The choice of lower limbs target muscles influences monitorability and reliability of muscle motor evoked potentials in spinal surgery

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NESSUNO DEGLI AUTORI HA CONFLITTI D'INTERESSE

- Intraoperative muscle Motor Evoked Potentials (m-MEPs) are widely used in spinal surgery with the aim of identify a damage to spinal cord at a reversible stage.
- Over the years the methodological aspects of m-MEPs have been extensively studied, especially as regards the stimulation parameters (current vs tension stimulators, type of electrodes, intensity, pulse widh).

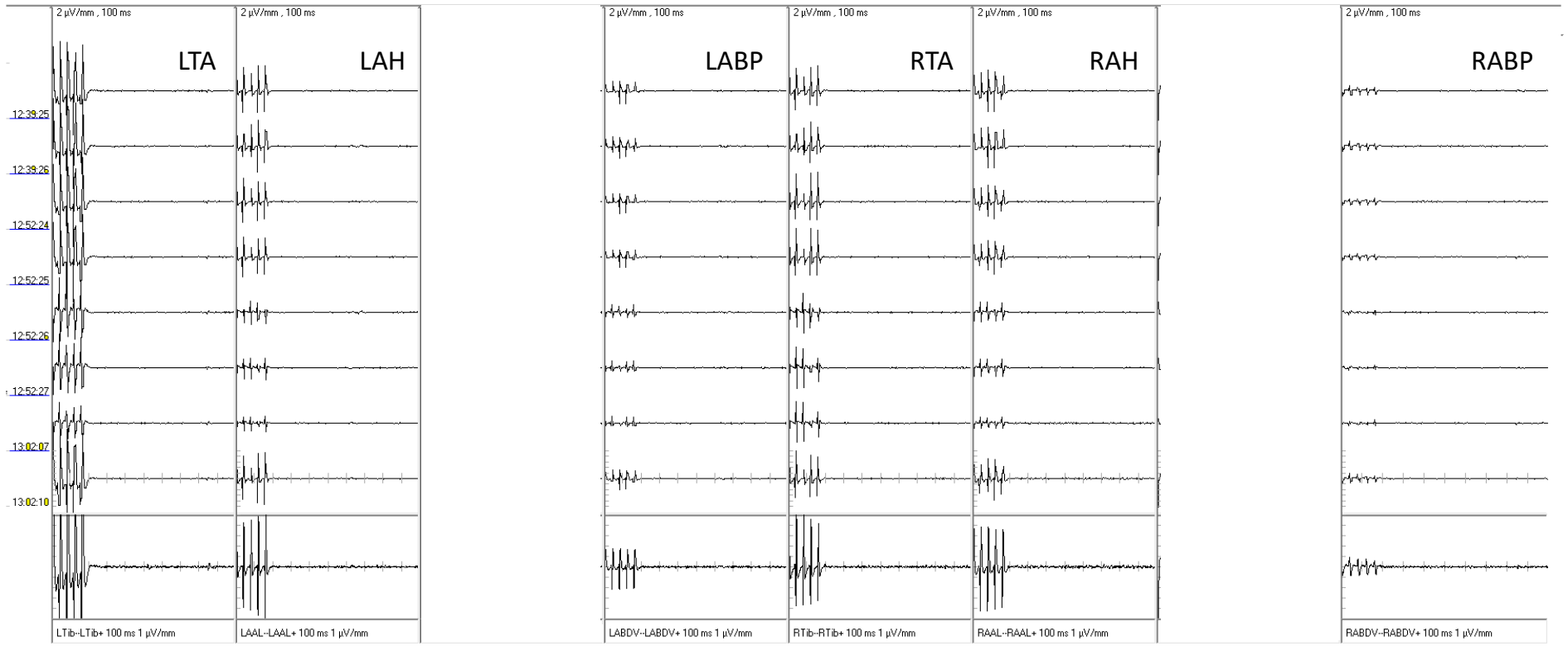
Intro

- Generally, m-MEPs are recorded by two muscles of the lower limbs to ensure monitoring in case of a malfunction of an electrode and to reduce the number of alarms in the eventuality of deterioration of responses from a single muscle.
- As for the choice of muscles, the small muscles of the extremities are generally used due to their greater cortical representation. In practice this translates into the use of the abductor hallucis [AH] and the tibialis anterior [TA] that are the most used muscles.

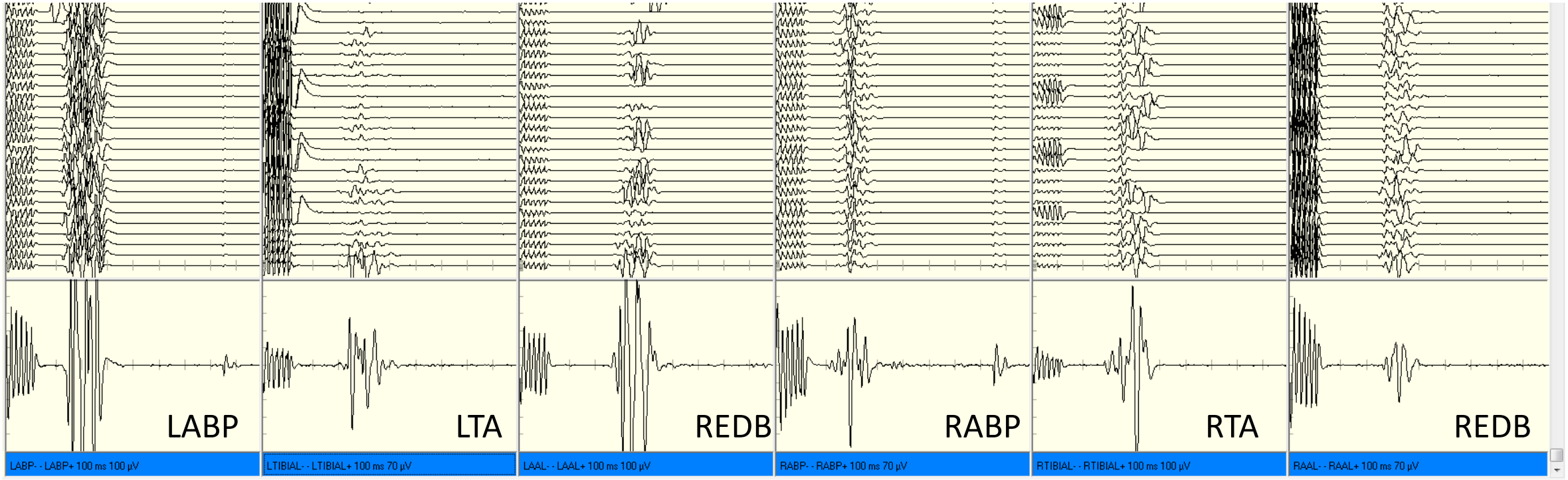
Autore	Anno	Setting	Casi	AASS	AAII	Monitorizzabilità
Hattori	2019	CARDIOCHIRURGIA	1248	ABP	RTP, AH	
Liu	2016	CARDIOCHIRURGIA	78	ABP-ADM	TA, TRIC, AH	99%
Dong	2002	CARDIOCHIRURGIA	56	IDO	TA, AH	
Keyhani	2009	CARDIOCHIRURGIA	233	ADV	TA, AH	
de Haan	1997	CARDIOCHIRURGIA	20	ABP	TA	
Meylaerts	1999	CARDIOCHIRURGIA	42	ABP	TA	
Jacobs	2006	CARDIOCHIRURGIA	112	ABP	TA	
MacDonald	2002	CARDIOCHIRURGIA	31	FDI, ABP	TA, AH	
Rizkallah	2019	SCOLIOSI	190	ADM, ECU	TA, AH	
Miller	2019	SCOLIOSI	127		VL, TA, PL, AH	
Shi	2020	SCOLIOSI	60 (chiari)	ABP	AH	80%
Lo	2018	SCOLIOSI	250	-	TA	96,2
Pelosi	2002	SCOLIOSI	126		TA, AH	98.4%
Pastorelli	2011	SCOLIOSI	66	TA, AH	TA, AH	
Hyun	2009	NEUROCHIRURGIA	17	ABP	TA, AH	90%
Weinzierl	2007	NEUROCHIRURGIA	100		TA	94%
Feng	2012	NEUROCHIRURGIA	176	FDI	AH	99%
Funaba	2021	NEUROCHIRURGIA	1176	SCM, DELT, BIC, TRIC, ADM, ABP	Qc, TA, GC, FHB AH	
Wang	2020	NEUROCHIRURGIA	105	FDI	AH	
Sala	2006	NEUROCHIRURGIA	50	ABP, ECD	TA, AH	
Hilibrand	2004	NEUROCHIRURGIA	427	FDI	TA, AH	
Schwartz	2007	NEUROCHIRURGIA	1121	FDI	TA, AH	

Michaeli A, Appel S, Korn A, Danto J, Ashkenazi E. Intraoperative monitoring of corticospinal tracts in anterior cervical decompression and fusion surgery: Excitability differentials of lower extremity muscles. Clin Neurophysiol Pract. 2020 Mar 10;5:59-63. doi: 10.1016/j.cnp.2020.02.002. PMID: 32258833; PMCID: PMC7110302.

- **Conclusions:** AH tcMEP is a more reliable candidate than TA tcMEP for intraoperative LE monitoring in ACDF procedure.
- **Significance:** The excitability differentials in LE tcMEP in ACDF is a variable that need to be considered while interpreting intraoperative neurophysiological data.


2 µV/mm , 100 ms
LTA
LAH
LABP
RTA
RAH
RABP
12:39:25
12:39:26
12:52:24
12:52:25
12:52:26
12:52:27
13:02:07
13:02:10
LTib-LTib+ 100 ms 1 µV/mm
LAAL-LAAL+ 100 ms 1 µV/mm
LABDV-LABDV+ 100 ms 1 µV/mm
RTib-RTib+ 100 ms 1 µV/mm
RAAL-RAAL+ 100 ms 1 µV/mm
RABDV-RABDV+ 100 ms 1 µV/mm

The aim of this work is to intraop. study an unselected population by recording the m-MEPs from TA, AH, and EDB, with the aim of identifying the most adjustable and stable muscles intraoperatively.



Material and methods

- Transcranially electrically induced m–MEPs were intraoperative recorded in a total of 107 surgical procedures.

- m-MEPs were recorded by a needle electrode placed in the muscle from the abductor pollicis brevis (ABP) in the upper extremities and in TA, AH and EDB muscles in the lower extremities.

CAUSES	Nr.	%
TUMOR	18	16,8
MYELOPATHY	68	63,6
TRAUMA	11	10,3
STABILIZATION*	10	9,3
	107	100

* anterior lateral interbody fusion

LEVEL	Nr.	%
OCCIPITO-CERVICAL	4	3,7
CERVICAL	64	59,8
CERVICO-DORSAL	1	0,9
DORSAL	23	21,5
DORSO-LUMBAR	4	3,7
LUMBAR	1	0,9
LUMBO-SACRAL	10	9,3

On 107 patients in 7 patients (93.5%) no m-MEPs were registered. Therefore, the data herein reported refer to 100 surgical procedures where it was possible to obtain motor muscle responses at least from 1 muscle.

In the remaining 100 surgeries in 3 cases the only muscle that could be recorded at baseline was one AH, in another 2 the EDB. Adding the EDB to target muscles of lower limb resulted therefore in a 2% increase in monitorability. In no case the TA was found to be the only recordable muscle.

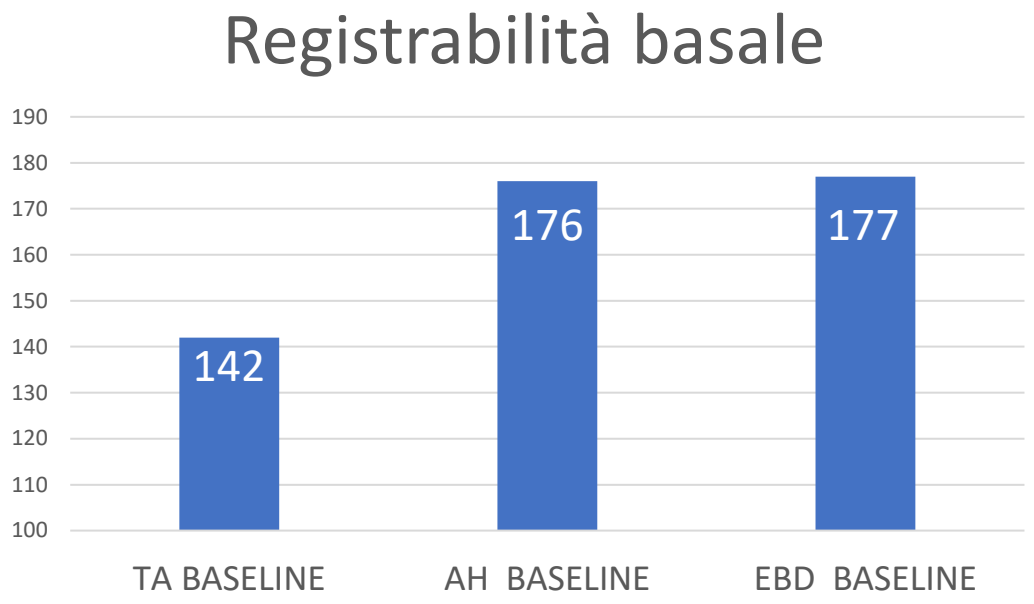
Totale chirurgie	*107*
Nessun muscolo	*7*
Monitorizzabilità	*100 ch (93,5)*

MONITORIZZABILITA’

PAZIENTI CON SOLO AH BILATERALMENTE	1
PAZIENTI CON SOLO AH+ SX	3
PAZIENTI CON SOLO AH+ DX	0
PAZIENTI CON SOLO EBD BILATERALMENTE	1
PAZIENTI CON SOLO EDB+ SX	1
PAZIENTI CON SOLO EDB+ DX	1

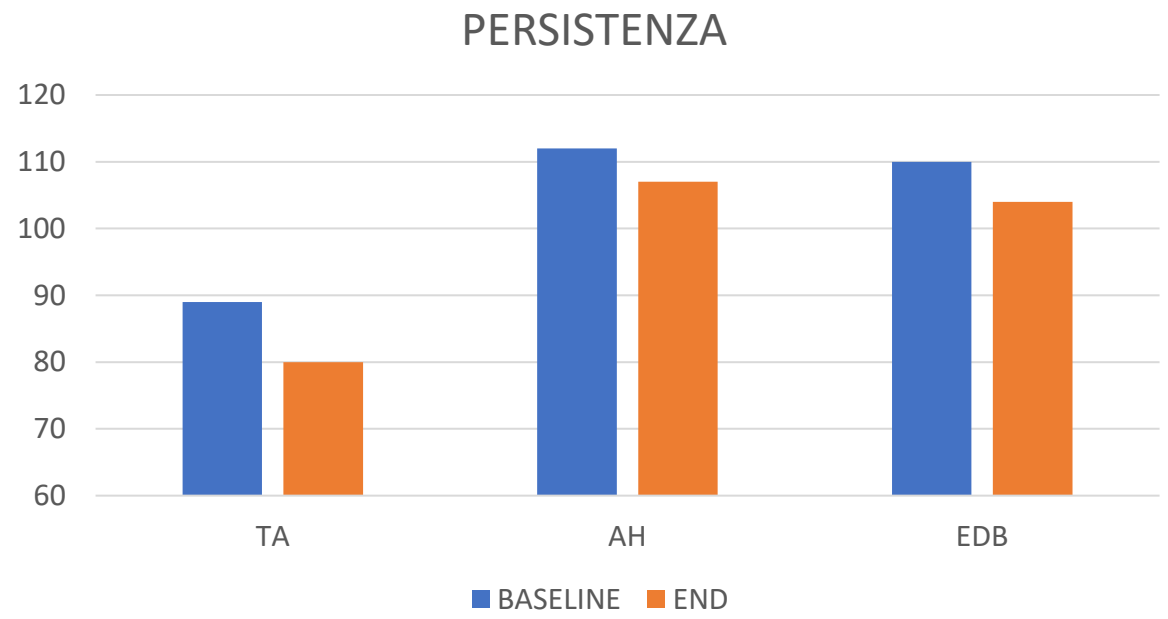
PRESENZA

CHIRURGIE	ARTI
100	200
	Nr
TA SX BASELINE	74
AH SX BASELINE	95
EBD SX BASELINE	93
TA DX BASELINE	68
AH DX BASELINE	81
EBD DX BASELINE	84
TA BASELINE	142
AH BASELINE	176
EBD BASELINE	177



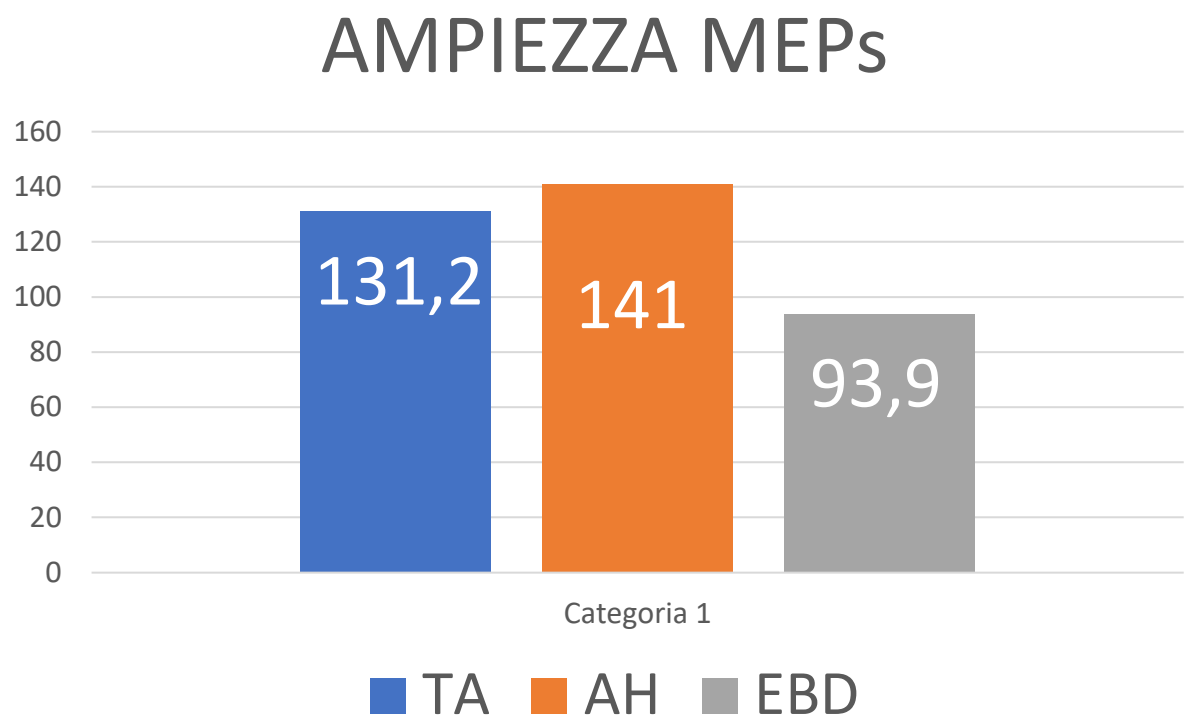
PERSISTENZA

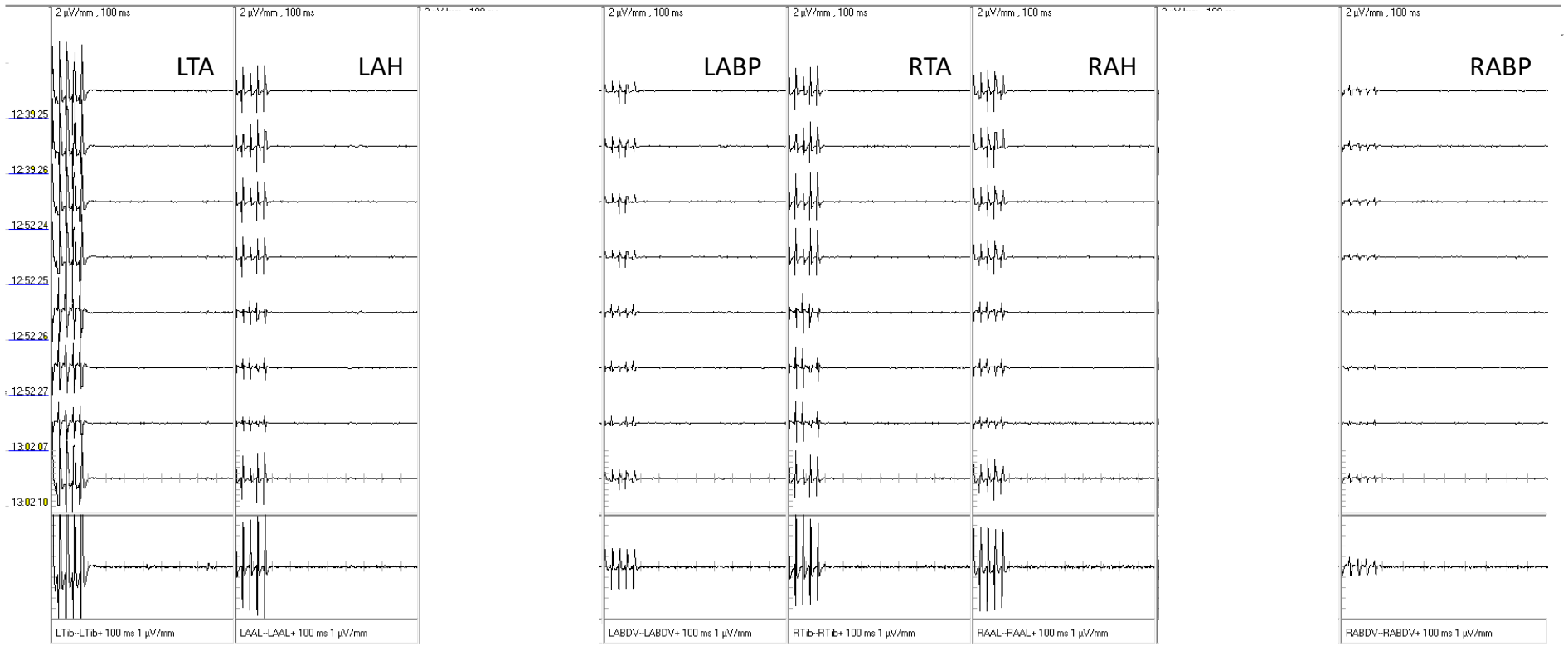
						Nr		%	%	
TA BASELINE	89				TA BASELINE + END +	80		89,9		
AH BASELINE	112				AH BASELINE + END +	107		95,5		
EBD BASELINE	110				EBD BASELINE + END +	104		94,5		



AMPIEZZA BASELINE (μv)

	TA	AH	EBD
MEDIA	131,2	141,0	93,9
SD	112,7	121,5	84,5
MIN	6,82	1	1,88
MAX	527	592	459
Nr.	86	109	109




2 µV/mm , 100 ms
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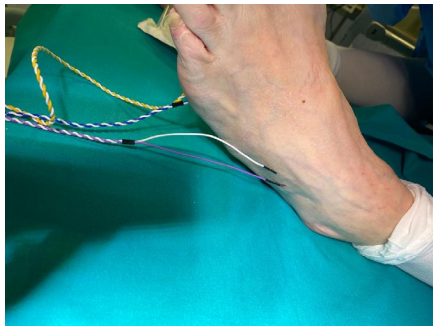
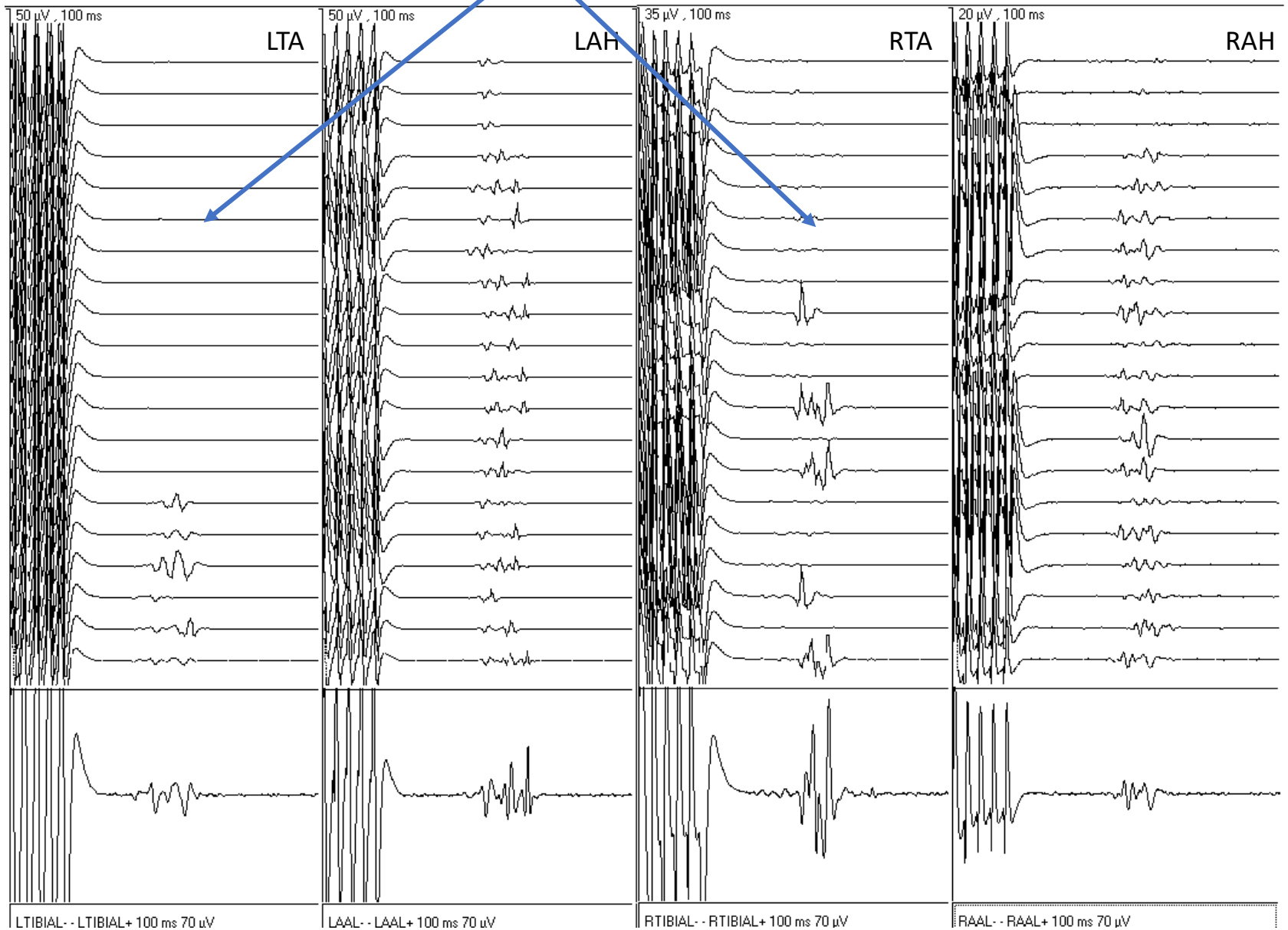
LTib--LTib+ 100 ms 1 µV/mm
LAAL--LAAL+ 100 ms 1 µV/mm
LABDV--LABDV+ 100 ms 1 µV/mm
RTib--RTib+ 100 ms 1 µV/mm
RAAL--RAAL+ 100 ms 1 µV/mm
RABDV--RABDV+ 100 ms 1 µV/mm



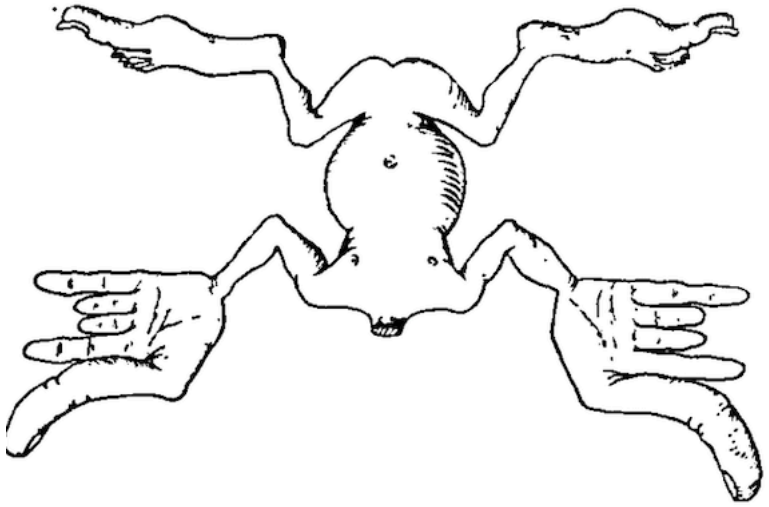

Cardinal Health

SOSTITUITO TA CON EBD



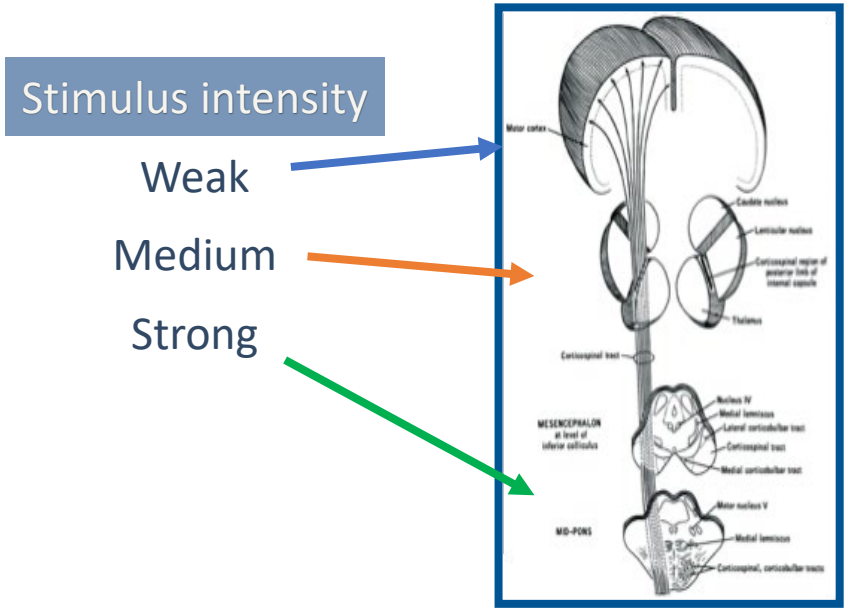
IPOTESI I: ECCITABILITA' CORTICALE

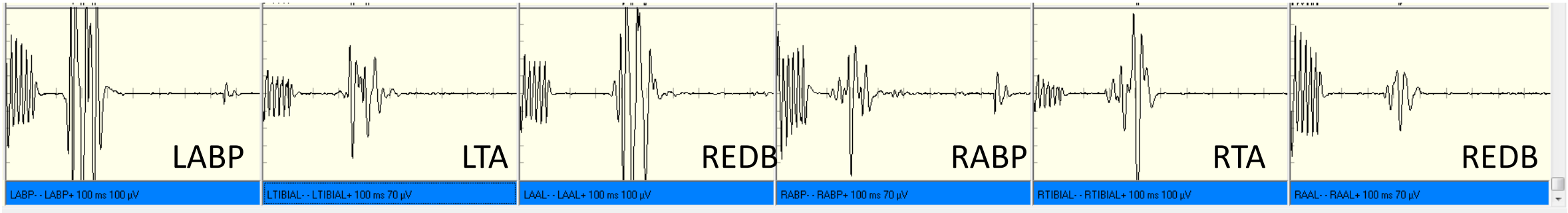
The preferred muscles for monitoring the MEPs are abductor digiti minimi, first dorsal interosseus, abductor pollicis brevis, tibialis anterior and abductor hallucis brevis.
are appropriate muscles because of the larger cortical representation and the reach of CT innervations to the spinal a-motoneurons.



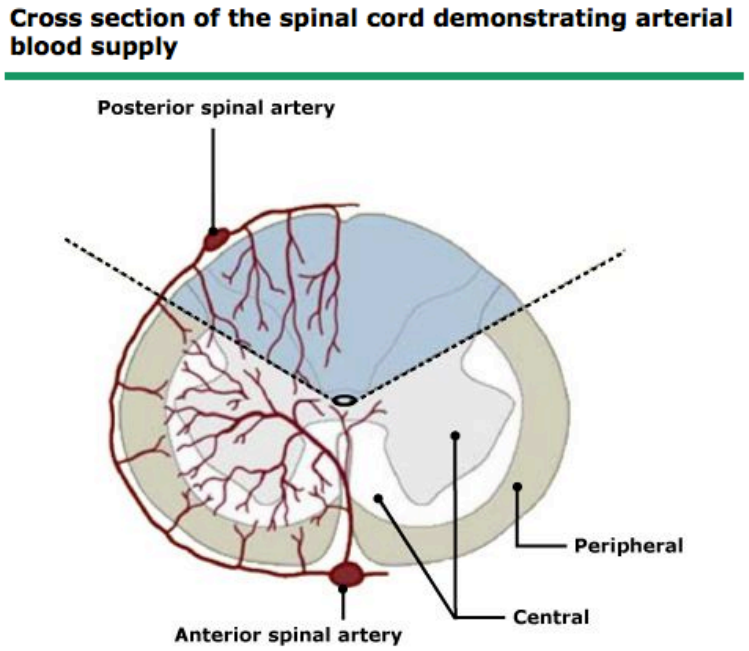
SOMATIC MOTOR AND SENSORY REPRESENTATION IN THE CEREBRAL CORTEX OF MAN AS STUDIED BY ELECTRICAL STIMULATION.[1]

BY WILDER PENFIELD AND EDWIN BOLDREY (MONTREAL). 1937





IPOTESI II: VASCOLARIZZAZIONE DEL MIDOLLO



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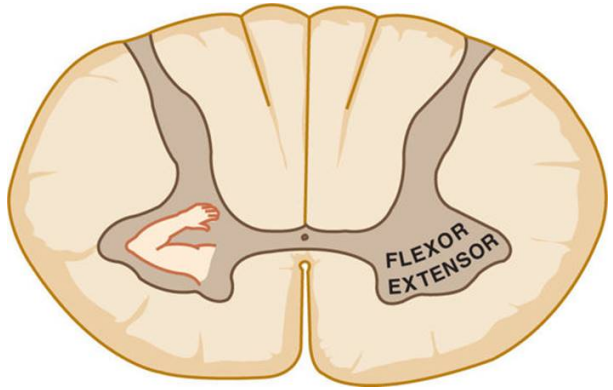
IPOTESI III: SOMATOTOPIA DEL II NEURONE DI MOTO



IPOTESI IV: DIVERSA SENSIBILITA' ALL'ISCHEMIA DEL MOTONEURONE SPINALE

Kim SM, Yang H, Park SB, Han SG, Park KW, Yoon SH, Hyun SJ, Kim HJ, Park KS, Lee KW. Pattern-specific changes and discordant prognostic values of individual leg-muscle motor evoked potentials during spinal surgery. Clin Neurophysiol. 2012 Jul;123(7):1465-70. doi: 10.1016/j.clinph.2011.11.035. Epub 2012 Jan 9. PMID: 22227063.

- Abstract
- Objective: The aim of the study is to evaluate the efficacy of muscle motor evoked potentials (mMEPs) in individual leg muscles for spinal surgery monitoring.
- Methods: Data were obtained from 209 patients who underwent spine surgery with intra-operative mMEP monitoring in the tibialis anterior (TA) and abductor hallucis (AH) muscles. The mMEP generation, pattern-specific mMEP loss and recovery, and the accuracy of individual mMEP changes in predicting postoperative motor deficit were assessed.
- Results: Generation rate of mMEPs was higher in the AH than in the TA ($p<0.001$). The mMEP in the TA was more sensitive in detecting mMEP loss than in the AH ($p<0.001$); however, mMEP in the AH was more sensitive in detecting mMEP recovery ($p<0.001$). The mMEPs in the TA had high sensitivity in predicting sustained postoperative motor deficits. By contrast, mMEPs in the AH showed a high positive predictive value.
- Conclusions: Although mMEPs were generated at a high rate in the AH, mMEP in the TA can play an important complementary role in intra-operative mMEP monitoring, because mMEP in the TA can be more sensitive to potential neural damage.
- Significance: Using a combination of muscles with individual sensitivities and clinical significances will improve intra-operative mMEP monitoring strategies.

Conclusions

- EBD can be used alternatively to TA or be added to TA and AH as a target muscle of the lower limb in spinal surgery-
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- Key point 1: TA and AH are the target muscles generally used for lower extremity m-MEPs in spinal surgery
- Key point 2: in our series EDB m-MEPs are more recordable and stable than TA m-MEPs
- Key point 3: EDB can represent a valid alternative to TA as target muscle of the lower limb in spinal surgery