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pH and Muscle Relaxants

To the Editor:—Recently Ono *et al.*¹ described potentiation of *d*-tubocurarine neuromuscular block *in vitro* by increased P_{CO_2} .

Potentiation of monoquaternary relaxants such as *d*-tubocurarine and vecuronium by low pH may be attributed to a change of a tertiary ammonium group into a quaternary group by combining with a hydrogen ion, and hence the molecule may change into a bisquaternary relaxant. This will increase attraction of the relaxant molecule to the anionic cholinergic receptors. Also, the increased polarity of the molecule may limit its passage across cellular barriers, including liver cells. Thus, a decrease of pH not only increases the neuromuscular block achieved by monoquaternary muscle relaxants, but may also delay its rate of elimination.

The effect of pH on *d*-tubocurarine block has been also explained by alteration of the percentage ionization of its phenolic hydroxyl groups.² The *d*-tubocurarine molecule has, beside its ammonium groups, two phenolic hydroxyl groups with pKa values of 8.1 and 9.1, and is therefore liable to vary its degree of ionization of these hydroxyl groups. This variation results in anionic charges that can decrease the attraction of the molecule to the anionic cholinergic receptors and facilitate permeation of cell membranes by the formation of zwitterions.³

In contrast to the effect of pH on monoquaternary muscle relaxants, Ono *et al.* showed that high pH potentiates and low pH counteracts the response to bisquaternary relaxants.¹ A possible mechanism is the ability of pH changes to vary the activity of both the plasma cholinesterase and acetylcholinesterase, and hence carbon dioxide may act as a physiologic anticholinesterase.⁴ Other factors such as change of protein binding and/or the degree of ionization of the cholinergic endplate receptors cannot be excluded.

Controlled animal studies demonstrate incomplete antagonism by neostigmine of blocks produced by *d*-tubocurarine⁵ and pancuronium⁶ during respiratory acidosis. Thus, although hypercapnia augments the neuromuscular block of monoquaternary muscle relaxants and de-

creases the block of bisquaternary relaxants, its effect may be complicated in both groups by "neostigmine-resistant curarization."⁷

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Discrepancies in Upper-limb Blood Pressure and Their Impact on Internal Mammary Artery-Coronary Artery Grafting

To the Editor:—Recently a difference between right and left arm blood pressures in vascular surgery patients has been described.¹ Despite the recommendation that routine measurement of blood pressure be performed in both arms prior to cardiac catheterization, it is not unusual for patients to come for coronary artery bypass graft (CABG) surgery without such measurements. Our recent experience with a patient scheduled for CABG surgery who had a marked difference in blood pressure between both arms reinforces this point.

A 59-yr-old man with a history of diabetes, hypertension, two previous myocardial infarctions, unstable angina, and a diagnosis of severe triple-vessel coronary artery disease was scheduled for CABG surgery with intended use of the left internal mammary artery. The patient

came to the operating room premedicated with morphine and scopolamine. Intraarterial blood pressure measured from the left radial artery showed a blood pressure of 80/60 mmHg. Simultaneous non-invasive blood pressure in the right arm (Dynamap) showed the blood pressure to be 125/80 mmHg.

Subsequent measurements of intraarterial blood pressure from the right radial artery confirmed the difference between the two arms to be accurate. We discussed this observation with the surgeon and recommended that the left internal mammary artery not be used, considering the pressure difference of 40-45 mmHg. We relied on the right radial artery pressure throughout the subsequent surgical management and the immediate postoperative course because it closely correlated

with the aortic pressure. The patient did well and was discharged home within 10 days.

As a result of the detection of a marked difference in blood pressure between the two arms, use of the internal mammary artery was avoided, thus preventing potentially life-threatening complications due to myocardial ischemia caused by subclavian–coronary artery steal.² Of interest is an identical case³ in which similar findings were noted. We believe that the best way to avoid the use of the internal mammary artery in a patient with unsuspected subclavian steal is to have blood pressure measurements in both arms routinely measured prior to anesthesia.

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Symptoms Following Lumbar Puncture May Be Related to Decreased Cerebrospinal Fluid Pressure and/or Venous Dilation

To the Editor:—Kelly *et al.* described an occurrence of shooting pains down both arms into the hands of a patient following lumbar puncture (LP).¹ They are correct in stating that this is a novel development since extensive reviews of the subject have revealed no similar occurrence.^{2,3} Furthermore, as Marshall⁴ and Page⁵ found, major decreases in cerebrospinal fluid (CSF) pressure can exist without development of posturally induced headache. This is one of several reasons why data on the incidence of post-LP headache vary so much from one source to another.

Insofar as post-lumbar puncture nerve palsies are concerned (not actually demonstrated in the Kelly¹ account), those most frequent involve the Abducens nerve, bilaterally on rare occasions.² The usual explanation for this selectivity of the sixth cranial nerve relates to the relatively long intracranial course of this purely motor nerve rendering it susceptible to both pressure and stretch. Some ophthalmologists, however, attribute the palsy to an increased venous pressure as the nerve courses through the cavernous sinus. Venous dilation, to be sure, does occur in the central nervous system in compensation for a decrease in CSF pressure, also accounting for development of headache.

That the spinal cord may sag (as may the brain) may be a fanciful explanation for the temporary paresthesias noted by Kelly *et al.*¹ One should not overlook the possibility of prior cervical pathology temporarily revealed by a decrease in CSF pressure and the ensuing venous congestion: disc protrusion, spondylosis, pachymeningitis, and vascular malformation. The presence of a spinal cord tumor has been revealed for the first time after LP, most likely due to venous congestion. Post-LP headache is relieved by blood patch because of a considerable and abrupt increase in CSF pressure, which persists for some time. *Pari passu* venous pressure must also decline.

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In Reply:—Vandam raises several pertinent points. Our patient was not highly muscular. While it is certainly possible that pressure from cervical ribs may present symptoms described in our case, we do not

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It would be interesting to learn the physical characteristics of the patient described—highly muscular or asthenic—as might relate to pressure on the brachial plexus from cervical ribs. It would also seem cogent to extend the posthospital observation period and, if necessary, perform magnetic resonance imaging studies of the cervical spinal cord and column if symptoms reoccur.

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believe that an epidural blood patch would dramatically resolve the symptoms if they were caused by pressure from cervical ribs. The possibility of preexisting cervical pathology (revealed by a decrease in