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COMPARATIVE EVALUATION OF PULMONARY PATTERNS BY CONVENTIONAL RADIOGRAPHY AND COMPUTED RADIOGRAPHY IN DOMESTIC SHORTHAIR CATS

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ABSTRACT

The aim of current study was comparing the diagnostic performance of computed radiography with that of conventional radiography in clinical thoracic imaging based on histopathology as a reference standard.

Twenty domestic shorthair cats apart from gender and age differences with clinical symptoms of lower respiratory disease were examined with both computed and conventional radiography. Lateral and ventrodorsal projections were obtained. Then, three radiologists independently evaluated the radiographs. Histopathology investigation used as gold standard to confirm the pulmonary patterns detected on radiography. Statistical data of two radiologic approaches analyzed by Cohen's Kappa test and the sensitivity and specificity of each approach calculated.

No statistical difference was noticed between two radiologic systems for evaluating the alveolar pulmonary pattern. The conventional radiography of bronchial pattern had a better

agreement with histopathology results and was more sensitive as compared to computed radiography. The agreement for the interstitial pattern was fair for both systems, but computed radiography was more sensitive.

In current study for evaluation of lung patterns, the ability of computed radiography was equivalent or superior to conventional radiography, because displaying more radiographic details. Accordingly, it can be substituted the conventional radiography considering its advantages including elimination of dark room, image post processing and wide dynamic range.

Keywords: Computed radiography, conventional radiography, alveolar pattern, bronchial pattern, interstitial pattern, histopathology exam

INTRODUCTION

The introduction of computed radiography (CR) in 1980 was a revolutionary turning point in medical imaging practice **[1]**. In recent years, digital radiography has rapidly developed and currently this technology is widely applied in human radiology departments and gained an extensive acceptance in veterinary medicine. As digital imaging is gaining a more prominent role in veterinary medicine **[2]**, further studies are required to evaluate the image quality and diagnostic performance of this new technology. The advantages of CR include: elimination of x-ray film and saving money, decreasing the necessary film storage space and digital image transfer **[3]**. Image post processing capability is useful to maximize the radiographic image quality using dedicated computer software **[4]**.

The major advantage of CR over the conventional radiography (SFR) is its wide dynamic range. Hence, low contrast structures are better visualized **[5]**. On the other hand, spatial resolution of the CR is inferior to SFR; but this disadvantage is clinically insignificant **[2]**.

Thoracic radiographs are one of the most commonly performed radiographic examinations in small animal practice **[6]**. Most thoracic radiographs are still obtained by conventional radiography, which provides good image quality, high spatial resolution and generally has lower cost **[5]**. As the role of CR is increasing in veterinary medicine, it is expected that its application parallels conventional radiography.

The objective of this study was comparing the diagnostic performance of CR with that of SFR in clinical thoracic imaging, using abnormal findings documented by histopathologic examination as reference standard.

SUBJECTS AND MATERIALS

Twenty domestic shorthair cats with clinical symptom of lower respiratory

disease were enrolled in this study. All cats were euthanasia candidates for the purpose other than this research project.

The cats were selected in an 8 months period and written consent was obtained from their owners.

Initially, the conventional images were obtained (X-ray tube: PXP-16HF-MICRO PORTABLE) on 24 × 30 cm cassette (Kodak-film screen combination cassette) with appropriate exposure parameters depending on the equipment (technique chart). Then, standard ventrodorsal and lateral radiographs were taken and radiographs developed using the automatic processor (Huq, HQ-350 XT X-Ray Film processor). Digital images were taken by CR on 24 × 30 cm cassettes (Toshiba dc-12m X-ray tube; computed system care stream-classic). Standard ventrodorsal and lateral projections were taken and appropriate exposure factors applied depending on the equipment (technique chart). The standard computed imaging plate processing used to obtain diagnostic images **(FIGURE 1, 2, 3, 4)**.

After taking radiographic images, the cats were anesthetized with intramuscular injection of Xylazine and Ketamine (Xaylazine 1.1 mg/kg, Ketamine 15.4-22, mg/kg) **[7]** and they had been euthanized, became unconscious and died without pain.

Multiple 5mm diameter lung cuts were collected during necropsy and they embedded in 10% buffered formalin. After fixation (7 to 10 days later), the tissue sections stained with Hematoxylin and Eosin for qualitative histopathologic examination **(FIGURE 5, 6)**.

All diagnostic thoracic images of the 20 cats assessed by three board certificated experienced radiologists independently and they were unaware of their clinical history (blind study). Radiologists were asked to determine the presence or absence of pulmonary abnormalities (alveolar, bronchial, interstitial and vascular lung patterns).

Image reading sessions for each radiologist were conducted for 2 days, one day for interpreting the hard copy images (SFR) and another day for interpreting the soft copy images (CR images). There was a 2 month interval between the conventional radiography images interpretation sessions and those related to CR images in order to minimize learning effect. The order of radiographic interpretation was randomized. For all observations by radiologists, image evaluation was always performed under equal conditions. X-ray film jacket, radiographs, computed soft copy images and scoring forms had case specific numbers to avoid mismatches between the radiographs and the

corresponding input data. The collected data compared with the histopathology results as gold standard method.

STATISTICAL ANALAYSIS:

In this study, agreement of CR and SFR based on histopathologic evaluation was determined by Cohen's Kappa analysis with CI=95 %(SDATA11). The guidelines of Landis and Koch were followed in interpreting Kappa values: 0.00-0.20 slight agreement, 0.21-0.40 fair agreement, 0.41-0.60 moderate agreement, 0.61-0.80 substantial agreement and 0.81-1.0 almost perfect agreement **[8]**. In addition, correct detection of true positive (sensitivity) and true negative (specificity) were analyzed.

RESULTS:

The interobserver agreement for alveolar pattern was moderate for CR with significant concordance (K=0.42, 95%CI: 0-0.829, P=0.0114).

For SFR, the agreement was also moderate with significant concordance (K=0.42, 95%CI: 0-0.829, P=0.0114) **(TABLE 1)**.

The interobserver agreement for bronchial pattern was found as fair and moderate for both computed radiography and conventional radiography, respectively (K=0.32, K=0.54, 95%CIS: 0-0.713, 0.191-0.900).

According to Cohen's Kappa coefficient, there was no significant concordance for the bronchial pattern evaluated by CR (P=0.0551), but a significant concordance for SFR was noticed (P=0.0031) **(TABLE 2).**

As shown in Table 3, interobserver agreement for the interstitial pattern was fair for both CR with significant concordance (K=0.34, 95%CI: 0.043-0.636, P=0.0216) and SFR with no significant concordance (K=0.24, 95%CI: 0-0.476, P=0.0504).

Based on histopathologic results, the sensitivity of CR was 78.8% for alveolar pattern. Regarding the correct number for alveolar pattern, the sensitivity of SFR was also 78.8 % **(TABLE 4)**.

The ability of detecting true negative (specificity) findings in alveolar pattern with both computed and conventional radiography, based on histopathology results was 100%.

In comparison to histopathology, sensitivity of CR and SFR in detecting bronchial pattern was 37.5% and 50% respectively.

The specificity of SFR was 100%, but as there were some false positive findings in CR evaluation, the specificity was 91.7 % **(TABLE 5)**.

The sensitivity of CR and SFR for evaluating the interstitial pattern was 56.3% and 43%respevtively and the specificity was 100% for both methods **(TABLE 6)**.

No vascular change (vascular pattern) in the lungs of cats was detected in present study.

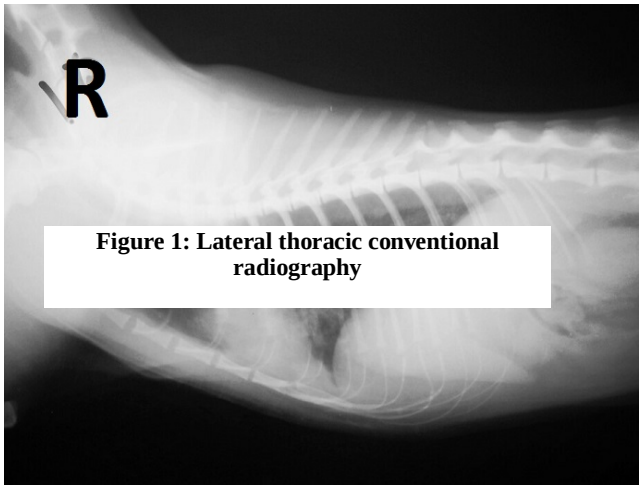

Figure 1: Lateral thoracic conventional radiography

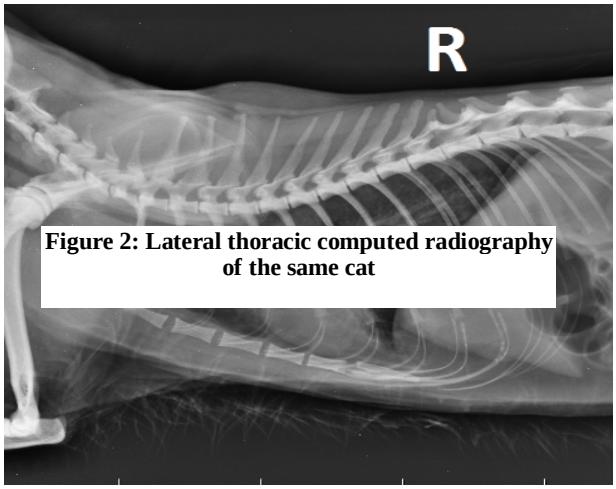

Figure 2: Lateral thoracic computed radiography of the same cat

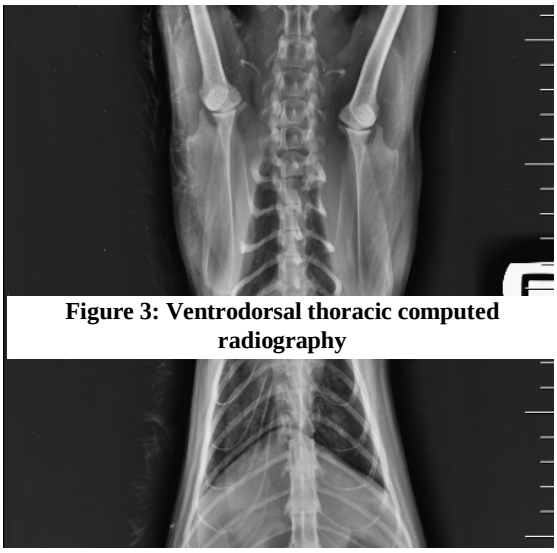

Figure 3: Ventrodorsal thoracic computed radiography

Figure 4: Ventrodorsal thoracic conventional radiography

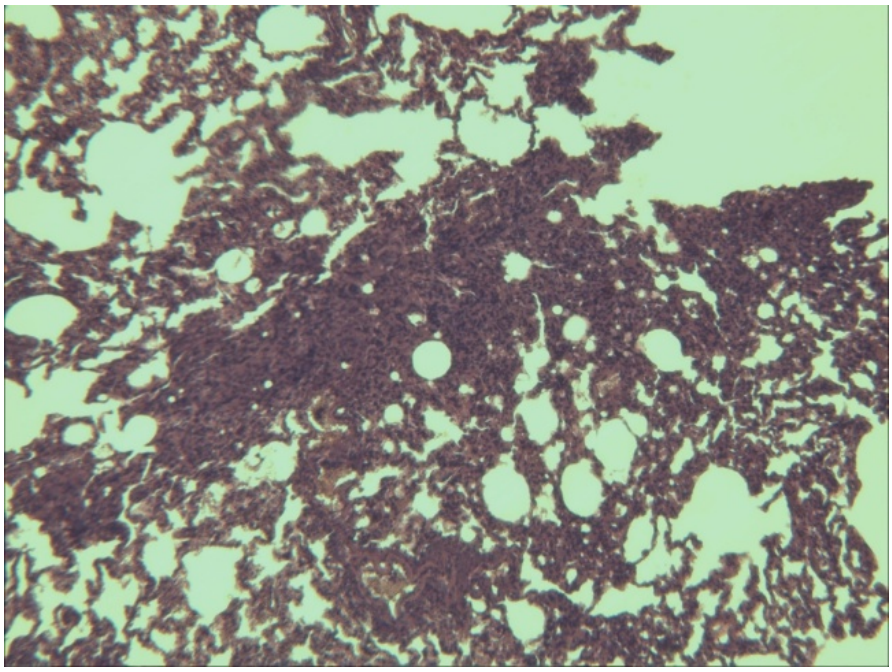

Figure 5: Interstitial pneumonia (H&E, 10×)

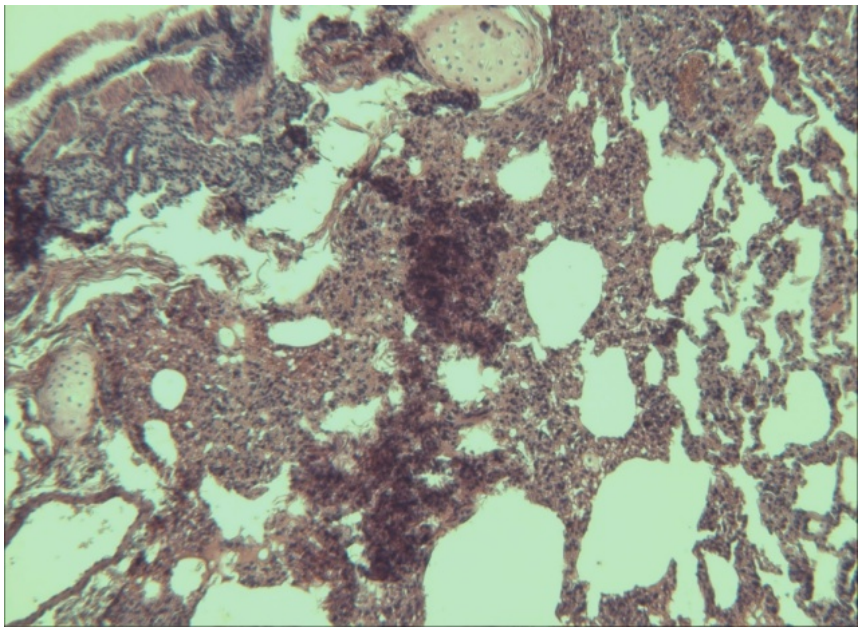

Figure 6: Interstitial pneumonia (H&E, 10×)

Table 1.Kappa value for radiography system compared with histopathology results for alveolar pattern

Radiography system	Kappa	Confidence interval	p	Agreement
Computed	0.42	0-0.829	0.0114	Moderate
Conventional	0.42	0-0.829	0.0114	Moderate

Table 2.Kappa value for radiography systems compared with histopathology results for bronchial pattern

Radiography system	Kappa	Confidence interval	p	Agreement
Computed	0.32	0-0.713	0.0551	Fair
Conventional	0.54	0.191-0.90	0.0031	Moderate

Table 3.Kappa value for radiography systems compared with histopathology results for interstitial pattern

Radiography system	Kappa	Confidence interval	p	Agreement
Computed	0.34	0.043-0.636	0.0216	Fair
Conventional	0.24	0-0.476	0.0504	Fair

Table 4.Values obtained for sensitivity and specificity of computed and conventional radiography compared with histopathology for alveolar pattern

Radiography system	Se (%) (95% CI)	Sp (%) (95% CI)
Computed	77.8 (52.4-93.6)	100 (15.8-100)
Conventional	77.8 (52.4-93.6)	100 (15.8-100)

Table 5.Values obtained for sensitivity and specificity of computed and conventional radiography compared with histopathology for bronchial pattern

Radiography system	Se (%) (95% CI)	Sp (%) (95% CI)
Computed	37.5 (8.52-75.5)	91.7 (61.5-99.8)
Conventional	50 (15.7-84.3)	100 (73.5-100)

Table 6.Values obtained for sensitivity and specificity of computed and conventional radiography compared with histopathology for interstitial pattern

Radiography system	Se (%) (95% CI)	Sp (%) (95% CI)
Computed	56.3 (29.9-80.2)	100 (39.8-100)
Conventional	43 (19.8-70.1)	100 (39.8-100)

DISCUSSION

One of the challenging problems among the radiologists has been interpretation of thoracic radiography. In the past years, the conventional radiography gained relatively good acceptance for displaying the abnormal pulmonary lesions. Nowadays in veterinary medicine, the computed radiography is rapidly expanded, thus, the comparison between SFR with CR is needed in order to evaluate the advantages and limitations of these two systems.

In this study, the results of Kappa analysis showed that both conventional and computed radiography had a perfect agreement in detecting alveolar pattern and there was no statistical difference between these two radiologic approaches. Based on radiologist's reports, the alveolar pattern appeared as patchy density and air bronchogram with proper contrast in radiographic images.

In present study, the CR comparing with SFR was not more sensitive and both systems had perfect accuracy for diagnosis of normal cases (true negative).

Thaete et al. carried out a study on application of CR versus SFR for detecting pulmonary abnormalities and concluded that there was no statistical difference between these two systems for showing the alveolar pattern **[9]**. The results of their investigation are consistent with findings of present study.

In this study, the evaluation of bronchial pattern revealed that the SFR based on histopathology had a better agreement comparing with CR. In addition, it showed that in the bronchial pattern detected by computed radiography as compared with histopathologic evaluation, more normal cases were diagnosed as false positive. On the other hand, the SFR had a superior specificity. This difference may be due to more recent application of CR and less familiarity of radiologists with digital radiographic images. In bronchial pattern evaluation, the only normal finding is manifestation of large bronchi around the hilus and bronchial tree is normally undetectable **[10]**. This finding is inconsistent with CR; in such a way that in this system with high contrast resolutions, displaying the low contrast structures are possible and the digital images reveal more details **[6]**. The same findings found in present study which were consistent with the results of previous investigations.

Ebermaier et al. compared the lung disease in dogs by two conventional and computed radiography methods and concluded that CR displays more details **[4]**. In another research, Meyer-Linderberg et al. compared the SFR and CR for evaluation of six body parts of dogs including thorax,

abdomen, skull, femur, hip joint and elbow. The investigators stated that CR is superior to SFR in showing more details **[11]**.

In present study, the investigation of the bronchial lung pattern despite our expectation was not consistent with concept of high quality image as well as high diagnostic performance and the assessment of bronchial pattern in digital images needed more experience. Additionally, in current study, since the interobservers agreement for detection of bronchial pattern by CR had insignificant concordance (P=0.0551), further studies with larger sample size are recommended.

The evaluation of interstitial pattern is always challenging and many radiologic studies focused on the interstitial pattern as a high frequency, low contrast abnormality. In previous studies, the influential factors affecting the quality of images were evaluated by both conventional and computed radiography. The conventional radiography has more inherent spatial resolution as compared to computed radiography and it has been a major reason for acceptance of this system for a long time. The factors such as operator error (overexposed and underexposed images) and poor equipment maintenance (especially underdevelopment) can decrease the image quality in conventional radiography. In contrast, computed radiography has a wide dynamic range and independent latitude factor resulted to better contrast resolution as compared to conventional radiography. The inherent ability of these two radiographic systems plays an important role in the quality of radiologic images **[12, 13]**.

The result of present study showed that both computed and conventional radiographies as compared to histopathology had fair agreement in detecting interstitial lung pattern, however, the CR comparing to SFR had more sensitivity. In addition, the recent study revealed that the inferior spatial resolution of the CR had no influence on diagnostic performance for detection of the interstitial pattern. This finding was consistent with the result of MacMahon et al. study **[14]**. Marolf et al. used computed and conventional radiography methods for diagnosis of pneumoperitoneum and compared the results. However, there was no statistical difference between these two systems, but the CR was more sensitive in detection of small amount of air in the abdomen due to its improved contrast resolution **[2]**. The same finding was detected in present study. Ishigaki et al. used both conventional and computed radiography and compared the results of diagnosis of subtle pulmonary abnormalities and indicated that the CR is

an acceptable modality for detection of this abnormality which is consistent with the results of current study **[15]**. Busch for evaluation of the mediastinal space (a low contrast structure) used SFR and CR. The result of their study showed the superiority of computed radiography **[16]**. On the other hand, in another study Fajardo et al. used SFR for diagnosis of pneumothorax as a high frequency, low contrast abnormality and showed that it was superior to CR **[17]**. In study of Theate et al. 310 thoracic images were evaluated by nine experienced radiologists. They compared the result of the conventional radiography with computed radiography and concluded that SFR is superior to CR for diagnosis of the interstitial pattern **[9]**. The difference between the results of present study with outcomes of two above-mentioned evaluations may be due to the fact that pulmonary abnormalities in many cats are presented as mixed pattern (the manifestation of more than one pulmonary pattern) which resulted in decrease of radiologic image contrast especially in the cases of alveolar pattern, and this in turn could impact on diagnostic performance in conventional radiography. In addition, in present investigation, some cats during positioning developed tachypnea which leaded to increased respiratory movements and affected the image quality. This disadvantage was the same in both conventional and computed radiography.

More confidence is detected in radiologists during interpretation of images taken by the conventional radiography. In addition, radiologist used magnification for evaluating the computed soft copy images. The result of present study confirmed that for evaluation of the thoracic imaging, added to the image quality, familiarity and experience of radiologists are very influential. In summary, in order to assess two systems of conventional and computed radiography, further studies with larger sample size, random sample selection (patients and normal cases) and independent evaluation of pulmonary patterns are recommended.

CONCLUSION

Our study showed that for evaluation of the lung patterns and obtaining more detailed images, CR is equivalent or superior to the SFR, considering its advantages including elimination of darkroom (chemical development and x-ray film), wide dynamic range, image post processing, facilitating image storage and their transfer, improved image qualities due to decreasing the human errors (overexposed or underexposed images) and this radiographic system could be a proper substitute of the conventional radiography.

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