Altered platelet $\alpha_2$ adrenoreceptor in acute myocardial infarction and its relation to plasma catecholamine concentrations

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SUMMARY Changes in platelet $\alpha_2$ adrenoreceptors and their relation to plasma catecholamine concentrations were studied in 11 patients with acute transmural myocardial infarction. A radio-labelled $\alpha_2$ adrenoreceptor antagonist, $[^3]$H]-yohimbine, was used to assay $\alpha_2$ adrenoreceptors on platelet membranes, and plasma catecholamine concentrations were measured by high performance liquid chromatography. The number of platelet $\alpha_2$ adrenoreceptors, the dissociation constant, and plasma noradrenaline and adrenaline concentrations were studied 6-6 (3-3) (mean (SD)) hours after the onset of acute myocardial infarction and one month later. The mean (SD) number of adrenoreceptors increased significantly from 94-5 (50-5) fmol/mg protein immediately after infarction to 157-0 (65-7) fmol/mg protein one month later. The dissociation constant, however, did not change significantly (4-33 (1-40) nmol/l vs 4-37 (1-22) nmol/l). Raised noradrenaline (5-60 (4-37) nmol/l) and adrenaline (0-28 (0-14) nmol/l) concentrations had fallen significantly from normal values (1-21 (0-67) and 0-09 (0-05) nmol/l respectively) a month after infarction. The decrease in the number of $\alpha_2$ adrenoreceptors soon after infarction may be beneficial because such a change will reduce the strength of various reactions to catecholamines, such as vasoconstriction.

Human platelets have been used to investigate the possible role of $\alpha_2$ adrenoreceptors in disease because they are easily obtained and their membranes contain $\alpha_2$ adrenoreceptors.1 In patients with angina pectoris the number of platelet $\alpha_2$ adrenoreceptors was reported to be significantly lower when patients had symptoms than when they did not.2 The number of $\alpha_2$ adrenoreceptors did not correlate with plasma noradrenaline concentrations. Changes in the number of $\alpha_2$ adrenoreceptors in acute myocardial infarction have not been studied. This is likely to be an important factor because $\alpha_2$ adrenoreceptors may affect coronary artery tone.

We used a radioligand binding technique to study $\alpha_2$ adrenoreceptors in patients with acute myocardial infarction and we investigated the possibility of a relation between changes in receptor number or affinity and plasma catecholamine concentrations.

Patients and methods

PATIENTS

We studied 11 patients (seven men) with a first acute transmural myocardial infarction. The infarction was anterior in five patients and inferior in six. They were selected from a consecutive series of 18 patients with acute myocardial infarction admitted to this hospital between May and September 1984. Two patients with cardiogenic shock and three with heart failure were excluded, as were two patients who underwent coronary artery bypass operation. The diagnosis of acute transmural myocardial infarction was based on the acute onset of chest pain that lasted for more than 30 minutes and was unresponsive to...
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glyceryl trinitrate, and on ST segment elevation >2mV in the standard 12 lead electrocardiogram. The diagnosis was subsequently confirmed by the evolution of typical electrocardiographic changes and an increase in creatine kinase MB isoenzyme.

One patient (case 4) had had angina before infarction and had been treated mainly with sublingual glyceryl trinitrate. One patient (case 9) had been taking a thiazide for hypertension. No patient had given \( \beta \) receptor blocking agents. After admission all patients were given nitrates. Five patients (cases 3, 5, 7, 10, and 11) were treated with diltiazem. Catecholamines and \( \beta \) receptor blocking agents were not given to any patients. No patient had chest pain or showed signs of heart failure while in hospital. None had enzymatic or electrocardiographic evidence of a recurrence of acute myocardial infarction.

**BLOOD SAMPLING AND ISOLATION OF PLATELET MEMBRANES**

Blood was drawn from an antecubital vein immediately after admission (6-6 (3-3) hours after the onset of chest pain). Three patients (cases 1, 5, and 9) were initially in Forrester haemodynamic subset II and eight were in subset I. Patients in group I were given frusemide which improved their haemodynamic condition. Blood samples were taken a month after the onset of infarction. All medication was discontinued for at least 24 hours before the second blood samples were collected.

Platelet membranes were obtained by the method of Garcia-Sevilla et al. Blood (30–40 ml) was collected in acid citrate dextrose (8:1, vol/vol). The sample was centrifuged at 160g for 10 minutes at 25°C, and the platelet rich plasma was titrated to pH 6.5 with the acid citrate dextrose solution. Plasma was then recentrifuged at 5100g for 15 minutes at 25°C to obtain a platelet pellet. The pellet was washed twice by 5ml of Tyrode's buffer (sodium chloride 137 mmol/l, potassium chloride 2.7 mmol/l, monobasic sodium phosphate 0.36 mmol/l, magnesium chloride 0.01 mmol/l, sodium bicarbonate 12-0 mmol/l, dextrose 0.56 mmol/l, pH 8-0) and centrifuged for 15 min at 5100g. The pellet was lysed by homogenisation in 3 ml of ice cold hypotonic buffer (TRIS edetic acid 5 mmol/l, pH 7.5). The platelet membranes were obtained by centrifugation at 39 000g for 10 min and then resuspended in the TRIS incubation buffer (TRIS-hydrochloric acid 50 mmol/l, magnesium chloride 10 mmol/l, pH 7-5) used in the radioligand binding assay.

**RADIOLIGAND BINDING ASSAY**

We used \([3H]\)-yohimbine (New England Nuclear, Boston, Massachusetts), an \( \alpha_2 \) adrenoreceptor antagonist to measure total radioligand binding in 0-1ml volumes of fresh platelet membranes (0-15 (0-1) mg protein). Samples were incubated in duplicate at 25°C for 20 minutes. Non-specific binding was measured by adding unlabelled yohimbine (10 \( \mu \)mol/l) to other duplicate samples. Specific binding was calculated as the difference between total and non-specific binding. Incubations were terminated by adding 5ml of the TRIS-incubation buffer to the samples. The membrane bound tritiated ligand was recovered by rapid filtration of the diluted sample under vacuum through Whatman GF/C glassfibre filters. The filters were washed twice with 10ml of TRIS-incubation buffer, air dried, and counted for radioactivity as described by Smith et al. Protein concentrations were determined by the method of Lowry et al. We used Scatchard analysis of the saturation isotherms to determine the maximal number of binding sites (x intercept of a plot of specifically bound ligand vs bound/free ligand) and the dissociation constant (negative reciprocal of the slope of the regression line).

**PLASMA NORADRENALINE AND ADRENALINE**

Plasma concentrations of noradrenaline and adrenaline were determined by the method of Yui et al.
Table  Patient profile and summary of data

<table>
<thead>
<tr>
<th>Case</th>
<th>Age/sex</th>
<th>Medication</th>
<th>*Angina</th>
<th>Kd (nmol/l)</th>
<th>Bmax (fmol/mg protein)</th>
<th>Noradrenaline/adrenaline (nmol/l)</th>
<th>Clinical course</th>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Soon†</td>
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<td>1.40</td>
<td>1.22</td>
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Bmax, maximal number of binding sites; Kd, dissociation constant; I and II, Forrester haemodynamic subset I and II; GTNO, glyceryl trinitrate ointment; LISDN, long acting isosorbide dinitrate.

*Before admission.
†Before onset of myocardial infarction.
‡Angina lasting for two weeks before onset of myocardial infarction.

Normal values are 1.24–0.89 nmol/l and 0.16–0.05 nmol/l respectively.

**STATISTICAL ANALYSIS**
Values are given as means and standard deviations. Statistical analysis was performed by Student's t test. Significance was defined as p < 0.05.

**Results**

**BINDING DATA**
Figure 1 shows that the specific binding of [3H]-yohimbine to platelet membranes from patients was both saturable and of high affinity. The Table shows data for individual patients. The number of the adrenoreceptors increased significantly from 96.5 (50.5) fmol/mg protein early (6.6-3.3) hours after infarction to 157.0 (65.7) fmol/mg protein one month later (p < 0.01) (Fig. 2). But there no significant difference in the dissociation constant (4.33 (1.40) nmol/l vs 4.37 (1.22) nmol/l).

**PLASMA CONCENTRATIONS OF NORADRENALINE AND ADRENALINE**
Plasma concentrations of noradrenaline and adrenaline were measured in nine of 11 patients. They

Fig. 2 Alpha2 adrenoreceptor number (Bmax; fmol/mg protein) and dissociation constant (Kd; nmol/l) in patients with acute myocardial infarction soon after and one month after onset.
were raised immediately after infarction, but they had fallen significantly one month later (noradrenaline from 5-60 (4-37) nmol/l to 1-21 (0-67) nmol/l, p < 0-05; adrenaline from 0-28 (0-14) nmol/l to 0-09 (0-05) nmol/l, p < 0-05). Changes in receptor number and concentrations of noradrenaline and epinephrine were not significantly correlated (noradrenaline r = 0-588, adrenaline r = 0-10, both NS).

**Discussion**

Alpha adrenergic stimulation has been shown to modulate coronary artery tone in dogs and patients with ischaemic heart disease.\(^8\)\(^-\)\(^\text{10}\) Alpha\(_2\) adrenoreceptors play an important role in the coronary vasoconstriction elicited by sympathetic nerve stimulation and in regulating the tone of both large and small coronary arteries.\(^9\) Thus alterations in \(\alpha_2\) adrenoreceptors might affect the coronary artery tone. In patients with symptomatic angina Weiss et al found a decrease in platelet \(\alpha_2\) adrenoreceptor number that did not correlate with plasma catecholamine concentrations.\(^2\) These findings raise the possibility that \(\alpha_2\) adrenoreceptor abnormalities may be associated with the pathogenesis of angina. There is, however, little information on the changes in \(\alpha_2\) adrenoreceptors in myocardial infarction. We found that soon after infarction the number of platelet \(\alpha_2\) adrenoreceptors was significantly lower than it was one month later. There was no alteration in affinity. This decrease in receptor number soon after infarction was accompanied by an increase in the plasma catecholamine concentrations.

In an experimental study plasma catecholamines increased rapidly within one minute of coronary occlusion.\(^1\)^\(^\text{11}\) This increase was considered to reflect enhanced release of noradrenaline from the postganglionic sympathetic nerve endings in the heart.\(^1\) Adrenaline secretion from the adrenal medulla was reflexly induced by stimulation of cardiac receptors at the site and the boundary of the infarct.\(^1\) The increase in plasma catecholamine concentrations was also demonstrated early in myocardial infarction in a previous clinical investigation.\(^1\)\(^\text{13}\) In the present study, catecholamine concentrations were significantly raised 6-6 (3-3) hours after infarction. The increase in our study, however, was less pronounced than that observed in previous investigations.\(^1\)\(^\text{12}\)\(^\text{13}\) This might be due to our excluding patients with cardiogenic shock or severe heart failure, which are both conditions that enhance sympathoadrenal responses.\(^1\)^\(^\text{13}\)

Receptor down regulation is believed to occur when the cell is exposed for some time to higher concentrations of an agonist. The results of experimental studies of down regulation of platelet \(\alpha_2\) adrenoreceptor are controversial.\(^1\)\(^\text{14}\)\(^\text{15}\) Previous clinical studies found an inverse relation between plasma catecholamine concentrations, especially noradrenaline concentrations, and the number of \(\alpha_2\) adrenoreceptors in various conditions such as pheochromocytoma,\(^1\)\(^\text{16}\)\(^\text{17}\) congestive heart failure,\(^1\)\(^\text{18}\) and idiopathic orthostatic hypotension.\(^1\)\(^\text{16}\) This suggests agonist induced down regulation as a possible underlying mechanism. Our results resemble these clinical investigations. The correlation between changes in the receptor number and catecholamine concentrations was not, however, statistically significant. Furthermore, the affinity of the receptor for catecholamines is much higher than the ranges of physiological concentrations.\(^1\)\(^\text{19}\) Therefore, it appears unlikely that down regulation of platelet \(\alpha_2\) adrenoreceptor occurs in vivo.

Some unknown mechanisms other than down regulation may be involved in the modulation of the receptor number. Further investigations are necessary to clarify the mechanisms which regulate \(\alpha_2\) adrenoreceptor in vivo. In any event this decrease in the receptor number when catecholamine concentrations are raised during the early phases of acute infarction may be beneficial because it may moderate catecholamine-induced reaction such as vasoconstriction.

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**References**

4. Smith CB, Sheldon MI, Bernarcyck JH, Villareal JE. Morphine induced increases in the incorporation of \(^{14}\)C-tyrosine into \(^{14}\)C-dopamine and \(^{14}\)C-norepinephrine in the mouse brain: antagonism by naloxone and tolerance. *J Pharmacol Exp Ther* 1972; 180: 547–57.