AV-fistula maturation: the failure rate reduced?

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Introduction
Functioning of hemodialysis arteriovenous fistula (AVF) immediately after surgical creation is mainly hampered by non-maturation, which is characterized by insufficient flow increase and vessel remodeling. Despite preoperative evaluation 20-50% of all newly created AVFs fail.1,2 The initial postoperative flow \(q_a\) increase is generally accepted to be indicative for proper maturation.2

Objective
The aim of this study is to test the feasibility of a 1D-model to predict the \(q_a\) patient-specifically.

Methods
For the 1D-model3 the vascular tree is divided into elements representing local blood and vessel wall properties (Fig.1). Viscous and inertial forces are modeled by a Womersley number dependent resistor and inductor respectively, and the vessel compliance by a capacitor.

The pressure-flow relation at the anastomosis, is derived from losses over a T-junction (Fig.2).

Results
Preoperatively, the flow waveforms in the brachial artery are similar for both simulation and MR measurement. However, in the ulnar artery waveforms differ (Fig.3).

Incorporating the nonlinear pressure-flow relation results in an extra pressure drop over the anastomosis (Fig.4).

The predicted preoperative and postoperative mean brachial flows are close to the measured flows (Table 1), except for one patient, for whom a major side-branch was not incorporated in the model.

### Table 1. Measured (m) and simulated (s) mean flows (pre and post)

<table>
<thead>
<tr>
<th>Patient</th>
<th>(q_a) (pre) [ml/min]</th>
<th>(q_a) (pre) [ml/min]</th>
<th>(q_a) (post) [ml/min]</th>
<th>(q_a) (post) [ml/min]</th>
</tr>
</thead>
<tbody>
<tr>
<td>S, AC</td>
<td>20</td>
<td>20</td>
<td>759</td>
<td>795</td>
</tr>
<tr>
<td>S, AL</td>
<td>125</td>
<td>125</td>
<td>579</td>
<td>2713</td>
</tr>
<tr>
<td>S, JL</td>
<td>108</td>
<td>111</td>
<td>404</td>
<td>445</td>
</tr>
<tr>
<td>S, AM</td>
<td>187</td>
<td>192</td>
<td>1162</td>
<td>1044</td>
</tr>
</tbody>
</table>

Conclusion
First results show that \(q_a\) can be reasonably predicted.

Future work
- Apply the model to a larger number of patients
- Determine a nonlinear pressure-flow relation for the anastomosis from 3D high flow simulations
- Determine the accuracy in \(q_a\) predictions

References