Evaluation of inter-departmental variability of ejection fraction and cardiac volumes in myocardial perfusion scintigraphy using simulated data

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Conclusion

The Monte Carlo method can be used for quality control of scintigraphic methods that require manual image processing and evaluation. Left ventricular volumes were underestimated, whereas EF was more accurately estimated. There was, however, large inter-departmental variability.

Background

Myocardial perfusion scintigraphy (MPS) is a non-invasive imaging modality for diagnosing patients with suspected coronary artery disease. By utilizing gated MPS, the end diastolic volume (EDV) and end systolic volume (ESV) can be measured and the ejection fraction (EF) can be calculated, which gives incremental prognostic value compared to assessment of perfusion only. Through the external quality assessment not-for-profit company Equalis, we aimed to evaluate the inter-departmental variability of EF, ESV and EDV during gated MPS in Sweden. To overcome the inconvenience of constructing and sending physical phantoms around, we instead evaluated the possibility to use Monte Carlo (MC) simulated gated MPS studies.

Methods

17 departments were included in the study. The SIMIND MC programme and XCAT phantom were used to simulate three patient cases with different EDV, ESV and EF (1: female, small heart, normal EF; 2: male, large heart, low EF; 3: female, normal heart size, normal EF). Individual simulations were performed for each department, corresponding to their specific method of performing MPS (camera system, camera settings such as energy window and administered radioactivity). In order to mimic cardiac motion, 32 instances of the XCAT phantom, with the heart in different positions in the cardiac cycle and different spatial positions in the thoracic cavity due to breathing were created for each case and used as input in the simulations. Images were sent to each department and were evaluated according to clinical routine. EDV, ESV and EF were reported back by one or several nuclear medicine technologists.

Results

There was a large underestimation of EDV and ESV for all three cases, as expected due to the limited spatial resolution and translocation of the heart due to breathing. The largest underestimation was seen in case 1, and the smallest in case 2. Mean underestimation for EDV varied between 26% and 52%, and for ESV between 15% and 60%. EF was more accurately estimated, but mean bias still varied between an underestimation of 24% to an overestimation of 14%. In general, the intra-departmental variability for EDV, ESV and EF was small, whereas inter-departmental variability was larger, which is partly explained by the different evaluation software used.

Table. Characteristics of patients

	Case 1	Case 2	Case 3
Sex	Female	Male	Female
Length (cm)	160	182	171
Weight (kg)	55	102	68
EF (%)	53	37	62
EDV (ml)	50	230	91
ESV (ml)	24	143	35

Figure. Dotted lines represent true values. Plus-signs represent answers from individual technologists (provided by 12 departments) and diamond-signs represent the department mean.