Publication Brief

Transit-Time Flow Measurement and Outcomes in Coronary Artery Bypass Graft Patients

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From this study, Kim H-H et al. suggest that Pulsatility Index (PI) may be more suitable for predicting clinical outcomes in sequential venous grafting than mean graft flow (MGF). This is contrary to Transonic's assertion that MGF is the primary CABG graft patency indicator. Please see Letter to the Editor on next page, submitted by Transonic, that questions the investigators' statistical analyses and reveals errors that may have led to their erroneous conclusions.

BACKGROUND

Sequential saphenous vein grafting has the following advantages: fewer proximal anastomoses, less aortic damage, shorter operation duration, and better long-term outcomes.

OBJECTIVE

Retrospective study to investigate whether TTFM values of sequential saphenous vein grafts (SVG) were predictive of graft failure and major adverse cerebral and cardiac events (MACCE).

STUDY

- Study population:1933 patients with 3-vessel coronary artery disease who underwent off-pump coronary artery bypass (OPCAB) between 2011 - 2018. Excluded were patients with total arterial grafting, no sequential grafting, or more than 4 anastomoses per SVG.
- 538 patients with 2-or 3-vessel coronary artery obstructive disease (CAOD) who underwent 2 or 3 sequential anastomoses using an SVG were included in the study.
- Pulsatility index (PI) and flow (mL/min) were measured in 1288 sequential venous grafts in 538 consecutive patients. An anastomosis with flow below 20 ml/min or PI (> 5) was revised.
- Multi-slice computed tomography or coronary angiography confirmed postoperative graft patency.
- Mean clinical follow-up time was 64.8 ± 21.2 months.

RESULTS

Sequential Graft Anastomosis Group	Number	Mean Graft Flow mL/min	PI	MACCE Prediction PI Cutoff Values
A: 1st Side-to-Side	538	59.1 ± 31.3	2.2 ± 1.3	3.65
B: 2nd Side-to-Side	212	41.0 ± 25.2	2.5 ± 3.4	3.55
C: End-to-Side	538	38.9 ± 22.8	2.4 ± 2.5	3.17

- 2.2% of sequential vein grafts failed.
- 5-year survival rate was 93.7%.
- 5-year MACCE rate was 6.9% (37/538 patients).
- Graft patency was significantly lower in low MGF (<20 mL/min) and high PI (>5).

CONCLUSIONS

- Sequential vein grafting was reliable and safe based on low overall graft failure and MACCE values.
- Intraoperative TTFM can assess graft function and predict early graft function, thus allowing the prediction of long-term outcomes regarding graft patency and MACCE.
- High PI (>5) could predict a high incidence of graft failures and MACCE.

REFERENCE

Kim HH, Kim JH, Lee SH, Yoo KJ, Youn YN. Transit-Time Flow Measurement and Outcomes in Coronary Artery Bypass Graft Patients. Semin Thorac Cardiovasc Surg. 2023 Summer;35(2):217-227. (Transonic Reference # CV-2022-6-4 Kim) (Transonic Reference # CV-2022-6-4 Kim)

Letter to the Editor: (Semin Thorac Cardiovasc Surg. 2024 Mar 19:S1043-0679(24)00025-X.)

Surgical Protocol for Patency Assessment of Sequential CABGs and Their Pass/Investigate Thresholds

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We read with interest Kim et al's paper[1], which addresses whether threshold values for transit time flow measurement (TTFM) metrics in coronary artery bypass graft (CABG) patency assessment need adjustment when sequential grafts are used, and whether these metrics have predictive value for long-term major adverse cardiac and cerebrovascular events (MACCEs). Such studies are relevant, not only to the research community and to CABG surgeons, but also to medical device manufacturers such as Transonic, seeking to improve and optimize the intraoperative decision-supporting value of their TTFM devices.

Mean graft flow (MGF)- and pulsatility index (PI)-based patency assessment on branches of a sequential graft (made sequentially after each anastomosis is completed) can be performed in several ways. Method 1: Measured proximal to each sequential anastomosis, with flow metrics viewed directly on the TTFM device. Method 2: Measurement site for all branches is proximal to the first anastomosis of the sequential graft; MGF and PI for each successive anastomosis are then calculated from the sequential graft's successive measurement and the first anastomosis' measurement. In Method 2, values calculated for MGF and PI will have increasing uncertainty for the second, third sequential branch: MFG is calculated as differences between measurement made at different times, and the numerator of PI (maximum flow volume – minimum flow volume) will record the effect of all finished anastomoses combined. The au-thors' Flow Measurement section appears to indicate that Method 2 was used. It would be informative for readers to have the mathematical equations used by the authors to calculate MFG and PI. It also would be of interest to hear the authors' assessment of the implications and (practical) advantages and disadvantages of their methods.

A question arises from a flaw in the statistical analysis. The authors' receiver operating characteristic (ROC) curves for MGF (Supplementary Figure 5) are plotted to quantify the sensitivity and specificity of high (rather than low) MGF as indicator of graft occlusion ("Fig. 5a Original", below). This is clearly not the authors' original hypothesis and finding of their study, as is evident from the Kaplan-Meier plots in Figures 3C and 4C."Fig.5a Corrected", below, would then be the proper ROC curve to establish threshold values for low MGF. Does this ROC plot revision provide low MFG cutoffs, similar for high PI as derived by the authors?

Finally, this large patient study found (commendably) only 37 MACCE cases. A Cox regression would then be limited to 2-3 variables. Considering the small percentage of MACCEs, and the long list of confounders, a single-center study like this seems to be only an initial step towards the stated purpose of MACCE prediction. To contribute to future longitudinal studies of sufficient size, would the authors be willing to share their raw results through a public database like PhysioNet[3,4]?

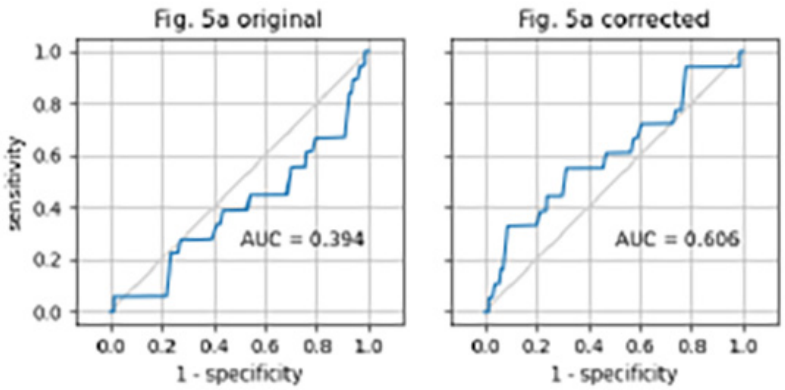

Figure 1: Left: ROC curve as presented in Supplementary Fig. 5a, showing sensiAvity and specificity of high MGF to detect failed grafts; Right: corrected ROC curve (constructed by digitizing Fig. 5a; underlying data not available). The area under the curve (AUC) is a measure of the ability of a metric (here: MGF), to distinguish between two classes (here: patent or failed graft). A perfect classifier would give AUC = 1, whereas random guessing would yield AUC = 0.5 (grey diagonal line). Values of AUC < 0.5 ("worse than random") indicate that a metric is better inverted (here: low rather than high MGF to indicate a failed graft).

REFERENCES

1. Kim H-H, Kim J-H, Lee SH, Yoo K-J, and Youn Y-N. Transit Time Flow Measurements and Outcomes in Coronary Artery Bypass Graft Patients. Semin Thorac Cardiovasc Surg 2023; 35(2):217-227.
2. Sandner SE, Gaudino MFL. Commentary: Transit time flow measurements for coronary artery bypass graft: Go with the flow. JTCVS Tech 2021; 7:144-145.
3. https://www.physionet.org/
4. Goldberger AL, Amaral LAN, Glass L, Hausdorff JM, Ivanov PCh, Mark RG, Mietus JE, Moody GB, Peng CK, Stanley HE. PhysioBank, PhysioToolkit, and PhysioNet: Compo-nents of a New Research Resource for Complex Physiologic Signals. Circulation 2020; 101(23):e215-e220.