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Residual Curarization in the Recovery Room

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Although 20 years ago Christie and Churchill-Davidson^{1,2} proposed the use of nerve stimulators for evaluation of the degree of neuromuscular blockade during anesthesia, nerve stimulators are seldom used in Danish hospitals. Magnitude of neuromuscular blockade and requirement for reversal drugs are still usually based on clinical judgment from evaluation of the patient's inspiratory volume, and ability to open the eyes, put out the tongue, and sustain a head lift. The failure of anesthesiologists to use nerve stimulators regularly probably reflects the fact that the two most common stimulation methods, single (twitch) stimulation and tetanic stimulation, both have distinct disadvantages. The single-stimulation method is not very sensitive and is valid only when a prerelaxant control evaluation has been made. Tetanic stimulation is very painful and, therefore, not appropriate for use in the conscious patient. Ali *et al.*³⁻⁵ proposed the use of train-of-four neural stimulation for evaluation of nondepolarizing neuromuscular blockade during anesthesia. There is no need to elicit a prerelaxant control response, and the stimulus is less painful than a tetanic stimulus. The method is, in fact, well suited for use in both the operating theater and the recovery room.

The present study was designed to evaluate the efficacy of clinically accepted reversal of nondepolarizing neuromuscular blockade in the recovery room using the train-of-four neural stimulation.

MATERIALS AND METHODS

Subjects of the study were 72 adult patients who were admitted for surgical procedures to one of three

university hospitals in Copenhagen. On three different days chosen at random, all patients in each of the three hospitals given a nondepolarizing relaxant drug during anesthesia were included in the study. None of the patients had neuromuscular disease, nor received any drug other than relaxants that might alter neuromuscular function. They ranged in age from 20 to 86 years (mean 57 years). There were 45 female and 27 male patients.

Most patients were premedicated with diazepam, 0.2 mg/kg, orally, or meperidine, 50-70 mg, and atropine, 0.5 mg, im. Anesthetic techniques used were: thiopental-nitrous oxide-halothane (33 patients); nitrous oxide-droperidol-fentanyl (35); cyclopropane (2); nitrous oxide-pentobarbital-meperidine (2). In 54 patients intubation was facilitated by succinylcholine, 1.5 mg/kg, preceded by a small dose of a nondepolarizing muscle relaxant (*d*-tubocurarine, 3 mg, gallamine, 20 mg, or pancuronium, 1 mg). Doses of nondepolarizing muscle relaxants used during operation and the adequacy of reversal of the neuromuscular block by neostigmine were based on clinical criteria only (table 1). In no patient was a peripheral-nerve stimulator used during anesthesia. The anesthesiologist did not know that the patient's recovery from neuromuscular blockade would be evaluated postoperatively by nerve-stimulator studies. The tracheas of all patients were extubated before arrival at the recovery room.

Immediately after arrival at the recovery room—and as soon as the anesthesiologist had left—the train-of-four ratio³⁻⁵ was determined for every patient using a technique previously described.⁶ In 66 patients the nerve stimulator was only used for a few minutes until a train-of-four ratio was determined with certainty. However, in the cases of four patients who had train-of-four ratios of less than 40 per cent and clinical evidence of respiratory insufficiency, the responses to neural stimulation were recorded at appropriate intervals for as long as six hours after arrival at the recovery room.

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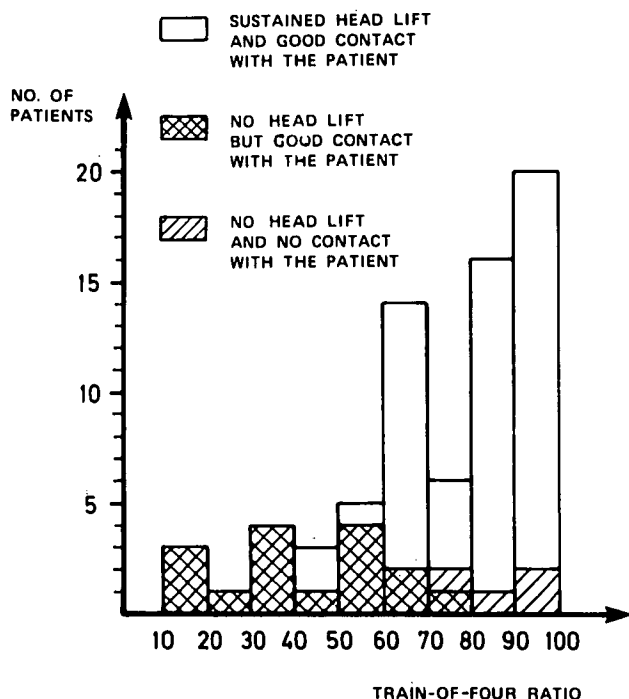


FIG. 1. Train-of-four ratios for 72 patients immediately after arrival in the recovery room.

Clinical assessment of recovery from the neuromuscular block (ability to cough, protrude the tongue, open the eyes, and sustain a head lift for 5 sec) was made in the recovery room by one of the authors.

The statistical analyses were performed using the chi-square test and Kruskal-Wallis test. Significance was assigned at a level of 0.05 per cent or less.

RESULTS

For 16 of 72 patients (22 per cent) studied immediately after arrival in the recovery room, the train-of-four ratios were less than 60 per cent, and for 30 patients (42 per cent), less than 70 per cent (Fig. 1). The ratios were not correlated with type of anesthesia, type of neuromuscular blocking agent, or hospital. Mean times from the last injection of relaxant to the injection of neostigmine and from injection of

neostigmine to evaluation of neuromuscular function were 81 min (range 15–180) and 26 min (range 10–65), respectively.

Fifty patients were given neostigmine, 2.5 mg, iv, at the end of anesthesia for reversal of neuromuscular blockade. Ten of these patients (20 per cent) had train-of-four ratios of less than 60 per cent after arrival at the recovery room. Six patients with train-of-four ratios of less than 40 per cent who were clinically still partly curarized were given additional neostigmine, 1–3 mg, in the recovery room. In three of these six cases, clinical recovery was dramatic, and in one of the three, the train-of-four ratio reached 70 per cent in 10 min. Unfortunately, time to 70 per cent train-of-four ratio could not be determined for the other two patients due to technical problems. In the remaining three cases there was no clinical response after the neostigmine injection, and the train-of-four ratio remained unchanged. Two of these patients had impaired renal function (times to 70 per cent train-of-four ratio: 100 and 340 min, respectively).

Of the 72 patients, 68 were awake (good verbal contact with the patient) on arrival at the recovery room. Sixteen of these 68 patients (24 per cent) were unable to sustain a head lift for 5 sec (fig. 1). Three patients who had train-of-four ratios of less than 60 per cent were able to sustain head lift for 5 sec (ratios: 47, 50, and 51 per cent). No patient with a train-of-four ratio of 40 per cent or less was able to do so.

DISCUSSION

The findings of the study give clear indication that irrespective of the chosen variable of recovery—a train-of-four ratio of 80, 70, or even 60 per cent, or head lift sustained for 5 sec—too many patients in the three hospitals had inadequate reversal of neuromuscular blockade on arrival at the recovery room. If a train-of-four ratio of 70 per cent is taken to reflect adequate recovery,⁷ then 42 per cent (30 of 72 patients) were not adequately recovered!

The validity of the study depended on the circumstance that the personnel did not know that it was in progress. Therefore, it was impossible to collect in-

TABLE 1. Dosages of Nondepolarizing Muscle Relaxants and Neostigmine

	Number of Patients	Total Dosage (mg)		Dosage in mg/kg/Hour	
		$\bar{x} \pm SD$	Range	$\bar{x} \pm SD$	Range
<i>d</i> -Tubocurarine	11	29 ± 9.3	21–54	0.19 ± 0.08	0.08–0.38
Gallamine	28	205 ± 60.5	100–340	1.04 ± 0.28	0.63–1.78
Pancuronium	33	7 ± 3.0	3–18	0.05 ± 0.01	0.03–0.09
Neostigmine	67*	2.1 ± 0.8	0.5–5.0		

* Five patients were not given neostigmine for reversal.

formation retrospectively about the specific criteria applied in determining sufficiency of reversal of block in the individual patient. That 24 per cent of all awake patients could not sustain a head lift for 5 sec on arrival at the recovery room suggests that, often, insufficient attention was given to clinical signs of residual curarization.

It has been stated that neostigmine, 2.5 mg, is sufficient to antagonize a nondepolarizing block in most adult patients.^{8,9} Our findings do not support this conclusion. The effectiveness of neostigmine depends on both the degree of neuromuscular blockade and the concentration of relaxant at the time of reversal.^{8,10,11} Katz,⁸ using single twitch, found that when the twitch height during neuromuscular blockade was at least 20 per cent of the preoperative control value, time from neostigmine injection (2.5 mg) to attainment of control twitch height was 3–14 min. When twitch height was less than 20 per cent, restitution took 8–29 min. It can be expected that recovery may take longer when reversal of an even more pronounced neuromuscular blockade is attempted. The nature of our study entails that the actual degree of neuromuscular blockade and the concentration of relaxant in the individual patient at the time of attempted reversal are matters of speculation. It is therefore possible that in some patients the maximal effect of neostigmine was not reached at the time of measurement in the recovery room—10 to 65 min after attempted reversal. However, taking a train-of-four ratio of 70 per cent to reflect adequate clinical recovery,⁷ the present findings indicate that in about 40 per cent of all patients receiving nondepolarizing relaxants in clinical practice, it is necessary to give neostigmine in doses greater than 2.5 mg, if establishment and reversal of neuromuscular blockade are based on clinical criteria alone. If neuromuscular transmission were monitored throughout anesthesia, the number of patients needing more than 2.5 mg neostigmine would probably be much smaller, partly because overdosage of relaxants could be avoided, and partly because the effects of neostigmine could be more easily evaluated.

Our results emphasize three points: first, that residual curarization in the recovery room remains a problem in patients not monitored with a nerve stim-

ulator; second, that anesthetists tend toward the use of high dosages of relaxants and are giving insufficient attention to the problem of residual curarization; third, that in the face of such relatively high relaxant dosages, a total dosage of neostigmine of 2.5 mg is insufficient for reversing neuromuscular blockade in about 40 per cent of patients. As we have found train-of-four nerve stimulation useful in evaluating residual curarization and in teaching the rational use of muscle relaxants, we recommend that neuromuscular monitoring be used more extensively during anesthesia, as well as postoperatively, for titrating reversal with anticholinesterase drugs.

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