Academic Department of Critical Care
Queen Alexandra Hospital Portsmouth

Portsmouth Hospitals NHS
NHS Trust

Neuromuscular Blockade in Critical Care

Aim To provide guidance in the optimal administration and monitoring of continuous neuromuscular blockade in Critical Care
Scope All adult patients in Critical Care receiving continuous neuromuscular blockade

Consider continuous neuromuscular blocking agents (NMBAs) for patients with:

- Severe respiratory failure requiring advanced ventilation strategies (see Hypoxia SOP)
- Severe head injury & raised intracranial pressure
- Shivering during targeted temperature management
- Uncontrollable muscle spasm or rigidity

Discuss with ICU Consultant, check no contraindications, and confirm choice of drug

Ensure deeply sedated (eg RASS -5) then test baseline train-of-four (TOF) response.
Note the current required: should be minimum needed for maximum response.

Give IV loading dose: Atracurium 0.3 - 0.6 mg/kg over 1 minute (1st line in Critical Care)
Start IV infusion: Atracurium 0.3 - 0.6 mg/kg/hr (1st line in Critical Care)

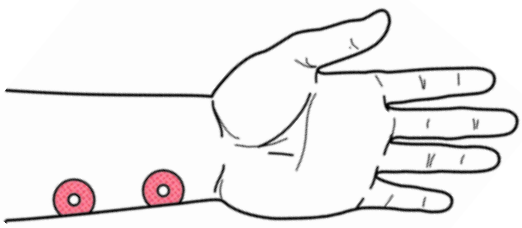
Check TOF every 30 minutes until infusion rate has been stable for two tests.
When infusion rate has been stable for two tests, check TOF routinely every four hours.

If more than two twitches seen or felt:

- Increase Atracurium infusion rate by 10%
- Consider bolus dose (discuss with doctor)
- Repeat train-of-four monitoring in 30 minutes

If fewer than two twitches seen or felt:

- Reduce Atracurium infusion rate by 10%
- Repeat train-of-four monitoring in 30 minutes



Electrode placement for ulnar nerve stimulation
- first choice site for train-of-four monitoring.
Place negative (black) electrode closest to hand.

Remember

- Daily break in NMBA if condition allows
- Eye and pressure area care
- Passive physiotherapy
- Adequate DVT prophylaxis

Version: 2.0 | Date: 01 May 15 | Revision Due: 01 May 17 | Authors: Dr M Ward Jones, N Tarmey

University of Portsmouth

TABLE OF CONTENTS

1. Introduction

Monitoring of neuromuscular block is seen as the 'gold standard' for patients receiving neuromuscular blocking agents (NMBA) in the operating theatre and other critical care areas. It has been suggested that this practice can help to individualise and optimise the dose of NMBA, help to reduce costs by decreasing overall NMBA use[1] and reduce the incidents of potential side effects such as prolonged muscular weakness[1], however this is contentious, and the published evidence is conflicting[2].

2. Purpose

This guideline has been created to help guide suitably trained practitioners in monitoring neuromuscular blockade using the Fisher & Paykel 'Innervator' NS242, where required. The guideline will also provide suggestions for management of the patient undergoing continuous neuromuscular blockade.

3. Scope

This guideline should be used by suitably trained critical care practitioners caring for patients undergoing continuous neuromuscular blockade. Ability to comply should not normally be affected under conditions of high demand on services (eg pandemic flu).

4. Definitions

- ***Neuromuscular blockade*** – The intentional interruption of transmission at the neuromuscular junction by external agents, usually neuromuscular blocking agents. Neuromuscular blockade is commonly used to produce muscle relaxation as an adjunct to anaesthesia during surgery and other medical procedures.
- ***Train-of-four stimulation*** – A method for measuring magnitude and type of neuromuscular blockade, based upon the ratio of the amplitude of the fourth evoked mechanical response to the first one, when four electrical currents are applied for 2 seconds to a peripheral motor nerve.
- ***Depolarising neuromuscular blocking agents*** – e.g. suxamethonium. Fast acting muscle relaxant, which causes ***fasiculation***. Depolarising muscle relaxants do not have a reversal agent. They are associated with tachyarrhythmias, hyperkalaemia and malignant hyperthermia.
- ***Non-depolarising neuromuscular blocking agents*** – e.g. vecuronium and atracurium. These muscle relaxants have a slower onset of action than suxamethonium and have varied duration of action. They do not cause fasiculation. They have no sedative or analgesic effects and do not provoke malignant hyperthermia. Their action may be reversed with anticholinesterases such as neostigmine.
- ***Fasiculation*** – A small local contraction of muscles, visible through the skin, representing a spontaneous discharge of a number of fibres innervated by a single motor nerve filament.

5. Duties and responsibilities

The registered nurse and doctor are responsible and accountable for the implementation of this guideline and the safety of the patient. They are also responsible for ensuring that the guideline is subject to professional judgement given individual patient situations.

6. Process

ACTION	RATIONALE
Discuss need for neuromuscular blockade with consultant; careful risk/benefit analysis is required	The use of neuromuscular blocking agents (NMBA) carries potentially serious risks, and therefore should be used only when necessary.
Consider using continuous neuromuscular blockade in patients with the following conditions: • Severe respiratory failure requiring advanced ventilation strategies • Severe head injury with raised ICP • Shivering during targeted temperature management • Patients with uncontrollable muscle spasm/rigidity (e.g. tetanus)	NMBA may aid ventilator synchrony and lower systemic oxygen consumption, thus helping to optimise cerebral perfusion if ICP is raised, and gas exchange in severe respiratory failure. There is evidence that a continuous infusion of NMBA reduces mortality in ARDS[3]. NMBA can also reduce muscle rigidity and facilitate patient positioning[1,2].
If neuromuscular blockade is required, ensure that the patient is receiving adequate sedation and analgesia prior to administering NMBA.	Sedation and analgesia are required to prevent patient awareness whilst in a state of imposed paralysis as this could be extremely unpleasant for the patient[1]. NMBA have no sedative, analgesic or amnesic properties.
Particular caution should be used if the patient falls into one or more of the following categories: • Children • Patients with neuromuscular disease • Patients with severe burns • Patients with severe asthma •Patients receiving high dose corticosteroid therapy	These patients may have an altered response to neuromuscular blocking agents[1,2]. Patients with some neuromuscular diseases and those receiving high dose corticosteroids are at risk of prolonged muscle weakness following NMBA use[2]. Patients with burns may become resistant to the effects of NMBA, and those with asthma may be at risk from histamine release with atracurium[4].
If neuromuscular monitoring is to be used, carry out train-of-four stimulation prior to commencement of NMBA (discuss with consultant)	This allows for a baseline measurement, and allows the practitioner to work out how much current is required to evoke a muscular response[1]. Using the minimum amount of current will reduce discomfort to the patient[5].
Atracurium (or cis-atracurium – stocked in limited quantities on DCCQ) should be the first choice of NMBA in continuous blockade.	Atracurium *may* be less likely to cause prolonged muscle weakness than aminosteroid NMBA. Atracurium is only partially eliminated by renal and hepatic metabolism, and may therefore be safer to use in multi-organ dysfunction than some other agents[2]. Evidence for NMBA improving mortality in ARDS only exists for cis-atracurium use[3].

Continued…

…continued

ACTION (continued)	**RATIONALE (continued)**
A bolus dose of atracurium should be given prior to infusion to ensure that an adequate block is achieved. This should be given slowly (over around one minute).	Histamine release after administration of atracurium can cause bronchospasm. If the bolus dose is given slowly, it may ameliorate this response[6].
Bolus dose (in mg) and starting infusion rate (in ml/hr) should be prescribed by the doctor with responsibility for the patient.	Recommended bolus dose is 0.3-0.6mg/kg with infusion starting at 0.3-0.6mg/kg/hr[4]. Requirements for infusion rates as high as 1.77mg/kg/hr have been reported[4].
If train-of-four monitoring is used, it should be carried out every 30 minutes until the infusion rate has been stable over the last two tests. It should then be carried out every four hours unless the infusion rate changes.	This recommendation is based on expert opinion only[1,2]. The only good quality study demonstrating improved outcomes in ARDS used a fixed-dose infusion of cis-atracurium without neuromuscular monitoring[3]. Other published evidence suggests train-of-four monitoring is not superior to clinical assessment alone[7,8].
The infusion of NMBA should be titrated so that 2 twitches are seen or felt on train-of-four stimulation (if used).	The aim of continuous neuromuscular blockade is to provide a block of approximately 90% at the neuromuscular junction (though this requirement varies somewhat depending on the indication for NMBA). This equates to 2 twitches in train-of-four monitoring.
If more than 2 twitches are seen/felt then increase infusion rate by 10% and consider a bolus dose (discuss with a doctor). If less than 2 twitches are present then reduce infusion rate by 10%.	These recommendations are based on expert opinion only[2].
Train-of-four stimulation should be carried out on the ulnar nerve according to manufacturer's instructions.	Instructions for carrying out train-of-four stimulation are taken from the manufacturers operating manual[5].
Patients undergoing continuous neuromuscular blockade should have regular eye care, passive exercises, pressure area care, and adequate DVT prophylaxis.	Patients unable to blink are at risk of developing 'dry eyes' and associated injury; they are also at risk of the complications of immobility. These measures are designed to minimise these risks[1,2].

7. Training

Staff will require training in the use of the 'Innervator' and the application of the guideline. This guideline will be supported by multidisciplinary training including at Departmental teaching sessions.

8. Monitoring compliance with, and the effectiveness of, procedural documents

This guideline will be reviewed initially at 6 months and thereafter 2 yearly by the DCCQ Guidelines Group. Measurement of compliance will be achieved by unit-based audit. Results reviewed will be fed back to members of the senior medical /nursing team and the Critical Care Governance Group.

9. References and associated documents

The flow chart and instruction guide form part of this guideline (see below).

1. Murray M, Cowen J, Deblock, H et al. Clinical practice guidelines for sustained neuromuscular blockade in the adult critically ill patient. *Critical Care Medicine* 2002; 30: 142-156

2. Tietze, K. Use of neuromuscular blocking medications in critically ill patients. *Uptodate.com,* topic version 10.0; accessed 8th December 2014.

3. Papazian L, Forel J, Gacouin A et al. Neuromuscular blockers in early acute respiratory distress syndrome. *N Engl J Med* 2010, 363:1107-1116

4. Atracurium 10mg/ml Solution for Injection/Infusion Summary of Product Characteristics. Accessed at http://www.medicines.org.uk/emc/medicine/23851 8th December 2014

5. Fischer & Paykel (1993) *NS242 peripheral nerve stimulator: Operating manual.* Fischer & Paykel Healthcare: Maidenhead.

6. Scott R, Savarese J, Basta S et al. Atracurium: clinical strategies for preventing histamine release and attenuating the haemodynamic response. *Br J Anaesth* 1985; 57: 550-3.

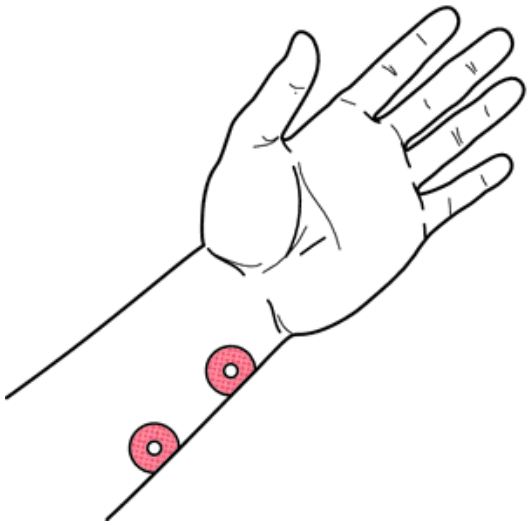
7. Baumann M, McAlpin W, Brown K et al. A prospective randomized comparison of train-of-four monitoring and clinical assessment during continuous ICU cisatracurium paralysis. *Chest* 2004; 126: 1267-1273

8. Strange C, Vaughan L, Franklin C et al. Comparison of train-of-four and best clinical assessment during continuous paralysis. *Am J Respir Crit Care Med* 1997; 156: 1556-61.

Appendix A – Train-of-four monitoring using the Fisher & Paykel Innervator

Process:

1. **Identify suitable site for monitoring** – the ulnar nerve is the site of first choice (see figure for electrode placement). Alternatives include the facial nerve and common peroneal nerve.
2. **Clean site with alcowipe** – ensures optimal electrode contact
3. **Apply electrodes** – these can be left in place for 24 hours
4. **Attach *Innervator* leads to electrodes** – the black lead should be connected to the most distal (closest to the wrist) electrode when monitoring the ulnar nerve
5. **Switch *Innervator* on**
6. **Press up arrow to increase current to 60 mA** – this should be sufficient to stimulate a response. In some patients, higher currents may be required.
7. **Press TOF button** – this will cause the innervator to deliver four pulses of current to the target nerve over 1.5 seconds.
8. **Observe and/or feel the thumb for movement (if ulnar nerve used)**



Electrode placement for ulnar nerve stimulation. From medical-dictionary.thefreedictionary.com

Appendix B

Checklist for the Review and Ratification of Procedural Documents and Consultation and Proposed Implementation Plan

To be completed by the author of the document and attached when the document is submitted for ratification: a blank template can be found on the Trust Intranet. Home page -> Policies -> Templates

CHECKLIST FOR REVIEW AND RATIFICATION			
TITLE OF DOCUMENT BEING REVIEWED:		YES/NO N/A	COMMENTS
1	**Title**		
	Is the title clear and unambiguous?	Yes	
	Will it enable easy searching/access/retrieval??	Yes	
	Is it clear whether the document is a policy, guideline, procedure, protocol or ICP?	Yes	
2	**Introduction**		
	Are reasons for the development of the document clearly stated?	Yes	
3	**Content**		
	Is there a standard front cover?	Yes	
	Is the document in the correct format?	Yes	
	Is the purpose of the document clear?	Yes	
	Is the scope clearly stated?	Yes	
	Does the scope include the paragraph relating to ability to comply, in the event of a infection outbreak, flu pandemic or any major incident?	Yes	
	Are the definitions clearly explained?	Yes	
	Are the roles and responsibilities clearly explained?	Yes	
	Does it fulfill the requirements of the relevant Risk Management Standard? (see attached compliance statement)		
	Is it written in clear, unambiguous language?	Yes	
4	**Evidence Base**		
	Is the type of evidence to support the document explicitly identified?	Yes	
	Are key references cited?	Yes	
	Are the references cited in full?	Yes	
	Are associated documents referenced?	Yes	
5	**Approval Route**		
	Does the document identify which committee/group will approve it?	Yes	DCCQ Clinical Governance Group
6	**Process to Monitor Compliance and Effectiveness**		
	Are there measurable standards or KPIs to support the monitoring of compliance with the effectiveness of the document?	Yes	
7	**Review Date**		
	Is the review date identified?	Yes	
6	**Dissemination and Implementation**		
	Is a completed proposed implementation plan attached?	Yes	
7	**Equality and Diversity**		
	Is a completed Equality Impact Assessment attached?	Yes	

Appendix B
continued

CONSULTATION AND PROPOSED IMPLEMENTATION PLAN	
Date to ratification committee	
Groups /committees / individuals involved in the development and consultation process	Critical Care Governance Group Multidisciplinary staff working in DCCQ
Is training required to support implementation?	Yes
If yes, outline plan to deliver training	Multidisciplinary teaching via unit based teaching teams, regular teaching sessions on Fridays and bedside teaching from experienced staff
Outline any additional activities to support implementation	Promotion of introduction of guideline via unit based webpage and verbally through presentation at teaching sessions

Individual Approval

If, as the author, you are happy that the document complies with Trust policy, please sign below and send the document, with this paper, the Equality Impact Assessment and NHSLA checklist (if required) to the chair of the committee/group where it will be ratified. To aid distribution all documentation should be sent electronically wherever possible.

Name	**Dr M Ward-Jones**	**Date**	09 Mar 15
Signature	*signed electronically*		

Committee / Group Approval

If the committee/group is happy to ratify this document, would the chair please sign below and send the policy together with this document, the Equality Impact Assessment, and NHSLA checklist (if required) and the relevant section of the minutes to the Trust Policies Officer. To aid distribution all documentation should be sent electronically wherever possible.

Name		**Date**	
Signature			

If answers to any of the above questions is ‘no’, then please do not send it for ratification.

Appendix C

Equality Impact Assessment

To be completed by the author of the document and attached when the document is submitted for ratification: a blank template can be found on the Trust Intranet. Home page -> Policies -> Templates

Title of document for assessment	Neuromuscular Block Monitoring in Critical Care
Date of assessment	06 Mar 15
Job title of person responsible for assessment	Dr N Tarmey
Division/Service	DCCQ / CHAT CSC

	Yes/No	Comments
Does the document affect one group less or more favorably than another on the basis of:		
Race	No	
Gender (including transgender)	No	
Religion or belief	No	
Sexual orientation, including lesbian, gay and bisexual people	No	
Age (for HR policies only)	No	
Disability – learning disabilities, physical disabilities, sensory impairment and mental health problems	No	
Does this document affect an individual's human rights?	No	
If you have identified potential discrimination, are the exceptions valid, legal and/or justified?		

If the answers to any of the above questions is 'yes' you will need to complete a full Equality Impact Assessment (available from the Equality and Diversity website) or amend the policy such that only an disadvantage than can be justified is included. If you require any general advice please contact staff in the Equality and Diversity Department on 02392 288511