

A modern look at hypertension and anaesthesia

James MFM, Professor and Head, Department of Anaesthesia, University of Cape Town

Dyer RA, Department of Anaesthesia, University of Cape Town

Rayner BL, Departments of Anaesthesia and Medicine, University of Cape Town

Correspondence to: Michael James, e-mail: mike.james@uct.ac.za

Keywords: hypertension, anaesthesia, risk

Abstract

Hypertension is common among patients presenting for surgery, and is frequently untreated or inadequately treated. While the approach to the patient with hypertension presenting for anaesthesia is controversial, and the evidence base for appropriate clinical decisions is weak, this is a problem that practising clinical anaesthetists face on a regular basis. This article seeks to present a unified approach to the problem of a hypertensive patient presenting for surgery, and offers suggestions as to the appropriate management options. As far as possible, the recommendations contained in this article have been based on the best available evidence.

The authors suggest that moderate degrees of hypertension (up to 180/120 mmHg), without obvious target organ disease, should never be grounds for postponing surgery. Even with greater degrees of hypertension, the relative risk of postponing surgery should always be considered. There is little evidence that, in patients without target organ disease, delaying surgery in order to establish antihypertensive therapy is beneficial. For very severe hypertension, the benefits of delaying surgery to establish adequate hypertensive control must be weighed against the risk of delayed surgery. Where a surgical delay is considered, adequate time to establish appropriate blood pressure control must be allowed, and there is no place for sudden "cosmetic" correction of blood pressure immediately prior to anaesthesia. Previously undiagnosed hypertension, presenting for the first time at surgery, requires a basic investigation of target organ disease prior to anaesthesia, and appropriate subsequent follow-up referral for further management.

S Afr J Anaesth Analg 2011;17(2):168-173

Introduction

During the first half of the last century, the management of hypertension was regarded with concern, and several authors considered the treatment of hypertension as potentially dangerous, particularly among older people. Much of this concern was related to the paucity of information on the disease, and the almost total lack of suitable pharmacological agents for blood pressure control. Today, the situation is very different, where failure to treat any form of hypertension is regarded as potentially poor medicine, and possibly even indefensible practice.

Background

Hypertension is extremely common, affecting over one billion people worldwide, and is responsible for over seven million deaths annually. The presence of hypertension increases the risk of myocardial infarction, heart failure, renal failure and stroke, and is associated with an ageing population, since older people are more likely to suffer from systolic hypertension. As this patient group is also more

likely to require surgery, the management of hypertension poses considerable challenges to anaesthetic practitioners.

Hypertension is not a disease entity in itself, but a diagnosis that incorporates a range of diseases. Most hypertension is referred to as "essential hypertension", implying that the underlying cause of the condition is unknown. This categorisation encompasses approximately 95% of all hypertensive patients, although increasing the understanding of the underlying medical conditions will allow better diagnosis of other causative conditions. The remaining five per cent of hypertension is "secondary", in which the underlying cause of the high blood pressure is a known medical condition. These can be categorised into vascular pathology, such as coarctation of the aorta or renal artery stenosis, endocrine conditions, particularly pheochromocytoma, Cushing's syndrome and primary hyperaldosteronism, renal disease, obstetric causes, and misuse of drugs for either clinical or recreational purposes. Secondary hypertension must always be considered in young patients with severe hypertension, in any patient

with resistant hypertension, or in patients with atypical presentations, as the consequences of a failure of diagnosis may be catastrophic, especially in the perioperative period. However, these conditions represent specific management problems, and will not be considered further here. Recently, endocrine causes have been extensively reviewed.¹

Definitions and classification

The severity of hypertension is categorised into fairly well-defined and accepted bands, as is illustrated in Table I (the classification is modified from Aronson et al and Dix P).^{2,3} It is most important to appreciate that the classification of hypertension is based on the average of two or more stable readings of arterial pressure, taken at two or more visits after initial screening, and not on a single isolated recording. However, it is increasingly recognised that office, or in-hospital pressure recording is the least reliable assessment of blood pressure, and that validated home blood pressure monitors are better equipped to assess blood pressure control as they avoid the problems of “white coating”.

Table I: Classification of hypertension (all values are in mmHg)

Category	Systolic arterial blood pressure (SBP)		Diastolic arterial blood pressure (DBP)
Optimal	< 120	and	< 80
Normal	< 130	and	< 85
High normal	130-139	or	85-89
Hypertension			
Stage 1: Mild	140-159	or	90-99
Stage 2: Moderate	160-179	or	100-109
Stage 3: Severe	180-209	or	110-119
Stage 4: Very severe	> 210	or	> 120
Isolated systolic hypertension	> 140	and	< 90
Pulse pressure hypertension	> 80		

Note: The South African Hypertension Society only recognises up to Stage 3,⁴ but the other grades are useful for perioperative decisions.

Pathogenesis

Systolic blood pressure (SBP) rises continuously with age, while diastolic blood pressure (DBP) reaches a plateau in the fifth or sixth decade, and may then decrease.⁵ Thus, systolic hypertension is more common in the elderly, and consequently an increase in pulse pressure is seen in older patients. Whereas it used to be thought that DBP is the most important determinant of outcome and the prime target for blood pressure control, current thinking is that systolic pressure hypertension, where the pulse pressure exceeds 65 mmHg, is the crucial issue. Consequently, systolic hypertension is now regarded as the principal target for blood pressure control in older patients.⁵ There is increasing emphasis on the importance of pulse pressure hypertension, which is now being recognised as imposing

a significant risk of myocardial infarction and stroke. The incidence of a raised pulse pressure increases with age, and is also found more commonly in patients with the metabolic syndrome, as well as in patients with coronary artery disease. The pulsatile stress on the vasculature is increased, and this leads to increased risk of plaque rupture, left ventricular hypertrophy and renal failure. This haemodynamic abnormality contributes to endothelial dysfunction, as well as an increase in pulsatile load. This may be particularly true in the elderly population requiring surgery, and in anaesthetic management.² A rise in pulse pressure in the first trimester of pregnancy is a marker for the development of pre-eclampsia. Hypertension of all types increases the risk of mortality, with severe hypertension (SBP greater than 180 mmHg) increasing the relative risk of death sixfold.⁶ Of importance here is that low diastolic pressure may limit myocardial perfusion, which occurs in diastole.

End-organ damage, predominantly of the heart, the kidney and brain, is common in hypertension. Even asymptomatic hypertension presents a risk of end-organ damage, and as the disease advances, renal injury may progress to end-stage renal failure. The heart will suffer from hypertrophy, coronary artery disease, and systolic and diastolic dysfunction, all ultimately increasing the risk of myocardial infarction, cardiac failure and death. The brain is also at substantial risk, with hypertension increasing the incidence of dementia and ischaemic or haemorrhagic cerebral events, leading to stroke.

In the heart, a vicious cycle is established by the increased myocardial oxygen demand caused by increased myocardial wall tension, which is amplified by left ventricular hypertrophy. Both of these changes lead to coronary insufficiency, infarction and heart failure. Concentric hypertrophy leads to increasing ventricular muscle thickness, but a relative reduction in cardiac chamber size, and an increase in ischaemic risk. The ratio of blood vessel cross-sectional area to left ventricular mass becomes progressively less favourable, meaning that cardiac oxygen supply is jeopardised.⁷ Subendocardial autoregulation is also impaired, leading to diminished tolerance of unstable blood pressure. Diastolic dysfunction is seen increasingly frequently with advancing age, occurring in up to 70% of patients with heart failure. It is associated with severe, long-standing hypertension and is frequently seen in patients with catecholamine excess.⁸

Loss of autoregulation predisposes the kidney to damage from hypotensive events, and there is an increasing incidence of glomerular sclerosis, and a reduction in glomerular filtration rate, with advancing hypertension. Pulse pressure hypertension significantly increases the risk of postoperative renal failure.⁹

The shift of autoregulatory thresholds in the brain in hypertensives is well known, and hypertension increases the perioperative risk of both ischaemic and haemorrhagic

strokes. Carotid stenosis is more common in hypertensive patients, adding to the ischaemic risk. Pulse pressure hypertension increases the risk of adverse cardiac and cerebral events, following coronary artery bypass surgery.¹⁰

Treatment

There is no doubt that treatment of hypertension has a marked effect on complications, reducing the incidence of stroke and cardiac failure, and substantially improving five-year morbidity and mortality. A variety of drugs have been used to manage hypertension, of which the thiazide diuretics have the longest and best established track record in improving outcome. This is partly because these drugs have been the most widely used agents, but they should also always be the first-line treatment of choice in essential hypertension. Beta blockade is widely used in the treatment of severe hypertension, with the probability of beta-blockade administration increasing with the severity of the disease and its complications.¹¹ However, no one drug is superior to another in the treatment of hypertension, although beta blockers are associated with reduced stroke protection, and calcium-channel blockers (CCBs) with slightly better stroke protection, according to a recent meta-analysis.¹² Five major classes of drugs are recognised for the treatment of essential hypertension [diuretics, angiotensin-converting enzyme (ACE) inhibitors, angiotensin-receptor blockers (ARBs), CCBs and beta blockers]. The choice of agent depends on conditions that favour, or relatively or absolutely contraindicate the use of individual drugs, for example beta blockers for patients with ischaemic heart disease (IHD). Increasing trial evidence suggests that an ACE inhibitor plus a CCB, offer better cardiovascular protection than an ACE inhibitor plus a diuretic, or a diuretic plus a beta blocker.¹³ The range of drugs widely used for chronic treatment of hypertension is shown in Table II.

Table II: Long-term management drugs

Drug group	Example	Action and effect
Thiazide diuretics	Hydrochlorothiazide, indapamide	Block sodium channels
Beta blockers	Atenolol, bisoprolol, carvedilol, esmolol	Slow heart rate, improve ventricular filling, block renin
Angiotensin-converting enzyme inhibitors	Perindopril, enalapril	Block angiotensin converting enzyme
Angiotensin-2 inhibitors	Candesartan, losartan	Block angiotensin-2 receptors
Calcium-channel blockers	Long-acting nifedipine, amlodipine	Vasodilatation

Perioperative risk

For a long time, the contribution of hypertension to anaesthetic risk has been controversial. Early studies suggested that hypertension presented a major hazard for

anaesthesia, and a number of studies in the 1960s and 1970s seemed to confirm this. However, both contemporaneous and later studies failed to support the concept that hypertension alone was a major anaesthetic risk factor.¹⁴ A meta-analysis from the Oxford group showed a small, but significant increase in the risk of perioperative complications in association with hypertension (OR 1.3, 95% CI 1.17-1.56), but the studies are very heterogeneous, particularly regarding the nature of the perioperative complications recorded, and the likelihood of risk.⁶ Certainly, the current weight of evidence suggests that hypertension alone carries minimal anaesthetic risk.¹⁵

An important issue, particularly related to the question regarding the postponement of surgery in hypertensive patients, is whether or not treating hypertension alters anaesthetic risk. One study, in particular, had a profound effect on this debate. In this very small study, untreated hypertensives showed a markedly higher rate of arrhythmia development during anaesthesia, and of postoperative myocardial ischaemia.¹⁶ The untreated and treated hypertensives both had similar resting arterial pressures, but the untreated group demonstrated greater fluctuations in arterial pressure, which possibly accounted for the adverse cardiac events. However, a subsequent much larger study failed to confirm this observation, finding similar risks for perioperative myocardial events in untreated, well-treated or poorly treated hypertensive patients.¹⁷ Another small study found much greater increases in blood pressure following tracheal intubation in patients who were found to have labile blood pressures, with a higher incidence of myocardial ischaemia in this group.¹⁸ In patients undergoing carotid endarterectomy, poorly controlled hypertension predicted transient neurological deficits in the postoperative period, but this difference disappeared after 24 hours.¹⁹ Perhaps more importantly, a major retrospective study by the Oxford group demonstrated that hypertension resistant to treatment was a major predictor for perioperative silent myocardial ischaemia.²⁰ It seems, on balance, that established treatment of hypertension with a good response may reduce the perioperative risks of hypertension, and that resistant hypertension may represent a higher risk group, but at present, data are inadequate to make this a definitive conclusion.

Hypertension is most certainly associated with increased haemodynamic instability in the perioperative period, and this is associated with an increased risk of myocardial injury. Furthermore, hypertension is a major risk factor for coronary artery disease, congestive cardiac failure, and renal and cerebral disease, all of which increase the perioperative risk. Hypertension is also associated with dyslipidaemia, diabetes and obesity, and the side-effects of the drugs required to treat these conditions. Hypertension is therefore associated with an increased risk of end-organ disease, which would certainly increase perioperative risk. However, it remains unclear whether uncomplicated hypertension is

a perioperative risk factor, and probably on its own, it is insufficient justification to cancel surgery.²¹

Perioperative approaches

As is clear from the above information, careful preoperative evaluation of the hypertensive patient is important. Such an evaluation should include a review of the quality of blood pressure control, and the antihypertensive agents needed to achieve that condition. It is perhaps more important to detect end-organ dysfunction that may have resulted from hypertension, as this is much more likely to predict perioperative adverse events than the hypertension alone. Such end-organ damage includes cardiac injury, cerebral vascular disease, renal dysfunction and peripheral vascular disease, all of which are independent risk factors for perioperative adverse events. All patients found to have preoperative hypertension require appropriate investigation. This should include a preoperative electrocardiogram (ECG), blood sugar analysis, electrolytes and creatinine measurement [with calculation of glomerular filtration rate (GFR)], together with a urinary dipstick. Where the situation is urgent, these investigations must be performed, even if only postoperatively.

Therefore, a decision as to when to delay surgery in a patient with hypertension must consider the risk-benefit ratio of such a delay. It seems unlikely that significant benefit will be gained in an otherwise uncomplicated hypertensive patient, even with Stage 3 hypertension or higher, unless the surgery can be safely delayed for the two to three months that will be required to produce significant changes in cardiovascular and arterial morphology.

There is evidence in hypertension studies that in high-risk patients, benefits from cardiovascular protection are seen within three months,²² and in some aggressive statin studies, there is evidence of benefit that may be seen within 30 days.²³ The decision to delay elective surgery in hypertensives should be based on risk, in other words blood pressure > 180/110mmHg (always high risk), evidence of target organ damage or subclinical organ dysfunction, and/or multiple risk factors such as diabetes, smoking and resting ischaemia on the ECG. Subclinical organ damage is indicated by proteinuria, estimated GFR < 60 ml/minute and ECG evidence of left ventricular hypertrophy. In such patients, surgery should be deferred for at least four to six weeks and all risk factors (arterial pressure, smoking, elevated cholesterol and diabetes) should be controlled aggressively. Sudden normalisation of arterial pressure over a few days immediately prior to surgery is not recommended.

All emergency surgery should proceed regardless of the level of blood pressure, and urgent surgery should also not be delayed for uncomplicated hypertension. However, there is some evidence that benefit may be gained from treating severe hypertension, particularly severe pulse pressure hypertension (> 80 mmHg) or severe diastolic hypertension,

especially in younger patients requiring elective surgery. Other patients, in whom a delay in elective surgery may be warranted, include those with treatable end-organ disease risk, and those experiencing complications of therapy, particularly related to renal, cardiac or cerebral vascular events. The American College of Cardiology (ACC)/American Heart Association (AHA) guidelines suggest that a systolic arterial pressure greater than 180 mmHg, and/or a diastolic arterial pressure greater than 110 mmHg, is justification for the establishment of control of hypertension prior to surgery. Furthermore, these guidelines state that the use of rapid-acting agents to control blood pressure in the hours prior to surgery may be considered, but advance no evidence for this view.²⁴ This practice may, in fact, be dangerous in patients who have lost cerebral, renal or cardiac autoregulation.

This recommendation may be completely inappropriate when applied to acute beta blockade in light of the subsequently published Perioperative Ischemic Evaluation Study (POISE). In this study, beta blockade was given acutely to at-risk patients two to four hours prior to major non-cardiac surgery. Although there was a reduction in the rate of myocardial infarction, all-cause mortality, particularly from stroke, was increased.²⁵ Immediate preoperative beta blockade should therefore be used with caution.²⁶ The addition of a statin is probably justified in any patient with a high risk of myocardial injury.²⁷ In high-risk patients, acute hypotension is more dangerous than modest elevations in blood pressure. Where urgent surgery is required in a patient with Stage 4 hypertension, it may be helpful to attempt to decrease arterial pressure with vasodilator agents by approximately 25%, prior to induction of anaesthesia. Short-acting agents such as nitroprusside or glyceryl trinitrate may be helpful, as they can be discontinued rapidly should hypotension become a problem, but there is no conclusive evidence to support this practice.

At present, the overwhelming evidence is that patients with mild-to-moderate hypertension (see Table I) without subclinical organ dysfunction, or additional risk factors, should proceed to anaesthesia and surgery without delay.⁶ An isolated recording of a very high blood pressure immediately prior to surgery is not necessarily a reason to postpone the surgery. In such cases, where prior information is available, such as ward blood pressures, or information from the patient's family practitioner that suggests that the resting arterial pressure is well controlled, it may be reasonable to proceed with anaesthesia, but there is no evidence for or against this position. However, such an episode identifies a patient as a potentially unstable hypertensive. There is growing evidence that such patients deserve increased medical surveillance.²⁸ For poorly controlled, severe hypertension patients (Stage 3) who are scheduled for elective surgery, it is probably justified to delay surgery to investigate target organ injury, if such an evaluation is not already available.^{6,29} In particular, it would seem indefensible

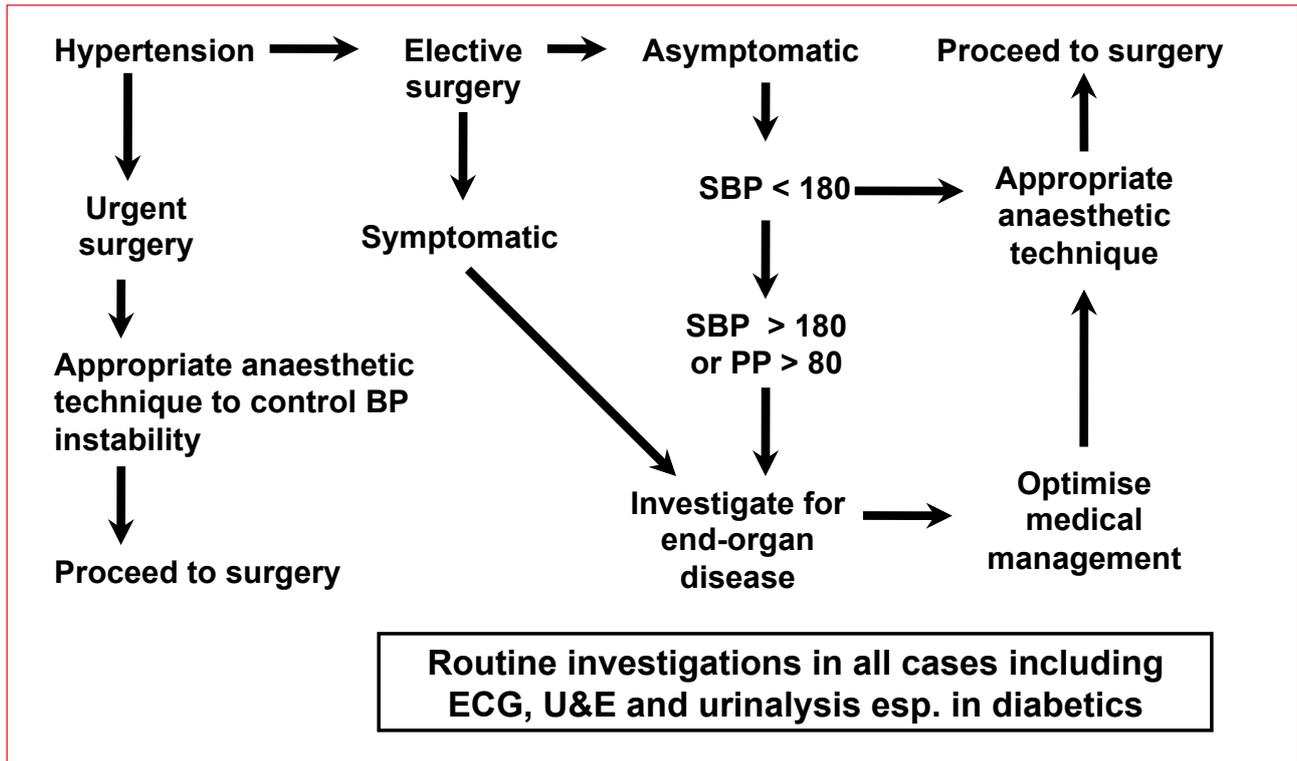


Figure 1: Algorithm for the approach to a patient with previously undiagnosed hypertension, presenting for anaesthesia and surgery.

to proceed with anaesthesia in such patients without an ECG, at the very least, and some evaluation of renal function. Clinical history of effort tolerance is important in these patients, and may assist in guiding further evaluation. Stage 4 hypertension does appear to present a significant perioperative risk, and such patients should be deferred for treatment if at all possible. A suggested algorithm for decision making is presented in Figure 1. All hypertensive patients should be investigated for target organ damage, but this may take place following surgery in asymptomatic patients with Stage 1 or 2 hypertension.

If the decision is made to delay surgery, the anaesthetist is obliged to advise the surgeon on how to best manage the patient. If the patient is already on antihypertensive medication, but is poorly responsive, simply increasing the dosage of currently prescribed drugs would seem to be an inadequate approach. Rather, in consultation with a physician, a change in therapy to beta blockade, calcium-channel antagonists or an ACE inhibitor is probably more appropriate. However, such a change in therapy will require re-evaluation of end-organ status. The untreated hypertensive appears to present less of a risk than the poor responder to therapy, unless the hypertension is Stage 4.

There seems little logic to the concept of rapid, overnight reduction in blood pressure, as such a strategy will probably increase the risk of intraoperative haemodynamic instability. Again, if surgery can be delayed, a combined approach with the physician is appropriate, and in the severe hypertensive, consideration should be given to the use of agents such

as beta blockers, calcium-channel antagonists or ACE inhibitors, which can favourably remodel the cardiac and vascular structures, together with statins for those with high cardiac risk. It is important that the anaesthetist emphasises the importance of following up the patient properly prior to reassessment for anaesthesia and surgery to surgical colleagues. In a recent retrospective study, increasing severity of pre-induction hypertension was an independent risk factor for postoperative myocardial injury/infarction or in-hospital death. However, only a small percentage of operations for patients presenting with severe hypertension was postponed, and the surgery delay did not result in interval normalisation of blood pressure,³⁰ indicating that inadequate follow-up of the postponed cases was conducted.

Once a hypertensive patient is accepted for anaesthesia, consideration must be given to the effects that the prescribed drugs may have on the anaesthesia. Withdrawal of antihypertensive medication is generally considered inadvisable, as many of these drugs may produce severe rebound effects when withdrawn. This applies to alpha-methyldopa and clonidine particularly, where severe hypertension may follow withdrawal. Withdrawal of beta blockers may precipitate angina. In the case of diuretics, the effects on renal function and electrolyte abnormalities must always be considered. The ACE inhibitors/ARBs represent a special case, and withdrawal of these agents 10 hours prior to surgery appears to be associated with a reduction in the risk of immediate post-induction hypotension.³¹ Intraoperatively, haemodynamic stability appears to be

more important than absolute values of the blood pressure.¹⁵ Controlling the intubation response is important, and a variety of agents (including short-acting opiates, glyceryl trinitrate and magnesium sulphate) can be considered for this purpose, but the risks of post-induction hypotension must be borne in mind. Intraoperatively, esmolol, where available, may be very valuable for controlling sudden tachycardia and hypertension, but it must be remembered that beta blockade is contraindicated if the hypertensive event is due to an excess of catecholamines, caused either by administration of adrenaline or cocaine by the surgeon, or by endogenous secretion (e.g. pheochromocytoma). In these latter circumstances, MgSO₄, as a 4-g bolus, is probably the safest and most effective first-line therapy, and should constitute routine initial treatment of any intraoperative hypertensive crisis. Alpha₂-agonists, as part of the anaesthetic technique, may provide useful blood pressure control, together with enhanced analgesia, and some protection against myocardial ischaemia.³² There is some evidence that volatile anaesthesia, in particular with sevoflurane, may be beneficial in that it may improve diastolic function,³³ and provide some degree of ischaemic preconditioning.³⁴ Postoperatively, care must be taken to ensure that a hypertensive crisis does not ensue, and that good analgesia is instituted. A strategy must be developed for blood pressure control, including a planned early return to standard preoperative therapy.

Conclusion

In conclusion, the following quotation best describes the current status of our understanding of hypertension and the indications for cancelling surgery: "Modern anaesthesia provided by a well-trained, experienced and dedicated anaesthetist offers sufficient perioperative cardiac protection to make cancellation of surgery for the sole purpose of controlling preoperative hypertension unnecessary under most circumstances".²¹

References

- James MFM. Anaesthesia for patients with endocrine disease. Oxford: Oxford University Press; 2010.
- Aronson S, Fontes ML. Hypertension: a new look at an old problem. *Curr Opin Anaesthesiol.* 2006;19:59-64.
- Dix P, Howell S. Survey of cancellation rate of hypertensive patients undergoing anaesthesia and elective surgery. *Br J Anaesth.* 2001;86:789-793.
- Seedat YK, Croasdale MA, Milne FJ, et al. South African hypertension guideline 2006. *S Afr Med J.* 2006;96:337-362.
- Williams B, Lindholm LH, Sever P. Systolic pressure is all that matters. *Lancet.* 2008;371:2219-2221.
- Howell SJ, Sear JW, Foex P. Hypertension, hypertensive heart disease and perioperative cardiac risk. *Br J Anaesth.* 2004;92:570-583.
- Harrison DG, Marcus ML, Dellspinger KC, et al. Pathophysiology of myocardial perfusion in hypertension. *Circulation.* 1991;83:III14-III18.
- Pirracchio R, Cholley B, De HS, et al. Diastolic heart failure in anaesthesia and critical care. *Br J Anaesth.* 2007;98:707-721.
- Aronson S, Fontes ML, Miao Y, Mangano DT. Risk index for perioperative renal dysfunction/failure: critical dependence on pulse pressure hypertension. *Circulation.* 2007;115:733-742.
- Fontes ML, Aronson S, Mathew JP, et al. Pulse pressure and risk of adverse outcome in coronary bypass surgery. *Anesth Analg.* 2008;107:1122-1129.
- Messerli FH, Williams B, Ritz E. Essential hypertension. *Lancet.* 2007;370:591-603.
- Law MR, Morris JK, Wald NJ. Use of blood pressure-lowering drugs in the prevention of cardiovascular disease: meta-analysis of 147 randomised trials in the context of expectations from prospective epidemiological studies. *BMJ.* 2009;338:b1665.
- Jamerson K, Weber MA, Bakris GL, et al. Benazepril plus amlodipine or hydrochlorothiazide for hypertension in high-risk patients. *N Engl J Med.* 2008;359:2417-228.
- Howell SJ, Sear YM, Yeates D, et al. Hypertension, admission blood pressure and perioperative cardiovascular risk. *Anaesthesia.* 1996;51:1000-1004.
- Hanada S, Kawakami H, Goto T, Morita S. Hypertension and anaesthesia. *Curr Opin Anaesthesiol.* 2006;19:315-319.
- Prys-Roberts C, Meloche R, Foex P. Studies of anaesthesia in relation to hypertension. I. Cardiovascular responses of treated and untreated patients. *Br J Anaesth.* 1971;43:122-137.
- Goldman L, Caldera DL. Risks of general anesthesia and elective operation in the hypertensive patient. *Anesthesiology.* 1979;50:285-292.
- Bedford RF, Feinstein B. Hospital admission blood pressure: a predictor for hypertension following endotracheal intubation. *Anesth Analg.* 1980;59:367-370.
- Asiddao CB, Donegan JH, Whitesell RC, Kalbfleisch JH. Factors associated with perioperative complications during carotid endarterectomy. *Anesth Analg.* 1982;61:631-637.
- Allman KG, Muir A, Howell SJ, et al. Resistant hypertension and preoperative silent myocardial ischaemia in surgical patients. *Br J Anaesth.* 1994;73:574-578.
- Spahn DR, Priebe HJ. Editorial II: Preoperative hypertension: remain wary? "Yes": cancel surgery? "No". *Br J Anaesth.* 2004;92:461-464.
- Weber MA, Julius S, Kjeldsen SE, et al. Blood pressure-dependent and independent effects of antihypertensive treatment on clinical events in the VALUE Trial. *Lancet.* 2004;363:2049-2051.
- Murphy SA, Cannon CP, Wiviott SD, et al. Reduction in recurrent cardiovascular events with intensive lipid-lowering statin therapy compared with moderate lipid-lowering statin therapy after acute coronary syndromes from the PROVE IT-TIMI 22 (Pravastatin or atorvastatin evaluation and infection therapy-thrombolysis in myocardial infarction 22) trial. *J Am Coll Cardiol.* 2009;54:2358-2362.
- Fleisher LA, Beckman JA, Brown KA, et al. ACC/AHA 2007 guidelines on perioperative cardiovascular evaluation and care for non-cardiac surgery: executive summary: a report of the American College of Cardiology/American Heart Association task force on practice guidelines (writing committee to revise the 2002 guidelines on perioperative cardiovascular evaluation for non-cardiac surgery). *Circulation.* 2007;116:1971-1996.
- Devereaux PJ, Yang H, Yusuf S, et al. Effects of extended-release metoprolol succinate in patients undergoing non-cardiac surgery (POISE trial): a randomised controlled trial. *Lancet.* 2008;371:1839-1847.
- Sear JW, Giles JW, Howard-Alpe G, Foex P. Perioperative beta-blockade, 2008: what does POISE tell us, and was our earlier caution justified? *Br J Anaesth.* 2008;101:135-138.
- Waters DD, Ku I. Early statin therapy in acute coronary syndromes: the successful cycle of evidence, guidelines, and implementation. *J Am Coll Cardiol.* 2009;54:1434-1437.
- Rothwell PM. Limitations of the usual blood-pressure hypothesis and importance of variability, instability, and episodic hypertension. *Lancet.* 2010;375:938-948.
- Sear JW. Perioperative control of hypertension: when will it adversely affect perioperative outcome? *Curr Hypertens Rep.* 2008;10:480-487.
- Wax DB, Porter SB, Lin HM, et al. Association of preanesthesia hypertension with adverse outcomes. *J Cardiothorac Vasc Anesth.* 2010;24(6):927-930.
- Comfere T, Sprung J, Kumar MM, et al. Angiotensin system inhibitors in a general surgical population. *Anesth Analg.* 2005;100:636-644.
- Wijeyesundera DN, Naik JS, Beattie WS. Alpha-2 adrenergic agonists to prevent perioperative cardiovascular complications: a meta-analysis. *Am J Med.* 2003;114:742-752.
- Filipovic M, Michaux I, Wang J, et al. Effects of sevoflurane and propofol on left ventricular diastolic function in patients with pre-existing diastolic dysfunction. *Br J Anaesth.* 2007;98:12-18.
- Zaugg M, Lucchinetti E, Garcia C, et al. Anaesthetics and cardiac preconditioning. Part II. Clinical implications. *Br J Anaesth.* 2003;91:566-576.