INTERVENTIONAL CARDIOLOGY AND SURGERY

Increased C reactive protein and cardiac enzyme levels after coronary stent implantation. Is there protection by remote ischaemic preconditioning?

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Aim: To investigate whether remote ischaemic preconditioning (RIPC) can attenuate the inflammatory response and enzyme leakage that can occur after uncomplicated routine percutaneous coronary intervention (PCI).
Methods: 41 consecutive normotensive patients with stable angina and single-vessel disease were assigned to be exposed to RIPC (n = 20) or not (control group; n = 21) before elective PCI with stent implantation. RIPC was induced by three cycles of 5-min ischaemia–reperfusion of both upper limbs (inflation/deflation of blood pressure cuff). C reactive protein (CRP), creatine phosphokinase (CK), CK cardiac isoenzyme (CK-MB) and troponin I (TNI) were serially measured for 48 h.
Results: No difference in baseline values was observed between the groups. The CRP rose significantly ($p<0.001$) and at 48 h was similarly increased (>fourfold) in both groups (15.7 (2.6) *v* 14.0 (3.3) mg/l, RIPC *v* control; p = NS). However, sub-group analysis on the basis of statin use showed that the highest rise was in the group of patients with RIPC not taking statins and was significantly greater than in patients with RIPC taking statins (23.8 (3.71) *v* 11.4 (3.0) mg/l, respectively, $p<0.01$). Both CK-MB and TNI leakage were raised (slightly but significantly) after PCI in controls at 24 h compared with baseline values. However, this small rise was significantly worse after RIPC (CK-MB, 1.33 (0.27) *v* 3.57 (0.97) ng/ml, $p<0.01$; TNI, 0.255 (0.059) *v* 0.804 (0.232) ng/ml, $p<0.05$, respectively at 24 h). The increase was more marked in the RIPC subgroup not taking statins.
Conclusions: RIPC does not reduce, but exacerbates, the enzyme and TNI release from the heart after single-vessel angioplasty with stent. Furthermore, the increased circulating CRP remains raised. It seems that there is an enhanced inflammatory response after RIPC in the absence of statin treatment.

The inflammatory response and enzyme leakage during coronary angioplasty is increasingly becoming a recognised issue.[1–4] A pro-inflammatory status with microembolisation, myocardial enzyme leakage and myocardial damage, albeit small, have been described,[5 6] and this may be more significant with multivessel angioplasty.[7]

Since the description of ischaemic preconditioning as the most powerful intrinsic modality against ischaemia–reperfusion injury,[8] methods are being developed for optimum clinical use.[9] Pharmacological preconditioning has not gained much clinical ground and ischaemia–reperfusion cycles have been used during cardiac surgery.[10] Although ischaemic preconditioning has also been applied during angioplasty (regional vessel preconditioning) to reduce inflammation[11] and enzyme leakage,[12 13] concerns about proximal vessel damage and embolisation have been raised.[14] This would also be cumbersome in multivessel angioplasty.

More recently, a novel way to apply preconditioning via remote organ (eg, limb) ischaemia–reperfusion cycles has been described.[15] An added advantage is that this way the entire heart may be preconditioned—that is, globally, not regionally.[16] For example, transient limb ischaemia induces ischaemic preconditioning in humans, attenuating endothelial dysfunction and preventing systemic neutrophil activation induced by ischaemia–reperfusion in the contralateral upper limb.[17] Limb ischaemia in pigs induces remote ischaemic preconditioning, which can then reduce the extent of myocardial infarction.[18]

In the present study, we sought to determine whether remote ischaemic preconditioning, immediately before elective stent implantation, reduces the pro-inflammatory response circulating CRP levels[19]) and cardiac enzyme release in stable patients with CAD with single-vessel disease.

PATIENTS AND METHODS

Forty one consecutive normotensive patients with stable angina, a positive exercise treadmill test and single-vessel disease, eligible for percutaneous coronary intervention (PCI), were included in the study. Patients with acute myocardial infarction, unstable angina, complex, multiple or close to side-branch lesions, additional cardiac disease, renal and hepatic insufficiency, malignancy, rheumatoid arthritis and active infection were excluded. Table 1 summarises the patients' demographic, clinical and angiographic characteristics. In all, 25 of 41 patients (13 in the RIPC group) were on statin treatment for at least 2 months before PCI (RIPC group: 4 atorvastatin, 3 pravastatin, 3 simvastatin, 3 lovastatin; control group: 4 atorvastatin, 5 pravastatin, 2 simvastatin and 1 lovastatin). All patients underwent coronary angiography and were then randomised to either the RIPC or the control group immediately before proceeding to elective stent implantation. An additional group of 12 patients with chronic stable coronary disease (all men, mean age 63.1 (10.4) years) was also evaluated to test the effect of remote preconditioning, with no coronary intervention, on pro-inflammatory response and cardiac enzyme release.

Abbreviations: CK-MB, creatine phosphokinase cardiac isoenzyme; CRP, C reactive protein; PCI, percutaneous coronary intervention; RIPC, remote ischaemic preconditioning; TNI, troponin I

Table 1 Demographic, clinical and angiographic data

	RIPC (n = 20)	Control (n = 21)
Age (years)	61 (10)	62 (8)
EF (%)	56 (7)	54 (5)
Diabetes mellitus	7 (35%)	7 (34%)
Hyperlipidaemia	16 (80%)	17 (81%)
Smoking	7 (35%)	9 (43%)
Exercise treadmill duration (min)	5.9 (0.3)	5.7 (0.3)
β blockers	13 (65%)	16 (77%)
ACE inhibitors	10 (50%)	13 (62%)
Aspirin	19 (95%)	18 (86%)
Statins	13 (65%)	12 (58%)
Nitrates	14 (70%)	17 (81%)
Calcium channel blockers	11 (55%)	2 (10%)
Clopidogrel	6 (30%)	7 (34%)
Diuretics	1 (5%)	4 (19%)
Antidiabetics	3 (15%)	3 (15%)
Angiotensin receptor antagonists	1 (0.5%)	1 (0.45%)
Left anterior descending	11	12
Right coronary artery	7	7
Left circumflex	2	2
Gp IIb/IIIa inhibitors after PCI	8 (40%)	9 (43%)

ACE, angiotensin-converting enzyme; EF, ejection fraction; Gp, glycoprotein; PCI, percutaneous coronary intervention; RIPC, remote ischaemic preconditioning.

The study complied with the Declaration of Helsinki regarding investigation in humans, and was approved by the institutional ethics committee. All patients provided oral informed consent.

Coronary angiography and PCI

Coronary angiography was carried out via the right femoral artery approach, using 6F introducers and catheters. PCI was conducted with the monorail technique and 6F catheters. The selection of coronary balloons and stents was left to the discretion of the interventional cardiologist. Coronary stents were implanted in all patients of both groups after balloon pre-dilatation of the target lesion according to the decision of the operators. All lesions treated were de novo lesions of native coronary arteries. Table 2 presents the details for the interventional procedure.

Remote ischaemic preconditioning

Remote ischaemic preconditioning was induced in the catheterisation laboratory by three cycles of 5 min ischaemia/5 min reperfusion of both upper limbs by inflating and deflating 12-cm-wide blood pressure cuffs placed around the upper arms. The blood pressure cuffs were inflated to 200 mm Hg in the RIPC group (n = 20), whereas in the control group they were only positioned around the limbs without inflating the cuffs (n = 21). Coronary angioplasty was carried out immediately after the end of the preconditioning protocol cycles and 30 min after positioning the cuff in the control group, which means that a total time of 30 min elapsed from the beginning of positioning the cuff for both groups. In the additional group of 12 patients, three 5-min blood pressure cuff inflations to 200 mm Hg with 5-min intervening deflations were carried out, with no additional intervention.

Table 2 Interventional procedure data

	RIPC (n = 20)	Control (n = 21)
Total time of ischaemia (s)	57.5 (4.9)	53.9 (8.5)
Balloon length (mm)	16.8 (0.96)	17.0 (0.83)
Balloon width (mm)	2.35 (0.08)	2.46 (0.09)
Stent length (mm)	18.4 (1.3)	17.2 (1.2)
Stent width (mm)	3.05 (0.09)	3.13 (0.10)
Total number of stents	20	21
DES/BMS	4/16	6/15

BMS, bare metal stent; DES, drug-eluting stent; RIPC, remote ischaemic preconditioning.

Blood sampling and laboratory measurements

Venous blood samples for measurements were obtained at enrolment, 12, 24 and 48 hours later. Creatine phosphokinase (CK), its cardiac isoenzyme (CK-MB), troponin I (TNI) and CRP levels were measured. Blood samples were collected in serum separation tubes. Serum was obtained by centrifugation at 3000 g for 10 min. Serum CRP and CK concentrations were determined by turbidometry with the Cobas Integra automated chemistry analyzer (Roche Diagnostic Systems, Basle, Switzerland). CRP concentrations as high as 5 mg/ml and CK concentrations between 26 and 174 U/l were considered to be within the reference range. CK-MB and TNI levels were measured with the Dimension RXL-HM analyser, using a two-site fluorometric enzyme immunoassay (Dade Behring, La Defense, France). Values are expressed as nanograms per millilitre. CK-MB concentrations as high as 3.6 ng/ml were considered to be within the reference range.

Statistical analysis

All data are expressed as mean (SEM). For comparisons between the two main groups, Student's t test (unpaired) was used. For multiple comparisons (in between subgroups or repeated measures), the non-parametric analysis of variance (Kruskal–Wallis or Friedman) was used. Pairwise comparisons were carried out using the Mann–Whitney U test (with downward adjustment of the α level to 0.013 to compensate for multiple comparisons where indicated) or the Wilcoxon signed-ranks test. The area under the curve (summary variable) was also calculated for changes in enzyme release. Significance was taken at a p value of <0.05.

RESULTS

Table 1 shows the demographics of the groups. There were no important differences between the groups. There were no significant differences between groups in baseline levels of CRP, CK, CK-MB and TNI.

Table 2 presents the details on the interventional procedures. No differences were observed between the studied groups in terms of morphology of the lesions, total time of ischaemia, stent type, etc. No differences in segment electrocardiograph changes and in the level of chest pain at the time of interventional procedures were observed between the studied groups.

C reactive protein

CRP increased substantially, considerably and equally in both groups after stent implantation; thus, from baseline to 48 h CRP levels increased from 3.3 (0.9) mg/l to 15.7 (2.6) mg/l ($p<0.001$) in the RIPC group and from 3.5 (0.6) mg/l to 14.0 (3.3) mg/l ($p<0.001$) in the control group (fig 1A). CRP did not appear to reach peak levels within the study limits of 48 h.

Within the study limits of 48 h, there were no differences between the two groups. However, subgroup analysis on the basis of statin use (and group) showed that there were important differences (fig 1B). The highest rise at 48 h (23.8 (3.7) mg/l) was observed in the RIPC patients not taking statins; such a profound rise was not observed in the RIPC patients taking statins (11.4 (3.0) mg/l; $p<0.01$ *v* RIPC with statins), which was similar only to the control group. There were no real differences in CRP levels on the basis of statin status in the control group.

Factors that showed a trend towards lower CRP levels at 48 h (but statistically not significant) include the presence of diabetes and the absence of smoking.

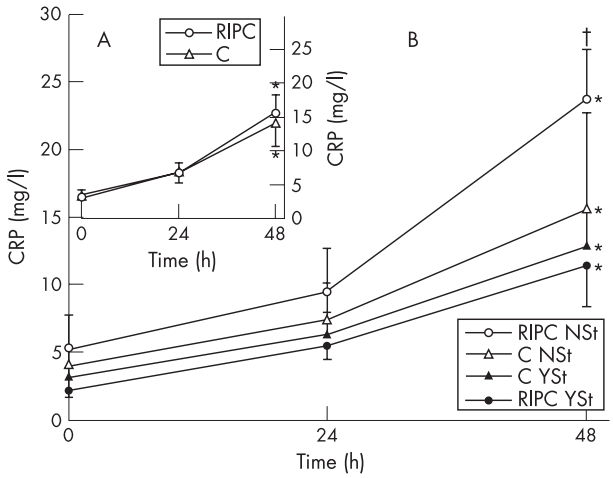

Figure 1 Serum C reactive protein (CRP) levels (mean (SE)) at baseline, 24 and 48 h after percutaneous coronary intervention. (A) Main group effect. C, control; RIPC, remote ischaemic preconditioning. *p<0.001 versus baseline and 24 h. (B) The influence of group and statin use. NSt, no statins; YSt, yes statins. *p<0.001 versus baseline and 24 h. †p<0.05 RIPC NSt versus RIPC YSt.

Creatine phosphokinase

CK levels did not change within the 48 h in the control group (fig 2). However, in the RIPC group there was a small but significant peak at 24 h (p<0.01 *v* baseline and 48 h), which subsided by 48 h; CK increased from 70.3 (7.2) U/l at baseline to 94.8 (10.7) U/l at 24 h and returned to 71.3 (8.1) U/l at 48 h. There were no statistical differences between the two groups.

CK-MB isoenzyme

In the control group, there was a small but significant peak at 24 h (p<0.05 *v* baseline), which subsided by 48 h; CK-MB increased from 0.72 (0.16) ng/ml at baseline to 1.33 (0.27) ng/ml at 24 h and returned to 0.81 (0.15) ng/ml at 48 h (fig 3A). In the RIPC group, there was a much more substantial increase in CK-MB enzyme release with a high peak at 24 h (p<0.01, 24 h *v* baseline and 48 h), which, however, also subsided by 48 h. Thus, CK-MB increased from 0.67 (0.12) ng/ml at baseline to 3.57 (0.97) ng/ml at 24 h and returned to 1.0 (0.24) ng/ml at 48 h (fig 3A). CK-MB enzyme release was significantly greater after RIPC both in terms of change in area under the curve (83 (24) *v* 21 (8), RIPC *v* control, p<0.05) and peak value at 24 h (3.57 (0.97) *v* 1.33 (0.27) ng/ml, RIPC *v* control, p<0.05).

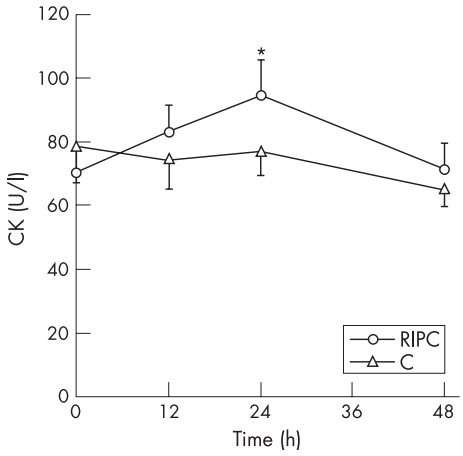

Figure 2 Serum creatine phosphokinase (CK) levels (mean (SE)) at baseline, 12, 24 and 48 h after percutaneous coronary intervention (PCI). *p<0.01 versus baseline and 48 h. RIPC, remote ischaemic preconditioning.

Subgroup analysis on the basis of statin use showed that the greatest release of CK-MB was observed in the RIPC group without statins (5.13 (2.2) ng/ml at 24 h). This reached significance compared with the controls on statins (1.11 (0.32) ng/ml at 24 h, p<0.05; fig 3B).

Troponin I

In the control group there was a small but significant peak at 24 h (p<0.05 *v* baseline), which was still (but less so) increased at 48 h. Thus, TNI increased from 0.041 (0.012) ng/ml at baseline to 0.255 (0.059) ng/ml at 24 h and returned to 0.204 (0.054) ng/ml at 48 h (fig 4A). In the RIPC group there was a much more substantial increase in TNI enzyme release, with a high peak at 24 h (p<0.01, 24 h *v* baseline), which also was still (but less so) increased at 48 h. Thus, TNI increased from 0.034 (0.010) ng/ml at baseline to 0.804 (0.232) ng/ml at 24 h and returned to 0.447 (0.121) ng/ml at 48 h (fig 4A). TNI enzyme release was significantly greater after RIPC both in terms of change in area under the curve (24 (7) *v* 8 (1.7), RIPC *v* control, p<0.05) and peak value at 24 h (0.804 (0.232) *v* 0.255 (0.059) ng/ml, RIPC *v* control, p<0.05). Also, there were 5 (20%) versus 0 (RIPC *v* CRP) patients who reached a TNI level >1 ng/ml at 24 h.

Subgroup analysis on the basis of statin use showed that there were trends similar to those for CK-MB (fig 4B). Statistical significance was not reached between the four subgroups.

There was an excellent correlation between TNI release and CK-MB release (r = 0.96).

CRP levels and cardiac enzyme and TNI release

We found no correlation between CRP levels and cardiac enzyme and TNI levels at any time point, within any group or statin subgroup.

Effect of statins

By dividing all the patients into those taking (n = 25) and those not taking (n = 16) statins the mean baseline values for CK, CK-MB, TNI and CRP were 76.7 (9.6) *v* 69.4 (9.5) U/l, 0.66 (0.13) *v* 0.76 (0.16) ng/ml, 0.04 (0.01) *v* 0.04 (0.01) ng/ml and 2.63 (0.38) *v* 4.67 mg/l, respectively. Although we did not find significant differences between the groups in the rate of increase of these markers after PCI (82.9 (7.7) *v* 89.7 (12), 1.95 (0.5) *v* 3.16 (1.0), 0.44 (0.13) *v* 0.65 (0.24) and 12.7 (1.96) *v* 19.18 (4.33)), we noticed that statins conferred milder increases.

Effect of limb ischaemia on circulating markers

Remote ischaemic preconditioning itself, without coronary intervention, did not change serum CK, CK-MB, TNI and CRP levels from the baseline, and their respective values were 77.1 (10.9) *v* 70.6 (9.9) U/l in 24 h, 0.75 (0.22) *v* 0.55 (0.1) ng/ml in 24 h, 0.03 (0.01) *v* 0.04 (0.01) ng/ml in 24 h and 3.11 (0.51) *v* 3.34 (0.42) mg/l in 48 h.

DISCUSSION

Our study shows that circulating CRP levels increase within 48 h after coronary angioplasty and stent implantation in patients with stable CAD and that this is not prevented by remote ischaemic preconditioning. Furthermore, remote preconditioning is associated with a worse increase in cardiac enzymes and troponin I release even after uncomplicated single-vessel angioplasty.

Since the description of ischaemic preconditioning by Murry *et al*,[8] the concept has expanded to include (1) other

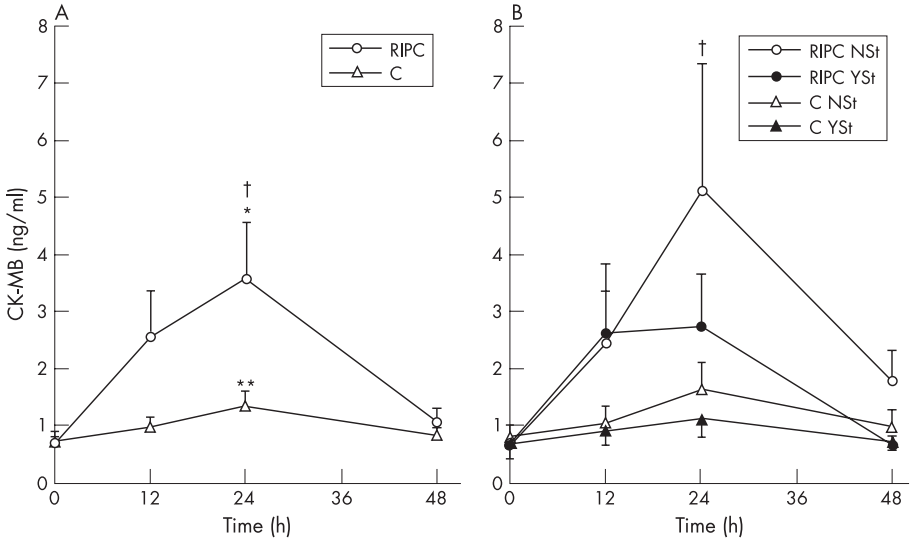

Figure 3 Serum CK-MB levels (mean (SE)) at baseline, 12, 24 and 48 h after percutaneous coronary intervention (PCI). (A) Main group effect. C, control; RIPC, remote ischaemic preconditioning; *p<0.01 versus baseline and 48 h. **p<0.05 versus baseline values. †p<0.05 versus control group. (B) The influence of group and statin use. NSt, no statins; TNI, troponin I; YSt, yes statins. †p<0.05 RIPC NSt versus C YSt.

tissues besides the myocyte, such as the endothelium and (2) other modes of induction—for example, pharmacological preconditioning—which does not use ischaemia. More recently, a novel concept has emerged that cycles of brief ischaemia–reperfusion in one organ can bring about the phenomenon of increased resistance to ischaemic damage in another distant organ—for example, the heart—in the same individual.[15 16] Kharbanda *et al*[17] reported that preconditioning of the forearm prevents endothelial dysfunction of the human radial artery and it attenuates systemic neutrophil activation induced by ischaemia–reperfusion in the contralateral arm. This ''remote preconditioning'' may be of great value to cardiologists carrying out coronary angioplasty for reducing both myocyte and endothelial dysfunction.[11 17 18]

Coronary angioplasty is not without problems. For example, mechanical disruption of a stable atherosclerotic plaque and possible microemboli, induced by the balloon at the time of PCI, may cause a systemic inflammatory response, as reflected by a rise in CRP levels. In fact, microembolisation results in infarctlets, arrhythmias, inflammation and myocardial dysfunction.[20] Almagor *et al*[1] have shown rises in CRP levels after stent implantation in patients with stable coronary disease. Our study also supports this. The mean baseline level of CRP in our patients with stable CAD was 3.4 (0.5) mg/l. Ridker *et al*[21 22] describe a level of >3.0 mg/l as ''high-risk group'' for the development of CAD, a finding shared by Pearson *et al*[23] for stable CAD. In our study, CRP increased by more than fourfold at 48 h after angioplasty. James *et al*[24] found that in acute coronary syndromes, although the myocardial infarction rates were independent of CRP quartiles, higher CRP levels (CRP >9.6 mg/l) were associated with greater mortality. If coronary angioplasty can be considered to be a ''controlled'' acute coronary syndrome (with small enzyme rises), then patients exhibiting higher CRP levels may in fact be at greater risk of an adverse event. Patients in our control group not taking statins reached a

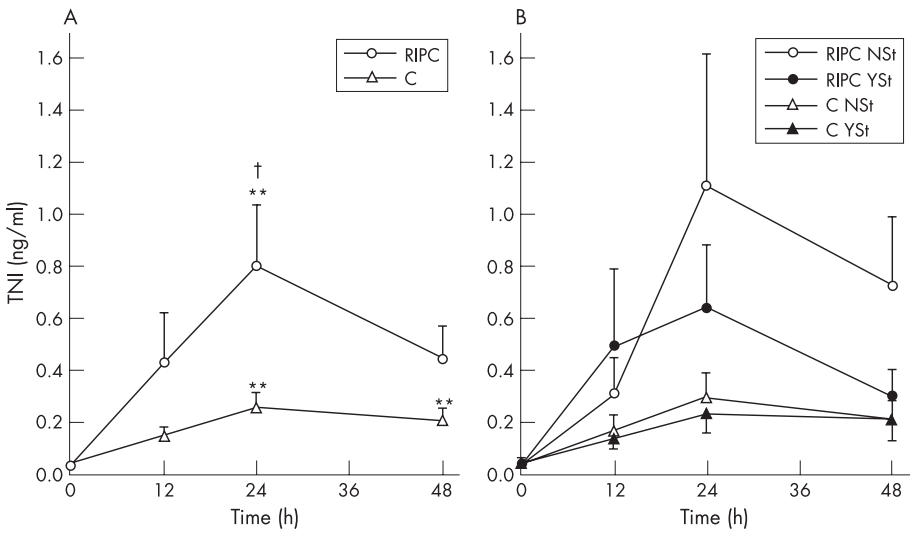

Figure 4 Serum troponin I levels (mean (SE)) at baseline, 12, 24 and 48 h after percutaneous coronary intervention (PCI). (A). Main group effect. C, control; RIPC, remote ischaemic preconditioning; **p<0.05 versus baseline, †p<0.05 versus control group. (B) The influence of group and statin use. NSt, no statins; YSt, yes statins.

mean peak level of CRP>15 mg/l at 48 h, thus placing them in the high-risk group as described by James *et al*.[24] Attempts to prevent such a CRP rise with remote preconditioning were not fruitful in our study. In fact, patients with RIPC feared worse, but only in the absence of statins, an observation that may be related to the anti-inflammatory properties of statins. A rise in CRP may be a surrogate marker of a sensitised pro-inflammatory environment rather than a causative agent. Thus, the interpretation of our results might be that a brief coronary occlusion will not trigger a large inflammatory response (CRP rise) in patients taking statins, whereas in the absence of statins in ''controls'' it may well do so and that this will be further worsened with preceding ischaemia–reperfusion of a distal vascular bed (RIPC group). As our study looked at single-vessel angioplasty, the present concern is that multi-vessel angioplasty in the absence of statins might give rise to very high CRP levels. This is because the first vessel intervention in a multi-vessel angioplasty will in effect produce inflammatory changes similar to those of the RIPC group in our study.

The relationship between the rise in CRP and subsequent cardiac enzyme and TNI release is noteworthy. We found no correlation between CRP levels and enzyme release. James *et al*,[24] the CAPTURE trial[25] and the FRISC trial[26] describe a relationship between high (>10 mg/l) CRP levels and the risk of death, without a relationship with the risk of myocardial infarction. It must be emphasised that this is in the acute phase after a coronary ''event'' (acute-phase reaction), which is different and contrary to the well-established relationship between CRP levels and coronary events in chronic CAD. It would be worthwhile to see a meta-analysis of the above studies on the basis of statin use.

Further evidence that angioplasty is not without concern is the small but considerable rise in CK-MB and TNI, even after single vessel angioplasty. If microembolisation was responsible for this rise, we were surprised to find that CK-MB and TNI levels were considerably higher in the remote preconditioning group than in the control group, as there is no interference of coronary microembolisation with ischaemic preconditioning.[27] However, the issue of reperfusion after microembolisation is a complex one; despite the fact that major vessel occlusion will have a certain area of no reflow, there is no evidence of such occurrence in the present study. Although the absolute level of these enzymes was not very high, the difference between the studied groups was impressive. In five patients in the RIPC group, TNI levels exceeded 1 ng/ml at 24 h, a level which is associated with multi-vessel angioplasty and major adverse cardiac events.[26] Kharbanda *et al*[18] reported that limb RIPC reduced infarct size in pigs. We must bear in mind that a severe stimulus, such as 40 min of LAD occlusion and subsequent infarct (which will induce a substantial inflammatory response), is a very different model from uncomplicated single-vessel angioplasty.

Remote ischaemic preconditioning with limb ischaemia in itself does not change the circulating levels of cardiac enzymes and troponin I or C reactive protein. This might be expected as RIPC itself does not cause myocardial necrosis or inflammation.[29 30]

It is not easy to understand why brief episodes of ischaemia–reperfusion in the upper limbs should affect enzyme release from the heart after PCI. However, it is prudent to discuss this in light of the CRP findings, even though a mathematical relationship could not be proven. Ischaemia–reperfusion (eg, of the heart) shares many of the pathways of inflammation. Thus, in an environment of enhanced inflammatory stimulation such as in the RIPC group without statins, we may well expect similar levels of ischaemia–reperfusion of the heart to result in greater damage and release of cardiac enzymes and TNI, which we did observe. Herrmann *et al*[31] found that treatment with statin reduces the incidence of post-procedural creatine phosphokinase increase. Although our study population was entirely different, we also observed a smaller, albeit non-significant, postprocedural increase of the examined markers in the patients taking statins (analysed as a group *v* those not taking statins).

Our study looked at the first window (1–2 h) of protection afforded by ischaemic preconditioning. The concept that the therapeutic windows may be different in remote ischaemic preconditioning is interesting and was studied by Loukogeorgakis *et al*,[32] who found no differences with classical ischaemic preconditioning.

A larger multicentre trial is now indicated, which may also allow us to analyse further the influence of more parameters.

CONCLUSIONS

RIPC does not reduce, but exacerbates enzyme and TNI release from the heart after single-vessel angioplasty with stent. Furthermore, the increased circulating CRP remains raised. There seems to be an enhanced inflammatory response after RIPC in the absence of statin treatment, which confers a benefit in this respect. The transfer of ischaemic preconditioning from the experimental laboratory with controlled conditions to clinical use requires careful thought and clinical trials.

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IMAGES IN CARDIOLOGY

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Percutaneous treatment of trisaccular coronary aneurysm with coil-embolisation

A 49-year-old woman underwent cardiac evaluation because of severe chest pain and diaphoresis. Physical examination revealed a regular heart rate of 64 beats/min and a blood pressure of 60/30 mm Hg. Echocardiography and computed tomography (CT) of the patient's chest identified moderate amounts of pericardial effusion and the round mass as a large aneurysm of the coronary artery (panel A). An emergency pericardiocentesis was performed immediately to alleviate the haemodynamic derangement. To delineate the size and location of the aneurysm, coronary angiography was performed (panel B). This revealed that the coronary artery fistula originated from the proximal left anterior descending artery, and was connected to the trisaccular aneurysm draining into the pulmonary artery. The aneurysm had a calcified wall and also contained swirling contrast with laminated thrombus.

Using the guidewire, the Guglielmi Detachable Coil (GDC, Hemostasis) was advanced and deployed into the first, proximal aneurysm. Then, six additional GDCs had to be placed and the flow of the coronary artery fistula was successfully closed.

After the coil embolisation, a follow-up angiogram of the fistula with aneurysm was obtained one week later. This showed successful obliteration of the left anterior descending artery fistula with aneurysm.

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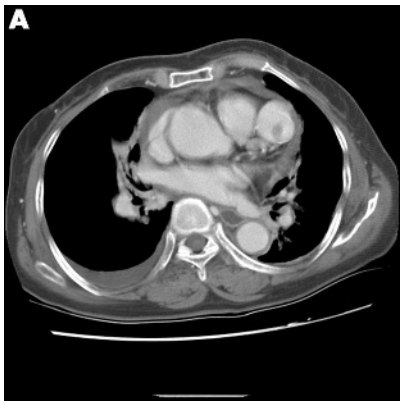
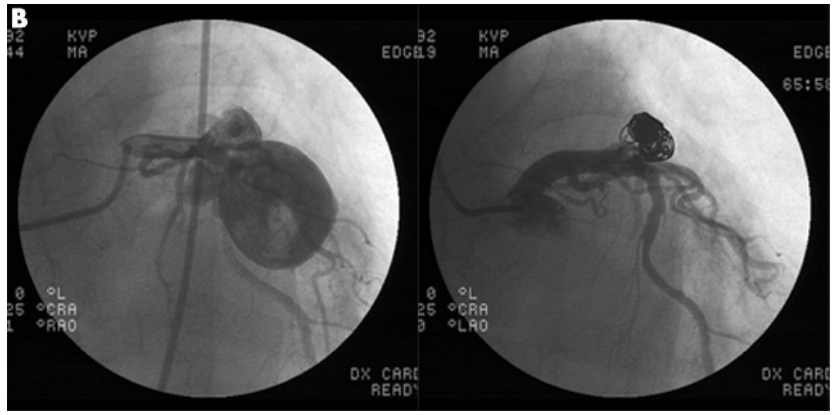


Computed tomographic scan showing pericardial effusion and a large aneurysm containing low density material-like thrombus.



Left: Coronary angiography shows the coronary-to-pulmonary fistula from the proximal left anterior descending coronary artery with a large trisaccular aneurysm. Right: Repeat angiography shows the coil embolisation and complete sealing of the aneurysm.