原 著

Chnages in Cerebral Oxygenation State and Blood Volume During Tracheal Intubation: Comparison Between Thiamylal and Propofol

Yuji Morimoto*, Osamu Kemmotsu*, Kenjiro Hisano*, Yu Hua*
Sijian Tang*, Yoshiko Morimoto*

Abstract

Tracheal intubation may affect the cerebral oxygenation state and the cerebral blood volume because cerebral blood flow has been reported to increase during this procedure. In this study, we evaluated these changes by using near-infrared spectroscopy during tracheal intubation after induction of anesthesia by propofol and thiamylal. We studied 30 females (ASA 1 or 2) undergoing elective obstetric laparoscopy. The patients were randomly allocated into thiamylal (5 $mg.kg^{-1}$) and propofol (2.5 $mg.kg^{-1}$) induction groups (n = 15 each). Changes in brain tissue concentrations of oxy- and deoxygenated hemoglobin were measured. We also evaluated changes in the sum of the concentrations of oxy- and deoxygenated hemoglobin, which reflects the changes in cerebral blood volume. Systemic hemodynamics was also monitored. During tracheal intubation, the concentrations of oxygenated hemoglobin was increased by more than 3 $\mu mol.L^{-1}$ in both groups. This increase was significantly higher compared to the preanesthetic values. Changes in the sum of the concentrations of oxy- and deoxygenated hemoglobin were insignificant and small (presumably within 3 % of the whole cerebral hemoglobin concentration) during the procedure. Although an increase in blood pressure and heart rate was better suppressed in the propofol group, changes in the cerebral oxygenation state were similar between the groups. During the tracheal intubation, cerebral oxygenation increased presumably due to an increase in cerebral blood flow. However, the changes in cerebral blood volume by the procedure were small and the effect of thiamylal and propofol on the changes were similar.

Key Words : Cerebral oxygenation, Cerebral blood volume, Near infrared spectroscopy, Tracheal intubation, Propofol, Barbiturates: thiamylal

Introduction

Both barbiturates and propofol decrease the cerebral metabolic rate[1]. The cerebral blood flow is proportionately decreased as the result of the change in the cerebral metabolic rate. During tracheal intubation, however, the cerebral blood flow was reported to be increased even when anesthesia was induced by barbiturates[2,3]. The cerebral blood flow was also reported to be increased during tracheal intubation after administration of propofol[4]. These findings suggest that the cerebral oxygenation state and cerebral blood volume change during this procedure. As far as we know, however, there have been no reports that evaluated the cerebral oxygenation state and cerebral blood volume during tracheal intubation.

Recently, it has been reported that near-infrared

*Department of Anesthesiology and Critical Care Medicine, Hokkaido University Graduate School of Medicine, Sapporo, Japan

spectroscopy is capable of detecting the small changes in the cerebral oxygenation state associated with the induction of propofol or thiopental[5]. Moreover, changes in the brain tissue concentrations of total hemoglobin reflect changes in cerebral blood volume if the hematocrit remains constant[6]. Accordingly, we evaluated the changes in the cerebral oxygenation state and the cerebral blood volume by using near-infrared spectroscopy during induction of anesthesia by propofol and thiamylal followed by tracheal intubation.

We hypothesized that the cerebral oxygenation and then cerebral blood volume increased due to increases in cerebral blood flow during tracheal intubation. We also hypothesized that the effects of propofol and thiamylal were different because many previous studies consistently found that propofol showed better suppression of the systemic hemodynamic changes during tracheal intubation[7-10].

Patients and Methods

We studied 30 females (ASA 1 or 2) undergoing elective obstetric laparoscopy for sterility after obtaining institutional approval and written informed consent. Patients with central nervous system, cardiovascular, or respiratory diseases were excluded. No premedication was used. All the patients underwent the traditional preoxygenation procedure consisting of 3 min of tidal volume breathing using an oxygen flow of 5 $l.min^{-1}$ via a face mask[11]. Then the patients were randomly allocated into thiamylal and propofol groups (n = 15 each). In the former group, anesthesia was induced with fentanyl 2 $\mu g.kg^{-1}$ and thiamylal 5 $mg.kg^{-1}$ for 30 s and followed 30 s later by vecuronium 0.15 $mg.kg^{-1}$. In the latter group, anesthesia was induced with fentanyl 2 $\mu g.kg^{-1}$ and propofol 2.5 $mg.kg^{-1}$ for 30 s, followed 30 s later by vecuronium 0.15 $mg.kg^{-1}$. When the spontaneous breathing weakened, ventilation was assisted to keep end-tidal CO_2 ($ETCO_2$) at 35±3 mmHg under subsequent oxygen flow of 5 $L.min^{-1}$ via the face mask. Two min after the injection of vecuronium, the trachea was intubated by one staff anesthesiologist who was blinded to the medications. After intubation, anesthesia was maintained with 1 % sevoflurane under the remaining oxygen. At the same time, the mechanical ventilation started at a tidal volume of $10mL.kg^{-1}$ 10 times per min. The tidal volume was adjusted to keep $ETCO_2$ at 35 ± 3 mmHg. No IV fluids were administered after t he induction of anesthesia until the end of the study.

We used a NIRO 500 spectrometer (Hamamatsu Photonics, Hamamatsu, Japan) for near infrared spectroscopy. The optodes were secured high on one side of the forehead 4-5 cm apart and shielded from ambient light. A sampling interval of 5 seconds was used. Changes in brain tissue concentrations of oxy- and deoxygenated hemoglobin ($[HbO_2]$ and [Hb]) were calculated assuming an adult differential pathlength factor of 6.26[12]. The values were transferred and recorded on a Macintosh computer. Blood pressure was monitored noninvasively at every 1 min. The heart rate, end-tidal CO_2 ($ETCO_2$), end-tidal sevoflurane concentration (ETsevo) and peripheral arterial oxygen saturation (SpO_2) were also monitored. Baseline values of variables were obtained at the induction of anesthesia. At the same time, we set $[HbO_2]$ and [Hb] values at 0 μ $mol.L^{-1}$ and changes in $[HbO_2]$ and [Hb] were monitored thereafter. Intubation conditions were assessed by the scoring system of Helbo-Hansen, Ravlo and Trap-Andersen[13] (Table 1). They were judged acceptable when an individual category score was 1 or 2.

Statistics

The values were expressed as mean ± standard deviation (mean (SD)). Patients' age and body weight were compared by using the unpaired t-test. We extracted HR, mean BP, SpO_2, $ETCO_2$, $[HbO_2]$ and [Hb] values at 0 (= start of anesthetic induction), 3 (= end of anesthetic induction), 4, 6 and 8 min (= 1,3 and 5 min after tracheal intubation) after the induction of anesthesia. We compared these changes within each group by one-way ANOVA and the Newman-Keuls test was utilized when significant results showed in one-way ANOVA. We compared these changes between the groups by repeated-measures ANOVA. We extracted ETsevo values at 6 and 8 min after induction

Table 1 Backgrounds of the patients

	Thiamylal	Propofol
Number	15	15
Age (yr) (mean(SD))	32 (5)	31 (5)
Body weight (kg) (mean(SD))	55 (9)	52 (5)
Intubation conditions (scores)		
Laryngoscopy		
Easy (1)	13	11
Fair (2)	2	4
Difficult (3)	0	0
Impossible (4)	0	0
Vocal cords		
Open (1)	15	15
Moving (2)	0	0
Closing (3)	0	0
Closed (4)	0	0
Cough response		
None (1)	12	15
Slight (2)	3	0
Moderate (3)	0	0
Severe (4)	0	0

of anesthesia (2 and 4 min after tracheal intubation) and compared the values at each time between the groups by using the unpaired t-test. StatView 5.0 was used for analysis. $P < 0.05$ was considered statistically significant.

Results

There was no significant difference in patients' age and body weight between the groups (Table 1). Intubation conditions in every category were acceptable for all the patients (Table 1). There was a significant difference in changes in mean BP between the groups (Fig. 1). In the thiamylal group, mean BP was significantly increased by the intubation compared to the baseline value, whereas mean BP significantly decreased after administration of propofol and was not increased significantly by the tracheal intubation. There was also a significant difference in changes in HR between the groups (Fig. 1). In the thiamylal group, HR was significantly increased by the intubation compared to the baseline values, whereas no significant change was observed in the propofol group. Accordingly, hemodynamic changes were better suppressed in the propofol group as was reported previously[7-10].

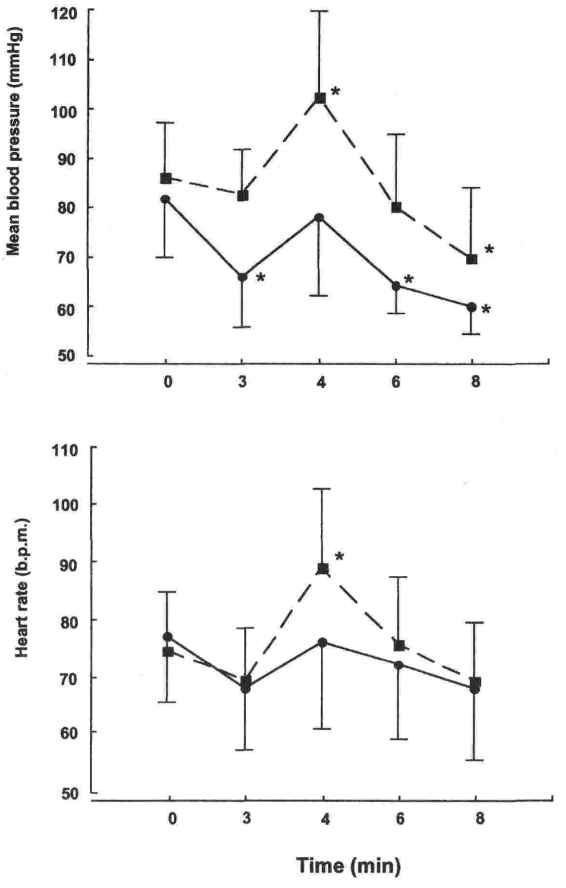

Fig. 1 Time courses of mean blood pressure and heart rate.

Squares with dashed line = thiamylal group
Circles and solid line = propofol group
Time
0 min = start of anesthetic induction (baseline value), 3 min = end of anesthetic induction, 4, 6 and 8 min = 1,3 and 5 min after tracheal intubation, respectively
There were significant differences between the groups by repeated measures ANOVA ($p < 0.01$ in both mean blood pressure and heart rate).
In the thiamylal group, there were significant differences in the changes in mean blood pressure ($p < 0.01$) and heart rate ($p < 0.01$) by one-way ANOVA.
In the propofol group, there was a significant difference in the changes in mean blood pressure ($p < 0.01$); however the change in heart rate was not significant ($p = 0.15$) by one-way ANOVA.
* indicates significance against baseline value (time = 0) by the Newman-Keuls test ($p < 0.05$).

Table 2 Time courses of SpO_2 and $ETCO_2$ (mean (SD))

	Thiamylal	Propofol
SpO_2 (%)		
0 min	100 (0.3)	100 (0.3)
3 min	100 (0.0)	100 (0.4)
4 min	100 (0.3)	100 (0.4)
6 min	100 (0.3)	100 (0.4)
8 min	100 (0.3)	100 (0.3)
$ETCO_2$ (mmHg)		
0 min	35 (1.2)	35 (1.5)
3 min	35 (3.0)	35 (3.4)
4 min	36 (2.0)	36 (2.3)
6 min	36 (2.3)	35 (2.2)
8 min	35 (2.6)	34 (1.5)

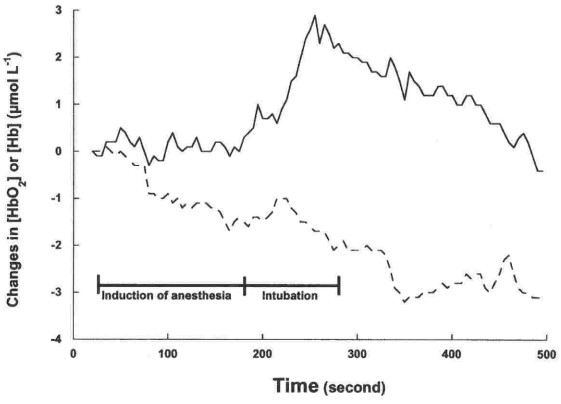

Fig. 2 A representative example of changes in the cerebral oxygenation state during induction of anesthesia followed by tracheal intubation
Continuous line = changes in [HbO_2]
dashed line = changes in [Hb]
Propofol was used for induction.

SpO_2 values were over 99% at every point in each group (Table 2). There were no significant differences in the changes in SpO_2 values between the groups ($p = 0.77$ by repeated measures ANOVA) or among those in each group ($p = 0.91$ and 0.89 in thiamylal and propofol groups by one-way ANOVA). There were no significant difference in changes in $ETCO_2$ values between the groups ($p = 0.95$ by repeated measures ANOVA) and among those in each group ($p = 0.47$ and 0.27 in thiamylal and propofol groups by one-way ANOVA). (Table 2). These findings suggested that the respiratory effect on cerebral circulation could be excluded in this study. ETsevo values were 0.7 (0.10) and 0.7 (0.06) % in thiamylal and propofol groups, respectively at 6 min after induction of anesthesia ($p= 0.79$ by the unpaired t-test). They were 0.8 (0.09) and 0.8 (0.07) % in thiamylal and propofol groups, respectively at 8 min ($p= 0.25$ by the unpaired t-test). These results excluded any difference of the effect of sevoflurane on cerebral circulation and metabolism between the groups.

Fig. 2 shows a representative example of changes in the cerebral oxygenation state during induction of anesthesia followed by tracheal intubation. [HbO_2] was significantly increased by the intubation (at 4 min) compared to 0 min in both groups (Fig. 3) However, there were no significant differences between the groups for the change in [HbO_2]. [Hb] decreased at later than 3 min after induction of anesthesia in both groups, and there was no significant difference between the groups (Fig. 3). Changes in total cerebral hemoglobin ([tHb]), which is the sum of [HbO_2] and [Hb], were not significantly different between the groups (Fig. 3). Although there were significant differences in the overall changes by one-way ANOVA in either group, no significant changes in [tHb] were observed compared to the preanesthetic value (0 min) by Newman-Keuls test.

Discussion

During anesthesia, cerebral hemodynamic changes may occur due to several events such as anesthetic induction, tracheal intubation, extubation, and cardiopulmonary bypass. These changes may cause changes in the cerebral oxygenation state and cerebral blood volume. For example, we reported that during tracheal extubation, [HbO_2] increased significantly, presumably due to an increase in CBF[14]. Inhaled anesthetics by themselves increase cerebral blood volume[15,16]. However, as far as we know, there have been no reports regarding the changes in the cerebral oxygenation state and the cerebral blood volume during tracheal intubation, although this procedure was reported to increase cerebral blood flow[2-4].

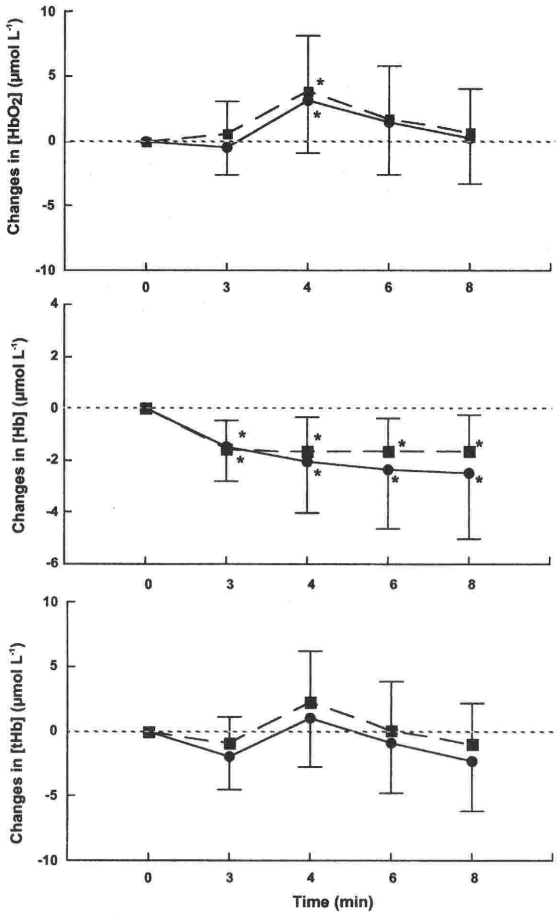

Fig. 3 Time courses of the cerebral oxygenation state
Squares with dashed line = thiamylal group
Circles and solid line = propofol group
Time
0 min = start of anesthetic induction (baseline value), 3 min = end of anesthetic induction, 4, 6 and 8 min = 1,3 and 5 min after tracheal intubation, respectively
There were no significant differences between the groups by repeated measures ANOVA ($p = 0.86$ in $[HbO_2]$, 0.16 in [Hb] and 0.74 in [tHb]).
In the thiamylal group, there were significant differences in the changes in $[HbO_2]$ ($p = 0.01$), [Hb] ($p < 0.01$) and [tHb]) ($p = 0.03$) by one-way ANOVA.
In the propofol group, there were significant differences in the changes in $[HbO_2]$ ($p = 0.02$), [Hb] ($p < 0.01$) and [tHb]) ($p = 0.03$) by one-way ANOVA.
* indicates significance against baseline value (time = 0) by the Newman-Keuls test ($p < 0.05$).

With the induction of anesthesia, [Hb] significantly decreased in both groups, whereas no significant changes in $[HbO_2]$ were observed. These findings indicated that cerebral oxygenation was relatively increased by the administration of thiamylal and propofol. This result was consistent with the report by Lovell, et al[5]. In their study, however, $[HbO_2]$ increased significantly, while [Hb] did not change during the administration of thiopental and propofol[5]. The use of nitrous oxygen (N_2O) during induction may cause the different changes in each variable. In Lovell's study, 75 % N_2O was inhaled during induction[5]. N_2O has been reported to increase cerebral blood flow[1]. The cerebral metabolic rate was reported to be increased in parallel with cerebral blood flow[17]. In Lovell's study, accordingly, the decrease in the cerebral metabolic rate and cerebral blood flow caused by thiopental or propofol might have been partially inhibited by N_2O[5].

By the tracheal intubation cerebral oxygenation increased more because $[HbO_2]$ was increased whereas [Hb] remained low. The findings presumably reflected the increase in cerebral blood flow caused by the tracheal intubation. The mechanism of the increase in cerebral blood flow during this procedure has not been clarified[3]. The changes in systemic hemodynamics or respiratory conditions may not be the cause because the range of blood pressure was within that of autoregulation and because SpO_2 and $ETCO_2$ values were within normal ranges. Cerebral blood flow increases in response to noxious stimuli of the trachea in tracheally intubated subjects due to a stimulated increase in muscle afferent activity[18]. We reported that during tracheal extubation the increase in cerebral blood flow might be related to a stimulated increase in the muscle afferent activity[14]. However, the patients were well paralyzed during the tracheal intubation in our study. Accordingly, we suppose that the stimulated increase in the muscle afferent activity did not contribute to the increase in cerebral blood flow during tracheal intubation.

Changes in [tHb] reflect change in cerebral blood

volume, if the hematocrit remains constant[6]. It is unlikely that the hematocrit would be altered during the short period of this study. Accordingly, the change in [tHb] can represent the change in cerebral blood volume in this study. [tHb] and hence cerebral blood volume did not change significantly compared to the preanesthetic value, because [Hb] remained negative during tracheal intubation. The total cerebral hemoglobin concentration was estimated to be 84 μ mol/L[19]. The changes in the absolute values of [tHb] were within 2.5 μ mol/L during tracheal intubation. Therefore, it is speculated that the percent changes in cerebral blood volume ([tHb] divided by the estimated total cerebral hemoglobin concentration) were within 3 % during the procedure. Inhaled anesthetics at about 1MAC increase cerebral blood volume by around 10 % after 30 minutes inhalation in dogs[15,16]. For conditions of hypocapnia ($PaCO_2$ = 26 mmHg), hypercapnia ($PaCO_2$ = 48 mmHg) and hypoxemia (PaO_2 = 38 mmHg), the changes in cerebral blood volume were reported to be -7.2 12.8, and 5.2 %, respectively, in healthy volunteers. Compared with these studies, the estimated changes in cerebral blood volume during tracheal intubation seemed small.

There have been many studies comparing systemic hemodyanamic changes such as blood pressure and heart rate during tracheal intubation between barbiturates and propofol[7-10]. They consistently found that propofol showed better suppression of the hemodynamic changes due to tracheal intubation[7-10]. In this study, however, the effects on the changes in the cerebral oxygenation state and cerebral blood volume were similar for thiamylal and propofol, although systemic hemodynamic changes were also better suppressed with propofol. This is presumably because the range of blood pressure was within that of autoregulation in both groups and also because their effects on the cerebral metabolic rate and blood flow were similar[1].

In conclusion, cerebral oxygenation increased during tracheal intubation, presumably because cerebral blood flow increased. However, the changes in cerebral blood volume estimated by [tHb] were small and insignificant. The effects of propofol and thiamylal on the cerebral oxygenation state and cerebral blood volume were similar. Accordingly, the methods we used for anesthetic induction and tracheal intubation in this study seem not to be detrimental with regard to the cerebral oxygenation state and cerebral blood volume in patients without cerebral disorders.

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