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Genel Anestezinin Ekstübasyon Aşamasında Hasta Durumu İndeksi Monitörü ile Ölçülen Frontal EMG ile Train of Four'un Korelasyonu

Correlation Between Train of Four with Frontal EMG Measured by Patient State Index Monitor in Extubation Phase of General Anesthesia

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ÖZET

AMAÇ: Bu çalışmada karpal tünel sendromlu olgularda uyku kalitesi, gün içi uykululuk düzeyi ve yaşam kalitesindeki etkilenme ile semptom şiddeti, fonksiyonel durum arasındaki ilişkiyi ortaya koymayı amaçlandı.

GEREÇ VE YÖNTEM: Karpal tünel sendromlu 61 hastanın demografik verileri, sinir iletim çalışmaları, Boston semptom şiddet skalası, Boston fonksiyonel durum skalası, Pittsburgh uyku kalitesi ölçeği, Epworth uykululuk skalası ve Kısa form-36 skorları değerlendirildi.

BULGULAR: Pittsburgh uyku kalitesi ölçeği ile sırasıyla; Boston semptom şiddet skalası ve Boston fonksiyonel durum skalası puanları arasında istatistiksel olarak anlamlı pozitif korelasyon saptanmıştır (p<0,05). Pittsburgh uyku kalitesi ölçeği ile sırasıyla Kısa form-36 fiziksel fonksiyon, fiziksel rol güçlüğü, ağrı, genel sağlık algısı, enerji/canlılık/vitalite, sosyal fonksiyon, emosyonel rol güçlüğü, emosyonel iyilik hali puanları arasında istatistiksel olarak anlamlı negatif korelasyon saptanmıştır (p<0,05). Epworth uykululuk skalası ile sırasıyla; Boston semptom şiddet skalası ve Boston fonksiyonel durum skalası puanları arasında istatistiksel olarak anlamlı pozitif korelasyon saptanmıştır (p<0,05). Epworth uykululuk skalası ile Kısa form-36 enerji/canlılık/vitalite puanları arasında istatistiksel olarak anlamlı negatif korelasyon saptanmıştır (p<0,05).

SONUÇ: Karpal tünel sendromu semptom şiddeti ve fonksiyonel durum uyku kalitesini, gündüz uykululuk düzeylerini olumsuz etkilemektedir. Ayrıca karpal tünel sendromlu bireylerde uyku kalitesi bozuldukça yaşam kalitesi azalmaktadır. Karpal tünel sendromu tedavisinde ağrı ve semptomların yanı sıra uyku kalitesine yönelik tedaviler göz önünde bulundurulmalıdır.

Anahtar Kelimeler: Karpal tünel sendromu, uyku kalitesi, yaşam kalitesi

ABSTRACT

AIM: In this study, we aimed to reveal the relationship between sleep quality, daytime sleepiness level and impact on quality of life, symptom severity and functional status in patients with carpal tunnel syndrome.

MATERIAL AND METHOD: Demographic data, nerve conduction studies, Boston symptom severity scale, Boston functional status scale, Pittsburgh sleep quality scale, Epworth sleepiness scale and Short form-36 scores of 61 patients with carpal tunnel syndrome are evaluated.

RESULTS: A statistically significant positive correlation was found between Pittsburgh sleep quality scale with Boston symptom severity scale and Boston functional status scale scores respectively (p<0.05). A statistically significant negative correlation was found between the Pittsburgh sleep quality scale and the Short Form-36 physical function, physical role difficulty, pain, general health perception, energy/fatigue/vitality, social function, emotional role difficulty, and emotional well-being scores, respectively (p< 0.05). A statistically significant positive correlation was found between the Epworth sleepiness scale with Boston symptom severity scale and Boston functional status scale scores respectively (p<0.05). A statistically significant negative correlation was found between the Epworth sleepiness scale and Short form-36 energy/fatigue/vitality scores (p<0.05).

CONCLUSION: Carpal tunnel syndrome symptom severity and functional status negatively affect sleep quality and daytime sleepiness levels. Additionally, as sleep quality deteriorates in individuals with carpal tunnel syndrome, their quality of life gets worse. In the treatment of carpal tunnel syndrome, treatments for sleep quality as well as pain and symptoms should be considered.

Keywords: Carpal tunnel syndrome, sleep quality, quality of life

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INTRODUCTION

Patient State Index (PSI) is a current method used in anesthesia and monitoring depth of sedation. Considering the limitations caused by autonomic effects and the effect of anesthetic drugs on the electroencephalography (EEG), it is thought that a monitor with anesthetic depth measurement will be advantageous in preventing complications such as awareness during anesthesia. [1,2]

Extubation, which is the end period of general anesthesia, is one of the high risk phases of anesthesia. During the extubation phase life-threatening complications such as hypoxia, aspiration, or even death may occur.[3,4] Therefore, the effect of the neuromuscular blocking agent should be reversed cautiously. Train of four (TOF), an accelerometric peripheral nerve stimulator, is regarded as an objective monitor used in the monitoring of neuromuscular block.[5,6]

Piper made the first electromyographic recording in 1907. By 1929, electromyography (EMG) measurement with surface electrodes became possible. Changes in the electrical activity of skeletal muscles can be observed on the electromyogram, and since there is a close proportion between electrical activity and mechanical strength under a number of conditions. EMG can show a muscle's contraction force, or conversely, the degree of relaxation. Therefore, the use of electromyography is useful in measuring the muscle response to surgical stimulation and its depression with anesthetic drugs.[7]

The PSI electrode simultaneously measures the frontal EMG parameter on the frontal muscles. As in the bispectral index, the depth of anesthesia can be followed closely with PSI monitoring.[8,9]

The aim of our study is to examine the correlation of the frontal EMG parameter, which can evaluate muscle strength in PSI monitoring, with the measured TOF value; thus evaluating both muscle strength and anesthesia depth with a single monitoring technique.

MATERIAL AND METHOD

The study was planned as an observational prospective study and started after the approval of Erzincan Binali Yıldırım University Clinical Ethics Committee (34/11 - 27/11/2018). The study registered on clinicaltrials.gov on 04/18/2019 with ClinicalTrials.gov ID: NCT03926650 by principle investigator Hakan G. Tas. Registration of our clinical trial occurred prior to the start of the trial and any patient enrollment undertaken. This manuscript adheres to the applicable STARD guidelines. The STARD flow chart is presented in Figure 1.

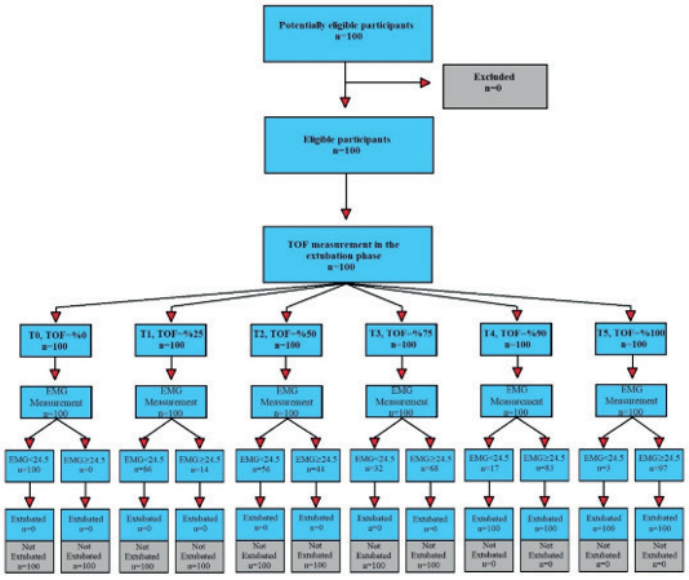

Figure 1. STARD flow diagram. The flowchart of the participants is summarized as indicated in the STARD guideline. Abbreviations: EMG, Electromyography; TOF, Train Of Four; T0-T5 time points (T0, TOF=0%; T1, TOF=25%; T2, TOF=50%; T3, TOF=75%; T4, TOF=90%; T5, TOF=100%).

Written informed consent was obtained from all subjects or a legal surrogate. The procedures of our study were carried out in accordance with the Declaration of Helsinki-2013.

The study included 100 ASA I-III patients aged between 18 and 65 who were undergoing laparoscopic cholecystectomy, total abdominal hysterectomy, and other elective abdominal surgery that would take longer than an hour. Patients with a history of drug allergy, neurological, neuropathic or neuromuscular disease, using drugs effective in neurological or neuromuscular junction, pregnant, electrolyte disorder, organ failure, pre-diagnosed liver dysfunction, pre-diagnosed kidney dysfunction, obese or cachectic according to body mass index, refusing to participate in the study and who could not be cooperated were excluded from the study.

Routine monitoring (electrocardiography (ECG), peripheral oxygen saturation (SpO2), body temperature and noninvasive blood pressure (NIBP)) and intravenous catheterization were performed in patients in the operating room. Afterwards, two TOF electrodes were placed on the ulnar nerve trace at the level of the wrist and accelerometer was placed on the left thumb, using the Dräger - TOFscan®™ (Drägerwerk AG & Co. KGaA Moislinger Allee 53-55 23558 Lübeck, Germany) device. Simultaneously, the frontal EMG-PSI electrode was placed on the supraorbital frontal region with Masimo Root™ and Masimo - Sedline™ (Masimo Corporation 52 Discovery Irvine, CA 92618 USA) devices.

No agent was used for premedication. General anesthesia was induced with propofol 2 mg/kg IV and fentanyl 1 mcg/kg IV in all patients. After the loss of eyelash reflex, the TOF device was calibrated and operated in TOF mode. Rocuronium 0.6 mg/kg IV was administered as a neuromuscular blocker. When the TOF was 0% and thumb movement disappeared, patients were intubated orotracheally and sevoflurane 2% and nitrous oxide 50%- oxygen 50% mixture with a flow of 4 L/min were used for maintenance of anesthesia. The level of muscle relaxant effect was assessed by TOF at 5-minute intervals during the maintenance of anesthesia, and rocuronium was added at additional doses of 0.1 mg/kg as TOF increased above 0%. Volatile anesthetics were given to maintain a PSI level of 30–50. The duration of surgery was recorded.

After the surgery was completed, the extubation phase was started. To reverse the neuromuscular block, neostigmine 0.04 mg/kg IV and atropine 0.015 mg/kg IV were administered. Sevoflurane and N2O were concurrently switched off, and 6 L/min of oxygen was used for ventilation. During the extubation process, we determined TOF=0% time point as T_0, TOF=25% time point as T_1, TOF=50% time point as T_2, TOF=75% time point as T_3 and TOF=90% time point as T_4. PSI and EMG were measured and recorded at each time point. When TOF was 90%, patients were extubated. Clinical consciousness was confirmed by tests such as following commands and raising the head for 5 seconds. Final measurements were made for PSI and EMG 5 minutes after extubation, and this time point (TOF=100%) was determined as T_5. Afterwards, the patients were taken to the postoperative care unit (PACU) where the Aldrete score was recorded at the 5th, 10th and 30th minutes. Patients with a score above 9 were transferred to the service. A predetermined researcher in addition to the anesthesia team performed all measurements recorded in the study.

Statistical Analysis

The sample size was calculated using G * Power 3.1.9.2 version. Although there are no studies showing the relationship between TOF and Frontal EMG in the literature, it is thought that there is at least a moderate relationship between them. For this reason, the effect size was accepted as 0.3 with the sample size calculated by establishing a two-way hypothesis with α=0.05 and β=0.8 using the bivariate correlation method aimed to reach at least 84 patients.

Results are presented as mean ± standard deviation for continuous variables and numbers for categorical variables. Spearman correlation was used to determine the relationship between TOF and EMG. EMG and PSI cut-off points for the extubation value measured at TOF were determined by Receiver Operating Characteristic (ROC) analysis. There was no missing data in the results.

IBM SPSS Statistics 22.0 (IBM Software, New York, United States) and Microsoft Office - Excel 2016 programs were used for statistical anal-

ysis and calculations.

RESULTS

One hundred patients were included in our study. There were no patients excluded from the study for any reason. The age of patients was 39.7±13.4 years, 61% of which were female. Median value of ASA Scores was determined as II and the mean duration of the surgical procedures was 91.2±31.1 minutes.

The measured PSI and EMG values are shown at Table 1.

Table 1: PSI and EMG measurements at each time points.

	PSI						EMG					
	T_0	T_1	T_2	T_3	T_4	T_5	T_0	T_1	T_2	T_3	T_4	T_5
Mean	32.0	51.0	64.4	71.5	77.0	80.9	0.0	10.3	26.3	42.4	54.0	64.1
Standard deviation	8.6	16.7	17.2	14.1	10.2	7.3	0.0	18.5	26.3	30.1	27.5	24.1

PSI and EMG measurements at T0-T5 time points (T0, TOF=0%; T1, TOF=25%; T2, TOF=50%; T3, TOF=75%; T4, TOF=90%; T5, TOF=100%).

Abbreviations: EMG, Electromyography; PSI, Patient State Index; TOF, Train of Four.

When the relationship between PSI and EMG was examined at each time point, no relationship could be detected since the EMG value was zero at the T_0 time point. A moderate positive correlation was found between PSI and EMG at the T_1 time point (r=0.61, p<0.001). A strong positive correlation was found between PSI and EMG at time points T_2 (r=0.73, p<0.001), T_3 (r=0.71, p<0.001) and T_4 (r=0.70, p<0.001). A moderate positive correlation was found between PSI and EMG at the T_5 time point (r=0.57, p<0.001) (Table 2).

Table 2: PSI and EMG correlation table

		T_0	T_1	T_2	T_3	T_4	T_5
PSI-EMG	r	-	**0,607**	**0,731**	**0,710**	**0,695**	**0,567**
Correlation	p	-	**0,000**	**0,000**	**0,000**	**0,000**	**0,000**

The correlation between PSI and EMG was examined using the Spearman technique. r (correlation coefficient): 0.00-0.19: no correlation, 0.20-0.39: weak correlation, 0.40-0.69: moderate correlation, 0.70-0.89: strong correlation 0.90-1.00: very strong correlation. T0: TOF=0%, T1: TOF=25%, T2: TOF=50%, T3: TOF=75%, T4: TOF=90%, T5: TOF=100%.

Abbreviations: EMG, Electromyography; PSI, Patient State Index; TOF, Train Of Four.

When the relationship of PSI and EMG with TOF was examined, a strong positive correlation was found both between TOF and PSI (r=0.74, p<0.001) and between TOF and EMG (r=0.76, p <0.001) (Table 3).

Table 3: Correlation of PSI and EMG with TOF

		PSI	EMG
TOF	r	0,737	0,754
	p	<0.001	<0.001
	n	600	600

The correlation between TOF and both PSI and EMG was examined using the Spearman technique. r (correlation coefficient): 0.00-0.19: no correlation, 0.20-0.39: weak correlation, 0.40-0.69: moderate correlation, 0.70-0.89: strong correlation 0.90-1.00: very strong correlation.

Abbreviations: EMG, Electromyography; PSI, Patient State Index; TOF, Train of Four.

TOF value of 90% was accepted as the extubation limit and ROC analysis was performed with the obtained data. In ROC analysis, calculation was made by evaluating TOF as ≥90%=1 (can be extubated), TOF<90%=0 (cannot be extubated).

When ROC analysis was performed to EMG and PSI variables, the cut-off point for the EMG variable was 24.5 (Area Under the Curve (AUC): 0.852, p<0.001, sensitivity: 90%, specificity: 68%), and it was 60.5 for the PSI variable (AUC: 0.834, p<0.001, sensitivity: 96%, specificity: 56%) (Figure 2) (Table 4).

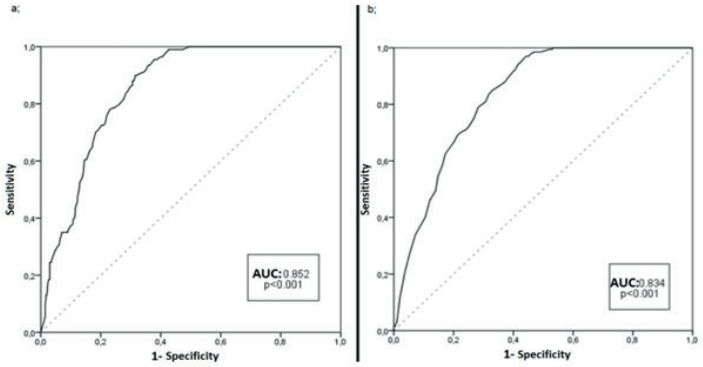

Figure 2. (a), EMG-ROC Curve. As a result of the ROC analysis, the appropriate cut-off value for the EMG variable was 24.5 (AUC: 0.852, p<0.001, sensitivity: 90%, specificity: 68%); (b), PSI-ROC Curve. As a result of the ROC analysis, the appropriate cut-off value for the PSI variable was 60.5 (AUC: 0.834, p<0.001, sensitivity: 96%, specificity: 56%). Abbreviations: AUC, Area Under the Curve; EMG, Electromyography; PSI, Patient State Index; ROC, receiver operating characteristic.

Table 4: Diagnostic accuracy criteria and optimal cut-off points for EMG and PSI

Cut-off point	Sensitivity	Specificity	Youden Index
EMG ≥ 23,5	0,900	0,679	0,579
EMG ≥ 24,5	0,900	0,684	0,584
PSI>59,5	0,970	0,557	0,527
PSI>60,5	0,965	0,562	0,527

EMG and PSI cut-off points for the extubation value measured at TOF were determined by ROC analysis

In both ROC analyzes; it was determined that the area under the curve was close to one and statistically significant. When the results of the ROC analysis are evaluated, the midpoint can be taken as the cut-off point because the diagnostic accuracy criteria of the PSI> 60.5 or PSI> 59.5 cut-off points are at a similar level and the Youden Indexes are equal. We think that a PSI value higher than 60 or an EMG value above 24.5 will support the view that the neuromuscular block has ended, thus helping to make the decision to extubate the patients.

DISCUSSION

In this study, we found a strong positive correlation between TOF and the frontal EMG value measured with the PSI electrode. Processed EEG monitoring (like PSI) is recommended for use in monitoring depth of anesthesia.[10] As a result of the subsequent ROC analysis, we determined the extubation cut-off point for EMG as 24.5 and for PSI as 60. By supporting TOF monitoring during the extubation phase, routine PSI-frontal EMG monitoring can help in the decision of extubation. Frontal EMG monitoring can be helpful when the TOF value is unclear, especially when it is necessary to support the measured value with a different monitoring technique, or when TOF monitoring is not possible. By simultaneous monitoring of the anesthetic depth and muscle strength, we believe it will help gain time in clinical practice. Literature review showed there is no study concerning the correlation between TOF and frontal EMG measurement among the studies on peripheral nerve monitoring. Our study is the first correlation study conducted on this subject in the literature, and this makes our study valuable.

Acceleromyography (AMG-TOF) is the most widely used objective neuromuscular function assessment method in clinical practice. This method is based on Newton's second law (Force = Mass x Acceleration) which postulates that as the mass stays constant, acceleration is directly proportional to the force. AMG is a simple technique for neuromuscular function assessment in both intensive care units and

operating rooms.[11] Studies show that acceleromyography is a more sensitive, useful and an objective monitoring technique in the detection of postoperative residual curarization compared to clinical tests and evoked response evaluation.[12]

EMG, another objective neuromuscular function assessment method, is one of the oldest known monitoring techniques.[13] It records compound action potentials generated by a peripheral nerve stimulation. EMG setup is simpler, and measurements show the condition that affects neuromuscular transmission. It is also possible to monitor muscles that are difficult to reach for mechanical recording. High quality measurements can be made when the electrodes are placed correctly.[11]

Most anesthesiologists think that the use of a reversal agent is not necessary unless there are signs of muscle weakness or fading in the peripheral nerve stimulator.[14] However, both methods are not sensitive enough to show clinically significant residual block (TOF=0.40-0.90).[15] Therefore, routine use of TOF will also eliminate the need for reversal agents. TOF can be detected as <0.90 even 2 hours after the use of vecuronium and rocuronium, and this situation reveals the need for quantitative muscle strength monitoring to replace clinical evaluation.[16] In our study, we compared TOF monitoring with frontal EMG parameter, which is not a nerve stimulation technique, but provides information about muscle strength by measuring on the frontal muscles.

Extubation phase is one of the most important and risky stages of general anesthesia in terms of possible complications. At this stage, many complications and side effects such as bronchospasm, aspiration can occur.

In previous studies, it has been shown that neuromuscular monitoring contributes to the comfortable work of both the anesthesiologist and the surgeon in abdominal surgery.[17,18] In our study, we determined that PSI-Frontal EMG monitoring, when used in the extubation phase of general anesthesia, can prevent possible complications by allowing an objective evaluation of the neuromuscular blocking agent effect. In addition, we determined that with PSI-Frontal EMG monitoring, anesthesia depth and muscle strength can be monitored with a single technique, so we can gain advantage in terms of time. When previous studies were examined, there were studies on the use of PSI - EMG monitoring in the depth of anesthesia, anesthesia depth monitoring during the recovery period and cerebral blood flow monitoring.[19,20,21] There is no study on the use of the frontal EMG parameter for monitoring muscle strength.

Objective quantitative monitoring of neuromuscular function has been emphasized as a necessity in cases where neuromuscular blockers are used in the National Audit Project (NAP) 4 and NAP 5 reports of the United Kingdom and Irish Society of Anesthesiologists.[10]

In a study by Brull et al. it is recommended to monitor neuromuscular function with an objective monitoring technique when using high-dose neuromuscular blockers, in long surgical procedures, in patients with high risk of complications, or in detecting the presence of residual block.[6] Similarly, in previous studies it has been shown that TOF rate should be higher than 0.90 in the post-extubation period in order to reduce the risk of complications.[22] Also, previous studies have shown that patients with a TOF measurement of less than 0.70 have a higher risk of postoperative complications.[23,24] When the studies in the literature are evaluated, it is seen that the required TOF limit to avoid postoperative complications is 0.90 and above. For this reason, we accepted the value of TOF>0.90 as the extubation criterion in our study.

Since the frontal EMG parameter provides data compatible with TOF monitoring, we think that it is advantageous in terms of safety during the extubation period for patients in whom close monitoring of anesthesia depth and muscle strength is important.

There are some limitations in our study. The sample size we have planned in our study is appropriate according to the power analysis performed, but studies with larger number of participants will provide valuable results in determining the cut-off points. Instead of Frontal EMG measurement points based on pre-determined TOF values as in our study, correlation studies of time dependent TOF and EMG values will allow determination of more accurate cut-off points.

CONCLUSION

In conclusion, we found a strong positive correlation between TOF, and the frontal EMG value measured with the PSI electrode. As a result of the subsequent ROC analysis, we determined the extubation cut-off point for EMG as 24.5. We believe that routine PSI-frontal EMG monitoring will help to make the extubation decision by supporting TOF measurement during the extubation phase. In our perspective, frontal EMG monitoring can be useful when the TOF value is ambiguous, when an alternative monitoring approach is required to support the measured value, or when TOF monitoring is not possible. Thus, we think that it will reduce the loss of labor and time by monitoring the depth of anesthesia and muscle strength at the same time.

Conflicts of interest

All of the authors state that they have no competing interests.

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Authors' individual contributions

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Hakan G. Tas, Didem Onk, Ufuk Kuyrukluyildiz and Suheyla Unver. The first draft of the manuscript was written by Hakan G. Tas and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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