AN EXPERIMENTAL MODEL TO VALIDATE ELECTROCARDIOGRAPHIC INVERSE ALGORITHMS

Bradley, CP, Cheng*, LK, Nash, MP, Paterson, DJ and Pullan AJ*, University Laboratory of Physiology, University of Oxford, United Kingdom, and *Department of Engineering Science, University of Auckland, New Zealand.

We present the development of an *in-vivo* experimental framework to validate inverse algorithms of electrocardiology and, in particular, a recently published activation inverse algorithm (2). This algorithm is based on determining the underlying cardiac activation sequence rather than in terms of epicardial potentials. The validation framework is based on concurrently recording body surface and epicardial potentials in the anaesthetised pig. The measured activation sequence in the heart can then be compared to the predicted activation sequence from the inverse algorithm applied to the recorded body surface signals using a computational model of the pig torso.

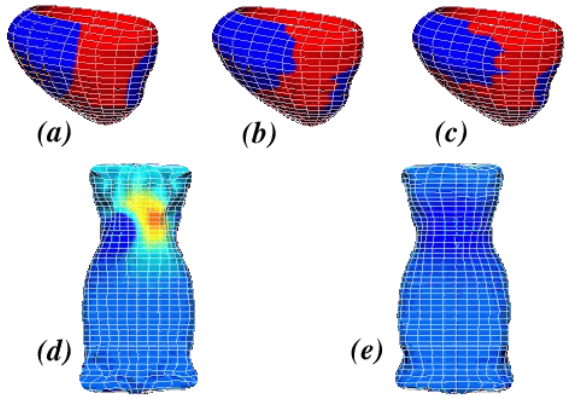

Figure 1: Example of the inverse solution using the pig model. (a) image shows the model heart with a prescribed activation sequence. This was then used to generate body surface maps viewed from the anterior (d) and posterior (e). (b) shows the activation sequence obtained from the inverse algorithm using the calculated body surface potentials with 20 μV RMS noise added. (c) shows the reconstructed activation sequence obtained when 100 μV RMS noise is added. On the heart, blue represents activated myocardium and red represents resting tissue. For the body surface, blue represents negative potential and red represents positive potential.

To obtain a computational model of the pig torso a pig was placed in a computed tomography (CT) scanner. The surface of the endocardium, epicardium, right and left lung and muscle and skin surfaces were then digitised from the CT images. A three-dimensional torso model was then constructed by fitting a high-order C^1 continuous mesh based on cubic Hermite elements to the data using a non-linear fitting procedure (1). This model can be further customised to tailor the mesh to the individual porcine anatomy used in the individual experiments.

To concurrently record the electrocardiographic potentials young domestic pigs were anaesthetised, artificially ventilated and thoracotamised. An elasticated electrode sock containing 127 electrodes (with an inter-electrode spacing of *ca.* 7 mm) was then placed over the epicardium in a known orientation. The chest was re-closed and an elasticated vest containing 256 electrodes (with an inter-electrode spacing of *ca.* 15 mm) was fitted. Simultaneous body surface and epicardial potentials were then recorded at a 2 kHz sampling rate.

In order to test the performance of the inverse algorithms in a variety of conditions a number of patho-physiological cases are investigated. These cases include (i) epicardial pacing; (ii) regional ventricular ischaemia and (iii) global hyperkalaemia. The results presented illustrate the various procedures involved in the validation study and show some preliminary inverse reconstructions. An example of a simulated inverse result is shown in Figure 1. As can be seen the inverse results from the simulation are close to the goal activation sequence even in the presence of a large amount of noise.

1. Bradley CP, Pullan AJ, and Hunter PJ. Geometric modelling of the human torso using cubic Hermite elements. Ann Biomed Eng 25: 96–111, 1997.

2. Huiskamp G and Greensite F. A new method for myocardial activation imaging. IEEE Trans Biomed Eng 44: 433–446, 1997.

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