SCIENTIFIC LETTER

Correlation of coronary artery bypass surgery-related myonecrosis with grafted vessel calibre: insights from cardiovascular magnetic resonance imaging

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Patients with extensive and diffuse coronary artery disease constitute a high-risk population for surgical coronary revascularisation. Previous studies showed a direct correlation between smaller coronary artery diameters and long-term adverse post-coronary artery bypass surgery (CABG) outcomes.^{1,2} Whether grafting smaller calibre coronary vessels has a direct relationship with surgery-related myocardial infarction, however, is unclear and, if so, whether the location of the perioperative infarction differs according to CABG technique (on-pump or off-pump CABG).

Delayed-enhancement magnetic resonance imaging (MRI) can quantify irreversible myocardial injury (seen as hyper-enhancement) and is superior to single-photon emission computed tomography imaging for the identification of subendocardial myocardial infarction.³ We have recently reported that in patients randomly assigned to either on-pump or off-pump CABG techniques, the groups did not differ significantly in the extent of surgery-related irreversible myocardial injury when assessed by delayed-enhancement MRI.⁴ Taking advantage of the existence of this group of patients undergoing CABG, we now set out to determine whether angiographic grading of target vessel diameter predicts the occurrence of irreversible myocardial injury after grafting. A secondary goal was to see whether patients with new surgery-related hyperenhancement would have focal injury in the territory (downstream) of the grafted artery or diffusely in the subendocardium, unrelated to the location of the grafted vessel.

METHODS

The study was approved by our institutional ethics committee. Both the patient population characteristics and cardiovascular MRI protocol have been described elsewhere.⁴ Sixty patients were enrolled into the study: 30 randomly assigned to off-pump surgery and 30 to on-pump surgery.

Any lesion with a diameter stenosis > 40% measured by handheld calliper was subsequently analysed by computerised quantitative methods with the QuantCor coronary analysis software (Siemens). The contrast-filled catheter was used to calibrate image magnification.

Values are expressed as mean (SD) when normally distributed or median (interquartile range 25–75%) when not normally distributed (for example, degree of coronary stenosis). The significance of any relationship between the mean target vessel diameter before surgery and the presence or absence of new post-surgery hyperenhancement was assessed by the unpaired t test. Multiple continuous variables that were not distributed normally were compared by the Kruskal–Wallis test. Dichotomous data were compared by the χ^2 statistic. A value of $p < 0.05$ was considered significant.

RESULTS

Both delayed-enhancement MRI (pre-surgery and early post-surgery) and quantitative coronary angiography results are available for 53 of 60 patients. The numbers of grafts and anastomoses by patient were 2.6 (0.5) and 2.9 (0.8), respectively; 99% (154/156) of grafts were arterial. The median diameter stenosis of the grafted vessel was the same across all three coronary territories (85% in the left anterior descending artery (LAD), 90% in the obtuse marginal and 85% in the posterior descending artery (PDA), $p > 0.05$).

As previously reported, early postoperatively, 21 patients (12 off-pump CABG; 9 on-pump CABG) had evidence of new hyperenhancement, quantified at 6.5 (4.1) g or 4.8 (3.0)% of left ventricular mass. The mean preoperative cardiac index was similar in the two surgical groups (2.9 (0.7) on-pump CABG v 2.9 (0.8) off-pump CABG, $p = 0.9$). Postoperatively, the cardiac index was significantly higher in the off-pump CABG group (2.7 (0.6) on-pump CABG v 3.2 (0.8) off-pump CABG, $p = 0.04$).⁴ Overall, the mean target vessel diameter was 1.7 (0.3) mm in the group with new surgery-related hyperenhancement and 2.0 (0.5) mm in the hyperenhancement-negative group ($p = 0.3$). When analysed according to each major coronary territory, target vessel diameter was significantly lower in the group with new hyperenhancement in the PDA territory than in the group without hyperenhancement in that territory ($p = 0.04$) (table 1).

In 16 of 21 (76%) patients (11 off-pump CABG and 5 on-pump CABG) the new irreversible injury was located in the territory of the grafted vessel, in an apical location (LAD territory 30%, obtuse marginal 18% and PDA 52%). In the remaining five (24%) patients, the new hyperenhancement was located in territory unrelated to the grafted vessel.

DISCUSSION

In a population of patients undergoing CABG with arterial grafts, we found no correlation between the target vessel diameter and the occurrence of perioperative myocardial infarction in the LAD and circumflex/marginal territories. We did, however, find a significant association between a smaller calibre PDA and new perioperative myocardial infarction in that territory as detected by delayed enhancement cardiac MRI. This probably reflects the fact that the grafted PDA had the smallest mean diameter in our study and hence myocardium subtended by this is prone to injury because of hypoperfusion or inadequate distal myocardial preservation.

Furthermore, although we did not document early angiographic patency of grafts and did not control for the adequacy of coronary collateral circulation in this study (both of which

Abbreviations: CABG, coronary artery bypass surgery; LAD, left anterior descending artery; MRI, magnetic resonance imaging; PDA, posterior descending artery

Table 1 Target vessel diameter (mm) versus absence or presence of new myocardial hyperenhancement after coronary artery bypass surgery subdivided according to major coronary artery territory

Hyperenhancement	LAD (n = 51)	OM (n = 39)	PDA (n = 48)
Positive (n = 21)	1.7 (0.3)	1.8 (0.2)	1.5 (0.2)
Negative (n = 32)	1.9 (0.9)	2.2 (0.4)	1.9 (0.5)
p Value	0.2	0.2	0.04

Data are mean (SD).

LAD, left anterior descending artery; OM, obtuse marginal branch; PDA, posterior descending artery.

remain important limitations), early graft failure could also have been more common in the PDA territory, accounting for some of the new hyperenhancement seen. Smaller native coronary arteries result in less favourable runoff with an increased likelihood of graft failure. However, this observation has to be confirmed in studies with more patients. In this study, in which 99% of grafts were arterial, the radial artery was usually used for grafting the PDA and the two internal mammary arteries were used for the LAD or the marginal/circumflex system. Evidence is increasing that, although radial grafts have higher patency rates than vein grafts, they still have lower early and medium-term patency rates than internal mammary grafts.⁵

Our findings show that most patients presenting with surgery-related myonecrosis have evidence of injury in a focal distribution, in the apical myocardium distal to the grafted artery. This suggests that inadequate distal myocardial preservation is a main mechanism of injury in both surgical groups. Interestingly, four of five patients having evidence of subendocardial injury remote from the grafted territory underwent on-pump surgery. It is tempting to speculate that the most likely reason for this is inadequate cardioplegia in the on-pump CABG group, resulting in global intermittent hypoperfusion and, in turn, leading to subendocardial ischaemic injury.⁶ The apical distribution of injury in the off-pump CABG group suggests that this form of injury may be reduced in the future with the routine use of intracoronary shunts (improved distal myocardial protection). These were not used in our study, however, because they can be difficult to introduce and raise concerns about endothelial damage.

We conclude that new perioperative injury as detected by cardiovascular MRI occurs most often in the apical myocardium, suggesting inadequate distal myocardial preservation as a main mechanism of injury. The occurrence of new myocardial necrosis after CABG is influenced by the calibre of the target vessel only in the PDA territory.

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