



Original Article

Blood pressure reduction in patients with irreversible pulpitis teeth treated by non-surgical root canal treatment



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Received 14 May 2017

Available online 10 August 2017

KEYWORDS

hypotension;
irreversible pulpitis
teeth;
non-surgical root
canal treatment;
blood pressure;
parasympathetic
effect;
vital pulpal
extirpation

Abstract *Background/purpose:* The hypotension in patients during non-surgical root canal treatment (NSRCT) has not yet investigated. This study aimed to assess the mean systolic blood pressure (MSBP), mean diastolic blood pressure (MDBP), and mean arterial blood pressure (MABP) reduction percentages in patients with irreversible pulpitis teeth treated by NSRCT.

Materials and methods: We prospectively recruited 111 patients with a total of 138 irreversible pulpitis teeth. All patients underwent two NSRCT sessions. The first NSRCT session involved mainly the removal of vital pulp tissue with the direct stimulation of the dental branches of the trigeminal nerve, and the second NSRCT session included the root canal debridement and enlargement with minimal disturbance to the dental nerves. The blood pressure of each patient was recorded before and during both NSRCT sessions.

Results: There were significantly higher reduction percentages of MSBP, MDBP, and MABP in the first NSRCT session than in the second NSRCT session for all treated patients (all the P-values < 0.001). If the patients were divided into 2 or more groups according to the clinical variables including the patients' gender, age, tooth type, and anesthesia type, we also found significantly higher reduction percentages of MSBP, MDBP, and MABP in the first NSRCT session than in the second NSRCT session for all treated patients except for patients below 40 years of age and for patients with lower anterior teeth treated (all the P-values < 0.05).

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Conclusion: The decrease in blood pressure in patients receiving vital pulpal extirpation is a relatively common phenomenon.

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Introduction

Most studies investigating the effects of hemodynamic changes during dental treatment have focused on the sympathetic effects, such as the changes in tachycardia and hypertension, resulting from pain or anxiety.^{1–3} However, on the other end of the spectrum exists the parasympathetic effects including hypotension and hemodynamic instability on patients during dental treatment, which are often overlooked by most dentists.⁴

Pain elicited during the first visit of non-surgical root canal treatment (NSRCT) may lead to a sympathetic response resulting in hypertension or tachycardia.^{3,5} Pain and anxiety can increase sympathetic tone. Some scholars who have examined the sympathetic response during local anesthesia have hypothesized that increased heart rate and alterations in blood pressure during dental procedures are due to endogenous catecholamine release resulted from the stimulation of emotional stress but not a pharmacological effect.³ Other authors, however, attribute the cardiovascular response in dental treatment to the drug of epinephrine added to the local anesthetic solution. They found that the mean systolic blood pressure (MSBP) and mean diastolic blood pressure (MDBP) during the different dental procedures of each appointment or between appointments for endodontic treatments of pulpitis teeth were statistically similar.⁶ On the basis of this previous study, it appears that endodontic treatment has no cardiovascular effect on patients without history of cardiovascular disease. The only significant difference in blood pressure change was found between the patients with symptoms and those without symptoms. This may be related to the presence of different severities of pain. Therefore, the condition of the patient, but not the treatment, may produce significant cardiovascular effect. Their findings suggest that patients demonstrate a physiological stress response during dental checkups and treatment. Local anesthesia and tooth extraction may activate the adrenal cortex to produce cortisol. Changes in adrenaline or noradrenaline concentrations in the plasma and urine have been reported after drilling and filling or extraction of teeth, and anticipation of a dental checkup increases blood pressure in patients. Both SBP and DBP may rise during restorative treatment without local anesthesia and during tooth extraction. In another study, no significant changes in blood pressure were observed during restorative treatment with local anesthesia, which suggests that the pain experienced by the patient contributes to the rise in blood pressure.¹ Dentists should be aware that this increase in blood pressure may induce cardiovascular complications during dental therapy.^{7–9}

Liau et al. hypothesized that the anxiety has an additive effect on cardiovascular responses in patients undergoing

dental extraction using the block anesthesia for the inferior alveolar nerve.¹⁰ Younger patients were more likely to have high anxiety levels during tooth extraction and were more likely to report a traumatic dental history. High anxiety, younger age, and traumatic dental history were correlated with greater increases in heart rate during the administration of local dental anesthesia. Their findings indicate that Corah's dental anxiety scale is a useful tool for estimating the impact of anxiety on heart rate during local anesthetic delivery to achieve mandibular block for dental extraction.¹⁰

Most studies on hemodynamic changes during dental treatment have focused on the sympathetic effect resulting from anxiety or pain.^{4,5} These studies did not investigate the parasympathetic effect including hypotension and possible hemodynamic instability on patients during dental treatments. In order to clarify the parasympathetic effect on blood pressure in patients during dental treatments, we recorded and analyzed the blood pressure before, during, and after NSRCT in patients with irreversible pulpitis teeth which were treated by two sessions of NSRCT. The main purpose of this study was to assess the MSBP, MDBP, and mean arterial blood pressure (MABP) reduction percentages in patients with irreversible pulpitis teeth which were treated by two sessions of NSRCT.

Materials and methods

We prospectively recruited 111 patients with 138 irreversible pulpitis teeth that received NSRCT under local infiltration or block anesthesia from June 2014 to October 2015. Patients between 20 and 69 years of age and patients with irreversible pulpitis teeth that showed complete root formation, tested positive by the vitality pulp test, and underwent NSRCT under local infiltration or block anesthesia were included. Patients with preexisting medical conditions such as diabetes mellitus, hypertension, severe renal, hepatic, or cardiovascular diseases and those with incomplete medical and dental records were excluded. This clinical study was approved by the institutional review board of Chung Shan Medical University Hospital (CSMUH, protocol CSMUH No. CS14112).

We documented the age, gender, treated tooth type, and type of anesthesia (local infiltration or block anesthesia) of each patient. Patients underwent two sessions of NSRCT under local infiltration or block anesthesia. Anesthesia was performed using 1.7 ml of xylocaine with 1:80,000 epinephrine. Rubber dam isolation was used during each NSRCT.

The first NSRCT session consisted mainly of removal of vital pulp tissues and instrumentation to working length by hand files and rotary instruments. The treated tooth was

then repeatedly irrigated with 2.5% sodium hypochlorite (NaOCl) solution, and medicated with calcium hydroxide paste in the root canals of the tooth. During the second NSRCT session, patients underwent complete root canal debridement and enlargement with hand files and rotary instruments. Repeated 2.5% NaOCl solution irrigations were also performed. In the absence of symptoms and signs during the second NSRCT, the root canals were firstly cleaned, dried, and then filled with gutta-percha points (DiaDen, Almere, Netherlands) and root canal sealer (Canals, Showa, Tokyo, Japan) using the lateral condensation technique. All NSRCT procedures were completed by the same clinician (James I-Sheng Huang).

During each session of NSRCT, blood pressures including systolic blood pressure (SBP) and diastolic blood pressure (DSP) were monitored and recorded with CSI Model 506 DXN (Criticare System Inc., Waukesha, WI, USA).

Statistical analyses

After recording SBP and DBP, we calculated MABP using the equation of $(MABP = 1/3 SBP + 2/3 DBP)$. The SBP reduction percentage was calculated by the equation of $[(initial SBP - minimal SBP during treatment / initial SBP) \times 100\%]$. The DBP reduction percentage was calculated by the equation of $[(initial DBP - minimal DBP during treatment / initial DBP) \times 100\%]$. Moreover, The MABP reduction percentage was calculated by the equation of $[(initial MABP - minimal MABP during treatment / initial MABP) \times 100\%]$. The MSBP, MDBP, and MABP reduction percentages between patients receiving the first and the second NSRCT were compared by paired *t*-test. The MSBP, MDBP, and MABP reduction percentages between male and female patients, between local infiltration and block anesthesia groups, and among different age groups or tooth type groups were compared by Student's *t*-test or analysis of variance, where appropriate. A *P*-value of less than 0.05 was considered statistically significant. All statistical analyses were undertaken using statistical software package R (version 3.3.3, The R Foundation for Statistical Computing, Vienna, Austria).

Results

This study included 111 patients with 138 irreversible pulpitis teeth. Sixty-nine teeth were from male patients and the other 69 teeth were from female patients. The patients' age ranged from 20 to 69 years. Of the 138 teeth, 28 (20.3%) were upper anterior teeth, 17 (12.3%) upper premolars, 29 (21.0%) upper molars, 7 (5.1%) lower anterior teeth, 19 (13.8%) lower premolars, and 38 (27.5%) lower molars. Local infiltration anesthesia was performed for treatment of 81 (58.1%) diseased teeth and regional block anesthesia was done for treatment of 57 (41.3%) diseased teeth.

In the first and the second NSRCT sessions of treating 138 irreversible pulpitis teeth, the MSBP reduction percentages were $13.7 \pm 13.8\%$ and $5.4 \pm 5.5\%$, the MDBP reduction percentages were $15.0 \pm 13.3\%$ and $6.3 \pm 7.6\%$, and the MABP reduction percentages were $13.4 \pm 12.4\%$ and $5.5 \pm 6.8\%$, respectively. There were significantly higher reduction percentages of the MSBP, MDBP, and MABP in the

first NSRCT session than in the second NSRCT session for all treated patients (all the *P*-values < 0.001, Table 1).

If the patients were divided into 2 or more groups according to the clinical variables including the patients' gender, age, tooth type, and anesthesia type, we also found significantly higher reduction percentages of the MSBP, MDBP, and MABP in the first NSRCT session than in the second NSRCT session for all treated patients except for patients below 40 years of age and for patients with lower anterior teeth treated (all the *P*-values < 0.05, Table 2). Moreover, there was a significantly higher MSBP reduction percentage in the first NSRCT session than in the second NSRCT session for patients of the 20–29-year group (*P* = 0.026, Table 2). Furthermore, we also found a significantly higher MDBP reduction percentage in the first NSRCT session than in the second NSRCT session for patients of the 30–39-year group (*P* = 0.014, Table 2). However, there were no significant differences in the MSBP, MDBP, and MABP reduction percentages between male and female patients, between local infiltration and block anesthesia groups, and among different age groups or tooth type groups in both the first and the second NSRCT sessions (Table 2).

Discussion

This study observed a decrease in blood pressure during the two sessions of NSRCT. The blood pressure reduction was greater in the first NSRCT session in which the vital pulp extirpation was performed than in the second NSRCT session in which only minimal interference with the dental nerve was experienced. The results of this study were opposite to the common impression that dental procedures

Table 1 Comparisons of mean systolic blood pressure (MSBP), mean diastolic blood pressure (MDBP), and mean arterial blood pressure (MABP) reduction percentages between patients receiving the first non-surgical root canal treatment (NSRCT) and the second NSRCT.

Variables	Total case number	Mean reduction percentage \pm SD (%)	<i>P</i> -value ^a
MSBP			<0.001
First NSRCT session	138	13.7 \pm 13.8	
Second NSRCT session	138	5.4 \pm 5.5	
MDBP			<0.001
First NSRCT session	138	15.0 \pm 13.3	
Second NSRCT session	138	6.3 \pm 7.6	
MABP			<0.001
First NSRCT session	138	13.4 \pm 12.4	
Second NSRCT session	138	5.5 \pm 6.8	

^a Comparison of MSBP, MDBP, and MABP reduction percentages between patients receiving the first and the second NSRCT by paired *t*-test.

Table 2 Comparisons of mean systolic blood pressure (MSBP), mean diastolic blood pressure (MDBP), and mean arterial blood pressure (MABP) reduction percentages between patients receiving the first non-surgical root canal treatment (NSRCT) and the second NSRCT according to patients' gender, age, tooth type, and anesthesia type as well as between male and female patients, between local infiltration and block anesthesia groups, and among different age groups or tooth type groups.

Clinical variables	Total tooth no. (%)	MSBP reduction percentage (%)			MDBP reduction percentage (%)			MABP reduction percentage (%)		
		First session	Second session	P-value ^a	First session	Second session	P-value ^a	First session	Second session	P-value ^a
Gender										
Male	69 (50.0)	14.7 ± 15.2	5.3 ± 5.1	<0.001	15.8 ± 14.1	6.5 ± 8.9	<0.001	14.3 ± 13.5	5.3 ± 6.3	<0.001
Female	69 (50.0)	12.7 ± 12.3	5.5 ± 5.9	<0.001	14.3 ± 12.4	6.1 ± 6.1	<0.001	12.5 ± 11.2	5.8 ± 7.3	<0.001
P-value ^b		0.397	0.832		0.508	0.591		0.395	0.667	
Age										
20–29	15 (10.9)	16.3 ± 17.7	4.8 ± 4.5	0.026	18.0 ± 15.5	10.3 ± 15.0	0.238	16.5 ± 16.4	7.2 ± 9.1	0.103
30–39	12 (8.7)	9.8 ± 12.5	4.3 ± 4.1	0.155	14.9 ± 16.4	2.6 ± 3.9	0.014	11.0 ± 14.6	2.7 ± 3.5	0.057
40–49	27 (19.6)	13.8 ± 14.3	6.5 ± 5.3	0.009	13.3 ± 10.4	7.5 ± 5.7	0.006	12.1 ± 11.2	7.8 ± 9.5	0.044
50–59	48 (34.8)	14.3 ± 12.0	5.2 ± 5.8	0.000	15.9 ± 13.8	5.2 ± 6.2	0.000	14.2 ± 11.5	4.5 ± 5.1	<0.001
60–69	36 (26.1)	12.6 ± 14.4	5.3 ± 6.0	0.007	13.7 ± 12.6	6.1 ± 6.4	0.003	12.3 ± 11.9	5.2 ± 5.6	0.003
P-value ^b		0.773	0.772		0.780	0.067		0.710	0.123	
Tooth type										
Upper anterior	28 (20.3)	12.0 ± 12.0	3.9 ± 3.8	0.001	13.8 ± 10.5	4.9 ± 5.7	<0.001	12.1 ± 9.7	3.9 ± 4.5	<0.001
Upper premolar	17 (12.3)	18.7 ± 16.3	6.1 ± 6.5	0.008	21.5 ± 17.1	7.1 ± 5.2	0.004	16.8 ± 13.3	5.4 ± 4.6	0.006
Upper molar	29 (21.0)	11.9 ± 13.9	6.2 ± 6.5	0.024	12.2 ± 12.7	4.7 ± 6.2	0.003	11.6 ± 13.0	4.7 ± 5.9	0.006
Lower anterior	7 (5.1)	9.1 ± 9.5	4.9 ± 6.9	0.088	9.3 ± 8.4	9.3 ± 7.6	0.996	9.1 ± 7.2	7.0 ± 6.6	0.526
Lower premolar	19 (13.8)	19.5 ± 17.5	7.0 ± 6.3	0.008	20.1 ± 17.2	7.9 ± 8.0	0.010	19.2 ± 16.9	6.8 ± 6.3	0.006
Lower molar	38 (27.5)	12.1 ± 11.5	4.9 ± 4.4	0.001	13.7 ± 10.9	6.8 ± 10.2	0.009	12.0 ± 10.7	6.5 ± 9.5	0.012
P-value ^b		0.165	0.422		0.070	0.489		0.171	0.585	
Anesthetic type										
Local infiltration	81 (58.7)	13.5 ± 13.9	5.3 ± 5.7	<0.001	14.9 ± 13.4	5.4 ± 5.8	<0.001	13.0 ± 11.9	4.5 ± 5.1	<0.001
Block	57 (41.3)	13.9 ± 13.7	5.6 ± 5.3	<0.001	15.1 ± 13.2	7.4 ± 9.2	<0.001	13.8 ± 12.9	6.7 ± 8.3	<0.001
P-value ^b		0.867	0.755		0.931	0.120		0.708	0.056	

^a Comparison of MSBP, MDBP, and MABP reduction percentages between patients receiving the first and the second NSRCT by paired *t*-test.

^b Comparisons of MSBP, MDBP, and MABP reduction percentages between male and female patients, between local infiltration and block anesthesia groups, and among different age groups or tooth type groups by Student's *t*-test or analysis of variance, where appropriate.

often lead to stimulation of the sympathetic nerve system resulting in elevated blood pressure due to pain and anxiety. The phenomenon of blood pressure drop during NSRCT session occurred more commonly than we expected. In addition, the MSBP, MDBP, and MABP reduction percentages were not associated with the clinical variables including the patients' gender, age, treated tooth type, and anesthesia type.

In patients of different age groups, those patients over 40 years of age tended to have stable response of blood pressure drop in MSBP, MDBP, and MABP during the NSRCT session. For patients between 20 and 29 years of age, only a significant reduction of MSBP but not MDBP and MABP was discovered. Moreover, for patients between 30 and 39 years of age, only a significant decrease of MDBP rather than MSBP and MABP was found. These findings may be attributed to the fact that young adults are probably more anxious or stressed when receiving NSRCT than the patients of older age groups, and thus a profound sympathetic response is elicited and this subsequently reduce or mask the parasympathetic effect on the blood pressure in patients receiving NSRCT.

In patients with irreversible pulpitis teeth of different tooth types, patients with irreversible pulpitis teeth of all tooth types except the lower anterior teeth treated by NSRCT showed significantly greater reduction in MSBP, MDBP, and MABP in the first NSRCT session than in the second NSRCT session. The reasons why the patients with diseased lower anterior teeth treated by NSRCT failed to demonstrate the significant differences in MSBP, MDBP, and MABP between the first and the second sessions of NSRCT may be explained as follows. Since the lower anterior teeth are supplied by the incisive nerves which are the small terminal branches of the inferior alveolar nerves. The dental nerves of the lower anterior teeth are far away from the Gasserian ganglion and trigeminal brainstem center and may contain the least sensory fibers in comparison to the dental nerves of the other tooth types. Thus, when vital pulp extirpation is performed in the lower anterior teeth, the less trigeminal stimulation may lead to a minor parasympathetic effect on blood pressure drop in patients receiving the first NSRCT and this in turn results in no significant differences in the reduction of MSBP, MDBP, and MABP between patients receiving the first and the second NSRCT. Further critical biostatistical analyses and clinical or animal model studies based on a large sample size are needed to confirm that trigeminocardiac reflex (TCR) plays a significant role in causing hypotension during NSRCT.

Factors contributing to hemodynamic changes may result from anxiety, pain, drug, and dental procedure.^{6,7,11} In a previous study, patients demonstrate a physiological stress response during dental checkups and treatment.¹² Local anesthesia and tooth extraction may activate the adrenal cortex to produce cortisol. Changes in adrenaline or noradrenaline concentrations in the plasma and urine have been reported after drilling and filling or extraction of teeth. Moreover, anticipation of a dental checkup increases blood pressure in patients.^{4,13} Both SBP and DBP increase during restorative treatment without local anesthesia and during tooth extraction. In a study by the same authors, no significant changes in blood pressure were observed during restorative treatment with local anesthesia; this finding

suggests that the pain experienced by the patient contributes to the rise in blood pressure. Dentists should be aware that the increased blood pressure during dental treatments may induce cardiovascular complications.⁸

In this study, similar procedures including local anesthesia and the root canal debridement and enlargement were performed in both the first and the second sessions of NSRCT. Since the blood pressure confounding factors including the emotional stress, physical stress, and drug are similar in the first and in the second sessions of NSRCT, the only one different factor is the vital pulp extirpation performed in the first NSRCT session. We suggest that the vital pulp extirpation in the first NSRCT session may stimulate the dental branch of trigeminal nerve and in turn lead to a greater drop in blood pressure in patients receiving the first NSRCT than in patients receiving the second NSRCT.

Our findings provide clues that TCR may be a possible mechanism contributing to the parasympathetic effect on blood pressure reduction during NSRCT. TCR is defined as a sudden decrease in MABP and heart rate by at least 10%–20% (varied in different studies) after stimulation of the trigeminal nerve.¹⁴ Since dental pulp is innervated by abundant sensory nerve fibers originating from the maxillary and mandibular branches of the trigeminal nerve, stimulations of the dental pulpal nerves may possibly result in TCR. Once the dental pulp is invaded or infected by the bacteria, the inflammatory response of pulp tissue is activated. If the inflammation is resolved and the dental pulp tissue returns to normal condition, the tooth is defined as having reversible pulpitis. If the inflammatory response persists and progresses, the dental pulp can not return to the normal status. In this situation, the tooth is defined as having irreversible pulpitis. At this stage, root canal treatment is indicated to remove the diseased dental pulp in order to preserve the tooth. During root canal treatment, the peripheral branches of trigeminal nerve may be stimulated, thereby inducing the occurrence of TCR.

The limitation of this study is that we do not include the possible interfering factors such as the physiological and emotional stresses, anxiety and pain into consideration during analyses of the blood pressure data obtained from patients during the two sessions of NSRCT.^{3,15} These interfering factors are supposed to have sympathetic effects on the rise of blood pressure in patients and these sympathetic effects may decrease or mask some of the TCR-induced parasympathetic effects in patients receiving NSRCT.

Our results showed significantly higher reduction percentages of the MSBP, MDBP, and MABP in the first NSRCT session than in the second NSRCT session for all treated patients. If the patients were divided into 2 or more groups according to the clinical variables including the patients' gender, age, tooth type, and anesthesia type, we also found significantly higher reduction percentages of the MSBP, MDBP, and MABP in the first NSRCT session than in the second NSRCT session for all treated patients except for patients below 40 years of age and for patients with lower anterior teeth treated. The decrease in blood pressure was less in the second NSRCT session than in the first NSRCT, because the dental nerve was removed in the first NSRCT and only minimal disturbance to the dental nerve was experienced in the second NSRCT session. The decrease in blood pressure in patients receiving vital pulpal extirpation

is a relatively common phenomenon. Clinicians should be aware of the possible drop in blood pressure and possible risk of hemodynamic instability when performing the vital pulpal extirpation.

Conflicts of interest

The authors have no conflicts of interest relevant to this article.

Acknowledgement

The authors would like to thank Yi-Ting Huang and Tsao-Li Chuang for assisting in data consolidation and statistical analysis.

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