ kidney should be taken to assist in the evaluation of normality of the hepatic parenchyma.

Liver surface
Subtle alterations in liver surface may be confirmed if the liver capsule can be demonstrated to be irregular rather than smooth. When capsular irregularity is suspected, it may be necessary to use an intercostal scan approach to help confirm this, either using a high frequency linear probe or a medium frequency microconvex probe with the depth decreased sufficiently to enhance the near field liver. Careful evaluation of the hepatic veins may also show irregularity or displacement relating to hepatic nodularity.

Liver vessels and blood flow
Images should routinely include the hepatic veins draining into the caudal vena cava (CdVC) and the portal vein at the liver hilum. Intrahepatic portal veins carry blood to the liver from the extrahepatic portal vein, formed by the gastroduodenal, splenic, and mesenteric veins and have hyperechoic vessel walls regardless of the main beam orientation. The venous return of the liver is via the hepatic veins, which are formed of thin-walled branches which drain into the CdVC.

If the liver texture is diffusely abnormal, or if the referral mentions portal hypertension, a portosystemic shunt or chronic hepatitis then Doppler studies of the portal venous flow at the level of the extra-hepatic main portal vein should be obtained. Record the peak velocity and the direction of flow in the portal vein (PV). Normal flow within the PV should be monophasic and hepatopetal (towards the liver), and pulsed wave Doppler pattern will show gentle trace undulations due to diaphragmatic motion with patient breathing. Normal range of peak velocity in the main PV is 10 – 25 cm/s in the fasted patient.
The PV/Ao ratio can be obtained near the hilus of the liver where a porto-systemic shunt is suspected[26]

Doppler spectral waveform (pulsed wave) patterns of the CdVC and the hepatic veins are more complex; the waveform is triphasic (due mainly to right atrial activity) and is influenced by respiration, cardiac function, and intra-abdominal pressures.

Highly pulsatile waveforms in either or both the portal vein or selected hepatic vein may be indicative of congestive cardiac failure and this should be considered when reporting.

High velocity / turbulent flow within hepatic or portal veins may be indicative of portosystemic shunts (intra or extra-hepatic portosystemic shunts). When a shunt is suspected, an in-depth assessment of the portal and hepatic vasculature, subjective liver and renal size, and identification of any mineralisation within the urinary tract should be commented upon.

Representative images of the liver to show:

- *The liver parenchyma from right to left borders and caudal and cranial borders*
- *the hepatic confluence draining into the CdVC*
- *the main portal vein at the porta hepatis*
- *the diaphragm to evidence that the most cranial aspect of the liver has been assessed*
- *Any abnormality and associated measurements e.g., the size of any mass, variation from expected normal measurement range etc*
- Hepatic lymph nodes with and without thickness measurement if visible

4.5; Ultrasound examination of the diaphragm

The diaphragm lies cranial to the spleen, right and left liver lobes and caudal to the lung interface. It is a hyperechoic curved structure when scanned in both the longitudinal and short axis planes. The mirror ultrasound artefact is commonly associated with the diaphragm; it is therefore important to appreciate the artefactual appearance of liver parenchyma cranial to the diaphragmatic dome when scanning this region in a patient with normal lungs. If artefactual liver parenchyma is not seen cranial to the diaphragm can be suggestive of pleural or pulmonary pathology.

When assessing the diaphragmatic region, it may be necessary to apply cranial pressure, particularly in deep-chested dogs, to visualise the sub and supra-diaphragmatic structures adequately. This pressure may be well-tolerated in sedated or anaesthetised patients, but can be uncomfortable in conscious patients, especially those with underlying pathology. It may also be necessary to employ an intercostal scan approach to view the diaphragm if it cannot be assessed in its entirety using the sub costal approach

When scanning the liver and spleen, the diaphragm should be included on representative images archived to demonstrate that the most cranial aspect of these structures has been examined and that there is no supra or sub-diaphragmatic pathology evident.

[26] Ultrasonographic diagnosis of portosystemic shunting in dogs and cats Marc-André d'Anjou 1, Dominique Penninck, Lilian Cornejo, Philippe Pibarot

Representative images of the diaphragm to show:

- *longitudinal and short axis views of the right and left hemi-diaphragm with liver and spleen respectively when possible*
- *Any abnormality and associated measurements e.g., the size of any mass, pleural effusion etc*

4.6; Ultrasound examination of the gallbladder and biliary tree

The gallbladder

The gallbladder is normally situated ventral to the right lobe of the liver, between the quadrate and right medial lobes and falls towards the ventro-lateral margin of the abdomen when the patient is in the right lateral recumbency position. Its size and shape vary. The gallbladder neck usually sits in the gallbladder fossa and the fundus is frequently mobile, dependent upon patient position.

The gallbladder should be scanned following a period of fasting to aid distension (water is permissible) longitudinal and short axis planes whenever possible. Whenever there is difficulty in visualising the gallbladder neck and the cystic duct, more than one scan approach and/or patient position may be necessary to ensure the entire structure can be assessed.

The shape and measurements of the gallbladder vary enormously. The gallbladder is normally pear-shaped when optimally dilated, with a narrow neck, widening towards the fundus. A very rounded shape can imply tense dilatation. Some gallbladders may be folded and a bilobed gallbladder is a normal variant in cats. The variation in gallbladder shapes can conceal small choleliths so care must be taken to examine it in its entirety.

The gallbladder wall should be thin (no more than 1 mm in both the canine and feline patient), smooth and well-defined. Measurements of wall thickness should ideally be taken in the ventro-dorsal (VD) direction on a longitudinal section of the gallbladder for standardisation, with the wall perpendicular to the main beam axis to reduce artefact due to beam thickness.

The gallbladder neck wall is slightly thicker than the wall of the body and fundus in a normal organ. Frequently the neck describes a 'J' or reversed J shape, and attention should be paid to this area to exclude pathology such as trapped choleliths which can lead to biliary obstruction. The bile contained within the gallbladder should be anechoic, however a small amount of hyperechoic, layered, mobile sludge present within the dependent aspect of the gallbladder can be considered a normal incidental finding in asymptomatic dogs.
Attention to equipment settings is important to remove reverberation artefacts which may mimic intra-luminal gallbladder contents and when demonstrating the presence of tiny choleliths, as posterior enhancement from the bile within the GB may obscure shadowing from small stones if incorrectly set

TOP TIP: Increasing the frequency or using a higher frequency probe is useful when the gall bladder is located superficially i.e., just beneath the abdominal wall.

Representative images of the gallbladder to show:

- *longitudinal and short axis views of the gallbladder and its contents*
- *Gallbladder wall thickness (VD diameter) in longitudinal plane*
- *Gallbladder neck*
- *Cystic duct with maximum VD intra-luminal diameter and wall thickness if visible*
- *Any abnormality and associated measurements e.g., the size of any mass, variation from expected normal measurement range*

The biliary tree

Bile is produced by the liver and stored in the gallbladder. The bile passes down the hepatic ducts and into the cystic duct, which in turn empties into the gallbladder. The common duct is a distal continuation of the cystic duct and normally lies ventral to the portal vein. The common duct is best imaged where it lies ventral to the main portal vein with the ultrasound beam perpendicular to the duct (adjusting the angle of the probe may be necessary to achieve this) and using the liver as an acoustic window. When the patient is scanned in the right lateral recumbency position, an 'underside' scan approach to the portal region is often necessary to obtain clear views of the bile ducts. It is good practice to attempt to trace the cystic duct at the gallbladder neck, following the common duct to the level of the duodenal papilla; this is especially important when biliary duct dilatation is evident to determine the cause and level of biliary obstruction. Duodenal gas obscuring visualisation of the duct can sometimes be overcome by altering patient position and/or displacing the intra-luminal gas with gentle graded pressure from the transducer.

The common duct opens into the duodenum at the major duodenal papilla. In dogs, the common duct opens directly into the duodenum and separately from the main pancreatic duct, whereas in cats, the pancreatic duct and common duct are fused prior to entering the duodenum. The site of duodenal papilla is also more aboral to the pylorus in dogs than in cats.

The authors take measurement of the ducts from inner-lumen wall to inner-lumen wall in the maximum ventro-dorsal (VD) diameter, but some recommend outer to outer wall; whichever method you use, it is important that everyone in your department uses the same measurement and that when deciding if it is within normal limits, the correct references are used. For the most accurate results the cystic duct should be measured as it exits the gallbladder neck and the common duct at the level of the main portal vein. Once the duct measurement has been taken, the clinical context of this value should be considered with reference to previous history, including previous cholecystectomy, and liver function tests.

The normal common duct has a variable diameter. The upper limit of normal inner calibre is generally accepted at 3 mm in dogs and 4 mm in cats.

TOP TIP: Whenever the biliary ducts are tortuous and/or dilated, it may be easier to trace the ducts in short axis rather than long axis to assess for site of obstruction / any filling defects.

It is important to note that a normal bile duct measurement does not necessarily exclude biliary obstruction, as this can occur with a non-dilated duct, particularly if diffuse liver disease prevents dilatation of the duct or if the patient has cholestatic disease.

Bile duct wall thickening is an abnormal sign, even in the absence of dilatation, and may be associated with cholangitis or cholestatic disease.

It is difficult to demonstrate normal intrahepatic bile ducts past the first order of duct (right and left hepatic ducts) but they can be visualised in some juvenile and some fasted patients with good image

resolution, however visualisation of the intrahepatic ducts is usually a sign of biliary disease and distension. Comparison should be made with the accompanying veins. In healthy patients, the bile duct should be narrower than the parallel portal vein.

Where there is evidence of intrahepatic, common duct and cystic duct dilatation, attempts should be made to establish the site and cause of obstruction by tracing the ductal system along its length to the point of obstruction. ***Representative images of the common duct to show:***

- *Intra-luminal VD diameter measurement of the common duct at the level of the main portal vein*
- *Intra-luminal VD diameter measurement of the common duct at the level of the duodenal papilla if dilated*
- *Any abnormality and associated measurements e.g., the size of any mass, variation form expected normal measurement range etc'*

4.7; Ultrasound examination of the pancreas

Ultrasound has a significant false negative rate for detecting serious pancreatic disease and the presence of a normal pancreas does not exclude pathology

Obtaining good images of the pancreas is often a challenge when imaging with ultrasound, partly due to gas in the adjacent gastrointestinal tract obscuring the gland, the intrinsic isoechoic nature of the normal pancreas compared to surrounding mesentery and the less well-defined 'capsular' outline of the gland itself.

The pancreas is an elongated, relatively thin structure comprised of:

- the left limb – which lies adjacent to the greater curvature of the stomach, across the patient midline and may extend to the left kidney
- the body, – which is nestled in the region of the porta hepatis and adjacent to the proximal duodenum/pylorus and the pancreaticoduodenal vein
- the right limb – which lies along the mesenteric border of the descending duodenum

The main pancreatic duct can usually be identified within the left pancreatic limb. Normal diameter varies between species and literature so the departmental protocols should be referred to.

Scanning technique
Although the left lobe may be difficult to see in dogs, and the right lobe may be difficult to see in cats, an attempt should be made to examine the entire organ.
The quality of the scan will be dependent on good technique, a sound knowledge of cross-sectional anatomical landmarks and patient breed/conformation. With the patient fasted (to reduce bowel gas), employing the use of gentle graded compression, different scan approaches and altered patient position will undoubtedly increase the likelihood of clearly visualising the pancreas.
The pancreaticoduodenal vein serves as a prominent landmark in the right limb of the pancreas in dogs and the pancreatic duct serves as a similar useful anatomical landmark within the left limb of pancreas in cats.

TOP TIP: Locate the left limb of pancreas in short axis by scanning longitudinally in the patient midline (dogs). Identify the caudal aspect of the greater curvature of the stomach, the transverse / ascending colon, and the spleno-portal vein. The left limb of pancreas lies in between these three anatomical landmarks. Normal pancreas is often isoechoic to the surrounding tissue so may not be easily seen.

TOP TIP: Locate the right limb of pancreas in long axis by locating the long axis section of the right kidney with the patient in right lateral recumbency. Relax the transducer pressure and scan dorso-laterally to identify the descending duodenum running cranio-caudally. The right limb of pancreas runs parallel and medial to the descending duodenum. A right intercostal approach may be needed, particularly in deep chested dogs.

It is important to document any focal or diffuse change in pancreatic echogenicity or increase in duct calibre. The presence of parenchymal atrophy, peri-pancreatic reactive fat or lymph nodes should also be noted.

Imaging of the pancreas should document the subjective impression of pancreatic size, the parenchymal echotexture, and any surface regularity.

Echotexture
The normal pancreas is homogenous in echotexture. In dogs, it tends to be isoechoic with the surrounding mesentery, in cats from isoechoic to mildly hyperechoic to adjacent liver and mesentery.

Size
The size of the pancreas is variable dependent on the species, breed, and conformation of the patient but as a rule a normal pancreatic limb measurement should be less than 10 mm maximum VD diameter. It is important to consider the full clinical picture, the breed size and conformation, any previous history of pancreatitis etc when interpreting measurements above 10 mm, as they may still be considered within normal limits for the patient. Measurements of >20 mm VD diameter, however, should raise the suspicion of acute pancreatitis or mass lesion.
The intraluminal diameter of the pancreatic duct should be measured if dilated.

Representative images of the pancreas to show:

- *Left and right limb of pancreas in longitudinal and short axis planes*
- *Measurement of pancreas, pancreatic duct if enlarged / dilated or abnormal*
- *Any abnormality and associated measurements e.g. the size of any mass, variation from expected normal measurement range etc*
- *If the pancreas and its landmarks cannot be visualised in still images, video clips should be made.*

4.8; Ultrasound examination of the spleen

The spleen is an elongated strap-shaped structure in its long axis with a triangular cross-sectional shape. The main body and tail of the spleen are relatively superficial within the abdomen, with the splenic lie varying with conformation and patient scan position – it can lie transverse, oblique within the abdomen or more longitudinal along the left abdominal wall.

The craniodorsal aspect is known as the head of spleen and forms a ‘hook’ shape between the left kidney and the gastric fundus. The head of the spleen lies in an extreme dorsal position when compared to the body.

It is important to appreciate the extreme dorsal position of the splenic head in relation to the left lateral costal margin. By directing the main beam axis parallel to the medial side/aspect of the left rib cage or perhaps using an intercostal approach can help to thoroughly assess the splenic head.

Adapting the scan technique and slight changes of the patient position are often required to enable the multiple, overlapping sweeps of the probe to ensure the whole organ is visualised.

Echotexture

The normal splenic parenchymal echotexture is finer than that of normal hepatic parenchyma. It is homogenous and has a thin hyperechoic capsulated outline. The spleen is hyperechoic when compared to normal renal cortices and liver. The splenic veins are seen leaving the spleen at the hilar regions as thin-walled branching vessels. Splenic arteries are not usually visualised using B-mode alone. Increase in the number and calibre of splenic hilar vessels may be indicative of porto-systemic disease.

Size

The spleen is a more consistent size in cats (usually a feline spleen will measure <10 mm maximum VD diameter), whereas the size of the spleen varies considerably within dogs due to multitude of breeds and differing conformations. There can be variation in splenic size in both cats and dogs when sedated. The splenic thickness should be measured at the level of the hilus in longitudinal plane. For cats there are published normal values. Like the liver, in dogs, the splenic size must be assessed subjectively, but measurements have value for follow-up examinations, Mild enlargement may be more sensitively identified by the blunting of the free inferior edge (splenic tail). Other signs may be indentation of the urinary bladder or a large portion of the liver being present in both the right and left abdomen.

Like the liver, the splenic size must be assessed subjectively (there is huge breed variation of what is normal), and mild enlargement may be more sensitively identified by the blunting of the splenic tail. Any variation in size and position of the spleen should be considered a potential pathology and documented within the report.

The report should document the subjective impression of the size, reflectivity, parenchymal echotexture, and surface regularity of the spleen.

Careful assessment of the peri-splenic region for the presence of varicosities, isoechoic accessory spleen or lymphadenopathy must also form part of the examination.

TOP TIP: Some sedation and anaesthetic drugs can affect the size and homogeneity of the spleen secondary to splenic congestion. The spleen may have a slightly more bulbous shape and display a diffuse subtle mottled echotexture throughout the parenchyma rather than a diffuse nodular one

Representative images of the spleen to show:

- *Head, body, and tail of spleen in longitudinal and short axis planes*
- *Splenic hilar vessels*
- *Splenic hilus with measurements*
- *Any abnormality and associated measurements e.g., the size of any mass, variation from expected normal measurement range etc*
- *Video clip of representative portion of the splenic parenchyma with Doppler if indicated*

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4.9; Ultrasound examination of the aorta and caudal vena cava

When performing an abdominal ultrasound survey, it is important to appreciate the vascular anatomy of the abdomen, the adjacent lympho-centres and the relative organs and structures.
The great vessels lie in the midline region of the dorsal abdomen. They appear as anechoic tubular vessels running the length of the abdomen in longitudinal plane or as round/ ovoid anechoic structures in short axis plane.

Venous flow within the abdominal cavity is separated between the systemic circulation and the portal system. The caudal vena cava (CdVC) lies to the right of the patient midline and carries blood in a caudo-cranial direction, with only the following veins visible on ultrasound draining directly into the great vessel.

- iliac veins (external, internal, and deep circumflex converging into CdVC)
- renal veins
- phrenicoabdominal vein
- hepatic veins

The abdominal aorta lies on the left of the patient midline and more dorsal than the CdVC. It provides the arterial supply for all abdominal structures with major abdominal arterial branches being well-visualised and serving as excellent anatomical landmarks for identifying neighbouring abdominal lymph nodes.

Abdominal arteries visible on ultrasound arising from the abdominal aorta.

- coeliac artery (branching into left gastric, hepatic, and splenic arteries)
- cranial mesenteric artery
- renal arteries
- aortic trifurcation

Luminal contents, diameter, wall abnormalities and congenital malformations should be reported. Routine assessment of the CdVC and aortic vessels using pulsed wave and/or colour/power Doppler application can be helpful when determining the presence of arterial or venous thrombi or other soft tissue/neoplastic wall-to-wall vascular filling defects.

TOP TIP: Transmitted pulsations can occur in the CdVC because of the proximity of the aorta. This can sometimes cause confusion. If you are not sure which vessel is which, keep in mind that the aorta lies to the left of midline, is non-compressible and has a hyperechoic intimal layer.

Representative images to show:

- *Longitudinal and short axis views of the aorta and CdVC adjacent to one another*
- *Colour Doppler application when appropriate e.g., whenever wall-to wall vessel filling is under question due to thrombus or tumour infiltration*
- *Any abnormality and associated measurements e.g., the size of any mass, variation from expected normal measurement range etc (both as still images and video)*

Refer to appendix 3: Ultrasound characteristics of the caudal vena cava (CdVC) and the abdominal aorta.

4.10; Ultrasound examination of the adrenal glands

The adrenal glands are paired endocrine glands which lie within the retroperitoneal space medial to their respective kidneys and lateral to the CdVC and aorta.
Because of their anatomical position and relatively small size, any surrounding or overlying bowel contents can make the adrenal gland assessment technically challenging.
In both cats and dogs, the adrenal glands lie at the approximate level of the cranial renal pole / cranial mesenteric artery and these anatomical landmarks can be used to locate the glands. The phrenicoabdominal vein can be identified as an anechoic linear vessel crossing the mid-body section of the adrenal glands in both cats and dogs. This can also be used as an anatomical landmark for locating the adrenal glands. Colour/power Doppler application will confirm the presence of venous flow within the vessel and help with adrenal identification. If not visible or not examined this should be stated in the report.

In cats and small dogs, using a higher frequency linear probe to examine the adrenal glands can provide excellent image resolution of these retroperitoneal structures. By applying gentle graded probe compression when scanning a sedated animal, it is possible to bring the adrenal glands into the near field to appear more superficial. However, if the patient is not sedated, the large footprint of the transducer can cause discomfort and often is not well-tolerated by the patient.

For medium to large dogs, a lower frequency microconvex probe may well be more appropriate as the beam requires sufficient penetration because the adrenal glands are likely deeper in the abdomen.

When scanning an animal from the dependent side, take care not to apply too much probe pressure to the CdVC as this will compress and obliterate the vessel rendering its identification and that of the right adrenal gland, lying in between the CdVC and the aorta more difficult.

Echotexture
In the canine patient, the adrenal glands have either a hyperechoic medulla with a narrow, well defined hypoechoic cortical rim or a uniform hyperechoic echotexture.

In the feline patient, the normal adrenal gland has a more uniform and hypoechoic echotexture with a poorly defined peripheral cortical rim making it harder to identify and differentiate from the medulla.

Identifying changes to the adrenal echotexture, cortices and medullae may be helpful in diagnosing adrenal-related endocrine diseases, for which clinical presentation may be non-specific. It is important to appreciate that veterinary medicine research has shown that non-visualisation of cortex/medulla differentiation within adrenal glands is not associated with adrenal disease. With practice, identifying assessing and measuring the adrenal glands will become easier over time. Experience will help in the identification of small or subtle focal or diffuse changes to the glands.

Shape

- The feline adrenal glands are ovoid in shape.
- The canine left adrenal gland is bi-lobed or peanut shaped.
- The canine right adrenal gland is commonly described as an arrowhead or folded ‘V’ shape

Size
Canine adrenal glands;
Giving a definitive measurement of normal adrenal sizes is difficult, particularly in dogs because of the wide variety of sizes across breeds.

A study by T de Chalus et al 'established new upper thresholds for the left and right height at the caudal pole measured in a longitudinal plane: 7.9 mm (left) and 9.5 mm (right) for the Labrador retrievers and 5.4 mm (left) and 6.7 mm (right) for the Yorkshire terriers'[27].
Measurements in dogs are generally taken of the VD diameter at the caudal pole.

Feline adrenal glands.
The maximum VD diameter of the feline adrenal glands should measure less than 4.3 mm. Clinical correlation is always important because of the difficulty of differentiating between benign and malignant lesions using ultrasound alone. The long axis measurements of the normal feline adrenal gland ranges from 10 -11 mm with a VD diameter of 3.5-4.5 mm (Coombs et al 2012)[28].

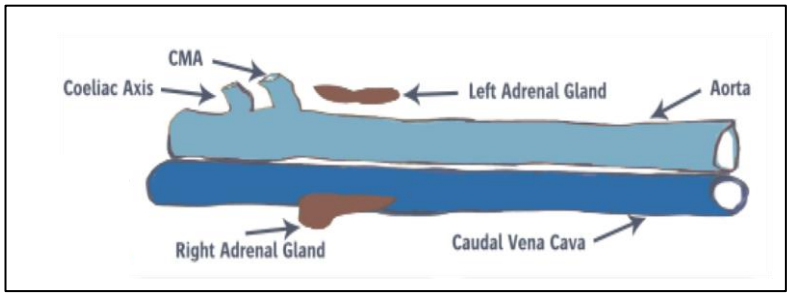
TOP TIP: Take care not to confuse ovoid feline adrenal glands with mesenteric lymph nodes, some of which may also appear ovoid in shape. Using the anatomical landmarks will help to avoid confusing the adrenal glands with bean-shaped para-aortic and mesenteric lymph nodes.

Scanning Technique
For locating the *LEFT adrenal gland* with the patient in the right lateral dorsal recumbency position.

- Scan the left flank to locate the long axis of the left kidney and sweep medially to identify the aorta, also in long axis
- Slide the probe cranially
- Identify the Cranial Mesenteric Artery (CMA) and coeliac artery arising from the ventral Aorta
- Scan laterally from the aorta towards the level of the left renal hilum
- The left adrenal gland lies in long axis, in between the aorta and left renal hilum

For locating **the *RIGHT adrenal gland* with the patient in the right lateral dorsal recumbency position.**

- Scan the right underside flank to locate the long axis of the right kidney and sweep medially to identify the aorta and CVC, also in long axis
- Slide the probe cranially
- At the level of the CMA, coeliac axis and right renal hilum, the right adrenal gland is seen in long axis, lying in between the CVC and the abdominal aorta



[27] Ultrasonographic Adrenal Gland Measurements in Healthy Yorkshire Terriers and Labrador Retrievers
T. de Chalus,A. Combes,A.-S. Bedu,P. Pey,S. Daminet,L. Duchateau,J. H. Saunders
First published: 04 June 2012
[28] Coombs A, Vandermeulen E, Duchateau L, Peremans K, Daminet S, Saunders J (2012) Ultrasonographic measurements of adrenal glands in cats with hyperthyroidism. Vet Radiol Ultrasound 53:210-216.

Representative images of the adrenal glands to show.

- *Longitudinal view of the left and right adrenal gland with caudal pole VD measurement (canine)*
- *Longitudinal view of the left and right adrenal glands with long axis and VD diameter measurements (feline)*
  Any abnormality and associated measurements, where indicated e.g., the size of any mass effect, variation from expected normal measurement range etc.

4.11; Ultrasound examination of the kidneys

As with many of the abdominal organs and structures included within a routine abdominal survey, the choice of probe for assessing kidneys will depend on the animal's size, adiposity, and body conformation.

As for all examinations use the transducer with the highest frequency for optimum resolution but for larger animals, you may well need a lower frequency to ensure depth of penetration.

If a focal scan of the renal tract alone is required, then the patient's fur should be clipped to include the ventral abdomen down to the caudal bladder region and laterally towards the hypaxial muscles along both the flanks. In some deep-chested patients, it may be necessary to extend the clip cranially to facilitate intercostal scanning of the cranial renal poles.

It is advisable and often easier to locate both kidneys in a long axis plane initially.
The left kidney is the easiest to locate, from a ventrolateral approach, whereas the right kidney can be more difficult to visualise as the normal kidney is located in a deeper, more craniodorsal position.

The use of an altered patient position and /or an intercostal scan approach may help to combat these difficulties in deep-chested animals or when bowel gas / faecal loading obscures the kidney.

Once the kidney has been located, sweep through the entire kidney in multiple para-sagittal sections from the medial to lateral aspect and beyond the renal borders. Then rotate the probe and assess in multiple short axis sections of the kidney from the very cranial to the very caudal aspect of the organ, paying attention to the hilar regions for any pelvic dilatation and/or mineralisation.

Assess the kidney for the following characteristics when undertaking the dynamic assessment:

- Subjective assessment of renal size
- Renal shape
- Capsular outline
- Echotexture (cortico-medullary differentiation and renal architecture)

Echogenicity
Appreciating the normal anatomy of the kidney will help the ultrasound operator to recognise and assess the normality of the renal architecture. The renal cortex is normally seen as a homogenous peripheral band which surrounds the medullae.

The renal cortex is hypoechoic to normal adjacent splenic parenchyma and either hypoechoic or isoechoic with normal adjacent liver parenchyma. However, it has also been reported that animals with normal renal function tests can have renal cortices which are hyperechoic when compared to the liver[29].

[29] Ivancic M, Mai W (2008) Qualitative and quantitative comparison of renal vs. hepatic ultrasonographic intensity in healthy dogs. Vet Radiol Ultrasound 49:368-373.

The accumulation of fat within the renal cortex of cats may also influence the hyperechogenicity of the renal cortex (Yeager and Anderson 1989)

The renal medulla are lobulated pyramidal segments which extend from the renal pelvis, with the outer borders running parallel to the renal cortex. Interlobar and arcuate vessels surround the renal medullae and can be detected using a colour or power Doppler functions. The normal renal medulla is hypoechoic when compared to the normal renal cortex giving the kidney its characteristic cortico-medullary differentiation. Sometimes the medullary pyramids can appear anechoic as can renal tract dilatation and care must be taken to identify the renal crest when questioning whether pyelectasis or hydronephrosis are present.

The renal hilum can usually be seen in both dogs and cats, and this is especially likely if intravenous fluid therapy has been administered. The normal renal pelvis is often easier to identify initially in the short axis plane, where the peri-pelvic sinus fat appears hyperechoic when compared to the adjacent cortex and medullae. The renal crest is seen as a pointed structure which in the presence of renal pelvic dilatation will be outlined by anechoic urine, otherwise it will lie up against normal hyperechoic sinus fat.

The anechoic mid-polar hilar vessels can also be identified clearly in a short axis plane arising from/entering the renal pelvis. Identifying the renal artery and veins using colour Doppler application will help to differentiate the between blood vessels and the presence of a dilated proximal ureter and renal pelvis as no colour flow will be seen within the latter. It is possible to visualise normal calibre ureters in both small dogs and cats, especially when using a higher frequency probe.

Mild pyelectasis can sometimes be seen when increased diuresis occurs through intravenous fluid therapy. It can also be a differential diagnostic sign for congenital abnormality, chronic renal insufficiency, lower urinary tract obstruction, pyelonephritis, or some neoplastic conditions. When the renal pelvic dilatation is significant to demonstrate dilatation of the proximal and/or distal ureters, vesico-ureteric junction and/or clubbing of the renal calyces, then the term hydronephrosis is more applicable, raising the possibility of ipsilateral, partial, or complete urinary tract obstruction.

TOP TIP: Try tracing the ureter in the short axis plane – the cross-sectional 'O' shape of the ureter is more likely to remain visible when compared to the = shape of the ureter in long axis. Using this technique, it is often easier to track the ureter as it courses through the different depths of the retroperitoneum and beneath overlying gastrointestinal structures.

It is important to trace the ureter along its course from the renal pelvis to the site of insertion at the bladder trigone region (the vesico-ureteric junction or VUJ). Specifically, whenever urinary tract obstruction or anatomical variation is suspected, this is essential as well as assessing for abnormal bladder wall insertion, wall to wall ureteric filling defect or a cause for mechanical obstruction.

Measurements of the maximum VD renal pelvic diameter in both short and long axis planes should be documented, especially in the event intervention / surgery is a possibility. It is important to measure the short axis VD diameter within the confines of the kidney rather than the pelvic ureter to standardise measurement technique and avoid any over-measurement. It is important to appreciate that pelvic dilatation can be an indicator for urinary tract obstruction.

Shape

A normal canine kidney is a classic bean-shaped structure, whereas it tends to be more oval in cats. The kidney commonly has a smooth hyperechoic capsule. The renal shape in longitudinal plane will vary

depending on the scan approach, with the kidney appearing more bulbous in a dorsal approach and more flattened and elongated in a sagittal section.

Size
The length of the kidney should be obtained at its greatest dimension in a longitudinal (either sagittal or dorsal) plane.
When assessing and measuring renal size, ensure you always measure the longest axis so that a true size comparison of the contralateral kidney can be made. Renal shape and depth can vary significantly if one kidney is scanned from the ventral approach and the other is scanned from a lateral approach.

The renal length in cats usually ranges from 30 mm to 45 mm, although this is dependent on breed, sex and neutering status. Older cats often show an aged-related reduction in renal size.

There are greater discrepancies in canine renal measurements due to the multitude of different breeds and body conformations, as well as body weight. Various research papers have cited a variety of methods for correlating normal renal size in dogs.

- Barr et al 1990 suggest a direct correlation between renal length in mm with patient body weight in kg[30].
- Barella et al 2012, suggest measuring the ratio of the left and right kidney length to the length of lumbar vertebrae 5 or 6 in mm, with the normal being 1.3 – 2.7[31]
- Mareschal et al 2007, suggest measuring the ratio of the kidney length to aortic diameter measurements in mm, with normal ranging from 5.5 to 9.1[32]

Representative images of the kidneys to show.

- *Longitudinal view of the left and right kidneys with and without bi-polar long axis measurement*
- *Short axis view of the left and right kidneys at the level of the hilum*
- *Maximum VD measurement of the renal pelvis in longitudinal and short axis planes whenever renal pelvic dilatation is demonstrated*
- *Any abnormality and associated measurements in 2 dimensions e.g., the size of any mass lesion, variation from expected normal measurement range etc.*

Representative images of the ureters to show:

- *Any abnormality and associated measurements e.g. the size of any mass, variation from expected normal measurement range etc*

4.12; Ultrasound examination of the urinary bladder and urethra

For small dogs and cats, having a high frequency linear array probe will provide sufficient beam penetration to assess the dorsal aspect of the urinary bladder and allow for the widest section of the bladder to fill the screen during the dynamic assessment. Larger breed dogs and those with increased adiposity may require a medium frequency micro-convex or curved array probe to provide sufficient beam penetration and the necessary wide far field of view for visualising all of the urinary bladder on the one screen.

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[30] Ultrasonographic measurement of normal renal parameters F. J. Barr,P. E. Holt,C. Gibbs First published: April 1990
[31] Barella G, Lodi M, Sabbadin LA, Faverzani S. A new method for ultrasonographic measurement of kidney size in healthy dogs. J Ultrasound 2012;15(3):186-191.
[32] Mareschal A, d'Anjou MA, Moreau M, et al. Ultrasonographic measurement of kidney-to-aorta ratio as a method of estimating renal size in dogs. Vet Radiol Ultrasound 2007;48(5):434-438.

A comprehensive assessment of the urinary bladder in both longitudinal and short axis planes is often dependent on the degree of bladder filling, size, and the patient position. The urinary bladder is best imaged when moderately full otherwise assessment of the lax bladder wall and the luminal contents of an under-filled urinary bladder can limit accuracy of diagnostic interpretation. An overly full urinary bladder may lead to a diagnostic impression of urinary tract obstruction with dilated renal pelvices.

The urinary bladder is usually assessed with the patient in dorsal or right lateral recumbency, but different positions may be necessary to fully evaluate bladder contents and if the patient is conscious, you can even scan with them standing. Altering a patient's position will help to clarify the presence of suspected suspended cellular debris or mineralisation as they move to alternative intra-luminal positions with gravity dependency.

The bladder is a moderately large structure when distended and it lies within the caudoventral abdomen. The great vessels lie dorsal to the bladder with the urethra extending caudally into the pelvis. The prostatic urethra can be seen in the male canine using a ventral approach, the urethral section caudal and ventral to the ischial arch can be assessed percutaneously taking care not to confuse acoustic shadowing generated by the os penis with the presence of any uretheroliths. There is limited visualisation of the pelvic urethra in canines and feline patients, however, in very young patients the pelvic urethra can be seen through the cartilaginous symphysis.

Echotexture

The urinary bladder is a hollow muscular organ, composed of layers, of a similar wall layer composition and echogenicity to those of the gastrointestinal tract (GIT), namely the mucosa, sub-mucosa, muscularis and serosal layers. However, unlike the characteristic GIT wall layers, the urinary bladder wall layers are difficult to define on ultrasound.

Shape and size

The bladder is essentially a pear shaped hollow muscular organ and can be divided into the three sections.

- bladder apex (most cranial aspect),
- body of the bladder (includes the bladder base or trigone region, the site of normal ureteric insertion)
- the bladder neck extending into the pelvic urethra

The shape, position and size of the urinary bladder will depend on the degree of filling. When distended, the normal urinary bladder is tense and ovoid in shape with a uniformly thin wall (<2.0 mm diameter when full). The wall thickness varies normally with the degree of bladder filling. The bladder wall is hyperechoic when compared to the normal anechoic urine content. The presence of echogenic urine is a non-specific sign, not necessarily indicative of underlying urinary tract disease and when demonstrated, clinical correlation is advised.

TOP TIP: Take care when interpreting the wall thickness measurements of a mildly filled or almost empty urinary bladder – the lax muscular nature of the urinary bladder wall can mimic focal wall thickening / neoplasia and cause an undulating appearance of the mucosal surface.

TOP TIP: Use the Doppler function to examine the vesico-ureteric junctions at the trigone. Place the colour box over the ureteral papillae and reduce the PRF scale to detect slow flow. Ureteric jets seen arising from the papillae demonstrate urine flow into the bladder and can help to confirm/dispute the presence of upper tract obstruction

TOP TIP: When investigating the urinary tract, gentle but firm ballottement of the urinary bladder and/or altered patient position can help to identify suspended debris which has settled to the dependent aspect of the urinary bladder wall and may otherwise go unnoticed

Representative images of the urinary bladder to show.

- *Urinary bladder wall thickness*
- *Any abnormality and associated measurements e.g., the size of any mass, variation from expected wall thickness measurement etc*.

4.13; Ultrasound examination of the gastrointestinal tract (GIT)

Gastric and bowel symptoms are a common cause for patients presenting at their local veterinary practices and being referred for imaging. Plain film radiographs are helpful and considered complimentary in assessing the quantity, location and pattern of gastrointestinal gas and fluid when disease or foreign body is suspected.

Diarrhoea and vomiting, suspected GIT foreign bodies, inflammatory bowel disease (IBD) are among the common conditions where ultrasound can make a major contribution in detection, determination of treatment options, and monitoring of underlying gastrointestinal diseases.

It is advisable for the patient to fast for 8-12 hours whenever possible prior to scanning the gastrointestinal tract as this will help to alleviate the technical difficulties faced when assessing the structures in the presence of large quantities of bowel gas, ingesta or faecal loading.

Ultrasound can be used routinely to assess the following sections of the gastrointestinal tract.

- the stomach (body, fundus, pyloric antrum, and canal)
- the duodenum (descending, flexure, and ascending)
- the jejunum where visualised
- the ileum, using its characteristic wagon-wheel cross-sectional appearance and the colon as a landmark for its identification
- the colon and the ileo-caecal colonic junction (ICCJ)

In general, the bowel diseases which are most easily demonstrated on ultrasound tend to be those which thicken and displace the bowel making them stand out against normal bowel segments and as such, inflamed bowel is often easier to identify than normal bowel, especially when associated hyperechoic reactive mesenteric fat is present contrasting with the multi-layered bowel wall.

To allow for examination of the full gastro-intestinal tract, the patient's abdominal fur should be clipped ventrally as for a full abdominal ultrasound survey and acoustic gel applied.

Altered patient position is a likely requirement when assessing the entire GIT to help to combat the presence of reflective bowel gas and ensure that the stomach and bowel loops are examined in a comprehensive manner in longitudinal and short axis scan planes. Many operators prefer to examine the GIT with the patient in a dorsal recumbency position, however the right lateral recumbency position is also well suited to a systematic approach as in the technique described below.

TOP TIP: It is helpful to apply acoustic ultrasound gel liberally to the clipped abdominal surface prior to commencing the scan as dynamically following sections of tortuous small intestines can be hindered by the absence of gel

Scanning technique

A routine assessment of the GIT can be undertaken using a microconvex probe in most medium to large dogs and indeed smaller pets (but a higher frequency linear probe will give greater resolution in smaller dogs and cats, assuming of course that the patient can tolerate any discomfort caused by a larger footprint probe). This will allow for sufficient image resolution with beam penetration adequate to assess the dorsal aspect of the stomach and the deeper sections of bowel within the mid-abdomen. Higher frequency probes (7.5 MHz or more) should be used for more detailed interrogation of the bowel wall, in particular sections which lie close to the abdominal wall.

To optimise image quality during GIT assessments consider using some or all the following.

- the highest frequency possible whilst allowing for adequate beam penetration
- either one carefully placed focal zone or 2-3 focal bands close together in the target zone/region of interest (note frame rate may be compromised)
- harmonics ON
- edge enhancement and/ or a low dynamic range setting to enhance the wall layer definition
- minimal compounding
- graded compression for assessing stubborn or immobile sections of bowel

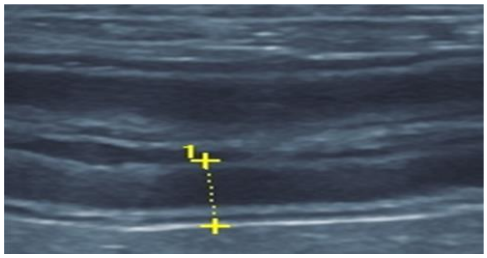
Localised tenderness is not an indicator of disease but may be helpful to note in the full clinical context of the report.

The following ultrasound appearances should be considered routinely when examining the stomach, small intestines, and colon, and especially whenever abnormalities associated with the GIT wall layer architecture are suspected:

- wall thickening (refer to **Appendix 5; Mean Reference Values for Gastrointestinal (GI) Wall Thickness)**
- altered wall layers
- bowel lumen, shape, contents, and echogenicity
- bowel plasticity/mobility/ peristalsis
- any altered or increased blood flow
- extramural mesenteric/ interloop changes

The gastrointestinal tract must be assessed in its entirety in a systematic manner, scanning all structures in both longitudinal and transverse planes, paying attention to any localised lymphadenopathy and/or changes within the surrounding mesenteric fat as these may be clinically relevant.

TOP TIP: To accurately measure the GIT wall thickness, select a well-defined section of bowel in longitudinal plane, place the horizontal calliper cross hair to lie along the white (hyperechoic aspect) of the white-black (hyper-hypoechoic) interface of the outer serosal wall layer and the inner luminal mucosal wall layer.



The following is an example of a technique strategy for assessing the full length of the GIT remembering to always assess in both long and short axis.

- Start by locating the stomach in the patient's midline with the probe in longitudinal plane of the animal and then follow the pyloric antrum aboral to identify the position of the pylorus.
- Return to the midline and scan the cranial gastric contour and towards the left of the patient, assessing the gastric body and fundus and then back along the caudal gastric wall towards the gastric outflow tract.
- Take representative maximum VD thickness measurements of the gastric wall (ideally) in the short axis plane in between the rugal folds.
- Move caudally from the pylorus along the descending duodenum, tracing the duodenum around the duodenal flexure and then cranially along the ascending duodenum.
- Take representative measurements of a longitudinal section of the duodenal wall.
- Assess the colon by identifying it dorsal to the urinary bladder. It may contain gas and/or faecal contents which are reflective or highly attenuating (bright signals deep to the thin bowel wall).
- Follow the descending colon cranially to the splenic flexure, across the patient midline along the transverse colon and then caudally along the ascending colon.
- Take representative measurements of the colon wall, with the bowel in long axis plane whenever possible.
- Identify the caecum and the ileo-caecal colonic junction (ICCJ). Refer to Top Tip for locating the ICCJ with confidence later in this section.
- The ileum can be traced for a short distance orad from the ICCJ
- The remaining ileum and jejunum located within the more central aspect of the abdomen can be assessed using the 'lawn-mower' over-lapping sweep technique.

Take care to assess the mid-gut sections in both longitudinal and transverse overlapping 'sweeps', investigating any suspicious characteristics in detail, possibly using a higher frequency probe if not already in use.

If mechanical ileus is suspected, an effort should be made to trace the entirety of the gastrointestinal tract. If this is not possible, all abnormally dilated intestinal segments should be traced orad and aborad until obstruction is confirmed or ruled out.

Echotexture
The walls of the gastrointestinal tract have a characteristic layered appearance which runs throughout the system, with variation in wall layer thickness depending on the anatomical site, the degree of distension due to internal contents and peristaltic contractions.

The ultrasound appearance of the bowel wall closely correlates with the anatomical layering and comprises of five alternating bands of higher and lower echogenicity. The inner (1) and outer (5) bright bands are extremely fine and may not be seen.

1. inner mucosa-to-luminal interface (fine bright/hyperechoic line)
2. mucosa including the lamina propria (dark/hypoechoic layer)
3. submucosa (bright/hyperechoic line)
4. muscularis propria (dark/hypoechoic layer)
5. outer serosa (fine bright/hyperechoic line)

Appreciation of the normal wall layer architecture is essential when assessing the GIT using ultrasound.

Wall thickening
Thickening of the bowel wall is the feature most identified. The full wall thickness of a normal section of intestines will vary depending on the species and the location, for example, in general, the GI wall thickness of a cat is less than that of a dog for each section of the GIT, except for the colon. Discrete wall layer components visualised on ultrasound also vary. For example, in a normal patient, the thickest mucosal layer can be found within the duodenum and the thinnest within the colon. The characteristic discrete wall layer thickening also varies between the species, with the thickest mucosal section in normal dogs located in the duodenum, compared to the ileum in cats.

Routine measurements of the wall will help to determine the presence of focal or diffuse disease processes. Measurements should be taken of the inter-rugal gastric wall, duodenal wall, and colonic wall thickness. Thickening may be associated with oedema, haemorrhage, inflammation, tumour growth or infiltration.
See appendix 5 for mean reference values for GI wall thickness.

Altered bowel wall layers (gut signature)
Depending on the disease process, the gut signature may be preserved, distorted, diminished, or obliterated. A normal ultrasound scan does not exclude bowel disease and subsequent endoscopy examination/biopsy may be clinically indicated to confirm the presence of some abnormalities.

Bowel lumen
On occasion when the bowel wall is thickened, the bowel lumen is compromised, becoming narrowed, forming a stricture. Ultrasound may also identify a dilated, fluid- filled, and/ or obstructed bowel segments.

Bowel mobility / peristalsis
Some diseases in and around the intestines may cause corrugation of the intestinal wall which can lead to reduced or absent peristalsis.

Altered blood flow
As a rule, Doppler signals are not evident in healthy bowel wall. However, with acute inflammation and tumour presentation, vascularity increases, and the well-optimised use of Power Doppler may be helpful in

identifying bowel wall perfusion and/or hypervascularity within tiny mural vessels and in the adjacent mesentery.

Extramural / mesenteric changes
Bowel wall disease may occasionally extend to involve peri-intestinal structures, adjacent loops, or solid organs. Collections, abscesses, and more commonly swollen, oedematous, hyperechoic mesenteric fat may be seen displacing adjacent structures in patients with inflammatory bowel lesions.

The stomach
It is important to appreciate there are differences in position of the gastric long axis in the feline and canine patient; in a cat the stomach crosses the midline more obliquely with the pylorus situated closer to the midline (at the midline in an empty stomach), whereas in a dog, the gastric long axis tends to lie across the patient with the pylorus more cranial and to the right of the patient midline. An intercostal approach may be required for assessing the gastric outflow tract in deep-chested dogs.

In both species, identify the stomach near the patient xiphoid process in the midline, caudal to the left lobe of liver, with the probe in longitudinal plane initially. Follow the stomach laterally in its short axis towards the patient's left-hand side, through the gastric body and towards the fundus, continually assessing the gastric contents, wall layer architecture and thickness. Take representative inter-rugal measurements of the gastric wall thickness.

Next follow the remainder of the stomach, still using a longitudinal scan plane, by sweeping the probe towards the right of the patient midline, continuing to assess the short axis plane of the stomach, through the gastric body and towards the pyloric antrum. Once the stomach has been assessed in its entirety with using the longitudinal probe orientation, rotate the probe through ninety degrees into a short axis orientation and reassess the stomach. This will now demonstrate the gastric rugal folds running parallel across the screen, highlighting a longitudinal axis of the stomach. In a fasted animal, with contracted stomach it may be harder to assess the wall thickness compared to one which contains a small amount of fluid, and it is not advised to measure wall thickness in an empty stomach. Therefore it is advised always to report the degree of luminal distension as it may influence the wall thickness.

When looking for gastric foreign bodies, look for solid material of variable echogenicity, which may be outlined by fluid or for heterogeneous material within the stomach contents which may or may not have an associated acoustic shadow artefact.

TOP TIP: Take care not to misinterpret the normal gastric fold (incisura angularis) as a dense foreign body with shadowing when it is aligned with the main beam axis (i.e., perpendicular to the gastric fold).

The duodenum
Although some people find it easier to find the duodenum in short axis, the authors find it easier to identify it in long axis, by placing the probe in a longitudinal plane along the right ventrolateral abdominal wall. Identify the long axis of the right kidney lying in a more dorsal position and then adjust the probe ventrally. The mid-section of the descending duodenum is normally the most laterally sited section of the small intestine and can usually be identified running across the screen from left to right in the near field. Take care not to press too hard on the probe or this may displace the duodenum from view. The right limb of the pancreas may also be identified from this approach, lying parallel and either medial or dorsomedial to the descending duodenum.

Once identified, follow the descending duodenal loop cranially to the pylorus and assess in both long and short axes. Follow the descending duodenum caudally towards the duodenal flexure and then cranially to its junction with the jejunum. Take representative measurements of the duodenal wall thickness in longitudinal section. Take note of the presence of peristalsis (1 – 3 contractions per minute on average, although when fasted, peristalsis may only occur once in 10 minutes), the uniformity of the wall layers and the luminal contents.

The duodenal papilla is seen as a hypoechoic extension (with a hyperechoic wall) arising from the lumen, obliquely crossing the duodenal wall and connecting to the common duct. It is sited aboral to the pylorus and at the more medial aspect of the proximal descending duodenal wall.

Triangular/T shaped Peyer patches can be seen at regular intervals within the descending duodenal wall and should not be confused with wall abnormalities.

The descending duodenum lies in a relatively superficial position. In dogs, the wall layer thickness of the duodenum is greater than that of the more distal small intestine, whereas in cats, the ileum tends to be the thickest section of small intestine.

The jejunum and ileum

The distal ileum can be identified from the ileo-caecal colonic junction (ICCJ) and traced orad for a short distance; however, the remainder of the ileum and jejunum are difficult to trace and assess in isolation due to their tortuosity and overlapping lie. Adopt a slow systematic 'lawn-mower' sweep of the small intestines to ensure that the probe sweeps overlap and are performed in more than one body plane for completeness.

Take representative measurements of the wall thickness on a longitudinal section of bowel. Assess the presence of peristalsis, the uniformity of the wall layers and the luminal contents.

The short axis view of the ileum has a distinctive 'wagon wheel' appearance and this can aid identification and differentiation between abnormal / affected sections of bowel. In cats, the mucosa-luminal interface of the ileum is often not well visualised on ultrasound, unlike dogs, where it can be seen more readily.

Any small intestinal double wall layering, corrugation, or plication may be indicative of abnormality and requires a more focussed assessment. If available a high frequency linear array probe may be helpful, to maximise the axial resolution to help differentiate bowel wall layers. Alternatively select the highest frequency on the existing probe.

TOP TIP: Adopting a right to left, cranio-caudal and caudo-cranial 'Lawn Mower' scan technique to include overlapping small intestinal loops is a recommended technique employed in diagnostic medicine for GIT ultrasound assessments. It enables the coverage and evaluation of large sections of bowel in a systematic and comprehensive manner, facilitating comparative assessments of adjacent small bowel loops for any abnormality.

The colon

The colon can be identified its position dorsal to the bladder, placing the probe in a short axis plane trace the thin-walled colon caudo-cranially following the descending colon, around the splenic flexure, towards the midline. The presence of gas or faecal content can render assessment of the dorsal wall more difficult and altered patient position / or scan approach may be necessary to try and combat this. The caecum and ascending colon can be seen by using a ventral approach as a continuation of the transverse colon,

although this section of colon is often easier to locate with confidence from the right lateral aspect; locate the ileocaecocolonic junction (ICCJ) and follow the colon cranially and aboral from this site (ICCJ) along the ascending, transverse, and proximal descending colon.

TOP TIP: To locate the ICCJ with confidence (patient in a right lateral recumbency patient position); locate the right kidney in long axis, keeping the probe at this level, sweep the probe upwards and point towards the ceiling from the underside of the patient. The ICCJ will usually come in to view in the near field. Scanning cranio-caudally and caudo-cranially in both long and short axes will demonstrate the ileum as it enters the ICCJ.

Representative images of the stomach to show.

- *Gastric body, fundus, and pyloric antrum*
- *Longitudinal and short axis view of the pylorus*
- *Measurement of the gastric wall thickness in between rugal folds*
- *Any abnormality and associated measurements e.g., the size of any mass, variation from expected normal measurement range etc.*
- *Video clips (max 20 s) of representative areas of the stomach including gastric fundus, body, antrum and pyloroduodenal junction*

Representative images of the duodenum and small intestines to show:

- *Descending duodenum in at least one or both planes if possible, including maximum VD single wall diameter thickness measurement of the duodenum*
- *Still image and video of representative jejunal segment (multiple if not uniform in appearance) in at least one or both planes if possible, including wall thickness*
- *measurement*
- *Any abnormality and associated measurements e.g., the size of any mass, variation from expected normal measurement range*

***Representative images of the colon to show**:*

- *Maximum VD single wall thickness of the descending colon*
- *Representative large intestinal segment (multiple if not uniform) in at least one or both planes if possible, in still images and a video*
- *The Ileocaecalcolonic junction (ICCJ) in at least plane*
- *Any abnormality and associated measurements e.g., the size of any mass, variation from expected normal measurement range*

4.14; Ultrasound examination of the (non-pregnant) female reproductive tract and mammary chains

The cervix, uterine body, horns and both ovaries are considered part of a standard abdominal ultrasound assessment in an intact dog or cat. If not visible or not examined this should be stated in the report. The vagina and vulva are better evaluated by clinical examination / direct visualisation or via contrast radiography/CT vaginography rather than by ultrasound.

If clinically indicated, each mammary gland and adjoining soft tissue should be assessed in the transverse plane, scanning along the chain, with transverse and longitudinal images obtained of any focal enlargement, nodules, masses, or heterogeneity.
It is beyond the scope of these guidelines to discuss fetal imaging in detail.

Scanning technique
Select the highest frequency possible to ensure optimum resolution.

A moderately full urinary bladder can be helpful serving as both a landmark and an acoustic window, displacing overlying gas-filled bowel loops laterally thus enabling improved visualisation and improved assessment of the uterine body and cervix.

The ovary
The ovaries are best visualised at the time of the renal ultrasound assessment considering their anatomical proximity to the caudal renal pole (although ovaries may be situated several centimetres from the renal pole

Locate the ovary on each side by scanning in the region of the caudal renal poles. Once identified, scan the respective ovary in both long and short axis planes, assessing the size of the ovary and noting follicular status. The latter may be helpful to report on when correlating the oestrus phase. Ovaries can be quite superficial and applying too much pressure may prevent them from being seen.

Normal ovaries are ovoid, or bean shaped and vary depending on the size of the dog. In cats the ovaries are smaller and harder to visualise. The ovarian stroma is hyperechoic or isoechoic with the adjacent renal cortex, whereas ovarian follicles and cysts are anechoic or hypoechoic in comparison. Haemorrhagic follicles or small ovarian cysts may be isoechoic with the normal ovarian stroma and become more difficult to differentiate. Ovaries are small during anoestrous and early proestrous and become larger in size as follicular activity increases.

The number and size of anechoic follicles present within the ovarian cortex depends on the hormonal phase of the oestrous cycle. Follicular development begins in the proestrous phase with follicular activity increasing in number and maximum diameter within the oestrous phase. Multiple follicles can be seen on each ovary just prior to ovulation with each of the dominant follicles measuring on average up to 10 mm in diameter. After ovulation there is a decrease in the number and size of the follicles present within the ovary.

After ovulation, it is not uncommon to detect traces of anechoic free fluid adjacent to the ovaries.
Ovarian lesions should be documented and measured at maximum dimension of the lesion(s).
The ovariectomy site should be evaluated in spayed female dogs and cats, if there is a clinical concern.

The uterus
The normal uterus is a homogenous (although the layers can be differentiated) hypoechoic structure with a smooth outline. Its wall is composed of three layers; the inner mucosa, middle muscularis and outer serosa. The endometrial-myometrial borders are difficult to identify on abdominal ultrasound but the cavity line echo i.e. the mucosal interface towards the lumen from the opposing ventral and dorsal uterine walls can often be seen as a hyperechoic line or rim, subject to the hormonal status at time of scanning.

The uterus is located dorsal to the urinary bladder and ventral to the distal descending colon and rectum, with the uterine body lying cranial to the os pubis. The uterine body bifurcates into the left and right uterine horns (cornua) which extend cranially from the body to the level of the ovaries and the respective caudal renal poles. Uterine horns can be difficult to identify and track when normal, often depending on

the echogenicity of the patient and/or the intestinal content. Pregnancy and certain pathological conditions will render short axis assessment and tracking of the uterine horns more favourable since their cross-sectional calibre subsequently increases in size.
The uterine cervix extends from the caudal margin of the uterine body and is continuous with the vagina. Probably the most reliable way to identify a small anoestrous uterine body and cervix is to scan the urinary bladder in a short axis view, with the bladder seen in the near field, the colon in the far field and the uterus/cervix is demonstrated in between the two as a hypoechoic round structure.

The size of the normal uterus will vary according to the species, size of the animal, gravida, and parity status and when abnormal uterine size is subject to the disease process

Representative images of the cervix, uterine body, horns and both ovaries to show:

- *Normal ovaries*
- *Uterine horns (left and right), uterine body, cervix and pre-pubic aspects of the vagina still images and videos if clinically indicated*

Any abnormality and associated measurements e.g., the size of any mass, variation from expected normal measurement range etc.

4.15; Ultrasound examination of the male reproductive tract

Scanning technique
The male reproductive organs include the testes and prostate gland, both of which can be visualised on ultrasound. The use of a higher frequency linear array probe (7.5 MHz or more) is advisable when examining the testes in detail as despite the long straight probe edge, application of a sufficient quantity of gel to expel air from the probe-scrotum interface will provide adequate skin contact whilst offering high resolution imaging. The microconvex probe used for most of a canine abdominal assessment may be suitable for examining the prostate gland in medium to large dogs, but it is unlikely to provide sufficient resolution to detect disease/ or subtle testicular parenchymal echotexture changes.

There is usually no need to clip the scrotum prior to ultrasound assessment of the testes unless there is excessive hair growth which would prevent adequate probe to skin contact. There is anecdotal evidence that using alcohol as a contact medium can cause scrotal skin irritation so we would recommend using ultrasound gel

Patients may be positioned in the dorsal recumbency position although the right lateral recumbency position adopted for the full abdominal ultrasound survey will also suffice. Take care to avoid confusion and correctly identify the relative positions of the left (uppermost) and right (lower) testicles (this is usually the case with the patient in the right lateral recumbency position but may not be when the patient is in the dorsal position).
The abdominal ultrasound survey should include routine assessment of the testes in intact dogs and cats.

TOP TIP: Use the split screen function on the ultrasound system to compare both the right and left testes on the one image when measuring and/or assessing their relative echotexture or vascularity

The prostate gland[33] [34] [35]

The prostate gland is a bi-lobed, solid structure separated by a median septum, which is better visualised when scanned in the short axis plane. The prostate glands is ovoid in shape when scanned in the longitudinal plane and more rounded in short axis (especially in castrated males). The gland lies immediately caudal to the urinary bladder trigone and is ventral to the rectum with the pelvic urethra running through the centre of the gland (known as the prostatic section of the urethra). The normal prostatic capsule is smooth and regular in outline

The feline prostate gland is not visualised on ultrasound as the gland is very small, intra pelvic and more caudal, but prostatic disease is rare in cats so there are unlikely to be many referrals. The size of the canine prostate gland will vary with breed, sexual maturity /age and intact or neutered status.

As the prostate gland enlarges, either through maturity or disease process, it displaces the urinary bladder cranially. Severe prostatomegaly may lead to chronic dysuria and urinary retention or may compress the descending colon potentially leading to obstipation.

Benign prostatic hypertrophy is considered a normal occurrence as intact dogs reach middle age (over 4 years of age).

Routine measurements to quantify prostatic size should be included in the ultrasound report, as baseline measurements may be relied upon to assess resolution or progression of disease at a later stage. Some ultrasound systems will have a 'volume preset' but prostatic volume can be measured using the maximum prostatic diameter with measurements entered using the following ellipsoid formula.

Volume = prostatic length x prostatic height x prostatic width x 0.524

Alternatively, many ultrasound operators quote the short axis maximum diameter or width of the prostate in their reports as a more simplified method of quantifying the prostate size, with the normal range measuring from 14 to 43 mm in diameter for intact status[36]

When quantitatively assessing prostatic symmetry, measure and compare the maximum ventro-dorsal (VD) diameter or height (scanned in the longitudinal plane) of each lobe of the gland.

The prostate gland can be located on ultrasound by scanning the urinary bladder neck in longitudinal plane in the patient midline and angling the probe caudad to identify the long axis of the prostate gland.

The normal canine prostate gland in a young to middle aged dog has a fine to medium homogenous echotexture. The prostatic capsule is easily recognised as a thin hyperechoic peripheral rim. The prostatic urethra is seen as a double-walled linear structure with hyperechoic walls and an anechoic lumen when viewed in long axis. In short axis, the prostatic urethra will appear round and lies centrally or slightly dorsal within the gland.

As the prostate gland enlarges with age (often due to benign prostatic hyperplasia), the gland can vary from being mildly inhomogeneous to heterogeneous with a coarser echotexture with a predominantly hyperechoic appearance and may contain hypoechoic cysts of variable size. Enlargement may be smooth and symmetrical or may be asymmetrical, leading to loss of the normal bi-lobed appearance and findings

[33] Atlas of Small Animal Ultrasonography, Dominique Penninck, Marc-Andre d'Anjou (2015). Wiley Blackwell.
[34] Small Animal Diagnostic Ultrasound, John.S.Mattoon, Thomas.G.Nyland (2015). Elsevier.
[35] Zohil AM , Castellano C. (1995) Pre-pubic and transrectal ultrasonography of the canine prostate: A comparative study. Vet Radiol Ultrasound 36:393-6
[36] Atalan G, Holt PE, Barr FJ (1999) Ultrasonographic estimation of prostate size in normal dogs and relationship to body weight and age. J Small Anim Pract 40:119-122

should be measured and detailed along with the location in the prostate in the report. If the prostate gland is suspected to be enlarged (including presence of paraprostatic lesions), assessment of the adjacent structures such as the periprostatic fat, colon, urinary bladder, and ureters should be performed to assess for presence or absence of obstructive processes. Mineralisation is not typically seen in dogs with benign prostatic hypertrophy (although it is often seen in humans).

The testes

The testicles normally lie in the scrotal sac and are best imaged using a high frequency (7.5 MHz or higher) linear array probe, using plenty of gel to offset probe-structure contact issues created by the curved nature of the testes and provide the necessary probe to skin contact. Some operators may prefer to use a gel stand-off, although altering the probe scan approach whilst keeping the stand-off still can be difficult.

If the testicles are mal descended, then it is important to extend the investigation to include the inguinal canal and the abdomen to the caudal pole of the kidneys to identify and locate them.

Normal testicular size will vary slightly and is dependent on the weight of the patient. The normal canine testis can measure from 15 mm in length by 22 mm in width in small dogs to 40 mm in length x 33 mm in width in larger breeds[37]

The normal testis is ovoid in shape with the smooth, thin, hyperechoic capsular outline of the tunica albuginea. The testes are separated within the scrotum by a thin, hyperechoic median septum which can be visualised on ultrasound and aid identification of the relevant right or left testis. Each normal testis will be of medium echogenicity (like that of the renal cortex) and will demonstrate a fine homogenous echotexture. A thin, hyperechoic line running centrally in the long axis of the testis is known as the mediastinum testis.

The head and tail of the epididymis are located at the cranial and caudal poles of the testis respectively with the body of the epididymis running along the dorsal aspect of the testis. The epididymides have a coarser echotexture and are more hypoechoic than the neighbouring testis. It is often possible to follow the spermatic cord cranially towards the level of the respective inguinal canal as it arises from the epididymal head.

The testes, scrotum, epididymides and associated vasculature should be assessed in the intact male dog as a part of a complete abdominal ultrasound examination, even if no related clinical signs are present, and abnormalities should be documented.

TOP TIP: Use the more sensitive Power Doppler (PD) setting to assess and compare vascularity within the testes. PD is less dependent on the Doppler angle and is more likely to identify low velocity flow or perfusion in tiny vessels than conventional Colour Doppler (CD).

Representative images of the prostate gland to show.

- *Longitudinal and short axis plane of the prostate*
- *Bi-lobar maximum VD diameter measurements at the widest point in both longitudinal and transverse planes*
- *Split screen demonstrating visualizing the median raphe or mediastinum testis*

[37] Hecht. S, (2001)Sonographische Diagnostik des Skrotalinhaltes beim Hund unter besonderer Beruecksichtigung testikulaerer Neoplasien (Doctoral theses). Munich:Chirurgische Tierklinik, Ludwig-Maximilians University

- *Any abnormality and associated measurements e.g. the size of any mass, variation from expected normal measurement range etc.*

Representative images of the testes and epididymides to show.[38]

- *Normal maximum testicular dimension measurements / comparison view on split screen*
- *Doppler application to show intra-testicular vascularity*
- *Any abnormality and associated measurements e.g., the size of any mas , variation from expected normal measurement range etc.*

4.16; Ultrasound examination of the lymph nodes

Abdominal lymph nodes should be routinely assessed during a full abdominal ultrasound survey as many are directly related to the drainage of abdominal organs and structures. An appreciation of the major abdominal vessels and their tributaries is essential to help with localizing and naming the lymph nodes. Comparison of ultrasound characteristic changes and size of localised lymph nodes is often a necessary requirement when staging neoplasia or for monitoring the response to oncology treatment.

Many enlarged or abnormal lymph nodes are accessible to fine needle aspiration (FNA) due to their increased size or superficiality. Since the ultrasonic appearances of lymph nodes are usually non-specific, ultrasound guidance of the fine needle into the target lymph node is an appropriate and usually safe method of obtaining cytology during the investigation disease processes which may or may not have lymphatic system involvement.

Abdominal lymph nodes can be divided into two groups; parietal and visceral:

- ***Parietal lymph nodes include*** lumbar aortic, renal, medial iliac, internal iliac sacral and deep inguinal lymph nodes
- ***Visceral lymph node includes*** hepatic, gastric, splenic, pancreatico-duodenal, jejunal and colic lymph nodes.

Size

Whilst the large number of abdominal lymph nodes have a classic oval or bean shape, there is still variety in the shape and length of many normal abdominal lymph nodes. The majority of reference values for lymph node measurements therefore tend to relate to the height or width of the lymph node when measured on ultrasound as opposed to the length.

It is common in juvenile animals to see a marked prominence in the size (mean diameter of the node 6-7 mm[39] [40]) and identification of the abdominal lymph nodes. If the characteristics of the nodes (i.e., the shape and echogenicity) are within normal limits, lymphadenopathy is less likely because larger nodes can be normal in juvenile patients[41]

Shape and echotexture

The normal lymph node varies in shape depending on their location with some having characteristic shapes for example:

- Jejunal lymph nodes are usually elongated in shape.

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[38] Atlas of Small Animal Ultrasonography, Dominique Penninck, Marc-Andre d'Anjou (2015). Wiley Blackwell.

[39] Stander N, Wagner WM, Goddard A, et al. (2010) Normal canine pediatric gastrointestinal ultrasonography. Vet Radiol Ultrasound 51:75-78

[40] Krol L, O'Brien R (2012) Ultrasonographic assessment of abdominal lymph nodes in puppies. Vet Radiol Ultrasound 53:455458

[41] Schreurs, E., Vermote, K., Barberet, V., Daminet, S., Rudorf, H., & Saunders, J. H. (2008). Ultrasonographic anatomy of abdominal lymph nodes in the normal cat. Veterinary Radiology and Ultrasound, 49(1), 68-72. https://doi.org/10.1111/j.1740-8261.2007.00320.x

- medial iliac lymph nodes are usually ellipsoid in shape.

Practice in assessing site-specific nodal shapes, sizes and ultrasound characteristics will increase the confidence in recognising subtle changes in nodal appearances, which is important when performing serial scans to inform follow-up treatment strategies.

Normal lymph nodes are regular in outline with a smooth fine hyperechoic capsular rim (although this is not often seen) and are isoechoic or mildly hypoechoic in comparison with surrounding fat. It is not uncommon to identify the hyperechoic hilar vessels within the central component of the lymph node. The slow velocity flow within these vessels would require the use of Power Doppler for flow to be detected at all.

TOP TIP: Reactive lymph nodes tend to maintain their oval shape, whereas neoplastic lymph nodes take on a more rounded or lobulated shape and often appear more hypoechoic than normal

See appendix 4: Location and drainage of abdominal lymph nodes

The aorta, caudal vena cava and portal vein as well as their major branches may serve as landmarks for identification of lymph nodes.

Representative images of the lymph nodes to show.

- Normal medial iliac and jejunal lymph nodes in longitudinal plane
- Any abnormal lymph node in longitudinal with measurements
- If discrete medial iliac lymph nodes are not identified, video clip in longitudinal and transverse of the region of the lymph nodes including both the left lateral aspect of the aorta and the right lateral aspect of the caudal vena cava at the level of the aortic trifurcation, between the deep circumflex and the external iliac arteries.
- If discrete jejunal lymph nodes are not identified, then video clips of the region of the jejunal lymph nodes along the cranial mesenteric artery and vein.
- the aorta and the right lateral aspect of the caudal vena cava at the level of the aortic trifurcation, between the deep circumflex and the external iliac arteries.
- If discrete jejunal lymph nodes are not identified, then video clips of the region of the jejunal lymph nodes along the cranial mesenteric artery and vein.

Appendix 1 Example for obtaining consent to scan a pet during a training event

***Insert Name of Training Establishment or Organisation*: Pet Ultrasound Consent Form**	
Pet Name:	

I confirm that I am the owner / I am acting as the representative of the owner of the pet named above.

I appreciate that it may be necessary to clip the fur to enable the scan to take place and I have no objections to this.

I understand that this pet will only be scanned if they are calm, comfortable, and compliant and this pet will not be placed under any stress or duress.

I give consent to allow this pet to take part in a **insert name of training establishment or organisation* ultrasound training event, during which he/she will be scanned to enable attendees to undertake the practical hands-on training necessary to learn correct ultrasound system skills and scan techniques.

I understand that any scan performed on this pet by a course attendee will be fully supervised by a suitably qualified ultrasound practitioner acting on behalf of **insert name of training establishment or organisation* and as such this pet will be treated with the utmost care, kindness, and respect during the scan process.

I confirm that I have not offered the pet as a subject at the training event to enable him/her to have a diagnostic ultrasound examination and I understand that he/she may have a medical condition which is not detected during the training course.

I understand that during this ultrasound training event, there may be occasions when incidental pathology or normal variant anatomy may be detected. If this situation arises, then a member of the **insert name of training establishment or organisation* will give a brief description of the findings to me to facilitate any referral to my vet practice. I understand that it is solely my responsibility to arrange any review of the pet.

**Insert name of training establishment or organisation* are not able to offer a diagnosis or diagnostic outcome for any incidental scan findings.

Date of Training Event:	
Venue for Training Event:	
Name of Pet Owner/ Representative of the Pet Owner:	
Signature of Pet Owner/ Representative of the Pet Owner:	
Insert name of training establishment or organisation* **Event Representative:	

Appendix 2: Example of an abdominal ultrasound report template for editing

Patient ID		Gender	
Patient name		Breed	
Client surname		Veterinary referrer	
Clinical history.			
Examination requested, full abdominal ultrasound survey			

Structure	Normal (N) or Abnormal (A)	Ultrasound Findings
Liver	**Normal (N) or Abnormal (A)**	The liver is regular in size with a smooth, homogenous echo pattern throughout the parenchyma. No focal lesion or intrahepatic duct dilatation evident.
Portal Vein	**N or A**	The portal vein is patent, demonstrates hepatopetal flow with a velocity of ** cm/s. Hepatic veins demonstrate a normal calibre and regular configuration.
Gallbladder	**N or A**	Normal distended gallbladder with a uniform thin wall. Sludge /Choleliths seen within the dependent portion of the gallbladder. The common duct measures * mm at the level of the main portal branch.
Spleen	**N or A**	Regular sized and shaped spleen with a normal homogenous parenchymal echo pattern. No evidence of splenic disease.
Pancreas	**N or A**	Where visualised, the pancreas is normal in size and echotexture with no evidence of pancreatic disease.
Stomach	**N or A**	The stomach is empty at time of scan. Where seen it has a normal wall layer architecture and gastric wall thickness (*mm). No obvious foreign body seen within the contracted rugal folds. The pylorus and gastric outflow tract are identified and are normal on ultrasound.
Small Intestines	**N or A**	The duodenum demonstrates a normal overall wall thickness (* mm) and characteristic wall layer echo pattern. The remaining small intestines are also normal with normal wall layer architecture and wall thickness. There is no evidence of a foreign body, focal or diffuse disease within the small intestines.
Colon	**N or A**	The colon contains air/faecal content/fluid at time of scan. The colonic wall layering and overall wall thickness, where seen, are unremarkable. The ICCJ is identified and is also normal.
Kidneys	**N or A**	Both kidneys are normal in size, shape, and echogenicity, demonstrating cortico-medullary differentiation. There is no evidence of hydronephrosis or mass lesion. The left kidney measures *mm and the right measures * mm in long axis.
Adrenal Glands	**N or A**	Both adrenal glands are normal in size and echogenicity, demonstrating a normal characteristic shape. The left adrenal gland measures * mm and the right measures *mm at the caudal pole.

Urinary Bladder	**N or A**	The bladder is moderately filled at time of scan. The bladder wall is smooth, uniform and demonstrates a wall thickness which is within normal limits for fill status (*mm).		
Prostate Gland Testes	**N or A**	Neutered/Intact status noted. The prostate gland is normal in size, shape, and outline with normal echotexture of the gland. The bilobar measurements are *mm and *mm. Neutered status noted/Both testes are correctly sited and appear normal in shape, size and echotexture		
Uterus/Ovaries	**N or A**	Neutered status noted / The uterine body, cervix and both uterine horns are normal. Both ovaries are identified/ and are normal. Left/right ovary not identified		
Lymph Nodes	**N or A**	Both the left medial iliac lymph node (LMILN) and the right medial iliac lymph node (RMILN) are identified and are normal in size, shape and echotexture, measuring * x*mm and * x *mm respectively. *Add measurements and location of atypical lymph nodes.* No gross lymphadenopathy evident.		
Peritoneum	**N or A**	No free abdominal fluid demonstrated.		
Other	**N or A**			
Ultrasound Guided Intervention	Performed by;	Fine Needle Aspiration (FNA) or Biopsy	Yes / No	Site;
		Cystocentesis	Yes / No	
		Abdominocentesis	Yes / No	

Differential diagnoses for abnormal appearances demonstrated.
Name and designation of ultrasound practitioner.
Name and designation of other professionals in attendance for scan.
Date of scan.

Appendix 3: Ultrasound characteristics of the caudal vena cava (CdVC) and the abdominal aorta

Caudal Vena Cava (CdVC)	Abdominal Aorta
Right of the patient midline	Left of the patient midline
Walls are thin	Walls are thicker due to bright intimal layer
Walls compressible when normal	Wall is non-compressible
Flow is in the caudo-cranial direction	Flow is in the cranio-caudal direction
Pulsed wave Doppler trace is non-pulsatile and monophasic when normal	Pulsed wave Doppler trace is pulsatile and biphasic when normal

Appendix 4: Location and drainage of abdominal lymph nodes[42]

Lymph Nodes	Location	Drainage Areas
Hepatic	Along portal vein, caudal to porta hepatis	Liver, stomach, duodenum and pancreas
Splenic	Along splenic veins and the left pancreatic limb	Liver, spleen, oesophagus, stomach, pancreas and omentum
Gastric	Near pylorus, close to lesser curvature	Diaphragm, liver, oesophagus, stomach, duodenum, pancreas and peritoneum
Pancreaticoduodenal	Near the cranial duodenal flexure, between the pylorus and right pancreatic limb	Duodenum, pancreas and omentum
Jejunal	Along the mesenteric vascular tree (cranial mesenteric artery and vein)	Jejunum, ileum and pancreas
Colic	Near the ileocolic junction (Right colic) mesocolon (middle colic) and caudal descending colon (left colic)	Ileum, caecum and colon
Lumbar Aortic and Renal	Along aorta and near the kidneys	Spinal structures, ribs, peritoneum, kidneys, adrenals, bladder, uterus, prostate and gonads
Medial Iliac, Internal Iliac and Sacral	At caudal aortic trifurcation, between deep circumflex and EIA (medial iliac), medial IIA (internal iliac) and along the median sacral artery (sacral)	Ureters, bladder, uterus, prostate, gonads, peripelvic and pubic area, abdominal skin, caudal vertebrae, pelvis, hindlimb muscles and bones

[42] Atlas of small animal ultrasonography, Dominique Penninck, Marc-Andre d'Anjou, Wiley Blackwell

Appendix 5; Mean Reference Values for Gastrointestinal (GI) Wall Thickness[43] [44]

Species		Stomach	Duodenum	Jejunum	Ileum	Colon
Dog	<15 Kg	2-5 mm	3.8 mm	3.0 mm	3.0 mm	1.5 mm
	15 – 30 Kg	2-5 mm	4.1 mm	3.5 mm	3.5 mm	1.5 mm
	>30 Kg	2-5 mm	4.4 mm	3.8 mm	3.8 mm	1.5 mm
Cat		1.7-2.4 mm	2.0-2.4 mm	2.1-2.5 mm	2.5-3.2 mm	1.4-1.7 mm

The above measurement values must be used with caution: measurement values of the stomach can vary with gastric distension, and all GI wall measurements must be used in context with the clinical presentation of the patient, the ultrasound appearances and distribution of any changes to wall layer architecture.

[43] Ultrasonographic evaluation of the thickness of the wall layers in the intestinal tract of dogs
Nicole E Gladwin 1, Dominique G Penninck, Cynthia R L Webster AMJ Vet Res 2014 Apr;75(4):349-53. doi: 10.2460/ajvr.75.4.349.

[44] Ultrasonographic measurement of the relative thickness of intestinal wall layers in clinically healthy cats.
Di Donato P, Penninck D, Pietra M, Cipone M, Diana A.
J Feline Med Surg. 2014 Apr;16(4):333-9. doi: 10.1177/1098612X13509080. Epub 2013 Oct 30. PMID: 24174500

Appendix 6: Image Protocol Small Animal Abdominal Ultrasound Examination

Adapted from International Veterinary Ultrasound Society (IVUSS), Suggested Imaging Protocol for Standard Abdominal Ultrasound Exam Consensus Statement:

https://www.ivuss.org/assets/PDFs/IVUSS%20Std%20AUS%20Imaging%20Protocol%2010.22.19.pdf

Structures	Evaluation
Liver	Representative images to show: • the liver in both longitudinal and short axis planes. • the hepatic confluence draining into the CVC in short axis plane • the main portal vein at the porta hepatis • any abnormality and associated measurements e.g., the size of any mass, variation from expected normal measurement range etc.
Diaphragm	Representative images to show: • longitudinal and short axis views of the right and left hemi-diaphragm with liver and spleen respectively when possible (as for liver views) • any abnormality and associated measurements e.g., the size of any mass, pleural effusion etc.
Gallbladder	Representative images to show: • longitudinal and short axis views of the gallbladder • gallbladder wall thickness (VD diameter) in longitudinal plane • gallbladder neck • cystic duct with maximum VD intra-luminal diameter • any abnormality and associated measurements e.g., the size of any mass, variation from expected normal measurement range etc.
Common duct	Representative images to show: • intra-luminal VD diameter measurement of the common duct at the level of the main portal vein • intra-luminal VD diameter measurement of the common duct at the level of the duodenal papilla if dilated • any abnormality and associated measurements e.g., the size of any mass, variation from expected normal measurement range etc.
Pancreas	Representative images to show: • left and right limb and body of pancreas in longitudinal and short axis planes • measurement of pancreas, pancreatic duct if enlarged / dilated or abnormal • any abnormality and associated measurements e.g., the size of any mass, variation from expected normal measurement range etc.
Spleen	Representative images to show: • head, body, and tail of spleen in longitudinal and short axis planes • splenic hilar vessels • any abnormality and associated measurements e.g., the size of any mass, variation from expected normal measurement range etc.
Aorta and CVC	Representative images to show: • longitudinal and short axis views of the aorta and CVC adjacent to one another • colour Doppler application when appropriate e.g., whenever wall-to-wall vessel filling is under question due to thrombus or tumour infiltration • any abnormality and associated measurements., the size of any intra-luminal filling defect / mass, variation from expected normal measurement range etc.

Adrenals	Representative images to show: • longitudinal view of the left and right adrenal gland with caudal pole VD measurement (canine) • longitudinal view of the left and right adrenal glands with long axis and VD diameter measurements (feline) • any abnormality and associated measurements e.g., the size of any mass, variation from expected normal measurement range etc.
Kidneys	Representative images to show: • longitudinal view of the left and right kidneys with and without bi-polar long axis measurement • short axis view of the left and right kidneys at the level of the hilum • maximum VD measurement of the renal pelvis in longitudinal and short axis planes whenever renal pelvic dilatation is demonstrated • any abnormality and associated measurements e.g., the size of any mass, variation from expected normal measurement range etc.
Ureters	Representative images to show: • any abnormality and associated measurements e.g., the size of any mass, ureteroliths, ureteric dilatation measurement etc.
Urinary bladder	Representative images to show: • any abnormality and associated measurements e.g., the size of any mass, variation from expected wall thickness measurement etc.
Uterus and ovaries	Representative images of the cervix, uterine body, horns and both ovaries to show: • normal ovarian measurements • normal uterine cavity line/intra-uterine contents measurements • any abnormality and associated measurements e.g., the size of any mass, variation from expected normal measurement range etc.
Prostate	Representative images to show: • longitudinal and short axis plane of the prostate • bi-lobar maximum VD diameter measurements at the widest point in longitudinal plane • any abnormality and associated measurements e.g., the size of any mass, variation from expected normal measurement range etc.
Stomach	Representative images to show • gastric body, fundus and pyloric antrum • longitudinal and/or short axis view of the pylorus when visualised • measurement of the gastric wall thickness in between rugal folds • any abnormality and associated measurements e.g., the size of any mass, variation from expected normal measurement range etc.
Duodenum and small intestines	Representative images of the duodenum and small intestines to show: • maximum single wall diameter of the duodenum • any abnormality and associated measurements e.g., the size of any mass, variation from expected normal measurement range etc.
Colon	Representative images of the colon to show: • maximum single wall diameter of the descending colon • the Ileocaecal-colonic junction (ICCJ)

	• any abnormality and associated measurements e.g., the size of any mass, variation from expected normal measurement range etc.
Testes and epididymides	Representative images of the testes and epididymides to show: • normal testicular dimension measurements / comparison view on split screen • Doppler application to show intra-testicular vascularity • any abnormality and associated measurements e.g. the size of any mass, variation from expected normal measurement range etc.
Lymph nodes	Representative images to show: • any abnormality and associated measurements e.g., the size of any mass, variation from expected normal measurement range etc.
Other Structures	Representative images to show: • any abnormality and associated measurements e.g., the size of any mass, variation from expected normal measurement range etc.