Autoregulation of Coronary Blood Flow in the Isolated Beating Pig Heart

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Introduction
The isolated beating pig heart model (Fig. 1) [1] forms an accessible platform to investigate the coronary circulation in its truly morphological and (electro)physiological way, while its use is beneficial from a time, cost and ethical perspective. However, whether the coronary autoregulation system is still intact is not known.

Figure 1: Isolated beating pig heart model comprising the circulatory system (left) and the isolated pig heart (right).

Materials and Methods
Four slaughterhouse pig hearts (472±51 g) were isolated, prepared and connected to a circulatory system (Fig. 1). Through coronary reperfusion and controlled cardiac loading, physiological cardiac performance was achieved. Subsequently, all hearts were subjected to brief periods of ischemia and to a wide range of loading conditions and contractile states.

Results
The isolated beating pig heart was capable of generating flow patterns and pressure curves that closely mimicked human coronary flow and pressure. After release of a coronary occlusion, coronary flow rose rapidly to an equal (maximum) level as the flow during control beats, independent of the duration of occlusion (Fig. 2).

Figure 2: Left circumflex coronary blood flow before, during and after a 20-second occlusion. No manifestation of reactive hyperemia was observed.

<table>
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<th>Heart</th>
<th>Weight (g)</th>
<th>n</th>
<th>Regression p-value</th>
<th>Correlation R²</th>
<th>p-value</th>
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<tr>
<td>3</td>
<td>476</td>
<td>11</td>
<td>0.94</td>
<td>&lt; 0.001</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>405</td>
<td>10</td>
<td>0.91</td>
<td>&lt; 0.001</td>
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</tbody>
</table>

Moreover, a linear relation was found between coronary flow and coronary driving pressure for a wide range of preload, afterload and contractility (Fig. 3, Tab. 1). Zero flow pressure intercepts were estimated by extrapolation and found to vary between 10 and 16 mmHg (Tab. 1). Selective intracoronary administration of papaverine did also not induce additional hyperemia.

Figure 3: Linear relation between coronary perfusion pressure and coronary flow for a wide range of loading conditions and contractile states for the different hearts.

Conclusion
The coronary circulation in the isolated beating pig heart is in a permanent state of maximal hyperemia, making the model suitable for coronary research in which this is paramount (fractional flow reserve, index of myocardial resistance).

References
1 De Hart et al. (2011) *Artif Organs*, 34:495-505.