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Routine Nerve Conduction Study (NCS) Recording Guideline

1. Purpose of the guideline
2. Introduction to the guideline
3. Limits of this guideline
4. Electrodes
   - (i) Recording electrodes
     - a) Electrode choice
     - b) Electrode impedance
   - (ii) Stimulation electrodes
     - a) Electrode choice
     - b) Electrode impedance
5. Machine parameters
   - (i) Common mode rejection ratio
   - (ii) Input impedance
   - (iii) Analogue to digital signal conversion
   - (iv) Automatic artefact rejection
   - (v) Filter settings
   - (vi) Sweep duration
   - (vii) Averaging
6. Recording
   - (i) Patient information
   - (ii) a) Patient preparation
     b) Skin preparation
   - (iii) Skin temperature
   - (iv) Stimulation
     - a) Stimulation type
     - b) Supramaximal stimulation
     - c) Stimulation rate
     - d) Stimulation duration
     - e) Stimulation intensity
   - (v) Sensory nerve conduction
     - a) Recording direction
     - b) Recording site
     - c) Sensory recording parameters
     - d) Stimulation site
     - e) Measured parameters

(vi) Motor nerve conduction
   a) Recording site
   b) Motor recording parameters
   c) Stimulation site
   d) Measured parameters

(vii) F-wave
   a) Recording site
   b) F-wave recording parameters
   c) Stimulation site
   d) Stimulation rate
   e) Measured parameters

(viii) H- reflex
   a) Recording site
   b) H-reflex recording parameters
   c) Stimulation site
   d) Stimulation rate
   e) Stimulation duration
   f) Stimulation intensity
   g) Measured parameters

(ix) Repetitive Stimulation
   a) Recording site
   b) Repetitive stimulation recording parameters
   c) Stimulation site
   d) Stimulation rate
   e) Stimulation procedure
   f) Measured parameters

(x) Blink reflex
   a) Recording site
   b) Blink reflex recording parameters
   c) Stimulation site
   d) Stimulation rate
   e) Measured parameters

7. Quality control
   (i) Normative data
8. Electrical Safety
9. References

Additional Readings

Appendix 1 – Stakeholders

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1. PURPOSE

   These guidelines have been prepared to offer guidance towards best practice for performing common nerve conduction studies (NCS) in the routine clinical setting within Australia.

2. INTRODUCTION

   The following guidelines should be considered as minimum standards to perform routine common nerve conduction studies in clinical practice including sensory, motor, F-wave, H reflex, repetitive stimulation and blink reflex studies. They have been prepared by a sub-committee governed by ANTA Inc. and have been presented to stakeholders within the field of Clinical Neurophysiology in Australia (see Appendix 1). A review of international guidelines was made to ensure that this ANTA Inc. guideline is consistent with worldwide standards.

3. LIMITS OF THE GUIDELINE

   This guideline relates to common routine NCS in clinical practice for adults and children and does not address the electromyography (EMG) component performed by a Consultant Neurologist. It does not relate to young children or infants although some of these guidelines are applicable to these age groups.

   NCS including percutaneous nerve stimulation poses little or no risk to patients with cardiac pacemakers [(1)] or cardiac defibrillators providing there are no external wires and that ground electrodes are functional [(2)]. If external wires are present advice should be sought on the safety in the particular clinical setting.
   See Section 8. Electrical Safety.

4. ELECTRODES

   (i) Recording electrodes

   Surface electrodes are most commonly used for motor and sensory NCS in a bipolar configuration [(1, 3)]. A separate surface ground electrode is used [(1)].

   a) Electrode choice

   Platinum, stainless steel, chlorided silver [(1)], silver and gold plated electrodes are generally recommended. Electrodes of the same material should be used whenever possible [(1)]. Recording surface electrodes include disc electrodes of 5-11mm, bipolar electrodes with fixed inter-electrode distance of 20-40mm with or without felt pads, conductive adhesive stick–on electrodes and ring electrodes [(1)].

b) Electrode impedance

The electrode impedance can vary from 1 to <300k ohm depending on electrode choice [(1)]. Equal electrode impedances will reduce environmental and stimulation artefact [(2)]. NB: It is not typical to measure the electrode impedance during the NCS recording. Providing the stimulus artefact does not exceed the time to the expected onset latency of the waveform and the baseline is stable, higher unmeasured impedances are acceptable.

(ii) Stimulation electrodes

Both surface and needles electrodes can be used for stimulation [(1)].

a) Electrode choice

Surface electrodes with inter-electrode distances of 20-40mm are generally used for motor and sensory NCS [(1)] including disc electrodes of 5-11mm diameter, bipolar electrodes with fixed inter-electrode distance with or without felt pads, fixed distance prong electrodes and ring electrodes.

b) Electrode impedance is usually not measured.

5. MACHINE PARAMETERS

(i) Common mode rejection ratio

The common mode rejection ratio should be 90dB or greater [(1)].
For common mode rejection to work effectively the recording electrodes should be of equal impedance [(1)].

(ii) Input impedance

The input impedance of the pre-amplifiers should be at least 100MΩ [(1)].

(iii) Analogue to digital signal conversion

A sample rate of at least 5-10 times the highest frequency component to be recorded should be used [(1)]. The sample rate should have a minimum resolution of 16 bits or more [(1)].

(iv) Automatic artefact rejection

Automatic artefact rejection excluding the duration of the stimulus, should be employed to eliminate high amplitude transients [(1)].

(v) Filter settings

Appropriate filter settings should be used.
See section 6(i-viii) c) Recording parameters for individual test filter settings.

(vi) Sweep duration

The sweep should range from 1-10ms/division [(4)].
See section 6(v-x) - Recording parameters for individual test sweep settings.

(vii) Averaging

Averaging of small amplitude potentials improves the signal to noise ratio and is most commonly used when recording sensory nerve action potentials [1, 5].

6. RECORDING

(i) Patient Information

Each study should have minimum patient information and detailed history stored with it. Minimum patient information should include but is not limited to:

- Patient name
- Patient identification number
- Date of birth
- Recording date
- Referring doctor
- Recording health professional identification
- Relevant clinical details
- Clinical question to be answered
- Description of symptoms
  - Side of symptoms
  - Dermatome distribution of paraesthesia, hypoaesthesia, weakness, and pain radiation
  - Neck or lower back pain.
  - Exacerbating factors:
- Current medication
- Anticoagulants (for EMG)
- Height
- Limb temperature
- Metabolic disorders
- Previous injury or surgery at site.

(ii) Patient preparation

a) The patient should be relaxed, in a position that ensures comfort and minimises muscle activation, particularly during sensory studies [2]. A neutral relaxed position of the distal hand and foot joints should be maintained reducing the stretching of nerves [2]. It is important to note that the position of the limb affects the length of the nerve, particularly in nerve segments across a joint. This is of particular concern in the ulnar nerve segment across the elbow [2]. When stimulating the ulnar nerve, the elbow should be moderately flexed (70^0 to 90^0 from horizontal) [6].

b) Skin preparation

The skin should be washed to degrease using alcohol or other skin preparation substances for best recording and stimulation results.

(iii) Skin temperature

Distal limb skin temperatures should be maintained between 32 and 34°C [2].

NB: Cool limb temperature may slow nerve conduction velocity, prolong distal latency, and/or increase amplitude and duration, more so in sensory studies [2].

(iv) Stimulation

The following stimulation parameters relate to most nerve conduction recordings unless otherwise stated.

a) Stimulation type: Square wave electrical stimulation of constant-current is preferred [1, 5].

b) Supramaximal Stimulation: Supra-maximal stimulation may be ensured by increasing the stimulus intensity 10-30% above what appears to be the lowest stimulus strength which gives a supra-maximal response. Stimulation above which gives a maximal response, may shift the stimulus point on the nerve, leading to erroneous measurement of true latency and miscalculation of nerve conduction velocity [2, 3, 5]. Start stimulation at baseline 0mA and increased increments until the compound muscle action potential (CMAP) or sensory nerve action potential (SNAP) has reached the supra-maximal level.

c) Stimulation rate

Rate: 0.5 – 50/s. Single pulses or trains of repetitive pulses are given [1].

NB: See individual stimulation rates for F-waves (section 6(vii) d), H-reflex (section 6(viii) d), repetitive stimulation (section 6(ix) d), and blink reflex (section 6(x) d).

d) Stimulation duration

Duration: 0.1-1.0s. Shorter duration is preferred for patient comfort, reduced stimulus spread and stimulus artefact [1, 2].

NB: H-reflexes require longer stimulation duration – see section 6(viii) e).

e) Stimulation intensity [1, 2, 5]

Intensity: incremental increase in stimulus within the range of 0-100mA (0-300V) sufficient to ensure supra-maximal stimulation [1] (excluding H-reflexes).

NB: H-reflexes require submaximal stimulation– see section 6(viii) f) for specific details.

(v) Sensory nerve conduction

Averaging of multiple potentials is almost always required to record sensory nerve action potentials (SNAPs) to reduce level of noise and artefact in the recordings [1, 5].

a) Recording direction

SNAPs may be recorded orthodromically or antidromically [5, 7].

b) Recording site [2, 3, 5].

Recording electrodes are placed longitudinally along the nerve or corresponding skin area [1, 3]. The inter-electrode distance between the recording electrodes should be fixed at 2-4cm [3]. The ground electrode should be placed between the recording and stimulating electrode [1].

Orthodromic: The recording electrodes are proximal (cephalad) to the stimulating electrodes.

Antidromic: The recording electrodes are distal (peripheral) to the stimulating electrodes.

c) Sensory recording parameters [1, 7]

Low Pass/High Frequency Filter: ≥ 2kHz (-3dB)

High Pass/Low Frequency Filter: ≤ 5Hz (-3dB)

Sweep: 1-2ms/division.

Sensitivity: 5-20μV/division

d) Stimulation site

The cathode of the stimulating electrode is placed over the nerve nearer the recording electrode and the anode placed further away [1].

See 'Recording site' for orthodromic vs antidromic techniques 6. (v) b).

e) Measured parameters

For each stimulation site, the onset latency, peak latency, or both and the base line to peak or peak to peak amplitude and duration are measured [2, 3,)

Conduction velocity is calculated using the distance between stimulating cathode and active recording electrode(s) and onset latency [2, 4, 5,).

(vi) Motor nerve conduction

a) Recording site

Recording surface electrodes are placed over the muscle of interest, with the recording electrode over the motor point (the bulky centre of the muscle) and the reference electrode over a more distal tendon or inactive bony prominence [2, 3, 5,].
The ground electrode should be placed on the extremity of the nerve studied [2].

b) Motor recording parameters [1, 2, 7].

Low Pass/High Frequency Filter: ≥ 10kHz (-3dB)
High Pass/Low Frequency Filter: ≤ 2Hz (-3dB)
Sweep: 1-5ms/division.
Sensitivity: 2-5mV/division

c) Stimulation site

The cathode is placed directly over the nerve closest to the active recording site with the anode proximal to the cathode along the nerve [1, 2, 5]. The nerve is stimulated at two or more sites, one distal and one or more proximal sites [2, 3, 5].

d) Measured parameters

For each stimulation site the onset latency, base to peak amplitude and often duration and the area under the compound muscle action potential (CMAP) is measured [2,5]. The conduction velocity between segments is calculated using the distance between two stimulation sites and the difference between the onset latency from the two recording sites [2, 4, 5].

(vii) F-wave

F-waves are recorded using similar techniques used for recording CMAPs [8].

a) Recording site

Recording surface electrodes are placed over the muscle of interest, with the active recording electrode over the motor point (the bulky centre of the muscle) and the reference electrode over a more distal tendon or inactive bony prominence [8].
The ground electrode should be placed between the recording and stimulation site[8].

b) F-wave recording parameters [1, 8]

Low Pass/High Frequency Filter: ≥ 10kHz (-3dB)
High Pass/Low Frequency Filter: ≤ 2-20Hz (-3dB)
Sweep: Upper limbs - 5ms/division with a total sweep of 50ms
Lower limbs – 10ms/division with a total sweep of 100ms
Sensitivity: 100-200µV/division

c) Stimulation site

The cathode is placed directly over the nerve with the anode distal to it along the nerve [2, 8] (opposite to CMAP stimulation).

d) Stimulation rate

Rate: 0.5Hz or less [8]. 10-20 single pulses are given to sample several axons [4, 8].

e) Measured parameters

For each stimulation site, the minimum and maximum onset latency, latency dispersion (difference between minimum and maximum onset latency) and amplitude of the F-wave is measured, [5, 7, 8] and persistence is noted.

(viii) H-reflex

The H-reflex is most commonly recorded from the soleus muscle with stimulation of the tibial nerve and from flexor carpi radialis (FCR) with stimulation of the median nerve [9].

a) Recording site

When recording the H-reflex the patient should be positioned to avoid stretch of the muscles studied [9].

Soleus: The active recording electrode is placed over soleus between the heads of the gastrocnemius muscles [9] and the reference electrode is placed 3-5cm distally.

FCR: The active recording electrodes are placed 4-5cm apart over the belly of the muscle [9].

The ground electrode should be placed between the recording and stimulation sites[7].

b) H-reflex recording parameters [7]

Low Pass/High Frequency Filter: ≥ 10kHz (-3dB)

High Pass/Low Frequency Filter: ≤ 2-3Hz (-3dB)

Sweep: 10ms/division

Sensitivity: 500µV/division

c) Stimulation site

For soleus the cathode is placed at the mid-popliteal crease and for FCR at the elbow with the anode distal along the nerve [9].

d) Stimulation rate

Rate: Should not exceed once every 3-5s (0.2-0.3Hz) [9].

e) Stimulation duration

Duration: 0.5-1.0ms [7, 9].

f) Stimulation intensity

The H-reflex is obtained at weak stimulus: maximum amplitude of the H-reflex waveform is usually obtained just above the M-wave (direct CMAP) threshold [9].

g) Measured parameters

For each stimulation site, the onset latency of the H-reflex is measured, initial positivity for soleus and initial negativity for FCR [9]. Amplitude may be measured from baseline to peak or peak to peak providing consistent measurement with M wave amplitude is maintained [9]. Calculation of the difference between the H-reflex and the M wave is made [9].

(ix) Repetitive Stimulation (RS)

Repetitive stimulation is performed using modified CMAP recording parameters [4]. Stimulation is applied in trains before and after exercise with distal and proximal muscles studied [4, 10].

a) Recording site

The test sites commonly used for repetitive stimulation [10] are

- deltoid (axillary nerve)
- trapezius (accessory nerve)
- abductor digiti minimi (ulnar nerve).

Other recording sites include [10]

- biceps (musculocutaneous nerve)
- anconeos (radial nerve)
- anterior tibial (fibular/peroneal nerve)
- extensor digitorum brevis (fibular/peroneal nerve).

Care must be taken to minimise movement of the muscle under examination and the recording electrodes. This may require immobilisation of the limb [4, 11].

b) Recording parameters

As for motor nerve conduction – see section 6(vi) b).

c) Stimulation site

The stimulation site for RS is the same used for recording the distal site of the CMAP. See section 6(vi) c).

d) Stimulation rate [4, 11]

Rate: Trains of 8-10 stimuli at rates of 2-5Hz or 20-50Hz.

Note: High stimulation rates are used to differentiate pre synaptic transmitter release disorders such as Lambert- Eaton Myasthenic Syndrome (LEMS) [4, 11].

e) Stimulation procedure [11]

Stimulation is applied in trains at rest and at 2 or more 30s intervals following muscle contraction exercise.

f) Measured parameters [4, 10]

Initial amplitude – amplitude and area of 1st M-wave

Decrement – percent reduction of amplitude and area from 1st to 4th or 5th M-wave.

Measurements are compared with stimulation at rest and at post exercise intervals.

(x) Blink reflex

Blink reflexes are usually elicited by stimulation of the supraorbital nerve (1st division of the trigeminal nerve) and are recorded from the obicularis oculi muscles. The blink reflex comprises an early response (R1) ipsilateral to the stimulated supra-orbital nerve and a later bilateral response (R2) [12]. Ipsilateral and contra-lateral responses are recorded [7, 12].

a) Recording site [7, 12]

The active recording electrode is placed in midway on the lower lid of each eye, the reference electrode on the side of the nasal bone and the ground electrode is placed under the chin.

b) Recording parameters [7, 12]

Low Pass/High Frequency Filter: ≥ 2kHz (-3dB)
High Pass/Low Frequency Filter: ≤ 20Hz (-3dB)
Sweep: 10ms/division
Sensitivity: 50-200µV

c) Stimulation site

Supra-orbital nerve: The cathode is placed over the supra-orbital foramen and the anode 2cm higher and rotated lateral [12].
The ground electrode can be placed under the chin [12], on the forehead or the cheek[7].
Stimulation is performed with the subject's eyes open and in an alert state [12].

d) Stimulation rate

Rate: Intervals of 7s or more to avoid habituation [12].

e) Measured parameters [12]

Onset latency of R1 ipsilaterally
Onset latency of R2 bilaterally
Difference between ipsilateral and contralateral R2
Side to side stimulation comparison of latencies R1 and R2

7. QUALITY CONTROL

(i) Normal Values

Each lab should establish its own normative data using standard stimuli and recording parameters [10].

Recording parameters such as stimulus type should be the same for all patients tested and for all subjects from which normative data is obtained [10].

Normative values from other institutions or sources may only be utilised if equivalent stimulation and recording parameters are employed [10]

Note that normative values may be influenced by age, gender limb temperature and height of the patient and that acquired normative data for adults must be in a given age and height range [10].

8. ELECTRICAL SAFETY

Electrical safety precautions in accordance with the 'Australian and New Zealand Standards: Guide to the Safe Use of Electricity in Patient Care AS2500:2004 Electrical Installations - Patient Areas' should be adhered to [3].

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Appendix 1 – Stakeholders

Stakeholders

- ANTA Inc. Members
- Document Development Committee
- Document Development Committee Advisory Group
- Other interested parties

Original Document

Document development Committee

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Advisory Committee

The document development committee identified a group of key stakeholders to view the draft documents for feedback. The advisory group was made up of technologists, scientists and neurologists working in the neurophysiology industry around Australia. The comments from this group were considered, compared against the reference material and included where appropriate

Members Feedback

On completion of the final draft the document was put out to all members of ANTA Inc. for feedback. The comments from members were considered, compared against the reference material and included where appropriate.

Guideline Acceptance

This Guideline was accepted by members in August 2015.

Amendments

2016 May	Disclaimer and Copyright statements added.
2023 July	Rebranded to ANSA Inc.

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