

# Installation of the hand influences acceleromyography measurement A comparison with mechanomyography during neuromuscular recovery

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**Summary :** Acceleromyography is commonly used to monitor perioperative neuromuscular blockade and to prevent residual neuromuscular blockade at the time of tracheal extubation. However, there are problems associated with this method, such as obtaining stable values, particularly beneath the surgical fields.

We compared TOF ratios obtained on both hands simultaneously using on one side mechanomyography and on the other acceleromyography, installed in four different ways : the hand simply lying on a board, fingers fixed with tape, use of the hand adaptor or the TOF-tube.

Further to maintaining free thumb movement, the TOF-tube improves feasibility of acceleromyography by reducing the measurement variability while retaining accuracy.

**Key words :** Neuromuscular monitoring ; acceleromyography ; mechanomyography ; rocuronium.

Extubation is one of the main safety concerns in anaesthesia. At the end of surgery, residual neuromuscular blockade interferes with the ventilatory response to hypoxaemia and the gag reflex with mechanical adductor pollicis train-of-four (TOF) ratio up to 0.9 (1, 2). Despite the use of intermediate acting neuromuscular blocking agents, residual neuromuscular blockade in the recovery room remains frequent (3). This causes discomfort to the patient. Furthermore, residual neuromuscular blockade can be associated with postoperative pulmonary complications (4). It is therefore recommended that the extent of neuromuscular blockade is monitored using objective means in each operating theatre (5, 6).

Because it measures the strength developed, mechanomyography (MMG) has for many years been the standard method of accurate quantification of neuromuscular block (7). Unfortunately, the complex set up and bulkiness of MMG makes its use in clinical practice difficult.

Since 1988, acceleromyography (AMG) is used in clinical practice as a simple, cheap, easy-to-use and reliable method of monitoring neuro-

muscular function (8, 9). However, there remains a few problems associated with this method. The thumb must be able to move freely in order to allow the measure of its acceleration. This is not always possible beneath surgical fields (10). Moreover, there are problems obtaining stable values, as BAILLARD *et al.* have recently demonstrated, making the interpretation of results difficult (11).

In this study, we describe four different installations of the hand adapted to the monitoring of neuromuscular transmission by AMG in clinical practice. The aim of the study is to compare TOF ratios at the end of surgery (time of potential extubation) obtained on both hands simultaneously using on one side MMG, and on the other AMG installed in four different ways.

## MATERIALS AND METHODS

After obtaining Ethics Committee approval and informed consent, 20 patients undergoing surgery under general anaesthesia were prospectively enrolled, excluding those who had any neuromuscular disease or receiving any drug known to interfere with neuromuscular transmission. Anaesthesia was induced and maintained with sufentanyl, propofol and rocuronium. The intubated patients were mechanically ventilated with oxygen/air mixture.

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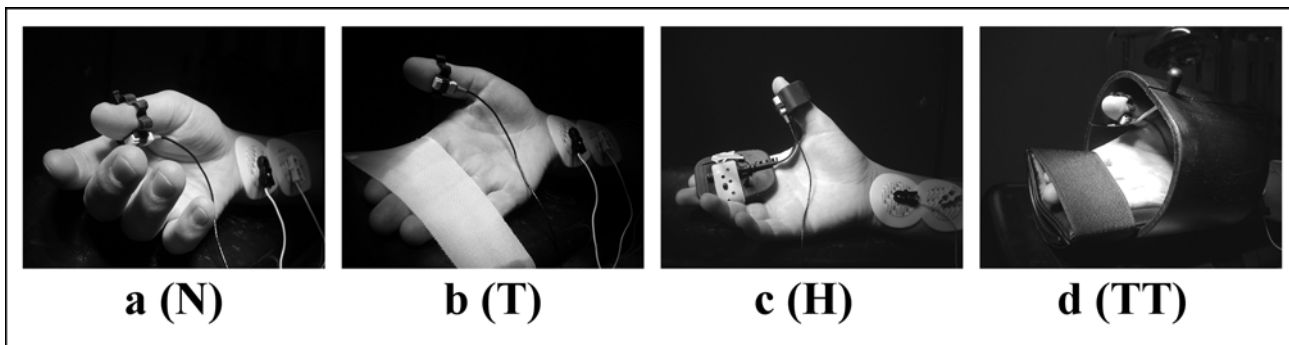


Fig. 1. — Installations of the hand for acceleromyography. a : Nothing ; b : Tape for fingers ; c : Hand adaptor ; d : TOF-tube

At the end of surgery, neuromuscular transmission was tested under anaesthesia. Patients were awoken up and extubated after completion of TOF measurements and with a minimum MMG TOF ratio of 0.9.

On each side, two ECG electrodes (Red dot, 3M Health Care, Germany) were stuck above the ulnar nerve at the wrist. On one side, chosen at random, we set up the MMG (Myograph 2000, Biometer, Denmark) firmly securing the hand and forearm on a board and applying a preload of 200-300 g to the thumb. On the other side, we installed the AMG (TOF-Watch SX, Organon, The Netherlands) by placing the piezzo-electric crystal on the thumb pad. All four installations (Fig. 1) were used in variable order on each patient.

The «N» (Nothing) installation simply left the hand on a board.

With the «T» (Tape) installation, four fingers were taped on the board preventing the thumb from coming into contact with them during its adduction.

The Hand Adaptor (Organon, The Netherlands) was used for the «H» installation. This is a device developed to improve the clinical feasibility of the AMG. A metallic strip joins the thumb to the second and third digits. Resistance to movement is minor. The strip allows the repositioning of the thumb back to the starting point after each contraction.

The «TT» installation used the TOF-tube (12). This protective rigid and tubular device allows stability of the wrist and hand, while at the same time ensuring total thumb mobility. It prevents outside forces from affecting the thumb and thus the acceleration transducer. A transverse elastic ensures thumb repositioning after each contraction, without interfering with the measurement of acceleration at the beginning of the movement.

The 2 Hz TOF ratio measurements (T4/T1), independent of initial calibration, were repeated

every 15 seconds using an intensity of stimulation of 60 mA. Four TOF ratios were recorded simultaneously on both hands before changing the AMG installation (four times).

Derived from the groups of four consecutive TOF ratios, indexes of variability (SD) and accuracy (mean) were compared between methods by Wilcoxon signed rank test. Correlation between measures of accuracy was assessed by Pearson coefficient, and prediction of one measure from another was estimated by linear regression. All statistical tests are two-tailed and were performed using SPSS software (SPSS Inc., Chicago, Ill).

TOF ratios are expressed in % as mean  $\pm$  SD.

## RESULTS

The population studied consisted of 8 women and 12 men ASA 1-3, aged  $59 \pm 16$  years, with a body weight of  $71 \pm 11$  kg for a height of  $170 \pm 8$  cm.

Results are listed on table 1. All MMG TOF ratio measurements were effective (320). Using AMG, 80 results were obtained from groups H and TT. Groups N and T had 11/80 and 3/80 values respectively which could not be interpreted. The TOF ratio obtained were between 41 and 102% with a mean from 75.8 to 89.3% according to the method. This corresponds well to the end of the neuromuscular block when the question of safety of extubation came into account.

Concerning variability, the SD of all AMG installations were significantly higher than MMG ( $p \leq 0.031$ ). The TT group was associated with less variability than groups N ( $p = 0.043$ ) and T ( $p = 0.014$ ) but not in comparison with group H ( $p > 0.5$ ) (Fig. 2).

Concerning accuracy, three AMG installations (groups T, H and TT) overestimated the TOF ratio measured by MMG on the contralateral hand ( $p \leq$

Table 1

Inter measurement variability (SD among 4 successive TOF ratio measurements) and accuracy (paired differences) of AMG (with four different installations : Nothing, Tape, Hand adaptor, TOF-tube) compared with simultaneous contralateral MMG  
 Correlation between AMG and MMG using Pearson coefficient (R)  
 Prediction of AMG TOF ratio from MMG 90% using linear regression  
 TOF ratio are expressed in %, as mean ± SD

TOF ratio %	MMG	N	T	H	TT
Variability : SD among groups	1.22 ± 1.1	4.6 ± 4.0	3.7 ± 2.8	3.1 ± 2.9	2.3 ± 2.4
Accuracy : Difference AMG – MMG		2.5 ± 11.6	7.3 ± 10.3	12.6 ± 10.7	7.7 ± 11.1
AMG TOF ratio prediction from MMG 90%		91.4	90.6	93.8	89.9
Correlation Coefficient (R)		N	T	H	TT
		0.750	0.674	0.681	0.743

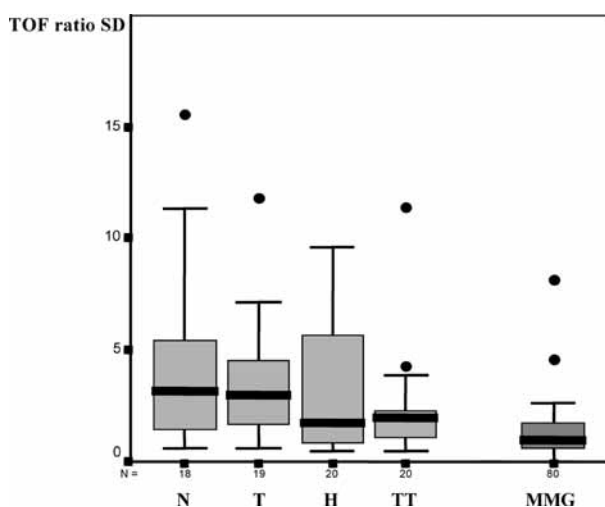


Fig. 2. — Standard deviations of the TOF ratios among the groups of four consecutive measurements, according to each method.

Boxes show SD values from the 25th and 75th percentiles with the median as bold line.

Whiskers are smallest and largest values that are not outliers (less than 1.5 box-lengths from 25th or 75th percentiles) which are depicted as dots.

0.011). However, the correlations with MMG values were good according to the following regressions :

$$\text{MMG} = 27.87 + 0.62 (\text{AMG N})$$

$$\text{MMG} = 0.46 + 0.91 (\text{AMG T})$$

$$\text{MMG} = -44.61 + 1.36 (\text{AMG H})$$

$$\text{MMG} = -18.81 + 1.14 (\text{AMG TT})$$

The regressions shown in figure 3 demonstrated that the overestimation became less severe with the TOF ratios approximating 90%. The reverse regressions  $\text{AMG} = f(\text{MMG})$  were performed to determine the AMG values which must be reached in order to correspond with a MMG TOF ratio of 90% (Table 1).

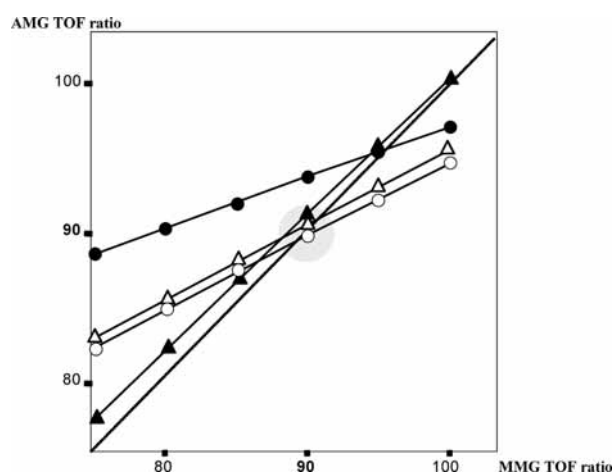


Fig. 3. — Regression lines from 75 to 100 %  
 Group N : ◻, group T : ◼, group H : ◃, group TT : ◅

DISCUSSION

The primary goal of neuromuscular blockade monitoring is to ensure complete recovery in order to allow safe extubation. The equipment used in clinical practice must therefore offer precise and stable measurements, especially around the critical TOF ratio of 0.9. On this topic, our results confirm the superiority of MMG over AMG. Unfortunately its clinical use remains difficult.

Although it is overall reliable (8, 9), the AMG has two problems influenced by its installation.

Firstly, there is a wide variability of TOF ratio, especially in groups N and T, which also have numerous failed measurements. Interpretation of single isolated values is difficult in clinical practice because of this variability, hence increasing the likelihood of mistakes in the evaluation of the level of neuromuscular blockade (3, 11). The use of the

Hand Adaptor and of the TOF-tube reduces this variability. This appears to be thanks to a better stability, as the thumb returns to its initial position after each contraction.

The second problem is the lack of accuracy of measurements. Considering the mean of four consecutive TOF ratios, the group N got the closest values to those of the MMG. But its high variability between measurements reduces this advantage in clinical practice. Groups T, H and TT overestimate slightly the TOF ratios, but benefit from good correlations with the MMG (especially group TT). Furthermore, these differences with the MMG are reduced for TOF ratios approaching 0.9. Although measurements seem to evolve slightly differently from one method to the other, they agree on the TOF ratio 0.9 being the key to safe extubation.

In conclusion, the TOF-tube and, to a lesser extent, the Hand Adaptor, improve the feasibility of AMG by reducing the measurement variability while maintaining accuracy. This allows reliable and easy confirmation of adequate recovery from neuromuscular blockade in clinical practice.

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