We reviewed the pathophysiology and treatment of hypertension in a recent edition of this journal (see key references). In this article, we discuss the management of the hypertensive patient presenting for surgery and anaesthesia.

Implications of hypertensive disease in surgical patients

Patients with arterial hypertension generally exhibit exaggerated hypotension after induction of anaesthesia and excessive pressor response to stresses such as laryngoscopy and intubation, surgical incision and extubation. They are also more prone to hypertensive responses postoperatively (bladder distension, inadequate pain relief). Hypertensive episodes are often associated with arrhythmias and/or myocardial ischaemia. Hypo- and hypertension can cause cerebrovascular accidents. At least in theory, long-term treatment of hypertension returns vascular reactivity to more normal levels thereby improving cardiovascular stability. Effective long-term treatment of hypertension also brings cerebral autoregulation to more normal levels.

Intraoperative haemodynamic abnormalities are associated with peri- and postoperative cardiovascular events (cardiac death, myocardial infarction or stroke). Indeed, bradycardia, tachycardia, hypotension and hypertension (including pulmonary hypertension) have been correlated significantly with cardiovascular complications of coronary bypass surgery. As patients with uncontrolled hypertension are very likely to develop major haemodynamic abnormalities, these data suggest indirectly that preoperative treatment of hypertension should be beneficial.

What is the effect of hypertension on cardiac outcome in postoperative surgical patients? There are two areas of interest: (i) the relationship between admission blood pressure and adverse outcomes; and (ii) the association between hypertension and outcomes. In assessing the latter, it was found in 1979 that the level of control of hypertension had no effect on the incidence of cardiovascular complications, although blood pressure control (using a blood pressure cut-off of <160/90 mm Hg) was associated with a lower incidence of perioperative hypertension.

Two more recent retrospective case-control studies by Howell and colleagues examined the risk factors for cardiovascular death within 30 days of anaesthesia in either elective or urgent/emergency surgery. The controls were matched for age, same operation and same surgeon, but did not die. For the elective patients, a diagnosis of hypertension was a risk factor; but there were no differences between admission blood pressures between cases and controls. In a similar study of urgent/emergency surgery, there were no differences in admission blood pressure between cases and controls although there was a tendency for the controls (i.e. survivors) to have a higher admission blood pressure. While both studies suggest there is no association between admission blood pressure and perioperative outcome, they are both limited by the fact that most of the patients had stage 1 or 2 hypertension with few patients showing blood pressures in the stage 3 range. Analysis of more recent data does not show an association between hypertension and 30 days cardiac mortality. This may reflect either changes in standards of perioperative care, perioperative drug therapies and monitoring or improvement in the standard of care of the hypertensive patient in the community leading to fewer patients exhibiting the complications of end-organ damage. However, there is evidence of a relationship between severity of disease and outcome in that an association exists between level of blood pressure control and the occurrence of silent postoperative myocardial ischaemia (a marker for postoperative cardiovascular complications).

Isolated systolic hypertension (ISH), which accounts for the majority of hypertensive patients aged over 60 yr, is a new focus of interest. As a corollary of the increase in systolic and pulse pressure, there is an increased cardiovascular risk. Early studies used a standard definition of hypertension (diastolic pressure >95 mm Hg) and it is clear from the data that many of the

Key points

Arterial hypertension is a risk factor for cardiovascular complications after anaesthesia and surgery. Ideally, all hypertensive patients should be treated before elective surgery; in practice only patients with stage 3 (systolic >180 mm Hg; diastolic >110 mm Hg) are regarded as needing preoperative treatment.

The importance of isolated systolic hypertension in the surgical patient is not well defined.

Patients with moderate hypertension (stage 2) but significant target organ involvement should be considered for preoperative treatment.

Most antihypertensive agents do not have adverse interactions with anaesthetic agents and should be continued throughout the perioperative period except for ACE inhibitors and angiotensin II receptor antagonists where the evidence for continuation or cessation is unclear.

I.V. antihypertensive drugs should be immediately available to treat hypertensive crises.

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patients had significant ISH. Similarly, later studies of the association of admission blood pressure and complications have focused on older patients. Therefore, it is likely that the majority of poorly controlled hypertensives in these studies had ISH.

A recent study has examined the association between ISH and cardiovascular complications in patients undergoing cardiac surgery. This was a prospective study of over 2000 patients who were classified according to their preoperative blood pressure: normal; ISH (systolic >140 mm Hg); diastolic hypertension (diastolic >90 mm Hg); or a combination of the two. After adjusting for other confounding risk factors, ISH was associated with a small but significant increase in the likelihood of perioperative morbidity (odds ratio 1.3; 95% confidence interval 1.1–1.6) but not mortality.

The relationship between hypertension and cardiac risk has been addressed by meta-analysis. A recent update has re-examined data from 30 studies published between 1978 and 2001 involving 13,666 patients. Outcome was assessed in terms of major cardiovascular complications including myocardial infarction and cardiac death. A fixed effects model of crude odds ratios gave a value of 1.31 (95% confidence interval 1.13–1.51). Most of the individual odds ratios were not significantly different from unity. Significant effects of hypertension were reported by some authors; however, the test for heterogeneity between the studies was significant. The source of this variability was sought through a number of sensitivity analyses grouping the data by year of study and type of surgery. These analyses yielded little impact on the odds ratio and heterogeneity between the studies remained. While the odds ratio of 1.31 was significant, it was small and must be interpreted with caution in this meta-analysis of observational studies with no correction for confounding factors. In the context of the low postoperative event rate, the small odds ratio probably represents a weak association between hypertensive heart disease and perioperative cardiac risk.

**Preoperative hypertension: ideal vs empirical approaches**

Ideally, all hypertensive patients should be treated because, in the long-term, their prognosis is substantially improved. Hypertension discovered on the occasion of a surgical admission provides a unique opportunity to start antihypertensive therapy. Also, studies published in the early 1970s showed that treated hypertensive patients, especially those receiving β-blockers, exhibited more stable responses to anaesthesia and awakening than their untreated counterparts. These studies led to the general agreement that: (i) treatment of hypertension should be maintained throughout the perioperative period; and (ii) that untreated hypertensive patients should be treated before elective surgery, in the hope that greater haemodynamic stability would reduce the risk of cardiovascular events. However, the policy of initiating long-term treatment of hypertension in all untreated hypertensive patients would cause a considerable number of cancellations or ‘deferrals’ of elective operations. This may not be associated with a significant reduction of the risk of complications, at least in those patients with hypertension of stages 1 and 2.

Thus, a practical, empirical, approach has been developed by the authors, based on the severity of the hypertension. Patients with severe hypertension (stage 3) defined as a systolic blood pressure of >180 mm Hg and/or a diastolic pressure >110 mm Hg should be treated before elective surgery. They are at risk of dangerous hypertensive crises likely to cause intracranial haemorrhage, acute left ventricular failure, life-threatening ventricular arrhythmias, or renal failure. For patients with moderate hypertension (stage 2) with systolic pressure of 160–179 mm Hg or diastolic pressure of 100–109 mm Hg, preoperative treatment is recommended if patients suffer from target organ involvement (coronary artery disease, impaired renal function, cerebrovascular disease). Finally, for those with mild hypertension (stage 1), for example systolic pressure 140–159 mm Hg and/or diastolic pressure 90–99 mm Hg, treatment is regarded as optional.

There are few substantive guidelines with respect to: (i) which patients should be cancelled to allow treatment before surgery; and (ii) how long such treatment should be instigated before proceeding. A recent American College of Cardiology/American Heart Association guideline states that uncontrolled systemic hypertension is a minor clinical predictor of increased perioperative cardiovascular risk. The same guideline proposes that Stage 3 hypertension (>180/>110 mm Hg) should be controlled before surgery. Control ‘can be achieved over several days to weeks of preoperative outpatient treatment’. However, ‘if surgery is more urgent, rapid-acting agents can be administered that allow effective control in a matter of minutes or hours’. Amongst the agents available, β-blockers appear to be particularly attractive. The guideline emphasizes that ‘continuation of preoperative anti-hypertensive treatment throughout the perioperative period is critical’. A similar approach has been suggested by others.

Nevertheless, high blood pressures are associated with high levels of afterload and cardiac work. These pressures, coupled with wide excursions in pressure, may predispose to myocardial ischaemia and infarction especially in the presence of coronary artery disease and left ventricular hypertrophy. To simply ignore markedly elevated blood pressure is not an appropriate option.

The issue of ‘white coat hypertension’ is unsettled. As many blood pressure measurements as possible should be obtained to inform any clinical decision. Even with this information, there is a danger that a usually normotensive patient may be started on inappropriate therapy. Finally, if surgery is to be deferred to allow the blood pressure to be treated, it is unclear for how long treatment should be given before the patient returns.

The major obstacle to the production of agreed guidelines is that no study has, as yet, conclusively shown that treatment of hypertension brings about a significant improvement in outcome in surgical patients. A possible explanation for lack of clear evidence of benefits of treating hypertension before anaesthesia and surgery is that most studies of risk factors have not distinguished
between treated and untreated hypertensive patients. Often patients with a history of hypertension have been included, whether or not they were currently hypertensive. No study has tried to divide the patients into subgroups as a function of the severity of their hypertension. This may explain why hypertension is not always identified as a significant risk factor.

In patients with arterial hypertension, a number of adverse factors (Table 1) are taken into consideration for their long-term medical management. It is legitimate to consider that patients with adverse factors need particularly careful assessment of the risk of anaesthesia and surgery and very careful monitoring during the perioperative period.

### Preoperative evaluation

There is a need to answer three questions:

1. **Is hypertension primary or secondary?** Although secondary hypertension is infrequent, the possibility of phaeochromocytoma, hyperaldosteronism, renal parenchymal hypertension, or renovascular hypertension must be considered because of the anaesthetic and perioperative implications.
2. **Is the hypertension severe?** This requires multiple blood pressure readings to distinguish ‘white coat hypertension’ from sustained hypertension.
3. **Are target organs involved?** Presence of coronary or cerebrovascular disease, impairment of renal function, signs of left ventricular hypertrophy, or heart failure put patients in a high-risk category and they may require further investigations and/or treatment of the underlying conditions as well as that of hypertension.

The frequent use of diuretics in the management of arterial hypertension often results in hypokalaemia—unless potassium supplements, ACE inhibitors or potassium-sparing diuretics are used. Potassium-sparing diuretics may be superior to non-sparing diuretics. Presence of chronic hypokalaemia raises the question of preoperative potassium replacement. This is controversial as rapid normalization of plasma potassium may worsen the transmembrane K⁺ gradient, thereby increasing rather than decreasing the risk of arrhythmias. In the absence of arrhythmia and U-waves, and with normal T-waves, the transmembrane K⁺ gradient is likely to be within acceptable limits (i.e. a 35-fold difference) and potassium supplements may not be indicated. If there are electrophysiological indicators of hypokalaemia, replacement is necessary and should be done slowly over days rather than hours.

### Haemodynamic response to anaesthesia and surgery

The influence of anti-hypertensive drugs on the haemodynamic response to anaesthesia and surgery has been studied extensively. Early studies showed that β-adrenoceptor blockers were well-tolerated and promoted haemodynamic stability. The benefits of β-blockade have been confirmed in terms of perioperative myocardial ischaemia and outcome, including a reduced relative risk of death after coronary artery bypass surgery.

In patients with mild or moderate hypertension, chronic treatment with calcium channel blockers, ACE inhibitors, diuretics, and β-blockers does not cause exaggerated hypertensive responses to induction of anaesthesia. However, ACE inhibitors have been reported to cause hypotension if they are given on the morning of surgery, especially if large doses are used. Therefore, some authors recommend omitting the morning dose of ACE inhibitors. This practice, however, may increase the need for active management of hypertensive episodes. The need to stop therapy the day before surgery is recommended for angiotensin II receptor antagonists because of the risk of refractory hypotension.

Premedication with α₂-adrenoceptor antagonists may be useful but is not widely used. Clonidine provides haemodynamic stability and reduces the risk of myocardial ischaemia by reducing sympathoadrenal activity. In addition, clonidine causes anxiolysis, sedation, decreases the need for both inhalation and intravenous anaesthetics, and improves the quality of regional anaesthesia. However, at least in coronary artery surgery, these benefits may be offset by an increased need for vasoactive and inotropic drugs. Dexmedetomidine is more selective for α₂-receptors than clonidine and attenuates both haemodynamic and stress responses to surgery.

### Perioperative risks and their management

In hypertensive patients, induction of anaesthesia is often associated with large reductions in arterial pressure. This may precipitate myocardial ischaemia as the diastolic pressure falls thus reducing both the coronary and the cerebral perfusion pressures. In these circumstances vasopressors may be indicated.

Laryngoscopy and intubation often cause large increases in blood pressure. Laryngeal spraying with local anaesthetics is ineffective in preventing this response which is attributable to sympathetic activation. Protection can be obtained with β-blockers...

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**Table 1** Adverse factors relevant to hypertensive patients

<table>
<thead>
<tr>
<th>Risk factors</th>
<th>Evidence of target organ damage</th>
<th>Cardiovascular events</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age &gt; 55 yr (male); &gt; 65 yr (female)</td>
<td>Left ventricular hypertrophy</td>
<td>Vascular events including transient ischaemic attacks</td>
</tr>
<tr>
<td>Smoking</td>
<td>Proteinuria or elevated creatinine</td>
<td>Ischaemic heart disease</td>
</tr>
<tr>
<td>Hypercholesterolaemia &gt; 6.5 mmol litre⁻¹</td>
<td>Congestive heart failure</td>
<td>Congestive heart failure</td>
</tr>
<tr>
<td>Diabetes</td>
<td>Atheroma (carotid, aorta, peripheral vessels)</td>
<td>Diabetic nephropathy</td>
</tr>
<tr>
<td>Family history of cardiovascular events</td>
<td>Abnormalities of retinal arteries</td>
<td>Severe hypertensive retinopathy</td>
</tr>
</tbody>
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The surgical hypertensive patient

including labetalol and i.v. bolus doses of esmolol. Glyceryltrinitrate, sodium nitroprusside, prostaglandin E1 and fentanyl have all been shown to be effective as well as deep anaesthesia, droperidol, and administration of vasodilators such as hydralazine and calcium channel blockers. As hypertension associated with tachycardia can cause myocardial ischaemia, prevention of the hypertensive response to laryngoscopy, intubation, and extubation is advisable.

Severe perioperative hypertension is a major threat to hypertensive patients, especially increases of blood pressure in excess of about 20% of the preoperative value. Consequences of pressure surges include bleeding from vascular suture lines, cerebrovascular haemorrhage, and myocardial ischaemia/infarction. The mortality rate of such events may be as high as 50%.

Perioperative hypertensive crises are generally caused by a sympathetically mediated increase in peripheral vascular resistance. The choice of the most appropriate antihypertensive therapy depends upon the clinical scenario, i.e. whether there is tachycardia, myocardial ischaemia, cardiac failure, or renal functional impairment (Table 2).

In the face of the most severe hypertensive episodes, sodium nitroprusside may be needed; as tachycardia may present a problem, the addition of a β-blocker may be required. Phentolamine given as boluses or as an infusion is also useful though tachycardia may also occur. Nitroglycerine is often advocated; it is not a very powerful arteriolar dilator but its anti-ischaemic properties are useful. Esmolol has gained wide acceptance in the control of hypertension and tachycardia in surgical patients. Its short half-life has the advantage that undesirable side-effects or poor tolerance, if they occur, are only short-lived. A continuous infusion is necessary if prolonged β-blockade is required. Other vasodilators for severe hypertension include diazoxide; and oral drugs such as prazocin, doxazocin and terazocin which combine peripheral vasodilator and α-blocking properties.

Labetalol, a more effective β- than α-blocker, is an effective antihypertensive agent. However, the relatively weak peripheral vasodilation effect potentiates the hypotensive action of β-blockade. I.V. hydralazine is an old ‘stand-by’ with a proven track record. Its disadvantage is that may cause a marked tachycardia, as well as flushing, headaches and dizziness. Sublingual nifedipine is effective but the reduction of blood pressure may be excessive and tachycardia may facilitate the development of ischaemia. The sublingual route is difficult to control. Intravenous fenoldopam, a dopaminergic receptor agonist, has been tested specifically in the management of postoperative hypertension. Unlike other vasodilators, it causes a sodium diuresis rather than sodium retention. There is a risk of tachycardia.

**Table 2 Drugs for the perioperative management of hypertensive emergencies**

<table>
<thead>
<tr>
<th>Clinical situation</th>
<th>Mechanism of action</th>
<th>Drug of choice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severe acute hypertension</td>
<td>Nitric oxide donor</td>
<td>Sodium nitroprusside</td>
</tr>
<tr>
<td>Hypertension plus ischaemia</td>
<td>Nitric oxide donor</td>
<td>Nitroglycerine infusion</td>
</tr>
<tr>
<td>tachycardia and ischaemia</td>
<td>β-Blocker</td>
<td>Esmolol, bolus or infusion</td>
</tr>
<tr>
<td>Hypertension plus heart failure</td>
<td>ACE inhibitor,</td>
<td>Labetalol, bolus or infusion</td>
</tr>
<tr>
<td>cardiac failure</td>
<td>modulator,</td>
<td></td>
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<tr>
<td></td>
<td>vasodilator</td>
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<tr>
<td>Hypertension without</td>
<td>Vasodilator</td>
<td>Hydralazine</td>
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<tr>
<td>cardiac complication</td>
<td></td>
<td>Phen tolamine</td>
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<td></td>
<td></td>
<td>Nifedipine</td>
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<tr>
<td>Hypertension caused by phaeochromocytoma</td>
<td>Vasodilator</td>
<td>Labetalol</td>
</tr>
<tr>
<td></td>
<td>α- and β-blocker</td>
<td>Doxazocin, prazocin, terazocin</td>
</tr>
</tbody>
</table>
Key references


See multiple choice questions 99–103.