spect to the other stimulatory and nonstimulatory techniques used to identify the brachial plexus; we fully concur with his opinions. The technical simplicity, the objective end point in identifying the brachial plexus, and the outcome of block have undoubtedly contributed to make neurostimulation the gold standard in plexus anesthesia.

Furthermore, Dr. Sia introduces the idea of multiple neurostimulation as a technique capable of affording an increased success rate in relation to plexus block, with a reduction in latency. The recent work by Sia et al.[1] and Serradell-Catalán et al.[2] attempt to answer the question: "How many responses must we identify?" In the study by Sia et al.,[1] comparing the identification of 2 or 3 responses to neurostimulation in the axillary technique, the authors conclude that the identification of 2 responses (radial and median) may suffice for surgery of the hand, whereas surgery of the forearm would require the added identification of the musculocutaneous nerve. Similar results have been reported by Serradell-Catalán et al.[2] in which comparisons were made of 5 groups of 20 patients with multiple neurostimulatory responses, suggesting the need to identify 3 motor responses (including that of the musculocutaneous nerve) for securing a block rate of 90%. In this same study, the identification of 4 terminal nerves secured a complete block in 100% of cases.

However, caution is indicated when interpreting these results as definitive. The complication rate related to neurostimulation techniques should be considered in the context of epidemiologic studies involving a sufficiently large and specifically designed series of patients. These studies will be clearly larger than those needed to simply assess success of the technique. Although extensive clinical series suggest that the incidence is indeed similar for both approaches (i.e., multiple and single stimulation),[3] Serradell-Catalán et al.[2] have reported an increased incidence of vascular punctures when attempting to elicit an increased number of motor responses.

In sum, 2 views can be identified in the conduct of plexus anesthesia: (1) classic single-stimulation techniques, considering the existence of the aponeurotic sheath and the presence of a neurovascular space; and (2) the application of the advantages of neurostimulation, in which selective block of the terminal nerve is regarded as a technique affording an increased success rate. Both views are undoubtedly valid and can coexist. Although multiple terminal-nerve neurostimulatory techniques yield increased complete block rates, the single techniques offer the possibility of selective anesthetic reinforcement limited to nonblocked nerve branches.

In our opinion, neurostimulation provides greatest localization of the neurostimulation needle, and therefore of the local anesthetic instillation close to the brachial plexus. Based on the location of multiple muscle responses, using the knowledge of the most common muscle responses of the different terminal nerves, we can improve the outcome of block. However, the needle puncture remains blind in that we know the puncture site, "imagine" the trajectory, and identify the location of the plexus. This may imply an increased risk of complications associated with these multiple punctures. Moreover, considerable interindividual anatomical variability exists as regards the location of the different "end-nerves" in relation to the axillary artery.[4]

Systematic application in the near future of imaging techniques, such as ultrasound,[5] may afford improvements, causing a "partially blind" multiple stimulation procedure to transform into a technique performed under direct and continuous visualization, thereby securing its 2 fundamental objectives, i.e., the best possible block result with the fewest puncture-associated complications.

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References

1. Sia S, Lepri A, Ponzecchi P. Axillary brachial plexus block using peripheral nerve stimulator: A comparison between double and triple-injection techniques. *Reg Anesth Pain Med* 2001;26:12-16.
2. Serradell-Catalan A, Moncho-Rodríguez J, Santos-Carnes J, Herrero-Carbo R, Villanueva-Ferrer J, Masdeu-Castellvi J. Anestesia del plexo braquial por via axilar. ¿Cuantas respuestas buscamos con neuroestimulación? *Rev Esp Anestesiol Reanim* 2001;48:356-363 (English abstr.).
3. Fanelli G, Casati A, Garancini P, Torri G. Nerve stimulator and multiple injection technique for upper and lower limb blockade: Failure rate, patient acceptance and neurologic complications. *Anesth Analg* 1999;88:847-852.
4. Retzl G, Kapral S, Greher M, Mauritz W. Ultrasonographic findings of the axillary part of the brachial plexus. *Anesth Analg* 2001;92:1271-1275.
5. De Andrés J, Sala-Blanch X. Ultrasound in the practice of brachial plexus anesthesia. *Reg Anesth Pain Med* 2002;27:77-89.

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Clinical Value of Adding Sodium Bicarbonate to Local Anesthetics

To the Editor:

After reading the article by Ramos et al.,[1] I write concerning the clinical value of adding sodium bicarbonate to local anesthetics to hasten the onset of conduction blockade. Adjusting the pH of local anesthetic solutions to speed the onset of analgesia is common practice despite a paucity of data to support the procedure. The time required to adjust the pH of a local anesthetic solution is

longer than any time saved in speeding the onset of block. For example, adding sodium bicarbonate to lidocaine[2] or to chloroproacaine[3] reduces the onset of epidural analgesia by 2 to 3 minutes at most. It often takes longer than that to locate, draw up, and add the sodium bicarbonate to the local anesthetic.

Nevertheless, and from an intellectual perspective, why shouldn't the addition of sodium bicarbonate hasten the onset of blockade so that this maneuver would be clinically useful? The answer is in a publication by Jorgen Rud.[4] He studied the effects of various lidocaine concentrations at varying pH on the compound action potential (CAP) amplitude of isolated frog nerve. His results are shown in Figs 1 and 2.

Figure 1 shows the relationship of the base concentration to the pH of the solution. This figure demonstrates that the base concentration is linked to the concentration of lidocaine. The higher the concentration of lidocaine in the solution, the greater the amount of base at any pH. Therefore, any effect of increasing the pH is greater with higher initial concentrations of lidocaine.

On the other hand, as seen by the plateau (knee in curve) in Fig 2, the onset of block is nearly maximal at concentrations of base as low as 1 to 2 mmol/L. Therefore, elevation of the pH has little effect on speeding onset with low concentrations (5 mmol/L) of lidocaine because the additional amount of base produced with increasing pH is small. Likewise, increasing the pH of higher concentrations of lidocaine (20 mmol/L and 40 mmol/L) has little effect on hastening onset because onset is already very fast, even at low pH.

When a more rapid onset is desired, it is easier to use a higher concentration of drug or to inject a larger volume rather than manipulating the pH of the local anesthetic. Higher concentrations of the same volume or larger volumes of a lower concentration will both provide more local anesthetic base and speed onset. Furthermore, the quality of the block will be improved and its duration prolonged.

Local anesthetic solutions that are premixed with epinephrine have a pH of 4.5 to prevent the oxidation of the epinephrine. Low concentration of these solutions will benefit more from pH adjustment than nonepineprhrine-containing solutions, which have a pH of 6.5. Alternatively, adding fresh epinephrine to plain local anesthetic solutions will result in epinephrine-containing solutions with a pH of 6.5. Note: 5 mmol/L = 0.115%, 20 mmol/L = 0.46%, and 40 mmol/L = 0.92%.

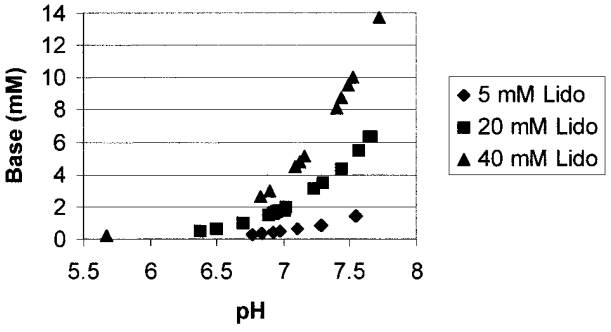

Fig 1. The relationship of base (nonionized) concentration of lidocaine as a function of pH. Note that there is little increase in base with the lowest lidocaine concentration (5 mmol/L), but a greater increase with higher lidocaine concentrations (20 and 40 mmol/L). Data from Rud.[4]

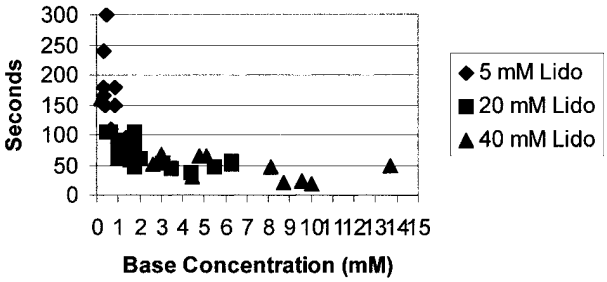

Fig 2. The time (in seconds) required to block 50% of the control CAP amplitude as a function of the base (nonionized) species of lidocaine. Note that a near maximum effect is achieved at base concentrations of 1 to 2 mmol/L. Data from Rud.[4]

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References

1. Ramos G, Pereira E, Simonetti MP. Does alkalinization of 0.75% ropivacaine promote a lumbar peridural block of higher quality? *Reg Anesth Pain Med* 2001;26:357-362.
2. DiFazio CA, Carron H, Grosslight KR, Moscicki JC, Bolding WR, Johns RA. Comparison of pH-adjusted lidocaine solutions for epidural anesthesia. *Anesth Analg* 1986;65:760-764.
3. Ackerman WE, Denson DD, Juneja MM, Herold J, Sweeney NJ, Nicholson CJ. Alkalinization of chloroprocaine for epidural anesthesia: Effects of pCO2 at constant pH. *Reg Anesth* 1990;15:89-93.
4. Rud J. Local anesthetics. An electrophysiological investigation of local anesthesia of peripheral nerves, with special reference to xylocaine. *Acta Physiol Scand* 1961;51:60-83: (suppl 178).

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Reply to Dr. Lambert

To the Editor:

The comments made by Lambert are pertinent and timely. I agree with them. I, too, question the clinical use of local anesthetics with adjusted pH, although I would like to make some observations. In fact, the time taken to adjust the pH of some local anesthetic solutions, including ropivacaine, may be greater than the time saved in the reduced onset of anesthetic blocks. In our specific study, 2 further clinical variables were observed, in addition to onset: dispersion and duration of anesthesia.[1] From the clinical point of view, dispersion may not be very significant. However, a few more hours of analgesia, especially in orthopedic surgeries, can mean increased postoperative comfort for the patient and a saving of one or more doses of analgesic anti-inflammatory medication.