Neuromonitoring for Spinal Deformity Surgery: Interactive Clinical Case Discussion

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Clinical Case

- 65 y/o woman with degenerative spine disease leading to lumbar kyphosis and fixed sagittal imbalance
- She is stooped over, has impaired ambulation, and intractable lower back pain
- Her deformity is likely too rigid to be corrected with instrumentation or facet release alone and will require osteotomy

- Surgeon is planning for a T10-pelvis posterior spinal fusion and L4 PSO (pedicle subtraction osteotomy)

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Pedicle Subtraction Osteotomy (PSO or 3 column osteotomy)

- A V-shaped wedge is taken out of the vertebral body
- The osteotomy is closed while hinging on the anterior cortex to reduce kyphosis by 30-40 degrees
- Risk for neurologic complications
  - Significant mobilization of neural tissue
  - Ischemia to spinal cord after straightening of the spine
  - Subluxation of thecal sac
  - Nerve root impingement
- Reported intraoperative and postoperative neurologic deficit rates between 3.6-12%

Eur Spine J (2013) 22 (Suppl 2) S254-S264.

What neuromonitoring techniques should be anticipated for this case?

A. SSEP
B. tcMEP
C. EMG
D. All of the above

A. SSEP Try again!

- While SSEPs are certainly indicated, there is a better answer choice.
- With only SSEP monitoring, only the ascending dorsal spinal tracts are monitored. A primary motor injury of the spinal cord or nerve root may be missed.
- In addition, changes in SSEP tend to lag behind changes in MEP by 5 minutes. The addition of MEPs will facilitate more rapid identification of impending spinal cord injury. (J Bone Joint Surg Am. 2007;89:2440-9)

B. MEP Try again!

- While MEPs have several advantages, such as the ability to immediately assess spinal cord function after high risk surgical maneuvers, there is a better answer choice.

C. EMG Try again!

- EMG is useful for identifying a single nerve root injury, but will not necessarily provide warning of injury to the spinal cord.

D. All of the above Correct!

- Multimodal neuromonitoring with SSEP, tcMEP and EMG is the best choice.
- The addition of each modality adds to the sensitivity and specificity of the neuromonitoring.
- In its 2009 information statement, the Scoliosis Research Society (SRS) considers the use of intraoperative spinal cord monitoring the preferred method to detect impending neurologic insult during spinal deformity corrections.

Scoliosis Research Society. Neuromonitoring information statement. Wisconsin: SRS; January 2009.
Electroencephalogr Clin Neurophysiol. 1995 Jan;96(1):6-11.

Which of the following is true about the blood supply of the spinal cord?

A. There is 1 posterior spinal artery and 1 anterior spinal artery
B. The anterior spinal artery supplies the anterior 1/3 of the spinal cord
C. The posterior spinal arteries originate from the carotid arteries
D. The anterior spinal artery receives reinforcement from additional blood vessels coming from the aorta called the segmental or radicular arteries. The largest one is the Artery of Adamkiewicz.

A. Try again

- There is one anterior spinal artery and two posterior spinal arteries that run along the length of the spinal cord

B. Try again

- The single anterior spinal artery supplies the anterior **2/3** of the spinal cord
- Disruption of the anterior spinal artery leads to paralysis below the lesion due to ischemia to the anterior motor tracts

C. Try again

- The statement is false.
- The posterior spinal arteries originate from the vertebral arteries.

D. Correct!

- The anterior spinal artery receives reinforcement from additional blood vessels coming from the aorta called the segmental or radicular arteries. The largest one is the Artery of Adamkiewicz.

A change in which of 3 modalities SSEP, tcMEP and EMG is most concerning for ischemia of the spinal cord?

A. SSEP

B. tcMEP

C. EMG

A. SSEP Try again!

B is correct!

- The corticospinal tracts, or the descending motor pathways, are located in the anterior portion of the spinal cord
- The anterior spinal artery provides 2/3 of the spinal cord blood supply
- Because tcMEPs monitor the anterior motor tracks of the spinal cord, normal tcMEPs responses suggest adequate spinal cord perfusion

Raw et al. BJA. 2003

C. EMG Try again!

T10-pelvis PSF with L4 PSO

- General anesthesia is induced and maintained on Sevoflurane 0.5 MAC, propofol gtt and a titratable narcotic infusion such as sufentanil or remifentanil
- A bite block is placed
- Arterial and venous access are obtained
- After the patient is turned prone, adequate baseline SSEP and tcMEP are obtained
- After exposure the surgeon requests to perform stimulus-triggered EMG during placement of pedicle screws

Stimulus-Triggered EMG

Myotome activation with a low current during pedicle screw/hole stimulation suggests that there is an adequate cortical bony layer between the screw/hole and a healthy nerve root

TRUE or FALSE

J Clinical Neurophysiology 2002: 19(5):444-453.

Try again!

- Spinal nerve roots are at risk of injury during pedicle screw placement if the pedicle wall is breached
- Direct electrical stimulation of a misplaced screw or hole will activate the muscles of adjacent nerve roots even when stimulated at a low level because the cortical bony layer is no longer impeding the passage of electrical current
- The stimulus current intensity at which the myotome is activated is called the “stimulus threshold”
- **Thresholds less than 4-6 mA are concerning for breach of the pedicle wall**

J Clinical Neurophysiology 2002: 19(5):444-453.

Correct!

- The statement is false.
- Spinal nerve roots are at risk of injury during pedicle screw placement if the pedicle wall is breached
- Direct electrical stimulation of a misplaced screw or hole will activate the muscles of adjacent nerve roots even when stimulated at a low level because the cortical bony layer is no longer impeding the passage of electrical current
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Free running EMG (electromyography)

- Free running EMG is also useful for identifying nerve root irritation/injury
- In contrast to triggered EMG, free running EMG signifies spontaneous muscle activation from specific nerve roots
- Multiple channels of different dermatomes can be monitored at once
- Neurotonic discharges indicate blunt mechanical irritation or injury to a nerve root

J Clinical Neurophysiology 2002: 19(5):444-453.

Signal Changes during L4 PSO

During the L4 PSO the surgeon extended the spine to close the vertebral defect. At this time the technician stated that the tcMEP from the rectus femoris, adductors, and vastus medialis decreased 80% from baseline. At that time there was no SSEP change.

What is the most likely cause?

A. Temperature change
B. Acute anemia
C. Surgical cause
D. Anesthetic reason

A. Temperature

- We would expect a global change in neuromonitoring signals with temperature change.

B. Acute anemia

- Acute anemia can certainly cause neuromonitoring changes, but would likely cause a global change.

C. Surgical cause

- Because of the focal tcMEP change and its temporal relation to extension of the spine, a surgical cause is the best choice of the answer choices. The surgeon should be immediately notified.
- Further, SSEPs tend to lag behind changes in MEP by 15-20 minutes. This explains why there was a change in MEP without an SSEP change at that time. (J Bone Joint Surg Am. 2007;89:2440-9)
- During trouble-shooting (ruling out technical causes, and although unlikely, other causes such as positioning, anesthesia and physiologic causes), the mean arterial blood pressure should be raised to a level above the patient's baseline blood pressure.

D. Anesthesia reason

- While an anesthetic reason could certainly cause a decrease in MEP potentials, (for example an increase in MAC or a bolus of propofol) an anesthetic reason would most likely affect both legs at the same time.
- It is prudent to maintain a stable anesthetic from the time when baseline recordings are made.

- After the tcMEP changes, the surgeon widened the osteotomy and performed a central spinal canal decompression.
- The tcMEP amplitudes recovered.

Wake-up Test

- A wake-up test is considered if there is no return of signals to baseline after trouble-shooting.
- During a wake-up test, there must be coordination between the surgeon, nursing, and anesthesiology.
- The volatile anesthetic and propofol infusions are turned off while narcotic infusions are continued or decreased.
- A team member stands by the patient's legs to examine for movement while the anesthesiologist orients the patient and awaits the patient to follow a simple command such as hand squeezing.
- Once the patient can follow commands, the patient is asked to wiggle the toes.

Koht et al (eds.) Monitoring the Nervous System for Anesthesiologists and Other Health Care Professionals. 2nd ed. 2017.

Patient Outcome

- After thoracic to pelvis posterior spinal fusion with L4 PSO, the patient has dramatic improvement in global sagittal alignment and lumbar kyphosis and no neurologic deficits.