Systemic Administration of Procaine Suppresses the Somato-sympathetic Reflex Discharges in Anesthetized Cats

Fang Wen XUE, Setsuro OGAWA*, Takashi NAKAMURA*, Jitsu KATO* and Hajime SUZUKI*

Somato-sympathetic reflex discharges (SSRDs) which were induced from the lumbar sympathetic truck elicited by train pulse stimulation of femoral nerves in anesthetized cats were examined during and after intravenous infusion of 1 $mg \cdot kg^{-1} \cdot min^{-1}$ of procaine. The infusion demonstrated that amplitudes were suppressed with prolonged latencies and/or their tendencies in A- and C-reflex potentials of SSRDs. Heart rate and blood pressure decreased slightly, and the decreases correlated with time courses of suppressed SSRDs. These results suggest that the systemic procaine infusion may be a reliable method to alleviate somato-sympathetic reflexes under such conditions as extreme stimulation of somatic afferent nerves observed in surgical procedures. (Key words: systemic procaine infusion, somato-sympathetic reflex discharge, A-reflex potential, C-reflex potential)

(Xue FW, Ogawa S, Nakamura T, et al.: Systemic administration of procaine suppresses the somato-sympathetic reflex discharges in anesthetized cats. J Anesth 6: 461–466, 1992)

It has been recognized that systemic administration of local anesthetics such as procaine and lidocaine is one of the method to supress the cough reflex and to alleviate postoperative pain and some neuralgic pain[1,2]. Moreover intravenous procaine infusion as a supplemental agent in general anesthesia has been practiced routinely in many hospitals in People's Republic of China. Fundamental studies concerning the protective effects of systemic local anesthetics on noxious stimuli, however, could be found in only a few reports[3–6]. In particular, it has not been identified clearly whether or not systemic procaine infusion effectively supresses sympathetic responses to noxious stimuli. This study was intended to evaluate these effects by means of somato-sympathetic reflex discharges (SSRDs) in anesthetized cats.

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Materials and Methods

Six cats were anesthetized with intramuscular injection of Ketamine, 75 to 100 mg, and intubated by pancuronium, 2 mg IV. They were ventilated with ambient air. Anesthesia was maintained by intermittent IV

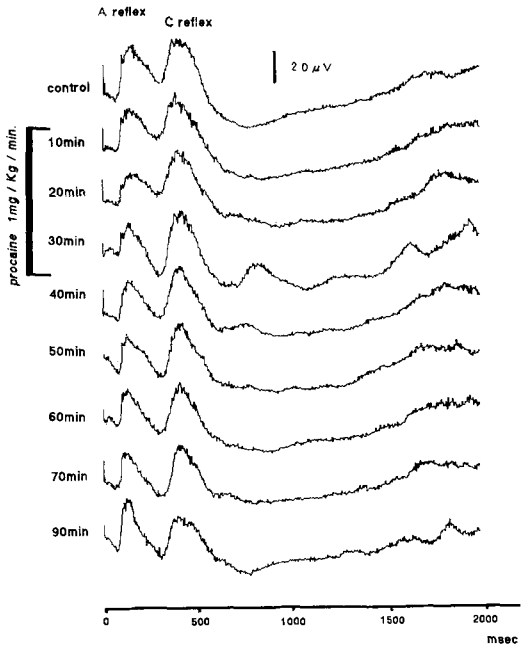

Fig. 1. A representative tracings of estimated reflex discharges.

Each trace shows A- and C-reflex potentials in relation to time course.

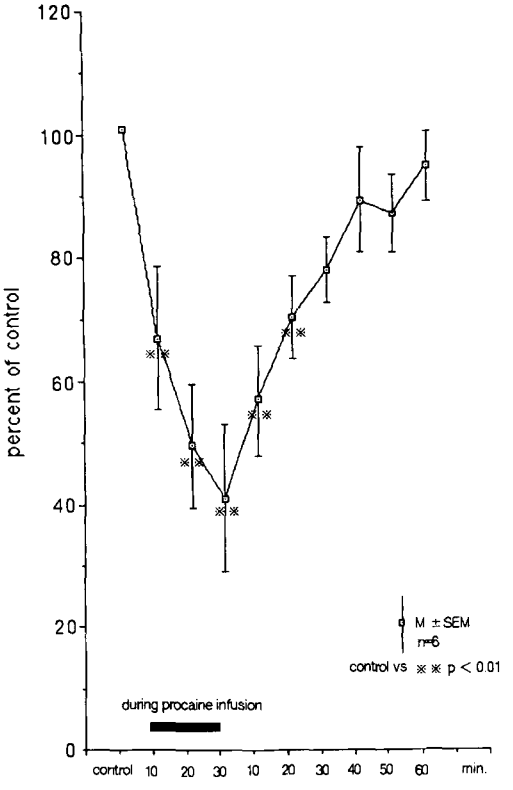

Fig. 2. The percent changes in amplitudes of A-reflex potentials.

Mean ± SEM (n=6) are shown.

injection of a mixture of Urethane, 100 mg·kg^{-1} and alpha chloralose, 50 mg·kg^{-1}. After an intravenous catheter was inserted into the femoral vein, vagus nerves were bilaterally severed at the cervical level. Lumbar sympathetic efferent nervous activities were induced from the sympathetic trunk at the L5 level by the methods by Ogawa et al[7]. Electrical train pulse stimulations (3 pulses of 0.5 msec duration at 20 Hz) witih supramaximal intensities for all afferent fibers including C- fibers were delivered to the proximal portion of a cut end of ipsilateral femoral nerve every 3 sec by an electric stimulator. Two reflex potentials which were identified as A- and C-reflex were evaluated by an averaging process of 16 serial stimuli as shown in figure 1.

The cardiovascular status was monitored by ECG recordings and direct blood pressure measurements from the carotid artery, and body temperature were kept within normal ranges.

After steady sympathetic discharges could be obtained as a control, 0.1% procaine solution was infused intravenously at the rate of 1 mg·kg^{-1}·min^{-1} continued for 30 min with a microinfuser. The discharges were estimated intermittently at each 10 min during the infusion.

Amplitudes and latencies of the SSRDs were analyzed and compared against the controls (baseline values) by percentage changes. The results in 6 cats were expressed as mean ± SEM, and the data was analyzed statistically by the ANOVA and Dunnett tests for comparison of results, and $P < 0.05$ was considered to be significant.

Table 1. Percent changes in comparison with control for each variable during 30 min and after termination of 1 mg·kg·$^{-1}$min^{-1} of procaine infusion

	n	control	during procaine infusion			after infusion				
		%	10 min.	20 min.	30 min.	10 min.	20 min.	30 min.	40 min.	50 min.	60 min.
amplitude A reflex	6	100	66.0** ± 11.8	48.4** ± 10.2	39.0** ± 12.0	55.9** ± 8.9	69.3** ± 6.8	77.0 ± 5.4	88.2 ± 8.4	87.9 ± 6.7	91.6 ± 5.0
amplitude C reflex	5	100	73.6 ± 13.5	66.1 ± 13.6	60.2 ± 12.8	66.0 ± 11.8	80.9 ± 7.0	81.3 ± 7.6	85.1 ± 6.9	91.6 ± 6.1	98.1 ± 11.3
latency A reflex	6	100	106.6 ± 3.0	110.8 ± 2.4	109.8 ± 2.4	105.6 ± 2.8	105.6 ± 3.4	101.4 ± 3.0	96.0 ± 4.6	97.4 ± 4.2	96.4 ± 4.2
latency C reflex	5	100	103.0 ± 1.5	108.2** ± 2.4	109.2** ± 1.7	107.4** ± 1.6	105.2 ± 1.7	103.0 ± 1.8	102.2 ± 1.8	101.0 ± 1.7	99.8 ± 1.6
heart rate	6	100	93.3** ± 0.8	92.3** ± 1.1	87.9** ± 1.3	95.4 ± 1.7	97.1 ± 2.2	97.0 ± 2.1	97.0 ± 2.3	97.9 ± 2.2	101.8 ± 1.8
mean arterial pressure	6	100	99.8 ± 6.3	87.9* ± 2.9	86.7** ± 2.8	101.7 ± 3.1	103.5 ± 3.5	102.7 ± 3.0	101.1 ± 2.5	101.3 ± 2.3	101.4 ± 3.5

control VS *$P < 0.05$ Mean ± SEM are shown.
control VS **$P < 0.01$

Results

Two potentials in a SSRDs were induced in each experiment as a typical sample in figure 1 except when a C-reflex potential could not induced in one animal.

1. *A-reflex potentials* (table 1, fig. 2)

During the time course of the infusion, amplitudes of A-reflex potentials were suprressed progressively to 66.0 ± 11.8% 10 min, 48.4 ± 10.2% 20 min, and 39.0 ± 12.0% 30 min when compared to controls ($P < 0.01$). The supressed amplitudes recovered to control levels within 60 min after cessation of infusions.

Latencies of A-reflex potentials showed a tendency to elongate during the infusion, but it was not significant.

2. *C-reflex potentials* (table 1, fig. 3)

Amplitudes of C-reflex potentials in 5 cats were supressed progressively, but the levels of suppression showed individual variation and their mean depression was less than seen with A-responses. At 30 min of infusion, the mean amplitude were supressed to 60.2 ± 12.8% of control levels but differences from controls were not significant.

Latencies of C-reflex potentials were prolonged to 108.2 ± 2.4% and 109.2 ± 1.7% at 20 and 30 min of infusion respectively ($P < 0.01$).

3. *Heat rate and blood pressure* (table 1, fig. 4)

Slightly decreased heart rate and mean blood pressure to 87.9 ± 1.3% and 86.7 ± 2.8% of controls respectively were shown at 30 min of procaine infusion ($P < 0.01$). The time course of their decreases were correlated to that of the suppressed SSRDs.

These decreased heart rate and blood pressure recovered promptly when infusions were terminated.

Discussion

Somato-sympathetic reflex discharges (SSRDs) which are induced from the lumbar sympathetic trunk by stimulation of somatic afferent nerves in cats has been introduced

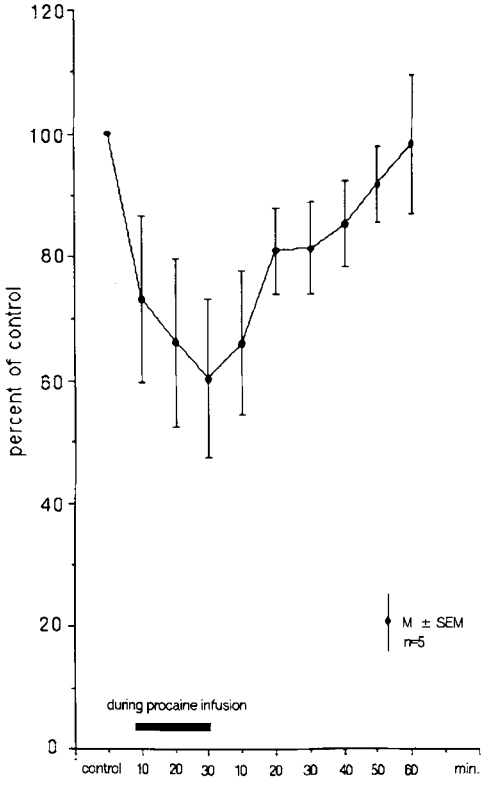

Fig. 3. The percent changes in amplitudes of C-reflex potentials.
Mean ± SEM (n=5) are shown.

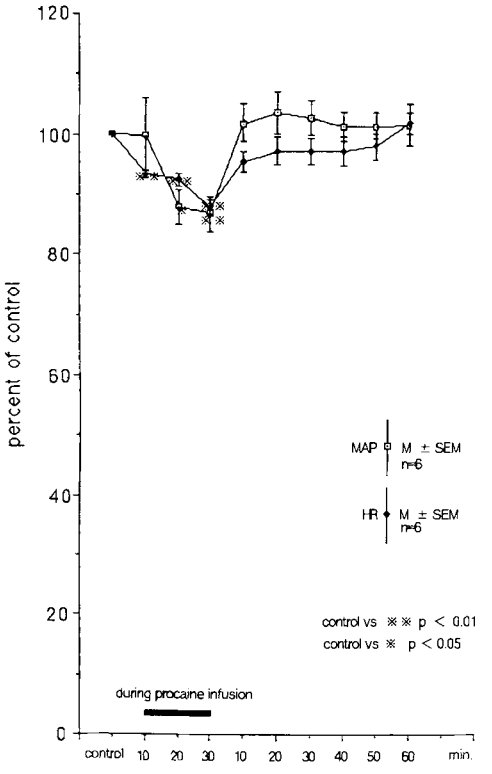

Fig. 4. The percent changes in heart rates and mean blood pressure.
Mean ± SEM (n=6) are shown.

and analyzed by Sato et al.[8–10] as a method to evaluate sympathetic activities. When supramaximal electrical stimulations for C-fibers were applied to somatic nerves, two responses are induced from the sympathetic trunk in accordance with varying afferent nerve fibers and pathways in the spinal cord. Schmidt et al.[11] and Sato[12] identified the potential with a shorter latency and lower threshold of the two as the A-reflex potential, which is derived from stimulation of myelinated afferent nerves (A-fibers) and the latter, the C-reflex potential, is derived from stimulation of C-fibers, although the reflex center of both responses is located in the medulla oblongata. Several investigators[13,14] recently demonstrated that the C-reflex potentials were inhibited selectively by systemic administration of opioid analgesics.

In this study, IV infusion of procaine, 1 $mg \cdot kg^{-1} \cdot min^{-1}$ demonstrated suppressed amplitudes with prolonged latencies and/or their tendencies.

Several observations which examined suppressive effects of systemically administered local anesthetics on discharges from the somatic reflex arc and the spinal cord strongly suggest that one of the primary sits of action are in spinal cord for instance the dorsal horn neurons. However, varied concentration of local anesthetics in plasma[4,5], cause inhibition of peripheral nerve firing and of nerve conduction at a lower degree than explained adequately by the analgesic effects of the dosage of local anesthetics[3]. Woolf et al.[6]

recorded compound evoked potentials from both the dorsal and ventral roots in rats by stimulation of the sural nerve under systemic administration of lidocaine at several dosages which did not block peripheral nerve conduction. They demonstrated that systemic lidocaine, 1 $mg \cdot kg^{-1}$ supressed selectively C-fiber inducing polysynaptic reflexes, and it supressed also the A-fiber inducing reflex at 5 $mg \cdot kg^{-1}$. They postulated from their results that the systemic lidocaine can produce a selective central block of certain types of afferent evoked activity in the spinal cord.

According to these findings, the suppression of SSRDs in this study is considered to be caused by inhibited conduction at the level of the somato-sympathetic reflex pathway in the spinal cord. Although there is a discrepancies between results of Woolf et al. and ours, the potential of A and C in the reflex discharge is inhibited more profoundly. The reasons may be due to the facts that reflex discharges in the two studies were induced from different efferent nerves in different animals, somatic efferent fibers of rats by Woolf et al.[6], and the sympathetic trunk of cats in our study. In addition, effects of infused procaine to higher level than the medulla in the central nervous system may have to be discussed when considering of the supressed SSRDs, because the results by Woolf et al. were obtained from decerebrated rats[6], and ours were with the higher levels intact.

Heart rate and mean arterial pressure were in good correlation with the suppression of SSRDs, and their decreased levels recovered immediately after the termination of procaine infusion. These finding suggest that the decreased levels of these variables may be reliable indicators in the control of infusion rates of procaine which is practiced in clinical settings.

In conclusion, intravenous infusion of procaine at dose of 1 $mg \cdot kg^{-1} \cdot min^{-1}$ induced supressed amplitudes with prolonged latencies and/or their tendencies in both A- and C-reflex potentials of SSRDs. Heart rates and blood pressure decreased slightly with good correlation to the time course of the suppressed SSRDs. These results suggested that IV infusion of procaine is an effective method to alleviate somato-sympathetic reflexes under conditions which strongly stimulate somatic afferent nerves as in surgical procedures.

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