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## Safety analysis of tooth extraction in elderly patients with cardiovascular diseases

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**Background:** This study aimed to evaluate the safety of tooth extraction in elderly patients with cardiovascular diseases.





**Material/Methods:** A total of 13 527 patients underwent tooth extraction at the Affiliated Ninth People's Hospital of Shanghai Jiaotong University. Age, sex, and diseases were analyzed. Cardiac monitoring during tooth extraction was performed in 7077 elderly patients with hypertension and other chronic diseases, and the influence of various factors on safety of tooth extraction was evaluated. Additionally, 89 patients with primary hypertension were recruited, and electrocardiogram was monitored with a general monitor or a Holter monitor, and the detection rate of cardiovascular events was compared between the 2 groups.

**Results:** The elderly accounted for 75.3%, and patients aged 70–79 years had the highest proportion. The most frequent comorbidities were hypertension, coronary heart disease, arrhythmia, cerebrovascular accident, and diabetes. In analysis of factors influencing the safety of tooth extraction in the elderly, a significant difference was noted in systolic blood pressure at different time points. In addition, change in heart rate was different between males and females. Detection rate of cardiovascular events by use of a Holter monitor was significantly higher than with a general monitor.

**Conclusions:** Hypertension was the most common comorbidity in elderly patients undergoing tooth extraction, followed by coronary heart disease and arrhythmia. Advanced age and increased comorbidity may increase the risk of complications. Risk score can be used to rapidly determine risk for complications during tooth extraction. The Holter monitor is superior to the general monitor in identifying cardiovascular events in high-risk elderly patients undergoing tooth extraction, and can be used in this population.

**MeSH Keywords:** **Tooth Extraction • Dental Care for Aged • Cardiovascular Diseases**

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## Background

The incidence of oral diseases increases with age in the elderly. Oral health is more important for elderly patients who have high risk for oral diseases, age-related diseases, or chronic diseases, or who require multidrug treatment [1]. In the past 5 decades, utilization of dental care and dental equipment has increased in the elderly. During the same period, the oral health and use of dental services among older adults in the United States have improved [2]. Chinese statistics shows 43.7% of the elderly population has hypertension (HBP) or cardiac-cerebral vascular disease (CCVD) [3]. Some chronic diseases may promote the occurrence of oral diseases and compromise the effectiveness of oral care [4]. In recent years, the elderly are paying more attention to their oral health. Oral surgery – especially tooth extraction – is also increasingly common in the elderly with cardiovascular diseases.

Thus, smoothly performing tooth extraction while limiting cardiovascular stress to within a safe range during tooth extraction is still a challenge in elderly patients with cardiovascular diseases. Properly managing tooth extraction in these patients with chronic diseases is crucial for their health and quality of life. Dental teams are amenable to understanding the expansion of requirement for oral care in the elderly and emphasize the education, research, and health management in this population [5].

We surveyed elderly patients with cardiovascular diseases who underwent tooth extraction, and cardiac monitoring was evaluated in these patients. On the basis of age, sex, and pre-existing chronic diseases in the patients, factors influencing the safety of tooth extraction were assessed, aiming to evaluate the risk for complications of tooth extraction, and take measures to reduce or avoid adverse cardiovascular events in these patients.

## Material and Methods

### Patients

A total of 14 832 patients, median age 67.3 years (range: 18–92 years), were retrospectively evaluated from January 2008 to December 2012. Patients with cardiovascular disease underwent tooth extraction in the clinics of the Affiliated Ninth People's Hospital, Shanghai Jiaotong University. Among these patients, 7077 patients with primary hypertension (median age: 68.125 years; range: 60–93 years) received cardiac monitoring during the tooth extraction. There were 2937 males and 4140 females. In addition, 89 patients (Hypertension Risk Group C [6]) were recruited from December 2012 to February 2013. The median age was 69.35 years, and they received cardiac monitoring with a Holter monitor during the tooth extraction.

### Methods

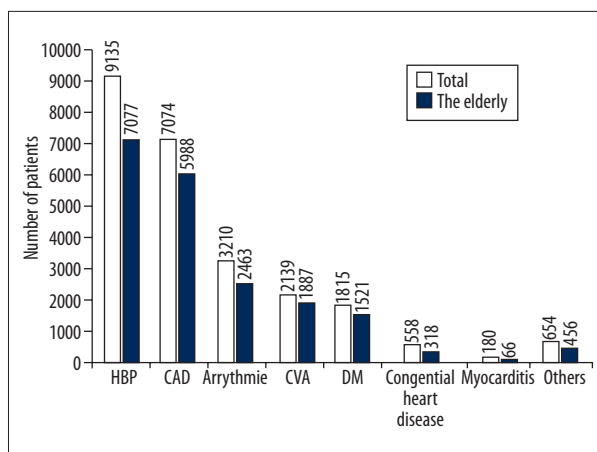
All patients were surveyed using the same questionnaire and physical examinations were performed by trained investigators. Items included in the questionnaire survey consisted of baseline characteristics and concomitant chronic diseases. The baseline characteristics included demographics, sex, and age. Chronic diseases and their conditions included: 1) coronary atherosclerotic heart disease (CAD): a history of angina pectoris, myocardial infarction (MI), percutaneous coronary intervention (PCI)/Coronary artery bypass grafting (CABG), and cardiac function. 2) Diabetes mellitus: diabetes mellitus was diagnosed according to the WHO criteria for diabetes (1999): fasting blood glucose  $\geq 7.0$  mmol/L, 2-h postprandial blood  $\geq 11.1$  mmol/L. Diabetes mellitus (DM) was divided into type 1 and type 2. 3) Hypertension: presence and course of hypertension, medication, and blood pressure. Hypertension was diagnosed according to the Guideline for the Prevention and Treatment of Hypertension in China [2005]: systolic blood pressure  $\geq 140$  mmHg, or diastolic blood pressure  $\geq 90$  mmHg; 4) other cardiovascular diseases: rheumatic heart disease, congenital heart disease, viral myocarditis; 5) Cerebrovascular diseases: cerebral infarction, cerebral embolism, and cerebral hemorrhage; 6) Digestive diseases: gastric ulcer, duodenal ulcer, acute viral hepatitis, cirrhosis, primary sclerosing cholangitis, and cholelithiasis; 7) Bleeding disorders: purpura, vitamin C deficiency, idiopathic thrombocytopenic purpura, and hemophilia.

### Criteria for exclusion from tooth extraction

Criteria for exclusion from tooth extraction [6]: 1) contradictions for tooth extraction; 2) a history of mental disorders or being uncooperative with tooth extraction; 3) patients with primary hypertension were not medicated on the day of tooth extraction or patients had secondary hypertension; 4) acute cardiovascular or cerebrovascular diseases within the last 6 months e.g., acute coronary syndrome, cerebral infarction, and cerebral hemorrhage), or patients received major surgery within the last 6 months; 5) anti-coagulation (warfarin, aspirin) or anti-platelet therapy was not discontinued at 1 day before surgery; 6) fasting blood glucose was poorly controlled before surgery and the fasting blood glucose was  $> 8$  mmol/L; 7) patients with DM or valve replacement surgery were not treated with antibiotics within 3 days after tooth extraction.

### Monitoring during tooth extraction

Patients were placed in a supine position and received cardiac monitoring. Anesthesia, tooth extraction, and management of bleeding were performed by professional dentists. During the tooth extraction, cardiac monitoring was done and data were recorded. Blood pressure was measured with the same monitor before, during, and after tooth extraction. Systolic blood



**Figure 1.** Number of elderly patients with different comorbidities. Other diseases: respiratory, renal and hematological diseases.

pressure (SBP), diastolic blood pressure (DBP), heart rate (HR), and saturation of peripheral oxygen ( $SpO_2$ ) were measured after anesthesia, after tooth extraction, and during sitting after tooth extraction.

#### Cardiac monitoring with Holter monitor

Following preparation for tooth extraction, patients were placed in a semi-recumbent position and connected to Holter probes. Patients were asked to rest for 5 min, and monitoring began after anesthesia performed by a dentist. At 1 min after anesthesia and after tooth extraction, another electrocardiogram was recorded.

#### Statistical analysis

Statistical analysis was performed with SPSS version 18.0. Qualitative data are expressed as mean  $\pm$  standard deviation, and qualitative data as rate or ratio. Means were compared with analysis of variance among groups. Data with abnormal distribution were subjected to natural logarithm transformation and then to analysis of variance. Means between 2 groups were compared with the t-test. A value of  $P < 0.05$  was considered statistically significant.

## Results

### Demographics of elderly patients with cardiovascular diseases receiving tooth extraction

#### Sex

A total of 14 832 patients participated in this survey, and, due to lack or insufficiency of data, 13 527 patients were finally

included into the present analysis. There were 5664 males (41.87%) and 7863 females (58.13%) among patients undergoing tooth extraction.

#### Age

Patients were divided into age groups according to WHO criteria: adolescence (16–44 years), middle-age (45–59 years), and elderly ( $\geq 60$ ). There were 419 patients younger than 45 years, 2922 patients aged 45–59 years, and 10 186 patients (75%) aged  $\geq 60$  attending our clinics in the past 5 years.

#### Age and sex in the elderly

Among patients undergoing tooth extraction, the elderly accounted for 75.3%. Thus, the elderly patients were recruited for further analysis. These patients were grouped according to age, with an interval of 5 years, and patients older than 85 years were grouped into a subgroup. Thus, a total of 6 subgroups were included, and the ratio of males to females was calculated in each age group. Results showed most patients were aged 75–79 years, and the number of females was significantly higher than that of males.

#### Chronic diseases in patients receiving tooth extraction

There were diverse comorbidities, including primary hypertension and coronary heart diseases. The number of elderly patients with 1 comorbidity is shown in Figure 1. Among 13 527 patients, 6000 patients (44.36%) had 1 comorbidity and 7527 patients (55.64%) had 2 or more comorbidities.

#### Influence of tooth extraction on blood pressure and heart rate in the elderly patients with primary hypertension

#### Sex

In the present study, 2937 males and 4140 females underwent tooth extraction. The highest blood pressure, blood pressure at initial diagnosis, and blood pressure and heart rate before tooth extraction, after 5-min resting, and after tooth extraction were compared between males and females. Results showed marked difference in the SBP between males and females at different time points ( $P < 0.05$ ), but there was no significant difference in the DBP ( $P > 0.05$ ) (Table 1). A dramatic difference was noted in heart rate between males and females, before tooth extraction, 1 min after anesthesia, and after tooth extraction ( $P < 0.05$ ), but the heart rate at baseline was comparable ( $P > 0.05$ ) (Table 1).

#### Different comorbidities

As shown in Table 1, blood pressure changed significantly during the tooth extraction. Thus, the blood pressure during the

**Table 1.** Blood pressure and HR of males and females at different time points ( $\bar{x}\pm s$ ).

	SBP (mmHg)		DBP (mmHg)		HR	HR	
	Male	Female	Male	Female		Male	Female
Max	168.41±16.52*	172.86±16.68*	94.25±8.30	94.66±9.97	–	–	–
First visit	151.7±22.28*	157.42±21.98*	79.49±11.94	78.93±10.70	77.06±10.43	76.58±7.90	77.33±11.29
Before dental extraction	149.34±18.43*	155.94±17.60*	78.48±10.65	77.16±10.75	80.32±9.30	79.2±13.2**	89.64±13.25**
During dental extraction	153.62±19.39*	161.52±17.85*	79.69±10.23	82.49±10.19	–	–	–
1 min after anesthesia	–	–	–	–	92.11±8.68	79.39±9.42**	95.64±14.22**
After dental extraction	149.67±19.04*	155.41±18.56*	77.78±10.9	76.03±10.13	82.32±11.89	80.07±10.43**	89.43±10.97**

\* Difference in the SBP between males and females at different time points ( $P<0.05$ ); \*\* difference was noted in the heart rate between males and females, before tooth extraction, 1 min after anesthesia and after tooth extraction ( $P<0.05$ ).

**Table 2.** Blood pressure of patients with different comorbidities during tooth extraction.

Comorbidities	SBP (mmHg)	DBP (mmHg)
HBP	160.61±12.37	82.46±9.33
CHD	162.96±13.29	79.29±13.31
Arrhythmia	156.74±15.16	90.14±9.17
Cerebrovascular diseases	159.54±18.84	80.07±8.32
DM	158.66±14.45	78.95±11.38

**Table 3.** Blood pressure at the supine position and at sitting ( $\bar{x}\pm s$ ). SBP at sitting after tooth extraction significantly reduced when compared with clinostatism (\*  $P<0.05$ ).

Position	SBP (mmHg)		DBP (mmHg)	
	Male	Female	Male	Female
Clinostatism	149.67±19.04*	155.41±18.56*	77.78±10.9	76.03±10.13
Seat	142.34±16.28*	147.63±17.66*	74.48±10.80	71.83±8.62

tooth extraction was compared among patients with different comorbidities (Table 2).

### Posture (body position)

When compared with middle-aged patients, the elderly were more likely to develop orthostatic hypotension. Blood pressure in the supine position and sitting was compared, aiming to explore the influence of body position on blood pressure. Results showed the SBP while sitting after tooth extraction was significantly reduced when compared with clinostatism ( $P<0.05$ ) (Table 3).

### Electrocardiogram monitored with Holter monitor during tooth extraction

The physicians recorded the disease conditions according to criteria, and patients were grouped according to the criteria for risk grouping. Of the 89 patients in the hypertension risk group C, who received cardiac monitoring before, during, and after tooth extraction, 32 patients received Holter monitoring. Atrial premature beats were noted in 10 patients and ventricular premature beats in 11 patients (Table 4). Cardiac monitoring results with a general monitor are shown in Table 5. The detection rate of cardiovascular events by using a Holter

**Table 4.** HR and heart rhythm monitored with Holter monitor during tooth extraction.

	Before	During	After
Increase	0	26 (81.25%)	24 (75.00%)
Decrease	0	3 (9.36%)	4 (12.50%)
Sinus tachycardia	2 (6.25%)	3 (9.36%)	3 (9.36%)
Sinus bradycardia	2 (6.25%)	1 (3.12%)	2 (6.25%)
Ventricular premature beats	3 (9.36%)	9 (28.13%)	11 (34.38%)
Atrial premature beats	1 (3.12%)	9 (28.13%)	10 (31.25%)
Atrial fibrillation	1 (3.12%)	1 (3.12%)	1 (3.12%)
I°AVB	5 (%)	5 (%)	5 (%)

**Table 5.** Change in P-QRS-T, HR and heart rhythm monitor during tooth extraction.

		Before	During	After
HR	Increase	0	73 (82.02%)	76 (85.40%)
	Decrease	0	7 (7.87%)	6 (6.74%)
Heart rhythm	Sinus tachycardia	16 (17.98%)	14 (15.73%)	15 (16.86%)
	Sinus bradycardia	1 (1.12%)	0	1 (1.12%)
	Ventricular premature beats	0	7 (7.87%)	7 (7.87%)
	Atrial premature beats	2 (2.25%)	6 (6.67%)	6 (6.67%)
Heart rhythm	Atrial fibrillation	9 (10.11%)	9 (10.11%)	9 (10.11%)
	Pacemaker rhythm	3 (3.37%)	3 (3.37%)	3 (3.37%)
	I°AVB	1 (1.12%)	1 (1.12%)	1 (1.12%)
	P wave	Rise	0	0
P wave	Broadening	0	1 (3.12%)	1 (3.12%)
	QRS amplitude	Decrease	0	0
QRS amplitude	Increase	0	3 (9.36%)	3 (9.36%)
	ST segment	Elevate	0	1 (3.12%)
ST segment	Level or tapered down under	2 (6.25%)	5 (15.63%)	5 (15.63%)
	The tapered down	1 (3.12%)	1 (3.12%)	1 (3.12%)
	T wave	Increase or high-edge	0	0
T wave	Decrease	1 (3.12%)	6 (18.75%)	6 (18.75%)
	Convert	3 (9.36%)	4 (12.5%)	4 (12.5%)

monitor was significantly higher than that by using a general monitor. The ST segment was further analyzed, and results are shown in Tables 5 and 6. The detection rate of ST segment change by using a Holter monitor was also markedly higher than that by using a general monitor.

### Discussion

Oral health problems become more important with age. According to the Third Oral Health Survey in China, the incidence

of tooth decay is 98.4% in subjects aged 65–74 years, the incidence in males is lower than that in females, and 78.9–91.7% of patients with tooth decay are not treated, consistent with our findings. With increased living standards, more attention has been paid to oral health, and the number of moderately old patients who visit the hospital is higher than that of extremely patients, but lower than that of younger elderly. Our results show that patients aged 70–79 years were the largest group of patients with systemic chronic diseases receiving tooth extraction. An epidemiological study [7] showed that 3.6% of patients aged >65 years do not receive oral care. Thus,

the U.S. Preventive Services Task Force recommends regular dental visits for patients aged  $\geq 65$  years [8].

Our results showed primary hypertension, coronary heart disease, arrhythmia, cerebrovascular accident, and DM were the 5 most common comorbidities among 13 527 patients undergoing tooth extraction, and patients with these diseases accounted for 67.53%, 52.29%, 23.73%, 15.81% and 14.42%, respectively. In addition, in the elderly the incidence of these diseases further increased. In adolescents, myocarditis and arrhythmia (ventricular or atrial premature beat) were major comorbidities, and hypertension and coronary heart disease were the major comorbidities in the elderly.

Griffin et al. [4] found that chronic diseases such as coronary heart disease and DM could increase the risk for oral diseases. Advanced age may undoubtedly increase risk for complications of tooth extraction in the presence of chronic diseases. An epidemiological study [9] showed that hypertension is well controlled in only one-third of hypertensive patients in most Latin American cities and China, only 2% of hypertensive patients have good control of blood pressure in the rural areas, and 12% and 9% of hypertensive patients showed blood pressure control in urban and rural areas, respectively, in India. Hypertensive elderly with poor blood pressure control are frequently found in the developing areas. A survey [10] conducted in 41 891 subjects (40–79 years) of 22 states and the District of Columbia in the USA showed a correlation between tooth loss and heart diseases, and that controlling risk factors of cardiovascular diseases (such as hypertension, smoking, obesity) improved oral health. A study [11] of 155 280 patients who hospitals due to tooth decay or periodontal diseases were evaluated found that the incidence of tooth loose was as high as 38.3% and was higher in DM patients than in non-DM patients, and showed that DM was an independent risk factor for tooth loss.

One concomitant chronic disease was present in 44.36% of patients ( $n=6000$ ), and 55.64% of patients ( $n=7527$ ) had 2 or more comorbidities. The prevalence of cardiovascular diseases increases with age in patients visiting dentists, and these diseases may increase the risk for tooth extraction complications, which has received increased attention in recent years [6].

In China, the prevalence of hypertension is about  $38.2 \pm 57.0\%$  in subjects aged  $>60$  years and as high as 70% in subjects aged  $>80$  years. Primatesta et al. [12] investigated 3513 patients aged  $>64$  years, and reported the prevalence of hypertension was 76.1% in the very elderly subjects. Montebugnoli et al. [13] reported that about 50% of patients felt nervous or fearful when they were at the dental clinic, and these feelings were accompanied by increased heart rate and blood pressure, which could induce cardiovascular stress, causing angina

pectoris, myocardial infarction, arrhythmia, and cardiac dysfunction. A multicenter, randomized, double-blind, controlled study showed blood pressure-lowering therapy was beneficial for elderly subjects [14]. There is evidence showing that to properly use blood pressure-lowering and antipsychotic drugs before tooth extraction was effective to prevent and reduce the incidence of complications of tooth extraction in hypertensive patients, which helps increase the safety of tooth extraction [15].

Women are susceptible to developing emotional tension and psychological stress, causing the activation of cardiac sympathetic nerves and inhibition of vagus nerves, which may reduce the heart rate variation. The pain caused by injection of anesthetic may further increase the heart rate. In the present study, a significant difference was noted in the heart rate between males and females before, during, and after tooth extraction (Table 1).

The product of HR and SBP determined at the same time is also known as the rate-pressure product (RPP). The change in RPP may reflect myocardial oxygen consumption (MOC). Research shows that the RPP in healthy subjects is about 12 000. RPP  $>12 000$  predicts high risk for myocardial ischemia, and cardiac monitoring is required during the surgery. When the RPP is  $>20 000$ , the risk for sudden heart events may increase markedly during the surgery [16].

We also investigated the blood pressure, heart rate, and their variations at different time points in males and females and in patients with different comorbidities, and the pre-operative risk evaluation was also briefly summarized. As shown in Table 2, the blood pressure and heart rate changed dramatically after tooth extraction, regardless of cardiovascular diseases in elderly patients, and this change was more evident in patients with cardiovascular diseases ( $P<0.05$ ). This suggests that tooth extraction significantly affects the elderly, especially those with cardiovascular diseases.

Tyberghein et al. [17] found that the elderly, especially the frail elderly, were susceptible to development of orthostatic hypotension (OH), and that OH usually caused severe consequences such as syncope. The incidence of OH is high in the elderly, and is influenced by various factors, and complications may cause severe consequences. In the present study, results (Table 3) showed that sitting SBP after tooth extraction declined significantly compared with that before tooth extraction ( $P<0.05$ ).

It was reported that sudden death was usually caused by ventricular fibrillation due to cardiac electrical instability and subsequent serious ventricular arrhythmia. Several studies have confirmed that T-wave alternation (TWA) is a potent predictor of ventricular tachycardia and ventricular fibrillation [18]. The risk for fatal arrhythmias and sudden death in patients with

TWA is 11 times higher than that in those without TWA. Using 12-Lead Holter monitoring, Brockmeier et al. confirmed that TWA was an important predictor of torsade de pointes ventricular tachycardia (TdP-VT) [19]. The change in TWA is usually minor and not easy to detect by general monitoring. As compared to the dominant TWA, dynamic electrocardiogram monitoring is more helpful in identifying patients with high risk for sudden death.

The cardiovascular complications of minor oral surgeries, including tooth extraction, have been emphasized in clinical practice. There is evidence that vagal reflex-induced coronary spasm may cause sudden death during tooth extraction, and it has been reported that tooth extraction may also cause acute myocardial infarction and malignant arrhythmias. These changes may be identified by general cardiac monitoring. However, the general monitor has poor sensitivity to painless myocardial ischemia during tooth extraction. Thus, 12-lead Holter monitoring

seems to be suited for the evaluation of asymptomatic myocardial ischemia. Our findings indicate that Holter monitoring is more suitable in the elderly than is general monitoring.

## Conclusions

Among the elderly patients undergoing tooth extraction, most have cardiovascular disease and other multi-organ diseases, and thus it is imperative to improve the pre-operative evaluation – it is better to evaluate the disease condition, and to reduce patient nervousness, by medication if necessary. Intra-operative cardiac monitoring is necessary to monitor heart rate, blood pressure, and oxygen saturation. For the elderly with concomitant conditions or high-risk chronic diseases, Holter monitoring is recommended, and is helpful to identify arrhythmia and painless myocardial ischemia and avoid surgical complications.

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