

Detection of regional myocardial tissue ischemia using visible light spectroscopy in a pig model

Background:

Regional changes of myocardial tissue perfusion occur during cardiac surgery. While early treatment can minimize ischemic injury, current methods of ischemia detection have limitations. Visible light spectroscopy (VLS) is a non-invasive method of rapidly determining localized microvascular tissue hemoglobin oxygen saturation (StO₂) by direct application of a VLS probe on the tissue; its reliability has been demonstrated in various human tissues. This study tests the ability of VLS spectroscopy to detect localized ischemia by changes in StO₂ measurements after coronary artery ligation in a pig model.

Methods:

All animal surgeries were performed in compliance with the 1996 National Research Council Guide for the Care and Use of Laboratory Animals. Six (n=6) anesthetized pigs underwent 20 min of proximal occlusion of the left anterior descending artery (LAD) after midline sternotomy. Systemic hemodynamics (heart rate; central venous, mean aortic and pulmonary artery pressure) and oxygen saturation from arterial and mixed venous samples were measured during the protocol. The VLS probe was placed on the epicardial surface to obtain StO₂ measurements from the ischemic site and a non-ischemic control region of the left ventricle. Measurements were obtained before LAD occlusion, and during the ischemic period at 1, 5, 10 and 20 minutes. Regional myocardial function was determined by offline analysis of regional wall motion abnormalities and Doppler strain images acquired by epicardial echocardiography.

Results:

Systemic hemodynamics, arterial and mixed venous oxygen saturation remained unchanged throughout the protocol. Pre-ischemia StO₂ was 69.2% ± 3.58 SE and 72.4% ± 3.58 SE in the ischemic and non-ischemic LV region, respectively. StO₂ remained stable in the non-ischemic region, whereas ischemia of the target region was rapidly detected with VLS, resulting in a steep StO₂ decrease in the first 5 min of ischemia and a persistent low StO₂ thereafter (Figure 1). This change from baseline and compared to the control site was statistically significant by 1 min (p<0.005) using a repeated measures analysis of variance model. Ischemia was confirmed by segmental wall motion abnormalities within the first minute of ischemia (p<0.05) and alterations in the strain and strain rate patterns while echocardiographic parameters remained unchanged in the non-ischemic myocardial region.

Conclusions:

Visible light spectroscopy (VLS) provides non-invasive, stable and reproducible measurements of myocardial StO₂. Easily obtained and interpreted measurements in myocardium allow for rapid detection of local tissue saturation and the potential for monitoring of myocardial ischemia during cardiac surgery.

