Effects of Intravenous or Endotracheal Lidocaine on Circulatory Changes during Recovery from General Anesthesia

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Intravenous lidocaine (1.5 $mg \cdot kg^{-1}$) was not effective in attenuating the circulatory changes and the cough reflex induced by airway stimulation during recovery from general anesthesia, whereas endotracheal 4% lidocaine (3 ml) was effective. The arterial concentration of the intravenously administered-lidocaine peaked at a level of 9.52 ± 0.81 $\mu g \cdot ml^{-1}$ 0.5 min later. The arterial concentration of the endotracheally administered-lidocaine peaked at 1.44 ± 0.13 $\mu g \cdot ml^{-1}$ 15 min later. These findings indicate that the endotracheal administration of lidocaine may be superior to the intravenous administration for attenuating the circulatory changes and the cough reflex during recovery from general anesthesia, and that the arterial concentration of lidocaine did not correlate with the clinical efficacy for this purpose. (Key words: general anesthesia, endotracheal suctioning, extubation, lidocaine)

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It is well known that direct stimulation of the airway causes various cardiovascular and respiratory reflexes, such as hypertention, tachycardia, and coughing[1–4]. These responses may also be marked during endotracheal suctioning and extubation after general anesthesia. For patients with ischemic heart disease, these responses are potentially life-threatening. Respiratory reflexes, such as cough reflex, can also be dangerous in patients undergoing retinal or cervical spine surgery. Many reports document that intravenous or endotracheal lidocaine administration attenuates the circulatory responses to laryngoscopy and endotracheal intubation[5–8]. However, methods for attenuating such responses during endotracheal suctioning and extubation in the recovery period after general anesthesia are not established.

We investigated the effects of intravenous and endotracheal lidocaine on the circulatory changes and the cough reflex during recovery from general anesthesia as well as the changes in arterial lidocaine concentration.

Patients and Methods

Thirty adult patients were chosen for the study. All patients were in ASA classes I–II and were undergoing elective non-cardiac surgery requiring endotracheal intubation. Institutional and patient consent were obtained before the study. The patients were randomly divided into Group I, II and III. Each group consisted of 10 patients. Anes-

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Table 1. Characteristics of patients

Group	n	age (yr)	weight (kg)	height (cm)
I	10	42 ± 16	54 ± 10	157 ± 7
II	10	46 ± 16	55 ± 8	157 ± 10
III	10	45 ± 16	55 ± 6	160 ± 6
		NS	NS	NS

NS = not significant

thesia was maintained with 40% O_2 and 60% N_2O combined with fentanyl. The radial artery was cannulated for blood pressure monitoring and blood sampling. At completion of surgical procedures, all patients were given atropine 0.02 $mg \cdot kg^{-1}$ and neostigmine 0.05 $mg \cdot kg^{-1}$ for reversal of muscle relaxant. When consciousness and gag reflex returned, lidocaine was given as was mentioned below. Opening eyes or hand grasp on verbal command was considered to indicate return of consciousness. In Group I, no lidocaine was given through any route. In Group II, 1.5 $mg \cdot kg^{-1}$ of lidocaine was given intravenously, and in Group III, 3 ml of 4% lidocaine was sprayed onto the bronchocarinal area via an endotracheal tube using a long endotracheal injection catheter (40 cm in length). In group II, arterial blood samples were drawn before lidocaine administration and after 0.5, 1, 3, 5, 10, 15 and 30 min. In Group III, blood sampling was performed before lidocaine administration and after 1, 3, 5, 10, 15 and 30 min. Patients were extubated when they were fully awake and breathing adequately.

Arterial plasma lidocaine concentrations were measured using a fluorescence polarization immunoassay (TDX analyzer, Abbott Laboratories).

All data are presented as the mean ± SEM. Statistical comparisons of data were performed using analysis of variance (ANOVA) followed by Fisher's least significant difference method. $P < 0.05$ was regarded as statistically significant.

Results

There were no significant differences in age, body weight and height of patients between the three groups (table 1). The effects of lidocaine are shown in table 2. All the patients were extubated between 5 and 10 min after the termination of anesthesia. At the restoration of consciousness and air-

Table 2. Circulatory changes

Time (min)	base line	0.5	1
Group I			
MAP (mmHg)	107 ± 3	120 ± 5*	123 ± 4*
HR (bpm)	93 ± 5	102 ± 6	107 ± 7*
Group II			
MAP (mmHg)	109 ± 2	116 ± 4*	117 ± 42*
HR (bpm)	99 ± 4	100 ± 5	98 ± 6
Lidocaine ($\mu g \cdot ml^{-1}$)	0.03 ± 0.01	9.52 ± 0.81*	4.34 ± 0.38*
Group III			
MAP (mmHg)	120 ± 4	—	109 ± 4*
HR (bpm)	97 ± 5	—	93 ± 8
Lidocaine ($\mu g \cdot ml^{-1}$)	0.02 ± 0.01	—	0.51 ± 0.12*

MAP = mean arterial pressure; HR = heart rate; Lidocaine = Values are mean ± SEM. *: $P < 0.05$ vs base line.

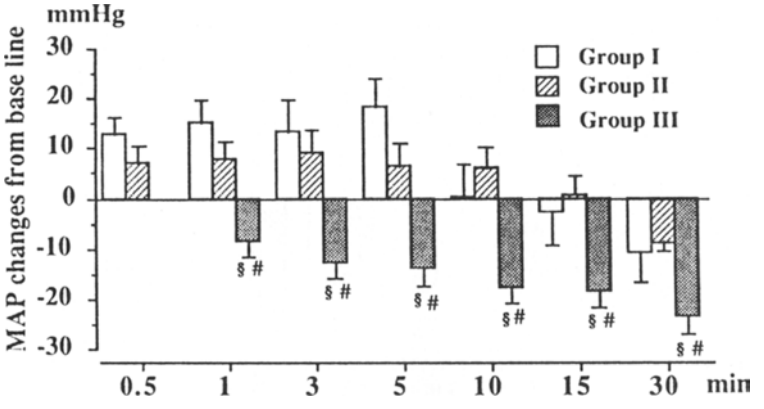

Fig. 1. Changes in mean arterial pressure (MAP) from base line. §$P < 0.05$ vs the control group. #$P < 0.05$ vs the intravenous lidocaine group.

way reflexes, all patients showed increases in MAP and HR. These values were considered as the base line levels. Mean arterial pressure increased progressively during the first 3 min after recovery from general anesthesia and intravenous lidocaine administration in Group I and II. Thirty minutes after extubation, MAP significantly decreased, compared with the base line levels. Group III showed a significant decrease in MAP from the base line level. Figure 1 shows the changes in MAP from the base line level. In Groups I and II, blood pressures increased by 10–15 mmHg and 5–10 mmHg above base line level, respectively in the first 5 min after recovery from general anesthesia and intravenous lidocaine administration. There were no significant differences between Groups I and II at any time during the study. In Group III, a progressive decrease in MAP from base line was observed after the endotracheal administration of lidocaine. Significant differences were seen in comparison with Group I ($P < 0.05$) and Group II ($P < 0.05$) from 1 min to 30 min. At extubation, MAP was 117 ± 22 mmHg in Group I, 119 ± 10 mmHg in Group II, and 105 ± 17 mmHg in Group III, respectively. There was a significant difference in MAP between Groups II and III at the time of extubation.

and arterial lidocaine concentrations

3	5	10	15	30
121 ± 6*	111 ± 5	108 ± 5	105 ± 5	97 ± 4*
103 ± 7*	95 ± 8	89 ± 6	84 ± 6	83 ± 6*
118 ± 5*	115 ± 4	115 ± 4	109 ± 4	100 ± 3*
96 ± 6	97 ± 4	103 ± 6	92 ± 7	76 ± 5*
2.24 ± 0.15*	1.70 ± 0.09*	1.37 ± 0.07*	1.06 ± 0.08*	0.48 ± 0.13
104 ± 6*	103 ± 6*	100 ± 6*	99 ± 5*	94 ± 5*
84 ± 9*	82 ± 8*	78 ± 6*	77 ± 5*	73 ± 4*
0.71 ± 0.15*	1.13 ± 0.19*	1.44 ± 0.13*	1.30 ± 0.09*	0.77 ± 0.10*

arterial lidocaine concentration.

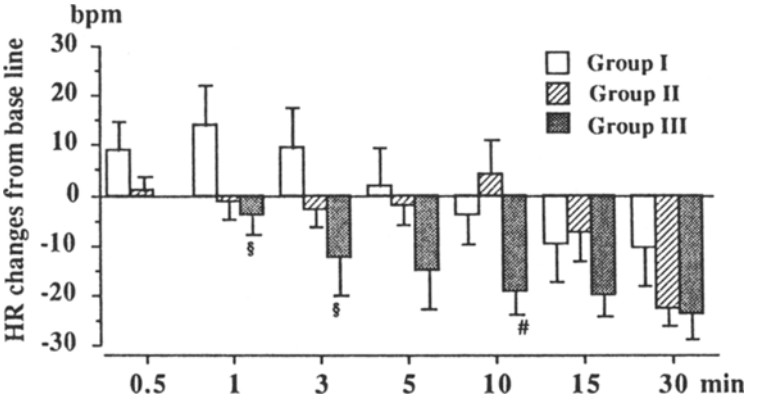

Fig. 2. Changes in heart rate (HR) from base line. §$P < 0.05$ vs the control group. #$P < 0.05$ vs the intravenous lidocaine group.

In Group I, HR significantly increased in the first 3 min after recovery from general anesthesia. Group II showed no significant changes in HR in the first 15 min after intravenous lidocaine administration. There were no significant differences in the HR changes from base line between Groups I and II (fig. 2). In Group III, HR significantly decreased from base line 3 min to 30 min after endotracheal administration of lidocaine. There were significant differences in the changes in HR from base line between Groups I and III at 1 and 3 min. At extubation, HR was 95 ± 15 beats·min^{-1} in Group I, 96 ± 20 beats·min^{-1} in Group II, and 89 ± 23 beats·min^{-1} in Group III, respectively. There were no significant differences in HR between the 3 groups.

The changes in arterial lidocaine concentrations are shown in table 2. Intravenous lidocaine administration (1.5 mg·kg^{-1}) rapidly produced a significant increase in arterial lidocaine concentration which peaked 0.5 min later. The highest and mean concentrations of lidocaine at 0.5 min were 16.0 μg·ml^{-1} and 9.52 μg·ml^{-1}, respectively. Cough reflex caused by endotracheal suctioning was observed in all the patients in Groups I and II.

Endotracheal lidocaine administration produced a significant increase in arterial lidocaine concentration which peaked 10 min later. The highest and mean concentrations of lidocaine were 2.5 μg·ml^{-1} and 1.44 μg·ml^{-1}, respectively. The cough reflex was suppressed in 8 out of 10 patients in Group III. There were no signs of lidocaine toxicity, such as convulsions, drowsiness, and coma in any of the patients.

Discussion

Extubation can be carried out when patients are still anesthetized or after they are fully awake. Extubation in a patient still under anesthesia increases the risk of aspiration. In conscious patients, the risk of aspiration is reduced, since protective airway reflexes have returned. However, allowing the intubated patient to awaken often causes a cough reflex and straining. These responses result in an increase in blood pressure and heart rate. These circulatory changes cause an increase in myocardial oxygen consumption, and therefore may be hazardous in patients with coronary artery disease. Hypertension may lead to cerebral hemorrhage after neurological surgery, and coughing may lead to unfavorable outcomes in operations on the retina and the cervical spine.

Many reports have stated that topical or intravenous lidocaine attenuates an increase in heart rate, blood pressure, and intracranial pressure associated with laryngoscopy and endotracheal intubation[5–8]. Steinhaus and Howland[9] reported that intravenous lidocaine decreased the activity of pharyngeal and laryngeal reflexes during nitrous oxide-thiobarbiturate anesthesia. It has also been

found that intravenous lidocaine suppresses the cough reflex in anesthetized[10] and awake subjects[11]. These reports suggest that intravenous lidocaine might attenuate these stress responses and suppress the cough reflex during recovery from general anesthesia.

However, the present study showed that intravenous lidocaine of 1.5 $mg \cdot kg^{-1}$ did not attenuate circulatory changes during the recovery from general anesthesia. Moreover, it could not suppress the cough reflex, whereas endotracheal administration of 3 ml of 4% lidocaine attenuated the changes in MAP and HR, and effectively suppressed the cough reflex.

Lidocaine has direct cardiac depressant and peripheral vasodilatory effects. The blood level necessary for these direct effects to occur has generally been accepted to be 1.5–5.5 $\mu g \cdot ml^{-1}$ [12]. In the present study, the peak arterial concentration exceeded 5 $\mu g \cdot ml^{-1}$ in the intravenous lidocaine group, whereas it was lower than 1.5 $\mu g \cdot ml^{-1}$ in the endotracheal lidocaine group. These results indicate that direct blockade of the tracheobronchial tree by spraying of lidocaine was more effective in attenuating the stress responses during recovery from general anesthesia than that by intravenous lidocaine. It is unknown why spraying lidocaine distal to the cuff is effective in attenuating the stress responses, because the most irritable site during the endotracheal tube in place is considerd around the cuff. In this regard, we would speculate that lidocaine administered at the bronchocarinal area would absorbed from the mucous membrane and infiltrate to around the cuff in a few minutes at the supine position.

In this study we administered lidocaine after the patients were fully awake, because lidocaine may increase the depth of general anesthesia[9]. From our results, endotracheal administration of lidocaine before reversal of muscle relaxants may be preferable to avoid circulatory changes and stimulation of the cough reflex.

In conclusion, the endotracheal administration of lidocaine appeared to be an effective and safe method for attenuating circulatory changes and the cough reflex during recovery from general anesthesia.

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