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Quantitative Comparison of Computed Radiography and Film Radiography in Detection of Peritoneal Effusion in Dogs

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Abstract : The aim of this report is to compare quantitatively computed radiography (CR) and screen-film radiography (SFR) in the detection of peritoneal effusion in dogs. Normal four beagle dogs and one Maltese dog were used. Each five CR and SFR abdominal images of right lateral and ventro-dorsal position were obtained after lodge of 6 ml, 8 ml, 12 ml, 15 ml, and 18 ml of normal saline by intraperitoneal injection within the abdomen. The reviewers were asked to evaluate each SFR and CR images for the presence of peritoneal effusion using the score by the presence of a peritoneal effusion on a five-point ordinal scale. A receiver operating curve (ROC) analysis compared the two imaging modalities. The present study showed that there was no statistical difference between SFR and CR in the detecting peritoneal effusion, but CR was relatively more sensitive based on the increased area under its ROC analysis. Moreover, Readers were more likely to detect peritoneal effusion on CR images than SFR.

Key words **:** computed radiography, dog, peritoneal effusion, screen film radiography.

Introduction

Conventional film-intensifying screen radiography has been used for decades and has served the medical profession well (6). In an age of computers and digital data, it is no surprise that digital diagnostic imaging has become the standard in human medicine (6). Introduced in the 1980s by Fujifilm Medical Systems, computed radiography (CR) was initially limited to a few select veterinary colleges and specialty private veterinary practices because of high cost. As technology has evolved, more and more veterinary practices have replaced conventional film-screens with CR. Further development has led to veterinary-specific CR systems, making digital radiography more accessible than ever before (6).

CR is a filmless digital imaging technology where a photostimuable phosphor imaging plate, enclosed in a standard size cassette, is used instead of a film-screen combination (4). The exposed imaging plate is computer processed to create the image. As opposed to chemical development of conventional film, the computer processed image can be altered using post-processing software (4,6).

Post-processing image enhancement is based on spatial filtering, or alteration in image contrast or brightness, to increase visibility of image details (8). The linear response of CR allows diagnostic quality images to be acquired over a wide range of exposures, thereby decreasing the need for repeat examinations (1,4,6,8). This wide latitude offers a distinct benefit in parts of the body that have a wide range of subject contrast. These properties of CR increase its contrast resolution, accentuating differences between the opacity of tissues of different types (5).

A disadvantage of CR is that spatial resolution of the digital image is determined by matrix and pixel sizes. As a result, the spatial resolution of CR is inherently less than conventional film (11). However, the decrease in spatial resolution associated with CR is clinically insignificant and not great enough to hinder the detection of pathologic lesions (2,3,7,9,10,11).

Veterinarians often need to determine the presence of peritoneal effusion in the canine abdomen. Large quantities of abdominal fluid can be found on the physical examination. However, small quantities of fluid are difficult to detect. When confirmation of peritoneal effusion is required, conventional radiography has been established as the definitive way (9). In some reports, as little as 25 ml of injected peritoneal fluid (6% Macrodex) can be detected by conventional radiography in human (9). However, It is not known how small an intra-peritoneal fluid volume can be detected by conventional radiography and CR in animals.

And, with the increase in radiographic contrast that is inherent in CR and with the ability to post-process images, the sensitivity for detecting a small volume of peritoneal effusion may be increased relative to conventional film imaging.

This purpose of this study was to compare the detection of peritoneal effusion between conventional radiography (screen-

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film radiography ; SFR) and CR, and to find the quantitative dose of peritoneal effusion which could be detected by radiography.

Material and Methods

Animals

Four healthy beagle dogs and one Maltese dog were used. All dogs were handled according to the care and use guidelines of Veterinary Medical Center at Chungbuk National University. Prior to the administration of fluid into the abdominal cavity, each dog has no history and clinical signs of haematological and abdominal dysfunction based on complete blood cell count, serum chemistry, abdominal radiograph, and abdominal ultrasonograph.

Each dog was premedicated with subcutaneous injection of atropine 0.05 mg/kg (Atropine®, Daewon Pharm, Korea). After sedation induced with medetomidine hydrochloride (Domitor®, Pfizer, USA), a 20-gauge needle attached to a syringe was inserted into the caudal abdominal cavity. During sedation, continuous monitoring of heart rate and respiratory rate were performed.

With each dog in right recumbency, 6 ml, 8 ml, 12 ml, 15 ml, and 18 ml of normal saline were injected into the intraperitoneal space. After each injection, the images of computed radiography (Kodak CR 500 system, Eastman Kodak Company, Rochester, NY.) were obtained in standard right lateral and ventro-dorsal projections and then, were enhanced using standard computed imaging processing software (Kodak Directview CR500 system, Eastman Kodak Company, Rochester, NY.) that has functions such as contrast, brightness, filtration and zoom. The images stored in PACS server and were evaluated in the same clinical reporting room on 4 megapixel monitors (SyncMaster 305T, Samsung, Korea) and viewer program (e-Film, Merge Healthcare, USA).

The images of conventional radiographs (Lanex regular screen, Listem., Korea) were also obtained in standard right lateral and ventro-dorsal projections. And then, the images using conventional film chemical development (Kodak X-OMAT 2000, Eastman Kodak Company, Rochester, NY.) were evaluated in the same darkroom on view-box.

The SFR and CR images were evaluated without knowledge of injected fluid volume by five veterinarians in individual image reading session. Each dog's entire set of images were randomly numbered and evaluated from the other studies. Especially, on CR images, the veterinarians were able to adjust the images with brightness and contrast by post-processing. And then, The reviewers were asked to evaluate each SFR and CR images for the presence of peritoneal effusion using the score by the presence of a peritoneal effusion on a five-point ordinal scale (0 = no peritoneal effusion, 5 = definite presence of peritoneal effusion) (6).

Statistical analysis

Logistic regression analysis was used to investigate whether use of SFR or CR was predictive in reference to detection of fluid. A receiver operating curve (ROC) analysis was produced for each logistic regression and the area under the curve calculated for each of the desired comparisons. ROC statistical analysis was used to evaluate the differences in detecting fluid by SFR vs. CR between different amount of fluid. Statistical significance was set at $P < 0.05$.

Results

Based on the ROC analysis comparing SFR and CR, there was no significant difference in detection of peritoneal effusion ($P = 0.02$). However, based on the area under the curve, CR (0.760) is relatively more sensitive than SFR (0.744) for detecting peritoneal effusion (Fig 1).

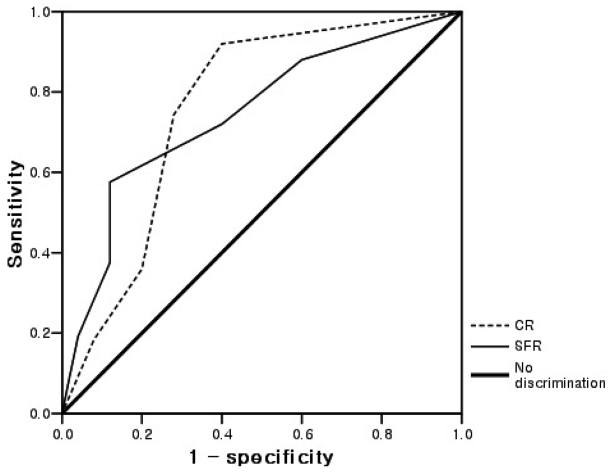

Fig 1. Receiver operating curve (ROC) comparing SFR and CR. there was no significant difference in detection of peritoneal fluid between SFR and CR. The area under the curve (AUC) for CR (0.760) is greater than for SFR (0.744).

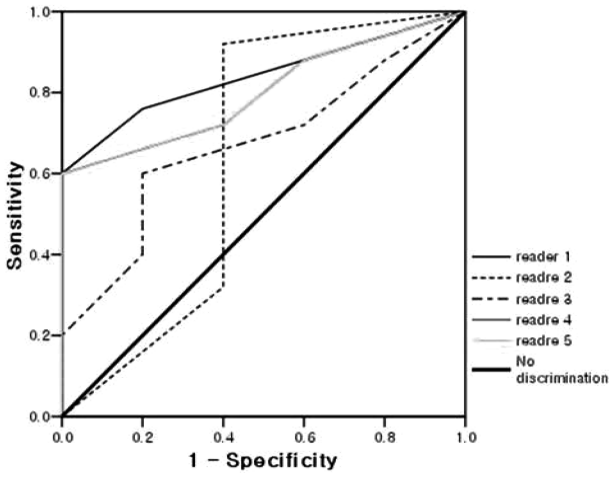

Fig 2. Receiver operating curve (ROC) for inter-reader variability when using SFR. There was no significant difference between reader 1,2,3,4 and 5.

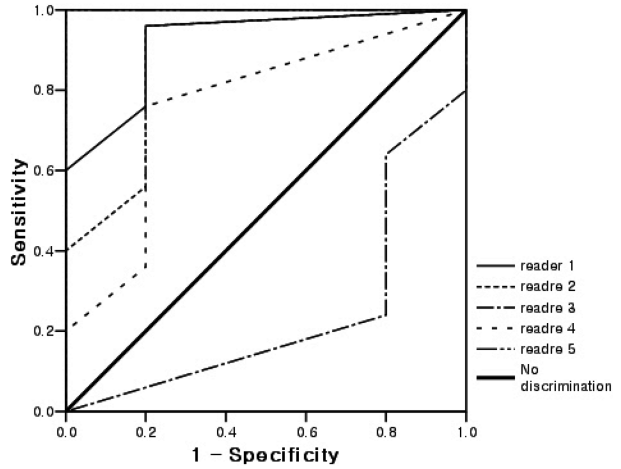

Fig 3. Receiver operating curve (ROC) for inter-reader variability when using CR. Reader 1 had significantly more sensitivity for detection peritoneal fluid than reader 2, 3, 4 or 5 ($P < 0.003$). Reader 2's aera under the curve (AUC) was 0.920 compared with 0.880, 0.240 and 0.760 for readers 1, 3, 4 or 5 respectively.

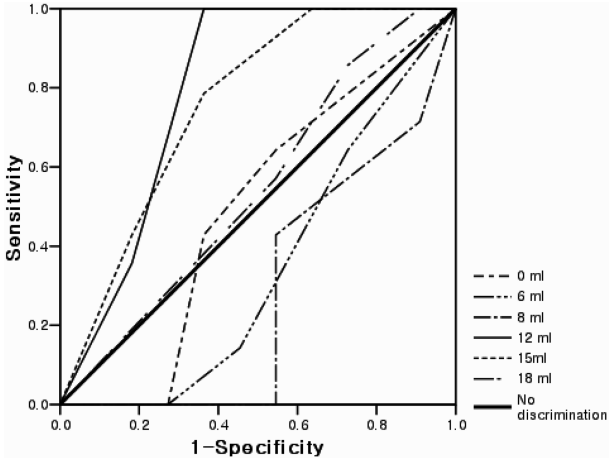

Fig 4. Receiver operating curve (ROC) for different amounts of injected fluid using SFR. There was increased accuracy in identification of 12 ml compared with 0, 6, 8, 15 or 18 ml.

Interobserver variability between veterinarians was evaluated for SFR and CR. For SFR, there was no statistical difference between reader 1, 2, 3, 4 and 5 (Fig 2). For CR, reader 5 had greater sensitivity for detection of peritoneal effusion than reader 1, 2, 3 or 4 ($P < 0.01$) (Fig 3). Table 1 list the sensitivities and specificities for each reader when evaluation SFR and CR (Table 1).

When comparing the ability of SFR and CR to identify different amount of peritoneal fluid, there was no statistical difference in detecting the different amounts of injected fluid. When using SFR, there was increased accuracy in identification of 12 ml compared with others ($P < 0.014$) (Fig 4). And, when using CR, there was also increased accuracy in identification of 15 ml compared with others ($P < 0.017$) (Fig 5).

Discussion

Digital radiography is probably the most important advance in veterinary imaging since the advent of diagnostic ultrasound (13). Over the past two decades, digital radiography

Table 1. Sensitivity/Specificity comparisons between reader 1,2,3,4 and 5 for CR and SFR

	Reader 1						Reader 2						Reader 3					
	0	1	2	3	4	5	0	1	2	3	4	5	0	1	2	3	4	5
CR sensitivity	96%	76%	60%	40%	20%	0%	96%	76%	56%	40%	20%	0%	80%	64%	44%	24%	12%	0%
CR specificity	80%	80%	100%	100%	100%	100%	80%	80%	80%	100%	100%	100%	0%	20%	20%	20%	60%	100%
SFR sensitivity	88%	76%	60%	40%	20%	0%	92%	72%	52%	32%	16%	0%	88%	72%	60%	40%	20%	0%
SFR specificity	40%	80%	100%	100%	100%	100%	60%	60%	60%	60%	80%	100%	20%	60%	80%	80%	100%	100%

	Reader 4						Reader 5					
	0	1	2	3	4	5	0	1	2	3	4	5
CR sensitivity	88%	76%	56%	36%	20%	0%	100%	80%	60%	40%	20%	0%
CR specificity	40%	80%	80%	80%	100%	100%	100%	100%	100%	100%	100%	100%
SFR sensitivity	88%	72%	60%	40%	20%	0%	88%	72%	60%	40%	20%	0%
SFR specificity	40%	60%	100%	100%	100%	100%	40%	60%	100%	100%	100%	100%

The 0,1,2,3,4,5 grading system utilized by each reader was ROC.

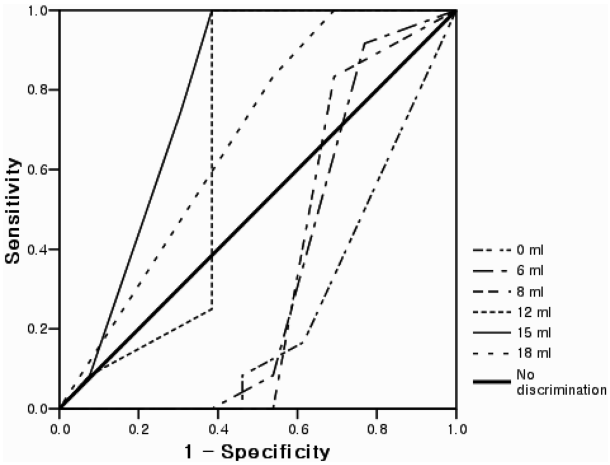

Fig 5. Receiver operating curve (ROC) for different amounts of injected fluid using CR. There was increased accuracy in identification of 15 ml compared with 0, 6, 8, 12 or 18 ml.

has largely replaced conventional radiography in human imaging center (13). Digital radiography is now commonly employed in veterinary teaching and referral hospitals, and in many private practices (13). However, whether it is more efficacious to use CR or SFR in the diagnosis of peritoneal effusion has been debated in the veterinary medicine.

We found no statistical difference between SFR and CR in the absolute detection of peritoneal fluid. However, based on ROC analysis, the greater area under CR curve compared with SFR suggests a relatively increased sensitivity in detecting peritoneal fluid, although not statistically different in this study.

When comparing the ability of SFR and CR to identify different amount peritoneal fluid, there was no statistical difference between SFR and CR. However, based on the data in table 1, there was a wide range of sensitivities and specificities between all readers at all points of the ROC curve. Proceeding from this fact, we could logically assumed that further studies comparing SFR and CR are warranted to evaluate the perceived and real benefits of image modality.

Several limitations were recognized before and during this study. The inter-reader variability during evaluation of the CR may have been related to reader experience. Furthermore, SFR or CR images were evaluated the non-specialized reader. However, as this study was a comparison of peritoneal effusion detection between SFR and CR, these limitations were equal for both imaging modalities.

As digital imaging is taking a more prominent role in veterinary medicine, studies are needs to ascertain the advantages and disadvantages of these systems. Current limitations of digital imaging systems are elevated start-up costs, adjustments of human patient designs to veterinary patients, storing and archiving capabilities of these system (5).

Summing up, the present paper showed that there was no statistical difference between SFR and CR in the detecting peritoneal effusion, but CR was relatively more sensitive based on the increased area under its ROC curve. Moreover, readers were more likely to detect peritoneal effusion on CR images than SFR.

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개에서 실험적으로 복수를 유발한 후, 컴퓨터 촬영술과 필름 촬영술을 이용한 복수량의 정량적 비교

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요 약 : 이 연구의 목적은 개에서 실험적으로 복수를 유발한 후, 컴퓨터 촬영술과 필름 촬영술을 실시하여 복수의 정량적인 비교를 한 것이다. 건강한 4 마리의 비글견과 1 마리의 말티즈 견을 사용하였으며, 각 개체마다 무균적으로 복강 내로 멸균 생리 식염수를 6 ml, 8 ml, 12 ml, 15 ml, 그리고 18 ml 을 주입하였으며, 우외측상과 복배상으로 컴퓨터 촬영과 필름 촬영을 실시하였다. 총 5명의 평가자에게 복수량에 따른 컴퓨터 촬영 사진과 필름 촬영 사진을 보였주었으며, 각 사진마다 복수량에 따라 5 가지의 점수를 순차적으로 평가하도록 하였다 (0 = 복수 없음, 5 = 중등도의 복수가 있음). 5명의 평가자가 평가한 데이터를 이용하여 ROC 분석 방법을 이용하여, 두 진단 모델간의 민감도와 특이도를 평가하였다. 이 연구를 통해, 복수의 양을 평가하는데 있어 두 진단 모델간의 유의적인 차이는 보이지 않았다. 그러나 RCO 분석 방법을 통해, 컴퓨터 촬영술이 필름 촬영술에 비해 민감도가 상대적으로 높았으며, 각 평가자 간에도 복수의 양을 평가하는데 있어, 상대적으로 컴퓨터 촬영술이 우위인 것을 알 수 있었다.

주요어 : 컴퓨터 촬영술, 개, 복수, 필름 촬영술