Multimodality Monitoring: Prognostic Value of Neuromonitoring Alerts

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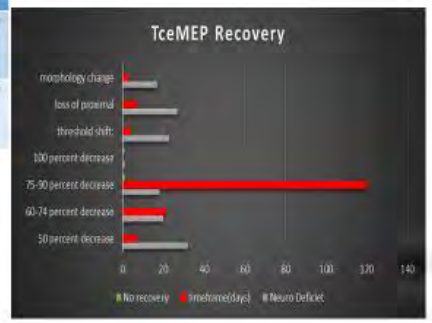
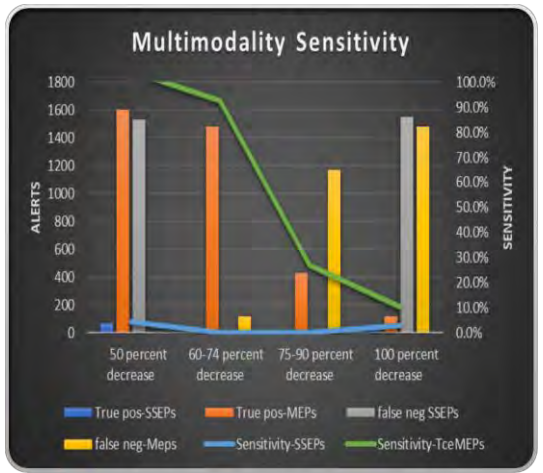
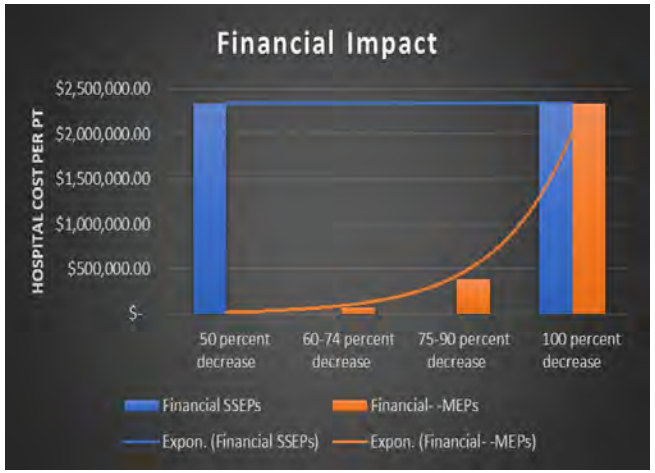
- **Objective**: Transcranial motor evoked potentials (TceMEP) and Somatosensory evoked potentials (SSEP) are a part of multimodality monitoring utilized during spinal deformity surgery, and may help to reduce post operative deficits that result from iatrogenic injury during surgery (Schwartz et al., 2007, Schwartz et al., 2011, Faulkerson et., 2007, Hwang 2012., & Zuccaro et al., 2017). Various alert criteria exist for TceMEPs throughout the monitoring literature. Such alert criteria includes: threshold increase (Clancy et al., 1998), amplitude decreases (Thirumala et al., 2007. , Langeloo et al., 2003, Schwartz et al., 2007), and morphology changes from baseline data (Langeloo et al., 2007). Alert criteria for SSEPs has been established as 50% decline in amplitude (Thirumala et al.,2017, Nuwer et al., 2008, Nuwer et al., 1995). Currently, no study has reviewed the associated post-operative deficit and recovery time for any alert criteria. This paper examined the incidence of post-operative deficits and recovery rates with the following TceMEPs alert criteria: threshold, loss of proximal muscles, morphology change, 0-49% decrease in amplitude, 50% decrease in amplitude, 60-74% decrease in amplitude, 75-90% decrease in amplitude, and 100% decrease in amplitude. Also, patient outcomes were investigated after SSEP alert criteria of 50 and 100% decreases in amplitude were used.
- **Methods:** After obtaining IRB approval, a retrospective quantitative analysis was performed on 992-patients (258-male, 734-female). All patients were diagnosed with scoliosis and undergoing spinal deformity correction surgery. TceMEPs were stimulated at the cortex and recorded from the following muscles through the use of subdermal electrodes; abductor polices brevis, quadricep femoris, tibialis anterior, gastrocnemius, and abductor hallicus. SSEPs were stimulated at the posterior tibial nerve at the ankle and recorded from the subcortical and cortical montages. All baselines were obtained by a consistent neuromonitoring team using Caldwell cascade pro. Anesthesia for each patient consisted of a total intravenous anesthetic protocol and no neuromuscular blockade. Baselines were recorded prior to incision and were present bilaterally in all recording muscles. TceMEPs and SSEPs were recorded every 15-20 minutes throughout the entire procedure.
- **Results:** Total number of TceMEPs performed and recorded for the 992-patients was 36,713, with 1600 amplitude decreases identified. This number of performed/recorded TceMEPs were categorized into one of the following: Threshold (N=490), loss of proximal muscles (N=520), morphology change (N=410), 0-49% decrease in amplitude (N=36,553), 50% decrease in amplitude (N=1600), 60-74% decrease (N=1480), 75-90% decrease (N= 430), and 100% decrease (N=120). Post operative neurological deficits for each group were as follows: Threshold (23 deficits), loss of proximal muscles (27 deficits), morphology change (17 deficits), 0-49% decrease (0 deficits), 50% decrease (32 deficits), 60-74% decrease (20 deficits), 75-90% decrease(18 deficits), and 100% decrease (1 deficits). TceMEPs sensitivity was calculated for the following groups: 0-49% decrease (100%), 50% decrease (93%), 60-74% decrease (27%), and 100% decrease (8%). SSEPs performed/recorded were categorized into one of the following: 50% decrease in amplitude (N=70) and 100% decrease (N=50). Post-operative neurological deficits for each group were as follows: 50% decrease (1 deficits) and 100% decrease (1 deficits). SSEPs sensitivity was calculated utilizing previous data published on motor evoked potentials. The SSEP sensitivity for the following groups was 50% decrease (4.4%), and 100% decrease (3.1%).
- **Conclusion:** TceMEP and SSEPs offer an increase in patient safety from iatrogenic injury during surgery (Schwartz et al 2007). Various alert criteria exist for interpretation of TceMEP that result in post operative deficits. Results from this study indicated TceMEPs were most sensitive with the alert criteria in the range of 50-60% decrease in amplitude and SSEPs with 50% decrease in amplitude. TceMEPs had greater sensitivity and lower false negative rates compared to SSEPs. Post-operative deficits rates were lower in TceMEP group compared to just SSEPs. In addition, post-operative injury recovery rates and hospital financial cost per patient were better in the TceMEP group compared to SSEPs only, specifically when 50 to 60 % TceMEP amplitude alert threshold was used for identifying an alert. It is recommended that a combination of TceMEP and SSEP are monitored, with 50% amplitude threshold alert, during spine surgery, to achieve the lowest post-operative injury rate.

	number	Neuro Deficit	Motor Strength (out of 5)	Recovery timeframe (days)	No recovery	Sensitivity-TceMEPs	Specificity-TceMEPs	Financial cost per patient
total number of MEPs	36713							
amplitude changes:	1600							
0-49 percent decrease	36553	0	5		0			
50 percent decrease	1600	32	1 to 3	7	0	100%	100%	$22,653.04
60-74 percent decrease	1480	20	1 to 3	21	0	93%	100%	$67,959.11
75-90 percent decrease	430	18	1 to 3	120	1	27%	100%	$388,337.75
100 percent decrease	120	1	0		1	8%	100%	$2,341,988.00
threshold shift:	490	23	3 to 4	4	0			$9,084.06
loss of proximal	520	27	3 to 4	7	0			$22,653.04
morphology change	410	17	3 to 4	3	0			$9,708.44

SSEPs	Total	Neuro Deficit	True pos-SSEP	true neg	false pos	false neg	no recovery	Sensitivity SSEPs	Specificity SSEPs	Financial cost per pt
50 percent decrease	70	1	70	42456	0	1530	1	4.4%	100.0%	$2,341,988.00
100 percent decrease	50	1	50	42456	0	1550	1	3.1%	100.0%	$2,341,988.00







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