Results
National audit of IONM of spinal cord during corrective spinal deformity surgery
2016

Presented by:
Helen Grover, CSci
Healthcare Scientist (Neurophysiology)
Norfolk and Norwich University Hospital

BSCN
Founded as the EEG Society in 1942

Joint National Audit Project

ASSOCIATION OF ANS
NEUROPHYSIOLOGICAL SCIENTISTS

Method

Prospective study

Participation

invited from all hospitals

providing monitoring for

spinal deformity surgery

Audit form B completed

5 consecutive

spinal deformity cases

(Feb-April 2016)

35 questions (yes/no answers)

+ 5 questions if neuromonitoring alert

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2016 Audit of intraoperative monitoring of spinal cord during corrective spinal deformity surgery.

Postcode of Centre (Please complete)		Local Case identification number		Project Code (Do not complete. For office use only)	

Details of case	Patient age:	Type of Surgical procedure:

Please complete the questions 1-32 for 5 consecutive IONM cases for *Corrective Spinal Deformity Surgery* only (ie paediatric/ adult scoliosis or kyphosis corrective surgery).
Questions 34-41 should be completed in the event of a neuromonitoring alert having been issued.

General		YES	NO
1)	Before the patient was anaesthetised patient was identified and the clinical information verified		
2)	Monitoring continued until at least 20 minutes after last surgical manoeuvre or until monitoring was no longer possible		
3)	Traces are available for review (i.e. offline for post-operative review)		
4)	Neuromonitoring log completed and available for review		

Are the following annotated in the Neuromonitoring log?			
5)	Patient name, Date of birth and hospital/ NHS number		
6)	Date of operation		
7)	Type of surgical procedure		
8)	Name of surgeon(s)		
9)	Name of anaesthetist(s)		
10)	Name(s) of neuromonitoring personnel		
11)	Monitoring protocol used and any changes to protocol documented including any technical issues.		

LOWER LIMB SENSORY EVOKED POTENTIALS (LLSEP)

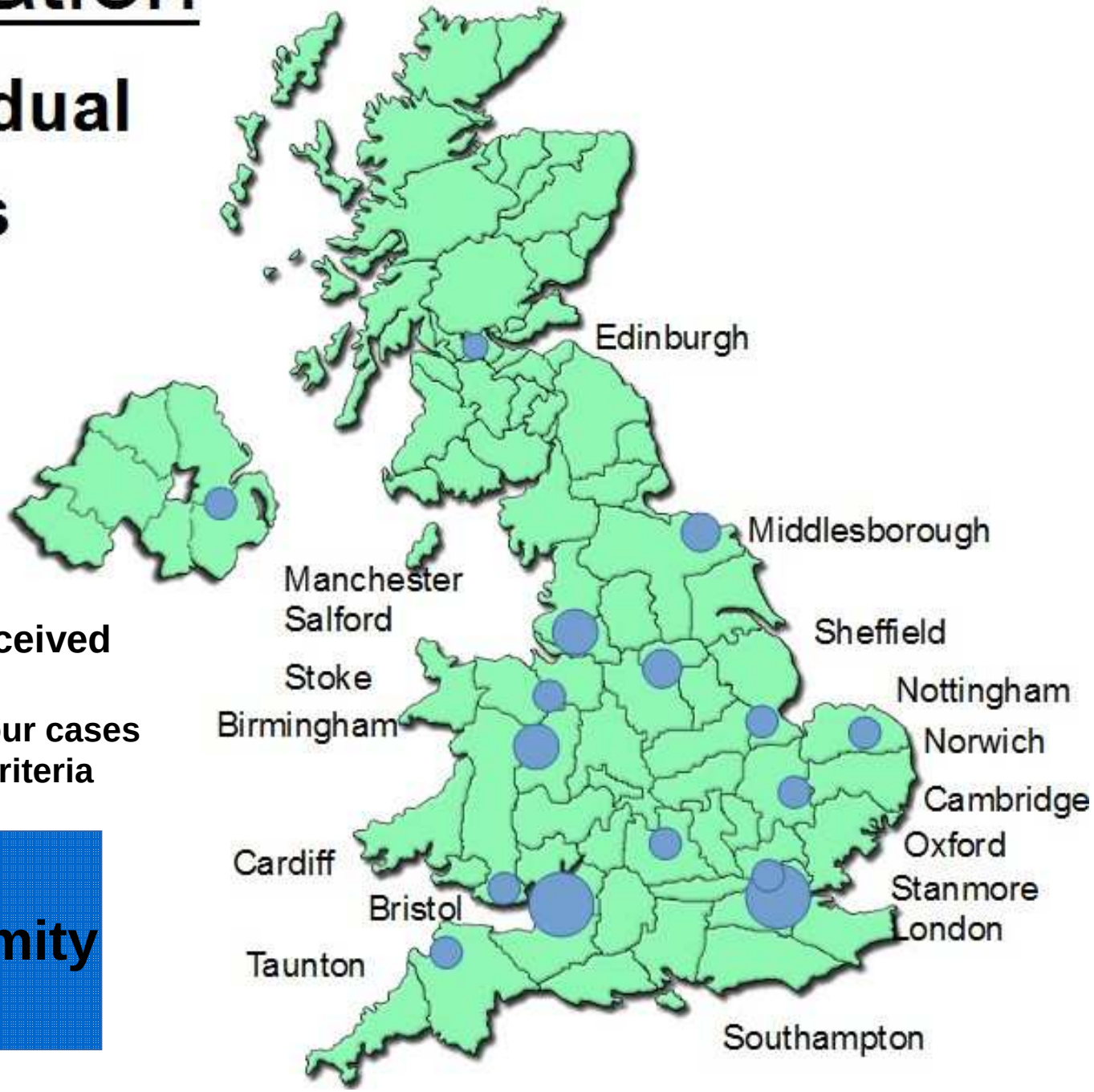
12)	LL SEPs performed		

If LLSEPs not performed please state the reason:.....

If LLSEPs are performed please complete the following section:			
13)	Reference LLSEP baselines recorded		
14)	LLSEP -bilateral, independent stimulation of peripheral nerve below the site of surgery		
15)	LLSEP -cortical, subcortical or epidural recording sites ie above the site of surgery		
16)	LLSEP peripheral control e.g. popliteal fossa recording *(guideline 9)*		
17)	LLSEP averaged traces obtained regularly throughout the monitoring period.		
18)	LLSEP waveforms are identified with the Stimulation and recording sites (right/left, name of peripheral nerve etc.), amplitude/latency markers		
19)	Recorded LLSEP waveforms are compared to baseline/preceding waveform.		

Participation

25 individual hospitals



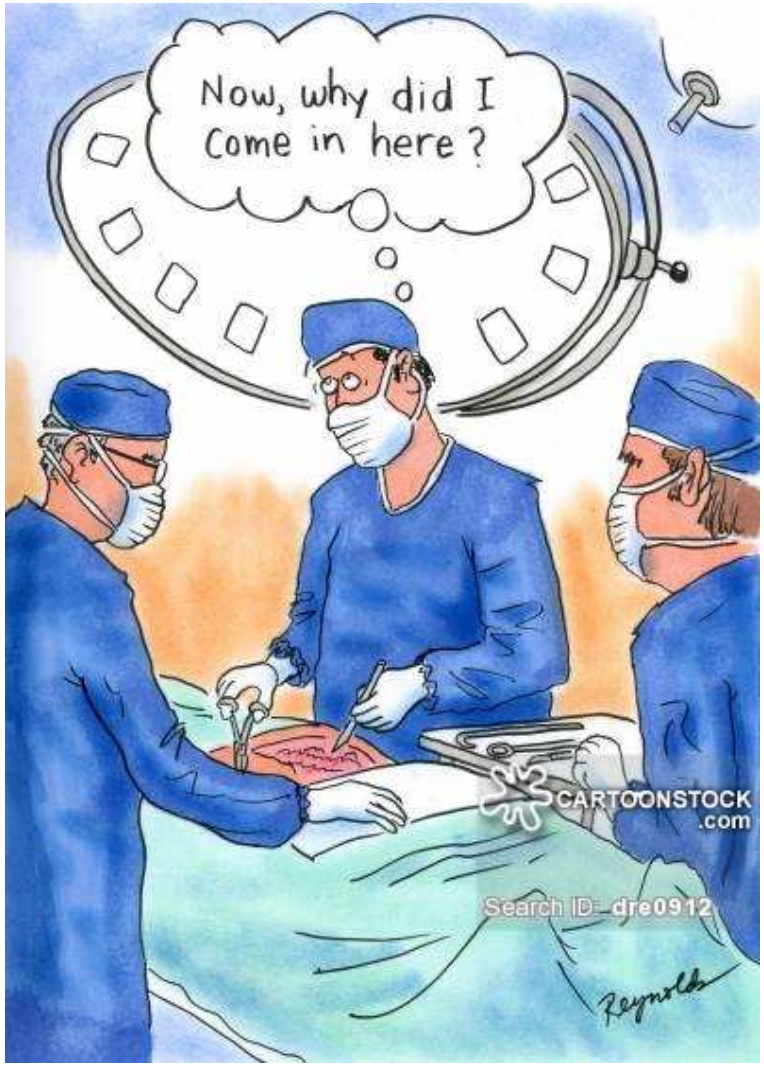
124 Audit forms received

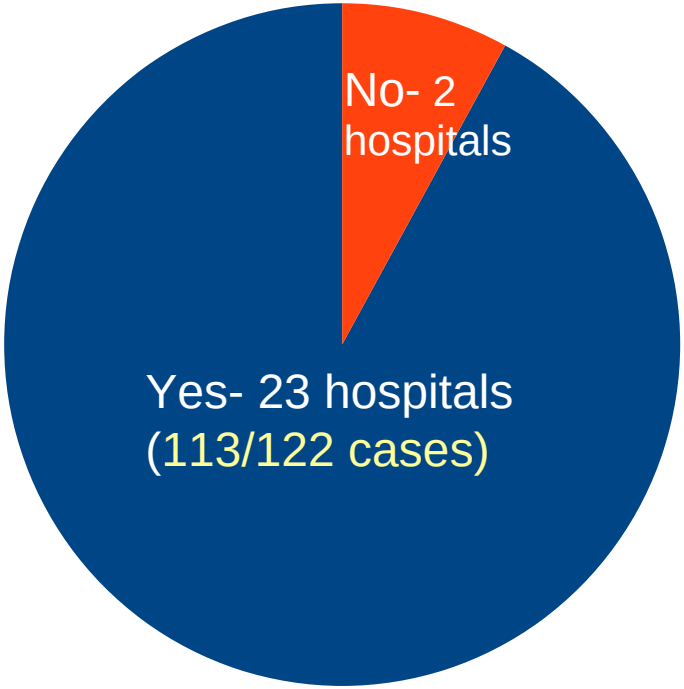
2 neurosurgical tumour cases did not fit inclusion criteria

122 spinal deformity cases

Question1

Standard 1
Prior to surgery the patients is identified, the clinical information is verified and the need for IONM us assessed.





Question 2
Monitoring continued for at least 20 minutes after last surgical manoeuvre or until monitoring was no longer possible

Standard 2

…responses are monitored……throughout the surgical procedure.

Practice

Monitoring should continue for 20 minutes after completing instrumented fixation or until monitoring is no longer possible

Yes 25/25 hospitals
122/122 cases

Question 3 & 4
Traces and Neuromonitoring log are available for review

Standard 7
A clear concise and accurate record of annotated waveforms should be kept.

Yes 25/25 hospitals
122/122 cases

Question 5-11-Annotations in the Neuromonitoring log

Standard 8-*Annotations in the record must include---*

Annotation	Audit result	
Patient name and date of birth	25/25 hospitals, 122/122 cases	
Hospital/ NHS number	24/25 hospitals 117/122 cases	
Date & type surgical procedure	25/25 hospitals, 122/122 cases	
Name surgeon & anaesthetist	24/25 hospitals 117/122 cases	
Name neuromonitoring personnel	25/25 hospitals, 122/122 cases	
Monitoring protocol used & any changes to protoco	25/25 hospitals, 122/122 cases	

Lower limb somatosensory Evoked Potentials

Standard 9
Sensory evoked potentials are recorded

Q13 & 19 Reference waveforms recorded and subsequent waveforms are compared to baseline/preceding waveforms

Standard 5

Q14 & 15 Bilateral, independent stimulation below site of surgery Recordings made above site of surgery *Standard 9*

Q17 Averaged traces obtained regularly throughout

Standard 2 & 10

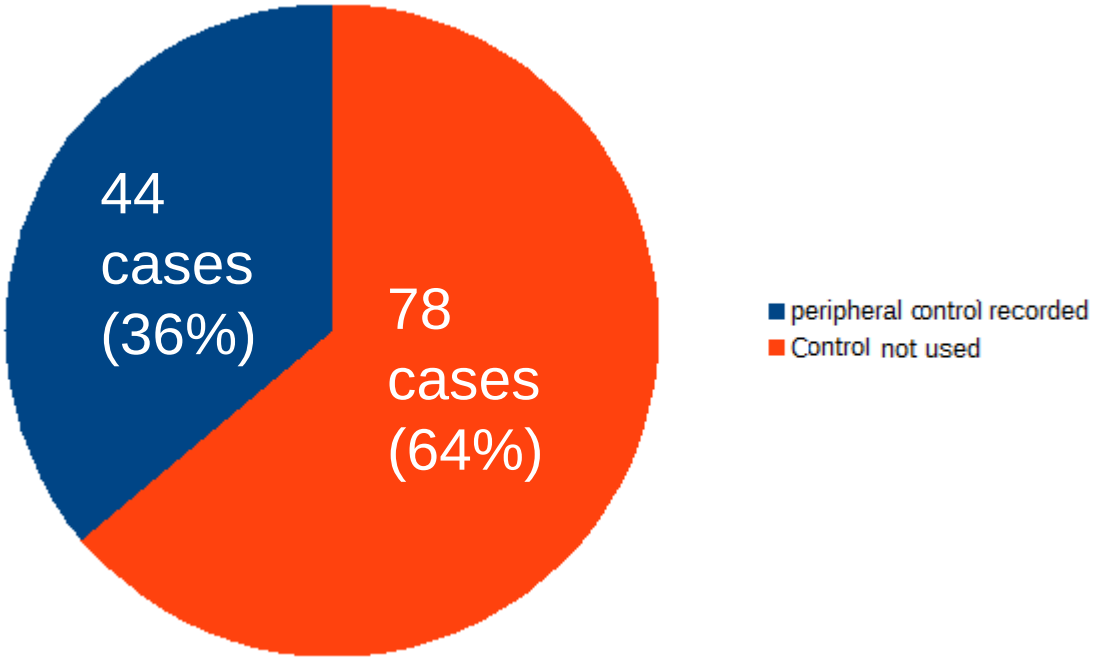
Q18 LLSEP waveforms identified with stimulation and recording sites, *Standard 3* amplitude and latency markers *Standard 5*

YES

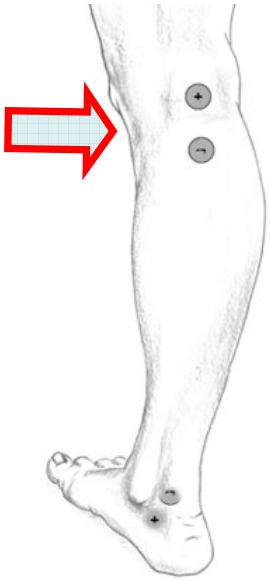
25/25 hospitals
122/122 cases

Q16. Use of peripheral control for lower limb SEP recording

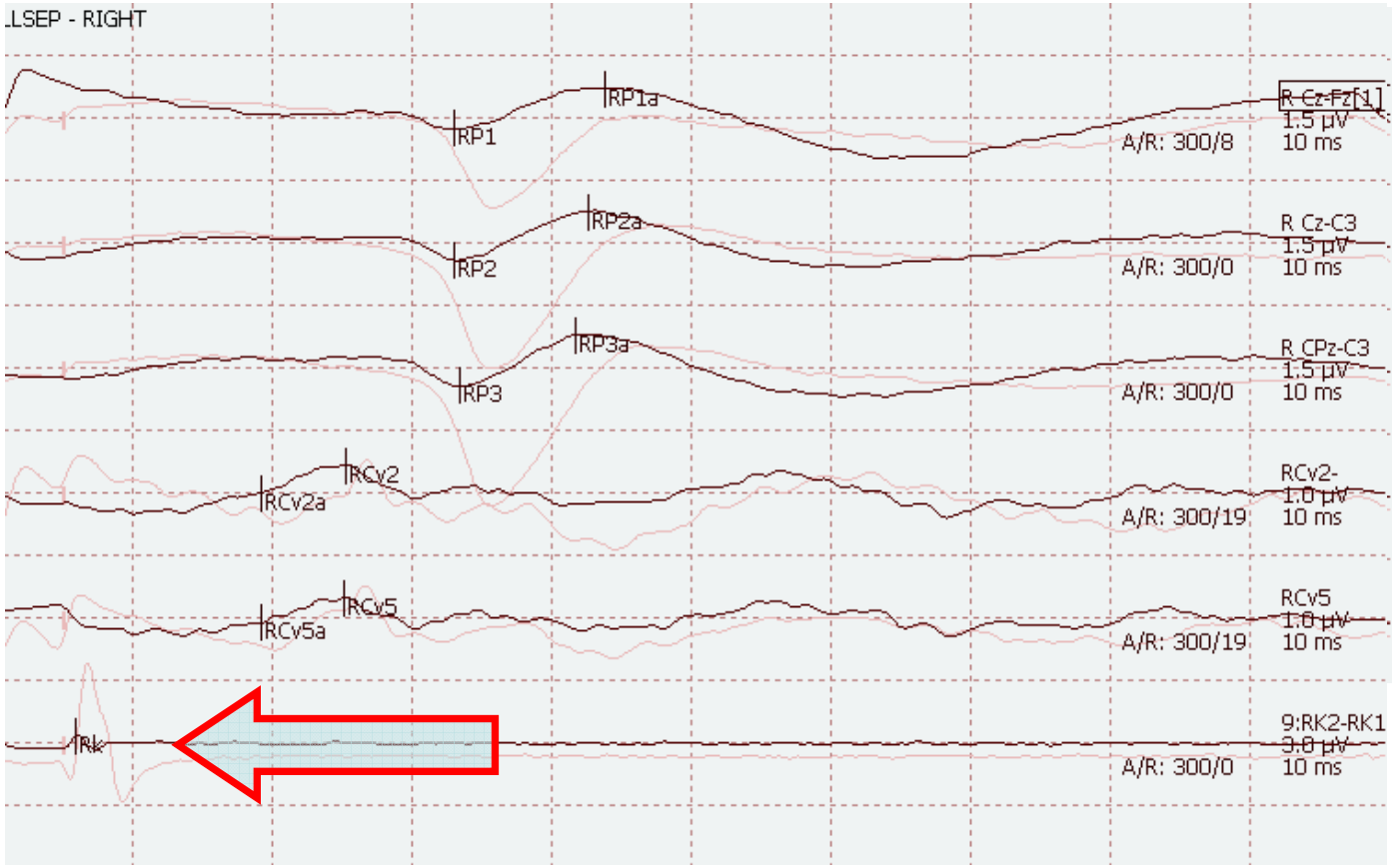
Guideline
'to help better distinguish technical and systemic changes from significant changes in spinal cord function related to surgery.



Guideline not a standard



Why record a peripheral control?



Quick technical check of stimulus

Helps reduce false positives

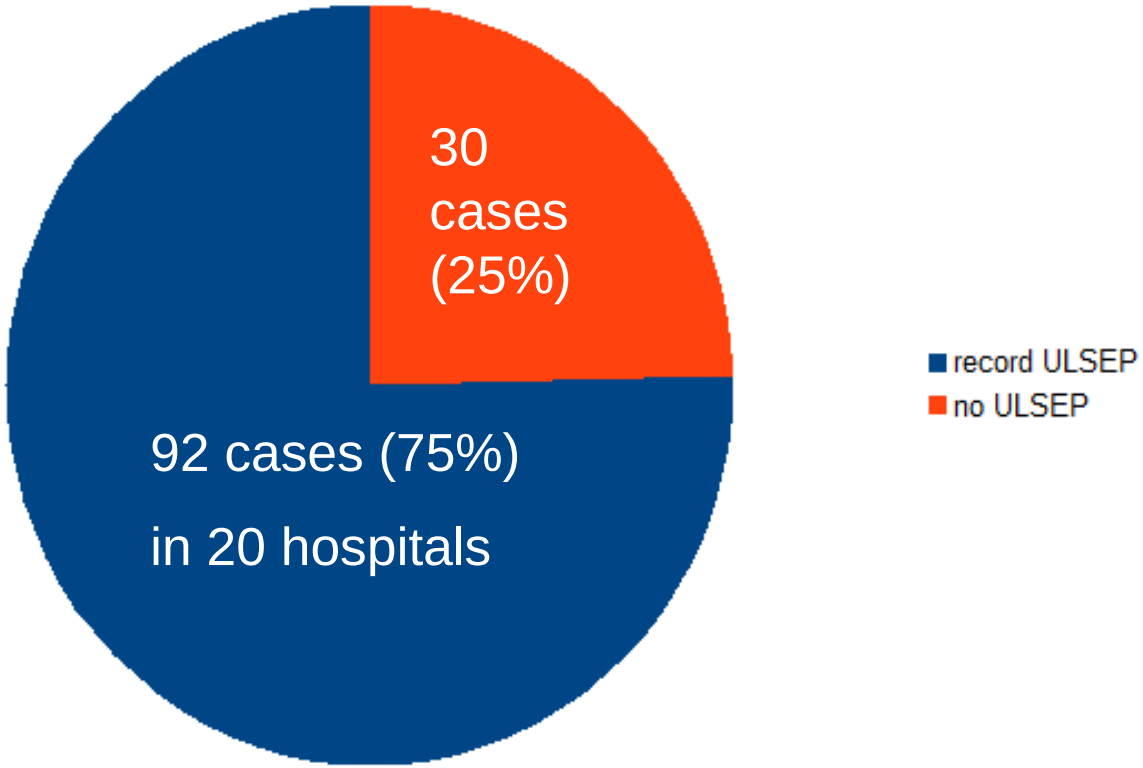
peripheral ischaemia?

Q20.The recording of control Upper Limb SEPs

Guideline

SEPs 'recorded above the site of surgery....

'Practice: stimulation of upper limb peripheral nerve, recording from cortex & where possible one of following sites: elbow/ACF, brachia, Erb's or cervical spine'



5 centres never record ULSEPs in thoraco-lumbar deformity cases

Reasons stated for not recording ULSEP

-‘not routinely recorded in scoliosis surgery’

-‘not department protocol’

-‘surgery not below C7’

-‘upper limb motor controls recorded instead’

-‘not relevant’

-‘not requested by surgeon’

-‘LLSEPs sufficient’

-‘not used in anterior surgery’

Guideline:
*SEPs ‘recorded **above** the site of surgery to help better **distinguish technical and systemic changes** from significant changes in spinal cord function’*

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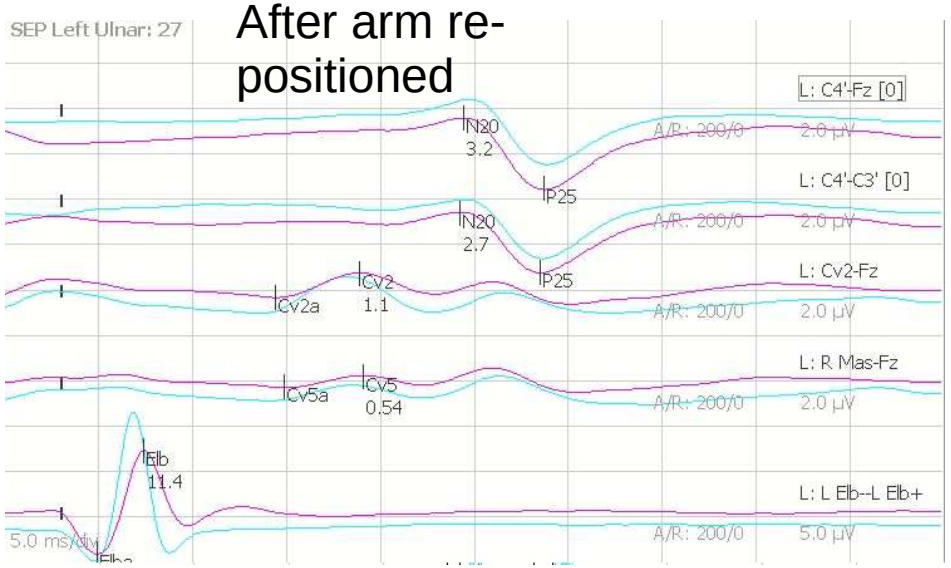
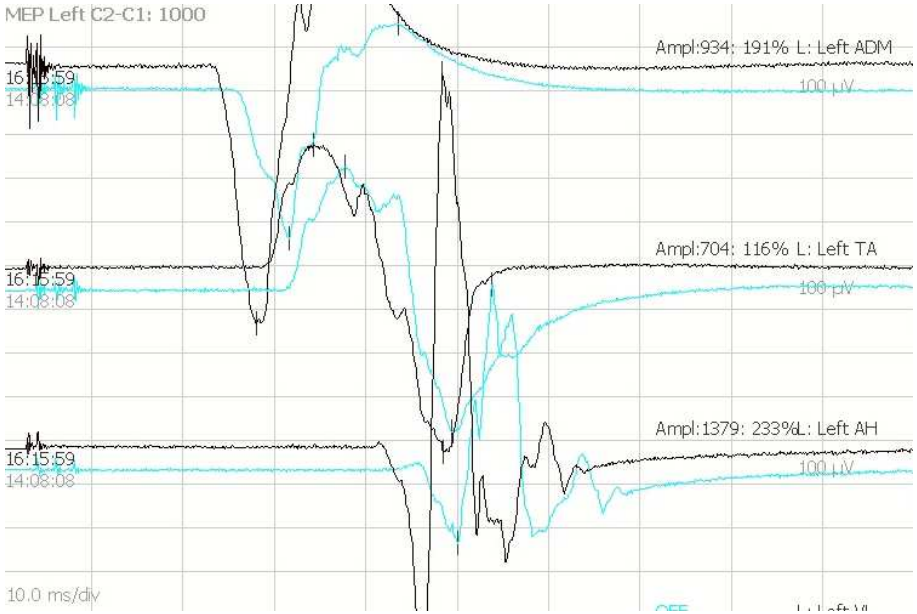
Example of usefulness of Ulnar nerve SEP during spine deformity surgery

Left ulnar SEP

After arm re-positioned



Left upper limb TcMEP



References for upper limb SEP & incidence ulnar neuropathy etc

Cheny et al 1999.

Ulnar neuropathy most common of cause lawsuit for anaesthetists

Brachial plexus injury second most common.

Warner et al 2000

0.5% Incidence ulnar neuropathy (all surgical procedures)

Prielipp et al 1999

Prolonged upper limb SEP changes can result in permanent nerve injury

Kamel at al 2014

1-8% to 15%-Incidence of position upper extremity SSEP alerts in spine surgery

Grover

10% (unpublished data)

UPGRADE RECORDING UPPER LIMB SEP TO STANDARD?

Q 21-25 If ULSEPs are performed

Q22 Recordings made above site of surgery *Standard 9*

Q24 ULSEP waveforms identified with stimulation and recording sites, amplitude and latency markers *Standard 3*

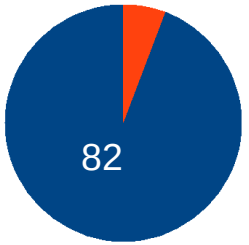
Q25 Reference waveforms recorded and subsequent waveforms are compared to baseline/preceding waveforms *Standard 2*

YES

20/20 hospitals
87/87 cases

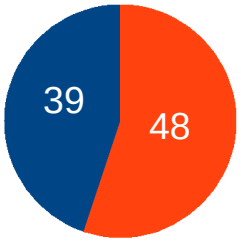
Q21 ULSEP -bilateral, independent stimulation of peripheral nerve *Standard 9*

82/87 cases



Q23 ULSEP peripheral control recorded eg Erbs, elbow *Guideline 9*

39/87 cases (44%)



Q26 Transcranial Motor Evoked Potentials

Guideline
Corticospinal pathways of the spinal cord may be monitored using MEPs across the site of the surgery.

*MEPs may be especially beneficial during **'high risk'** cases or where SEP monitoring is limited*

Yes 25/25 hospitals

120/122 cases
2 cases in 2 hospitals
growing rod lengthening
-no MEPs recorded

What does 'high risk' mean?

This is a Guideline- it should be a standard!

Recording TcMEPs

Q27. Reference MEP baselines recorded

Standard 2

Q28. Bilateral recording of 2 or more muscle sites below level surgery

Standard 12

Q31. Each MEP trace is identified with recording site

Standard 12

Q32. Recorded MEP is compared to baseline/preceding waveform

Standard 5

Q 33. MEPs recorded at key points during procedure

Standard 13

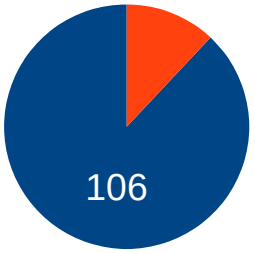
YES

25/25 hospitals
122/122 cases

Q29. Bilateral recording upper limb muscles

Guideline- recording control MEPs

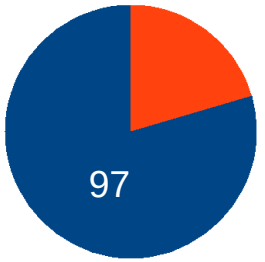
22/25 hospitals;
106/120 cases



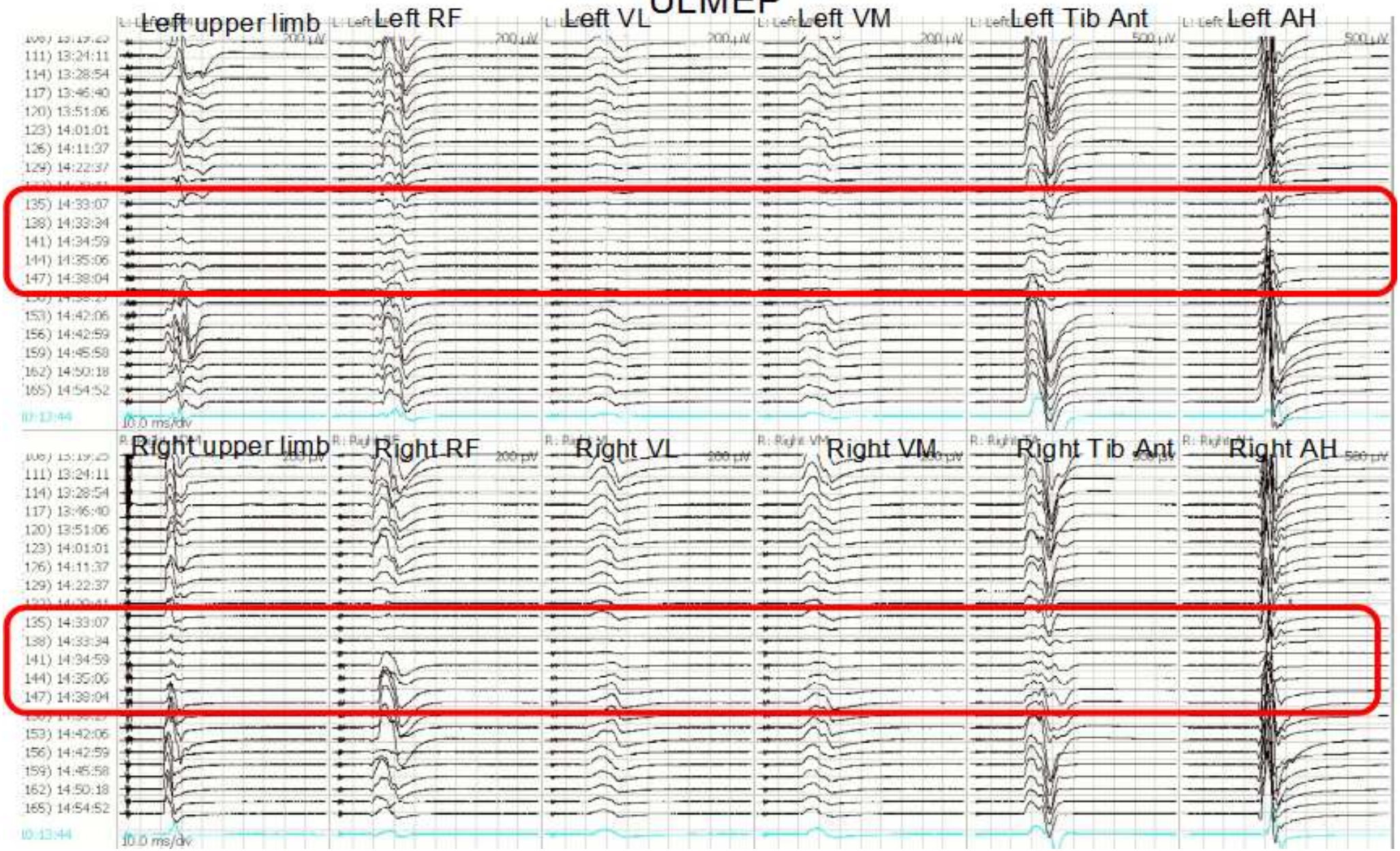
Q30. Each MEP trace is identified with stimulation site

Standard 3

21/25 hospitals;
97/120 cases



Example of systemic MEP changes- why record ULMEP



CHECK it is reversible- ?? could be cervical spine compromise eg. positional

Neuromonitoring alert criterion

Standard 4

A predetermined warning criterion is established……

…defines a significant repeatable change in amplitude, morphology and/or latency of the waveform, ***that cannot be explained by reversible technical or anaesthetic changes****.*

Q34. Predetermined definition of neuromonitoring alert for SEP available?

Yes
25/25 centres

Q35. Predetermined definition of neuromonitoring alert for SEP available?

Yes
25/25 centres

13/25 hospitals stated this in the alert criterion

Q39. reversible with technical changes?	2 in 2 centres
Q40. reversible with anaesthetic changes?	1 centre

Neuromonitoring alerts

Standard 6

The operating team is alerted to a significant change in the waveforms in a timely manner.

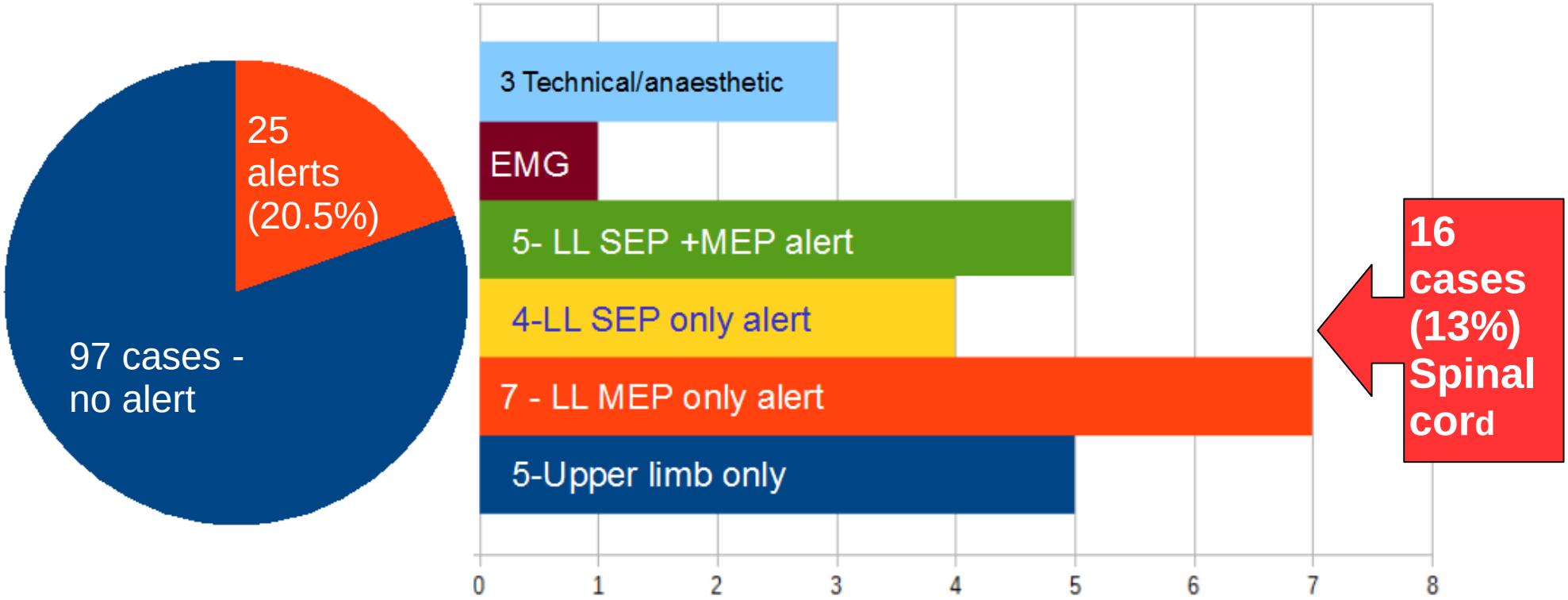
Standard 7

--any information conveyed to the surgeon and/or anaesthetist, and any response/action or outcome should be recorded/ annotated

Question	Audit result
Q36. Time of alert noted in log	23/24 cases (1 no answer)
Q37. Surgical team informed at time of alert	24/24 cases
Q38. Surgeons response noted in log	24/24 cases

Reported Neuromonitoring alerts

25 alerts reported (20.5%) in 15 centres



2 cases reported new neurological deficits (1.6%)

(Scoliosis Research Society 2007 1.87% risk iatrogenic spinal cord injury)

16 spinal cord monitoring events = 13%

?

Why so many alerts?

Too small sample size to make any conclusions

? what percentage of these are false positives (14 with no NND)

Published figures for alerts during spinal deformity surgery:

Samandi et al, 2016 - 5.3 % alerts in series 676 patients

Bhagat et al, 2014- 7.1% alerts in series 354 patients

Swartz et al 2007. 3.4% alerts in 1121 patients

Major / moderate alert criteria

MacDonald et al 2013
Guidelines: Intraoperative motor evoked potential monitoring – A position statement by the American Society of Neurophysiological Monitoring. Clinical Neurophysiology, 2013. 214: 2291-2316.

(1) Disappearance is a MAJOR criterion
mandating restorative efforts, including undoing surgical manoeuvres and modifying or even abandoning instrumentation.

(2) Depending on the monitoring program's technique and experience, marked amplitude reduction or acute threshold elevation (*based on deterioration clearly exceeding spontaneous variability with no apparent confounding factor explanation)* could be MODERATE criteria prompting restorative efforts, but might not justify major surgical modifications and might increase false positives. There are currently no published studies of morphology criteria for orthopaedic surgery.

2 MEP +SEP monitoring events with new neurological deficit (NND)

2 Major alerts

- 1 bilateral loss LLMEP + reduced LLSEP with spinal cord contusion

  →not reversible→NND

- 1 loss Right LLMEP + reduction Rt SEP evolving to bilateral loss LLMEP

  →not reversible→ NND= weak R leg

3 MEP +SEP monitoring events with no NND

2 MAJOR ALERTS

- 1 bilateral disappearance LLMEP + reduction LLSEP
  →reversal of correction & recovery signals

- 1 unilateral disappearance LLMEP and reduction LLSEP

→reversal of correction & recovery signals

? alert

1 bilateral 50% reduction LLMEP + 40%reduction LLSEP

→during insertion cages, no other details

Note this hospitals alert criteria 50% MEP and 30% SEP amplitude reduction

Reported LLMEP monitoring events

7 Lower limb MEP- no NND +1 difficult to assess NM

4 Major alerts

- 2 unilateral disappearance MEPs- recovered by reversal of surgical correction
- 1 bilateral disappearance MEPs - reversed by loosening of wires
- 1 unilateral disappearance MEPs not reversed by surgical changes (no details)

Moderate alert

1 unilateral 90% reduction MEPs after cord contusion, recovered after surgical pause

2 focal MEP alerts- limited detail

- 1 loss single muscle LLMEP and reduction bilaterally post correction, no recovery of responses
- 1 loss single muscle MEP, other muscles OK, occurred during correction, recovered with surgical pause

Reported LLSEP monitoring events

4 Lower limb SEP alerts- no NND

1 bilateral >50% reduction cortical LLSEP only, *no ULSEP recorded*, no MEP change-post correction ? details

1 bilateral 30% reduction cortical LLSEP, *no ULSEP recorded,* no MEP change, **artefact** , no alteration surgery?

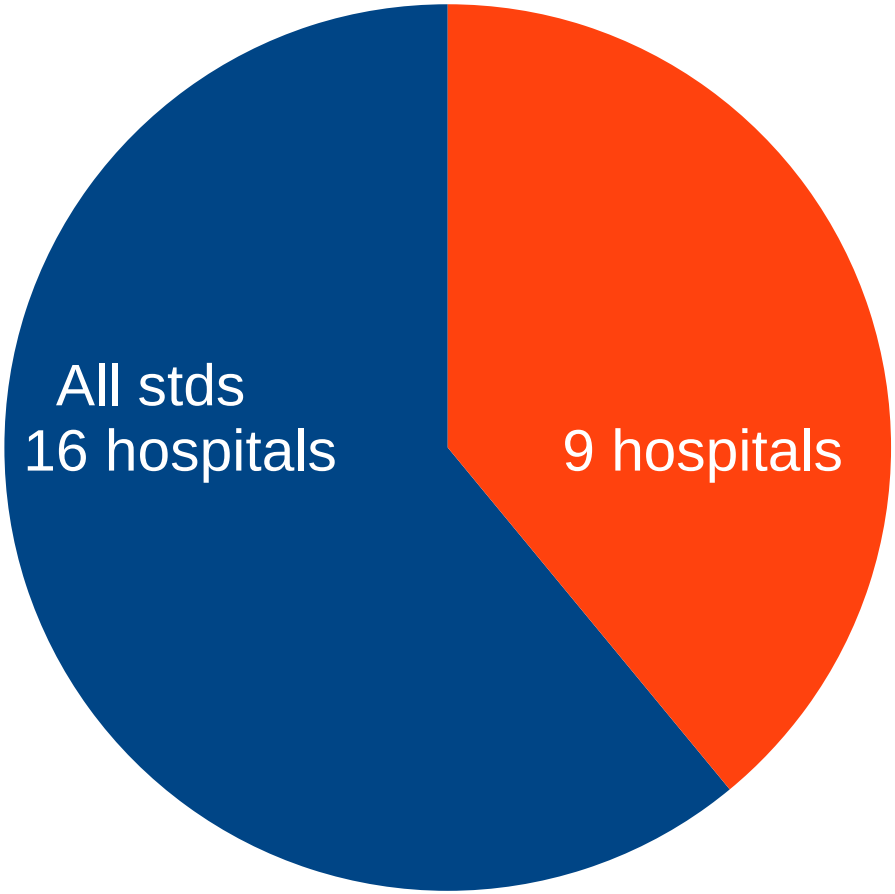
1 unilateral 50% reduction LLSEP, *no ULSEP recorded*, during unspecified surgical event, ? If reversed

1 bilateral reduction cortical LLSEP with preservation subcortical ULSEP during growing rod lengthening (MEPs *& cortical ULSEPs* not recorded)

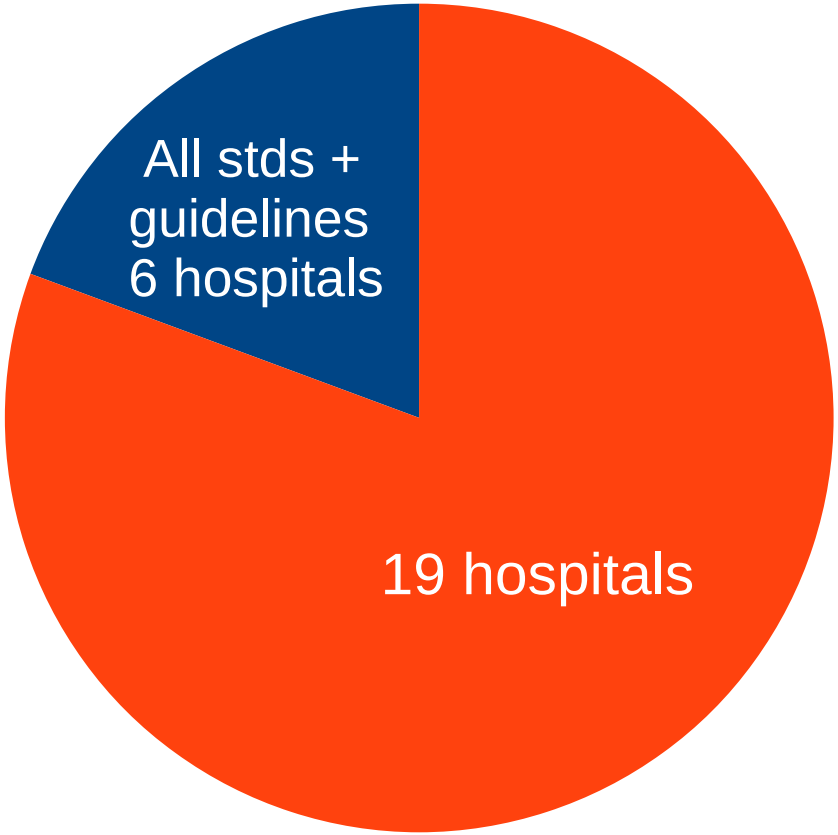
→spont recovery responses after 15 minutes

Overall adherence to standards

Adherence to standards



Adherence to standards AND guidelines



Recommendations

- TcMEPs as ‘standard’ when not contraindicated
  - (inc bilateral upper limb MEPs)
- Bilateral Upper limb SEP recording as ‘standard’
- Peripheral nerve recording for SEP recording as ‘standard’

False positives- can standards help reduce these???

More specific Alert criteria required (evidence based)

MEP-No evidence for use change of morphology (MacDonald et al 2013)

MEP-‘major’ / ‘moderate’ (MacDonald et al 2013)

Include details of technical/ anaesthetic checks

Alert criteria for SEP standardised >50% amplitude and 10% latency increase

Acknowledgements

Thank you to

- all participants of the audit
- the ‘trial’ centres for their comments
- members of the Joint National Audit Planning committee
- ANS/BSCN

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