Resistant hypertension and preoperative silent myocardial ischaemia in surgical patients†


Summary
We studied 325 patients undergoing elective non-cardiac surgery who had preoperative ambulatory ECG monitoring performed for a duration of 5130 h (range 8–24 h; mean 15.8 h). Sixty-four subjects (20%) had one or more episodes of ST segment depression consistent with myocardial ischaemia. Of all preoperative cardiovascular variables measured, the presence of elevated arterial pressure, despite patients being maintained on long term antihypertensive therapy, was the only factor associated significantly with the presence of preoperative silent myocardial ischaemia (P < 0.002). This correlation was confirmed when arterial hypertension was defined in four separate ways. The incidence of silent ischaemia in these patients was 33–55%. We suggest that admission arterial pressure may therefore be a useful screening test to identify patients at risk of preoperative myocardial ischaemia. (Br. J. Anaesth. 1994; 73: 574–578)

Key words
Heart, ischaemia. Complications, hypertension.

Perioperative cardiac morbidity is the leading cause of death after anaesthesia and surgery [1]. In the UK, between 12 and 20% of patients presenting for non-cardiac surgery have preoperative evidence of cardiovascular disease and of these the commonest cardiovascular complaint is arterial hypertension [2, 3]. Despite this, the role of arterial hypertension as a determinant of perioperative morbidity is still uncertain. Early work suggested that pre-existing hypertension was associated with intraoperative cardiovascular instability and myocardial ischaemia [4–7] and recently a history of arterial hypertension has been found to be associated with a poorer postoperative outcome [8, 9]. However, a prospective multivariate analysis of more than 1000 non-cardiac operations by Goldman and colleagues failed to show arterial hypertension as an independent predictor of postoperative cardiac complications [10].

The use of ambulatory ECG monitoring is now a widely accepted method of detecting myocardial ischaemia. Modern microprocessing technology enables continuous and accurate measurement of ST segment changes; in patients with coronary artery disease, these have been shown to correlate with reduced myocardial perfusion [11, 12], such episodes being clinically silent in more than 70% of patients [13]. The presence of silent myocardial ischaemia in patients after myocardial infarction or with known stable coronary artery disease is predictive of adverse cardiac events and sudden death [14–17].

In the present study we have investigated the relationship between incidence of preoperative myocardial ischaemia and arterial hypertension in patients undergoing general or vascular surgery.

Patients and methods
We studied 351 patients presenting for elective non-cardiac surgery. Patients gave informed consent and the study was approved by the Central Oxford Research Ethics Committee. All patients were interviewed and examined by one of four investigators (K.G.A., A.M., A.E.H., S.J.H.) and details of cardiovascular risk factors noted. Preoperative investigations, ECG and arterial pressure readings were recorded. Admission arterial pressure was defined as the first in-hospital recording taken by one of the investigators, ward nurse or house physician. All pressure readings were obtained with a manual mercury sphygmomanometer.

Patients subsequently underwent ambulatory ECG monitoring using a Medilog FD-2 or 6000 FD ambulatory ECG monitoring unit (Oxford Medical Limited, Abingdon, UK) for up to 24 h before surgery (minimum 8 h). Recordings were made from silver–silver chloride skin electrodes placed to record standard lead III and CMV. Data from the ambulatory unit were then downloaded via optical link onto an IBM compatible 286 microcomputer and analysed for ST segment changes using the Medilog Prima ECG analysis software. A significant ST segment change was defined as a horizontal or downsloping depression of greater than 1 mm or an elevation of greater than 2 mm, for a period of more than 60 s. The ECG baseline was measured at a point 60 ms before the maximum R wave and the ST segment measured 100 ms after the maximum R wave.
Preoperative silent ischaemia

Table 1 Patient characteristics and numbers of patients with silent myocardial ischaemia

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<tr>
<th></th>
<th>No. with silent ischaemia (%)</th>
<th>P</th>
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<tr>
<td></td>
<td>(n = 64)</td>
<td></td>
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<tr>
<td>Male</td>
<td>41 (19.3)</td>
<td>0.942</td>
</tr>
<tr>
<td>Vascular surgery</td>
<td>39 (22.0)</td>
<td>0.307</td>
</tr>
<tr>
<td>Previous myocardial infarction</td>
<td>14 (23.7)</td>
<td>0.496</td>
</tr>
<tr>
<td>History of angina</td>
<td>9 (29.0)</td>
<td>0.255</td>
</tr>
<tr>
<td>Peripheral vascular disease</td>
<td>25 (23.8)</td>
<td>0.254</td>
</tr>
<tr>
<td>Smoking (&gt; 20 pack years)</td>
<td>30 (20.3)</td>
<td>0.921</td>
</tr>
<tr>
<td>Obesity (&gt; 20 % ideal weight)</td>
<td>12 (16.0)</td>
<td>0.444</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>4 (16.7)</td>
<td>0.904</td>
</tr>
<tr>
<td>Age ≥ 70 yr</td>
<td>25 (22.5)</td>
<td>0.437</td>
</tr>
</tbody>
</table>

wave. Each ST segment deviation was terminated by a return to baseline of more than 60 s. All reported episodes of ST segment change were verified visually.

Inclusion criteria were age greater than 40 yr, ASA grade I–III and elective admission for major non-cardiac surgery. All subjects had at least three preoperative arterial pressure measurements recorded, including admission arterial pressure. Patients were then classified into one of four groups: normotensive not taking antihypertensive medication (normotensive); normotensive taking regular antihypertensive medication (well treated); hypertensive not taking regular antihypertensive medication (untreated); and hypertensive despite regular antihypertensive medication (poorly treated).

Each patient was classified on the basis of four separate definitions of arterial hypertension. This was done to reduce the introduction of bias from, and to examine the effect of, different hypertensive definitions. These were as follows: (1) adm ≥ 150/80 = either admission systolic ≥ 150 or admission diastolic ≥ 80 mm Hg; (2) adm ≥ 160/90 = either admission systolic ≥ 160 or admission diastolic ≥ 90 mm Hg; (3) adm ≥ 170/100 = either admission systolic ≥ 170 or admission diastolic ≥ 100 mm Hg; and (4) diast. 3 ≥ 100 = three or more diastolic readings ≥ 100 mm Hg.

After ECG analysis, the ischaemic load (duration of myocardial ischaemia/duration of recording) was calculated for each patient.

STATISTICAL ANALYSIS

Admission arterial pressures for each of the four categories were compared using unpaired two-tailed Student’s t tests with correction for multiple testing. The adequacy of pressure control (as defined earlier) was compared with the presence or absence of preoperative silent myocardial ischaemia using the chi-square test or contingency table analysis with a continuity correction. A similar approach was used to assess the relationship between antihypertensive therapy and the incidence of silent myocardial ischaemia.

The duration of ECG monitoring was divided into 4-h epochs and compared with the presence or absence of silent myocardial ischaemia and hypertensive–treatment category, again using contingency table analysis with a continuity correction. Indices of specificity, sensitivity and positive-
myocardial infarction for patients undergoing car-
anaesthetic room to be predictive of postoperative
and Keats found silent ischaemia occurring in the
postoperative adverse myocardial events. Slogoff
has been shown to be a significant predictor of
The presence of silent myocardial ischaemia (SMI)
Discussion
The presence of silent myocardial ischaemia (SMI) has been shown to be a significant predictor of postoperative adverse myocardial events. Slogoff and Keats found silent ischaemia occurring in the anaesthetic room to be predictive of postoperative myocardial infarction for patients undergoing car-
diac surgery [7, 18]. Raby and colleagues [19–21], in
a series of 176 patients, and Pasternack and co-
workers [22], in a series of 200 patients undergoing
vascular surgery, found preoperative SMI to be the
most significant predictor of postoperative morbid
cardiac events. Similar results were described for
those undergoing both vascular and non–vascular
surgery [23]. However, Mangano and colleagues
found preoperative SMI to be weakly associated
only with, and not a predictor of, postoperative
cardiac events and death [24, 25]. Other studies have
shown preoperative SMI to be predictive of intra-
operative myocardial ischaemia [26] and post-
operative SMI [27, 28]. Detection of SMI therefore
has important implications in the management of
patients presenting for major surgery.
We have shown that patients who appear to be
resistant to conventional antihypertensive therapies
have an extremely high incidence (> 50%) of
preoperative SMI on 24-h ambulatory ECG moni-
toring. The mechanism for this remains unclear. It is
likely that patients with long–standing arterial hy-
pertension who do not respond well to treatment
have more severe and widespread arterial disease.
Using a definition of hypertension as three diastolic
readings > 100 mm Hg, 55% of poorly treated
patients had preoperative episodes of SMI compared
with 18% of well treated patients and 28% of
untreated patients. It is important to note that the
poorly treated group, although resistant to treat-
ment, did not have grossly elevated arterial pressure
readings. There was no significant difference be-
tween the admission pressures of the poorly treated
and untreated groups. As our population consisted
of patients presenting for routine major surgery and
presently accepted practice recommends postpone-
ment if diastolic pressure is consistently greater than
100 mm Hg [5], it is not surprising that we did
not find a large incidence of treatment–resistant
patients. At present the importance of “white coat”
hypertension on admission to hospital remains
unclear. In this study, there was no significant
difference in the rates of SMI among the four
categories, regardless of whether hypertension

<table>
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<tr>
<th>Table 2</th>
<th>Number of patients in each of the four classification groups of arterial hypertension (n = 325) (see text for definitions of groups)</th>
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<tbody>
<tr>
<td></td>
<td>Adm ≥ 150/80 (No. (%))</td>
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<tr>
<td>Normotensive</td>
<td>112 (34)</td>
</tr>
<tr>
<td>Well treated</td>
<td>41 (13)</td>
</tr>
<tr>
<td>Untreated</td>
<td>81 (25)</td>
</tr>
<tr>
<td>Poorly treated</td>
<td>91 (28)</td>
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<tr>
<th>Table 3</th>
<th>Number of patients with silent myocardial ischaemia in each of the four classification groups of arterial hypertension (n = 64) (see text for definitions of groups)</th>
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<tbody>
<tr>
<td></td>
<td>Adm ≥ 150/80 (No. (%))</td>
</tr>
<tr>
<td>Normotensive</td>
<td>14 of 112 (13)</td>
</tr>
<tr>
<td>Well treated</td>
<td>5 of 41 (12)</td>
</tr>
<tr>
<td>Untreated</td>
<td>15 of 81 (19)</td>
</tr>
<tr>
<td>Poorly treated</td>
<td>30 of 91 (33)</td>
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<tr>
<th>Table 4</th>
<th>Admission arterial pressure for each of the four groups classified on the basis of three or more diastolic readings ≥ 100 mm Hg (mean (SD)). *P &lt; 0.0001 normotensive vs well treated group</th>
</tr>
</thead>
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<tr>
<td></td>
<td>Mean systolic pressure (mm Hg)</td>
</tr>
<tr>
<td>Normotensive</td>
<td>141 (21)</td>
</tr>
<tr>
<td>Well treated</td>
<td>153 (22)</td>
</tr>
<tr>
<td>Untreated</td>
<td>181 (22)</td>
</tr>
<tr>
<td>Poorly treated</td>
<td>178 (23)</td>
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</table>

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<tr>
<th>Table 5</th>
<th>Number of patients taking each antihypertensive treatment (n = 132). (Data analysed for each drug treatment using chi-square test with a continuity correction for small numbers)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>No. (%)</td>
</tr>
<tr>
<td>ACE inhibitors</td>
<td>25 (19)</td>
</tr>
<tr>
<td>Beta blockers</td>
<td>55 (42)</td>
</tr>
<tr>
<td>Calcium antagonists</td>
<td>52 (39)</td>
</tr>
<tr>
<td>Diuretics</td>
<td>63 (48)</td>
</tr>
</tbody>
</table>

For poorly treated patients classified as having three or more diastolic readings ≥ 100 mm Hg, the sensitivity and specificity for silent myocardial ischaemia were 25 and 95%, respectively, with a positive predictive value of 55% and a negative predictive value of 84%.

When the poorly treated and well treated groups
were analysed further according to treatment, no
single therapy was found to be associated with the
presence of, or was protective against, silent myo-
cardial ischaemia (table 5).
Preoperative silent ischaemia

was defined as an admission pressure of \( \geq 170/100 \) mm Hg or as three diastolic readings \( \geq 100 \) mm Hg. This would suggest that in this study at least, "white coat" hypertension had little or no measurable effect.

The problem of preoperative arterial hypertension is a common one. In a prospective study of more than 17,000 patients presenting for routine general anaesthesia and surgery, Forrest and co-workers found a prevalence rate of 13.6% [3]. Arterial hypertension itself has been shown in several studies to be an independent predictor of perioperative SMI [7, 27, 29] and also of postoperative morbidity and mortality [8, 21]. This is the first time, however, that patients resistant to antihypertensive medication have been shown to have such a high incidence of preoperative SMI, and indeed it may be that this group is responsible for the increased morbidity associated with a history of arterial hypertension.

Previous studies have found antihypertensive treatment to be protective against perioperative arterial pressure lability and associated ischaemia [4, 30]. Stone and colleagues found that preoperative treatment with beta blocking agents reduced the incidence of intraoperative myocardial ischaemia in mild to moderate untreated hypertensive patients [6]. However, beta blockers did not appear to decrease the incidence of preoperative SMI in this study. Indeed, there was no significant reduction in SMI for any particular long-term treatment.

It is important to note that the precise definition of hypertension appears to be irrelevant; poorly treated patients having a significantly greater incidence of SMI, independent of the precise level at which hypertension is defined. Also interesting is that an admission arterial pressure of \( \geq 170/100 \) mm Hg appeared to be as good a predictor of SMI as three or more diastolic readings \( \geq 100 \) mm Hg. This suggests that a single admission pressure reading may be used to define a population of patients who are at risk of preoperative SMI and therefore more likely to suffer adverse postoperative myocardial events.

The positive predictive value of resistant hypertension (three or more diastolic readings \( \geq 100 \) mm Hg) for preoperative SMI was found to be 55%, with a negative predictive value of 84%. With increasing concern about the most appropriate methods of preoperative assessment in patients presenting for routine major surgery, we have shown that routine preoperative arterial pressure measurement may be a simple, cheap and effective method of identifying a group of patients in whom further more invasive cardiological investigations could be warranted.

Acknowledgements

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References


