### SCIENTIFIC LETTERS

**Renin angiotensin system inhibition is associated with reduced free radical concentrations in arteries of patients with coronary heart disease**

Angiotensin II, which is also thought to play a key role in atherosclerosis, has recently been shown to have pro-oxidant effects, by increasing superoxide \( (\cdot O_2^-) \) production in human arteries.\(^1\) Oxidative stress, a state of excessive free radical activity which is associated with reduced bioavailable nitric oxide (NO), may be evident in patients with coronary heart disease (CHD).\(^1\) Lately ACE inhibitors have been shown to reduce cardiovascular morbidity and mortality in patients at high risk of CHD.\(^1\) The aim of the present study was to determine, if any, risk factors and drug treatments were associated with altered free radical concentrations in the arteries of CHD patients undergoing coronary bypass grafting (CABG).

Distal segments of left internal mammary artery which were obtained at the time of CABG were taken to the laboratory in Krebs-Hepes buffer (pH 7.4 ± 0.2), carefully dissected free of loose connective tissue, divided into 4–5 mm segments and weighed. Vascular \( \cdot O_2^- \) was measured by lucigenin enhanced chemiluminescence in a liquid scintillation counter (Hewlett Packard Model Tricarb 2100TR).\(^1\) Absolute counts were quantified with a xanthine/xanthine oxidase calibration curve for \( \cdot O_2^- \) generation and reported as picomol per milligram per minute of tissue. Statistical analyses of vascular \( \cdot O_2^- \) concentrations after log transformation were undertaken using the non-parametric Mann-Whitney Test and a stepwise multiple regression analysis was also performed. A probability value of \( p < 0.05 \) was considered significant. This study was approved by the hospital's ethics committee.

Data on age, sex, risk factors, and drug treatment are given in table 1. The profiles of risk factors and different classes of drug treatments were similar between patients who were taking an angiotensin converting enzyme inhibitor (ACEI) or an angiotensin type 1 receptor antagonist (ARA), compared to those who were not taking these treatments. An ACE inhibitor or ARA was prescribed in 16 and three patients, respectively. The median rate of production of \( \cdot O_2^- \) in internal mammary arteries was 1137 (interquartile range (IQR) 1290) pmol/mg/min. Superoxide concentrations were lower in those patients taking either an ACE inhibitor or an ARA (857 (IQR 670) pmol/mg/min; \( n = 19 \)) compared to those who were not (1600 (IQR 511) pmol/mg/min; \( n = 60 \); \( p = 0.002 \); 95% confidence interval for median difference 487 to 1228 pmol/mg/min (fig 1)). No other associations between age, sex, risk factors or drug treatments and superoxide concentrations were identified.

We have shown, for the first time in human arteries, that \( \cdot O_2^- \) concentrations were lower in patients treated with either an ACE inhibitor or an ARA, compared to those who were not. The clinical characteristics of both of these groups were similar such that the observed differences in vascular \( \cdot O_2^- \) concentrations were unlikely to be explained by any other patient characteristic or treatment. It is of interest that despite the fact that a large proportion of these patients were taking drugs with putative antioxidant properties, such as aspirin, \( \beta \) blockers and HMG-CoA reductase inhibitors, vascular free radical concentrations were detected at physiologically important concentrations. The absence of any important antioxidant effect of these other treatments suggests that the sample size may not be sufficiently large to detect what may be a lesser antioxidant effect of these drugs. The variation in basal vascular \( \cdot O_2^- \) concentrations observed in this and other investigations in humans,\(^1\) and the lack of correlation of \( \cdot O_2^- \) production with some atherosclerotic risk factors, may be caused by the heterogeneous clinical characteristics of patients with CAD.

Our observations raise two questions. The first is how does such treatment exert this effect? Though some ACE inhibitors may have direct free radical scavenging properties, this effect has been difficult to show at therapeutically elevated concentrations in humans.\(^4\) A more likely explanation is that the antioxidant effect of this treatment is caused by inhibition of the effects of angiotensin II.\(^1\) The second question is what, if any, might be the therapeutic significance of this effect of RAS inhibition. A reduction in vascular free radical production associated with RAS inhibition, as is the case in the current study, may lead to enhanced bioavailable nitric oxide in vivo.

Taken together, these observations suggest that RAS inhibition leads to a reduction in oxidative stress in patients with CHD. Given the damaging effects of increased free radical activity in the vasculature, the antioxidative effects of this treatment may be one further mechanism which may contribute to their beneficial effects in patients with CHD.

**Table 1 Patient characteristics, including risk factors and treatments**

<table>
<thead>
<tr>
<th>Risk factor</th>
<th>RAS inhibitor</th>
<th>No RAS inhibitor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smoking</td>
<td>3 (16)</td>
<td>10 (17)</td>
</tr>
<tr>
<td>Hypertension</td>
<td>9 (47)</td>
<td>21 (35)</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>2 (10)</td>
<td>4 (7)</td>
</tr>
<tr>
<td>Hypercholesterolemia</td>
<td>14 (73)</td>
<td>41 (68)</td>
</tr>
<tr>
<td>Mean (SD) plasma cholesterol, mmol/l</td>
<td>5.9</td>
<td>5.2 (0.9)</td>
</tr>
<tr>
<td>Medication, n (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aspirin</td>
<td>14 (74)</td>
<td>48 (80)</td>
</tr>
<tr>
<td>( \beta ) Blockers</td>
<td>13 (68)</td>
<td>33 (55)</td>
</tr>
<tr>
<td>Calcium channel blockers</td>
<td>11 (58)</td>
<td>34 (57)</td>
</tr>
<tr>
<td>HMG-CoA reductase inhibitors</td>
<td>7 (37)</td>
<td>31 (52)</td>
</tr>
<tr>
<td>Nitroglycerin</td>
<td>12 (63)</td>
<td>34 (57)</td>
</tr>
</tbody>
</table>

RAS, renin angiotensin system; HMG-CoA, hydroxymethylglutaryl-CoA.

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**Figure 1** Boxplot graphical representation of superoxide concentrations (pmol/mg/min) in internal mammary arteries from patients undergoing coronary artery bypass surgery who were taking either an angiotensin converting enzyme inhibitor (ACEI) or an angiotensin type 1 receptor antagonist (ARA), compared to those patients not taking these treatments. Means are indicated by solid circles, rectangles represent the lower and upper limits of the interquartile range, and median values are denoted inside the rectangles. The vertical lines (or “whiskers”) represent the spread of the data. The upper line represents the upper, or third quartile, plus 1.5 (interquartile range), and the lower line represents the lower, or first quartile, minus 1.5 (interquartile range). The asterisks (*) represent outlying values which lie between 1.5 and 3 times away from the middle 50% of the data.
3 Vaulat S, Phil D, Sleight P, et al. Effects of an angiotension-converting enzyme inhibitor, tami-
285–90.
5 Huraux C, Makita T, Kurz S, et al. Superoxide production: risk factors, and endothelium-
6 Chopra M, Bewick H, Clapperton M, et al. Antioxidant effects of angiotension-converting (ACE) inhibitors—free-radical and oxidant scavenging are sulfhydril dependent, heart rate—diastolic blood pressure. Antioxidant e

7 Chopra M, Bewick H, Clapperton M, et al. Antioxidant effects of angiotension-converting (ACE) inhibitors—free-radical and oxidant scavenging are sulfhydril dependent, heart rate—diastolic blood pressure.

The exact role of natriuretic peptides in gen-

eral practice remains to be defined. 1 While raised plasma concentrations of N-terminal atrial natriuretic peptide (N-ANP) or brain natriuretic peptide (BNP) are associated with left ventricular systolic dysfunction and heart failure, 2 the prognostic value of these peptides outside hospital populations re-
mains uninvestigated. We recently showed that the risk of left ventricular systolic dysfunction in heart patients from general practice can be assessed from abnormal N-ANP concentrations, abnormal ECG, and a heart rate—diastolic blood pressure. 3 The importance of these prespecified variables, in particular a raised N-ANP, would be con-

In practice, the idea of using natriuretic peptide measure-

ment in selected patients rather than advocating it for an unrestricted use. The strength of this study lies in its validation of prespecified variables, and that N-ANP remained the strongest predictor of death after considering recognised prognostic factors. A larger study is required to show the prognostic value of N-ANP in subjects with a normal ECG. BNP measurements were not available for this

Table 1 Survival of patients according to having an ECG with QRS or ST changes and N-terminal atrial natriuretic peptide (N-ANP) > 0.8 nmol/l or not

<table>
<thead>
<tr>
<th>Patients &lt; 70 years of age (n=53)</th>
<th>3 year follow up</th>
<th>6.1 year follow up</th>
<th>Median survival (years)</th>
<th>Log rank test p value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total (n)</td>
<td>Deaths (n)</td>
<td>Survival actual (%)</td>
<td></td>
</tr>
<tr>
<td>Normal ECG, normal N-ANP</td>
<td>26</td>
<td>1</td>
<td>96</td>
<td>&gt; 6.1</td>
</tr>
<tr>
<td>Abnormal ECG, normal N-ANP</td>
<td>22</td>
<td>2</td>
<td>91</td>
<td>&gt; 6.1</td>
</tr>
<tr>
<td>Normal ECG, raised N-ANP</td>
<td>1</td>
<td>0</td>
<td>100</td>
<td>4.0</td>
</tr>
<tr>
<td>Abnormal ECG, raised N-ANP</td>
<td>4</td>
<td>3</td>
<td>25</td>
<td>1.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&lt; 0.0001</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Patients ≥ 70 years of age (n=67)</th>
<th>3 year follow up</th>
<th>6.1 year follow up</th>
<th>Median survival (years)</th>
<th>Log rank test p value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total (n)</td>
<td>Deaths (n)</td>
<td>Survival actual (%)</td>
<td></td>
</tr>
<tr>
<td>Normal ECG, normal N-ANP</td>
<td>28</td>
<td>4</td>
<td>86</td>
<td>&gt; 6.1</td>
</tr>
<tr>
<td>Abnormal ECG, normal N-ANP</td>
<td>24</td>
<td>4</td>
<td>85</td>
<td>&gt; 6.1</td>
</tr>
<tr>
<td>Normal ECG, raised N-ANP</td>
<td>7</td>
<td>0</td>
<td>100</td>
<td>4.0</td>
</tr>
<tr>
<td>Abnormal ECG, raised N-ANP</td>
<td>7</td>
<td>6</td>
<td>14</td>
<td>1.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.0003</td>
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</table>

The p values test the hypothesis that 6.1 year survival in a group equals survival in the age matched reference group with a normal ECG and N-ANP. Survival is shown as actual percentages at 3 years and as Kaplan-Meier (K-M) estimates at 6.1 years.

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study. Nor have we evaluated those variables in acute patients, which is a different situation.\(^1\)

Just half the target group accepted our invitation for a full cardiac assessment. Those who withdrew were old, they were probably more disabled, and their prognosis may have been worse than for subjects who were examined. In view of the understandable withdrawal pattern, we believe our results are applicable to a scenario in general practice where a physician wants to make a risk assessment for a presumed heart patient without overt congestive heart failure. A normal ECG will convince the physician and patient of a favourable prognosis and a low likelihood of left ventricular systolic dysfunction. Our study suggests that measurement of natriuretic peptide is particularly useful in subjects with an abnormal ECG. If both N-ANP and the ECG are abnormal, further cardiac assessment seems sensible to determine whether treatable conditions exist, although we have no data on how cardiac assessment will indeed change the outcome.

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Circulating concentrations

<table>
<thead>
<tr>
<th></th>
<th>1 day before chemotherapy</th>
<th>1 day after chemotherapy</th>
<th>3 weeks after chemotherapy</th>
</tr>
</thead>
<tbody>
<tr>
<td>BNP (pg/ml)</td>
<td>13.7 (1.9)</td>
<td>53.8 (3.5)*</td>
<td>12.6 (2.4)</td>
</tr>
<tr>
<td>ANP (pg/ml)</td>
<td>24.9 (4.9)</td>
<td>30.3 (4.6)</td>
<td>27.4 (3.9)</td>
</tr>
<tr>
<td>Noradrenaline (pg/ml)</td>
<td>277.1 (35.3)</td>
<td>277.1 (33.8)</td>
<td>257.9 (51.9)</td>
</tr>
<tr>
<td>Adrenaline (pg/ml)</td>
<td>33.0 (6.0)</td>
<td>32.4 (5.7)</td>
<td>39.0 (12.8)</td>
</tr>
<tr>
<td>Renin (reninogen) (ng/ml/h)</td>
<td>1.37 (0.32)</td>
<td>1.30 (0.23)</td>
<td>1.09 (0.48)</td>
</tr>
<tr>
<td>Aldosterone (pm/l)</td>
<td>70.6 (8.2)</td>
<td>69.2 (7.0)</td>
<td>74.6 (16.0)</td>
</tr>
</tbody>
</table>

Echocardiographic parameters

<table>
<thead>
<tr>
<th></th>
<th>Fractional shortening (%)</th>
<th>Ejection fraction (%)</th>
<th>Mitral inflow E:A ratio</th>
<th>Deceleration time (ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>36.4 (1.0)</td>
<td>72.9 (5.2)</td>
<td>1.45 (0.16)</td>
<td>192.1 (9.9)</td>
</tr>
</tbody>
</table>

Maximum diameter of IVC (mm)

|                | 1.5 (0.8)                  | 12.9 (1.0)            | 12.0 (2.0)              |

All data are expressed as mean (SEM).


Implementation of the NICE guidelines for the primary prevention of mortality from ventricular tachyarhythmias: implications for UK electrophysiology centres; activity modelling from the UK-HEART study

It is now well established that the implantable cardioverter-defibrillator (ICD) is the most effective treatment for the primary prevention of life threatening ventricular arrhythmia.\(^1,2\) Despite this, its widespread use in the UK for this indication has been minimal, at least in part because of perceived resource implications. In September 2000, the National Institute for Clinical Excellence (NICE) recommended echocardiological testing (EPS) for all patients with a history of myocardial infarction who have an ejection fraction of less than 35% and three or more beats of non-sustained ventricular tachycardia (NSVT) on a 24 hour Holter monitor. NICE further recommended that all patients in whom a significant ventricular arrhythmia is induced at EPS should have an ICD
implanted. The potential effect of the NICE guidelines on workload in UK electrophysiology centres has not been evaluated.

UK-HEART examined the utility of heart rate variability as a predictor of mortality in heart failure patients. Ambulant patients with stable heart failure were enrolled in four UK cardiac centres over a 17 month period (1 December 1993 to 30 April 1995). Patients with diabetes and atrial fibrillation were excluded; otherwise all comers to cardiology clinics were eligible. All patients underwent echocardiographic estimation of ejection fraction and screening for arrhythmia, including NSVT, using 24 hour ambulatory electrocardiography. The baseline demographic and clinical characteristics of these patients were similar to those in MADIT and MUSTT, the two primary prevention trials on which the NICE guidelines are based.

A total of 555 patients were entered into UK-HEART, of whom 551 had interpretable 24 hour ECGs. Of these, 57 fulfilled the NICE criteria for EPS. If diabetics and patients with atrial fibrillation had been included this figure would increase to 88 as approximately 35% of heart failure populations suffer from either of these conditions. Recent data have demonstrated that a second 24 hour tape will identify a further 38% of patients with NSVT, increasing numbers to 142. In MUSTT, sustained ventricular arrhythmia was induced at EPS in 35% of patients. Other smaller studies in similar populations have found equivalent positivity rates. A four cohort reacted in the same way there would be 50 positive studies and hence 50 ICD implants.

During the period of recruitment 68 electrophysiological studies for ventricular arrhythmia were performed on patients within the four centres. During an equivalent, contemporary period (1998-2000), 72 studies were performed. Application of NICE guidelines would lead to a further 142 studies, equivalent to three extra per month in each of the three centres performing this procedure. During 1993-95 there were 11 ICDs implanted. Between 1998-2000 there were 79 implanted. The NICE guidelines would mean a further increase of 50, representing one extra ICD per implanting centre per month.

The UK-HEART study was primarily designed to investigate the prognostic utility of measures of heart rate variability in a heart failure population and therefore has some limitations in its application to NSVT. Diabetics and patients with atrial fibrillation were excluded from UK-HEART because of the heart rate variability analysis. Diabetics make up 20% and patients with atrial fibrillation 15% of major heart failure studies. We have assumed that if these patients had been included, our population eligible for further investigation would increase by 35%. Clearly there will be some crossover between the groups and they may have different rates of NSVT. The patients in the study were allcomers to cardiology clinics. Numbers would increase if all primary and secondary care physicians had enrolled patients.

The numbers of investigations and ICDs estimated apply to the first year of guideline implementation. The numbers requiring investigation and treatment the following year, including new diagnoses and those whose disease had progressed, would differ; theoretically fewer than in the first year. The numbers would also fall as some patients eligible for investigation or treatment would be unsuitable for non-cardiological reasons.

Overall, these data provide evidence that implementation of the NICE guidelines for the use of ICDs in primary prevention is unlikely to lead to an unmanageable increase in EPS or ICD implantation in UK electrophysiology centres.

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