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Brachial Plexus Nerve Block Exhibits Prolonged Duration in the Elderly

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Background: **Upper limb trauma occurs frequently in elderly patients for whom peripheral nerve blocks are often preferred for anesthesia. The characteristics of such regional blocks have, however, never been described in an elderly population. Therefore, the authors assessed prospectively the onset and duration of upper extremity peripheral nerve block (the mid-humeral block) in elderly and young patients undergoing emergency upper extremity surgery.**

Methods: **Consecutive patients aged > 70 yr or < 70 yr received a mid-humeral block with a small volume of ropivacaine, 0.75%. Five milliliters was injected onto each of the musculocutaneous, radial, ulnar, and median nerves. Time to complete sensory and motor block and durations of complete sensory and motor block were assessed. Results are shown as median and its 95% confidence interval.**

Results: **Median ages were 77 yr (95% CI, 72–81 yr) and 39 yr (95% CI, 27–46 yr) in the two groups. Both groups had similar times to complete sensory blockade. The elderly group had longer durations of complete sensory (390 min [range, 280–435 min] *vs.* 150 min [range, 105–160 min]; $P < 0.05$) and motor (357 min [range, 270–475 min] *vs.* 150 min [range, 90–210 min]; $P < 0.05$) blockade. Duration of complete sensory block was significantly correlated with age ($\rho = 0.56$; $P < 0.05$).**

Conclusions: **Age is a major determinant of duration of complete motor and sensory blockade with peripheral nerve block, perhaps reflecting increased sensitivity to conduction failure from local anesthetic agents in peripheral nerves in the elderly population.**

PERIPHERAL nerve blocks are often advocated for surgery in the elderly population.[1] Although there is a common perception among anesthesiologists that peripheral nerve blocks have longer duration in elderly patients *versus* younger patients, at the present time, no study has compared the characteristics of regional blocks in the two age groups.

In elderly patients, epidural bupivacaine induces a shorter onset,[2] a higher level of block,[3] and a longer duration of anesthesia compared with in younger patients.[4] On the other hand, the effect of epidural bupivacaine on duration of anesthesia in elderly patients remains controversial, as studies found either an increased or a decreased duration of sensory and motor blockade.[3,5] Furthermore, the influence of age on the characteristics of epidural block is not only observed with bupivacaine but also with ropivacaine.[4]

Several mechanisms may account for the increased sensitivity of older persons to epidural local anesthetic agents. As some evidence suggests that age does not influence the systemic absorption of bupivacaine from the epidural space,[5] clinical changes of epidural bupivacaine observed with aging may not be the result of altered pharmacokinetics but may be more related to changes in the pharmacodynamics of the drug in the older population.[2] Anatomic changes of the spine caused by aging may also increase the sensitivity to epidural local anesthetic agents. Among the changes, reduction of epidural fatty tissue may perhaps affect the spread of local anesthetic agents.[6] Finally, aging induces a decrease of sensory and motor conduction velocities and of the number of fibers, which may also partly account for these differences.[7]

The effect of age on peripheral blocks has not been studied and probably cannot be extrapolated from epidural studies. We think that we are now compelled to study the characteristics of onset and duration of regional blocks in elderly patients as the age of the population increases.[8] Therefore, the purpose of this prospective study was to compare onset and duration of brachial plexus block using ropivacaine, 0.75%, in elderly and younger patients undergoing emergency surgery for upper extremity trauma.[9] Because there is preclinical evidence supporting an increase in sensitivity to local anesthetic blockade in aged peripheral nerves, we hypothesized that duration of sensory and motor blockade in elderly patients would be equal or greater than that in younger patients.[7,10–12]

Methods

Patients

After Institutional Review Board approval (Comité Consultatif pour la Protection des Personnes se prêtant à la Recherche Biomédicale [CPPRB] Pitié-Salpêtrière) and obtaining informed consent, consecutive trauma patients undergoing emergency hand, wrist, forearm, or elbow surgery with mid-humeral block of the brachial plexus were studied between January 2000 and January 2002. Exclusion criteria were refusal of regional anesthesia by the patient, any neurologic or neuromuscular disease, diabetes mellitus, and clinical signs of cutaneous infection at the site of needle insertion. Patients were

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divided into two groups according to age: a young group (aged ≤ 70 yr) and an elderly group (aged ≥ 70 yr).

Technique of Mid-humeral Block of the Brachial Plexus

Standard monitoring was applied to all patients. Two anesthesiologists (X.P. or G.B.) experienced in the technique performed all mid-humeral blocks. After cutaneous landmarks had been drawn on the skin and after skin disinfection, a 22-gauge, 50-mm insulated needle (Stimuplex B; Braun, Boulogne-Billancourt, France) connected to a peripheral nerve stimulator (Stimuplex HNS 11; Braun, Melsugen, Germany) was used to identify nerves according to their specific motor-evoked response as follows: median nerve—flexion and pronation of the wrist, flexion of the second and third fingers; musculocutaneous nerve—arm flexion; radial nerve—wrist and finger extension; ulnar nerve—fourth and fifth fingers flexion and thumb adduction. Motor responses were sought using a peripheral nerve stimulator set at 1 Hz frequency and 1.5 mA current and reduced to 0.5 mA or less before injection of local anesthetic solution. The four nerves were always identified in the following order: radial nerve, musculocutaneous nerve, median nerve, and ulnar nerve. The local anesthetic agent used was ropivacaine, 0.75%, with 5 ml injected onto each of the four terminal nerves of the brachial plexus. Five milliliters of lidocaine, 2%, was injected subcutaneously on either side of the humeral artery to anesthetize the medial cutaneous nerves of the arm and forearm. The time to perform the block was defined as time from needle insertion to its removal. No patient received any intravenous medication during the procedure. Patients presenting with fractures had the block performed without removing the splint, and great attention was paid to minimize the magnitude of evoked motor responses to avoid pain at the fracture site.

Block Assessment

For the purposes of block assessment, time zero was defined as the time of removal of the insulated needle from the skin. Sensory and motor block were assessed every 5 min for 45 min thereafter by an anesthesiologist not involved in the placement of the block. Sensory block was assessed by pinprick on a three-point scale (2 = normal sensation, 1 = blunted sensation, and 0 = absence of sensation) in the peripheral sensory distributions of the median, ulnar, radial, and musculocutaneous nerves. A complete sensory block was defined as a score of 0 in each of the four areas. Otherwise, blockade was considered incomplete (score of 1 in at least one area). Onset time of complete sensory block was defined as the interval between time zero and the occurrence of a complete sensory block.

Motor block was assessed for voluntary motor responses by asking the patient to perform successively a flexion of the elbow (musculocutaneous), an extension of the wrist or of the fingers (radial), a flexion of the wrist (median), and an opposition of the thumb (ulnar). Motor block intensity was classified using a three-point scale (2 = normal movement, 1 = decreased movement, and 0 = no movement). Motor block was considered complete when motor response in each of the four distributions had a score of 0; otherwise, it was considered incomplete (score of 1 for at least one voluntary motor response). Onset time of complete motor block was defined as the interval between time zero and the occurrence of a complete motor block.

If the sensory block score was not 0 in at least one of the peripheral sensory distributions 45 min after time zero, the block was considered incomplete, and a complementary block was performed at the elbow (5 ml ropivacaine, 0.75%) to anesthetize the missed nerve or nerves.

Postoperatively, sensory and motor blocks were assessed hourly for 9 h after time zero using the aforementioned tests by the anesthesiology resident on call in the postanesthesia care unit. Recovery from sensory and motor blocks was defined as any score greater than 0 in any distribution. The durations of complete sensory and motor blockade were calculated for each patient as follows: (onset time to a complete sensory or motor block) − (time of recovery from complete sensory or motor block).

The elderly group was not only older compared with the young group, but also it essentially comprised women (19 women and 1 man). As a gender difference might also explain part of our results, we compared the durations of complete sensory and motor blockade among women of the elderly and young groups.

Statistical Analysis

In a preliminary study, we determined that the duration of complete sensory block was 180 ± 150 (SD) min in middle-aged patients. We estimated that at least 20 patients would be needed in each group to detect a 100% difference (doubling of the duration) with 95% certainty (1-β) and a two-sided 5% significance level (α). Because recruitment of elderly patients was expected to be slower than that of younger patients, patient accrual continued until 20 elderly patients had been included.

Data are expressed as median and its 95% confidence interval because most variables were not normally distributed (intensity of stimulation, onset times, and duration of complete sensory and motor block). Comparison of two medians was performed using the Mann–Whitney U test, and comparison of two percentages was performed using the chi-square test or the Fisher exact test when appropriate. Correlation analysis was performed using the Spearman rank test. All *P* values were two sided, and a *P* value of less than 0.05 was considered

Table 1. Patients' Characteristics According to Group Assignment

	Young Group (n = 27)	Elderly Group (n = 20)
Age (yr)	39 (27–46)	77 (72–81)
Height (cm)	170 (165–172)	161 (159–165)*
Weight (kg)	70 (63–77)	63 (55–68)
Body mass index (kg/m^2)	23.5 (22–25)	23.5 (22–26)
Male/female	18/9	1/19*
ASA physical status		
1	15 (56)	2 (10)
2	11 (41)	14 (70)
3	1 (3)	3 (15)
4	0	1 (5)
Surgical procedures		
Colles fractures	16 (59)	16 (80)
Other fractures	2 (7)	3 (15)
Wound and soft tissue surgery	9 (34)	1 (5)

Values are median (95% CI) or number (percentage).

*$P < 0.05$ *versus* young group.

significant. Analyses were performed using NCSS 6.0 software (Statistical Solutions Ltd., Cork, Ireland).

Results

Forty-eight consecutive trauma patients scheduled for emergency upper extremity surgery with mid-humeral block were enrolled. Failure of mid-humeral block occurred in only one patient in the young group; sensory block was not complete in this patient at 45 min, and the patient refused a complementary block, requiring general anesthesia for surgery. Therefore, the analysis was conducted in 47 patients (20 in the elderly group and 27 in the young group), whose characteristics are reported in table 1. Elderly patients were more likely to be women and with more significant disease, as indicated by American Society of Anesthesiologists (ASA) physical status, than younger patients (table 1). Even though elderly patients were shorter than younger patients, body mass index was similar between the two groups (table 1).

Intensity of stimulation before the injection of the local anesthetic agent was 0.38 mA (range, 0.33–0.40 mA) and 0.37 mA (range, 0.30–0.43 mA) in the young and elderly groups, respectively. Onset time of complete sensory block was comparable in both groups, whereas onset time of complete motor block was 5 min shorter in the elderly group (table 2). A complementary block to make up for an incomplete sensory block in one nerve distribution was performed at the elbow in five patients (two in the young group and three in the elderly group). No patient required more than one complementary block. All patients had complete motor block at 45 min, with the exception of one patient of the young group. In all patients, surgery was pain-free, and no additional analgesic or sedative drugs were required.

Table 2. Durations of Complete Sensory and Motor Blocks

Complete Block (min)	Young Group (n = 27)	Elderly Group (n = 20)
Sensory block		
Onset	30 (25–30)	27.5 (20–30)
Duration	150 (105–160)	390 (280–435)*
Motor block		
Onset	30 (30–35)	25 (15–30)*
Duration	150 (90–210)	357 (270–475)*

Values are median (95% CI).

*$P < 0.05$ *versus* young group.

Complete sensory and motor block lasted 2.6 and 2.4 times longer in elderly than in young patients (table 2). The increase in duration of complete sensory block was significantly correlated with age ($\rho = 0.56$; $P < 0.05$; fig. 1A), as was duration of complete motor block ($\rho = 0.46$; $P < 0.05$; fig. 1B). The subgroup analysis according to gender revealed that elderly women (n = 19) had longer duration of complete sensory (390 min [range, 280–405 min] *vs.* 150 min [range, 105–165 min]; $P < 0.05$) and motor (350 min [range, 270–475 min] *vs.* 112 min [range, 90–325 min]; $P < 0.05$) block compared with younger women (n = 9).

Discussion

As far as we are aware, this is the first study to characterize onset and duration of peripheral nerve block in a population of elderly patients. Onset time of complete

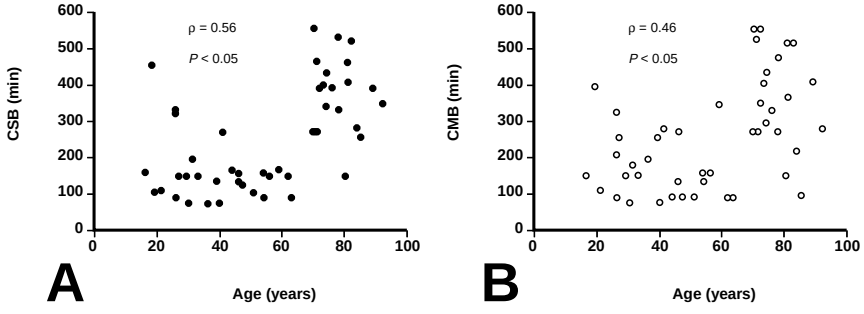

Fig. 1. The age of all patients (x-axis) in the elderly and young groups and complete sensory (CSB, *A*) or motor block (CMB, *B*) duration (y-axis) are shown. Postoperatively, sensory and motor blocks were assessed hourly for 9 h after time zero. Recovery from sensory and motor blocks was defined as any score greater than 0 in any distribution of the radial, median, musculocutaneous, or ulnar nerve. The durations of complete sensory and motor blockade were calculated for each patient as follows: (onset time to a complete sensory or motor block) − (time of recovery from complete sensory or motor block). Durations of complete sensory ($\rho = 0.56$; $P < 0.05$) and motor blocks ($\rho = 0.46$; $P < 0.05$) were significantly correlated with aging.

motor block was shorter in the group of elderly patients, whereas onset time of complete sensory block was not statistically different between the two populations despite a trend toward a shorter onset in the elderly group. The number of patients is probably insufficient to demonstrate a difference, as the estimated number of patients to be included into the study was based on the duration of complete block and not on the onset time of block. Surprisingly, in young patients, ropivacaine, 0.75%, behaved like a short-acting local anesthetic agent, providing approximately 2.5 h of anesthesia, whereas in elderly patients, ropivacaine, 0.75%, behaved like a long-acting local anesthetic agent, providing up to 6.5 h of complete sensory and motor blocks. Thus, mid-humeral block with a low-volume ropivacaine, 0.75%, was of short or long duration depending on the age of the patient.

The present study is in agreement with the current body of literature showing that multiple nerve stimulation techniques and small volumes of local anesthetic agents allow a reduction of the required volume of local anesthetic agents and an improvement of the success rate of regional blocks.[13] Koscielniak-Nielsen *et al.*[9] found a higher success rate when an axillary plexus block was performed with 20 ml of local anesthetic agents and targeted injections on the four terminal nerves of the brachial plexus compared with a single administration of a high volume (50 ml) of local anesthetic agents. At the lower limb level, Casati *et al.*[14–16] performed several studies on the minimal volume required to block the femoral nerve. Their results show that performing a femoral nerve block with multiple nerve stimulation and injection techniques, compared with the usual single-shot technique, allows an important reduction of the volume of local anesthetic agent to achieve the same clinical goal.

This study was designed to compare two populations of different ages. Thus, according to our basic hypothesis, both populations could not be homogenous. Patients were divided preoperatively into two groups, and a threshold of 70 yr was arbitrarily chosen during the study design as the limit between these two groups to ensure that the elderly patients would be made of physiologically old patients. The elderly group comprised almost all women (with the exception of one man). It should be noted that it is not possible to completely rule out any influence of sex on the duration of anesthesia because it is now well established that there are sex differences in the perception of pain and in the sensibility to analgesic drugs. Therefore, an influence of sex on the current results cannot be ruled out. Unfortunately, as durations of sensory and motor block were also longer in elderly than in young women, our results do not reinforce this hypothesis. Further, because no relationship was found between the administered ropivacaine dosage and body mass index, it is unlikely that this difference of action duration would be the result of a relative increase in the amount of ropivacaine administered in the elderly group compared with the young group. The stimulation intensity was also similar in both groups. Therefore, the observed difference cannot be explained by a closer distance to the nerves in one of the groups.

Conduction velocities, number of large diameter fibers, and peripheral nerve (Na^+, K^+)ATPase decrease during aging.[11,17,18] Thus, the most probable hypothesis for the observed difference involves alterations of nerve electrophysiology and sensitivity to local anesthetic agents. In an electrophysiologic study, Benzon *et al.*[19] demonstrated that vagus nerves from young and old rabbits were more sensitive to local anesthetic-induced conduction blockade, suggesting that smaller doses of local anesthetic agents are required for regional blocks in pediatric and elderly patients.[19]

This study was only intended to describe the characteristics of onset and recovery of mid-humeral block in elderly and young adults. Thus, we focused on the assessment of onset and duration of complete sensory and motor blocks. These time intervals might be only considered as a representation of the duration of surgical anesthesia. Therefore, no extrapolation can be made from these data on the actual duration of postoperative analgesia provided with low-dose ropivacaine in mid-humeral block.

In conclusion, after a mid-humeral block performed with a small volume of ropivacaine, 0.75%, complete sensory and motor blocks lasted longer in elderly compared with young patients (approximately 2.5 times longer), and a positive relationship was found between age and duration of complete sensory and motor blockade. Although we cannot completely rule out a theoretical minor influence of sex or of the ASA physical status on the action duration of local anesthetic agents, this study demonstrates for the first time that local anesthetic agents administered in peripheral nerve blocks have a dramatically different effect on the elderly population. However, further research is necessary to understand the mechanisms involved in this difference.

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