Flow Patterns in Externally Stented Saphenous Vein Grafts as Related to the Development of Intimal Hyperplasia

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Failure Per Vein Graft

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A Randomized Trial of External Stenting for Saphenous Vein Grafts in Coronary Artery Bypass Grafting

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*Background.* External stents inhibit saphenous vein graft (SVG) intimal hyperplasia in animal studies. We investigated whether external stenting inhibits SVG diffuse intimal hyperplasia 1 year after coronary artery bypass graft surgery.

*Methods.* Thirty patients with multivessel disease undergoing coronary artery bypass graft surgery were enrolled. In addition to an internal mammary artery graft, each patient received one external stent to a single SVG randomly allocated to either the right or left coronary territories; and one or more nonstented SVG served as the control. Graft patency was confirmed at the end of surgery in all patients. The primary endpoint was SVG intimal hyperplasia (mean area) assessed by intravascular ultrasonography at 1 year. Secondary endpoints were SVG failure, ectasia (>50% initial diameter), and overall uniformity as judged by Fitzgibbon classification.

*Results.* One-year follow-up angiography was completed in 29 patients (96.6%). All internal mammary artery grafts were patent. Overall SVG failure rates did not differ significantly between the two groups (30% stented versus 28.2% nonstented SVG, p = 0.55). The SVG mean intimal hyperplasia area, assessed in 43 SVGs, was significantly reduced in the stented group (4.37 ± 1.40 mm² versus nonstented group 5.12 ± 1.35 mm², p = 0.04). In addition, stented SVGs demonstrated marginally significant improvement in lumen uniformity (p = 0.08) and less ectasia (6.7% versus 28.2%, p = 0.05). There was some evidence that ligation of side branches with metallic clips increased SVG failure in the stented group.

*Conclusions.* External stenting has the potential to improve SVG lumen uniformity and reduce diffuse intimal hyperplasia 1 year after coronary artery bypass graft surgery.

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Unsupported SVG’s to RCA 12 Months Post Implantation
Numerical analysis of Venous External Scaffolding Technology for Saphenous Vein Grafts

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Abstract

This paper presents a method for analyzing and comparing numerically Saphenous Vein Grafts (SVGs) following Coronary Artery Bypass Graft surgery (CABG). The method analyses the flow dynamics inside vein grafts with and without supporting using Venous External Scaffolding Technology (VEST). The numerical method uses patient’s specific computational fluid dynamics (CFD) methods to characterize the relevant hemodynamic parameters of patients’ SVGs. The method was used to compare the hemodynamics of six patient’s specific model and flow conditions of stented and non-stented SVGs, 12 months post-transplantation. The flow parameters used to characterize the grafts’ hemodynamics include Time Averaged Wall Shear Stress (TAWSS), Oscillatory Shear Index (OSI) and Relative Residence Time (RRT). The effect of stenting was clearly demonstrated by the chosen parameters. SVGs under constriction of VEST were associated with similar spatial average of TAWSS (10.73 vs 10.29 dyn/cm²), yet had fewer lesions with low TAWSS, lower OSI (0.041 vs 0.08) and RRT (0.12 vs 0.24), and more uniform flow with less flow discrepancies. In conclusion, the suggested method and parameters well demonstrated the advantage of VEST support. Stenting vein grafts with VEST improved hemodynamic factors which are correlated to graft failure following CABG procedure.

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Hemodynamic parameters

- **Time Average Wall Shear Stress (TAWSS)**
  WSS quantifies the tangential friction force exerted by the flowing blood on the vessel wall. TAWSS is calculated by integrating the magnitude of WSS over the cardiac cycle.

- **Oscillatory Shear Index (OSI)**
  A non-dimensional parameter which measures the directional change of WSS during the cardiac cycle (range: 0-0.5).
Flow Pattern Analysis & Diffuse SVG Disease

- To assess the severity of DIFFUSE flow disturbances along the entire SVG, MEAN values of different hemodynamic parameters were analyzed per graft.
To assess the severity of **FOCAL** flow disturbances, comparable SVG segments (80\(^{th}\) / 90\(^{th}\) / 95\(^{th}\) percentiles), with the most disturbed flow pattern, were analyzed.
Time Average WSS (TAWSS)

- Supported: $p=0.651$
- Unsupported: $p=0.732$
- $p=0.546$
- $p=0.411$

Percentile vs. TAWSS
Oscillatory Shear Index (OSI)
Prognostic Factor for Intimal Hyperplasia

- For each SVG, mean value of OSI and TAWSS were analyzed with respect to the mean value of the intimal area assessed by IVUS.

- Group analysis, of both the stented and non-stented group, was performed to study relationship between a mean value of each hemodynamic parameter and the development of diffuse intimal hyperplasia.

<table>
<thead>
<tr>
<th>Hemodynamic Parameter</th>
<th>P-Value for Effect on Intimal Hyperplasia Area</th>
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<tbody>
<tr>
<td>Mean TAWSS</td>
<td>0.432</td>
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<tr>
<td>Mean OSI</td>
<td><strong>0.010</strong></td>
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Conclusions

- External Stenting improves SVG hemodynamics 1 year after CABG.
- Oscillatory shear stress, unlike average WSS, is correlated with the development of SVG diffuse intimal hyperplasia 1 year after CABG.
Thank You