

Neuromonitoring of Acute Spinal Cord Injury: Verona experience

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Introduction: Clinical neurophysiological studies are routinely performed in the subacute and chronic phase after spinal cord injury (SCI), while there are virtually no studies in the acute (0-72 h) phase. Yet, most of the transition from primary to secondary injury takes place within hours after trauma and therefore this is the critical time where the pathophysiology of the injured cord should be investigated.

In this pilot study, we explored the possibility to apply intraoperative neurophysiological monitoring (INM) to surgical procedures performed during the acute phase (0-72 h) after SCI, with the aim of defining the neurophysiological profile of the injured spinal cord. We focused specifically on the research of the so called killed-end potential (KEEP), also known as “injury potential”. This has proved to be a neurophysiological landmark of SCI in experimental studies, while clinical data are only anecdotal.

Methods: From December 2006 to October 2008 we succeed in performing INM in 13 patients (11 males, 2 females) operated on within 72 hours after acute spinal cord injury. Posterior decompressive laminectomy and fixation were performed in 12 patients; an anterior decompression was done in one patient. The ASIA score was assessed on admission and then 12 hours, 7 days and 3, 6, 12 months after surgery.

Transcranially elicited motor evoked potentials were recorded from limb muscles (mMEPs) after multipulse stimulation and from the epidural spinal space after single transcranial stimulus (D-wave). Somatosensory evoked potentials were elicited after median and tibial nerve stimulation and recorded from the spinal cord (spinal SEPs) and the scalp (cortical SEPs). Epidural electrodes were placed rostral and caudal to the level of the laminectomy to record D-waves and spinal SEPs both proximal and distal to the injury site. This epidural electrode was also moved across the injury site to attempt the recording of the KEEP. All patients received methylprednisolone prior to surgery according to the National Acute Spinal Cord Injury Study protocol.

Results (table 1): On admission, 7 patients were on ASIA A, 2 on ASIA C, 4 on ASIA D.

Time between SCI and surgery was 7.5 hours (median; range 3.5-24 hours). After surgery, these patients were followed with a mean follow-up time of 11.3 months (range 4-22). At surgery, caudally to the level of the lesion mMEPs were absent in all but two ASIA D patients, and unmonitorable in one because of myorelaxation. D-wave caudal to the level of injury was absent in 6 patients (5 ASIA A, 1 ASIA D), present in 2 (one ASIA C, one ASIA D), unmonitorable in 4 patients (3 because of low spinal cord level, 1 because of anterior surgical approach), and questionable in one (ASIA A). Spinal SEPs cranially to the level of the lesion were absent in 7, present in 4 (1 ASIA C, 3 ASIA D) and unmonitorable in 2 patients. A D-wave and spinal SEP KEEP was recorded in 4 patients: these 4 patients were ASIA A on admission and remained ASIA A at the follow-up. The other 2 patients with absent D-wave caudally to the lesion (one ASIA A, one – with extradural hematoma- ASIA D), were unchanged at discharge from hospital, but one recovered to ASIA B at the follow-up. The

patient with questionable D-wave on admission (ASIA A), recovered to ASIA B at discharge and ASIA D at the follow-up.

Conclusions: This preliminary study suggests that the presence of a KEEP may represent a neurophysiological landmark indicating irreversible complete SCI. Conversely, whether or not – in the absence of a KEEP - the absence of D-wave on the acute phase after SCI necessarily indicates a complete and irreversible motor deficit does not emerge clearly from our results.

Further data should clarify whether the combination of D-wave and KEEP recordings will allow to establish reliable prognostic criteria, possibly differentiating transient block of conductivity from permanent corticospinal tract injury.

Table 1: Correlation between intraoperative neurophysiological data and ASIA scores

Pt.	Tc-MEP from limb muscles caudal to the level of injury	D-wave caudal to the level of injury	Spinal SEPs rostral to the level of injury	D-wave KEEP	Spinal SEPs KEEP	ASIA on admission	ASIA at discharge	ASIA at follow-up
GF	Absent	Questionable (absent)	Absent	Questionable (no)	Questionable (no)	A	B	D
TM	Unmonitorable (anesthesia)	Unmonitorable (anesthesia)	Unmonitorable (cortical SEPs only)	Unmonitorable (L1)	Unmonitorable (L1)	C	D	D
SS	Absent	Absent	Absent	Yes	Yes	A	A	A
TC	Absent	Present	Present	No	No	C	D	E
SG	Absent	Absent	Absent	No	No	D	D	D
PMK	Absent	Unmonitorable (anterior approach)	Unmonitorable (anterior approach)	Unmonitorable (anterior approach)	Unmonitorable (anterior approach)	A	A	A
CG	Absent	Absent	Absent	Yes	Yes	A	A	A
AM	Present	Unmonitorable (L1)	Present	Unmonitorable (L1)	Unmonitorable (L1)	D	D	D
DRG	Absent	Absent	Absent	Yes	Yes	A	A	A
SB	Absent	Present	Present	No	No	D	D	D
KA	Absent	Absent	Absent	Questionable (no)	Questionable (no)	A	A	B
TG	Present	Unmonitorable	Present	No	No	D	D	D
ZC	Absent	Absent	Absent	Yes	Yes	A	A	A