Blood Pressure Response during Dental Surgery

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To investigate blood pressure and pulse rate responses to dental surgery, 21 patients 18 to 73 years of age (mean age, 42±4 years) who visited our hospital for tooth extraction were studied. Before dental treatment, the patients underwent a mental arithmetic stress test, electrocardiography, and an anxiety evaluation with the State-Trait Anxiety Inventory. Baseline blood pressure and pulse rate were 118±4/70±3 mmHg and 69±2 beats/min, respectively. Blood pressure rose by 24±3/17±2 mmHg during the mental stress test, and the magnitude of the rise in systolic blood pressure was significantly correlated with age ($r=0.81$, $p<0.001$) and baseline blood pressure ($r=0.56$, $p<0.01$). After the topical injection of local anesthetic containing 1: 80,000 epinephrine, a transient increase in systolic blood pressure was observed. The maximum blood pressure and pulse rate increases during dental surgery were 24±4/13±2 mmHg and 17±3 beats/min, respectively. Similarly, the rate pressure product increased from 8,196±486 to 11,802±682. The magnitude of the blood pressure increase during dental surgery was not correlated with age, sex, family history of hypertension, baseline blood pressure, anxiety score, or response to mental stress. On the other hand, when the subjects were divided into two subgroups according to the blood pressure response during dental surgery, the larger response group (increase in mean blood pressure greater than 15 mmHg, $n=9$) required a significantly larger dose of local anesthetic than did the smaller response group. The number of cases of pericoronitis of the third molar tended to be greater in the larger response group. These results indicate that an increase in blood pressure during dental surgery cannot be predicted on the basis of baseline blood pressure or the response to mental stress, but is related to the cause of tooth extraction and the volume of local anesthetics required to control the pain. (*Hypertens Res* 1996; 19: 189-194)

Key Words: **blood pressure, tooth extraction, mental stress, local anesthetic**

The elderly population is growing every year in Japan. As a consequence, many patients who visit dental clinics have systemic diseases such as hypertension,) ischemic heart disease, and other atherosclerotic diseases. Indeed, 64% of the elderly patients who visited the gerodontic clinic were found to have one or more systemic diseases, and among them hypertension was the most frequent disease, occurring in up to 30% of the subjects (*1*). Blood pressure screening in 1,004 consecutive patients who presented at a dental surgery in Hungary also revealed that 24% of the adult patients had hypertension (*2*). The blood pressure response during dental treatment seems to be influenced by many factors. When the patient is conscious during dental treatment, an increase in blood pressure is attributed to psychological and physical stress, including painful stimuli, and to the action of catecholamines contained in local anesthetics. The increment of blood pressure during dental treatment can be greater in hypertensive patients than in normotensive subjects (*3*), and even a case of fatal subarachnoid hemorrhage during dental treatment has been reported (*4*). Since complications are most likely to occur during tooth extraction, and more than 50 percent of the complications involve the use of local anesthetics (*5*), it is important to identify factors useful in predicting the blood pressure response during tooth extraction under local anesthesia. This study was designed to investigate the changes in blood pressure and pulse rate during local anesthesia and tooth extraction and to evaluate the factors that may determine the blood pressure response during dental surgery.

Subjects and Methods

The subjects consisted of 21 patients (18-73 years old; mean age, 42±4 years; 8 men and 13 women) who visited Kyushu Dental College for tooth extraction. The details of the protocol were explained, and written consent was obtained from each subject. On the day of dental surgery, each patient was asked to fill out a questionnaire concerning medical

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Table 1. Baseline Characteristics of the Subjects

Case	Age	Sex	Diagnosis	Family history of HT	Baseline BP
1	67	M	periodontitis	+	140/96
2	39	F	pericoronitis	+	112/64
3	22	M	pericoronitis	−	122/67
4	35	F	pericoronitis	−	108/61
5	62	F	pericoronitis	+	113/72
6	24	M	pericoronitis	+	110/57
7	39	M	periodontitis	+	123/79
8	20	F	pericoronitis	+	109/62
9	26	M	pericoronitis	−	122/73
10	48	F	stump tooth	−	106/64
11	32	F	pericoronitis	−	104/58
12	18	F	pericoronitis	−	101/58
13	21	F	pericoronitis	+	112/62
14	60	M	stump tooth	+	139/87
15	51	F	stump tooth	−	99/52
16	73	M	periodontitis	−	121/73
17	51	F	periodontitis	−	137/76
18	38	F	pericoronitis	+	102/54
19	61	M	stump tooth	−	170/105
20	67	F	periodontitis	+	135/82
21	32	F	pericoronitis	+	106/66

HT: hypertension, BP: blood pressure.

history, drug administration, and the presence or absence of a family history of hypertension in second-degree or closer relatives. Then, the patients' anxiety status was assessed using the State-Trait Anxiety Inventory (STAI) (*6*). STAI consists of 40 items. Twenty of these items are used to evaluate the current status of anxiety (A-state) and the other 20 to evaluate the basic trait of anxiety (A-trait). After recording a 12-lead electrocardiogram, the patient was maintained in a supine position for at least 10 min in a quiet room, and blood pressure was measured every 2 min by an oscillometric method using an automatic device (BP-203i, Nippon Colin). The average of last two measurements was defined as the baseline blood pressure. A mental stress test was then performed by asking the patient to continually subtract 13 from a five-digit number for 10 min. Next, the patient moved to the dental department to undergo tooth extraction. The patient was kept in a supine position, and local anesthesia was administered after a stabilization period of at least 5 min. In 20 of the 21 patients, 2% lidocaine with 1: 80,000 epinephrine was used as an anesthetic. In the remaining patient, 3% propitocaine with 0.03 U/ml of the vasopressin analogue felypressin was used. The operation was begun 6 to 8 min after injection of the local anesthetics. Blood pressure and pulse rate were measured every 2 min throughout local anesthesia and the operation. The surgeon was asked to evaluate the technical difficulty of each operation as follows: 1, easy; 2, moderate; 3, difficult.

Analysis

The results are expressed as means ± SEM. Statistical analysis was performed with a paired *t*-test. One-way analysis of variance (ANOVA) was also used for group comparisons. To compare the frequency between the groups, a chi-square test was used. *P* values less than 0.05 were considered to indicate statistical significance.

Results

Table 1 shows the baseline characteristics of the subjects. The main cause of tooth extraction was pericoronitis of the third molar (12 patients), followed by periodontitis (5 patients), and stump tooth (4 patients). Eleven patients had a positive family history of hypertension. Although 2 patients (Cases 1 and 19) had hypertension according to the WHO criteria, no patient was taking antihypertensive drugs. The response of blood pressure and pulse rate to the mental stress test are shown in Fig. 1. Baseline blood pressure was 118 ± 4/70 ± 3 mmHg. Blood pressure increased significantly during mental stress. The maximum increases in systolic and diastolic blood pressures during mental stress were 24 ± 3 and 17 ± 2 mmHg, respectively. Similarly, baseline pulse rate was 69 ± 2 beats/min and rose by 17

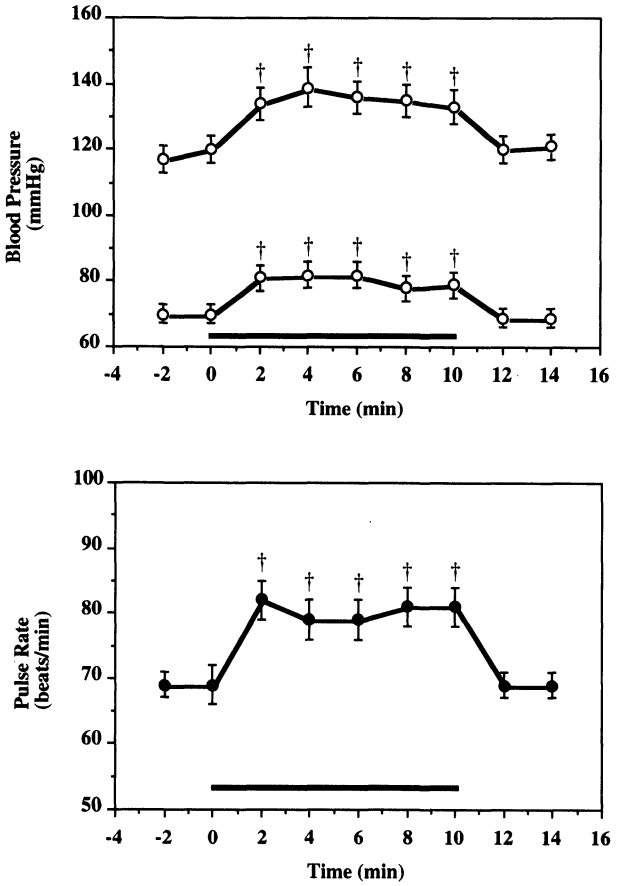

Fig. 1. *Time course of blood pressure (upper panel) and pulse rate (lower panel) during mental stress test. Horizontal bars represent the time of mental stress. Data are shown as means ± SEM.* †p<*0.01* vs. *0 min.*

± 3 beats/min during mental stress. The maximum increase in systolic blood pressure during mental stress was significantly correlated with age ($r=0.81$, $p<0.001$) and with baseline systolic blood pressure ($r=0.56$, $p<0.01$). Table 2 shows the time course of blood pressure and heart rate during local anesthesia. Blood pressure and pulse rate measured in a supine position before local anesthesia were significantly ($p < 0.01$) higher than the baseline values (before mental stress). Systolic blood pressure rose slightly but significantly 2 min after local injection of the anesthetic. Diastolic blood pressure and pulse rate did not change significantly. The duration of the operation for tooth extraction was 29 ± 3 (6-50) min, which was significantly correlated with the volume of local anesthetics required to control the pain ($r = 0.68$, $p < 0.001$). The changes in blood pressure and pulse rate after the initiation of the operation are illustrated in Fig. 2. Diastolic blood pressure rose significantly at 6, 12, 14, 18 and 22 min, whereas systolic blood pressure and pulse rate did not change significantly. Figure 3 compares the changes in blood pressure and pulse rate during mental stress and tooth extraction. The maximum

Table 2. Time Course of Blood Pressure and Heart Rate during Local Anesthesia

Time (min)	*n*	Blood pressure	Heart rate
−2	21	129±5 / 76±4	73±3
0	21	128±4 / 75±3	75±3
2	21	133±5*/ 77±3	77±4
4	21	130±5 / 74±3	79±3

Values are means±SEM. *$p<0.05$ *vs.* 0 min.

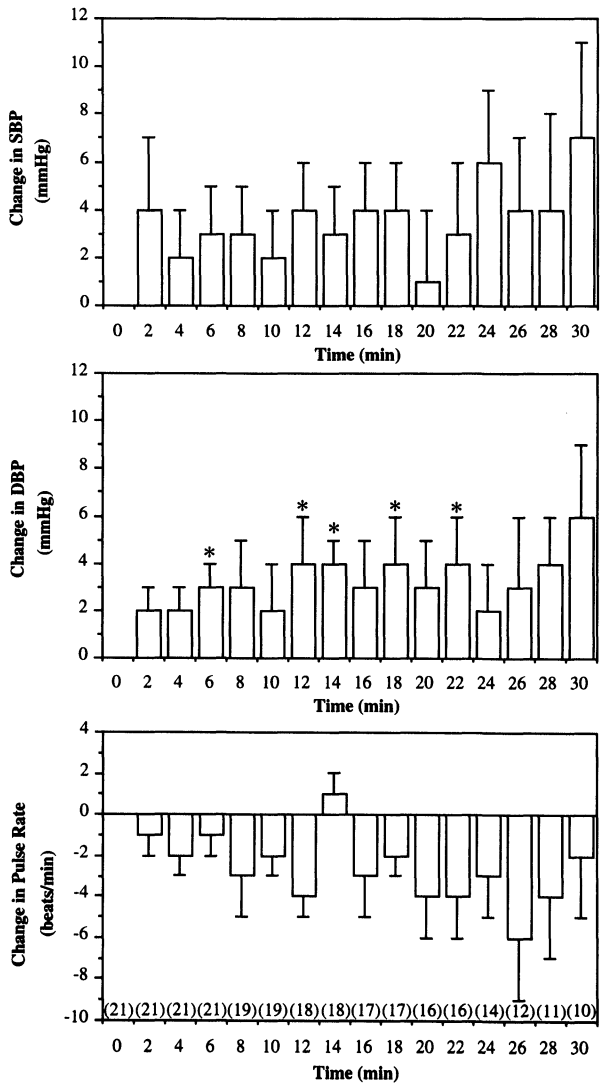

Fig. 2. *Changes in systolic (SBP, top panel) and diastolic (DBP, middle panel) blood pressure and pulse rate (bottom panel) during tooth extraction. Data are shown as means ± SEM. Number of patients appears in parentheses.* *p<*0.05* vs. *0 min.*

increases in blood pressure and pulse rate during tooth extraction, which occurred 14 ± 3 min after the initiation of the operation, were 24 ± 4/13 ± 2 mmHg and 17 ± 3 beats/min, respectively. Similarly,

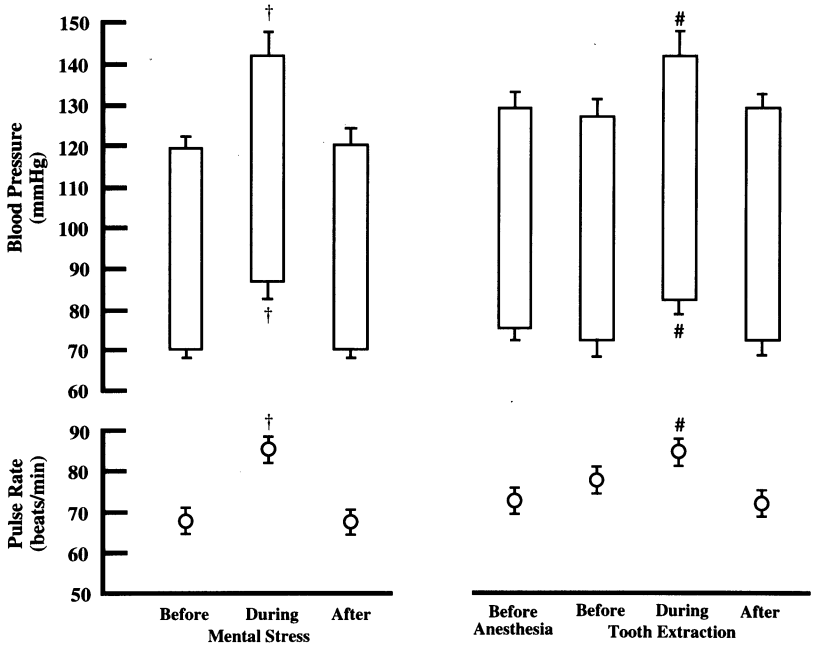

Fig. 3. *Blood pressure (open bars) and pulse rate (open circles) before, during (maximum), and after mental stress and tooth extraction. Data are shown as means ± SEM.* $^{\dagger}p<0.01$ *vs. before mental stress,* $^{\#}p<0.01$ *vs. before anesthesia.*

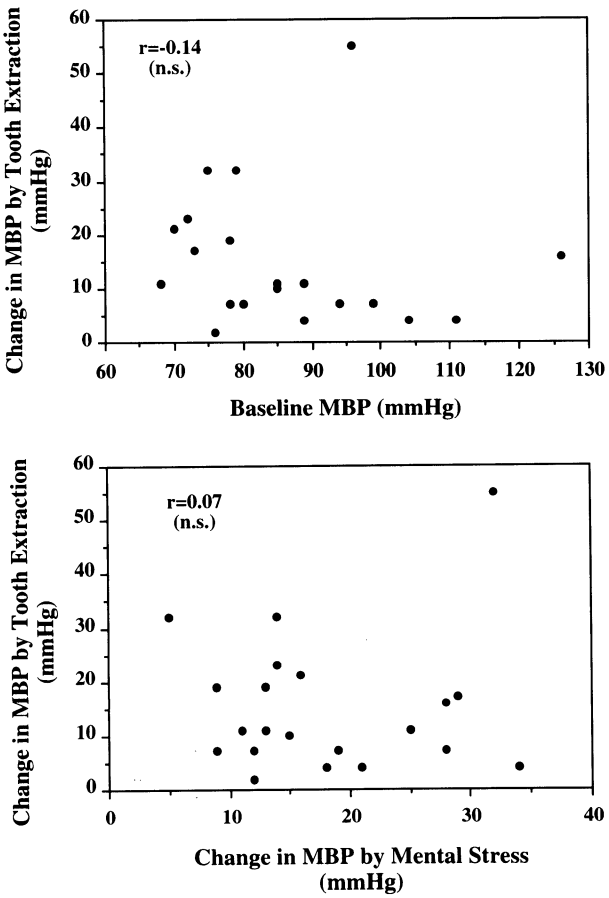

Fig. 4. *Correlation between the change in mean blood pressure (MBP) during tooth extraction and baseline MBP (upper panel) or the change in MBP by mental stress (lower panel).*

the rate pressure product increased significantly from the baseline value of 8,196 ± 486 to 11,802 ± 682 ($p<0.01$). Although the maximum increment in blood pressure during tooth extraction was comparable to that observed during mental stress, the change in mean blood pressure during tooth extraction was not correlated with either baseline blood pressure or the change in blood pressure during mental stress (Fig. 4). Similarly, the increase in blood pressure during tooth extraction was not correlated with age, voltage in the electrocardiogram, or the anxiety score. In addition, there were no significant differences in the increases in blood pressure and pulse rate between patients with a positive family history of hypertension and those with a negative family history of hypertension. Table 3 shows the characteristics of the patients subgrouped according to the blood pressure increase during tooth extraction. In the subgroup in which the increase in mean blood pressure during tooth extraction was greater than 15 mmHg, a significantly greater volume of local anesthetic was used and a longer operation time was required. In addition, there was a trend toward more cases of pericoronitis of the third molar in this subgroup. However, there were no significant differences in age, sex, body mass index, anxiety score, or baseline blood pressure between the subgroups.

Discussion

Previous studies evaluating the blood pressure response to dental treatment showed conflicting results. For example, Vanderheyden *et al.* (7) reported that blood pressure did not change significantly during dental treatment using local anesthesia in patients with coronary artery disease, while

Table 3. Characteristics of the Patients Subgrouped According to the Increment in Mean Blood Pressure during Tooth Extraction

Variable		BP increase≥15 mmHg	BP increase<15 mmHg	*p*
Age (yr)		36±5	47±5	ns
Sex	Female/Male	7/2	6/6	ns
Diagnosis	Pericoronitis/Other	7/2	5/7	0.10
Difficulty	≤2/3	4/5	8/4	ns
Volume of Anesthetic (ml)		3.6±0.6	2.2±0.2	<0.05
Duration of Operation (min)		34±5	24±4	0.10
BMI (kg/m^2)		20±1	21±1	ns
STAI	A-State	45±3	47±2	ns
	A-Trait	43±4	41±3	ns
Baseline BP (mmHg)		116±8 / 66±5	120±4 / 72±4	ns

Values are number of the subjects or means ± SEM. BMI, Body mass index; STAI, State-Trait Anxiety Inventry; A-State, Anxiety state; A-Trait, Anxiety trait; BP, Blood pressure; ns, not significant.

Abraham-Inpijn *et al.* (*3*) showed that the increase in systolic blood pressure during tooth extraction varied from 10 to 70 mmHg in normotensive and hypertensive subjects. In the present study, a significant increase in blood pressure was observed during tooth extraction, which was consistent with reports by Abraham-Inpijn *et al.* (*3*) and by Yoshimura (*8*). The blood pressure response to dental surgery is considered to be influenced by many factors, including psychological and physical stress induced by painful stimuli. The baseline blood pressure level, a positive or negative family history of hypertension, and the dose of catecholamines administered with the local anesthetic may also be determinants of the blood pressure response. As for the blood pressure response in hypertensive subjects, previous studies revealed that the increase in blood pressure during dental surgery was comparable to (*9*) or greater than (*3*) that in normotensive subjects. The small number of hypertensive patients in the present study did not permit us to compare the blood pressure response during tooth extraction between hypertenisve and normotensive subjects. However, evidence that the increase in blood pressure during surgery was not correlated with baseline blood pressure suggests that the baseline high blood pressure is not a major determinant of the increment in blood pressure during tooth extraction. The lack of a difference in the increment in blood pressure during tooth extraction between subjects with a family history of hypertension and those without such a history also suggests that the genetic predisposition to hypertension does not affect the blood pressure response to dental surgery.

Another important factor that may influence the blood pressure response during dental surgery is the use of catecholamines with the local anesthetic. In the present study, the average volume of local anesthetic used was 2.8 ml, which contained approximately 35 μg of epinephrine. This dose of epinephrine may lead to a several-fold increase in the serum epinephrine concentration (*10*). Evidence that epinephrine in local anesthetics produces significant cardiovascular effects is supported by the observation by Meyer (*11*) that lidocaine with and without epinephrine alters blood pressure and heart rate differently. In the present study, the increase in blood pressure after the injection of local anesthetic was significant but transient. This transient increase in blood pressure cannot be explained by the effect of exogenously injected epinephrine because the maximum increase in serum epinephrine concentration is achieved 3 to 6 min after the injection of local anesthetics and high serum epinephrine levels are expected to last at least 20 min (*10*). Interestingly, Gortzak *et al.* (*12*) reported an increase in blood pressure during the administration of a local anesthetic solution, followed by a decrease in blood pressure shortly after removal of the needle from the mouth. Therefore, our observation that blood pressure increased transiently after local anesthesia may be attributable to pain caused by insertion of the needle for local anesthesia. Sympathetic activation can be elicited both by exogenous and endogenous epinephrine. The critical role of sympathetic activation of the heart in cardiovascular responses during dental surgery is further supported by the finding that patients with heart transplants show no changes in blood pressure or heart rate during dental surgery (*13*). The significant contribution of painful stimuli to the increase in blood pressure during dental treatment was demonstrated by Gortzak *et al.* (*12*). They compared the blood pressure response to restorative dental treatment with and without local anesthesia, and found a significant rise in blood pressure only in the patients treated without local anesthesia. In the present study, the patients showing the greater increase in blood pressure during tooth extraction had been given larger volumes of local anesthetic, suggesting that pain-related stress is a major determinant of the increment in blood pressure during dental surgery. Further studies evaluating the threshold or the intensity of pain are necessary to clarify the role of pain in the

blood pressure response to dental surgery. Psychological stress may be another factor causing an increase in blood pressure during tooth extraction. However, neither the anxiety score nor the blood pressure response to mental stress predicted the blood pressure response during tooth extraction. This observation does not support a major role of psychological stress in the blood pressure response during tooth extraction.

Limitations of the present study include a small number of patients examined. Since most patients were healthy except for dental diseases, we were unable to address potentially critical cardiovascular responses during tooth extraction in patients with systemic diseases. Increases in blood pressure and heart rate can provoke arrhythmias (*3*), ischemic changes on the electrocardiogram (*14*), or anginal attacks (*8*) in patients with coronary artery disease.

In conclusion, the increase in blood pressure during tooth extraction cannot be predicted on the basis of the baseline blood pressure level or the response to mental stress, but is related to the cause of tooth extraction and the volume of local anesthetics required to control pain. Further studies in larger numbers of patients with and without systemic diseases are necessary to establish the cardiovascular responses to dental surgery and to determine the optimal use of local anesthetics in patients undergoing dental surgery.

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