ORIGINAL ARTICLE

Peri-operative Blood Pressure Changes in Normotensive and Hypertensive Patients

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SUMMARY

Controversy surrounds the acceptance of hypertension as an independent risk factor for anaesthesia. In an attempt to identify variables that are associated with increased haemodynamic instability during surgery, the blood pressure profiles of 128 patients were analysed. The two variables that contributed most to the instability were pre-operative control of blood pressure and anaesthetic technique. To reduce the fluctuation in blood pressure, it is advisable for patients to be given a regional anaesthetic. Current therapy for hypertension appears to exaggerate the depressant effects of anaesthetic drugs. Care must be taken not only to prevent hypertensive episodes during surgery, but also hypotension.

KEY WORDS:
Hypertension, Anaesthesia, Surgery

INTRODUCTION

Hypertension has been a major health problem in many parts of the world for more than a century. In Malaysia, according to the National Health and Morbidity Survey II, the prevalence of hypertension in the adult population has reached 24%. Hypertension is an important risk factor for diseases such as coronary artery disease and cerebrovascular diseases. It has also become one of the most common causes for the cancellation of elective surgery[1].

However, controversy still surrounds the acceptance of hypertension as an independent risk factor for anaesthesia. Some researchers have suggested hypertension increases the peri-operative morbidity and mortality, while others have refuted this claim [2-5]. In addition, there is a lack of agreement as to what constitutes a safe range of blood pressure in the peri-operative period [6]. A recent review reported an association between hypertensive disease and peri-operative cardiac outcomes [7]. However, this association was statistically but not clinically significant.

Haemodynamic instability is more likely to occur in patients with hypertension [6]. Severe hypertension and hypotension may occur in the hypertensive patient during the peri-operative period [8]. Much of the abnormal haemodynamic responses seen intra-operatively reflect the response to antihypertensive medications and the cardiovascular response to anaesthetic drugs. Risk of adverse events related to hypertension occurring during surgery can be reduced by good pre-operative control of the blood pressure, and continuation of pre-operative antihypertensive therapy [9].

The aim of this study is to review the peri-operative blood pressure profile of patients presenting for surgery in Hospital Kuala Lumpur. In particular, this study attempts to identify variables that are associated with increased haemodynamic instability at the start of surgery, and during the post-operative period. This will provide some information on how much current hypertension therapy is contributing towards the control of peri-operative blood pressure fluctuation.

MATERIALS AND METHODS

A hospital-based, descriptive cross sectional study was conducted over eight weeks in Hospital Kuala Lumpur (HKL).

Study Population

The target population was patients aged 18 years and above, presenting for elective surgery under general or spinal anaesthesia. Patients who had previously been diagnosed by a medical practitioner as having hypertension were categorized as hypertensive patients. Such patients were excluded if they were poorly controlled (systolic above 180 mmHg or diastolic above 110 mmHg).

Patients were sampled from three different surgical disciplines: General Surgery (1 list per week), Urology (5 lists per week) and Gynaecology (1 list per week). The choice of the anaesthetic to be used was left to the anaesthetist attending to the patient.

Data Collection

All patients in the designated lists were interviewed on the day before operation. A standard proforma data collection sheet (Appendix) was used to collect the demographic data, medical history, pharmacological therapy, systolic blood pressure (SBP), diastolic blood pressure (DBP) and pulse rate (PR) readings. The pre-operative blood pressure was defined as the mean of the last 5 awake BP readings taken on the day before surgery.

All the BP and pulse rate readings in the operation theatre (OT) were taken by the same researcher (KSP), using a standard non-invasive blood pressure monitoring device. The first BP reading taken when the patient entered the operation room was recorded as the BP 'On Arrival'.

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In patients who were given a general anaesthetic, a maximum of 13 BP and pulse rate readings were taken between induction of anaesthesia and 10 minutes after the surgical incision was made ('Start of Surgery'). Readings were taken:

a. on arrival in OT.
b. at induction of anaesthesia and at 1 and 2 minutes after induction.
c. at endotracheal intubation and at 1, 3, 5 and 10 minutes after intubation.
d. at incision and at 1, 3, 5 and 10 minutes after incision.

During the post-operative period, up to 10 readings during the first 24-hour period were taken from the nurses' observation chart ('Post-operative').

In patients who received a spinal anaesthetic, a maximum of 11 BP and pulse rate readings were taken at 3-minute intervals after the anaesthetic procedure was performed ('Start of Surgery'). In the post-operative period, up to 10 readings during the first 24-hour period were taken ('Post-operative').

Data Analysis
For each SBP and DBP reading, the percentage change from baseline was calculated using the formula:

$$\left(\frac{BP_x - \text{Pre-op BP}}{\text{Pre-op BP}} \right) \text{X } 100\%$$

where BP_x = blood pressure at the x measurement point.
For each patient, the maximum increase and maximum decrease in BP and pulse rate occurring during the 'Start of Surgery' and 'Post-operative' periods were then identified.

Students' *t*-test and one-way Analysis of Variance (ANOVA) were used to analyze the difference in BP change between patients grouped according to their demographic characteristics and medical condition. Correlation analysis was used to determine if there was a relationship between the BP change and the patient's age, weight or pre-operative BP. Further analysis using the General Linear Model (GLM) was done to determine which variables were significant predictors of the change in BP. A similar analysis was carried out for changes in the pulse rate.

Demographic data was tested using Students' t-test and Chi-square test as appropriate. A value of $p < 0.05$ was considered significant. All data were analyzed using the computer package SPSS 10.01.

RESULTS

One hundred and twenty eight patients were enrolled into the study. Eighty-nine patients were given general anaesthesia and 39 patients received a spinal anaesthetic. Demographic data and pre-operative medication of the patients are shown in Table I. Patients with hypertension were significantly older ($t = 4.1$, $p < 0.01$). However, there was no difference in weight between normotensive and hypertensive patients ($t = 0.95$, $p = 0.35$). The proportion of patients who were given a sedative premedication was not significantly different between the two groups ($\chi^2 = 2.34$, $p = 0.13$). Pre-operative blood pressure and pulse rate are shown in Table II.

Comparison between hypertensive and normotensive patients
Hypertensive patients had significantly higher pre-operative SBP and DBP when compared with normotensive patients (Table II). Similarly, the change in SBP on arrival in OT was significantly greater in hypertensive patients. However, the change in DBP and pulse rate on arrival in OT was not significantly different between the two groups. During recovery, the average change in the haemodynamic parameters was not significantly different between hypertensive and normotensive patients.

BP and pulse rate changes on arrival in OT
Table III shows a comparison of the absolute change in BP in the normotensive and hypertensive patient groups. Taken as a sole independent variable, a diagnosis of hypertension was associated with a significantly greater change in SBP. However, when age was included as a variable in the GLM analysis, a diagnosis of hypertension did not result in a significantly higher BP on arrival in the operation theatres.

The percentage change in SBP on arrival in the OT was significantly greater in patients who were not given a premedication ($p = 0.03$), and in elderly patients ($p = 0.02$). The percentage change in DBP was significantly greater in female patients ($p < 0.01$), and in elderly patients ($p < 0.01$). The increase in pulse rate on arrival in the OT was not significantly related to any variable.

BP and pulse rate changes at the start of surgery
General anaesthesia consistently resulted in a significantly greater change in SBP and DBP at the start of surgery (Table IV). The same effect was also seen with pulse rate. However, the maximum change in BP was not significantly different between patients in the hypertensive and normotensive groups. Irrespective of a diagnosis of hypertension, pre-operative SBP, DBP and PR values were inversely related to the maximum increase in their values at the start of surgery ($p < 0.01$, $p < 0.01$ and $p < 0.01$ respectively). In addition, age was inversely related to the maximum increase in pulse rate ($p = 0.02$) while pre-operative SBP was directed related to the maximum decrease in SBP ($p < 0.01$).

BP and pulse rate changes during the post-operative period
Haemodynamic changes during the post-operative period appears to be affected by different factors, including the type of anaesthetic given, pre-operative BP / PR readings, gender and weight of the patient. No one factor appeared to dominate the changes.

DISCUSSION

This study was undertaken to investigate blood pressure lability soon after administration of an anaesthetic, and in the post-operative period. We chose the initial period after induction of anaesthesia as this is when there is minimal influence of the surgical procedure on the blood pressure. As the operation progressed, other factors such as blood loss will need to be considered and would have made the data analysis too complicated.

The blood pressure profile might have been affected by the intervention of the attending anaesthesiologist as it was unlikely for the BP to have been left alone if it had been

Table I: Demographic data and pre-operative medication

	Normotensive	Hypertensive	Total
N	80	48	128
Age (yrs)	46.4 ± 15.7	57.0 ± 11.9	50.4 ± 15.2
Weight (kg)	60.4 ± 11.2	62.6 ± 13.0	61.2 ± 11.9
Number of patients given premedication	58	29	87
Anti-hypertensive medication			
Nil	80	4	84
β blockers	-	24	24
Diuretics	-	1	1
ACE inhibitors	-	6	6
Ca channel blockers	-	8	8
Combination	-	5	5

Age and weight given in mean ± SD

Table II: Blood pressure and Pulse rate [mean ± SD] during the peri-operative period.

	Normotensive	Hypertensive	p-value
Pre-operative			
BP (mmHg)	122.1 ± 11.7	137.8 ± 15.6	< 0.01
	73.9 ± 6.7	81.1 ± 10.3	< 0.01
PR (bpm)	79.3 ± 8.3	77.7 ± 11.2	0.34
On arrival in OT			
change in BP	15.1 ± 17.7	27.2 ± 27.6	< 0.01
	5.0 ± 11.3	7.4 ± 11.5	0.26
change in PR	2.8 ± 13.3	-0.9 ± 11.3	0.11
Post-operative (general anaesthesia cases)			
Max. change in BP	-2.2 ± 12.5	0.13 ± 17.2	0.50
	-3.1 ± 8.6	-3.5 ± 10.7	0.85
Max. change in PR	3.0 ± 11.3	4.1 ± 12.6	0.72
Post-operative (regional anaesthesia cases)			
Max. change in BP	-2.4 ± 9.6	-7.2 ± 11.2	0.16
	-1.8 ± 5.7	-5.7 ± 7.1	0.07
Max. change in PR	0.52 ± 4.5	-2.4 ± 9.6	0.21

P-values calculated for comparison between normotensive and hypertensive patients using Students' t-test.

Table III: Changes in blood pressure (mmHg) on arrival in the operation room seen with premedication and gender.

	Normotensive	Hypertensive
Effect of premedication:		
Given premed	10.7 ± 16.1	24.6 ± 23.9
	4.9 ± 11.1	5.8 ± 12.1
Not given premed	28.0 ± 16.1	31.1 ± 32.8
	5.7 ± 12.3	9.7 ± 10.3
Comparing between normotensive and hypertensive patients:		
Change in SBP: **p = 0.04**		
Change in DBP: p = 0.27		
Comparing between patients with and without premedication:		
Change in SBP: **p < 0.01**		
Change in DBP: p = 0.30		
Sex of patient		
Male patients	13.0 ± 17.8	25.2 ± 25.5
	2.1 ± 10.7	5.7 ± 9.2
Female patients	17.5 ± 17.5	30.8 ± 31.6
	8.4 ± 11.3	10.4 ± 14.6
Comparing between normotensive and hypertensive patients:		
Change in SBP: **p < 0.01**		
Change in DBP: P = 0.18		
Comparing between male and female patients:		
Change in SBP: p = 0.22		
Change in DBP: **p = 0.01**		

Comparisons were made using GLM analysis.
Values are expressed as mean ± SD

Table IV: Changes in blood pressure (mmHg) at the start of surgery seen with type of anaesthesia as a variable.

	Normotensive	Hypertensive
Maximal increase at start of surgery:		
General Anaesthesia	45.2 ± 22.5 / 30.2 ± 13.4	46.8 ± 18.9 / 31.7 ± 13.7
Regional Anaesthesia	23.2 ± 14.7 / 10.6 ± 5.8	31.5 ± 22.1 / 16.3 ± 16.8
Comparing between normotensive and hypertensive patients:		
Change in SBP: p = 0.26		
Change in DBP: p = 0.28		
Comparing between patients given general or regional anaesthesia:		
Change in SBP: **p < 0.01**		
Change in DBP: **p < 0.01**		
Maximal decrease at start of surgery		
General Anaesthesia	30.5 ± 14.4 / 24.6 ± 11.2	43.0 ± 20.7 / 25.8 ± 14.1
Regional Anaesthesia	20.2 ± 11.3 / 14.2 ± 8.5	32.2 ± 21.1 / 22.2 ± 14.0
Comparing between normotensive and hypertensive patients:		
Change in SBP: **< 0.01**		
Change in DBP: **0.07**		
Comparing between patients given general or regional anaesthesia:		
Change in SBP: **p < 0.01**		
Change in DBP: **p < 0.01**		

Comparisons were made using GLM analysis.
Values are expressed as mean ± SD

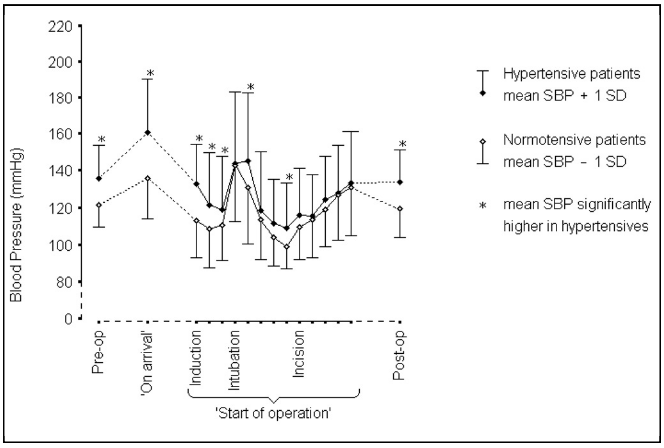

Fig. 1: Peri-operative systolic blood pressure profile of patients who presented for surgery under general anaesthesia

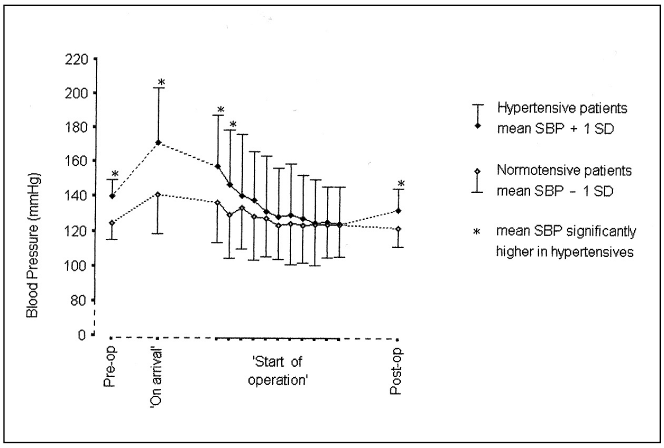

Fig. 2: Peri-operative systolic blood pressure profile of patients who presented for surgery under spinal anaesthesia

extremely high or low. However, as the aim of the study was to examine the BP fluctuations in a real-life rather than a controlled environment, such intervention was allowed.

To determine lability, we examined the highest and lowest blood pressure readings taken during the study period. We estimated the time interval between readings that would allow us to pick up the likely minimum and maximum points. While a continuous measurement would be scientifically more accurate, it would be clinically unethical to have the BP cuff continuously inflating and deflating for 30 minutes. It was also considered inappropriate to use intra-arterial monitoring for this purpose.

Effect of premedication

Patients who received a sedative premedication experienced a lower rise in SBP on arrival in the operation theatre. This could be because of its anxiolytic effect, thus blunting the increase in BP. Other investigators have suggested that the premedication could have induced a significant cardiovascular depressant effect [10].

A lower BP is important as high arterial pressures may predispose to myocardial ischaemia and infarction, especially in the presence of coronary artery disease and left ventricular hypertrophy.

Intra-operative changes in blood pressure

During surgery, patients are subjected to a series of noxious stimuli which provoke haemodynamic responses. Patients who receive general anaesthesia usually experience a pattern of BP changes (Figure 1). There is initially a drop in BP at induction of anaesthesia, followed by an increase after tracheal intubation. The rise in BP is short, and returns to a downward trend almost immediately. The BP rises again when the surgical incision in made. On emergence from anaesthesia, endotracheal extubation usually results in a rise in BP, which gradually falls back nearer to the baseline in the recovery room.

The blood pressure profile is different in patients who are given spinal anaesthesia (Figure 2). There are less of the ups and downs seen at the start of surgery under general anaesthesia. Instead, there is a slight decrease at the start due to the vasodilatation effect of the spinal anaesthetic. The blood pressure then stabilises and continues to remain so during most of the operative procedure.

Response in hypertensive patients
Out of the 128 patients who were included in this study, 37.5% were known hypertensive patients. This shows that hypertension is not uncommonly discovered among the surgical patients in the local population.

Hypertensive patients undergoing surgery have a significantly higher pre-operative BP than normotensive patients, even when on medication. However, the percentage change in BP during the peri-operative period was dependent on the baseline pre-operative BP rather than a diagnosis of hypertension. In fact, patients presenting with a higher pre-operative BP tend to have a lower percentage increase during events that cause a rise in BP. On the other hand, when the blood pressure was depressed, patients with a higher pre-operative SBP had a greater percentage decrease. This is consistent with earlier reports that hypertensive patients are more vulnerable to blood pressure fluctuations in response to anaesthetic agents and vasodilators [9].

Effect of the anaesthetic technique
The most important factor affecting the percentage change in BP appears to be the type of anaesthetic used. The maximal rise and maximal fall in BP were significantly less in patients who received a spinal anaesthetic. This could be because spinal anaesthesia is better at blocking the nociceptive stimuli than general anaesthesia. This is in agreement with the findings of a previous study [11].

All our patients who received a general anaesthetic had their tracheas intubated. Laryngoscopy and endotracheal intubation usually causes hypertension and tachycardia as a consequence of the activation of the sympathetic nervous system and an accompanying elevation in plasma catecholamine level [12,13]. This is another cause for the greater fluctuation in blood pressure seen in the patients who had general anaesthesia.

Post-operative changes in blood pressure
Anaesthetic technique and the pre-operative baseline BP continue to have an influence on the lability of the BP in the post-operative period, albeit to a lesser degree. Post-operative patients would probably have some degree of pain, but the intensity of the stimulus would be much lower than that during the intra-operative period. As such, the degree of fluctuation in BP would be lower. Patients who were given a spinal anaesthetic might have had better pain relief during the early post-operative period, leading to a lesser degree of change in BP.

Peri-operative changes in pulse rate
Changes in the pulse rate generally follow that of the BP. It is also worthwhile to note that in our study, patients with hypertension had a lower pulse rate. This could be because most of the hypertensive patients had a β-blocker as part of their treatment.

CONCLUSION
Our study clearly identified pre-operative control of blood pressure and anaesthetic technique as the two variables that affect the lability of the blood pressure at the start of surgery. To reduce the haemodynamic response to noxious stimuli, it would be advisable for patients to be given a regional anaesthetic, alone or together with a general anaesthetic.

Patients with a high pre-operative blood pressure have a lower percentage increase in BP when given a noxious stimulus. Current therapy for hypertension appears to accord some protection against the surge in blood pressure in response to such stimuli. However, in these patients, the depressant effects of the anaesthetic drugs are exaggerated. As it is advisable to keep the BP within 20% of the pre-operative value, care must be taken not only to prevent hypertensive episodes during surgery, but also hypotension.

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DATA COLLECTION PROFORMA SHEET

Date: Reference No.:

DEMOGRAPHIC DATA & SOCIAL HISTORY OF PATIENT

Name:
Registration No.:
I/C No.:
Address:

Race:	Malay / Chinese / Indian / Others (Specify:)	
Age:		
Weight:		
Marital Status:	Single / Married	
Smoking Status:	Never / Ex-smoker / Current smoker (Quantity: /day)	
Use of Alcohol:	Yes / No	

<u>Surgical Information</u>

Type of surgery:	General / Urological / O&G	
ASA Class:		
Concomitant Disease:	CVS disease	Diabetic
	Renal disease	Respiratory disease
	Haemotological disease	Clinical anaemia
	Liver disease	Hepatobiliary Disease
	Other (Specify:)	
Medication:	Yes / No	
If yes:	1.	
	2.	
	3.	
	4.	
	5.	

Patient is:	Hypertensive / Non-hypertensive
If hypertensive, duration after been diagnosed:	Within 1 year / 1-3 year / 3-5 years / 5-10 years / 10 years and above

GENERAL ANAESTHETIC TECHNIQUE

	Drug	Dose	Time Given
Pre-Medication			
Analgesic			
Induction Agent			
Maintaining Agent			

PRE-OPERATIVE BLOOD PRESSURE READING (date:)

	1	2	3	4	5	Average
Systolic BP						
Diastolic BP						
Pulse Rate						
Remarks						

INTRA-OPERATIVE BLOOD PRESSURE READING (date:)

	On arrival	Minutes after induction			Minutes after intubation					Minutes after incision				
		0	1	2	0	1	3	5	10	0	1	3	5	10
Systolic BP														
Diastolic BP														
Pulse Rate														
Remarks														

POST-OPERATIVE BLOOD PRESSURE READING (date:)

	First 12 hours					Second 12 hours					Average
	1	2	3	4	5	1	2	3	4	5	
Systolic BP											
Diastolic BP											
Pulse Rate											
Remarks											

REGIONAL ANAESTHETIC TECHNIQUE

	Drug	Dose	Time Given
Pre-Medication			
Analgesic			
Regional Anaesthetic			

PRE-OPERATIVE BLOOD PRESSURE READING (date:)

	1	2	3	4	5	Average
Systolic BP						
Diastolic BP						
Pulse Rate						
Remarks						

INTRA-OPERATIVE BLOOD PRESSURE READING (date:)

	On arrival				Minutes after Spinal Anaesthetic given							
		0	3	6	9	12	15	18	21	24	27	30
Systolic BP												
Diastolic BP												
Pulse Rate												
Remarks												

POST-OPERATIVE BLOOD PRESSURE READING (date:)

	First 12 hours					Second 12 hours					Average
	1	2	3	4	5	1	2	3	4	5	
Systolic BP											
Diastolic BP											
Pulse Rate											
Remarks											