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Degree of Motor Block Measured by Bromage Scale is not Correlated with Muscle Relaxation

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Abstract

Background and Aim

Achieving adequate motor and sensory blockage in spinal anesthesia allows the comfortable performance of surgical interventions. However, in certain operations on the lower extremities, surgeons report that adequate muscle relaxation is not achieved. The purpose of this study was to evaluate muscle relaxation subsequent to the administration of spinal anesthesia in orthopedic cases of the lower extremities, using muscle monitoring (Train-of-four) (TOF) and comparing these values with motor and sensory block levels.

Methods

Ninety-four patients were divided into 3 groups after spinal anesthesia according to maximum sensory block levels. Group I: T10 (n=30), Group II: T8 (n=35), Group III: T6 (n=29). The patients' sensory, motor blocks and TOF values were recorded at the 5th, 10th, 20th, and 30th minutes.

Results

Significant differences were seen between groups ($p<0.001$) in terms of TOF values at the 5th, 10th, 20th, and 30th minutes. In Group III, with the highest sensory block level, the Bromage score was 3 in 28 of the 29 patients at the 30th minute, and the median TOF value was found to be 83.

Conclusion

It was seen in our study that as sensory and motor block levels increased with the level of spinal anesthesia, the TOF ratios that show muscle relaxation fell. However, the TOF values were still found to be above the 70% level indicating effective muscle relaxation. It may therefore be said that during spinal anesthesia, although maximum motor and sensory blockage is achieved, full muscle relaxation cannot always be ensured.

Keywords: Spinal anesthesia; Train-of-four; Muscle relaxation

Introduction

In lower extremity surgeries, surgeons not only expect adequate analgesia but also sufficient muscle relaxation. Spinal anesthesia provides excellent analgesia for surgery on the lower extremities, however, surgeons very often complain of inadequate relaxation when compared to general anesthesia.

The assessment of spinal anesthesia in terms of sensory and motor blockage is widely carried out by using the pinprick test and the Bromage scale [1]. A maximum level of motor block has generally been used as the clinical criterion during spinal anesthesia in orthopedic surgery. However, there are reports in the literature that the Bromage score provides too rough an assessment, and that alternative tests should be used [2-4].

In recent years, different models of nerve stimulation techniques have been developed for the purpose of nerve muscle conduction block monitoring when performing general anesthesia [5]. Four supramaximal warnings at 2 Hz frequency are given in Train-of-Four (TOF) method. Accordingly 4-stimulus amplitude, (T4) stimulus (T1) ratio indicates the degree of non-depolarizing block. This ratio is known as the "T4/T1 ratio" or "TOF ratio" [6]. Train-of-four stimulation is a noninvasive technique and it is used only in neuromuscular relaxant monitoring according to the literature.

We intended to evaluate and compare the degree of muscle block measured with bromage with muscle relaxation measured with TOF levels in lower extremity surgery. There are no data, however, on the assessment of muscle relaxation by means of such tests during spinal anesthesia. In the present study, our objective was to assess muscle relaxation during the course of spinal anesthesia by means of comparing motor block levels with TOF levels in the lower extremities.

Methods and Materials

The study was performed after the approval of the local ethics committee (from Adnan Menderes University) and written informed consent were gained of 94 patients, aged between 18-75, with an ASA physical status of I–III, who were scheduled to undergo elective surgery of the lower extremities.

Patients who were taking medications that would interfere with neuromuscular transmission (e.g., magnesium sulfate, anticonvulsants or polypeptide antibiotics) and those with neuromuscular disease were excluded from the study. Patients with peripheral temperatures of below 32°C during the neuromuscular monitoring calibration were also excluded.

Protocol

All the patients were monitored for electrocardiogram, non-invasive blood pressure, and peripheral oxygen saturation (SpO2). Venous access was achieved from the dorsum of the hand with an 18 G catheter and an infusion of Isolyte S 10 mL/kg/hour was initiated. In addition to routine monitoring, preparation was made to use the anesthesia monitor Datex-Ohmeda to carry out neuromuscular monitoring of the flexor hallucis brevis muscle. Before the electrodes were attached for nerve stimulation for the neuromuscular monitoring, the ankle on which the electrodes would be placed was cleaned and wiped with alcohol. The electrodes were placed as seen in Figure 1. The pattern of electrical nerve stimulation chosen was TOF.

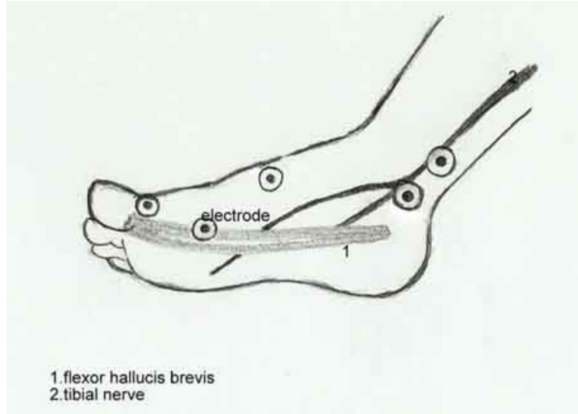

Figure 1. Attachment of the neuromuscular transmission module (M-NMT) sensor

No premedication was given to patients. Patients were then positioned on their sides, lying on the table on the side on which the operation was to be performed, and spinal anesthesia was done at the level of the L4–5 or L3–4 intervertebral space with a 25 G Quincke spinal needle; 2 mL of 0.5% bupivacaine was injected in 20 sec. Following the injection, the patients were placed for 10 minutes in a lateral decubitus position on the side that was to be operated.

The automatic start-up procedure was initiated on the neuromuscular monitor for calibration. The tibial nerve was stimulated, and the responses of the flexor halluces brevis were monitored. The stimulus was delivered in 15-second intervals for 0.2 ms at 0.2 Hz. The patients' sensory block levels were monitored with the pinprick test and their motor block levels on the Bromage Scale (0=no motor block--ability to raise extended leg against gravity; 1 = inability to raise extended leg, able to bend knee; 2 = inability to bend knee, able to flex ankle; and 3 = complete motor block) were assessed at the 3 levels. TOF ratios were recorded at the 5th, 10th, 20th and 30th minutes.

Ninety-four patients were divided into 3 groups according to maximum sensory block levels reached after spinal anesthesia. Patients in Group I reached level of T10 (n=30), Group II reached T8 (n=35) and Group III patients reached T6 (n=29) levels.

Statistical Analysis

Results are expressed as means ± SD, with using SPSS for Windows, statistical package. Pearson Chi square test was used for the comparison of non-parametric variables. When the demographic variables and normally distributed variables were compared using independent t-test, one-way ANOVA was used to compare the abnormally distributed variables of the three groups.

Statistically significant values were considered as $P<0.05$. In a one-way ANOVA study, sample sizes of 29, 29, and 29 are obtained from the 3 groups whose means are to be compared. The total sample of 87 subjects achieves

100% power to detect differences among the means versus the alternative of equal means using an F test with a 0. 05 significance level. The size of the variation in the means is represented by their Standard deviation, which are 6.04. The common Standard deviation within a group is assumed to be 6.63.

Results

There were no differences between the groups in terms of demographic data (Table 1). However, there were significant differences seen between groups ($p<0.001$) in terms of TOF values at the 10th, 20th, and 30th minutes (Figure 1-3). In Group III, the Bromage score was 3 in 28 of the 29 patients at the 30th minute, and the median TOF value was found to be 83 (Table 2, Figure 3).

In terms of TOF ratios, the patients were divided into 3 groups where the TOF values were 50–70, 70–90, and 90 and above. These three groups were compared at the 10th, 20th and 30th minutes in terms of 1–2–3 on the Bromage scale. Significant differences were observed between the Bromage score and the TOF values in the 10th, 20th and 30th minutes (Figures 1-4).

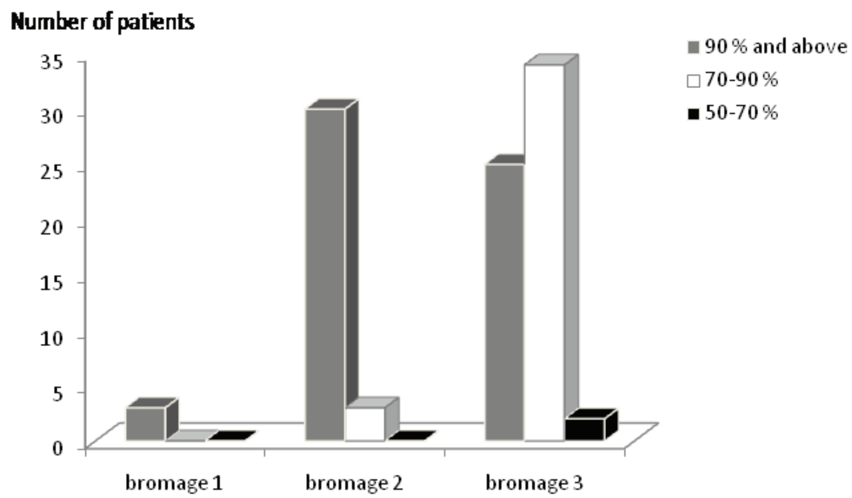

Figure 2. TOF values of all patients who developed bromage 1,2,3 motor block at 10th minute
Patients included in this study were divided into 3 groups in terms of TOF values (70–80, 80–90, and 90 and above). TOF values, bromage 3 compared with bromage 2 and bromage 1 were observed to be significantly lower (p< 0,0001)

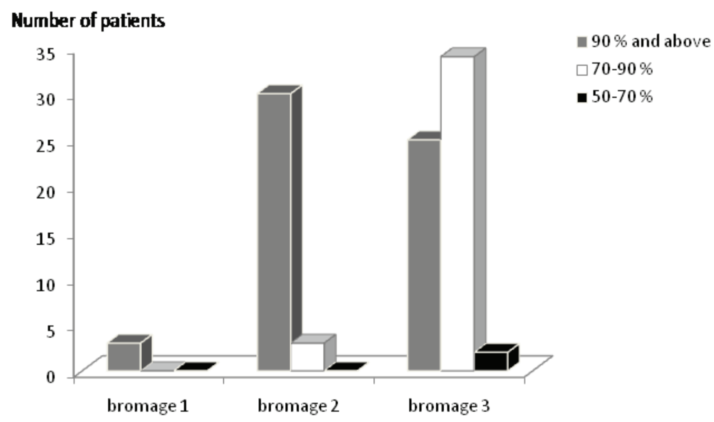

Figure 3. TOF values of all patients who developed bromage 1,2,3 motor block at 20th minute
Patients included in this study were divided into 3 groups in terms of TOF values (70–80, 80–90, and 90 and above). TOF values, bromage 3 compared with bromage 2 and bromage 1 were observed to be significantly lower (p< 0,0001)

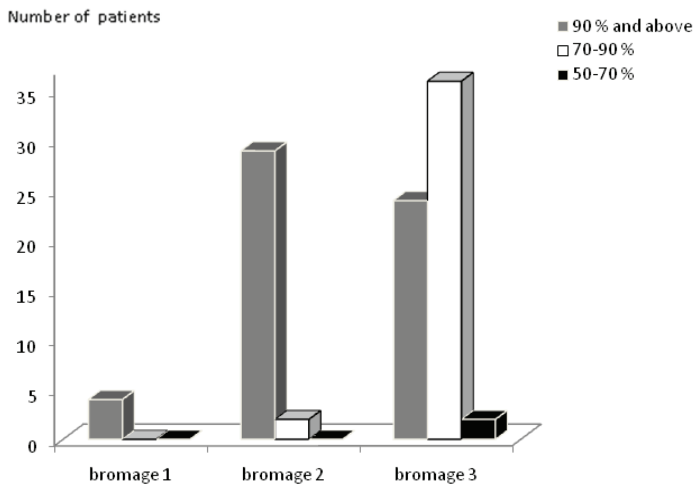

Figure 4. TOF values of all patients who developed bromage 1,2,3 motor block at 30th minute
Patients included in this study were divided into 3 groups in terms of TOF values (70–80, 80–90, and 90 and above). TOF values, bromage 3 compared with bromage 2 and bromage 1 were observed to be significantly lower ($p< 0,0001$)

Table1. Patient characteristics

	Group I (n=30)	Group II (n=35)	Group III (n=29)
Age (year)	50.8± 17.4	53.3±15.6	52.3±16.6
Gender (F/M)	8/22	15/20	18/11
Height (cm)	172.6± 8.3	168.6± 8.8	165.3± 9.2
Weight (kg)	76.5± 12.3	74.0± 10.5	72.6± 14.5

Values are numbers and means with (standard deviation).
There was no significant difference between the groups.

Table 2. Motor block levels at 10th, 20th, and 30th minutes

	Group I (n=30)	Group II (n=35)	Group III (n=29)
10th bromage1/2/3	2/23/5	1/11/23	0/3/26*
20th bromage1/2/3	2/22/6	0/9/26	0/1/28*
30th bromage1/2/3	2/22/6	1/7/27	0/1/28*

Values are numbers of patients
In group III, motor block levels increased more than in group 2 at 10th, 20th and 30th minutes ($p<0.0001$)

Discussion

The patients in our study were divided into 3 groups according to maximum sensory block levels reached after spinal anesthesia. The increase in the maximum level of sensory block in the groups was parallel to the increase in Bromage levels. At the same time, the increase in Bromage levels was correlated with a decrease in TOF ratios.

As a result of spinal anesthesia, the afferent and efferent innervation of somatic and visceral structures is interrupted. Loss of sensation and muscle relaxation does not stem from the spinal cord but from the spinal nerve roots. The local anesthetic injected into the cerebrospinal fluid is absorbed into the vessels by the nerve tissue and routed away from the area. There are studies that report that the administration of mepivacaine and bupivacaine in patients under general anesthesia prolongs the effectiveness of the muscle relaxant [7,8]. As it is mentioned in these studies, a local anesthetic injected into the spinal space may directly affect the neuromuscular junction or display a centralized effect that causes muscle relaxation. Some local anesthetics are absorbed into the systemic circulation when injected into the spinal space and at a sensory block at the T6 level, the whole of the neuromuscular junction at the lumbar level is directly affected. As it is known, the innervation of the lower extremities occur from the lumbar and sacral plexus, and the tibial nerve forms the anterior segment of the sacral plexus while the peroneal nerve forms the posterior one [7,8]. Thus, in our study, it was accepted that the tibial nerve, which we monitored using the TOF ratios, had been blocked.

The linear relationship between patients' sensory and motor blocks and TOF ratios may be explained by the mechanism of action of local anesthetics. It does not, however, explain why muscle relaxation is not adequate when the motor block is at maximum.

In a study comparing muscle relaxation in the upper and lower extremities with TOF stimulation following general anesthesia in paretic and nonparetic patients, it has been reported that the TOF measurement in the lower extremity was higher than that in the upper extremity in both nonparetic and paretic patients, but that in paretic patients, it was even higher compared to nonparetic cases [9]. In the same study, it was also reported that TOF in the paretic extremity needed to be 60–70% to be adequate for surgical relaxation [9]. The study used the tibial nerve and the halluces brevis muscle in the lower extremity to assess TOF ratios. In the present study, it was found that in patients that were clinically evaluated with a full block according to the Bromage score, TOF ratios were over 75%. The amount of tension present in muscles, even while at rest, is known as muscle tone and is dependent upon two physiological factors. These are the degree of activation of the contractile apparatus and the characteristics of the fundamental viscoelastic muscle and related soft tissue. In anesthesia, it is essentially the contractile apparatus that is controlled [10,11]. Besides certain pathological conditions, as skeleton muscle fibers do not contract when stimulated by action potentials, the muscle tone is completely dependent on the low-speed nerve impulses coming from the spinal channel. This is controlled partially by impulses carried from the brain to suitable anterior horn motor neurons and partially by the stimuli from muscle fibers imbedded in the muscle [12]. In spinal anesthesia, although impulses coming from the spinal channel are blocked, the impulses coming from the muscle itself still continue. We suppose that this situation may explain why full relaxation may not be obtained in the muscle even though a full motor block has been achieved with spinal anesthesia.

To conclude, although clinical muscle relaxation was parallel to the motor block and sensory block, we did not encounter TOF ratios that would indicate what would be considered adequate relaxation for surgery, even in patients at Bromage 3. Following spinal anesthesia, we should remember that we inadequately evaluate muscle relaxation with the assessments we make for sensory and motor blocks.

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