Use of radiography in small animal practice in the UK and Republic of Ireland in 2013

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Abstract

Background: Radiography is an essential diagnostic tool in small animal practice. A major transition is currently underway from film-screen to digital systems. However, there is limited published research detailing the use of radiography in practices in the UK and Republic of Ireland (ROI).

Aim: To describe the uptake of digital radiographic systems, wider aspects of radiographic practice and use of other diagnostic imaging techniques in the UK and ROI.

Design: A cross-sectional study using paper and online questionnaires.

Participants: Veterinary surgeons, veterinary nurses and veterinary radiographers working in small animal practice in the UK and ROI were eligible to participate in the survey.

Results: Seventy-five per cent of respondents worked in practices using digital radiography systems. Cost appeared to be the largest barrier to digital conversion. Chemical restraint was used on 86% of cases, however 3% of cases were reported to be restrained by hand. Thirty-one percent of respondents had not received specific training in radiation safety. Ultrasonography was reportedly now widely utilised on a regular basis.

Conclusions: These results provide useful information on the use of radiography and additional diagnostic imaging techniques in the UK. These results should be used to indicate future training requirements, particularly to improve radiation safety.

Introduction

Radiography is an important diagnostic tool that is used daily in the majority of small animal veterinary practices (Johnson 2013, Ewers 2007). In human medical practice, diagnostic imaging examinations are performed according to specific, evidenced protocols (Kelly and Toomey 2015, Pekmezci and others 2015, Compagnone and others 2013, Redlich Hoeschen and Doehring 2005). However, in veterinary practice only generic recommendations are available (Thrall 2013, Ewers 2007, Lavin 2007, Caine 2009). An exception is radiation safety, which is controlled by legislation and for which there are strict, mandatory guidelines (HSE 1999, BVA 2002).

Limited research has been undertaken focusing on how radiography is used in veterinary practice. Most recent studies have concentrated on specific areas, such as radiation safety or image quality (Barber and McNulty 2012, Ewers and Hofmann-Parisot 2000).

A study of aspects of the use of veterinary radiography in small and large animal practice was performed 25 years ago (Dennis 1992). At this time, there was a major technical change with the transition from manual to automatic chemical processing of film radiographs. Veterinary imaging is currently undergoing another such major change with the transition from film-screen (FSR) to digital radiography (DR). Digital radiography systems comprise computed radiography (CR) and direct digital radiography (DDR) systems. With CR, the radiographic image is captured using an imaging plate, usually placed in a cassette that is exposed similarly to a film cassette in FSR. After exposure, the cassette is placed into a processor unit, where the plate is removed, and read to produce the image displayed on the screen. In DDR, the detector produces an electrical output on exposure to radiation, without the need for a processing unit, and the image is displayed directly on the screen. There are two main types of DDR systems, based on either a charge coupled device detector or a flat panel detector (either indirect or direct) (Widmer 2008). The advantages of DR over FSR are well recognised, including increased exposure latitude, speed and ease of processing, ability to post-process images and digital storage and distribution (May Deer and Dackiewicz 2000, Peer and others 2002, Cowen Kengyelics and Davies 2008, Barneveld Binkhuysen and Ranschaert, 2011). In addition to the transition to DR, the use of additional imaging technologies in veterinary practice is increasing, such as ultrasonography, computed tomography (CT), magnetic resonance imaging (MRI) and teleradiology (Johnson 2013).

The aim of this study was to describe the uptake of digital radiographic systems, wider aspects of radiographic practice and use of other diagnostic imaging techniques in the UK and ROI.

Materials and Methods

Questionnaire

The target population was practicing veterinary surgeons, veterinary nurses or veterinary radiographers working in small animal practice in the UK or ROI at the time of the study.

A questionnaire was developed comprising 5 sections: radiographic working practices, radiographic workload, types of processing system, use of additional imaging modalities and respondent demographics. The questionnaire contained 27 closed and 1 open-ended question and took approximately 10 minutes to complete. Sixteen questions related to the use of diagnostic imaging, 7 to respondent demographics and 4 to follow-up preferences. To optimise clarity, avoid leading terminology and minimise ambiguity, questions were constructed using published recommendations (Dohoo and others 2003).

Pre-testing of the paper-based questionnaire was carried out with 3 veterinary surgeons and 2 veterinary nurses. Pre-testing of the online questionnaire was carried out by 22 persons (8 veterinary surgeons, 3 veterinary nurses, 3 trainee veterinary nurses, 1 radiographer and 7 participants did not specify their job role). After minor typographical and lay-out adjustments, the questionnaire was finalised for distribution.

The questionnaire was distributed using a number of methods including mixed-mode survey design (utilising both paper-based and online methods) (Edwards and others 2002) to attempt to increase the response rate. The online version was created using a proprietary survey tool (SurveyMonkey, Palo Alto, USA).

A cover letter was included explaining the purpose of the study and offering the option of entering a £100 prize draw for an online high-street retailer as an incentive.

Between October and November 2013, 700 paper questionnaires were distributed to participants at meetings in the UK, including: the British Veterinary Nursing Association (BVNA) conference, British Veterinary Dermatological Society (BVDSG) autumn meeting, European Association of Veterinary Diagnostic Imaging - British and Irish Division (EAVDI-BID)/ Small Animal Medicine Society (SAMSoc) autumn meeting and the British Small Animal Veterinary Association (BSAVA) Certificate in Small Animal Medicine course. Eight practices local to the University of Nottingham also participated. This distribution was selected by convenience sampling with the meetings falling within the study period (Dohoo and others 2003). Questionnaires were completed at the events or practice contacts submitted the replies.

The link to the online questionnaire was open between 11 October and 13 November 2013 and was distributed by email to 2758 veterinary practices, and to staff at the University of Nottingham for participation or forwarding to potential respondents. Emails were personally addressed except in the case of 79 practices where ‘contact us’ forms on the practice website were utilised. Three hundred and fifty-eight emails were returned unsent. The principal sampling frame was the Royal College of Veterinary Surgeons (RCVS) register of members. The register incorporates practicing, non-practicing and retired individuals who have provided consent for their details to be passed to external providers for marketing or research purposes. Requests were also made to the BSAVA affiliate groups for distribution to members, of which EAVDI, SAMSoc, Veterinary Cardiology Society and BVDSG responded. The link was also placed on online forums through contacts made at the aforementioned events, and advertised through media release by Vision Media (VN Online, MRCVS Online and Vet Times) and on a social networking site (Facebook).

Responses were excluded from analysis if the respondents did not work in the UK and ROI, did not undertake small animal work or did not complete any of the diagnostic imaging questions.

Data analysis

A datasheet was created using Microsoft Excel 2010 (Microsoft, Redmond, USA) and questionnaire responses either manually entered from paper-based questionnaires or downloaded via Survey Monkey.

Descriptive statistics were produced and statistical significance ($p<0.05$) was evaluated using Chi-squared tests on categorical variables using Microsoft Excel 2010 (Microsoft, Redmond, USA). Responses were analysed for individual respondents as well as for groups, e.g. job title and type of practice worked in.

For four questions, it was possible to select more than one answer; in those cases, the cumulative proportions could exceed 100 per cent.

Ethical approval

Ethical approval for the project was granted by the ethics research committee of the School of Veterinary Medicine and Science at the University of Nottingham. Information for participants was included at the start of the questionnaires and consent was implied by participation. All responses were treated anonymously.

Results

Respondent demographics

The questionnaire was returned by 1224 respondents between October and November 2013, with 66% (812/1224) completing the survey online and the other 44% (412/1224) on paper. Some respondents did not answer all survey questions. The denominator given in the results below relates to the number who responded to the question being considered. The response rate for the paper-based survey was 59% (412/698). It was not possible to determine the response rate for the online component as the questionnaire was distributed through open routes such as web links. One hundred and twenty-two responses were excluded leaving 1102 responses available for analysis.

Responses were received from across the UK and ROI, although only 15 (1%) stated they worked in the ROI. The largest responding group who indicated their job role reported they were veterinary surgeons (598/1077; 56%), followed by veterinary nurses (469/1077; 44%). Respondents stated they most commonly worked in first opinion practice (822/1068; 77%), eight per cent (89/1068) in referral only practice and the remaining 15% (157/1068) in practices offering first opinion and referral services. The reported median time from graduation was 9 years (range 0 – 52 years) and 78% (840/1078) of respondents stated they were female. Thirty-seven per cent (397/1063) of respondents indicated they had completed Continuing Professional Development (CPD) on radiography, whereas 57% (602/1063) stated they had no active interest in radiography. Only six per cent (64/1063) stated they possessed or were working towards a certificate or diploma in veterinary diagnostic imaging or a diploma in advanced veterinary nursing (including imaging).

Type of processing system

Digital radiography was reportedly used by 75% (827/1097) of respondents at the time of the survey, 28% (304/1097) stated a film-based system and three per cent (37/1097) indicated they used both. The most common digital system reported was CR used by 67% (736/1097) of respondents, with an increasing proportion of DDR as the referral work load increased (FIG 1).

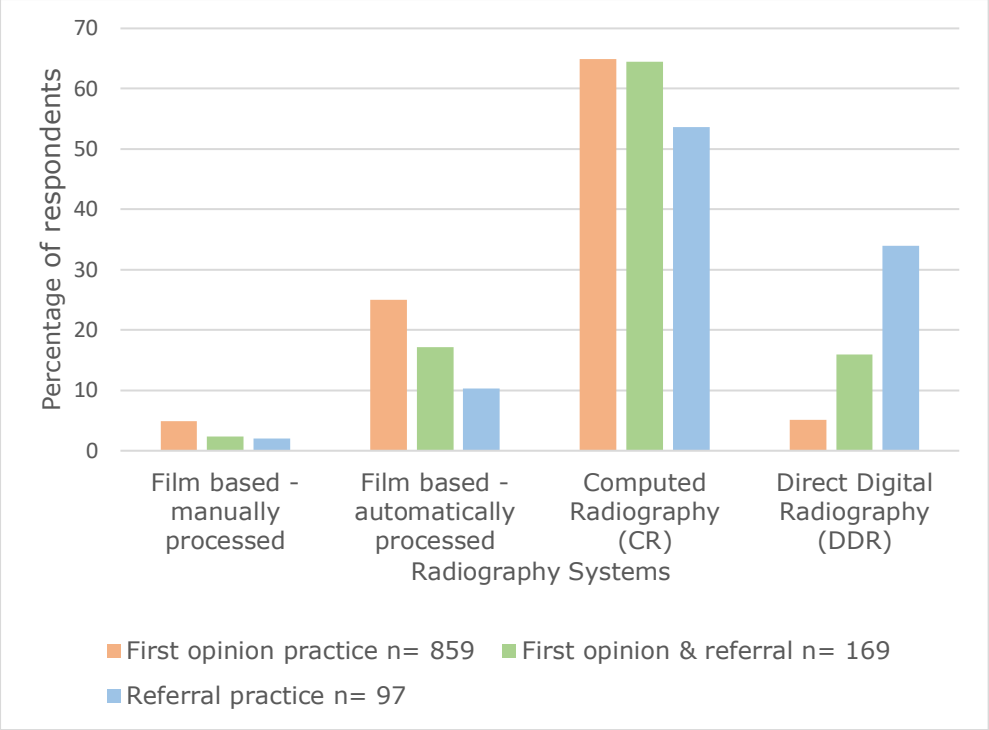

Fig 1: Type of radiography used by respondents, who specified their practice type (1074/1097), in a questionnaire-based survey of UK and ROI veterinary professionals about radiography. More than one type of radiography could be selected.

Users of digital systems were asked which brand of unit they used. However, of those that responded to this question, 45% (363/815) did not know, making it impossible to obtain a meaningful measure of the most popular brands.

Sixty-nine per cent (181/263) of respondents working in practices currently using film-based systems reported the practice had considered changing to digital radiography. Eighty-one per cent (214/263) included cost in their reasons for not yet changing (TABLE 1). "Other" reasons cited included potentially better radiographic quality with FSR compared to some DR systems, or the practice was to change to DR soon.

TABLE 1. Barriers identified to changing to digital radiography from a film-screen system (n=263).

Reason for remaining with a film-screen system	percentage of respondents
Cost	81.4
Space	14.8
Limited understanding of digital systems	9.1
Availability	2.3
Other	16.0
Don't know	9.1

n=263. More than one reason could be selected.

Of those respondents using film-based systems, 85% (258/304) indicated the use of automatic processing but manual processing was still reported by 16% (49/304). Of those respondents using

digital radiography, 83% (670/808) reported its use for 5 years or less, with referral practices reportedly moving to digital earlier than those involved in first opinion work (FIG 2).

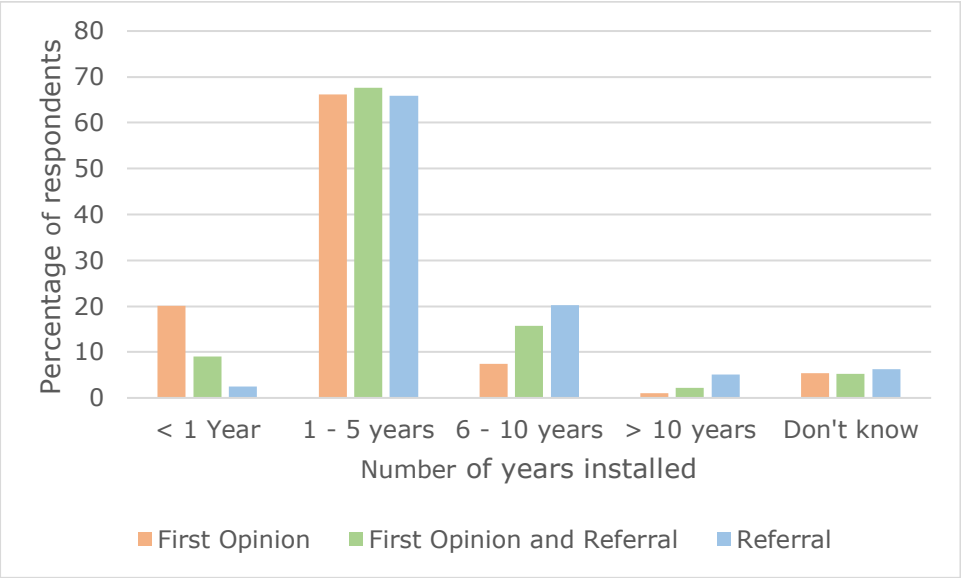

FIG 2. Number of years practices were reported to have been using digital radiography, compared by practice type, by respondents who specified their practice type in a questionnaire-based survey of UK and ROI veterinary professionals about radiography, (n=808).

Radiographic working practices

Respondents stated that in their practice veterinary surgeons took the majority of radiographs (477/808; 59%) followed by veterinary nurses (259/808; 32%) and trainee veterinary nurses (48/808; 6%). Ninety per cent of respondents indicated they performed radiography themselves, with the modal number of cases radiographed per week being two, with 83% (800/965) of respondents radiographing less than five cases per week.

On average, 50% of patients were reported as radiographed under general anaesthesia with 36% under sedation. Three per cent of patients were reported to be conscious and manually restrained, with 10% (114/1099) of respondents indicating that 10% or more of cases were manually restrained in their practice. In referral only practice, more sedation and less general anaesthesia or manual restraint was reported compared with those engaged in first opinion work (FIG 3).

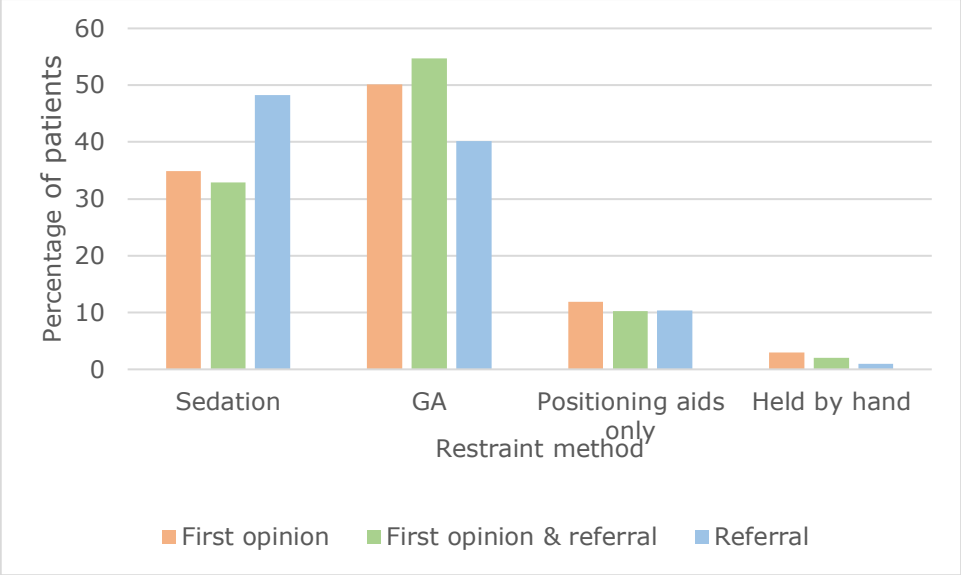

FIG 3. Average percentage of patients reportedly restrained using sedation, general anaesthesia (GA) and manual restraint methods, compared by practice type, by respondents who specified their practice type in a questionnaire-based survey of UK and ROI veterinary professionals about radiography, (n=1075).

The majority of staff indicated they had received radiation safety training whilst working in their current practice (753/1098; 69%). However, 41% (244/596) of veterinary surgeons, 22% (77/358) of veterinary nurses and 12% (13/109) of trainee veterinary nurses responded that they had not received safety training.

Forty-four per cent of staff using digital radiography reported they had received training on its use, with the manufacturer/supplier being the most common source of instruction (362/823). Eleven percent (91/823) indicated no training and only two per cent (16/823) stated they had attended CPD on digital radiography (FIG 4).

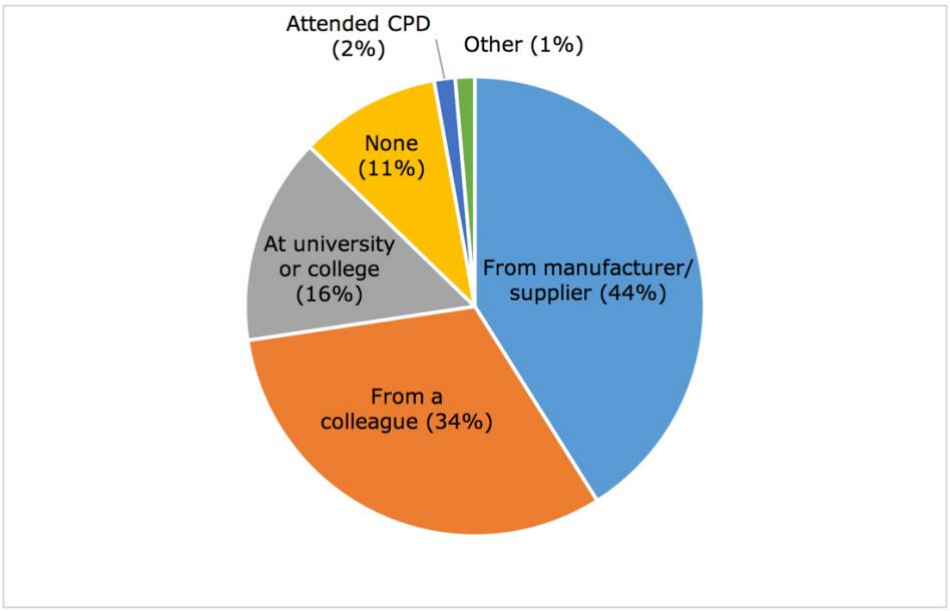

FIG 4. Training sources on digital radiography reported by respondents in a questionnaire-based survey of UK and ROI veterinary professionals about radiography, (n=823). More than one option could be selected. (CPD = Continuing Professional Development.)

Sixty-eight per cent of respondents (660/973) reported they needed to repeat radiographs due to inadequate image quality for 1 in 5 cases or less, whilst 7% (65/973) repeated radiographs for 1 in 2 cases. Significantly more repeat radiographs were reported when using film as opposed to digital systems (chi-squared; p=0.035). Significantly fewer repeats (chi-squared; p=0.001) were reportedly taken in those practices involved in referral work compared to first opinion only. Trainee nurses took significantly more repeat radiographs than other staff types (chi-squared; p=0.002).

Fifty-seven per cent (557/978) of respondents indicated they used an exposure chart specifically developed in the practice and 53% used exposures from a similar patient in the practice log (516/978) to determine exposure factors to use. Nineteen per cent (186/978) reportedly decided on these from memory, some or all of the time (FIG 5).

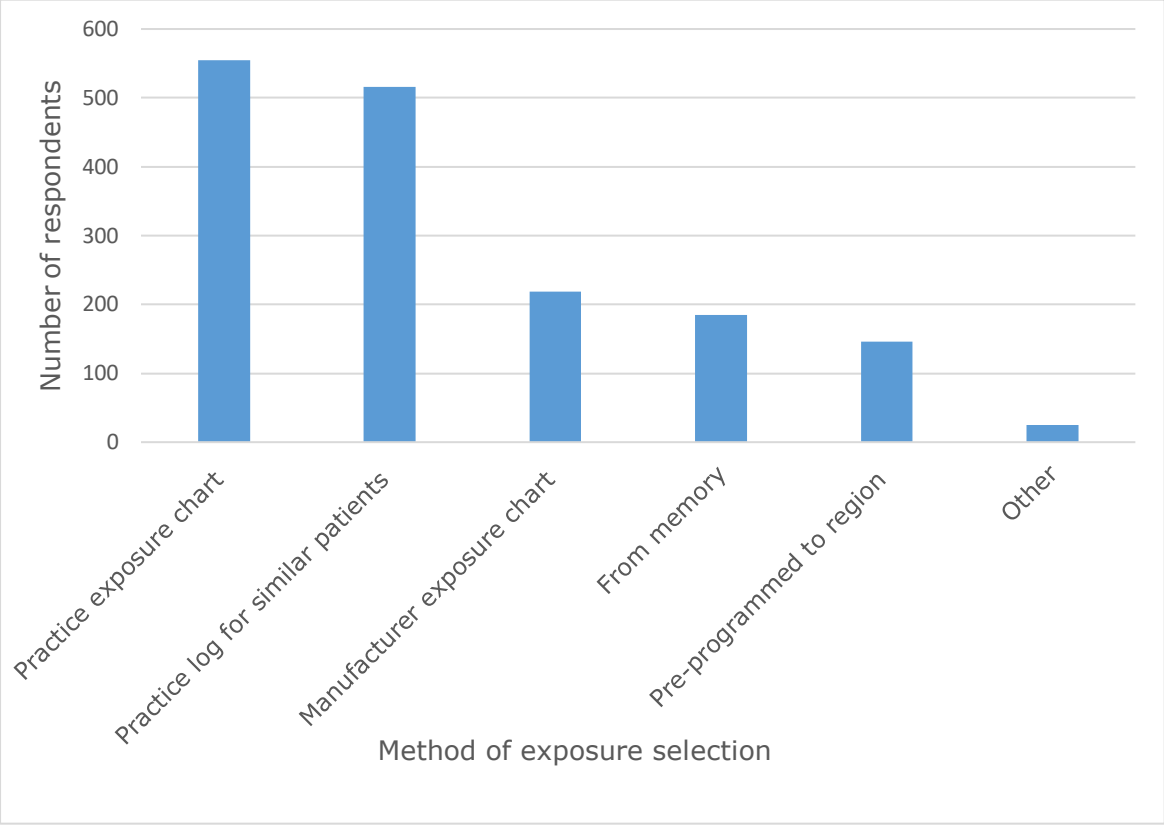

FIG 5. Method of radiographic exposure factors selection in a questionnaire-based survey of UK and ROI veterinary professionals about radiography, (n= 978). More than one option could be selected.

Overall, 29% (240/820) reported that they did not use a Picture Archiving and Communication System (PACS), including 36% (211/592) of all respondents from first opinion practices, 14% (19/133) of first opinion/referral practice respondents and 5% (4/79) of respondents from solely referral practices.

When working up cases, 81% (782/969) of respondents found the radiographs they took very useful and 17% (169/969) quite useful (FIG 6).

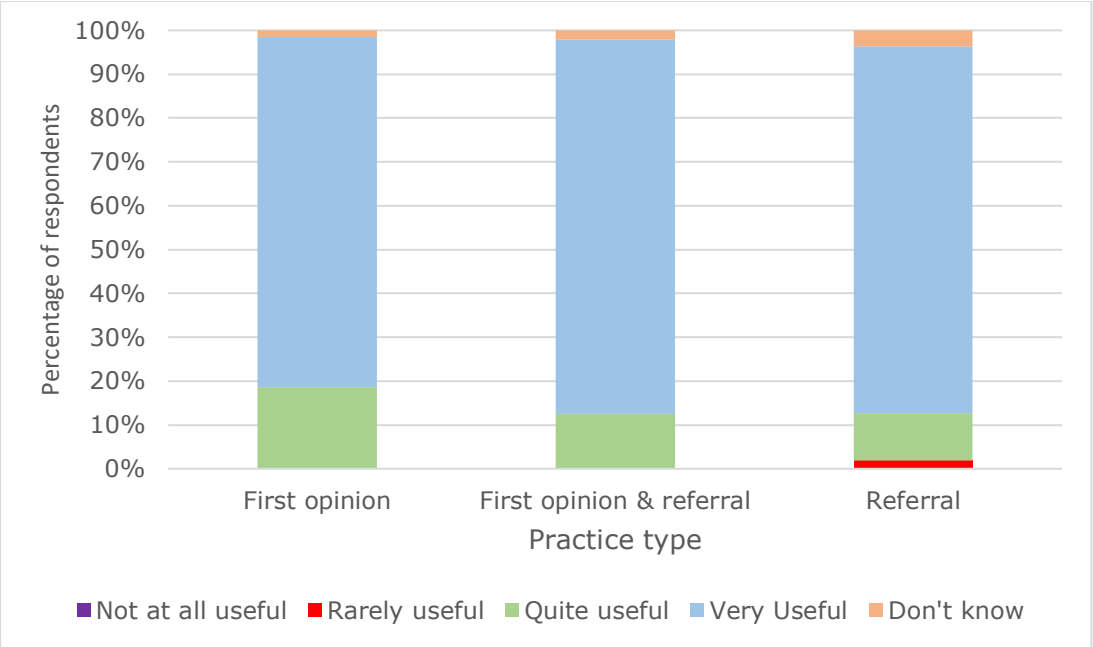

FIG 6. Perceived usefulness of the radiographs taken by respondents when working up a case, compared by practice type, by respondents who specified their practice type in a questionnaire-based survey of UK and ROI veterinary professionals about radiography, (n= 969).

Additional imaging modalities used

Ninety-five percent (1045/1102) of respondents reported use of additional imaging modalities in their practice, with ultrasonography the most commonly used (1025/1102; 93%). Of those indicating ultrasonography, 86% (878/1025) stated it was used 'at least once monthly'. A visiting ultrasonographer was reported by 12% (135/1102) of respondents, computed tomography (CT) by 10% (112/1102), in-house magnetic resonance imaging (MRI) by 9% (99/1102), visiting MRI by 5% (55/1102) and teleradiology by 4% (45/1102). In first opinion only practice, 81% (668/821) were reportedly using ultrasonography at least once monthly, with two per cent (45/821) using a teleradiology service.

Discussion

The methodology used in the study resulted in a large number of total respondents (1224). The response rate to the paper-based survey of 59% was above the average response rate of 54% quoted by Nulty (2008). The demographic of the respondents indicates that a reasonably representative sample of those undertaking imaging in small animal practice was obtained, including practice types (RCVS 2014). However, the very low response rate from the ROI indicates that these results are not representative of practices in this country. As more than half of respondents stated they had no active interest in radiography, the results represent a significant perspective from "non-specialists". Although Dennis' (1992) study was on a smaller scale, there were similar findings as only 38% had an active interest in radiography.

This study indicates that the transition to DR was advanced at the time of the survey, with 75% of respondents stating they used this technology and with most migration occurring in the previous 5 years. Computed radiography systems were reported as more commonplace than DDR, with 67% of respondents working in practices using this system. Information as to why this was the case was not collected as part of the present study. However, findings from other studies suggest some likely reasons. The start-up and maintenance costs of CR systems are lower than DDR due to the technology involved. Also, CR cassettes can easily be incorporated into existing radiographic equipment and, if a plate was to malfunction, it can be replaced without the need for specialised equipment or service company callout, unlike for a malfunctioning DDR detector (Körner and others 2007). In this study, direct digital radiography was more commonly reported in practices undertaking referral work. Although the cost of these systems is greater, DDR systems allow a higher throughput of radiographs, and may allow enhanced image contrast to be obtained or lower exposure factors to be used. As a result, these systems may be more appropriate in referral practices where the case load, charging structure and desire for optimum image quality could justify the higher purchase and maintenance costs (Widmer 2008, Drost 2011, Nelson Zekas and Reese 2012, Thrall 2013). However, it is important to recognise that there is considerable variation in the image quality achievable and cost between different CR systems and also different DDR systems (Thrall 2013). It is not true that all DDR systems are inherently superior to all CR systems.

Respondents indicated several barriers to changeover to DR with cost the most commonly cited issue. Space concerns were also cited as a reason for not changing over. This is somewhat surprising, as digital systems generally need less space than FSR, for example CR processors are relatively small and no darkroom is required. Some respondents stated they had not changed as film radiographs may have higher resolution than some digital systems. However, lower spatial resolution of digital systems does not make a difference to diagnostic usefulness in practice and therefore does not provide an adequate reason to choose one technology over the other (Alexander and others 2012, Bernhardt and others 1999, Kirchner and others 2001). This suggests further education and training in relation to DR would be useful to address these misconceptions.

Respondents reported they radiographed, on average, 2 cases per week and the majority considered these radiographs to be very useful, which is similar to the study by Dennis (1992). Significantly fewer repeat radiographs to improve quality were taken with DR than FSR. Repeating radiographic exposures due to poor image quality is a radiation safety issue due to the increased exposure used, and this contradicts the "As Low As Reasonably Practicable" (ALARP) principle that applies to radiographic exposure in the UK (HSE 1999). It also increases the time taken and costs of an examination and may compromise patient care. Reasons for taking repeat radiographs were not collected in this study. We postulate that this difference is due to the increased exposure latitude offered by digital technology. Radiographs taken with suboptimal exposure factors may be of

diagnostic quality with DR, whereas with FSR they may have had inadequate density or contrast. This advantage is widely described (Kirchner and others 2001, Caine 2009, Drost 2011, Nelson Zekas and Reese 2012, Johnson 2013, Thrall 2013). However, the requirements for the rest of the radiographic process, e.g. positioning, centring and collimation, remain the same, so good technique is still needed in these areas. Also, the radiation safety benefits may be less than expected from this result due to the increased exposure factors needed for some digital, particularly CR, systems compared to fast film-screen systems (Körner and others 2007).

Chemical restraint was reportedly used for radiography in the majority of cases. This is encouraging as appropriate chemical restraint improves the likelihood of obtaining good quality radiographs, and also improves the safety of the patient and personnel (Ewers 2007). Half of cases were restrained under general anaesthesia. Respondents were not asked the reasons for their choice, but anaesthesia may have been chosen because of operator preference, the particular study being undertaken or the likelihood of proceeding to surgery. Sedation was the second most popular choice, with use of positioning aids and manual restraint with a conscious patient being much less common. Future research into decision making for restraint for radiography would be useful, and the results could be used to help rationalise this choice and so improve radiographic quality and patient safety.

It was surprising that three per cent of cases overall were reported as hand-held, particularly in first opinion practice, with 10% or greater being reported by a significant number of respondents. Whilst this represents a significant reduction from the numbers reported by Dennis (1992), where 19% of practices held 25% or more cases and 3% held all cases, patients should not be manually restrained for radiography unless there is a clinical reason that contraindicates restraint by any other means. This should only occur in exceptional circumstances (BVA 2002). Manual restraint can significantly increase the amount of radiation exposure received by personnel holding the animal, which represents a safety hazard (Barber and McNulty 2012). The reasoning behind this restraint method was not assessed in this study, but we regard this result a real cause for concern. Furthermore, radiography of conscious patients may increase the risk of movement blur and other factors that could reduce image quality (Martin and Mahoney 2013).

Safe practices of radiographic work depend on adequate radiation safety training. Thirty-one per cent of staff reported they had not received this in their current job. This could be regarded as similar to the situation in Dennis' (1992) study, where 35% reported they did not have a very good knowledge of radiation safety. The practice is legally responsible to ensure all staff involved in work with ionising radiation are given sufficient training in radiation safety and protection (HSE 1999). Possible reasons for this reported lack are that employers may not feel the need to provide training to staff who have previously received this in another practice or who are already competent in radiography, or that they do not deliver this training at all. It is also possible that those responsible for this believe veterinary surgeons do not need training in this area due to their previous professional studies. It is particularly concerning that 21% of veterinary nurses and 12% of trainees stated they had not received any training in radiation safety. It may be that some of these respondents had received some instruction, but their perception was that formal safety training had not been delivered. These findings indicate that the appropriate training of staff, as outlined by guidelines and legislation (HSE 1999, BVA 2002) is not always provided. This is an important issue that needs to be addressed.

It is concerning that a significant number of respondents reported their practice did not use a PACS. It is possible that some respondents did not understand that the system they have in their practice was a PACS, although it was specified in the questionnaire that this related to any system allowing

archiving and distribution of images in the practice. Nevertheless, the results suggest that some acquisition systems were not being used with a system that backed up the data and allowed easy access to the images. This is a clinical governance concern as imaging files could be lost should there be an acquisition unit failure (Drost 2011).

With regard to additional imaging tools used, 94% of practices used ultrasonography and the majority of these used the modality at least monthly, including first opinion clinics. This finding supports the statement by Johnson (2013) that ultrasound was one of the most influential developments in veterinary practice in the past fifty years, and demonstrates a substantial rise in its use since the early 1990's when around 30% of practices utilised the technology (Dennis 1992). Ultrasonography is generally regarded as complementary to radiography as a diagnostic tool, including facilitating additional diagnostic and therapeutic techniques, such as fine needle aspiration or biopsy (Thrall 2013, Sammon and others, 2012). In this study, decision making regarding choice of imaging modalities was not investigated. Consequentially, the rationale used to make this choice is unknown. Further research in this area could be used to produce recommendations for better decision making regarding which imaging modality to use and to inform future training needs.

We recognise that the convenience sampling technique used may have introduced some bias. Some surveys were distributed through veterinary practices local to the University of Nottingham, as well as at specialist and non-specialist veterinary meetings (not all related to imaging). A significant proportion of the paper-based responses were returned from a small number of sources, e.g. BVNA Congress. However, the reasonably representative nature of the sample, as discussed above, suggests the impact of this is likely to be of little significance. It was not practicable to prevent the same person contributing more than once, although we would anticipate this is unlikely and so should only have a small effect on the results. Also, as is inherent with all questionnaire-based surveys, we cannot be sure that responses accurately reflect what happens in practice.

In conclusion, these results provide useful information on the use of radiography in small animal practice in the UK. Key findings include an apparently rapid changeover to digital radiography over the previous 5 years. Radiation safety concerns include a significant number of animals being reported as manually restrained for radiography and an apparent lack of radiation safety training in practices. Regarding other imaging modalities, many practices appear to be using ultrasonography regularly. These findings can be used to support future training initiatives. In particular, action should be taken to raise awareness of the importance of radiation safety training in practice, avoiding manual restraint, and developing understanding of alternatives for restraint. Also, CPD sessions could be developed that specifically target the technical aspects of digital radiography. These initiatives should lead to improved quality of digital radiographs, resulting in enhanced diagnosis, and improved radiation safety.

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