COMMISSIONED PAPER

How to report radiographs

C. R. Lamb[(1)]

SUMMARY

Although only radiologists and radiology residents produce radiographic reports regularly, committing the results of radiography to the written medical record is a potentially useful discipline for all practitioners. A radiographic report should always confirm the patient's identity and date of the study, state what images were made, describe any abnormalities and summarise the likely meaning of the radiographic signs. Descriptions are normally based on a hierarchy of terms: shadow; anatomy; pathology; and diagnosis. Abnormal shadows, anatomy or pathology are described according to the contribution of one or more of the six categories of radiographic ("Roentgen") signs, namely number, size, shape, position, margination and opacity. Radiography is invariably done with the aim of answering some clinical question(s) about the patient. This question should be known at the time the radiographs are made and it should be addressed, if not answered, in the conclusion of the radiographic report. It is desirable that radiographic reports conclude with a sensible estimate of the probability of specific diagnoses; however, that can be difficult to achieve.

Although only radiologists and radiology residents produce reports regularly, committing the results of radiography to the written medical record is a potentially useful discipline for all practitioners. The medical record for any patient should include the results of all diagnostic tests including radiographs; however, I have observed that radiographs (and ultrasound scans) in first opinion practices are frequently archived without any written record of the results. This can make it difficult for a deputising colleague to communicate with an owner or, if necessary, take over the care of a patient. Apart from minimising this problem, it seems likely that a routine requirement to produce a radiographic report will encourage more careful interpretation of the radiographs. Opinions differ about many of the details of writing radiography reports [1]. This review will attempt to concentrate on aspects about which there is likely to be a consensus.

The structure and use of a radiographic report

The radiographic report should always confirm the patient's identity and date of the study, state what images were made, describe any abnormalities, and summarise the likely meaning of the radiographic signs. [1,2] (Table 1). Above these basic requirements, the primary clinician who will receive the report may require additional information [1,3], such as a list of differential diagnoses and/or an answer to a specific clinical question will be expected (Table 2).

Any technical errors that adversely affect the quality of the radiographs should be mentioned, especially if interpretation is made more difficult as a result. In an ideal world, the adequacy of radiographs would be assessed as soon as they are made by personnel with the authority to obtain additional or improved radiographs whenever necessary to obtain an optimal study. This is not always possible, particularly for out-of-hours emergencies; however, measures that make it easier for staff to make good radiographs and training that helps personnel to recognise inadequate radiographs or incomplete studies will ultimately increase the quality of radiographic reports. Those writing reports should routinely give feedback to those making radiographs.

If radiographic reports are produced and distributed quickly, the primary clinician will be readily able to incorporate new information into their case management. It is common practice in veterinary schools for residents to produce draft reports that are reviewed, usually the following day, by a supervising radiologist before being typed and distributed. Hence, it may be at least 24-48h before the report is available and, by that time, it may be redundant. In my view, reports are best produced by a resident and supervisor viewing the radiographs together in an attempt to produce a definitive report at the first opportunity. Dual viewing of the radiographs can increase sensitivity, enhance

(1) University of London, Department of Veterinary Clinical Sciences, The Royal Veterinary College, Hawkshead Lane, North Mymms, Hertfordshire GB-AL9 7TA E-mail: clamb@RVC.AC.UK

*This article is the sequel to: LAMB (CR.), How to look at radiographs. EJCAP 2007, **17 (1)** : 79-84

- Patient's identity and date of study
- What images are being reported
  - Limitations, if any
- Description of radiographic signs
  - Shadows
  - Anatomy
  - Pathology
  - Diagnosis
- Interpretation, reading or diagnosis
  - Relationship between the radiographic findings and the clinical context
  - Prioritised differential diagnosis
  - Answer to primary clinician's questions
- Recommendations, if any

Table 1. The usual structure of a radiographic report

1. Express an opinion
2. Provide a list of differential diagnoses
3. Answer the primary clinician's questions
4. State limitations of the examination, if any
5. Make appropriate open-ended recommendations for further work-up
6. Integrate the radiographic findings with the clinical context
7. Integrate the results of multiple imaging modalities (when applicable)
8. Provide a complete description of the findings

Table 2. Priorities for a radiographic report [3]

resident training [4] and facilitate prompt release of reports to clinicians.

It is not essential that radiographic reports are typed, but it is essential that they are legible, so radiologists with poor handwriting should consider typing. In hospitals with electronic patient records, it is efficient to have radiographic reports entered directly into the hospital records system by the radiologist. For radiologists who prefer to dictate their reports, it is necessary either to have them transcribed by a typist or to use voice-recognition software. [5]

The descriptive part of the report

Descriptions of radiographic abnormalities depend on how we interpret what we see. There is no observation without interpretation. Depending on our interpretation, findings may be described at different levels in a hierarchy of terms: shadow; anatomy; pathology; and diagnosis. [6] At the most fundamental level, what we see in a radiograph is a variation in grey shades that represents the shadow cast by the patient placed in an x-ray beam. Lucent (dark) areas of the image represent parts of the body that have absorbed less of the x-ray beam than opaque (light) parts. [7] Hence "shadow", "lucency" and "opacity" are terms that we use when unable to confidently ascribe the appearance to anything more specific. When anatomic structures are recognised, it is usual to name them directly. Anatomic descriptions are the second level of radiographic interpretation. Alterations in anatomy may occur because of pathology, which is the third level.

Abnormal shadows, anatomy or pathology are described according to the contribution of one or more of the six categories of radiographic ("Roentgen") signs, namely number, size, shape, position, margination and opacity. Although this list sounds very basic, it encompasses all the possible ways in which the appearance of a radiograph may be abnormal. This list is a useful prompt for novices describing abnormalities. In addition, radiologists recognise characteristic combinations of radiographic signs – particularly shape and opacity – that have diagnostic significance. Well-known examples include the air bronchogram, extradural sign, ring around the artery sign and the meniscus sign (Figure 1).

Pathological terms used to describe radiographic findings may be basic or specific, again depending on our degree of certainty about what the images represent. For example, in some animals it may be necessary to limit our description to a basic level ("The cardiac silhouette is obscured"); in others, our understanding of the radiographic appearance may enable a more specific description ("There is lobar consolidation"); in the remaining cases, we may consider the combination of clinical history and the radiographic appearance to be diagnostic ("There is a fracture of the radius"). Diagnosis is the highest level in the hierarchy of radiographic findings. Although diagnosis is the usual aim, it is essential that the radiographic report contains no more inference than can be justified by the clinical history and the radiographic findings.

Most clinicians expect a report to include a description of the findings. [1,8] Studies have concluded that the preferred form of the radiographic report is a relatively detailed, itemised list. [9,10] Although it does not necessarily take any longer to read a prose report than an itemised report, [10] long complex sentences can be difficult to read and should be avoided. [11] Ideally, the most important findings will be described first and incidental findings last, so that the development of the report follows a logical sequence. [2] This aim is likely to be fulfilled routinely only if the radiologist completes the visual search of the radiographs and integrates their observations before starting to write the report.

The amount of description or detail provided in the report will vary according to the complexity of the radiographs. For example, a radiograph that appears normal or has a characteristic appearance is described more easily than a radiograph that has multiple, subtle, equivocal or bizarre findings. The length of a radiographic report tends to be inversely proportional to the confidence of the radiologist because the descriptive part of the radiographic report must address any uncertainties about the findings. When there is some uncertainty about the presence of an abnormality, it is usual to revert to the lowest level of the hierarchy terms and/or to qualify the description by with "possible", "suspected" or "equivocal". Use of such qualifying terms is best limited to one per sentence. [1]

Good radiographic reports communicate clearly by using correct terminology. Unfortunately, it is easy to find examples of outdated terminology, poor expressions and jargon in radiographic reports (Table 3). Acronyms are used routinely in practice and hence are acceptable in radiography reports [1], although

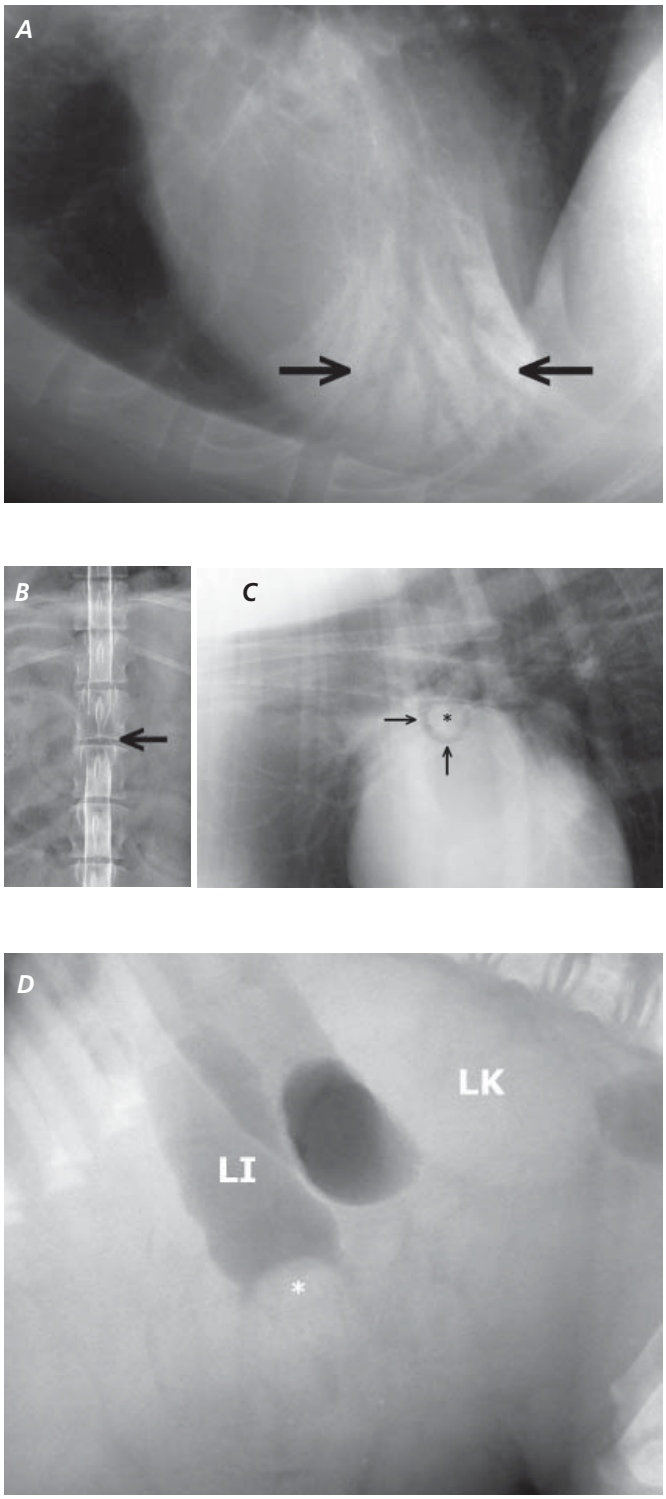


Figure 1. Examples of radiographic signs.
A) Air bronchogram (between arrows) in a dog with bronchopneumonia;
B) extradural sign (arrow) in a dog with intervertebral disc extrusion;
C) ring around the artery sign (arrows) in a dog with pneumomediastinum (, right pulmonary artery);*
D) meniscus sign in a puppy with intussusception (, tip of intussusceptum, LI, large intestine, LK; left kidney). D is reproduced from Lamb CR, Flynn T, Allen C. What is your diagnosis? (Ileocolic intussusception in a puppy). J Small Anim Pract 2005;46:357-358 with permission of Blackwell Publishing Ltd.*

misunderstandings sometimes occur when new staff members encounter local acronyms. Although eponyms are widely used in medical radiology (e.g. Barrett oesophagus, Zollinger-Ellison syndrome, Ménétrier disease, Meckel diverticulum, Hirschsprüng disease – all affecting the alimentary tract in humans [12,13]), they obscure rather than elucidate the diagnosis. Hence eponyms should be either avoided in radiographic reports or accompanied by the relevant pathological description.

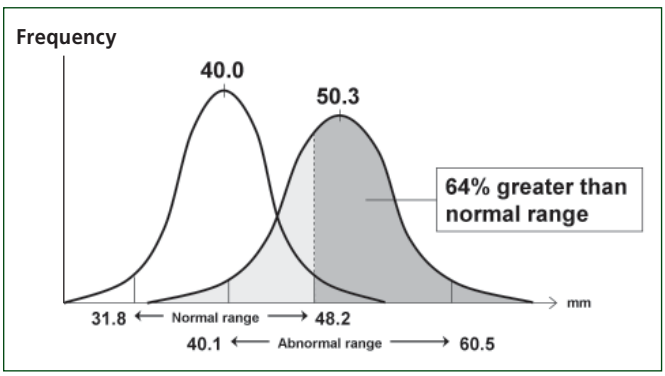
Under-reading is the error that occurs when a radiographically visible lesion is not observed by the radiologist. [14] In contrast, under-reporting may be a deliberate act by a radiologist attempting to avoid serious repercussions for a patient with an equivocal or non-specific radiographic finding. For example, if a focal opacity is faintly visible superimposed on the lung of a dog with a mammary mass, it might be reported in purely descriptive terms, avoiding the label "pulmonary nodule" that could be assumed to represent a metastasis. Obtaining additional radiographs at a later date is an appropriate response to many equivocal findings.

When interpreting a new set of radiographs of a patient that has been examined repeatedly, reviewing the previous radiographs facilitates new observations, and may enable more specific diagnosis. [15] Reviewing previous radiographs is more useful than just reading the previous report. [15,16]

Is it necessary to record measurements?

It is possible to measure radiographically many organs and structures to supplement the descriptive part of the report and, in animals having repeated radiography, comparing previous measurements provides objective evidence of the effects of disease or treatment. In animals having orthopaedic procedures, such as correction of angular limb deformities or fracture fixation, measurements can help describe the severity of the condition. Intuitively, it seems likely that making radiographic measurements will increase our ability to detect disease; however, this is not true. The normal ranges for linear measurements of most thoracic and abdominal viscera are very wide. [17-20] As a result, radiographic measurements have limited sensitivity for changes in organ volume (Figure 2). Subjective assessments of organ size

Figure 2. Illustration of the effect of doubling of renal volume on feline renal length. Data are hypothetical and distributed Normally with plausible mean and standard deviation (SD). Range equals mean ±2 SD. Assuming that kidneys enlarge symmetrically, the mean renal length increases from 40mm to 50.3mm when volume doubles, but length exceeds the normal range in only 64% of kidneys.



Archaic	
• X-ray plate	Radiographic images have not been produced on plate glass for nearly 100 years!
Jargon	
• Dye	Iodinated radiographic contrast media are colourless
• Cardiac waist	In normal animals, there is no symmetrical narrowing of the cardiac silhouette that could be described as a waist
Incorrect nomenclature	
• Anterior, posterior	Quadripeds do not have anterior or posterior aspects; they have cranial & caudal, dorsal & palmar/plantar [30]
• Hip fracture	Joints *luxate*; bones *fracture*
• Fracture of the ileum	!
• Inhomogeneous	Should be replaced by *hetero*geneous
• Mild	This is a functional term; *slight* is the preferable term for size or quantity
Unclear meaning	
• Prominent	Prominent in what way? e.g. protruberant, enlarged or more opaque?
• Atypical	Caution: if this word is mistyped or mistranscribed, it can become *a typical,* which reverses the meaning.

Table 3. Examples of poor terminology in radiographic reports

and objective measurements tend to have similar accuracy [21], hence there is little to be gained from making measurements. One of the few useful radiographic measurements is maximal small intestinal luminal diameter, which can be used to predict intestinal obstruction in dogs. [22]

Ending the report

The concluding remarks of a radiographic report are best labelled "interpretation" or "reading". Other terms have been used but are considered less suitable. [23] "Diagnosis" may be an appropriate heading when the radiographic findings are considered pathognomonic, but in most cases it will be the primary clinician or a pathologist that determines the diagnosis with the radiographs providing supporting evidence.

If the radiographs appear normal, it is acceptable to conclude by simply stating "Normal". Concluding with less categorical statements, such as "No obvious abnormality" leaves some doubt in the reader's mind that there might be a subtle abnormality that the radiologists are keeping to themselves. Similarly, it is not a good idea to conclude a normal study with "No significant abnormality identified" because the determination of what is significant may depend on multiple factors other than the radiographs.

Radiography is invariably done with the aim of answering some clinical question(s) about the patient. This question should be known when the radiographs are made and it should be addressed, if not answered, in the conclusion of the radiographic report [1,3], even if the radiographs appear normal, for example, "Normal; no signs of pulmonary metastasis." This helps reassure the primary clinician that their concerns about the patient have been considered.

Frequently there are signs of breed-associated variations in conformation or age-related conditions that are unrelated to the clinical signs. "Study within normal limits" is medicolegal jargon that intends to convey that the appearance of the radiograph, although not perfect, represents nothing more than the imperfections that might be expected in a patient of this breed, age etc. "Normal for this breed" is a useful concluding statement for patients (e.g. chondrodystrophoid dogs) that have congenital abnormalities typical of their breed but no radiographic signs that elucidate the clinical condition currently under investigation.

Estimating the probability of diagnosis

"The best radiologist is not the one who is always the most certain but the one who most accurately conveys the degree of uncertainty inherent to each case…" [24]

The effect of any useful diagnostic test – including radiography – is to modify the probability that our patient has the disease or condition we seek and it is desirable that radiographic reports conclude with a sensible estimate of the probability of specific diagnoses; however, there are major difficulties with this objective. For example, the terms that clinicians use to communicate the perceived frequency or likelihood of disease are very imprecise. [25] As a result, there is a great deal of overlap in the frequencies implied by clinicians using terms such as frequent, infrequent, probably, possibly, rarely or common (Figure 3). It is evident that frequency terms mean different things to different people, and hence there is great potential for misunderstandings to occur if these terms are used in the conclusion of a radiography report. Ideally these terms should be replaced by numbers, and we should calculate the probability of a diagnosis following radiography (the post-test probability) using the prevalence (the pre-test probability) and the accuracy of the test. [26,27] However, it is difficult even for experienced clinicians to produce precise numerical estimates of prevalence,

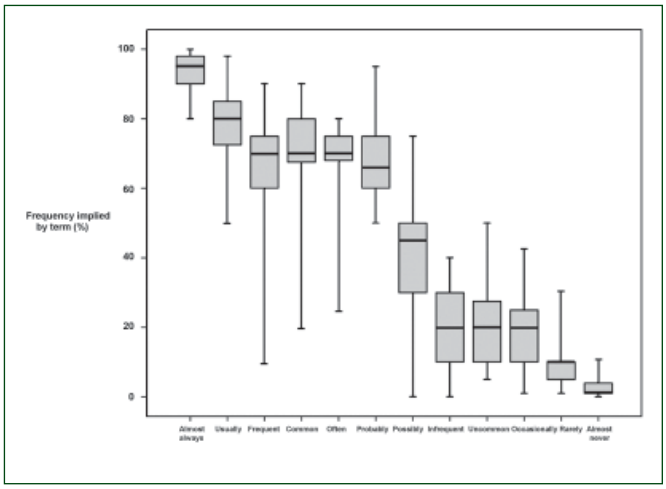


Figure 3. Box plot showing distribution of frequencies implied by terms used by 55 small animal clinicians. [25] Bold horizontal lines indicate median; boxes indicate interquartile range; vertical lines indicate full range. There are such wide variations in the frequencies implied by clinicians using these terms that most ranges overlap. Reproduced from Lamb CR. Statistical briefing: describing frequency. Vet Radiol Ultrasound 2007;48:89-90 with permission of Blackwell Publishing Ltd.

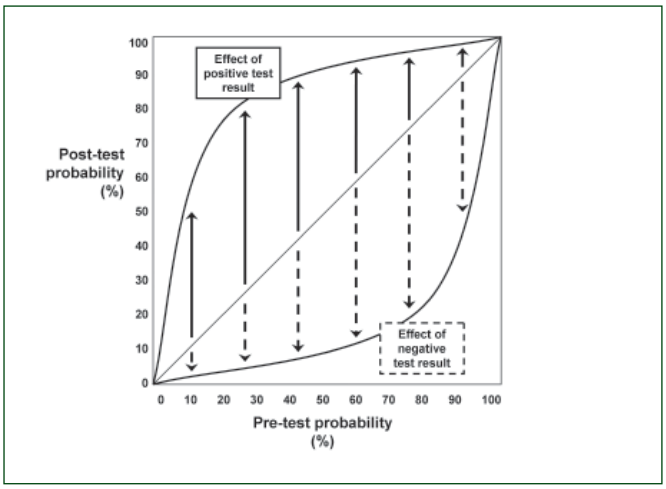


Figure 4. In a graph that plots post-test probability against pre-test probability, the effect of a diagnostic test may be described using two curves (one for a positive result and one for a negative result). The degree to which a test result changes the probability of disease (vertical arrows) is progressively reduced as pre-test probability approaches zero or 100%. This graph represents a relatively accurate diagnostic test (sensitivity 90%, specificity 90%); for a less accurate test, the curves will lie closer to the line of equality.

[28], and for most radiographic procedures the accuracy is not known. This makes it impossible to calculate numerically the probability of a diagnosis following radiography in the majority of our patients.

Given these difficulties, a more feasible objective may be to assess whether the results of radiography are likely to have *affected* the probability that our patient has disease. Rather than attempt to calculate this, it is possible to visualise graphically the effect of a test result. In a graph that plots post-test probability against pre-test probability, the effect of a test result is described by two curves (one for a positive result and one for a negative result) (Figure 4). The more accurate the test, the further these curves are pushed away from the line of equality towards the corners of the graph. For tests with high specificity, a positive result greatly increases the post-test probability of disease, whereas for tests with high sensitivity, a negative result leads to a marked decrease in the post-test probability of disease. [27] The effect of a test result is progressively reduced as pre-test probability approaches zero or 100%. This is an important effect: it means that if it is either very unlikely or highly likely that our patient has the disease before we make any radiographs, that probability may be little changed afterwards. [29] Conversely, the results of radiography tend to have the greatest effect on the probability of disease when the pre-test probability is in the middle of the range.

Making recommendations for further testing

When the person writing the radiographic report is also the primary clinician responsible for the patient, they are likely to have a balanced view of the role of radiography in the diagnostic work-up, be able to decide rationally if further testing is necessary, and be aware of what facilities for further testing are available. When the person writing the radiographic report is a radiologist working with limited clinical information, they should be cautious about recommending further testing that may prove to be inappropriate for a variety of reasons. [1] Superfluous suggestions may be resented and, conversely, some clinicians may feel pressured to act on recommendations because of medico legal considerations rather than concerns for their patient.

References

[1] HALL (F.M.) - Language of the radiology report: primer for residents and wayward radiologists. *Am J Roentgenol,* 2000,**175**:1239-1242.

[2] FRIEDMAN (P.J.) - Radiologic reporting: structure. *Am J Roentgenol,* 1983;**140**:171-172.

[3] BLAIS (C.), SAMSON (L.) - The radiologic report: a realistic approach. *Can Assoc Radiol J,* 1995;**46**:19-22.

[4] STEELE (J.L.), NYCE (J.M.), WILLIAMSON (K.B.), *et al.* - Learning to report. *Acad Radiol,* 2002;**9**:817-820.

[5] RANA (D.S.), HURST (G.), SHEPSTONE (L.), *et al.* - Voice recognition for radiology reporting: is it good enough? *Clin Radiol,* 2005;**60**:1205-1212.

[6] FRIEDMAN (P.J.) - Radiologic reporting: the hierarchy of terms. *Am J Roentgenol,* 1983;**140**:402-403.

[7] THRALL (D.E.) - Opacity and density. *Vet Radiol* 1986;**27**:162.

[8] McLOUGHLIN (R.F), SO (C.B.), GRAY (R.R.), *et al.* - Radiology reports: how much descriptive detail is enough? *Am J Roentgenol*, 1995;**165**:803-806.

[9] NAIK (S.S.), HANBIDGE (A.), WILSON (S.R.). - Radiology reports: examining radiologist and clinician preferences regarding style and content. *Am J Roentgenol* 2001;**176**:591-598.

[10] SISTROM (C.L.), HONEYMAN-BUCK (J.) - Free text versus structured format: information transfer efficiency of radiology reports. *Am J Roentgenol,* 2005;**185**:804-812.

[11] SIERRA (A.E.), BISESI (M.A.), ROSENBAUM (T.L.), *et al.* - Readability of the radiologic report. *Invest Radiol,* 1992;**27**:236-239.

[12] KANNE (J.P.), ROHRMANN (C.A.) Jr., LICHTENSTEIN (J.E.) - Eponyms in radiology of the digestive tract: Historical perspectives and imaging appearances: Part I. Pharynx, esophagus, stomach, and intestine. *Radiographics,* 2006;**26**:129-142.

[13] KANNE (J.P.), ROHRMANN (C.A.) Jr., LICHTENSTEIN (J.E.) - Eponyms in radiology of the digestive tract: historical perspectives and imaging appearances. Part 2. Liver, biliary system, pancreas, peritoneum, and systemic disease. *Radiographics,* 2006;**26**:465-480.

[14] RENFREW (D.L.), FRANKEN (E.A.) Jr., BERBAUM (K.S.), *et al.* - Error in radiology: classification and lessons in 182 cases presented at a problem case conference. *Radiology,* 1992;**183**:145-150.

[15] AIDEYAN (U.O.), BERBAUM (K.), SMITH (W.L.) - Influence of prior radiologic information on the interpretation of radiographic examinations. *Acad Radiol,* 1995;**2**:205-208.

[16] WHITE (K.), BERBAUM (K.), SMITH (W.L.) - The role of previous radiographs and reports in the interpretation of current radiographs. *Invest Radiol,* 1994;**29**:263-265.

[17] LEE (R), LEOWIJUK (C.) - Normal parameters in abdominal radiology of the dog and cat. *J Small Anim Pract,* 1982;**23**:251-269.

[18] FEENEY (D.A.), THRALL (D.E.), BARBER (D.L.), *et al.* - Normal canine excretory urogram: effects of dose, time, and individual dog variation. *Am J Vet Res,* 1979;**40**:1596-1604.

[19] VAN BREE (H.), JACOBS (V.), VANDEKERCKHOVE (P.) - Radiographic assessment of liver volume in dogs. *Am J Vet Res,* 1989;**50**:1613-1615.

[20] BUCHANAN (J.W.), BUCHELER (J.) - Vertebral scale system to measure canine heart size in radiographs. *J Am Vet Med Assoc,* 1995;**206**:194-199.

[21] LAMB (C.R.), TYLER (M.), BOSWOOD (A.), *et al.* - Assessment of the value of the vertebral heart scale in the radiographic diagnosis of cardiac disease in dogs. *Vet Rec,* 2000;**146**:687-690.

[22] GRAHAM (J.P.), LORD (P.F.), HARRISON (J.M.) - Quantitative estimation of intestinal dilation as a predictor of obstruction in the dog. *J Small Anim Pract,* 1998;**39**:521-524.

[23] ORRISON (W.W.), NORD (T.E.), KINARD (R.E.), *et al.* - The language of certainty: proper terminology for the ending of the radiologic report. *Am J Roentgenol,* 1985;**145**:1093-1095.

[24] GUNDERMAN (R.B.) - Education and the art of uncertainty. *Radiology,* 2005;**237**:801-802.

[25] LAMB (C.R.) - Statistical briefing: describing frequency. *Vet. Radiol. & Ultrasound,* 2007;**48**:89-90.

[26] GROSS (R.) - Making medical decisions. Philadelphia: *American College of Physicians*, 1999.

[27] SACKETT (D.L.), STRAUS (S.E.), RICHARDSON (W.S.), *et al.* - Evidence-based Medicine: How to Practice and Teach EBM. 2nd ed. Edinburgh: *Churchill Livingstone*, 2000.

[28] ATTIA (J.R.), NAIR (B.R.), SIBBRITT (D.W.), *et al.* - Generating pre-test probabilities: a neglected area in clinical decision making. *Med J Aust,* 2004;**180**:449-454.

[29] JOHNSON (M.R.), GOOD (C.D.), PENNY (W.D.), *et al.* - Lesson of the week: Playing the odds in clinical decision making: lessons from berry aneurysms undetected by magnetic resonance angiography. *BMJ,* 2001;**322**:1347-1349.

[30] SMALLHOOD (J.E.), SHIVELY (M.J.), RENDANO (V.T.), *et al.* - A standardized nomenclature for radiographic projections used in veterinary medicine. *Vet. Radiol.*, 1985;**26**:2-9.