Development of a cardiac evaluation method using a dynamic flat-panel detector (FPD) system: A feasibility study using a cardiac motion phantom

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1. Introduction

Dynamic flat-panel detectors (FPD) can provide sequential radiographs with a large field of view and high image quality. Circulation dynamics are reflected on dynamic chest radiographs as changes in pixel values. The present study investigated the feasibility of cardiac evaluation with a dynamic FPD, based on changes in pixel values during cardiac pumping. Furthermore, the optimal imaging rate and need for contrast media were assessed. We also attempted to develop computerized methods of quantifying and visualizing the results similar to perfusion images.

2. Methods

Sequential radiographs of a self-produced cardiac motion phantom were obtained using a modified FPD system, in various combinations of cardiac output (50, 75, 100 ml) and cardiac rate (24, 36, 48, 60, 72, 84 beat per minute), with and without contrast media. Ventricular area and summation of pixel values in the ventricles were measured in sequential radiographs, and the changes during cardiac pumping were then calculated. We then calculated ventricular EF using the changes in area and summation of pixel values (EF_{area} and EF_{pv}), for each cardiac output and rate. To visualize slight changes in pixel values as blood flow, inter-frame differences were obtained using all frames of sequential radiographs. Perfusion images were then created by superimposing difference values on original images in the form of a color display using a color table.

3. Results

There was a strong correlation between cardiac output and changes in ventricular area, and changes in summation of pixel value, r=0.83 and r=0.99, respectively. There was no significant difference between the findings with and without contrast media, indicating that contrast media was not necessary in the present method. When the cardiac rate was greater than 60 beat per minute (bpm), EF_{area} and EF_{pv} were further underestimated. Assuming that 6 fps was sufficient for imaging a patient with a cardiac rate of 48 bpm, it is necessary for a patient with cardiac rate from 60 bpm to 84 bpm to be examined at an imaging rate between 7.5 and 10 fps at least. We succeeded in visualizing changes in pixel value as perfusion images, which were very useful for interpreting slight changes in pixel values. We could evaluate blood flow velocities during each cardiac phase.

4. Conclusion

The present method had the potential to evaluate cardiac output and EF without contrast media. Since FPD is expected to become more widely available soon, the present method is expected to be a rapid and simple method for evaluating cardiac function, as an additional examination in conventional chest radiography.