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Comparison of Direct Digital Radiography and Conventional Film Screen Radiography for Detection of Peritoneal Fluid in Dogs

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Abstract : This study was performed to evaluate the sensitivity of conventional film-screen radiography (CFSR) and direct digital radiography (DDR) for detection of various amounts of free peritoneal fluid. Ten adult male healthy beagles were used in this study. Radiographic examinations were performed in the right lateral and ventrodorsal positions. Fluid was injected in increments of 2.0 ml/kg of body weight up to 20.0 ml/kg of body weight. The images of CFSR and DDR were evaluated by two veterinary radiologists for evidence of abdominal fluid without knowledge of injected fluid volume. Data were evaluated by using the receiver operation curve (ROC) analysis and the area under the curve (AUC). There was no significant difference in detection of peritoneal fluid between DDR and CFSR in the ROC analysis. The accuracy of CFSR (0.805) was relatively higher than that of DDR (0.733), based on the ROC analysis and AUC. AUC of CFSR was higher in most injection doses. These results suggest that CFSR is more accurate than DDR for the detecting peritoneal fluid. Therefore, for situation in which digital radiographs are equivocal or small amount of fluid is suspected, other imaging modalities, such as ultrasonography would be helpful for determining the presence of fluids.

Key words **:** direct digital radiography, film-screen radiography, abdominal effusion, dog.

Introduction

Conventional film-screen radiography (CFSR) remains widely used in veterinary medicine, however the transformation to digital radiography (DR) is currently underway, and film-screen will likely become obsolete (1,11,17). Advantages of DR compared to traditional CFSR cause these changes. The main advantage of DR is the separation of image acquisition, processing, and display, allowing optimization of each of these stages. Computer processing can improve image quality by changing the overall contrast and brightness of images, as well as image manipulation such as edge enhancement and smoothing. These manipulations are mostly beneficial, although there is a potential for image degradation if incorrectly implemented (1,8,11,17).

Studies about comparison between CFSR and DR for imaging quality of thorax, abdomen, and skeletal systems have been reported in human (4,12,16) and veterinary medicines (10). In some studies, DR was superior to CFSR for detecting of small sized lesions (10,12), while other studies reported that no difference was found between DR and CFSR (2). In one study (10), there is no significant difference between computed radiography (CR), a kind of DR, and CFSR in detecting free abdominal air, but overall CR was relatively more sensitive. However, the study for how these characteristics of DR, such as improving image quality, affect on the evaluation of peritoneal fluid that brings decreased abdominal details is insufficient.

The purpose of this study was to evaluate the sensitivity of CFSR and direct digital radiography (DDR) for detection of various amounts of free peritoneal fluid.

Materials and Methods

Ten male, beagle dogs (mean age: 3 years) in weight from 9.8 to 14.0 kg were studied. Physical examinations, complete blood count, serum biochemical analysis, thoracic and abdominal radiography, and ultrasonography were performed to evaluate the health status of each dog. Food was withheld for 24 hours before experiment.

For taking CFSR and DDR, the dogs were premedicated with atropine (0.04 mg/kg, SC, Atropine sulfate inj.®, Jeil, Korea) and sedated with medetomidine (0.01-0.03 mg/kg, IV, Domitor®, Pfizer Animal Health Korea, Korea) and midazolam (0.1-0.3 mg/kg, IM, MIDACUM Inj.®, Myung Moon, Korea). The medetomidine was reversed using atipamezol (0.04-0.12 mg/kg, IV, Antisedan®, Pfizer Animal Health Korea, Korea) after the examinations.

Radiography was performed in the right lateral and ventrodosal positions. One-minute interval was allowed between positional changes for the fluid to redistribute. Film-screen

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radiographs were taken by using a 3-phase X-ray unit with X-ray film (Medical X-ray film general Purpose Green®, Kodak, USA) and screens (X-Omatic Lanex regular screen®, Kodak, USA), and speed for film-screen combination was 400. Digital images were obtained by using a direct digital X-ray imaging machine (XPLORER-900®, Medien international co., Ltd., Korea) and displayed on an interactive electronic workstation monitor (HP L1910®, HP, USA).

Radiography was performed prior to the administration of fluid (Sodium Chloride CJ Inj. 0.9%®, CJ, Korea) into the cavity on each animal. An indwelling catheter attached to 3-way valve was inserted into the peritoneal cavity, near umbilicus, and fluid was injected in increments of 2.0 ml/kg of body weight up to 20.0 ml/kg of body weight.

All the images of CFSR and DDR were collected, randomized, and assigned a number from one to 110 by an independent source. Each radiograph was analyzed by two veterinary radiologists for evidence of abdominal fluid using the following criteria: 1) overall loss of the abdominal visceral detail; 2) poor visualization of the abdominal visceral silhouettes, including the hepatic angle; 3) increased distance between segments of bowel loops; 4) floating of gas-containing bowel loops; and 5) distention of the abdominal cavity (14).

The direct digital images were evaluated without knowledge of injected fluid volume in individual reading sessions at a single workstation. The readers were able to adjust the images with post processing option as desired. Conventional film-screen radiographs were evaluated without information of injected fluid volume in individual reading sessions. The radiologists evaluated the presence or absence of free peritoneal fluid on each image. A grading system from 1 to 4 was used; 1indicating definite absence of fluid, 2 representing probably not presence of fluid, 3 indicating probably presence of fluid, and 4 indicating definite presence of fluid.

Data were evaluated by using the receiver operating curve (ROC) analysis and the area under the curve (AUC).

Result

Based on the ROC comparing DDR and CFSR, there was no significant difference in detection of peritoneal fluid between DDR and CFSR (Fig 1). However, the accuracy of CFSR (0.805) was relatively higher accuracy than DDR (0.733), based on the ROC analysis and AUC.

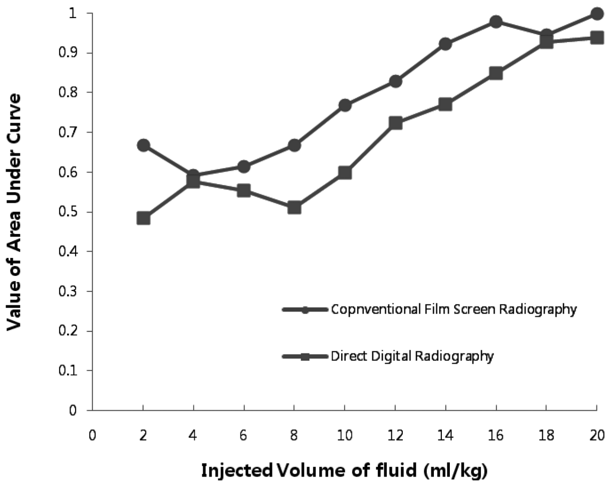

Fig 2. Values of area under the curve in the direct digital radiography and conventional film screen radiography resulting from each dose.

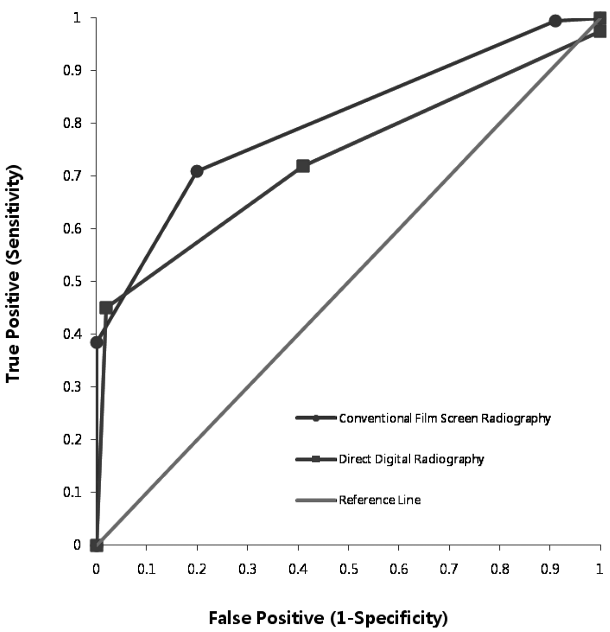

Fig 1. Receiver operating curve comparing direct digital radiography and conventional film screen radiography.

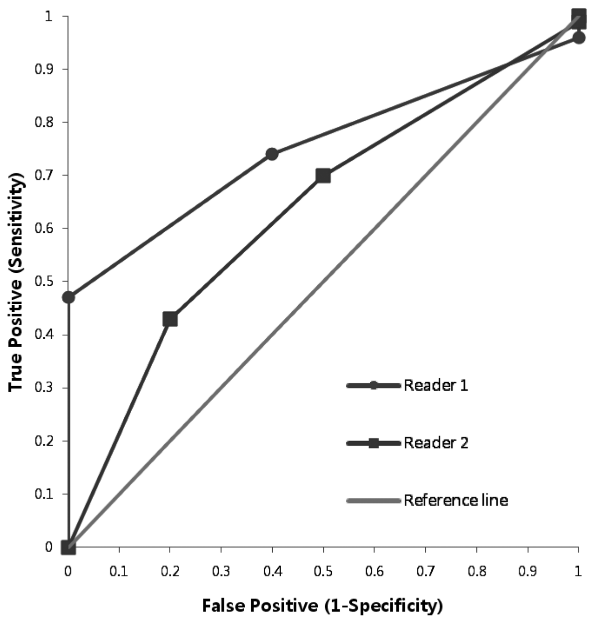

Fig 3. Receiver operating curve for inter-reader variability using direct digital radiography.

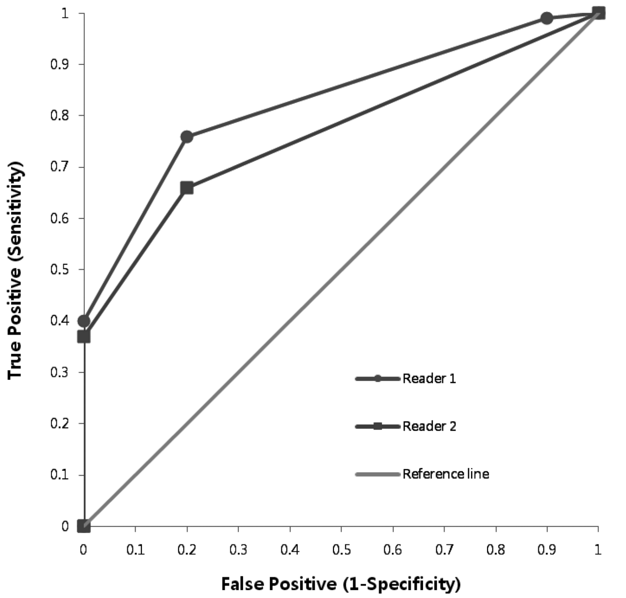

Fig 4. Receiver operating curve for inter-reader variability using conventional film screen radiography.

AUC values of the DDR and CFSR for each dose are presented in Fig 2. AUC values in CFSR were higher than that of AUC values of DDR in most injected volume of fluid.

Inter-reader variability between radiologists was evaluated for DDR and CFSR. No difference was noted between readers in evaluating DDR (Fig 3) and CFSR (Fig 4) for reader 1 and 2.

Discussion

DR is probably the most important advance in veterinary imaging since the advent of diagnostic ultrasound (17). There are two general types of DR; CR and DDR (1,3,17). All of these type use conventional X-ray equipment including the X-ray machine, table and grid. DR system is available without cassette and film because the images are presented on a computer monitor (1,3,6,9,13). The several recent studies demonstrated that DR is significantly superior to CFSR in human and veterinary medicine (10,12). Although spatial resolution of CFSR is higher than that of DR, DR with advantages is becoming more widely used in clinical practice. One of the major advantages is the linear response to X-ray intensity over wide latitude (dynamic range). Additional advantages include a decreased number of retakes attributable to technical errors (underexposure or overexposure), computed image enhancement (edge and contrast), image manipulation tools, digital storage, and transmission to the outside (1,6,8,9). Dynamic range is one of the biggest advantages of a digital imaging system. With windowing, the blackness and contrast of an image can be manipulated after the image has been acquired. This postprocessing is impossible in CFSR; if a radiographic image is not optimal, it must be replaced. Windowing allows accurate assessment of both bone and soft tissue in the same image (1,8,9).

Radiographic contrast refers to the difference in film blackness between areas in the image. Radiographic contrast depends on three factors: subject contrast, film contrast, and fog and scatter. Subject contrast is the difference in X-ray absorption through one part of subject compared with another. Subject contrast is affected by thickness differences, physical density differences, atomic number differences, and X-ray beam energy (15). When fluid accumulates in the intraperitoneal space, the additional soft tissue opacity added by the fluid, coupled with fluid disrupting the normal organ-fat interface, results in decreased visualization of organ edges (4,12). Thus, the finding of decreased visualization of organ edges, and bowl serosal margins, in the abdomen, with preservation of retroperitoneal detail is a reliable radiographic sign of intraperitoneal fluid (5,15).

In this study, we evaluated peritoneal fluid using CFSR and DDR in Beagle dogs. We found no significant difference between DDR and CFSR in the absolute detection of peritoneal fluid. However, the higher AUC in CFSR suggested that CFSR is relatively higher in accuracy for detecting peritoneal fluid. CFSR system typically has either good latitude, or good contrast, but not both. Once film is exposed and processed, the image contrast or opacity cannot be adjusted. However, the blackness and contrast of a DDR can be manipulated after the image is acquired. The evaluation of peritoneal fluid by decrease of serosal detail is easily affected by physical density. The readers have a tendency to manipulate the contrast and opacity control for better visualization of abdominal organs. The processing would cause inaccurate evaluation for detecting decrease of the serosal detail. In other words, the post-processing which is one of the advantages of DR could cause the accuracy of diagnosis for peritoneal effusion.

In the other study, CR was compared with CFSR in detection of peritoneal effusion in dogs (7). The study revealed that no significant difference was shown between two modalities, but AUC of CR was higher than that of CFSR (7). The discrepancy with our results was likely due to the different characteristics between CR and DR with charge coupled device detectors, although the main differences between CR and DDR are acquisition of the image, not the final image quality. For CR systems, the quantum efficiency and spatial resolution of the detectors are directly comparable to the best analog systems (17).

The limitation of this study is to compare hard copy with soft copy images. It should be done for evaluating the post-processing effect of digital radiography on detecting peritoneal fluid. However, further study should be required to compare the digital radiographs as hard copies with the conventional radiographs for evaluating peritoneal effusion.

Conclusion

In conclusion, there was no difference between the ability of

DDR compared with CFSR for detection of peritoneal effusion. However, AUC of DR was somewhat lower than that of CFSR. When the radiographic signs of peritoneal fluid on DR images are equivocal or a small amount of fluid is suspected, other imaging modalities, such as ultrasonography would be helpful for determining the presence of fluids.

Acknowledgement

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개에서 복수의 평가에 있어서 필름-증감지 방사선 사진과 디지털 방사선 사진의 비교

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요 약 : 디지털 방사선 사진은 촬영 후 영상처리를 통해 대비도를 향상시킬 수 있다. 하지만 복강 내 대비도를 감소시키는 복수가 존재 할 경우, 디지털 방사선 촬영술의 장점이 어떻게 적용되는가에 대한 연구는 부족하다. 따라서 본 연구에서는 다양한 양의 액체를 복강 내 주입한 후, 필름-증감지 사진과 디지털 방사선 사진을 비교 판독하여 두 기법의 복수 검출 능력에 대해 평가하였다. 실험 결과 receiver operation curve를 이용한 평가에서 복수를 검출하는 데 디지털 방사선 촬영술과 필름-증감지 기법 간의 유의적인 차이가 없었지만 필름-증감지 기법이 디지털 방사선 촬영술보다 비교적 높은 정확도를 나타냈다. 곡선 아래 면적은 필름-증감지 기법이 디지털 방사선 촬영술보다 높은 값을 나타내었으며, 대부분의 주입 용량에서 필름-증감지 기법이 디지털 방사선 촬영술보다 더 높은 값의 곡선 아래 면적을 나타냈다. 이러한 결과는 복수의 검출에 있어서 필름-증감지 기법이 디지털 방사선 촬영술보다 다소 민감하다는 것을 의미한다. 이는 판독자가 최적의 영상을 찾는 과정에서 영상의 조절 기능을 통해 소량의 복수에 의해 복부 대비도가 감소된 것을 저평가하게 되는 경향 때문인 것으로 생각된다. 따라서 디지털 방사선 사진을 이용하여 복수를 평가하는 경우, 과도한 대비도 증가와 같은 촬영 후 조절 기능을 사용하는데 주의해야 하며, 초음파와 같은 다른 영상 진단 장비를 사용하여 복수를 확인하는 것을 추천한다.

주요어 : 디지털 방사선 사진, 필름-증감지 방사선 사진, 복수, 개