Evaluation of Alkalinized Lidocaine Solution in Brachial Plexus Blockade

Noriaki KANAYA, Hitoshi IMAIZUMI, Maki MATSUMOTO, Akiyoshi NAMIKI and Kazumasa TSUNODA*

The effect of alkalinization of lidocaine solution in brachial plexus blockade was evaluated in a double blind study. Commercial 1.5% lidocaine with epinephrine 1:200,000 (pH 5.72) was compared with an alkalinized solution of lidocaine (pH 7.12). 10 $mg \cdot kg^{-1}$ of each solution was administrated by the axillary perivascular technique in 34 adult patients scheduled for elective surgery. The onset and spread of sensory blockade and the intensity of motor blockade were determined. An alkalinized lidocaine solution produced more complete sensory blockade in all of four main nerves of the upper extremity as compared with the control lidocaine solution. The onset of sensory blockade in the musculocutaneous, radial, ulnar and median nerves was shortened 58%, 40%, 30% and 28%, respectively, by employing the alkalinized lidocaine solution. Also the analgesic onset in the radial and musculocutaneous nerves was significantly faster than the other two nerves ($P < 0.05$ and $P < 0.01$). Furthermore, the intensity of motor blockade was greatly potentiated when alkalinized lidocaine solution was employed. There was no significant increase in plasma concentration of lidocaine in patients who were given alkalinized solution. (Key words: brachial plexus block, axillary approach, lidocaine with epinephrine, alkalinization)

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Increasing the pH of a local anesthetic solution has been reported to potentiate the quality of neural blockade in vitro[1,2]. Hilgier observed a rapid onset and a prolongation of the action of bupivacaine by the addition of sodium bicarbonate to a local anesthetic solution resulting in an increase in the pH of the solution[3]. In addition, DiFazio demonstrated that an incremental addition of sodium bicarbonate into lidocaine caused a more rapid onset of analgesia and a greater spread of sensory blockade[4].

Based on these reports, the current study was initiated to determine if an increase in the pH of lidocaine with epinephrine (1:200,000) by the addition of sodium bicarbonate would result in a more rapid onset of brachial plexus blockade. The effect of pH on vascular absorption of lidocaine was also evaluated.

Method

This double blind study included 34 adult patients subjected to elective surgery of the upper extremity. The protocol was reviewed and approved by the committee of Sapporo Medical College and Hospital on medical ethics, and informed consent was obtained from each patient prior to anes-

Department of Anesthesiology, Sapporo Medical College, Sapporo, Japan

**Department of Anesthesia, Nikkou Memorial Hospital, Muroran, Japan*

Address reprint requests to Dr. Kanaya: Department of Anesthesiology, Sapporo Medical College, S-1, W-15, Chuo-ku, Sapporo, 064 Japan

Table 1. Onset of sensory blockade (minutes)

	I (control)	II (alkalinized lidocaine)
Median nerve	12.14 ± 0.74	8.68 ± 0.53
Ulnar nerve	3.21 ± 0.31	2.24 ± 0.07
Radial nerve	22.57 ± 0.80	13.75 ± 0.52*
Musculocutaneous nerve	22.54 ± 0.82	9.55 ± 0.41**

All values are given as mean SEM.
*$P < 0.05$, as compared with group I
**$P < 0.01$, as compared with group I

thesia. The patients were randomly divided into two groups. The control lidocaine solution (pH 5.72) contained 1 ml of normal saline in 10 ml of 1.5% lidocaine with 1:200,000 epinephrine. The alkalinized lidocaine solution (pH 7.12) contained 1 ml of 7% NaHCO3 in 10 ml of 1.5% lidocaine with 1:200,000 epinephrine.

All blockades were performed by the axillary perivascular technique. The injection of local anesthetic was carried out over 1 min. Thirty to 40 ml of either control lidocaine solution (Group I) or alkalinized lidocaine solution (Group II) was given so that the total dose of lidocaine was 10 $mg \cdot kg^{-1}$ of body weight.

The sensory blockade was evaluated every 30 second after the injection using pinprick technique until analgesia was established. Analgesic effect was evaluated in the following four nerve areas, i.e. median (M), ulnar (U), radial (R) and musculocutaneous (MC). The evaluation of sensory blockade was continued until 30 min after the injection.

The degree of motor blockade was assessed by measuring the gripping force 5 min after the injection.

Arterial blood was sampled to determine the concentration of plasma lidocaine 30 min after administration.

Statistical analysis was performed with the aid of a non-parametric method and chi-square method. Differences were considered to be statistically significant when P-values were less than 0.05.

Results

Both groups had similar demographic characteristics in terms of age and sex. All patients showed sensory blockades of two or more main nerves in the upper extremity. Thirteen patients (75%) in group II showed a complete sensory blockade of the axillary nerves, whereas only 4 patients (29%) in group I demonstrated the same effect. The difference observed in the two groups was statistically significant ($P < 0.05$).

The onset of sensory blockade in the two groups is shown in table 1. In both of the groups, the order of analgesic onset was ulnar, median, musculocutaneous and then followed lastly by radial nerves. The onset of sensory blockade in the musculocutaneous and radial nerves was significantly later than that of the ulnar and median nerves in the control group ($P < 0.05$). The onset of analgesia was significantly shortened in the radial ($P < 0.05$) and musculocutaneous ($P < 0.01$) nerve areas when alkalinized solution was employed. In contrast, there was not as significant on effect of shortening the onset of analgesia in the ulnar and median nerve areas in the alkalinized lidocaine group.

In terms of motor blockade (fig. 1), the gripping force of group II decreased from 23 to 4 kg five minutes after the injection. In group I, the gripping force decreased from 17.4 to 7.7 kg. Thus the difference between the two groups on motor blockade was significantly great ($P < 0.05$).

The average plasma concentrations of li-

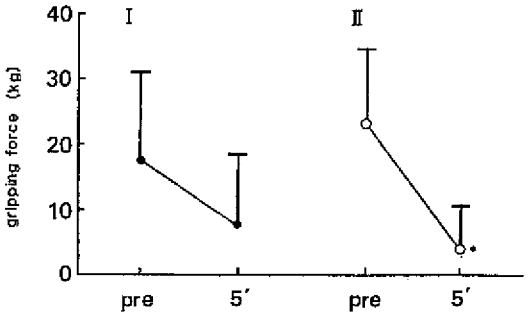

Fig. 1. Graphic comparison of the decrease of gripping force 5 min after performing the block in the two groups.

Values expressed as mean (± S.D.); *Significantly different ($P < 0.05$) from control values.

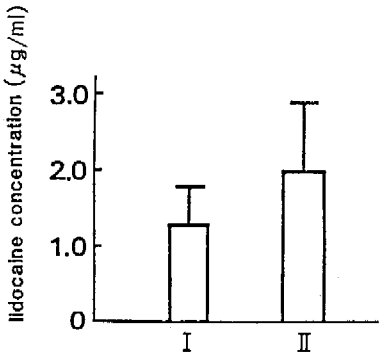

Fig. 2. Graphic comparison of the plasma lidocaine concentration 30 min after performing the block in the two groups.

Values expressed as mean (± S.D.); p=NS.

docaine in group I and group II were 1.3 and 2.0 $\mu g \cdot ml^{-1}$ thirty minutes after the injection. There was no significant difference between the concentrations of the two groups (fig. 2). No patient showed any symptoms of local anesthetic toxicity in either group.

There was no case of either motor paralysis or other persistent deficit of the nerves in both groups, when the analgesia disappeared.

Discussion

There are numerous investigations which report that local anesthetics can be potentiated by adjusting their pH. Ritchie et al. reported that the percentage of the nonionized form could be increased by elevating the pH of the local anesthetic in vitro[5–7]. Hille demonstrated that the activity of local anesthetic was dependent on the rate of nerve membrane penetration by the nonionized local anesthetic[8].

In a recent clinical report, Galindo indicated that an addition of sodium bicarbonate (pH 7.0–7.4) could shorten the onset of neural blockade in humans[9]. DiFazio reported that pH-adjusted lidocaine solution produced a more rapid onset and a greater spread of sensory blockade in epidural anesthesia[4]. In brachial plexus blockade, Hilgier demonstrated that shortening of the onset time of analgesia was brought about when sodium bicarbonate (0.1 mM) was added to 0.5% bupivacaine solution with epinephrine (1:200,000)[3]. He also reported the onset of analgesia was shortened by about one-half and the duration of surgical analgesia was prolonged more than two fold when alkalinized solution was used. Bedder et al. demonstrated that alkalinization of bupivacaine 0.5% solution did not confer any added clinical advantage in subclavian perivascular brachial plexus blockade when compared with commercially available bupivacaine[10].

However, none of these reports demonstrated, which nerve's onset time was affected by using pH adjusted local anesthetics. In this study, we found different effects on each of the four main nerves of the upper extremity. In control, the onset of analgesia in both the radial and musculocutaneous nerve areas were delayed compared with that of the ulnar and median nerve areas. The slow onset for the radial and musculocutaneous nerves is due to their greater distance from the site of injection. Alkalinized lidocaine solution significantly shortened the onset of sensory blockade for the more distant radial and musculocutaneous nerves. Hilgier has suggested that an increase of the pH of bupivacaine solution would appear a more rapid diffusion through nerve sheaths, and this should insure a more rapid onset

of action[3]. We similarly suggest that the alkalinization of lidocaine solution will provide a more rapid diffusion not only in the nerve but also in the connective tissues as compared to commercial lidocaine.

Motor blockade was determined by measuring the gripping force which mainly coincided with forearm muscles corresponding to the median nerve. Winnie et al. reported that the onset of motor blockade preceded sensory blockade because of the somatotopic arrangement of fibers in nerve bundles; motor fibers located more peripherally than sensory fibers[11]. In our study complete motor blockade preceded the sensory blockade of the median nerve in group I, however sensory blockade preceded motor blockade in group II. This fact may be related to the accelerated intraneural diffusion of lidocaine solution by alkalinization. It is known that the minimal effective concentration (Cm) of motor fibers is approximately twice that of pain fibers. Therefore, the Cm of sensory fibers will be reached faster than that of motor fibers by employing alkalinized solution.

If alkalinization of local anesthetics enhances the diffusion of the drug, absorption of anesthetics is also affected. However, there was no significant increase of the plasma concentration of lidocaine by alkalinization in our study.

In conclusion, alkalinized lidocaine solution which is employed in axillary brachial plexus blockade can hasten the onset of analgesia and confer a wider spread of analgesia as compared with the same dose of commercial lidocaine. Moreover, a low concentration of lidocaine in plasma is maintained.

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