PROCEDURE 93

Peripheral Nerve Stimulators

PURPOSE: Peripheral nerve stimulators (PNSs) are used in association with administration of neuromuscular blocking agents (NMBAs) to assess nerve impulse transmission at the neuromuscular junction of skeletal muscle.

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PREREQUISITE NURSING KNOWLEDGE

- Peripheral nerve stimulators are used to assess neuromuscular transmission (NMT) when NMBAs are given to block skeletal muscle activity.
- Neuromuscular blocking agents are given in the intensive care unit (ICU), along with sedatives and narcotics; most commonly they are administered to facilitate mechanical ventilation and promote ventilator synchrony with newer modes of ventilation in patients with severe lung injury. NMBAs are also used to decrease oxygen consumption and carbon dioxide production during the work of breathing, assist with management of increased intracranial pressure following head injury, and promote healing of surgical wounds that would place the patient at extreme risk if disrupted.[1, 2]
- Neuromuscular blocking agents do not affect sensation or level of consciousness. Because NMBAs lack amnestic, sedative, and analgesic properties, sedatives and analgesics should *always* be given concurrently and should be initiated *before* NMBAs to minimize the patient's awareness of blocked muscle activity. Sedatives and analgesics should also be given prophylactically, because neuromuscular blockade hinders the assessment of pain.[3]
- The muscle twitch response to a small electrical stimulus delivered by the PNS corresponds to the number of nerve receptors blocked by NMBAs and assists the clinician in assessment and titration of medication dosage. The level of blockade is estimated by observing the muscle twitch after stimulating the appropriate nerve with a small electrical current delivered by the PNS.
- The train-of-four (TOF) method of stimulation most commonly is used for ongoing monitoring in the critical care unit. After delivering four successive stimulating currents to a selected peripheral nerve with the PNS, in the absence of significant neuromuscular blockade, four muscle twitches follow. The four twitches signify that 75% or less of receptors are blocked. Three twitches correspond to approximately 80% blockade, and one to two twitches in response to four stimulating currents correlate with approximately 85% to 90% blockade of the neuromuscular junction receptors.[4, 5] This is the recommended level of block, although the appropriate level has not yet been determined through research in the critically ill population.[5] Zero twitches may indicate that 100% of receptors are blocked, which exceeds the desired level of blockade (Table 93–1).
- Titration of the medication according to clinical assessment and muscle twitch response may help provide a sufficient level of blockade without overshooting. Overshooting the level of blockade by using excessive doses of NMBAs is of special concern in the critically ill patient because it may predispose the patient to prolonged paralysis. Prolonged paralysis and severe weakness following termination of NMBAs in critically ill patients has been reported extensively in the literature.[6–8] Monitoring with a PNS during administration of NMBAs results in the use of less medication and hastens the recovery of spontaneous ventilation.[9] Expert opinion holds that exposing nerve receptors to lower medication dosages enables faster recovery of skeletal muscle and helps to prevent persistent paralysis and weakness after termination of the medications.[3]
- The stimulating current is measured in milliamperes (mA). The usual range of mA required to stimulate a peripheral nerve and elicit a muscle twitch is 20 to 50 mA, although it may be necessary to increase the current to 80 mA, the highest setting on the instrument.
- Some stimulators do not indicate the mA. Instead, digital or dialed numbers ranging from 1 to 10 represent the range of mA from 20 to 80 mA. When using these instruments, the usual setting is 2 to 5, although a setting of 10 is sometimes necessary.

Table 93–1 **Train-of-Four Stimulation as a Correlation of Blocked Nerve Receptors**

TOF (Number of Twitches)	% of Receptors Blocked (Approximately)[4, 5]
0/4	100
1/4	90
2/4	85
3/4	80
4/4	75 or less

- The ulnar nerve in the wrist is recommended for testing, although the facial and the posterior tibial nerves may also be used.

EQUIPMENT

- Peripheral nerve stimulator
- Two gelled electrode pads (the same as is used for electrocardiography monitoring)
- Two lead wires packaged with the nerve stimulator

Additional equipment as needed includes the following:

- A ball electrode attachment may be substituted for the electrodes and lead wires

PATIENT AND FAMILY EDUCATION

- Explain the purpose of nerve monitoring; for example, assessing effect and guiding dosage of the medication infusion. ➳***Rationale:*** May decrease anxiety.
- Describe the equipment to be used. ➳***Rationale:*** May decrease anxiety.
- Describe the experience of the stimuli as a slight prickly sensation. ➳***Rationale:*** The use of sensation descriptors is effective in reducing anxiety.
- Explain that the electrodes require periodic changing, which feels like removing a bandage. ➳***Rationale:*** May elicit patient and family cooperation.

PATIENT ASSESSMENT AND PREPARATION

Patient Assessment

- Assess the patient for the best location for electrode placement. Consider criteria such as edema, diaphoresis, wounds, dressings, and arterial and venous catheters. ➳***Rationale:*** Improves conduction of stimulating current through dermal tissue.
- Assess if burns are present or if topical ointments are being used. ➳***Rationale:*** In patients with burns or topical ointments, for whom electrode adherence is difficult, the ball electrodes may be more effective than the electrode pads and lead wires. Poor electrode adherence interferes with conduction of the stimulating current.

Patient Preparation

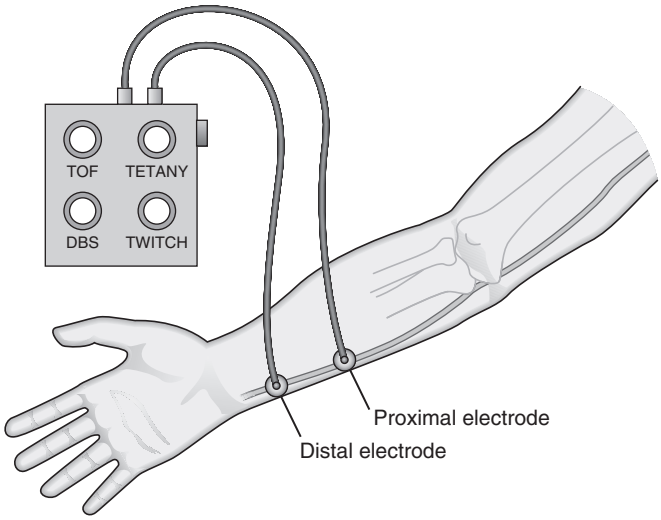
- Ensure that the patient and family understand preprocedural teaching. Answer questions as they arise and reinforce information as needed. ➳***Rationale:*** Evaluates and reinforces understanding of previously taught information.
- If possible, apply the electrodes and test the TOF response to determine adequacy of the location prior to initiating NMBAs. ➳***Rationale:*** Improves reliability in interpretation of the TOF response.
- It may be helpful to determine the supramaximal stimulation (SMS) level prior to initiating NMBAs. The SMS is the level at which additional stimulating current elicits no further increase in the intensity of the four twitches. ➳***Rationale:*** Helps establish adequate stimulating current; improves reliability.

Procedure for Peripheral Nerve Stimulators

Steps	Rationale	Special Considerations
Testing the Ulnar Nerve		
1. Wash hands.	Reduces transmission of microorganisms; standard precautions.	
2. Extend the arm, palm up, in a relaxed position (Fig. 93–1).	The ulnar nerve is superficial and easy to locate.	
3. Apply two gelled electrodes over the path of the ulnar nerve (see Fig. 93–1). Place the distal electrode on the skin at the flexor crease on the ulnar surface of the wrist. Place the second electrode approximately 1 to 2 cm proximal to the first, parallel to the flexor carpi ulnaris tendon.	Enables stimulation of the ulnar nerve.	
4. Use caution in selecting the site of electrode placement in order to avoid direct stimulation of the muscle rather than the nerve.	Direct muscle stimulation elicits a response similar to the TOF, making it difficult to evaluate blocked nerve impulse transmission.	
5. Plug in the lead wires to the nerve stimulator, matching the black and red leads (negative and positive) to the black and red connection sites.	Necessary for conduction of electrical current.	

Procedure for Peripheral Nerve Stimulators *Continued*

Steps	Rationale	Special Considerations



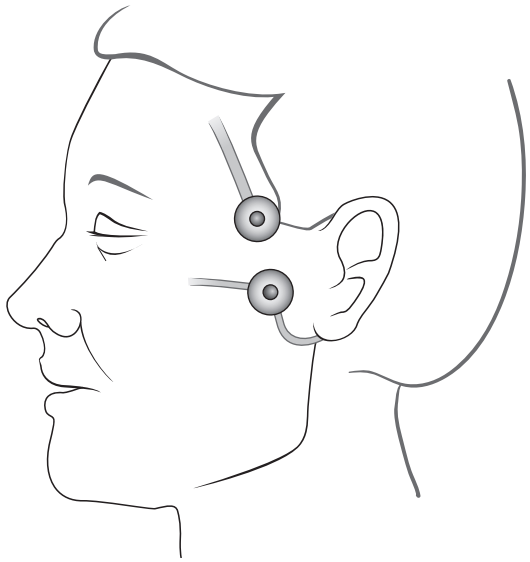
■ ● **FIGURE 93–1.** Placement of electrodes along the ulnar nerve.

6. Attach the lead wires to the electrodes. The negative and positive leads can be placed on either electrode. *(Level V: Clinical studies in more than one or two different patient populations and situations to support recommendations)*	Polarity usually does not matter when electrodes are placed close together directly over the nerve.[2, 10]	Occasionally twitch height is altered with reversed polarity; place the red lead proximally when a poor twitch response occurs.[10]
7. Turn on the PNS and select a low mA.	Excessive current results in overstimulation and can cause repetitive nerve firing.	
8. Depress the TOF key and observe twitching of the thumb, counting the number of twitches. Do not count finger movements, only the thumb.	Finger movements result from direct muscle stimulation.	Placing the operator's hand over the fingers helps reduce interpretation of artifactual movement.
9. Wash hands.	Reduces transmission of microorganisms; standard precautions.	
Testing the Facial Nerve		
1. Place one electrode on the face at the outer canthus of the eye and the second electrode approximately 2 cm below, parallel with the tragus of the ear (Fig. 93–2).	Stimulates the facial nerve.	When wounds, edema, invasive lines, and other factors interfere with ulnar nerve testing, the facial or posterior tibial nerves may be substituted. The risk of direct muscle stimulation is greater, however, with resulting underestimation of blockade. Also, the alternate nerves correlate less well with the blockade in the diaphragm.[4]
2. Plug the lead wires into the nerve stimulator, matching the black and red leads to the black and red connection sites.	Necessary for conduction of electrical current.	
3. Attach the lead wires to the electrodes.		
4. Turn on the PNS and select a low mA.		

Procedure continued on following page

Procedure for Peripheral Nerve Stimulators *Continued*

Steps	Rationale	Special Considerations

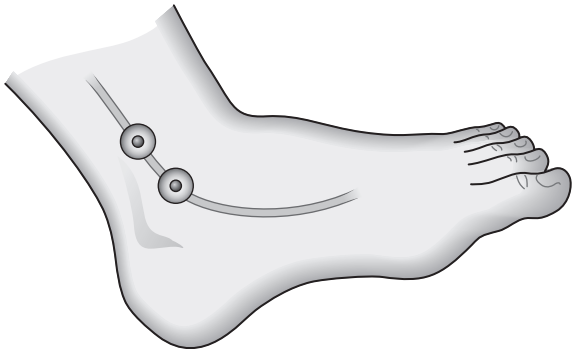


■ ● **FIGURE 93–2.** Placement of electrodes on the face.

5. Depress the TOF key and observe the muscle twitching above the eyebrow, counting the number of twitches.	Determines the neuromuscular blockade at the junction between a branch of the facial nerve and orbicularis muscle.
6. Wash hands.	Reduces transmission of microorganisms; standard precautions.

Testing the Posterior Tibial Nerve

1. Place one electrode approximately 2 cm posterior to the medial malleolus in the foot (Fig. 93–3).	Stimulates the posterior tibial nerve.
2. Place the second electrode approximately 2 cm above the first (see Fig. 93–3).	
3. Plug the lead wires into the nerve stimulator, matching the black and red leads to the black and red connection sites.	Necessary for conduction of electrical current.
4. Attach the lead wires to the electrodes.	
5. Turn on the PNS and select a low mA.	



■ ● **FIGURE 93–3.** Placement of electrodes on the foot.

Procedure for Peripheral Nerve Stimulators *Continued*

Steps	Rationale	Special Considerations
6. Depress the TOF key and observe the plantar flexion of the great toe, counting the number of twitches.	Determines block at the junction between the posterior tibial nerve and the flexor hallucis brevis muscle.	
7. Wash hands.	Reduces transmission of microorganisms; standard precautions.	
Determine the SMS		
1. Increase the mA in increments of 1 until four twitches are observed.		
2. Note the mA that corresponds to four vigorous twitches. Administer one to two more TOFs.	If there is no increase in intensity of the muscle twitch when the mA is increased, the SMS is the level at which four vigorous twitches was observed. For example, if a strong response was observed at 3 mA, raise the current to 4 mA. If there is no increase in intensity of the twitch, the SMS is 3 mA. If there is an increase, raise the mA to 5. If there is an additional increase in twitch intensity, raise it to 6. If the intensity shows no further increase, the SMS is 5 mA.	
Determine the TOF Response During NMBA Infusion		
1. Ten to fifteen minutes after a bolus dose and continuous infusion of NMBA is given, retest the TOF.	Evaluates the level of blockade provided.	
2. Retest every 1 to 2 hours until clinically stable and a satisfactory level of blockade is achieved.	Evaluates the level of blockade and avoids under- and overestimation of blockade.	Always assess electrode condition and placement before testing.
3. If more than one or two twitches occurs and neuromuscular blockade is unsatisfactory, increase the infusion rate as prescribed or according to hospital protocol.	Signifies that less than 85% to 90% of receptors are blocked.	
Troubleshooting when There Are Zero Twitches		
1. Retest another nerve (the other ulnar nerve or facial or posterior tibial nerves).	Avoids overestimating the level of blockade.	
2. Change electrodes.	Drying of the gel or poor contact compromises conduction.	
3. Check lead connections and PNS for mechanical failure (ie, the battery may need changing).	The most common cause of PNS malfunction is low battery voltage.[10]	
4. Increase the stimulating current.	After troubleshooting leads and PNS, current may be inadequate to stimulate the nerve.	
5. If there are no other explanations for a zero response, check the NMBA infusion for rate, dose, and concentration. Reduce the infusion rate of the NMBA as prescribed or according to hospital protocol.	Excessive neuromuscular blockade produces absence of twitch response.	

Expected Outcomes	Unexpected Outcomes
• Slight discomfort is experienced during the TOF test. • The muscles of the thumb twitch, rather than the fingers, when the ulnar nerve is stimulated. • The twitch response approximates the number of blocked peripheral nerve receptors; for example, four twitches before initiating the NMBA infusion and one to two twitches when a desired level of blockade is achieved. • The NMBA dosage is titrated according to the TOF test and clinical goals. • Resumption of four twitches occurs within 2 hours when the NMBA is discontinued.	• Moderate to severe discomfort from the TOF test • Impaired skin integrity when the electrodes are removed • The fingers twitch when the ulnar nerve is stimulated • Resumption of four twitches does not occur within 2 hours of discontinuation of NMBA

Patient Monitoring and Care

Patient Monitoring and Care	Rationale	Reportable Conditions
		These conditions should be reported if they persist despite nursing interventions.
1. Cleanse and thoroughly dry the skin before applying electrodes.	Improves electrode adherence.	
2. Change the electrodes whenever they are loose or when gel becomes dry.	Optimizes conduction of stimulating current.	
3. Select the most accessible site with the smallest degree of edema, with no wounds, catheters, or dressings that impede accurate electrode placement over the selected nerve.	Facilitates ease in testing, electrode adherence, and conduction of current.	
4. Never use the "Single Twitch," "Tetany," or "Double Burst" settings if available on the PNS.	These methods are less accurate and may cause extreme discomfort.[11]	
5. The patient may demonstrate subtle movement of the extremities with an acceptable TOF response.	Clinical decisions should never be made solely on the TOF test results. Assessment of oxygenation and ventilation, neurologic function, tissue perfusion, and other clinical goals should be evaluated when deciding to increase the rate of NMBA infusion.	• Patient movement despite acceptable TOF
6. Microshock hazard may be a risk to patients with external pacing catheters. Extreme caution must be exercised to prevent the PNS lead wires from contacting the pacing catheter or pacing lead wires.	Direct electrical current can be conducted from the PNS through the pacing wires to the heart.	• Cardiac dysrhythmias or change in patient condition
7. Perform TOF testing every 4 to 8 hours during NMBA infusion.	Aids in dosing NMBA.	• Abnormal TOF results

Documentation

Documentation should include the following:

- Patient and family education
- The time, TOF twitch response, the mA, and the nerve site tested
- The TOF response as 0/4, 1/4, 2/4, 3/4, or 4/4
- Unexpected outcomes
- Troubleshooting attempts
- Additional interventions

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Additional Readings

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