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LETTER TO THE EDITOR

Intraoperative Graft Patency Verification and Postoperative Angiography: A Word of Caution

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We have read with interest Dr. Hol's report [Hol 2001] about graft control by transit time flow measurement (TTFM) and intraoperative angiography. Although we congratulate the authors for their timely manuscript, we believe that some clarifications about intraoperative TTFM should be given.

The authors describe their experience with testing intraoperative graft patency via TTFM in a group of 72 patients. A total of 67 left internal mammary arteries (LIMA) and 57 saphenous vein grafts (SVG) were tested intraoperatively. At chest closure all the grafts were reevaluated, in the operating room, with angiography. Based on angiography, the grafts were graded as type A (fully patent), type B (more than 50% diameter reduction), or type O (occluded). Out of the 67 LIMA grafts, 51 were classified as type A, 14 as type B, and 2 as type O. No significant differences in intraoperative flow measurement and pulsitility index (PI) were found between type A and type B LIMA grafts. Interestingly, 7 of the 14 type B LIMA grafts normalized their pattern at a follow-up angiographic study. When considering the 57 SVGs, 49 were classified as type A, 7 as type B, and 1 as type O. No differences in flow values and PI values were noticed between the type A and B SVGs. Five of the seven type B SVGs normalized their pattern at a follow-up angiographic study. The authors conclude that TTFM can not correctly predict intraoperative graft patency and TTFM findings should be addressed cautiously.

We strongly believe that TTFM should always be performed following precise rules in order to maximize the diagnostic potentiality of this new technology. Flow measurements should always be performed with and without proximal coronary snare in order 1) to exclude any steal phenomenon from the native coronary circulation, and 2) to test the antegrade flow of the anastomosis. As previously documented [D'Ancona 2000], coronary grafts may present excellent flow values and flow curves even when critical stenosis are present at the toe of the anastomosis. In this situation the majority of the measured flow is retrograde flow that passes through the heel of the anastomosis. Only application of a proximal snare will demonstrate a sudden drop of graft flow and will permit prompt diagnosis of the anastomotic inperfection (Figure 1,).

We believe that, having omitted to use proximal coronary snares, Dr. Hol et al. may have misinterpreted some of their intraoperative TTFM findings. Furthermore, a few focal rules to correctly understand the TTFMs findings should be respected.

Flow values, PIs, and flow curves should always be regarded simultaneously in order to correctly diagnose the status of the anastomosis. Although flow and PI values are objective measurements, flow curve shapes are subjective parameters that may be difficult to correctly address but have, nevertheless, a focal importance. Ideal coronary graft flow curves are mainly diastolic with some negative systolic spikes. In order to simplify the interpretation of this subjective variables, mathematical derivations, such as the fast Fourier Transformation (FFT) [Milnor 1989], may be applied. The FFT permits to break down the complex flow curves into simpler harmonics and calculate the FFT ratio between the power of the frequency of the original waveform (F0) and the power of the first armonic (H1) in which the original curve is broken down to. A significant difference in FFT ratio values, as derived from intraoperative flow measurements, has been noticed when comparing patent versus non-patent coronary grafts [Takami 2001]. Patent grafts have generally a FFT ratio value of more than 1, while the ratio in abnormal grafts is generally less than 1 [Takami 2001]. We believe that Dr. Hol et al. should reevaluate their conclusions, taking into consideration not only PI and flow values but also flow curve shapes and maybe FFT ratio values.

TTFM technology should be compared with functional tests for graft patency verification. Differently from TTFM, perioperative angiography is a purely anatomical study that represents, in a two dimensional space, the status of the anastomosis. Furthermore, intraoperative angiography allows only for a limited number of coronary projections and, for this reason, may be even more misleading. As reported by Dr. Hol, 7 LIMA and 5 SV grafts that were classified as type B at

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a previous intraoperative angiography, resulted to be fully patent at a follow-up angiography. This may be due to a remodeling process at the anastomostic site or, more simply, to a perioperative angiographic misdiagnosis. TTFM should be compared and tested with other functional studies such as graft magnetic resonance or intra-graft free flow measurement. Although we understand that it is logistically more complicated and economically more demanding to use the above-mentioned technologies, we also believe that no correct evaluations of TTFM findings may be done with standard angiography. More sophisticated systems such as quantitative angiographies that provide multiple projections of the anastomosis and computer assisted analysis of angiographic findings should be adopted. A study performed by Takami et al. [Takami 2001] has demonstrated a significant relationship between intraoperative TTFM findings and postoperative quantitative angiography. After analyzing the TTFM and angiographic patterns of 82 grafts, the authors reported significant differences between all intraoperative flow parameters of angiographically patent versus stenotic grafts (more than 25% stenosis), concluding that intraoperative flow measurement may well predict anastomotic stenosis.

Although the real potential of intraoperative TTFM is still to be defined, we believe that precise rules should be followed to correctly use this technology and interpret its findings. Special attention should be given to adopt a correct, validating method. In this regard, standard angiography is definitely not the gold standard method to assess the quality of intraoperative TTFM findings. Furthermore, we believe that studies on larger cohorts of patients should be performed testing intraoperative TTFM with the most advanced methods of postoperative evaluation of graft patency, including magnetic resonance, free flow measurement, and quantitative angiography.

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