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Risks of General Anesthesia and Elective Operation in the Hypertensive Patient

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To determine the risks of general anesthesia and elective surgical procedures in patients who have histories of hypertension, the authors prospectively studied 676 consecutive operations in a series of patients more than 40 years old. All patients were examined preoperatively, monitored intraoperatively, and closely followed postoperatively. Although patients with higher preoperative blood pressure values had larger absolute intraoperative blood pressure decreases, the mean intraoperative systolic pressure nadirs in patients with tightly-controlled hypertension (100 ± 2 torr) did not differ from those in patients with persistent treated (97 ± 3 torr) or untreated (98 ± 2 torr) mild to moderate hypertension. Similarly, among these three groups of patients, the needs for intraoperative adrenergic agents or fluid challenges (20, 33, and 27 per cent, respectively) and the incidences of perioperative hypertensive events (27, 25, and 20 per cent, respectively) were not significantly different. Multivariate analysis of data for the patients with histories of hypertension showed that neither the preoperative in-hospital diastolic nor preoperative in-hospital systolic blood pressure values independently correlated with any of these three indices of perioperative blood pressure lability, with the development of cardiac arrhythmias, ischemia, or failure, or with postoperative renal failure. Effective intraoperative management may be more important than preoperative hypertensive control in terms of decreasing clinically significant blood pressure lability and cardiovascular complications in patients who have mild to moderate hypertension. (Key words: Blood pressure: hypertension; hypotension. Heart: arrhythmias; failure; infarction.)

THE PROPER preoperative approach to the hypertensive patient has been widely debated. While results of early studies[1–3] indicated that antihypertensive medications might be more dangerous than hypertension itself in the patient receiving general anesthesia, subsequent investigations demonstrated the apparent safety of preoperative antihypertensive medications.[4,5] In fact, more detailed recent data have suggested that elective surgical procedures should be postponed until blood pressure has been decreased to the normal range.[6–8] In a prospective study of elective surgical procedures with general anesthesia, we analyzed hypertension and its treatment in relation to perioperative changes in blood pressure and to intraoperative and postoperative cardiovascular complications.

Materials and Methods

Between October 1975 and April 1976 we prospectively studied 1,001 consecutive patients more than 40 years of age who underwent major noncardiac, non-neurologic operations other than transurethral resection of the prostate or uncomplicated endoscopy.[9,10] As part of the study, a senior medical resident obtained a full cardiac history and performed a physical examination of each patient preoperatively. All pertinent laboratory data were recorded. Known history of hypertension and use of antihypertensive medications were determined by direct questioning and by review of all available medical records. Each patient had a preoperative electrocardiogram and roentgenogram of the chest. The present report includes all 676 non-emergent procedures performed on 617 patients for whom general anesthesia was the primary technique of anesthesia and from whom adequate histories could be obtained.

We defined preoperative antihypertensive medications as thiazide drugs (or thiazide-like diuretic agents), furosemide, propranolol, alpha-methyldopa, reserpine, guanethidine, and hydralazine. No patient had been taking clonidine. We defined the preoperative blood pressure as the reading obtained the evening before operation by arm cuff; when this single reading deviated from other hospital readings, the available in-hospital readings were averaged.

Patients were grouped by preoperative blood pressures and medications: Group I, normotensive (diastolic pressure less than 90 torr and systolic pressure less than 160 torr) now and by history without use of antihypertensive medications, 431 patients; Group II, normotensive, but taking diuretics for reasons other than hypertension, 49 patients; Group III, histories of hypertension (diastolic pressure 90 torr or higher or systolic pressure 160 torr or higher) but now normotensive with use of antihypertensive medications, 79 patients; Group IV, hypertensive (diastolic pressure 90 torr or higher or systolic pressure 160 torr or higher) despite present use of antihypertensive medications, 40 patients; Group V, hypertensive, not

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taking antihypertensive medications, 77 patients. Of those 117 patients who were still hypertensive (Groups IV and V), 64 patients had mild diastolic hypertension (pressures 90–99 torr), 34 patients had moderate diastolic hypertension (pressures higher than 100 torr, including five patients who had values of 111 torr or higher), and 19 patients had pure systolic hypertension (pressures of 160 torr or higher). No patient had severe preoperative hypertension (diastolic pressure higher than 120 torr) or had signs or symptoms of accelerated or malignant hypertension, but 16 patients were known to have had markedly increased blood pressures at some time in the past. Thirty-seven patients had preoperative histories of transient cerebral ischemic attacks or cerebrovascular accidents. These central nervous system complications of hypertension were found in 13 per cent of patients in Group III, 18 per cent of patients in Group IV, and only 4 per cent of patients in Group V. Blood urea nitrogen values of more than 30 mg/dl were found in 8 per cent of patients in Group III, 13 per cent of patients in Group IV, and 1 per cent of patients in Group V. Ischemic heart disease (defined as a history of myocardial infarction, angina, or ischemic changes on electrocardiogram) or a history of congestive heart failure was present preoperatively for 19 per cent of patients in Group I, 69 per cent of patients in Group II, 47 per cent of patients in Group III, 40 per cent of patients in Group IV, and 26 per cent of patients in Group V.

Surgical procedures included 61 abdominal aortic aneurysm resections; 57 peripheral vascular operations; 223 intraperitoneal procedures; 25 intrathoracic operations; 40 mammary procedures; 32 retroperitoneal or pelvic operations; 63 perianal procedures; 153 operations on the head, neck or extremities; 22 endoscopies (principally mediastinoscopies). For most of the succeeding analyses, surgical procedures are classified into four groups: abdominal aortic aneurysm resections, peripheral vascular operations, intraperitoneal or intrathoracic procedures, and others. Patients who had histories of hypertension were more likely to have either abdominal aortic aneurysm resections or other vascular procedures than were patients who had always been normotensive (29 per cent versus 13 per cent, $P < 0.001$); otherwise, the type of procedure did not correlate with a history of hypertension, with hypertension treatment, or with severity of preoperative hypertension.

Anesthetic Management

Nitrous oxide was virtually always part of the anesthetic regimen (98 per cent of procedures). Other inhalational agents included halothane (34 per cent of procedures), enflurane (20 per cent of procedures), fluroxene (2 per cent of procedures), and other agents (<1 per cent of procedures). Intravenous agents included barbiturates (77 per cent of procedures), narcotics (42 per cent of procedures), and various tranquilizers and other agents (total of 9 per cent of procedures). Patients undergoing abdominal aortic aneurysm resections were more likely to receive halothane (52 per cent) or narcotic agents (76 per cent) than were patients having other procedures (31 and 38 per cent, respectively; both P values < 0.01), but were less likely to receive intravenous barbiturates (48 versus 78 per cent, $P < .01$). Otherwise, there was no important difference in anesthetic agents among the various types of operations.

During the operation, the anesthesiologist measured blood pressure every 5 min, or more frequently when it was changing rapidly. Each patient had continuous electrocardiographic monitoring in the operating room. The blood pressures of about 10 per cent of patients were monitored by intra-arterial catheterization, the remainder by arm cuff. Intraoperative central venous pressure monitoring and pulmonary capillary wedge pressure monitoring were performed in 139 and 28 patients, respectively, as part of routine patient care. Intra-arterial pressure, central venous pressure, and pulmonary arterial pressure monitoring tended to be used for sicker patients undergoing more extensive procedures. During part of our study, there was a simultaneous randomized study to assess whether monitoring intra-arterial pressure and pulmonary arterial pressure would be of benefit for patients undergoing aortic aneurysm resections. However, our uncontrolled observations do not permit an accurate assessment of whether such monitoring can facilitate the management of intraoperative blood pressure fluctuations.

Any natural or synthetic adrenergic agent given for the purpose of increasing intraoperative blood pressure was recorded. We defined an intraoperative fluid challenge as 500 ml of intravenous fluid in no more than 15 min, or 1,000 ml in no more than 30 min, for the purpose of increasing blood pressure. Postoperatively, patients routinely remained in the recovery room until cardiovascular and respiratory functions were stable. Perioperative hypertension was defined as an intraoperative or recovery room systolic blood pressure that was a) more than 50 torr higher than preoperative systolic blood pressure, b) more than 200 torr, or c) such that the physicians caring for the patient acutely used intravenous medications expressly for the purpose of decreasing blood pressure.

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Postoperative Complications

Each of the ward patients was followed postoperatively on a surgical service that had a senior medical resident acting as a full-time consultant. Medically unstable patients were seen daily by the medical senior resident. Others were always seen when abnormal cardiac symptoms, signs, or EKG changes developed. Private patients were seen at least once postoperatively by a participating senior resident, and were seen whenever abnormal cardiac symptoms, signs, or EKG changes developed. Patients' charts were reviewed daily during hospitalization and in detail after discharge. When a patient experienced abnormal cardiac symptoms or signs or was believed by his physicians to have any potential cardiac problem, an EKG or serial EKG tracings were obtained. In addition to any clinically indicated EKG tracings, the study protocol provided for at least one postoperative EKG on about the fifth postoperative day. Cardiac enzymes were studied whenever a patient complained of chest pain or had any change detectable on physical examination or EKG that raised the clinical question of myocardial infarction.

Any postoperative cardiac complication that developed prior to discharge or death was recorded. Postoperative transmural myocardial infarction was diagnosed when new Q waves at least 0.04 sec in duration and 1 mm or more in depth developed. In our series, these Q waves were almost always associated with new ST-segment elevation. The diagnosis of nontransmural myocardial infarction required new ST-segment depression or T-wave inversion that a) was associated with chest pain typical of myocardial ischemia, persisted for at least 72 hours, and could not be explained on the basis of medications or electrolyte imbalance, b) was associated with increases in serum glutamic oxaloacetic transaminase (SGOT), creatine phosphokinase (CPK) or, when available, CPK isoenzyme values out of proportion to the operation itself, or c) persisted as new ST-segment depression of 1 mm or more and symmetrical T-wave inversion for at least seven days without other explanation. Any questionable diagnoses were reviewed by independent cardiology observers.

Heart failure was diagnosed when new signs of pulmonary congestion were found on physical examination, a new S_3 gallop developed, or a roentgenogram of the chest was diagnostic; only patients who had new congestive heart failure or a worsening of old congestive heart failure such that new or increased medications were needed were considered to have postoperative congestive heart failure. Pulmonary edema was diagnosed when a patient had a classic roentgenogram of the chest or experienced respiratory distress at rest and rales at least three fourths of the way up the lung fields. Supraventricular arrhythmias necessitated a diagnostic electrocardiogram for review; the only exceptions were intraoperative arrhythmias, which were seen on continuous electrocardiographic monitoring and could not be verified by formal electrocardiograms. A cardiac death was diagnosed when a patient died either from an arrhythmia or with refractory low-output cardiac failure, as verified by the thermodilution technique, which was not part of an inexorable downhill course primarily caused by some non-cardiac condition such as sepsis, respiratory failure or metastatic malignancy. A non-cardiac death was defined as death from any other cause, regardless of whether there was an associated cardiac condition or complication.

Intraoperative and postoperative cardiac complications were grouped as follows: fatal, life-threatening (pulmonary edema, myocardial infarction, or ventricular tachycardia), or minor (new or worsened heart failure without pulmonary edema; supraventricular tachyarrhythmia; or intraoperative or postoperative ischemia, as indicated by typical chest pain or EKG changes, without documented myocardial infarction). Each patient was categorized according to the most severe cardiac complication present. We also calculated a cardiac risk index score for each patient; in our original series of 1,001 operations, the risk index score was the best multivariate preoperative estimate of the chance of development of a fatal or life-threatening cardiac complication.[9]

For our statistical analysis, we defined five important end-points: the intraoperative systolic blood pressure nadir; the use of an intraoperative fluid challenge or adrenergic agents to maintain blood pressures at levels acceptable to the anesthesiologist: perioperative hypertensive events; intraoperative or postoperative cardiac complications; intraoperative or postoperative renal or cerebrovascular complications. We determined whether these end-points had significant ($P < 0.05$) univariate relationships with preoperative blood pressure values, treatment, control, or complications, or with the type of operation or the anesthetic technique. Continuous dependent variables were analyzed using the Student t test if the independent variable had two categories and using analysis of variance if the independent variable had three or more categories; yes–no variables were analyzed by the chi-square test.

Multivariate analysis was performed using the regression technique for the first three end-points and

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TABLE 1. Relationship of Preoperative Hypertension and Treatment to Perioperative Changes in Blood Pressure

	Mean Preoperative Systolic Pressure* (torr ± SEM)	Mean Intraoperative Systolic Pressure Nadir† (torr ± SEM)	Patients with Perioperative Hypertensive Episodes‡		Patients Receiving Intraoperative Fluid Challenge or Adrenergic Agents to Maintain Blood Pressure§	
			Number	Per Cent	Number	Per Cent
Group I (normotensive, no therapy) (n = 431)	126 ± 1	94 ± 1	33	8	82	19
Group II (diuretics, no history of hypertension) (n = 49)	129 ± 3	95 ± 3	3	6	9	18
Group III (now normotensive receiving therapy) (n = 79)	136 ± 2	100 ± 2	21	27	16	20
Group IV (hypertensive despite therapy) (n = 40)	154 ± 2	97 ± 3	10	25	13	33
Group V (untreated hypertension) (n = 77)	161 ± 2	98 ± 2	15	20	21	27

* All possible pairs are significantly different ($P \leq 0.05$) except Group II versus Group I.

† The only significant different pair is Group I versus Group III.

‡ Group I had significantly fewer hypertensive episodes than Group III, IV, or V; Group II had fewer episodes than Group III or Group IV.

§ No significant difference among the five groups.

the discriminant technique for the fourth end-point via a standard statistical program.[11] The multivariate correlates of each end-point were determined both for all five hypertension treatment groups (676 operations) and then just for the groups of patients who had histories of hypertension (196 operations).

Results

Despite very different mean preoperative systolic pressure values, systolic pressures of patients in all five hypertension treatment groups fell to remarkably similar mean intraoperative nadirs (table 1). Blood pressure responses among patients taking thiazide diuretics or furosemide for reasons other than hypertension (Group II) were no different from those among normotensive patients not taking diuretics (Group I). Among patients who had persistent preoperative hypertension (Groups IV and V), systolic pressures of those with mild diastolic hypertension decreased from a preoperative mean of 152 ± 2 torr to a mean intraoperative nadir of 94 ± 2 torr, while those of patients who had moderate diastolic hypertension (mean preoperative systolic blood pressures 166 ± 4 torr) and pure systolic hypertension (mean preoperative values 167 ± 2 torr) both decreased to mean intraoperative nadirs of 101 torr. The mean intraoperative systolic pressure nadir in patients with persistent mild diastolic hypertension was significantly lower than that in patients who had persistent moderate diastolic hypertension, persistent pure systolic hypertension, or adequately treated hypertension (all P values $< .05$), but was identical to the mean intraoperative systolic pressure nadir of the normotensive patients not receiving therapy (Group I).

The preoperative presence of ischemic heart disease or congestive heart failure did not correlate with the intraoperative systolic pressure nadir in the total series or even in the hypertensive patients. However, patients who had histories of hypertension (Groups III, IV and V) complicated by strokes, by transient ischemic attacks, or by blood urea nitrogen values of more than 30 mg/dl had higher mean intraoperative systolic pressure nadirs (108 ± 5 torr) than those without such complications (96 ± 2 torr; $P < .05$).

Patients undergoing vascular procedures were more likely to have histories of hypertension and did have higher mean preoperative systolic pressure values, but the mean intraoperative systolic pressure nadirs among all types of procedures were not significantly different (range 94–97 torr). Of all the various anesthetic agents, only halothane correlated with the intraoperative systolic pressure nadir; this correlation was statistically but not clinically significant in the always normotensive patients (91 ± 1 torr with halothane versus 95 ± 1 torr without halothane, $P < .05$) but was more marked in those with histories of hypertension (94 ± 2 torr versus 101 ± 2 torr, $P < .01$).

When the full series of 676 operations were subjected to multiple regression analysis, we could find only three variables that had independently significant correlations with lower intraoperative systolic pressure nadirs: lower preoperative systolic blood pressure values, the absence of renal or cerebrovascular complications of hypertension, and the use of halothane anesthesia. Among patients with histories of hypertension (Groups III, IV, and V), the latter two factors again had independently significant correlations with lower intraoperative systolic pressure nadirs, but other factors such as the preoperative

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systolic and diastolic pressure values, antihypertensive medications, pre-existing cardiac complications, and type of operative procedure did not.

Another way to examine decreases in intraoperative blood pressure is to see how often the anesthesiologist decided to use a fluid challenge or adrenergic agents to prevent or to treat blood pressure decreases to values below what he considered an acceptable range. When analyzed in this way, none of the differences among all the possible pairs of the five hypertension treatment groups was significant at the .05 level (see table 1). Among the still hypertensive patients (Groups IV and V), the severity of persistent preoperative diastolic or systolic hypertension did not correlate with the use of intraoperative fluid challenges or adrenergic agents.

Anesthesiologists used fluid challenges or adrenergic agents in 39 per cent of abdominal aortic aneurysm resections, 25 per cent of intraperitoneal or intrathoracic operations, 24 per cent of peripheral vascular operations, and only 14 per cent of other operations. For the full series of 676 operations, multiple regression analysis identified only one independently significant correlate of the use of a fluid challenge or adrenergic agents: the type of operative procedure. When, however, the multiple regression analysis is limited to those patients with histories of hypertension (Groups III, IV, and V), halothane anesthesia becomes a second independent correlate of the use of a fluid challenge or adrenergic agents. The severity or treatment of past or present hypertension and the presence of complications of hypertension did not correlate with the use of adrenergic agents or a fluid challenge.

Normotensive patients (Groups I and II) were significantly less likely to experience perioperative hypertension than were patients with histories of preoperative hypertension (table 1); however, hypertensive patients whose blood pressures had been normalized by medications (Group III) were no less likely to have perioperative hypertensive episodes than were inadequately treated or untreated hypertensive patients (Groups IV and V). Perioperative hypertensive events were more common in patients with *past* histories of markedly increased blood pressure values, but such events were not independently correlated with the *present* severity of preoperative hypertension or with renal, cerebrovascular, or cardiac complications of hypertension.

Hypertensive events occurred during or after 57 per cent of abdominal aortic aneurysm resections, 29 per cent of peripheral vascular procedures, 8 per cent of intraperitoneal or intrathoracic procedures, and only 4 per cent of other procedures (differences significant at $P < .05$ among all possible pairs). By multiple regression analysis, the only preoperative predictors of perioperative hypertensive events were the type of operation and a history of previous hypertension, especially previous hypertension to a diastolic pressure value of 111 torr or higher. The adequacy of preoperative hypertensive control and the types of anesthetic agents were not significant factors.

The mean cardiac risk index scores and the incidences of intraoperative and postoperative cardiac complications differed among the five groups (table 2). However, patients with inadequately treated or untreated hypertension (Groups IV and V) were no more likely to experience cardiac complications than were normotensive patients taking no diuretic agents (Group I). Even when hypertensive patients were divided by the severity of past or present hypertension, there was no correlation with intraoperative or postoperative cardiac complications. By multivariate discriminant analysis, the very high rate of perioperative cardiac complications found in Group II (patients taking diuretic agents for reasons other than a history of hypertension) is totally explained by pre-existing cardiac risk factors. Among the patients with histories of hypertension (Groups III, IV, and V), multivariate discriminant analysis identified just two independent correlates of perioperative cardiac complications: the calculated preoperative cardiac risk index score and the development of severe decreases in intraoperative blood pressure (a decrease to less than 50 per cent of preoperative levels or a decrease of 33 per cent or more for more than 10 min (table 3).

In 11 patients, new postoperative renal failure developed; three needed dialysis and eight did not. Postoperative renal failure did not correlate with present or past severity or treatment of preoperative hypertension. Our only postoperative cerebrovascular accident occurred in a patient who had adequately treated preoperative hypertension and a history of a prior cerebrovascular accident.

Discussion

For more than 20 years, controversy has raged about how to minimize perioperative blood pressure lability and cardiovascular complications among hypertensive patients undergoing surgical procedures. Our single study from one hospital should not settle this controversy, because our patients with persistent hypertension had only mildly to moderately increased values, because our series is not as large as an epidemiologic study might ideally be, and because a randomized trial would be preferable to our prospective cohort approach. Nevertheless, our data describe the results of current medical practice and can provide directions for future investigation.

We found greater absolute intraoperative blood

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TABLE 2. Cardiac Risk and Complications

	Mean Cardiac Risk Index Score (±SEM)	Patients with No Cardiac Complication		Patients with Minor Complications Only		Patients with Major Nonfatal Complications		Patients with Cardiac Death	
		Number	Per Cent	Number	Per Cent	Number	Per Cent	Number	Per Cent
Group I (n = 431)	4.3 ± 0.3	383	89	37	9	10	2	1	0.2
Group II (n = 49)	10.9 ± 1.1	35	71	6	12	5	10	3	6
Group III (n = 79)	6.9 ± 0.6	60	76	12	15	6	8	1	1
Group IV (n = 40)	4.4 ± 0.5	37	93	3	8	0	—	0	—
Group V (n = 77)	5.5 ± 0.6	68	88	7	9	1	1	1	1

pressure decreases among patients who had persistent hypertension as compared with those with tightly controlled hypertension. However, by multivariate analysis, the preoperative in-hospital systolic and diastolic blood pressure values of our patients with hypertensive histories did not independently correlate with the intraoperative systolic pressure nadir, the use of a fluid challenge or adrenergic agents to maintain intraoperative blood pressure at values deemed acceptable by the anesthesiologist, or the development of hypertensive events. Prys-Roberts and colleagues, in their careful hemodynamic studies, also found greater absolute decreases in intraoperative blood pressures in patients with higher preoperative values.[6,7] In terms of the actual values reached, Prys-Roberts *et al.* first reported markedly lower values among untreated hypertensive patients,[6] but in a subsequent report showed no significant difference between the treated and untreated hypertensive patient groups at any time after induction of anesthesia.[7]

Among patients with histories of hypertension, those with renal or cerebrovascular complications actually had higher intraoperative systolic pressure nadirs; this finding was independent of the preoperative in-hospital blood pressure. If this result represented the anesthesiologist's conscious attempt to maintain blood pressure values at a higher level, we would have expected a similar attempt among patients with cardiac complications of hypertension. However, patients whose hypertension was complicated by heart failure or ischemic heart disease had neither higher intraoperative systolic pressure nadirs nor more frequent treatment with a fluid challenge or adrenergic agents than did those patients with uncomplicated hypertension. Perhaps patients with renal or cerebrovascular complications of hypertension have more inherent resistance to intraoperative decreases in blood pressure than do other hypertensive patients.

There was only one other independently significant correlation between preoperative blood pressure or treatment and perioperative lability among the patients with histories of hypertension: new hypertensive events were more common in those with histories of more severe pre-hospital increases regardless of the success of preoperative in-hospital control. These findings argue against the need for tight preoperative blood pressure control and for the impression that, at least in our series, perioperative blood pressure lability may be as much a function of a patient's inherent vascular characteristics as of any modification of such characteristics by antihypertensive medication.

The type of operative procedure was strongly correlated with the use of an intraoperative fluid challenge or adrenergic agents but not with the intraoperative systolic pressure nadir. This finding suggests that the potential hypotensive effects of more extensive operative procedures can be neutralized by effective intraoperative management. We previously reported a strong correlation of abdominal aortic aneurysm resections and peripheral vascular procedures (especially carotid endarterectomy) with perioperative hypertension.[10] This correlation was independent of recent or distant preoperative blood pressure values and of cardiovascular complications of hypertension.

Among all the various anesthetic agents, only halothane independently correlated with any type of perioperative blood pressure lability: it was related to lower intraoperative systolic pressure nadirs (especially in those with histories of hypertension) and to the use of a fluid challenge or adrenergic agents (only in those with histories of hypertension). Prys-Roberts *et al.* also found that halothane, when it is added to nitrous oxide, will further lower blood pressure because it decreases cardiac output without changing vascular tone.[7] These combined data suggest that special care should be taken when halothane is added to nitrous oxide in anesthetizing patients who have histories of hypertension.

While blood pressure lability during the perioperative period is a good reflection of the ease or difficulty of anesthetic management, another important question is whether preoperative hypertension, hypertensive control, or perioperative lability correlates with perioperative cardiovascular complications. We found that perioperative cardiac complications were strongly correlated with preoperative risk factors,[9] but that

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hypertension, hypertensive control, and the severity of previous hypertension are not among these risk factors.[9,10] In patients with histories of hypertension, only marked intraoperative blood pressure decreases of 50 per cent or of 33 per cent for more than 10 min independently correlated with perioperative cardiac complications. Similarly, Mauney *et al.* reported a correlation between intraoperative blood pressure decreases of 33 per cent for more than 10 min and postoperative cardiac complications.[12] Prys-Roberts *et al.* also found electrocardiographic evidence for myocardial ischemia when five of their seven untreated hypertensive patients had mean arterial blood pressure decreases to less than 50 per cent of preoperative levels; these electrocardiographic changes were transient, and they reverted to normal when arterial pressure increased during recovery from anesthesia.[6] Our finding that inadequately treated and untreated hypertensive patients were not at increased risk for recognized minor, major or fatal cardiac complications either in the operating room or during the hospitalized postoperative period may have reflected the fact that our patients had less severe hypertension than those of Prys-Roberts *et al.* (who had a mean preoperative systolic pressure of 211 torr and a mean preoperative diastolic pressure of 105 torr) but probably also reflected the anesthesiologist's ability usually to prevent marked intraoperative blood pressure decreases.

Ideally, all hypertensive patients should be identified and adequately treated prior to hospitalization for elective surgical procedures. Both our data and those of Prys-Roberts and colleagues demonstrate that untreated or inadequately treated hypertensive patients have larger absolute decreases in blood pressure during anesthesia and operation than do adequately treated hypertensive patients. Thus, patients who have persistent preoperative hypertension may need more careful anesthetic management to prevent the myocardial ischemia that can result from severe intraoperative hypotension. However, our data suggest that elective operations in the absence of ideal antihypertensive control need not subject patients to an added clinical risk provided: a) diastolic blood pressure is stable and not higher than 110 torr; b) intraoperative and recovery room blood pressures are closely monitored and treated to prevent hypertensive or hypotensive episodes, especially decreases to less than 50 per cent of waking values or decreases of 33 per cent for more than 10 min.

The postponement of scheduled operations because of incidentally discovered mild to moderate hypertension can cause great inconvenience to patients, doctors, and hospital schedules. Patients who are already hospitalized may have to be discharged, and adequate control may take months to achieve. Such inconveniences are certainly justified if postponing surgical procedures until hypertension has

TABLE 3. Independently Significant Correlates of Blood Pressure Lability and Cardiac Complications

	Independent Correlates in:	
	A. Entire Series (676 Operations)	B. Patients with Histories of Diastolic Pressure Values above 90 torr or Systolic Values above 160 torr (196 Operations)
I. Lower intraoperative systolic blood pressure nadir	1. Lower preoperative systolic pressure 2. Absence of renal or cerebrovascular complications of hypertension 3. Halothane anesthesia	1. Absence of cerebrovascular or renal complications of hypertension 2. Halothane anesthesia
II. Use of intraoperative adrenergic agents or fluid challenge	1. Type of operative procedure	1. Type of operative procedure 2. Halothane anesthesia
III. Perioperative hypertensive episodes	1. Type of operative procedure 2. History of hypertension 3. Higher in-hospital preoperative systolic blood pressure values	1. Type of operative procedure 2. History of higher pre-hospital blood pressure values, especially diastolic values above 111 torr (but not in-hospital preoperative values)
IV. Perioperative cardiac complications	1. Cardiac risk index score 2. Intraoperative blood pressure decrease of 50 per cent, or of 33 per cent for more than 10 min	1. Cardiac risk index score 2. Intraoperative blood pressure decrease of 50 per cent, or of 33 per cent for more than 10 min

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been controlled will decrease the risk of perioperative complications. However, in our study, patients who had persistent hypertension to diastolic pressures of 110 torr or less fared no worse than did patients in whom hypertension was tightly controlled in terms of perioperative cardiovascular complications, and any tendency toward more perioperative blood pressure lability could be managed by the anesthesiologist. We believe that a prospective randomized trial of preoperative blood pressure control of hypertensive patients who fulfill the criteria listed above will be needed to determine the precise costs and benefits of postponing elective surgical procedures in patients who have mild to moderate hypertension.

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