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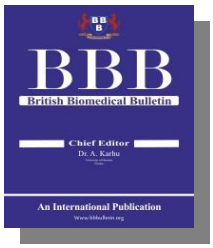


Original Article

# Hemodynamic Changes after Infiltration of Local Anesthetic into Oral Mucosa during Oral Maxillofacial Surgery

**Kenichi Satoh*, Mami Chikuda and Shigeharu Joh**

*Division of Dental Anesthesiology, Department of Reconstructive Oral and Maxillofacial Surgery, School of Dentistry, Iwate Medical University, Iwate, Japan*

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**Corresponding author:** Division of Dental Anesthesiology
Department of Reconstructive Oral and Maxillofacial Surgery School of Dentistry, Iwate Medical University
1-3-27 Chuo-dori, Morioka, Iwate 020-8505, Japan

**Tel:** 81-19-651-5111 (ext. 4331)

**E-mail address:** satoken@iwate-med.ac.jp

A B S T R A C T

**Background:** Episodes of hypotension occur in association with local anesthetic infiltration of the oral mucosa during oral maxillofacial surgery. We investigated the hemodynamic and cerebral circulation effects of local anesthetic infiltration of the oral mucosa with a combination of adrenaline and lidocaine during general anesthesia.
**Materials and Methods:** Sixteen patients (five men, 11 women; mean age, 21 ± 5 years; mean weight, 60.4 ± 6.2 kg) with an American Society of Anesthesiologists physical status of I who were scheduled to undergo sagittal split ramus osteotomy were included in the study. We measured patients' systolic arterial pressure, mean arterial pressure, diastolic arterial pressure, pulse rate, and the concentrations of cerebral oxyhemoglobin, deoxyhemoglobin, total hemoglobin, and cytochrome oxidase.
**Results:** There was a mean 36.8% decrease in systolic arterial pressure, a mean 31.4% decrease in mean arterial pressure, a mean 32.7% decrease in diastolic arterial pressure, and a mean 14.8% increase in pulse rate after infiltration of local anesthetic with adrenaline. Data were normalized to the values immediately before infiltration and expressed as a relative percentage. The average time from infiltration to minimum arterial pressure was 96.8 ± 20.6 s; the mean duration of the trough was approximately 1 min. Oxyhemoglobin decreased by 2.4 ± 1.6 nmol/L, deoxyhemoglobin increased by 0.6 ± 1.3 nmol/L, total hemoglobin decreased by 1.6 ± 0.5 nmol/L, and cytochrome oxidase increased by 0.4 ± 0.3 nmol/L after infiltration (mean ± standard deviation).
**Conclusions:** Infiltration of the oral mucosa with lidocaine solutions containing adrenaline causes temporary but severe hypotension, which affects cerebral blood circulation.

## Introduction

Lidocaine containing adrenaline is widely used during dental treatments and in oral and maxillofacial surgery. Administering a vasoconstrictor concomitantly with local anesthetics decreases blood loss and improves visualization; it also slows the rate of absorption, reduces toxicity, and prolongs the duration of local anesthetics[1–3]. However, adrenaline has several side effects, including hypertension, hypotension, tachycardia, bradycardia, and arrhythmias. Infiltration of the scalp before craniotomy[3–5], of the nasal mucosa for functional endoscopic sinus surgery[6,7], and of the oral mucosa for oral and maxillofacial surgery and dental treatment induces marked hemodynamic changes[8], including decreased blood pressure during general anesthesia[1,2,9]. In a previous study we reported the occurrence of hypotensive episodes in association with infiltration of local anesthetic into the oral mucosa during sagittal split ramus osteotomy[10]. Our aim in the current study was to investigate whether this hypotension affected cerebral perfusion.

## Materials and Methods

This observational study was approved by the Committee on Clinical Investigation for Human Research at Iwate Medical University.

Sixteen patients (five men, 11 women; mean age, 21 years; mean weight, 60.4 kg) with an American Society of Anesthesiologists physical status of I who were scheduled for sagittal split ramus osteotomy were included in the present study (Table 1). All patients received intravenous administration of atropine (0.05 mg/kg) and midazolam (0.5 mg/kg) 30 min before transfer to the operating room. Anesthesia was induced with a mixture of either thiopental (5 mg/kg) or propofol (2 mg/kg) with fentanyl and vecuronium bromide (0.1 mg/kg), and was maintained with sevoflurane (1.0–1.5%) in oxygen (40%). Fentanyl and remifentanil were administered after endotracheal intubation. A catheter was inserted into a dorsal artery of the foot after anesthetic induction. Arterial cannulation was performed to monitor arterial blood pressure (ABP). The patient's hemodynamics and respiration were confirmed to be stable. The surgeon infiltrated the oral mucosa around the right or left ramus with 1% lidocaine (1.5 ± 0.4 mg/kg) combined with 1/100,000 adrenaline (1.5 ± 0.4 μg/kg). Local infiltration was performed at three or four points along the oral mucosa incision, and the infiltration time was controlled at 30 to 40 seconds with the same needle gauge.

We measured systolic arterial pressure (SAP), diastolic arterial pressure (DAP), mean arterial pressure (MAP), pulse rate (PR), and blood oxygen saturation ($SpO_2$) with a Life Scope 8® (Nihon Kohden, Tokyo, Japan).

We monitored changes in oxyhemoglobin (oxy-Hb), deoxyhemoglobin (deoxy-Hb), total hemoglobin (total-Hb), and cytochrome oxidase (cyt) with a near infrared oxygenation monitor (NIRO 500; Hamamatsu Photonics, Hamamatsu, Japan). The NIRS sensors were placed on opposite sides of the forehead before surgery. The NIRO measured changes in parameters from baseline, which was set at zero at the start of measurement.

All parameters were continuously recorded with a PowerLab 4/25T data acquisition system (ADInstruments, Bella Vista, Australia). The value for each parameter immediately before infiltration (control) was compared with the value when ABP reached its minimum value and at 30 s, and 1, 2, 3, 4, 5, and 10 min after minimum ABP.

Values are presented as mean ± standard deviation. "Intragroup comparisons

were made with one-way analysis of variance for repeated measurements followed by Dunnett's test for multiple comparisons. Differences were considered statistically significant at $P < 0.05$."

## Results

The changes in each parameter were recorded with the Powerlab data system. When local anesthetic was infiltrated into the oral mucosa, ABP decreased rapidly; the duration of the trough was approximately 1 min (Figure 1). There were significant differences between the values of SAP, DAP, MAP, and PR before infiltration versus those when ABP reached its minimum and 30 s after reaching the minimum. At minimum ABP, SAP decreased by 36.8% (mean, 39.8 mmHg), MAP decreased by 31.4% (mean, 22.1 mmHg), DAP decreased by 32.7% (mean, 18.5 mmHg), and PR increased by 16.2% (mean, 9.2 bpm). Data were normalized to the values before infiltration and expressed as a relative percentage (Figure 2). The average time from local anesthetic infiltration to minimum ABP was 96.8 ± 20.6 s and the mean duration of the trough was approximately 1 min (Figure 3), suggesting that there was a lag time of approximately 97 s for changes in hemodynamics after infiltration of local anesthetic into the oral submucosa.

The changes in the intracerebral oxygen environment are shown in Figure 4. There were significant differences in oxy-Hb before infiltration (control) compared with 30 s after minimum ABP. Oxy-Hb decreased by 2.4 ± 1.6 nmol/L 30 s after minimum ABP, then gradually rose to 0.6 ± 1.71 nmol/L higher than baseline 10 min after minimum ABP. There were no significant changes in deoxy-Hb. There was a 0.7 ± 0.4 nmol/L increase in deoxy-Hb 5 min after minimum ABP, followed by a decrease to 0.1 ± 0.8 nmol/L below baseline 10 min after minimum ABP. There were significant differences in total-Hb before infiltration versus 30 s after minimum ABP. There was a 1.6 ± 0.5 nmol/L decrease in total-Hb 30 s after minimum ABP, followed by an increase to 0.5 ± 0.8 nmol/L above baseline 10 min after minimum ABP. There were no significant changes in cyt. There was a 0.4 ± 0.3 nmol/L increase in cyt 30 s after minimum ABP and a 0.1 ± 0.6 nmol/L increase above baseline 10 min after minimum ABP.

## Discussion

Blood pressure changes, such as severe hypertension or hypotension, affect brain oxygen metabolism and blood circulation[11, 12]. Near-infrared spectroscopy (NIRS) has been proposed as a non-invasive method of assessing intracerebral oxygenation[13 ,14]. This method measures the concentrations of cerebral oxyhemoglobin (oxy-Hb), deoxyhemoglobin (deoxy-Hb), total hemoglobin (total-Hb), and cytochrome oxidase (cyt). In this study, we investigated the effects of adrenaline-induced severe hypotension on brain oxygen metabolism and blood circulation by measuring changes in oxy-Hb, deoxy-Hb, total-Hb, and cyt after infiltration of local anesthetic into the oral submucosa.

Our findings revealed two important clinical issues. Local infiltration of the oral submucosas with lidocaine containing adrenaline causes temporary but severe hypotension. Severe hypotension affects the intracerebral oxygen environment.

Local infiltration of the oral submucosa with lidocaine containing adrenaline causes temporary but severe hypotension. Studies have found that infiltration of lidocaine containing adrenaline into the scalp before craniotomy, into the nasal mucosa for functional endoscopic sinus surgery, and into the oral mucosa for oral and maxillofacial surgery

and dental treatments induces marked hemodynamic changes, including decreased blood pressure during general anesthesia[1-3, 10]. In our previous study we found a 30% decrease in SAP (mean, 33.7 mmHg), a 29% decrease in MAP (mean, 20.9 mmHg), a 33% decrease in DAP (mean, 18.7 mmHg), and a 13% increase in PR (mean, 9.1 bpm) after local infiltration[10]. The average time from infiltration of local anesthetic to minimum ABP in that study was 88 ± 46 s and the mean duration of the trough was approximately 1 min. Another study found that during craniotomy MAP temporarily decreased by more than 30% after infiltration, with the average time from initiation of local infiltration to the lowest MAP being 102 s. In that study, changes in blood pressure and PR were relatively stable 5 min after administration of 1% lidocaine with 40, 80, or 160 μg of adrenaline. Neither MAP nor PR changed significantly when 1% lidocaine without adrenaline was administered; the average increase in PR was approximately 10 bpm after the initiation of local infiltration.[4] In the present study, the average dose of adrenaline was 1.5 μg/kg (approximately 90.6 μg), the average time to minimum MAP was almost 97 s, the average duration of the trough was approximately 1 min, and the average increase in PR was approximately 9.2 bpm. The decrease in SAP, MAP, and DAP, the increase in PR, and the average time to the lowest MAP in the present study were similar to findings in other studies. This similarity indicates that plasma adrenaline concentrations resulting from infiltration of the oral submucosa are the same as those resulting from infiltration of the scalp.

Severe hypotension affects the intracerebral oxygen environment. Blood pressure changes, such as severe hypertension or hypotension, affect brain oxygen metabolism and blood circulation[11, 12]. We evaluated changes in the intracerebral oxygen environment by using NIRS to measure oxy-Hb, deoxy-Hb, total-Hb, and cyt. We found a mean decrease in oxy-Hb, a mean increase in deoxy-Hb, a mean decrease in total-Hb, and a mean increase in cyt, suggesting cerebral ischemia. Oxy-Hb decreases as result of decreased arterial blood flow to the brain, deoxy-Hb increases as a result of the increased oxygen extraction fraction, and total-Hb decreases as a result of decreased cerebral blood volume[13, 14]. We conclude that infiltration of lidocaine containing adrenaline into the oral mucosa during maxillofacial surgery causes temporary hypotension, which may increase the risk of or exacerbate cerebral ischemia. The effects of the observed changes in oxy-Hb detected by NIRS during general anesthesia deserve comment. NIRS currently measures changes in oxy-Hb and total-Hb from an arbitrary baseline, and it is therefore not possible to calculate saturation changes directly. "NIRS evaluates samples from arterial, venous, and capillary compartments, but the relative contribution of each to the signal has not been defined. It is therefore not possible to determine whether the observed changes in saturation and blood volume occurred equally in all three compartments"[12]. The changes in intracerebral oxygen environment returned to normal within 10 min after temporary but severe hypotension induced by local anesthetic.

In the present study, the sample size was small (n = 16) and may be insufficient to determine statistical significance. However, we believe that the data provide accurate and reliable information on the hemodynamic changes induced by infiltration of lidocaine containing adrenaline into the oral submucosa, and that this information is clinically useful in the management of anesthesia.

## Conclusion

Local infiltration of lidocaine containing adrenaline into the oral submucosa causes temporary but severe hypotension, which affects the intracerebral oxygen environment. Such hypotension may also increase the risk of or exacerbate cerebral ischemia. It is prudent to consider the possibility of marked hemodynamic changes when infiltrating the oral submucosa with lidocaine containing adrenaline.

## Acknowledgements

None

## Competing Interests

The authors declare that they have no competing interests.

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**Table 1:** Demographic data (mean ± SD)

| Number of patients (Case; both right and left side, n) | 16 (32) |
|---|---|
| **Age (yrs)** | 21±5 |
| **Weight (kg)** | 60.4±6.2 |
| **Dose of lidpcaine (mg/kg)** | 1.5±0.4 |
| **Dose of adrenaline (ug/kg)** | 1.5±0.4 |
| **Type of surgery** | Sagital splitting ramus osteotomy |

**Table 2:** Changes in arterial blood pressure, pulse rate, $SpO_2$ and intracerebral oxygen environment

**(a)** Changes in arterial blood pressure, pulse rate, and $SpO_2$

| Time | Systolic arterial pressure (mmHg) | Mean arterial pressure (mmHg) | Diastolic arterial pressure (mmHg) | Pulse rate (bpm) | $SpO_2$ (%) |
|---|---|---|---|---|---|
| **Before injection** | 108.0±13.2 | 70.3±10.3 | 56.5±9.7 | 56.6±7.3 | 99.8±0.1 |
| **Reaching minimum value of blood pressure** | 68.2±15.8* | 48.2±8.4* | 38.0±6.3* | 64.7±10.0* | 99.1±0.6 |
| **30 seconds after reaching minimum** | 86.5±14.3* | 58.6±9.2* | 46.1±7.5* | 65.8±7.7* | 98.5±1.2 |
| **1 min after reaching minimum** | 105.8±16.3 | 65.1±11.1 | 51.1±8.0 | 60.4±6.2 | 99.8±0.1 |
| **2 min after reaching minimum** | 108.0±17.9 | 68.9±12.8 | 49.6±9.5 | 60.7±6.7 | 99.8±0.1 |
| **3 min after reaching minimum** | 107.2±20.4 | 70.1±9.7 | 49.1±8.8 | 61.5±3.3 | 99.8±0.2 |
| **4 min after reaching minimum** | 105.3±15.3 | 71.3±8.8 | 47.6±7.0 | 61.2±4.5 | 99.8±0.2 |
| **5 min after reaching minimum** | 104.6±15.3 | 69.8±10.3 | 47.4±7.1 | 60.7±4.5 | 99.8±0.1 |
| **10 min after reaching minimum** | 96.2±15.4 | 66.3±8.8 | 44.4±7.4 | 60.7±6.8 | 99.8±0.1 |

*$P < 0.05$ vs before injection

**(b)** Changes in intracerebral oxygen environment

| Time | Δ oxy-hemoglobine (nmol/L) | Δ deoxy-hemoglobine (nmol/L) | Δ total-hemoglobine (nmol/L) | Δ cytochrome oxidase (nmol/L) |
|---|---|---|---|---|
| **Before injection** | 0.0 | 0.0 | 0.0 | 0.0 |
| **Reaching minimum value of blood pressure** | -2.2±1.3 | 0.1±0.4 | -1.3±0.9* | 0.1±0.4 |
| **30 seconds after reaching minimum** | -2.4±1.6* | 0.1±0.1 | -1.6±0.5* | 0.4±0.3 |
| **1 min after reaching minimum** | -1.1±0.9 | 0.2±0.9 | -0.8±0.5 | -0.1±0.1 |
| **2 min after reaching minimum** | -1.5±1.9 | 0.2±0.9 | -1.0±0.5 | -0.2±0.5 |
| **3 min after reaching minimum** | -1.6±1.9 | 0.5±0.9 | -0.9±1.0 | -0.2±0.6 |
| **4 min after reaching minimum** | -0.6±1.5 | 0.6±1.3 | -0.2±0.8 | -0.2±0.6 |
| **5 min after reaching minimum** | -0.4±1.8 | 0.6±1.3 | -0.1±1.1 | 0.1±0.6 |
| **10 min after reaching minimum** | 0.6±1.7 | 0.1±0.8 | 0.5±0.8 | 0.1±0.6 |

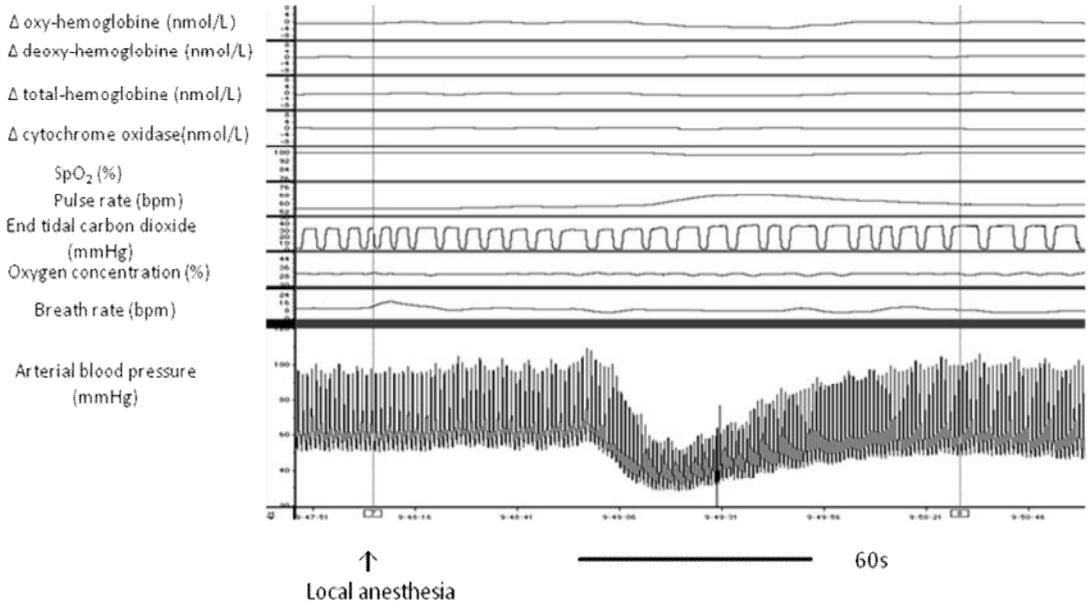


**Figure 1:** Change in various parameters during hypotension occurred

Arterial blood pressure changes seen approximately 75 seconds after infiltration. When arterial blood pressure decreases to its minimum, the pulse rate increases and oxyhemoglobin and total hemoglobin decrease. Deoxyhemoglobin and cytochrome oxidase are unchanged.

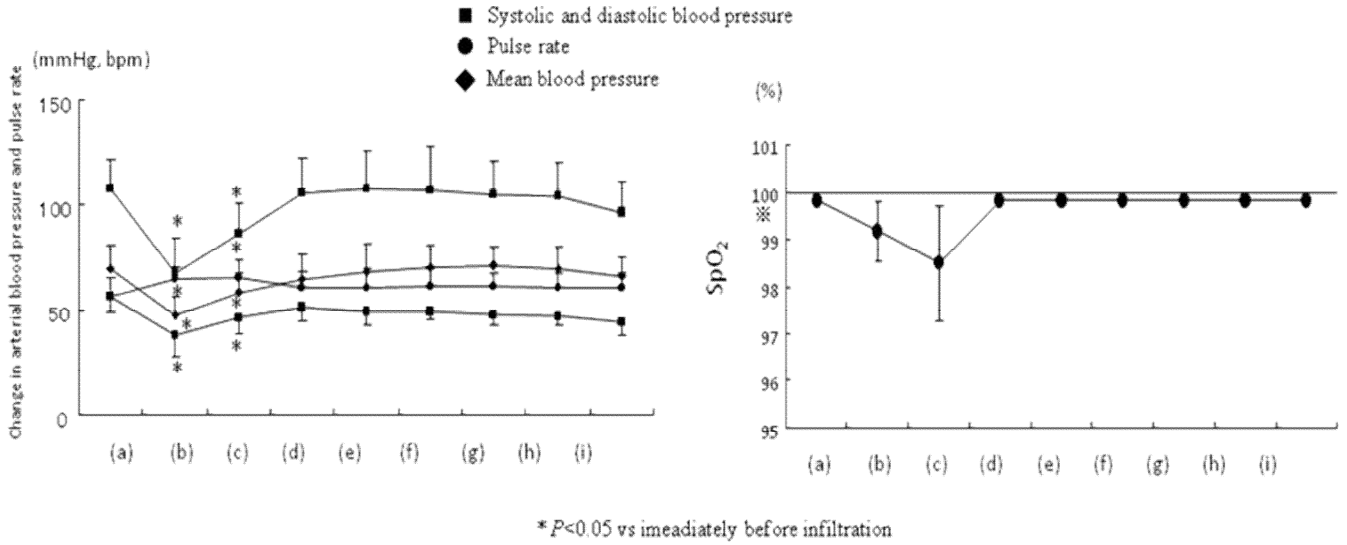


**Figure 2:** Change in arterial blood pressure, pulse rate and $SpO_2$

Values (a) before infiltration, (b) at minimum arterial blood pressure (ABP), (c) 30 s after minimum ABP, (d) 1 min after minimum ABP, (e) 2 min after minimum ABP, (f) 3 min after minimum ABP, (g) 4 min after minimum ABP, (h) 5 min after minimum ABP, and (i) 10 min after minimum ABP. When systolic, diastolic, and mean blood pressure decreases to minimum, pulse rate increases. There are significant differences in these parameters before infiltration compared with 30 seconds after minimum ABP.

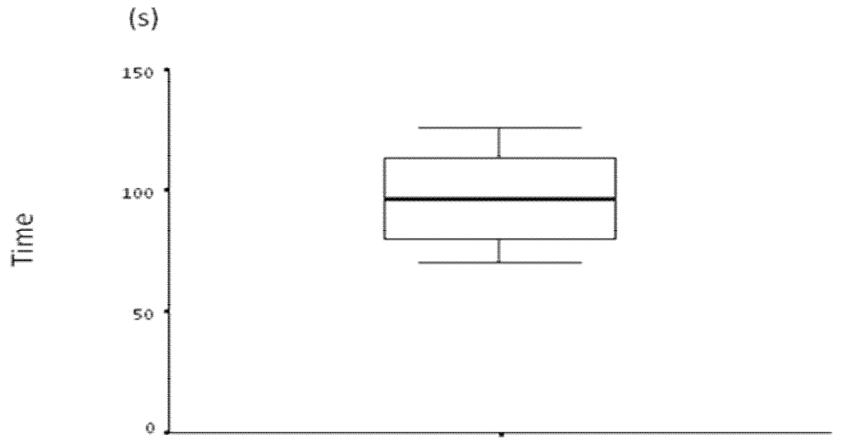


**Figure 3:** Average time from infiltration to the minimum arterial blood pressure

Median time is indicated with a horizontal bar. The vertical bars indicate the range, and the horizontal boundaries of the boxes represent the first and third quartiles. The average time from infiltration to minimum arterial blood pressure is 96.8 ± 20.6 s.

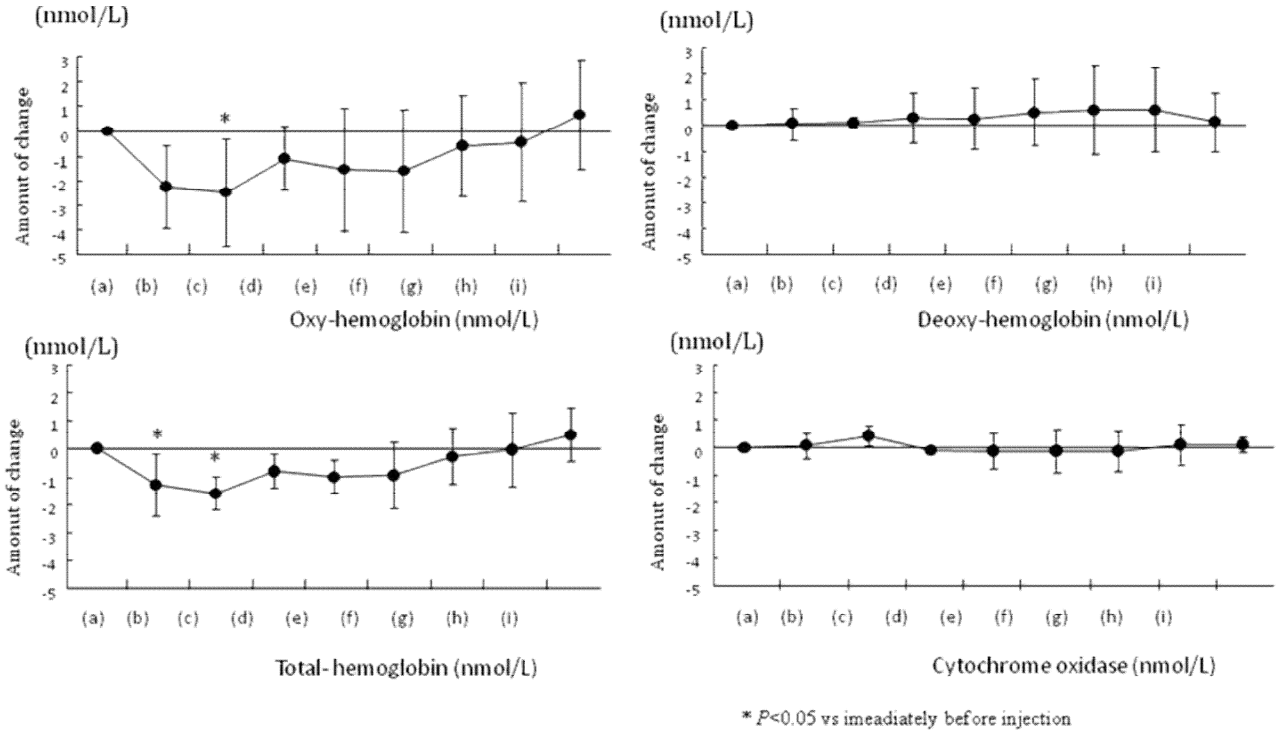


**Figure 4:** Average time from infiltration to the minimum arterial blood pressure

Values (a) before infiltration, (b) at minimum arterial blood pressure, (c) 30 s after minimum arterial blood pressure, (d) 1 min after minimum arterial blood pressure, (e) 2 min after minimum arterial blood pressure, (f) 3 min after minimum arterial blood pressure, (g) 4 min after minimum arterial blood pressure, (h) 5 min after minimum arterial blood pressure, and (i) 10 min after minimum arterial blood pressure. There is a significant difference between oxyhemoglobin before infiltration (control) and at 30 seconds after minimum arterial blood pressure. There are significant differences in total hemoglobin before injection, and at minimum arterial blood pressure and 30 seconds after minimum arterial blood pressure. There are no significant differences among times in deoxyhemoglobin or cytochrome oxidase.