Anesthetists frequently provide intraoperative muscle relaxation in addition to general anesthesia. However, visual interpretation of the effect of neuromuscular blocking drugs is not always possible.

This study examined two alternative methods (electromyography/electrocardiography [EMG/ECG] and mechanical/ECG) of interpreting neuromuscular blockade and compared these methods to visual interpretation. EMG/ECG and mechanical/ECG methodologies were found to provide reliable valid intraoperative interpretation of nondepolarizing neuromuscular blockade for single-twitch and train-of-four stimuli.

EMG/ECG and mechanical/ECG measures of neuromuscular blockade were performed with an electrocardiographic monitor and a pressure transducer, respectively. Both EMG/ECG and mechanical/ECG, when compared to visual interpretation, were found to be equally, and usually more, valid indicators of neuromuscular blockade. The clinical significance of this study is its contribution to quality care and patient safety. When visual monitoring of neuromuscular blockade is not feasible, either EMG/ECG or mechanical/ECG provide an alternative method of monitoring neuromuscular blockade.

Introduction

It is common practice to use adjunctive neuromuscular blocking drugs during general anesthesia to provide muscle relaxation. However, determining the degree of blockade can be difficult. The peripheral nerve stimulator (PNS) is used to determine the degree of residual muscle activity in the presence of neuromuscular blocking agents. In standard clinical anesthesia practice, the degree of neuromuscular blockade is visually evaluated through interpretation of the evoked muscular response to the PNS. Interpretation of the evoked PNS response allows the anesthetist to titrate neuromuscular blocking drugs, thereby ensuring adequate muscle relaxation as well as prompt reversal of neuromuscular blockade.

Although visually monitoring the degree of neuromuscular blockade is the clinical standard, certain surgical procedures preclude visual access to the site stimulated by the PNS. The research problem addressed by this study involved the need to validate alternative methods for monitoring the degree of neuromuscular blockade in patients for whom visual access is not available. The purpose of this study was to determine if two nonvisual measures (electromyography and mechanical) of nondepolarizing neuromuscular blockade could be substituted and prove a reasonable alternative to visual interpretation of PNS stimuli.

The proposed alternative methods were developed from concepts derived from a review of the physiology of neuromuscular transmission and the action of specific blocking agents. A review of that material will be presented, followed by a discussion...
of evaluation of neuromuscular blockade and then a full discussion of this study.

**Physiology of neuromuscular transmission**

A motor nerve enters a muscle and then branches repeatedly depending on how far the movement is for that particular muscle. Neuromuscular transmission starts with a nerve action potential at the nerve terminal and terminates with depolarization of the postjunctional membrane. In summary, neuromuscular transmission has multiple components. First, acetylcholine (ACH) is synthesized in the nerve terminal from choline and acetate. Depolarization of the nerve terminal results in the influx of sodium and calcium and the efflux of potassium ions. The effect of the action potential is a quanta release of ACH molecules. ACH diffuses across the synaptic cleft and interacts through a complex process with the muscle at the postjunctional membrane end-plate receptors to produce depolarization and muscle contraction. ACH is rapidly hydrolyzed by the enzyme acetylcholinesterase, and the neuromuscular junction's capacity to be depolarized is reestablished.

**Neuromuscular blockade pharmacology**

Anesthetists use two major classes of neuromuscular blocking drugs to counter depolarization at the neuromuscular junction and produce muscular relaxation. The depolarizing neuromuscular blocking drugs (e.g., succinylcholine) act like a massive dose of ACH. Therefore, by the law of mass action, the neuromuscular junction remains depolarized and muscles remain relaxed until hydrolysis of the depolarizing muscle relaxant drug occurs.

The nondepolarizing neuromuscular blocking drugs (e.g., atracurium, vecuronium, pancuronium, d-Tubocurarine) were the primary focus of this study. The nondepolarizing muscle relaxants compete with ACH for the end-plate receptor sites and prevent depolarization of the postsynaptic membrane (i.e., the muscle). The nondepolarizing muscle relaxant drugs are reversed with anticholinesterase drugs. Anticholinesterase acts to increase the concentration of ACH. By the law of mass action, ACH displaces the nondepolarizing drug which allows ACH to act at the end-plate receptor site.

**Interpreting neuromuscular blockade**

Movement of respiratory muscles, surgical relaxation and sustained head lift are indices of the degree of neuromuscular blockade; however, during the intraoperative period the most effective monitoring technique to determine the effect of nondepolarizing muscle relaxant drugs is interpretation of the evoked response to PNS stimuli. The stimulus from a PNS, when applied to a motor nerve with intact neuromuscular transmission, will result in the contraction of those muscles supplied by the stimulated nerve. The stimulus from the PNS must be of supramaximal intensity, that is, of sufficient intensity to ensure that all muscle fibers supplied by the nerve will contract. As muscle relaxant drugs are administered, the force of muscle contraction will be reduced. The measured reduction in contractile force at unchanged supramaximal stimulation is an expression of the degree of neuromuscular blockade. The adductor pollicis muscle is innervated solely by the ulnar nerve.

This study included recording the mechanical force and electromyographic (EMG) activity of the patient's adductor pollicis muscle.

**Type of stimulation.** Clinical nerve stimulators are capable of eliciting three basic types of supramaximal stimuli: single twitch, tetanic and train-of-four (TOF). Supramaximal single-twitch stimulation is delivered at a frequency of 0.15 Hz and the impulse is rectangular with a duration of 0.2 milliseconds. The twitch response is not reduced until 75-80% of the nicotinic receptors in the neuromuscular end plate are blocked; the response disappears completely when 90% of the receptors are blocked. Tetanic stimulation is a continuous rapid rate (50 Hz or 100 Hz). The most physiologic tetanic stimulation is 50 Hz for five seconds which is equivalent in stress to a maximal voluntary effort. As neuromuscular blockade increases, the tension, or sustained tetanic response to the tetanic stimulation, decreases. This phenomenon is known as fade.

Tetanic stimulation results in a large amount of ACH release from immediately available stores in the nerve terminal. As these stores become depleted, the rate of ACH release is proportional to the rate ACH is manufactured. Fade develops as a result of both the decrease in rate of release of acetylcholine and decrease in the muscle's ability to rapidly respond to the tetanic stimulation. Tetanic stimulation only gives a crude interpretation of degree of block when compared to TOF stimulation. The tetanic stimulus is primarily useful when it is used in conjunction with post-tetanic twitch to interpret intense nondepolarizing neuromuscular blockade in the absence of response to single-twitch or TOF stimulation. On average, post-tetanic twitch appeared 36 minutes before response to TOF during pancuronium administration and eight minutes before response to TOF during vecuronium administration. The post-tetanic twitch may be present when the tetanic stimulus has disappeared. The phenomena of post-tetanic twitch facilitation is due to the mobilization of ACH from the reserve to the readily available stores. The in-
increased concentration of ACH outlasts the period of tetanic stimulation.

Train-of-four includes the concepts TOF fade and TOF ratio.\textsuperscript{4,6} TOF is defined as four individual supramaximal stimuli at intervals of 0.5 seconds over a period of 2 seconds (2 Hz). The TOF ratio is calculated by comparing the amplitude of the fourth response of the TOF to the first response of the TOF. TOF fade refers to both the decrease in size and number of subsequent stimuli following the initial stimulus in one TOF.

The TOF has several advantages compared to single-twitch or tetanic stimulation.\textsuperscript{1,3,4,6,11} First, the TOF allows the anesthetist to quantitatively estimate the degree of neuromuscular blockade without a control response. The TOF at 2 Hz (2 stimuli per second) is not as uncomfortable to a conscious patient as a 50 Hz (50 stimuli per second) tetanic stimuli. The TOF ratio of 0.8 or greater corresponds with other indices of adequate reversal of neuromuscular blockade. The degree of neuromuscular blockade ranging from 75-95% twitch inhibition defines satisfactory clinical muscle relaxation.\textsuperscript{6} During nondepolarizing neuromuscular block, the fourth response of the TOF is eliminated at 75% twitch inhibition; the third and fourth TOF responses are eliminated at 80% twitch inhibition; and the second, third, and fourth TOF responses are eliminated at 90% twitch inhibition.

Unlike tetanic stimulation, the TOF does not affect the subsequent patterns of recovery from neuromuscular blockade (i.e., it does not cause poststimulation facilitation of subsequent PNS stimuli). To ensure that the PNS stimulus does not alter interpretation of neuromuscular blockade, nerve stimulation frequency limits have been established.\textsuperscript{1} The single-twitch, TOF or tetanic nerve stimulation should not be administered more frequently than every 6–10 seconds, 10 seconds or 6–10 minutes, respectively.

Intraoperatively, in order to achieve sufficient muscle relaxation, it may be necessary to increase neuromuscular blockade to the extent that there is no reaction to nerve stimulation. Respiratory movements may occur with twitch depression of 90% due to decreased sensitivity of respiratory muscles to myoneural blocking drugs, surgical stimulation during superficial anesthesia or peripheral cooling which results in respiratory muscles recovering faster than cooler peripheral muscles secondary to inhibited diffusion of myoneural blockers.\textsuperscript{13}

**Methods for response interpretation**

There are five methods used to interpret the PNS-evoked muscular response: visual, tactile, electromyographic, mechanical and neuromuscular transmission analysis.\textsuperscript{2,4,6} Neuromuscular transmission studies are primarily used in formal drug studies and are not in general clinical use. As previously mentioned, the standard method is visual interpretation of the PNS-evoked response. Often anesthetists will use the tactile method when visual access is impossible. Tactile methods are generally impractical or impossible whenever visual access is a problem. The only two clinically feasible alternatives to visual/tactile interpretation are the electromyographic and mechanical methods.

- **EMG/ECG interpretation.** Generally, EMG studies are conducted with sophisticated computerized monitors. These expensive, complicated instruments are not available in many operating suites. However, an adequate electromyography reading can be obtained from a simple rearrangement of the leads for the standard electrocardiograph (ECG) monitor, which is uniformly available in operating room suites. In this study, this arrangement will be referred to as the "EMG/ECG." The EMG records the compound action potential, that is, the action potentials of many muscle fibers rather than a single muscle fiber.\textsuperscript{2}

  An oscilloscope and ECG strip chart recorder can be used for electromyography.\textsuperscript{2} The ECG leads are positioned at the insertion of the stimulated muscle, and the PNS-evoked activity is reproduced on the oscilloscope and strip chart recorder.

- **Mechanical/ECG interpretation.** Mechanical methods of interpreting neuromuscular blockade require recording the evoked force of the muscular contraction.\textsuperscript{2} Any mechanical force (for example, muscular contraction) can be measured with a pressure transducer.

  Transducer is the general term for an instrument that converts a mechanical force into an electrical signal. The pressure transducer most commonly used in biomedical instrumentation is a mechanical or displacement transducer, so called because it consists of a mechanical element that is displaced as a result of changes in pressure. A fluid pressure wave in the dome results in displacement of a mechanical element in the transducer hub. The displacement in the hub causes a proportional change in the electrical signal emanating from the transducer.\textsuperscript{14} The mechanical pressure transducer used in the anesthesia clinical setting is the standard strain gauge pressure transducer which allows measurement of low-frequency parameters (e.g., central venous pressure) when the transducer is connected to an ECG monitor.\textsuperscript{15} Mechanical activity of neuromuscular blockade can be recorded using the ECG and pressure transducer and will therefore be called "mechanical/ECG."

  The specific purpose of this study was twofold:
(1) to determine intraoperatively, during general anesthesia requiring nondepolarizing muscle relaxation, the effectiveness of both of the proposed EMG/ECG and mechanical/ECG methods of interpreting PNS stimuli (when compared to visual interpretation); and (2) to show that the proposed EMG/ECG and mechanical/ECG interpretation methods are reliable substitutes if visual interpretation is impractical.

**Methodology**

- **Design and sample.** A modified counterbalance design was used, that is, visual evaluation of the response to a particular PNS stimulus served as the control while simultaneous EMG/ECG and mechanical/ECG responses to the same stimulus were recorded. Therefore, every PNS stimulus was simultaneously evaluated by visual, EMG/ECG and mechanical/ECG methods. Since each PNS interpretation method (visual, EMG/ECG and mechanical/ECG) was performed simultaneously and acted as its own control, the dosage schedules and time periods of the nondepolarizing drugs did not have to be regulated. This allowed random sampling to be done before, during and after the infusion of a nondepolarizing muscle relaxant. All the subjects received an infusion: 11 subjects received atracurium (0.5 mg/cc) and 1 subject received vecuronium (0.1 mg/cc).

Four to six random simultaneous samples for each subject were taken during the intraoperative period when different degrees of neuromuscular blockade existed. There was a total of 66 samples obtained for the 12 subjects. A sample consisted of PNS stimuli administered in a prescribed order. Since the visual response to the PNS stimuli acted as the control, the simultaneous responses of the EMG/ECG and mechanical/ECG were recorded while each subject received a nondepolarizing muscle relaxant infusion.

Subjects were 12 adult males, ASA Class II-III, 56-77 years old, 60-107 kilograms body weight with no prior history of neuromuscular disease. All subjects were scheduled for surgery at the Cleveland Veterans Administration Medical Center, were given general anesthesia with adjunct nondepolarizing muscle relaxant drugs and were scheduled for surgical procedures which permitted visual, EMG/ECG and mechanical/ECG interpretation of ulnar nerve neuromuscular blockade.

- **Apparatus/instruments.** Ulnar nerve stimulation was achieved using the Bard Critical Care (Model 750 Digital®) peripheral nerve stimulator. The Mennen ECG monitor (Model 742®), with built-in strip recorder and ECG cable, was used to simultaneously observe and record the EMG and transduced mechanical pressure waves. Mechanical interpretation of pressure was accomplished with a standard strain gauge pressure transducer (Gould P23XL®). Other materials included a dorsal support arm board for the wrist and hand, two 250 ml bags of saline, one set of low pressure and one set of high pressure intravenous (IV) tubing and one pressure bag. Data interpretation was performed using the Statistical Package for the Social Sciences (SPSS).

  - **Procedure.** Approval of the Cleveland Veterans Administration Medical Center's human investigative and Case Western Reserve University's School of Nursing review boards was obtained. The study was explained in detail and informed consent was obtained. The principal investigator's role was limited to data collection. The investigator did not serve as anesthetist for any subject and had no role in selecting or administering anesthesia. General anesthesia was provided using a balanced narcotic-inhalation technique and adjunct nondepolarizing muscle relaxant infusion. Normal core body temperature was maintained.

Prior to the induction of general anesthesia, each patient was prepared as in Figure 1. Once the patient was supine on the operating table, one arm was placed on a standard padded operating table arm board in a supine position with the palm up and the arm positioned at approximately 80 degrees to the torso. Ulnar nerve stimulation of the adductor pollicis muscle was achieved by attaching the PNS at the elbow with two cutaneous electrodes; the negative electrode was placed at the ulnar notch between the olecranon and medial epicondyle and the positive electrode was placed approximately one-inch distal to the negative electrode. Placement of the PNS electrodes distal to the elbow resulted in recording the nerve stimulus rather than the EMG, that is, there was a "leakage of PNS current" which only permitted recording of the PNS stimulus rather than recording the desired EMG activity. A sample consisted of PNS stimuli administered in the following order: TOF, single-twitch stimulus, tetanic stimulus (50 Hz x 5 seconds) and post-tetanic single-twitch stimulus. As previously discussed, recommended time intervals among stimuli and between samples were maintained.

Following placement of the PNS, the hand of the same arm was prepared to permit simultaneous EMG/ECG, mechanical/ECG and visual recording of the PNS stimuli.

- **Electromyography (EMG/ECG) procedure.** With the ECG monitoring lead II, the positive ECG lead was placed on the palmar surface of the thumb at the insertion of the adductor pollicis muscle, the negative lead was placed on the palmar surface of the index finger, and the ground lead was placed on
the dorsum of the hand (Figure 1). All leads were attached with cutaneous nonallergenic adhesive electrode pads. The patient's hand was placed in a dorsal support arm board.

■ Mechanical/ECG procedure. With the exception of not heparinizing the solution, the pressure transducer was assembled using the standard arterial pressure monitor assembly method. All air was removed from a 250 ml bag of normal saline and replaced with fluid to a calibrated pressure reading of approximately 50 torr. The pressure sensitivity on the ECG monitor was maintained at 25 torr. A 14-gauge, 2-inch Bectin-Dickinson IV catheter was used to attach the high pressure line to the bag of saline. The transduced bag of normal saline was placed in the same hand with the EMG/ECG electrodes (Figure 1). The EMG/ECG and mechanical/ECG apparatus were secured to the hand with a dorsal arm board support.

Results

■ Waveform results. The specific neuromuscular activities measured by EMG/ECG recordings were found to be more rapid and circumscribed than the "mechanical" muscular contraction events that are measured by the transducer. An example of simultaneous EMG/ECG and mechanical/ECG recordings for each of the three PNS stimuli (TOF, pretetanic single-twitch and post-tetanic single-twitch) are presented in Figure 2. As can be seen, the EMG/ECG waveform is very narrow and specific to the stimulus. See tracings A, B and C in Figure 2.) The mechanical/ECG waveform is relatively wide (tracings D, E and F in Figure 2) compared to the EMG/ECG tracings. Counting the number of waveforms on the mechanical/ECG recording for the TOF stimulation (e.g., tracing D in Figure 2) was often difficult especially when there were more than two out of four TOF stimuli detected by the mechanical/ECG method. It was interesting to note for Figure 2 that visual interpretation of the PNS TOF stimulation saw only one of the four TOF stimuli while the simultaneous EMG/ECG and mechanical/ECG recordings (tracings A and D in Figure 2), recorded four and three of the four TOF stimuli, respectively.

■ Statistical results. Employing the SPSS statistical package, each PNS stimulus (single-twitch pretetanus, single-twitch post-tetanus and TOF) was correlated with EMG/ECG interpretation of PNS stimuli versus visual interpretation of PNS stimuli, as well as mechanical/ECG interpretation of PNS stimuli versus visual interpretation of PNS stimuli. With visual interpretation of PNS stimuli serving as the control, the correlation (percentage of agreement) between visual and EMG/ECG and the correlation between visual and mechanical/ECG interpretation of the PNS stimuli are presented in Table I. Table II presents the instances when either EMG/ECG and/or mechanical/ECG actually proved more sensitive to interpreting PNS stimuli than the visual control method of interpreting PNS stimuli. As was previously noted, tetanic stimuli were not able to be recorded by EMG/ECG or mechanical/ECG methodologies; therefore, there were no correlations between the visual interpretation with either the EMG/ECG or the mechanical/ECG interpretation methods.

The TOF PNS stimulus is one of the most useful stimuli for determining the degree of neuro-
muscular blockade. Cross tabulation comparing the number of individual stimuli simultaneously counted by the visual method versus the EMG/ECG method of PNS interpretation proved that the EMG/ECG method was just as accurate as visual interpretation of the TOF stimulus (Figure 3). Comparing visual interpretation of the TOF stimulus with simultaneously recorded mechanical/ECG interpretation proved that the mechanical/ECG method of interpretation was usually as accurate as visual interpretation of the TOF stimulus (Figure 4).

**Figure 2**
Examples of EMG/ECG and mechanical/ECG waveforms

**EMG/ECG**

A. Train-of-four stimulation

B. Pretetanic single-twitch stimulation

C. Post-tetanic single-twitch stimulation

**Mechanical/ECG**

D. Train-of-four stimulation

E. Pretetanic single-twitch stimulation

F. Post-tetanic single-twitch stimulation

1. EMG/ECG and mechanical/ECG recordings were simultaneous on lead II and pressure setting of 25 torr, respectively.
2. Visual saw only one of the four train-of-four stimuli.

**EMG/ECG versus visual interpretation**

For response to the PNS single-twitch (pre- and post-tetanus) and TOF stimuli, there was perfect congruence between visual and EMG/ECG recognition of neuromuscular response (Table I). That is, each time the PNS stimulus was delivered to the ulnar nerve, the adductor pollicis muscle response visualized was also reflected in an oscilloscope deflection. However, the EMG/ECG and mechanical/ECG methods frequently recorded responses to PNS stimuli (Table II and Figure 3) before these same stimuli were able to be visually recognized.
However, there was no agreement between visual and EMG/ECG interpretation of the PNS tetanus stimulus. That is, each time the tetanic stimulus was delivered to the ulnar nerve, the adductor pollicis muscle tetanic response was not reflected in an oscilloscope deflection.

Mechanical/ECG versus visual interpretation

For response to the PNS single-twitch (pre- and post-tetanus) and TOF stimuli, there was a high percentage of congruence between visual and mechanical/ECG recognition of PNS stimuli at varying degrees of neuromuscular blockade (Table I). Again, each time the stimulus was delivered to the ulnar nerve, the adductor pollicis muscle response seen was also reflected in an oscilloscope deflection. Mechanical/ECG interpretation of the PNS tetanus stimulus was similar to EMG/ECG interpretation. That is, interpretation of the tetanus stimulus was not possible with either mechanical/ECG or EMG/ECG methods.

Discussion

The EMG/ECG and mechanical/ECG were found to be reliable indicators of neuromuscular activity for both the single-twitch and TOF PNS stimuli (Figure 2). The EMG/ECG measurement not only proved to be a reliable, valid alternative to visual interpretation, but it was often more sensitive than visual interpretation (Table II and Figure 3). The mechanical/ECG waveform increased in size as neuromuscular blockade decreased. Consequently, it was sometimes difficult to separate individual TOF waveforms. However, mechanical/ECG interpretation often proved more reliable than visual interpretation of PNS stimuli (Table II).

Limitations of the study included sex (all male subjects), age (more than 55 years old), and the type of nondepolarizing muscle relaxant drugs (atracurium = 11 cases, vecuronium = 1 case). Generalizing these results to other types of nondepolarizing muscle relaxants will require further study. Also, "leakage" of PNS current occurred when stimulating PNS electrodes were placed distal to the elbow. PNS current leakage may affect the use of the EMG/ECG in pediatric cases due to the decreased olecranon to adductor pollicis distance. Finally, there are other sites recommended for interpretation of PNS stimuli in addition to the ulnar nerve (i.e., posterior tibial nerve or the lateral popliteal nerve).6

In spite of the aforementioned limitations, findings in this study are of benefit to the patient when visual interpretation of PNS stimuli is impractical. The apparatus used for EMG/ECG and mechanical/ECG interpretation of neuromuscular blockade allowed reliable, valid interpretation of both single-twitch and TOF stimuli. Although neither EMG/ECG or mechanical/ECG recording of tetanic PNS stimulation is possible, the PNS, itself, provides a tetanic stimulation. Therefore, either ECG method can be used to interpret and compare
pre- and post-tetanic stimulation. The comparison of pre- and post-tetanic stimulation is especially important for interpreting profound neuromuscular blockade when no reaction to TOF or single-twitch stimulation is realized. It has been established that the TOF is the most advantageous of the three PNS stimuli. Therefore, it is important to note that both ECG methods permitted interpretation of the TOF PNS stimulus (Figures 3 and 4).

The fact that the EMG/ECG and mechanical/ECG waveforms can be measured and recorded is significant. One can calculate a TOF ratio when the EMG/ECG and mechanical/ECG methods of interpretation are used. Calculation of a TOF ratio is not possible with visual interpretation.

Conclusions

The significance of this study lies in its potential to improve anesthesia practice and increase patient safety. Insufficient relaxation of the patient under general anesthesia can inhibit surgery or, at worst, result in injury to the patient due to unexpected movement. Excessive neuromuscular blockade can inhibit neuromuscular blockade reversal resulting in prolonged ventilatory support. The potential benefit of this study is that it presents two alternatives to determine the degree of neuromuscular blockade when visual interpretation of PNS stimuli is not practical.

Another benefit of using either the EMG/ECG or mechanical/ECG methods of interpretation concerns determining the TOF ratio. Adequate neuromuscular blockade reversal is evidenced by a TOF ratio greater than 0.8. One can calculate a TOF ratio when the EMG/ECG and mechanical/ECG methods of interpretation are used. However, calculation of a TOF ratio is not possible with visual interpretation.

In addition to the clinical significance, permanent recordings of EMG/ECG and mechanical/ECG waveforms have clinical, educational and, possibly, legal significance. That is, permanent waveform recordings can be used to interpret neuromuscular blockade, the recordings permit visualization of neuromuscular concepts (e.g., fade and posttetanic facilitation), and recordings provide evidence of adequate reversal of neuromuscular blockade (e.g., TOF ratio greater than 0.8). Finally, there is a financial benefit. Transducers and ECG monitors in anesthesia departments can be used in lieu of purchasing special expensive neuromuscular analyzers for use when the visual analysis of neuromuscular blockade is not possible.

In summary, this study has shown that apparatus, currently available in most clinical anesthesia settings, can be reconfigured to allow reliable, valid EMG or mechanical interpretation of single-twitch or TOF stimuli when nondepolarizing muscle relaxants are administered to adult males. These find-
tings are significant in cases when general anesthesia with adjunct muscle relaxation is required and visual interpretation of the PNS-evoked stimulus is impractical. Use of either the EMG/ECG or mechanical/ECG methods of interpretation will complement the anesthetist's ability to control the effect of nondepolarizing muscle relaxant drugs and enhance the quality of anesthesia care.

REFERENCES


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