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DICOM Standard Conformance in Veterinary Medicine in Germany: a Survey of Imaging Studies in Referral Cases

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Abstract In 2016, the recommendations of the DICOM Standards Committee for the use of veterinary identification DICOM tags had its 10th anniversary. The goal of our study was to survey veterinary DICOM standard conformance in Germany regarding the specific identification tags veterinarians should use in veterinary diagnostic imaging. We hypothesized that most veterinarians in Germany do not follow the guidelines of the DICOM Standards Committee. We analyzed the metadata of 488 imaging studies of referral cases from 115 different veterinary institutions in Germany by computer-aided DICOM header readout. We found that 25 (5.1%) of the imaging studies fully complied with the "veterinary DICOM standard" in this survey. The results confirmed our hypothesis that the recommendations of the DICOM Standards Committee for the consistent and advantageous use of veterinary identification tags have found minimal acceptance amongst German veterinarians. DICOM does not only enable connectivity between machines, DICOM also improves communication between veterinarians by sharing correct and valuable metadata for better patient care. Therefore, we recommend that lecturers, universities, societies, authorities, vendors, and other stakeholders should increase their effort to improve the spread of the veterinary DICOM standard in the veterinary world.

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Introduction

In 1983, a joint committee was formed by the American College of Radiology (ACR) and the National Electrical Manufacturers Association (NEMA) [1–3]. In 1985, they published the ACR-NEMA Standards Publication No. 300-1985 with the goal of interoperability between diagnostic imaging modalities and connected systems, as well as improvement of workflow and efficiency in medical environments [1–3]. Since the publication of the currently valid version 3.0 of the DICOM (Digital Imaging and Communications in Medicine) standard in 1993, the committee released several supplements to address technological changes and adjust to new requirements [1–3]. DICOM is an open and cooperative standard that is adopted by most of the societies, vendors, and medical professionals and is also used in veterinary medicine [1, 3, 4]. Veterinary applications require additional identifying attributes, like definition of the owner, discrimination between the names of the owner and the animal, neuter status, radiofrequency identification (RFID) microchip number, species, breed, and breed registration number [4]. In 2006, the DICOM Standards Committee released a supplementary correction item to address the special needs in veterinary medicine and veterinary diagnostic imaging [4]. In recent years, there has been increasing availability and use of digital radiography in veterinary medicine [5]. Almost all vendors of diagnostic imaging equipment have incorporated the DICOM standard [3]. In veterinary referral cases, when a veterinary practitioner refers an animal patient to a veterinary clinic for further diagnostic imaging or treatment, the initial radiographs are usually transmitted on digital media (compact

disk, USB flash drive) or via email or cloud services [6–8]. Based on the growing proportion of digital imaging in the last decade, there is increasing exchange of digital imaging data and metadata between practices and clinics; teleradiology is also well established in veterinary medicine [9–11].

The DICOM standard describes attributes (data tags) used to store information belonging to the patient or the examination in the DICOM header (metadata). Each tag is characterized by two 4-character hexadecimal codes, for example "0010, 0020" corresponds to the patient ID. The "patient ID" is the primary hospital identification number. It should be unique within the institution and is an important attribute for patient data assignment and reconciliation. In many countries, each institution uses its own patient ID number [7]. The interchange of data between institutions can require the incorporation of the outpatient imaging studies into the local in-house PACS to improve workflow [7, 8]. The DICOM header of the external images needs to be changed to affiliate the external imported studies to the internal patient data [7, 8]. The veterinary DICOM standard further describes an "other patient ID," a number or code used to identify the patient. In animals, it is recommended to use the number of the microchip. This is an important additional identification tool using passive radio-frequency identification (RFID) technology [4]. The patient name tag consists of five components for human use—family name, given name, middle name, name prefix, name suffix—that are delimited by a circumflex mark (^). In order to avoid confusion and ensure compatibility to human software, veterinarians should not use the animals' name exclusively. Instead, the use of two components is recommended, responsible person family name combined with the animal patient name [4]. In addition to the patient name complex, the tag "responsible person" should contain the name of the owner and the tag "responsible person role" the value "OWNER" [4]. The "patient birthdate" must conform to the format "YYYYMMDD" [4]. "Patient sex" has to contain the enumerated values "M" = male, "F" = female, and "O" = other (or unknown) [4]. In veterinary medicine, five different categories are common: male, male-neutered, female, female-neutered, and other or unknown. Therefore, an additional tag "Patient sex neutered" contains the values "ALTERED" or "UNALTERED" [4]. Also, tags for patient species and breed are available [4]. Breed registry and breed registration number are useful for breeding animals [4]. In veterinary medicine, most imaging equipment and use of the DICOM standard are derived and adopted from human medicine [5]. Despite the fact that commonly available imaging equipment is DICOM conformant [1, 5, 10–15], it was our impression and the hypothesis of this study that the veterinary-specific identification tags of the DICOM standard [4] are not correctly or regularly used by most of the veterinarians in Germany. The goal of our study was to survey the veterinary DICOM standard conformance in Germany regarding the specific identification tags that should be used in veterinary medicine.

Materials and Methods

At the Clinic of Small Animal Surgery and Reproduction at the Centre for Clinical Veterinary Medicine at the Ludwig-Maximilians-University (LMU) (Munich, Germany), digital medical images sent in with referral patients, or for teleradiology interpretation, are primarily stored on a network-attached storage (NAS). If the external patient becomes an in-house patient, a copy of the images is transferred from the NAS into the clinic PACS. During the PACS import, the metadata in the DICOM header is adjusted using a DICOM worklist. This enables the assignment of patient images for comparison with follow-up studies. Based on this workflow, the DICOM header with the original DICOM metadata is still available on the NAS. The DICOM header of all external DICOM imaging studies that were submitted to the clinic and copied to NAS in the period between January 1, 2011 and December 12, 2015 were reviewed using the command line tools of the software DicomBrowser (Version: 1.5.2, Neuroinformatics Research Group, http://nrg.wustl.edu/). The software was used to generate a spreadsheet using the following command "DicomSummarize -c metadata-config-file.xml -v metadata.csv [directory_of_dicom_files]" (Source: http://nrg.wustl.edu/software/dicom-browser/instructions/batch-anonymizations/). The tags that were exported from the DICOM header were configured in the xml file. We configured the software to create a spreadsheet with the following tags: Study Instance UID, Institution Name, Patient's Name, Patient ID, Patient's Birth Date, Patient's Sex, Patient Species Description, Patient Breed Description, Breed Registration Number, Other Patient IDs Sequence, Responsible Person, Responsible Person Role, Patient's Sex Neutered, Modality, and Study Date. The resulting comma-separated value file (metadata.csv) was converted to an excel spreadsheet (Microsoft Office 2010) and data were grouped and sorted for further analysis. Duplicate Study UIDs and accidentally stored studies from our institution as well as studies with an empty modality tag and structured reports were removed to exclude studies not acquired on primary diagnostic imaging devices. Descriptive statistical analysis of the data was performed using SPSS (Version 23, IBM, 2015).

In addition to the recommended veterinary naming scheme "<Owner Family Name>^<Patient Name>," we also accepted additional naming schemes in this study. "<Owner Family Name, Owner Given Name>^<Patient Name>" was accepted as the additional given name does not influence the sorting. Sole use of the "<Patient Name>" was only accepted if the responsible person tag was filled in. Correctly completed

DICOM tags for patient sex, patient species, and patient breed were a requirement, whereas values for patient sex neutered, breed registry, breed registration number, and other patient's ID (microchip number) were not required.

Results

Initially, a total of 618 DICOM imaging studies were read. After the exclusion process, 488 DICOM veterinary diagnostic imaging studies remained for further analysis. The studies were generated in 115 different institutions with acquisition dates between 2002 and 2015. We found 285 (58.4%) radiographic, 128 (26.2%) computed tomographic, 56 (11.5%) magnetic resonance, 17 (3.5%) ultrasound, and 2 (0.4%) positron emission tomographic (PET) studies. The 488 studies originated from 308 different patients. There were 217 (70.4%) patients that had only one single imaging study, 51 (16.5%) patients had two, 21 (6.8%) patients had three, and 19 (6.2%) patients had more than three studies.

For the tag "patient's name," 236 (48.4%) studies were classified as conformant, while 87 (17.8%) studies were insufficient due to missing patient name and/or owner name. The patient name was available in 165 (33.8%) studies, but did not comply with the two component classification or contained non-tag conformant information. The data in tags "responsible person" and "responsible person role" fulfilled the DICOM criterions according to our definition in 71 (14.5%) studies, and 416 (85.2%) studies did not contain any values. There was one study where the field contained the institution name. The tag "patient ID" contained institutional identification numbers in 420 (86%) studies, 28 (6.7%) studies had modality generated ID's, 17 (3.5%) studies did not have any value, and 51 (10.5%) studies contained other non-tag conformant information (patient name, owners name, patient breed, or microchip number). In the tag "other patient's ID," none of the studies contained a value, but in 33 (6.8%) studies, the microchip number was encoded in other tags. The tag "patient's birth date" was completed correctly in 481 (98.6%) studies. Unrealistic birth dates (between the years 1700–1971) were found in six (1.2%) studies and one study (0.2%) did not contain any value. In the attribute "patient's sex," 239 (49%) studies contained value "M," 186 (38.1%) studies value "F," 52 (10.6%) studies value "O," and 11 (2.2%) studies did not contain any value. The "patient sex neutered" tag was completed in 53 (10.8%) studies. The tag "patient species description" was completed in 68 (13.9%) studies. Three hundred ninety-three (80.5%) studies did not include information about species, and in 27 (5.5%) studies, the species was encoded within other tags. The attribute "patient breed description" was correctly filled in 46 (9.4%) studies. In 88 (18%) studies, the breed was encoded in a wrong tag. The breed was not available in 354 (72.5%) studies. The tag "breed registration number" was correctly completed in three (0.6%) studies, and in seven (1.4%) studies, this information was available in other attributes. Figure 1 shows the results.

Altogether, 25 (5.1%) studies met the requirements to comply with the "veterinary DICOM standard" according to our definition in this study.

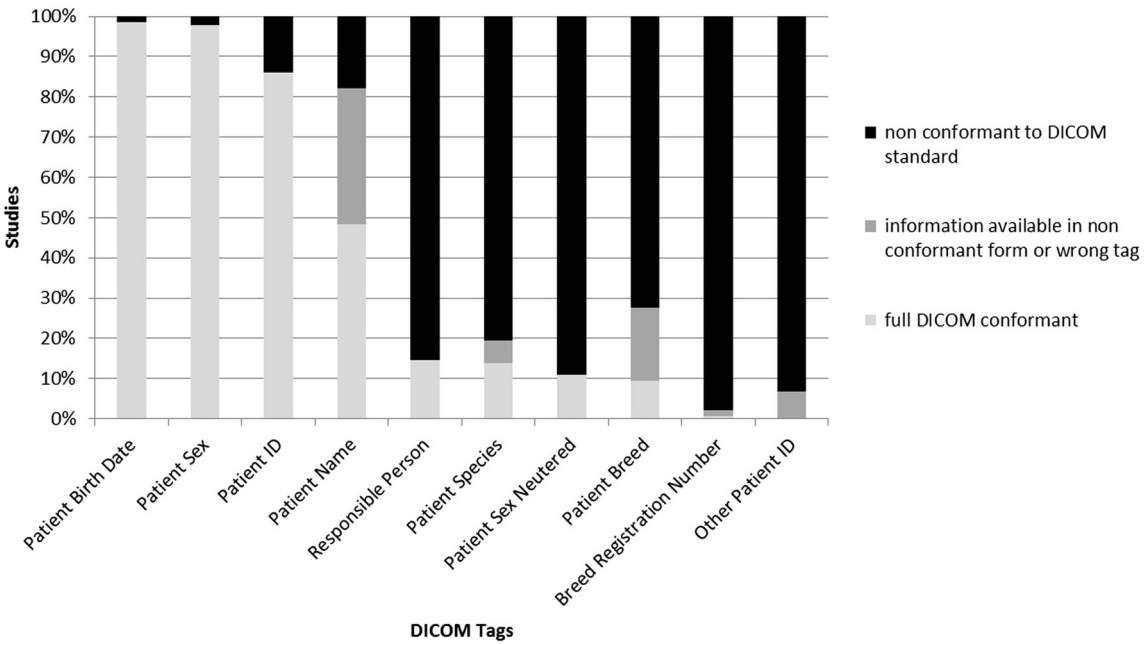

Fig. 1 DICOM standard conformance of selected DICOM tags in veterinary medicine

Discussion

We hypothesized that most veterinarians in Germany do not follow the guidelines of the DICOM Standards Committee regarding the use of veterinary identification tags, although the recommendations were previously published in 2006 [4].

In this survey, we found that only 25 (5.1%) of the analyzed 488 imaging studies of referral cases submitted from 115 different institutions to a German veterinary teaching hospital met the requirements to fully comply with the veterinary DICOM standard, supporting our hypothesis.

To the authors' knowledge, our study is the first comprehensive analysis regarding the use of veterinary identification tags in Germany. Compared to a human medicine caseload, 488 analyzed veterinary imaging studies are not a vast number, but institutions and case numbers are generally much smaller in veterinary medicine. Being a veterinary university referral center that receives first, second, and third opinion cases from small practices and large referral clinics, we consider these cases and numbers, and therefore, the results of this survey (at least regionally) representative for southern Germany. Instead of DICOM data, many veterinarians submit JPEG files. Due to the lack of metadata, we could not analyze JPEG images in our survey. Considering the clear-cut results, and the fact that DICOM studies came from 115 different institutions, we do not expect a relevant bias by the accumulation of cases from a single veterinary practice.

The high number of radiographic studies (58.4%) correlates to the high importance of radiography in veterinary diagnostic imaging. Additionally, there was a relatively high percentage of CT (26.2%) and MR studies (11.5%) that sum up to a proportion of more than one-third cross-sectional imaging studies. We speculate that cases undergoing these relatively expensive diagnostic procedures requiring general anesthesia in the veterinary patient more likely become referral cases than other study types. Animal owners that spend money for CT or MR are more likely willing to pay for second opinions and expensive treatments like surgery or radiation therapy. CT and MR are relatively new in veterinary diagnostic imaging and there is limited experience, which might also contribute to the high proportion in a referral center. It is uncommon to submit sonographic videos to our institution for second opinion. Inability to create diagnostic ultrasound videos, limited capabilities for interpretation of still ultrasound images, general reserve to exchange ultrasound images, or the lack of confidence in our interpretation skills could be various causes for the low proportion of ultrasound studies. The use of PET is negligible in veterinary medicine, which explains the insignificant numbers. The two cases originated from a single research study. We do not expect a significant bias, even if the surveyed referral studies do not accurately represent the distribution of diagnostic imaging modalities in veterinary medicine.

Our study does not answer, whether a lack of awareness, acceptance, or compliance causes the low DICOM conformance. In general, veterinary imaging equipment is technically DICOM conformant. The vendors have accepted the DICOM standard and DICOM imaging data are regularly produced. If veterinarians in Germany produce and transmit DICOM data, why do they not follow the recommendations for the DICOM identification tags? DICOM is a cooperative standard and there is no obligation to comply with the recommendations [1–4, 12]. In general, there are good reasons to follow the DICOM Standards Committee guidelines in human medicine, but these reasons might not apply to the situation commonly encountered in veterinary medicine. The exchange of imaging data and the improvement of workflow by interoperability between various imaging modalities, PACS, and Hospital Information System (HIS) is crucial in a veterinary research and teaching hospital, or in a large veterinary referral specialist center that covers radiography, ultrasound, CT, MR, and scintigraphy, but these factors might not play an important role in a small veterinary practice.

Another cause could be the lack of knowledge and awareness of the DICOM standard in the veterinary field in Germany. Currently, there are only a few veterinary radiologists in Germany and veterinary practitioners might not be familiar with the DICOM standard and veterinary identification tags. The information can be found in the internet, but a specific search is required. There are only a few DICOM-related publications for veterinarians in English [1, 10, 12, 15, 16], but the language barrier might be a problem. In the available literature, we could not find publications regarding the veterinary DICOM standard written in German. In addition, the DICOM standard plays an insignificant role in the curriculum for education and training of veterinary students. Currently, the DICOM standard is not even mentioned in the Bavarian and German syllabus for veterinary radiologists.

Looking at the results of this study, and given the fact that DICOM is the common denominator of all digital diagnostic imaging modalities [1–4, 12], we strongly recommend the incorporation of DICOM concepts into the curriculum of the vet schools at universities and the syllabus for veterinary radiologists. Veterinary societies should include the topic in continuing education and conferences and authorities in the guidelines for radiology and radiation safety courses. Analysis of valuable metadata offers a great chance for research [17–19]. In human medicine, automatic metadata readout from the DICOM header of imaging databases substantially improved the calculations of diagnostic reference levels for standard imaging examinations compared to the use of questionnaires [17–19].

We assume that it is not a lack of information which causes fragmentary or inconsistent image metadata. In the veterinary patient, the species should always be obvious and the breed information and neuter status are most often available and

regularly stored in the practice management system (PMS) or HIS. The same is true for the microchip number and breed registration number in breeding animals and diagnostic procedures that are relevant for breeding selection, e.g., radiographic screening for hip and elbow dysplasia. There are two common ways to adhere the patient data to the image data: manual input or the use of a DICOM worklist. Manual keyboard entry at the imaging modality is technically simple but cumbersome and error prone. Many digital imaging devices in veterinary medicine were adopted from human medicine; therefore, the graphical user interfaces are not specifically designed for veterinary use. Data entry masks therefore do not commonly offer input boxes for neuter status, species, breed, breed registration number, or microchip ID. Based on the low availability of these data in our survey, we assume that most veterinarians perform manual patient data entry at the imaging modality. Manual patient data entry could have caused the six (1.2%) studies with unrealistic birth dates [20, 21], but we did not analyze the typographic failure rate. Alternatively, the veterinarians could have used the owner's birthdate (e.g., 1971), or they purposely used an impossible year of birth (e.g., 1700). In human medicine, normally, the birthdate is known, and the input field for the birthdate is often a mandatory box on imaging equipment. In veterinary medicine, having shelter and foundling animal patients, the birthdate often is unknown. If the birthday field is a mandatory requirement, the operator can estimate the age of the animal or use an obviously artificial birthdate, e.g., 01.01.1700, to indicate that the birthdate of the animal is unknown. The use of the term "unknown" is not possible because the entry has to follow a specific format (YYYYMMDD). In veterinary diagnostic radiology, the patient characteristics, anamnesis, clinical findings, and laboratory results strongly affect the interpretation of imaging studies. There are many, and to some extent, significant disease dispositions for species, breed, age, sex, and neuter status [22]. Correct metadata are important and valuable for the interpretation of veterinary diagnostic imaging studies, especially when using teleradiology [1, 4, 6, 10, 12, 22, 23]. From a practical perspective, it is not an easy task, not routinely feasible, or not possible to customize the attributes in the DICOM header in a veterinary clinic. Therefore, vendors of veterinary imaging equipment should design their software more specifically for the needs of the veterinarians to allow manual input of species, breed, breed registration number, and microchip ID. Using a DICOM modality worklist, the veterinarian can easily, accurately, consistently, and quickly export the patient data from the PMS to the imaging modality, but initially, this requires technical adjustment and likely technical support [7, 20, 24]. To obtain consistent DICOM data, we strongly recommend the use of a DICOM worklist in veterinary practices and clinics. Most PMS/HIS provide an interface to pass patient data over a DICOM worklist server to the imaging devices. Even those modalities equipped with graphic user interfaces for human medicine are most often able to handle the given information and produce DICOM files that comply with the veterinary DICOM standard. For diagnostic procedures that are relevant for breeding selection, we recommend the use of the appropriate DICOM tags for microchip number and breed registration number.

Conclusion

As DICOM metadata contain valuable information, they are important to ensure the best patient care. Our results showed that the recommendations for the veterinary DICOM standard were followed by only 5% of the referral cases in our study. This proves our hypothesis that the use of veterinary identification tags has barely found conformance amongst German veterinarians. We highly encourage all relevant stakeholders, including lecturers, universities, societies, authorities, and vendors, to support and increase the use of veterinary identification tags.

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Compliance with Ethical Standards

Disclosure The authors report state no financial or other conflicts of interest related to this report.

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