Use of the peripheral nerve stimulator

RICHARD J. JONES, MD
Detroit, Michigan

The author discusses various procedures for assessing the patient's degree of muscle relaxation utilizing a peripheral nerve stimulator. Based on clinical observation, a preferred method is offered.

To obtain the relaxation necessary for certain surgical procedures, the usual technique is to administer a pre-calculated dose of non-depolarizing muscle relaxant. The most common method to calculate the correct dosage is to multiply the patient's weight by an average recommended figure that varies from one relaxant to another. Although this method generally produces satisfactory relaxation, we have seen cases where more relaxation was required, making additions to the calculated dose necessary.

Conversely, we have seen cases that were extremely difficult or even impossible to reverse upon termination of surgery. In most cases, this suggests that too much muscle relaxant was given. This situation was particularly prevalent when Pavulon® was first introduced into this country; many practitioners relied upon the upper end of the dosage scale to produce relaxation in their patients.

These incidences clearly demonstrate that the calculated dose method of giving muscle relaxants, although adequate in the average situation, is little more than an educated guess. With the many variants that come into play with each individual patient, it is evident that a simple, reliable method of titrating muscle relaxants would give a more exacting, accurate anesthetic dosage, and remove some of the guesswork from our task. Such a method would increase the margin of safety of the anesthetic. The peripheral nerve stimulator, already available on the market, provides this method.

Increasing the margin of safety

Investigations involving the use of this instrument have pointed to other factors that, when properly utilized, also add to the margin of safety. It has been the practice of many anesthetists to avoid reversing non-depolarizing muscle relaxants at the end of the procedure if the patient demonstrated what seemed to be an adequate tidal volume. This philosophy seemed reasonable until 1967 when Paton and Waud showed that a muscle could be made to contract fully with only 20-25% of the receptors in the muscle available for use. When applied to the respiratory muscles, a patient could conceivably have an adequate tidal volume but still be 75-80% paralyzed.

This implies that patients have a very small margin of safety available to them should something occur requiring them to exert more strength than the partially recovered respiratory muscles could manage.

An obstructed airway momentarily unnoticed in a busy recovery room, or more complex events such as electrolyte shifts and temperature changes may affect the ability of the muscles to contract efficiently. This is perhaps one reason why many patients experience post-operative difficulty, reflected in the high number of law suits involving anesthesia.

The majority of experts in the muscle relaxant field believe that almost all patients who have received a non-depolarizing muscle relaxant should be given a reversal agent at the end of the case, whether their tidal volume appears normal or not. There are of course, exceptions to this rule, for example, when a patient (especially one with...
severe cardiac or pulmonary problems) requires extensive mechanical post-operative ventilation until respiration is adequate.

In circumstances such as this, the use of the peripheral nerve stimulator can not only provide the anesthetist with a reliable guide to the patient's available muscle strength, but it also enables the anesthetist to use as little muscle relaxant as possible. This makes reversal of the relaxant less difficult, and increases the postoperative margin of safety.

The peripheral nerve stimulator is not a new instrument. The most familiar model, the Block-Aide Monitor, has been in use for a number of years. This instrument utilizes an electrical stimulus, usually applied over the area of the ulnar nerve, and provides either a series of single contractions or one tetanic contraction of the flexor muscles of the hand. Since the initial popularity of the Block-Aide Monitor, more sensitive tests of muscle relaxation and more versatile peripheral nerve stimulators have been developed.

**Testing the patient's response to tetanic stimuli**

Waud and Waud have described three different tests that can be performed with a peripheral nerve stimulator. These tests give us more reliable information concerning the patient's muscular relaxation than other methods. The investigators point out that, of the three tests, the older single twitch response is the least sensitive because it returns to normal limits while the patient remains 75-80% paralyzed. Furthermore, this test has the added disadvantage of requiring that a control be established prior to administration of the muscle relaxant.

Waud and Waud found that the patient's response to certain tetanic stimuli is a much more sensitive indication than the single twitch. Tetanic stimuli of three strengths were tested: 30 Hertz, 100 Hertz and 200 Hertz, each were of 5 seconds in duration. (A summary of these results is shown in Table 1).

With a 30 Hertz tetanic stimulation, the strength of contraction returned to normal at the same level of paralysis (75-80%) as was demonstrated when using the single twitch. This suggests that the two tests are similar in information rendered.

A tetanic stimulus of 100 Hertz, however, did not return to normal until the patient was only 50% paralyzed, thus increasing the margin of safety available at that time. It was demonstrated that a 200 Hertz tetanic stimulus returned to normal only when the patient was 30% paralyzed, thus increasing the margin of safety even further. The disadvantage of the latter two tests is that they are painful for awake patients and are therefore limited to patients still under anesthesia.

**Advantages of the “train of four” technique**

In this day of busy surgical schedules, it can be disadvantageous to take valuable time establishing control values for the single twitch and tetanus stimuli tests. Instead, a test that does not require a control would be of greater value to us.

In 1968, Roberts and Wilson assessed the progress and treatment of myasthenia gravis patients by using a series of four supramaximal stimuli to assess the resulting exponential decline in twitch heights when a nerve block is present. In 1970, Ali, Uting and Gray investigated the twitch response to various frequencies of nerve stimulation in an attempt to assess the degree of recovery from antidepolarizing neuromuscular blocks in human subjects. They selected as the ideal test a series of four stimuli, the four being repeated at selective intervals, with the height of each twitch being recorded. Thus, the modern version of the *train of four* came into being as a series of four supramaximal stimuli with a strength of 2 Hertz given within a 2-second time span.

It was found that the ratio of the amplitude of the fourth-, third- and second-evoked response to the amplitude of the first response in the same train, offered a convenient method for assessing the patient's present state of paralysis.

The relationship between the percentage of neuromuscular blockade in the patient and the train of four suppression is shown in Table 2. When the fourth response is abolished, the patient is 75% paralyzed. Subsequently, the degree of paralysis increases as responses are abolished until all four elicit no response. This indicates that complete paralysis has occurred.

This test can be compared with the subjective measurements long used to assess the patient's strength after paralysis. With a neuromuscular block of 74±5, patients should be able to lift their heads for 5 seconds or more, open their eyes.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Return to Control Level of Contraction</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Strength of Tetanus</strong></td>
<td><strong>% Neuromuscular Block</strong></td>
</tr>
<tr>
<td>Hertz/Second</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>75-80</td>
</tr>
<tr>
<td>100</td>
<td>50</td>
</tr>
<tr>
<td>200</td>
<td>30</td>
</tr>
</tbody>
</table>
widely, cough, protrude their tongues, have a vital capacity of at least 15-20 ml/kg and sustain a tetanus stimulation of 30-50 Hertz for 5 seconds.

By utilizing the train of four, we gain the advantage of having a simple tool for estimating the degree of paralysis in the patient and are able to titrate accurately the amount of relaxant required at any stage of the surgical procedure. It also removes the disadvantage of establishing control responses necessary with both the single twitch and tetanus tests.

Also, as reported in laboratory muscle preparations of animals, the diaphragm has a greater resistance to relaxants than peripheral muscles. Should this apply to human subjects as well, it is worthwhile to utilize a peripheral nerve stimulator.

Conclusion

Three different procedures for assessing the degree of muscle relaxation with a peripheral nerve stimulator have been reviewed. Of the three, the train of four test is easiest to apply. Although it is not the most accurate of the three, the results are well within the range of usefulness to the anesthetist.

If a peripheral nerve stimulator is used routinely during surgery, we can reduce the amount of relaxant used during each procedure and also lessen the possibility of the patient possessing inadequate muscle ability to overcome any stressful situations that may arise postoperatively. This would, in effect, increase the margin of safety for patients, something we must all strive to do if we are to give the safest possible anesthetic at all times.

REFERENCES


AUTHOR

Richard J. Jones, MD, received his BS degree from Michigan State University and his medical degree from Howard University College of Medicine, Washington, D.C. He interned at Mount Carmel Mercy Hospital, Detroit, Michigan and served his residency at Henry Ford Hospital in Detroit, Michigan. While in the U.S. Army, he was Chief of Anesthesiology at the 8th Field Hospital in South Vietnam and at Irwin Army Hospital in Fort Riley, Kansas. Dr. Jones was appointed Assistant Chief of Anesthesia and Respiratory Care and Director of the School of Nurse Anesthesia at Mount Carmel Mercy Hospital in 1971 and named Chief of Anesthesia at Southwest Detroit Hospital in 1974.