ECG-triggered high resolution positron emission tomography – a breakthrough in cardiac molecular imaging of mice

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Molecular imaging by small animal positron emission tomography (PET) is an important noninvasive means to phenotype transgenic and knock out mouse models *in vivo*. However, the quality of non-gated cardiac PET imaging is degraded by heart movement and respiration, reducing both the spatial resolution of the images and the accuracy of quantification. We here present a breakthrough in the field of PET mouse imaging, the first successful ECG-triggered gated PET image of a mouse heart. This method has potential to dramatically improve image quality of cardiac small animal PET. A C57/Bl6 mouse (38 g) was positioned on the bed of a submillimetre resolution small animal PET device (32-module quadHIDAC, Oxford Positron Ltd., Oxford, UK)[1], anaesthetised by isoflurane (2%, 0.5 l/min O_2) and intravenously injected with 6 MBq ^{18}F-fluorodesoxyglucose (^{18}F-FDG). ECG electrodes were placed on both forepaws and the left hindpaw and the ECG signal was recorded on a dedicated ECG monitor (BioVet, Spin Systems Pty Ltd, Brisbane, Australia). One hour post injection a 30 min PET acquisition was initiated while the ECG was simultaneously recorded (heart rate ~480 bpm). PET list-mode data was sorted into 12 gates and images were reconstructed using an OPL-EM iterative algorithm.[2] Images were resliced into cardiac short as well as horizontal and vertical long axis (Fig. 1). Furthermore, a 3D contour finding algorithm based on elastic surfaces[3] was used to detect the left and right ventricular myocardium (Fig. 2). A 2D and 3D display of the „beating“ mouse heart is available online.

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Figure legends

Figure 1. Representative (every second gate of the original 12-gate reconstruction; from gate G1 to G11) short axis (SA), horizontal (HLA) and vertical (VLA) long axis images of the heart of a 38 g mouse 1 h after injection of 6 MBq ^{18}F-fluorodesoxyglucose (acquisition time 30 min). Note the high image quality with clear presentation of the left and right ventricular myocardium throughout the cardiac cycle, which is at least comparable to human cardiac PET studies on clinical PET scanners. The photography of a match is added to the image to illustrate the dimensions of the heart.

Figure 2. Feasibility of contour detection on the ECG-triggered image of the mouse heart. The left row illustrates end-diastolic (ED) and end-systolic (ES) horizontal long axis slices superimposed by mid-myocardial (solid line) and epi-/endocardial (dotted lines) contours. Three-dimensional displays of the left (coloured) and right (white) ventricular surfaces are shown on the right panel.

Figure 3 (For online purposes, animated GIF). Animated short axis (left), horizontal (middle) and vertical (right) long axis images of the heart of a 38 g mouse 1 h after injection of 6 MBq ^{18}F-fluorodesoxyglucose (acquisition time 30 min).

Figure 4 (For online purposes, animated GIF). Three-dimensional animated surface view (12 gates per cardiac cycle) of the beating heart (left ventricle coloured, right ventricle white) of a 38 g mouse 1 h after injection of 6 MBq ^{18}F-fluorodesoxyglucose (acquisition time 30 min).

References

1 Jeavons AP, Chandler RA, Dettmar CAR. A 3D HIDAC-PET camera with submillimetre resolution for imaging small animals. *IEEE T Nucl Sci.* 1999;46:468-473.

2 Reader AJ, Ally S, Bakatselos F et al. One-Pass List-Mode EM Algorithm for High Resolution 3D PET Image Reconstruction into Large Arrays. *IEEE T Nucl Sci.* 2002; 49:693-699.

3 Stegger L, Biedenstein S, Schäfers KP et al. Elastic surface contour detection for the measurement of ejection fraction in myocardial perfusion SPET. *Eur J Nucl Med.* 2001;28:48-55.

Figure 1

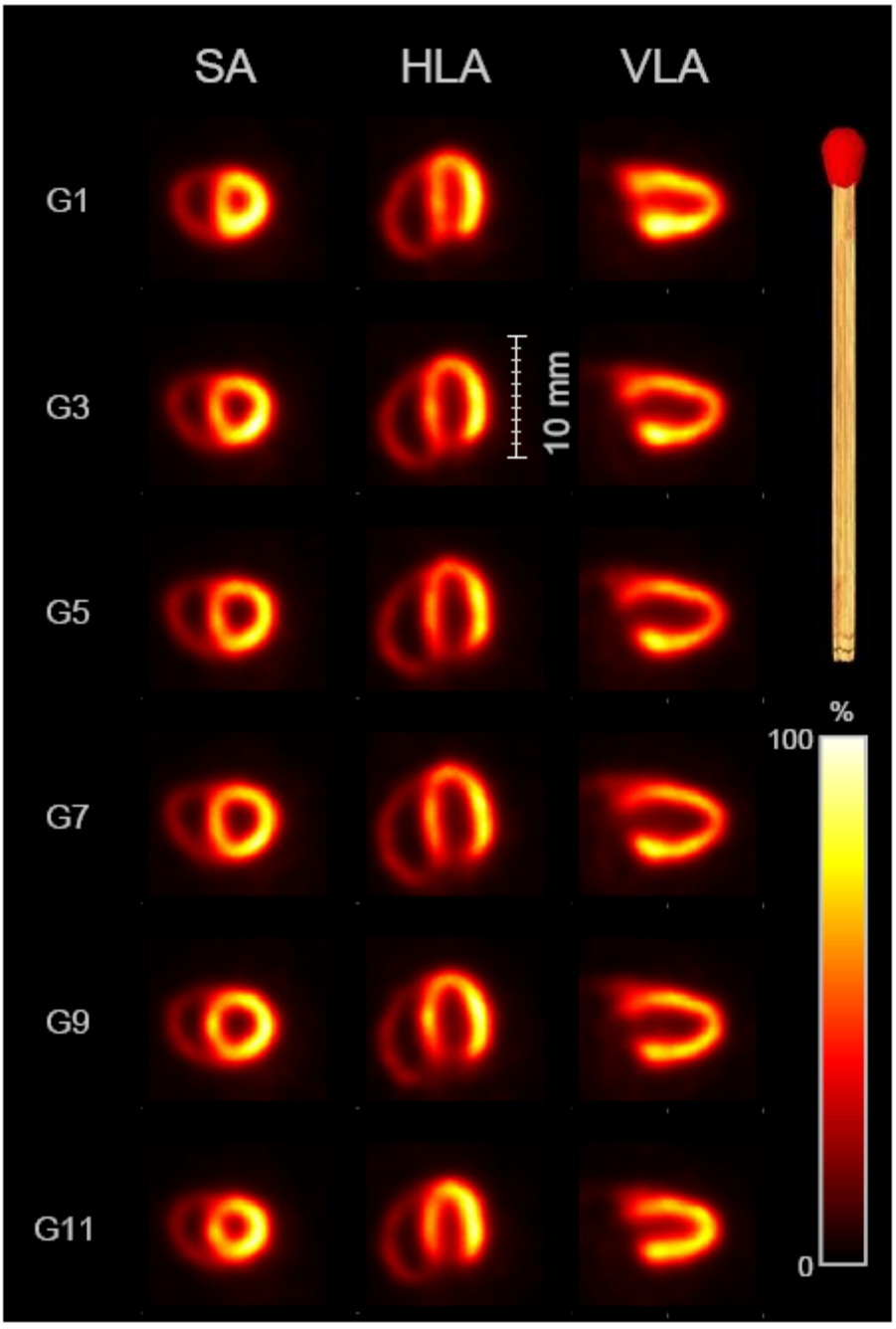

Figure 2