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Intraoperative Neurophysiological Monitoring in Tethered Cord Syndrome: Clinical Experience with 30 Cases

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ABSTRACT:

Intraoperative neurophysiological monitoring in tethered cord syndrome: clinical experience with 30 cases

Objective: The tethered cord syndrome (TCS) refers to lesions that can cause the conus medullaris to be low-lying or incapable of movement within the spinal canal. Tight conus medullaris is untethered by microneurosurgical operation. Patients may have additional persistent or transient neurological deficits in postoperative follows. The use of intraoperative neurophysiological monitoring (IONM) reduces risks of being neurological deficits. In our article, we aimed to show the importance of using intraoperative neurophysiological monitoring with results of cases operated in our department.

Material and Methods: The results of IONM findings, preoperative and postoperative neurological findings of 30 patients who were operated in our clinic between 2015-2016 were reported. Intraoperative neurophysiological monitoring (IONM) was used in all cases with tethered cord sydrome. Somatosensory evoked potential (SEP), motor evoked potential (MEP), free-run EMG responses, external sphincter muscle MEP and direct monopolar probe-evoked potentials were recorded.

Results: There were 20 male and 10 female patients with a mean age of 9.03 in our study. There was an increase in SEP values in only one of the cases. Additional neurological deficit arised in three cases; 1 transient (48 hours) and 2 persistent.

Conclusion: As our and other studies in literature has shown that using appropriate monitorization with experienced team decreases the risk of developing neurological injury; IONM should be used with its all modalities.

Keywords: Intraoperative neurophysiological monitoring, neurophysiology, tethered cord syndrome, untethering

ÖZET:

Gergin omurilik (tethered cord) sendromlu hastalarda intraoperatif nörofizyolojik monitörizasyon: 30 olguluk klinik deneyim

Amaç: Gergin omurilik sendromu, konus medullarisin normal seviyesinden daha aşağıda sonlanması veya konus medullarisin fizyolojik olarak normal seviyesine gelmesine engel olan lezyonların genel adıdır. Mikronöroşirürjikal müdahale ile gergin olan konus serbestleştirilir. Bu cerrahi sırasında, anestezi sonlandırıldığında ya da postoperatif takiplerde geçici veya kalıcı nörolojik defisitler oluşabilmektedir. İntraoperatif nörofizyolojik monitörizasyon (İONM) kullanımı bu riski azaltmaktadır. Bu çalışmamızda kliniğimizde opere edilen olgular üzerinden intraoperatif nörofizyolojik monitörizasyon kullanımının önemini ve klinik sonuçlarımızı bildirmeyi amaçladık.

Yöntem ve Gereçler: 2015-2016 yılları arasında kliniğimizde ameliyat edilen 30 olgunun İONM bulguları, preoperatif ve postoperatif nörolojik bulguları değerlendirilerek sonuçlar bildirildi. Gergin omurilik ameliyatlarının hepsinde intraoperatif nörofizyolojik monitörizasyon (İONM) kullanıldı. Somatosensoriyal potansiyeller (SEP), motor uyarılmış potansiyeller (MEP), free-run EMG yanıtları, eksternal sfinkter kası MEP ve prob ile direkt uyarılan sinir dokusu potansiyelleri kaydedildi.

Bulgular: Vakaların 20'si erkek, 10'u kadın hasta, yaş ortalaması 9.03 idi. Olgulardan sadece 1'inde SEP değerlerinde artış gözlendi. Olgulardan 3 tanesinde ek nörolojik hasar gelişti. Bunlardan 1 tanesi 48 saat süreyle geçici seyretti, diğer iki olguda ise kalıcı nörolojik hasarlar gözlendi.

Sonuç: Gergin omurilik sendromu ameliyatlarında, çalışmamızda ve literatürde de gösterildiği üzere deneyimli bir ekip ve uygun monitörizasyon ile nörolojik hasar görülme ihtimali azalabileceğinden, tüm modaliteleri ile İONM kullanımı önerilir.

Anahtar kelimeler: Intraoperatif nöromonitörizasyon, nörofizyoloji, gergin omurilik sendromu, untethering

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INTRODUCTION

Tethered cord syndrome (TCS) is the stretching of the spinal cord due to an abnormal condition, which is rare because of the incidence of 0.05-0.25 at 1000 births (1-3). The tightness of the spine may be due to low conus medullaris and a adherent filum terminale. On the other hand, secondary spinal adhesions due to bone spur, fibrous band, or operations performed at birth, which prevent the spinal cord from reaching its normal physiological level, may also cause tethered cord syndrome (4). Untethering procedure should also be performed for lesions that cause tension. The filum terminale may be mixed up with the normal nerve bundles in some cases, and experience may sometimes be insufficient to distinguish. Therefore, intraoperative neurophysiological monitoring (IONM) is recommended in cases with TCS. It helps to distinguish normal nerve tissue. In our study, we evaluated the preoperative and postoperative clinical and neurophysiological outcomes of cases with TCS in the light of the literature, who were operated using IONM.

MATERIAL AND METHOD

Decompression surgery was performed to 30 patients who admitted for TCS between January 2015-December 2016. Ten patients with a split cord due to a bone spur or fibrous band (Table-1) were performed the excision of the lesion in the same session. In all cases, during the surgical procedure, motor evoked potentials (MEPs), somatosensory evoked potentials (SEPs), free-run EMG potentials,

Table-1

Patient no	Gender	Age	The operation outcome	Postoperative additional neurological finding	IONM* findings	Result
1	M	30	FTD*	PP: 3/5	-	Normal after 48 hours
2	M	13	FBE* +FTD	-	-	-
3	M	10	FTD	-	-	-
4	F	10	BSR * +FTD	-	-	-
5	F	4	FTD	-	-	-
6	M	2	FTD	-	SEP* increase	-
7	M	7	FTD	-	-	-
8	M	4	BSR+FTD	-	-	-
9	F	11	FBE+FTD	-	-	-
10	F	14	BSR+FTD	RFDF*: 3/5	-	Permanent deficit
11	F	2	FTD	-	-	-
12	M	3	FTD	-	-	-
13	F	5	FTD	-	-	-
14	M	36	FTD	-	-	-
15	M	9	FTD	-	-	-
16	M	3	FTD	-	-	-
17	M	5	BSR+FTD	-	Transient MEP* decrease	-
18	F	3	FTD	-	-	-
19	M	2	FTD	-	-	-
20	F	17	FTD	-	-	-
21	M	7 months old	FBE+FTD	-	-	-
22	K	5	BSR+FTD	-	-	-
23	M	1	FTD	-	-	-
24	M	20	FTD	-	-	-
25	M	17	FTD	LFDF* and LKJE* 3/5	MEP decrease	Permanent deficit
26	M	10	FTD	-	-	-
27	M	4	FTD	-	-	-
28	F	7	BSR+FTD	-	-	-
29	M	2	FTD	-	-	-
30	M	14	BSR+FTD	-	-	-

*:IONM: Intraoperative neuromonitorization, FTD: Filum terminale decompression, BSR: Bone spur resection, FBE: Fibrous band excision, PP: Paraparesis, RFDF: Right Foot Dorsiflexion LFDF: Left Foot Dorsiflexion, LKJE: Left knee joint extension, SEP: Somatosensory Evoked Potential, MEP: Motor Evoked Potentials.

external sphincter muscle motor evoked potentials and potentials that were obtained by direct probe touch to the nerve tissue, of the iIONM modalities were used. Immediately after the intubation procedure of the anesthesia team in the operating room, the electrodes were inserted into the respective muscle regions of the patient for potential records. At the same time, records were made with free-run EMG throughout the operation from the beginning to the end of the anesthetic procedure. During the surgical procedure, the monopolar probe was also used to directly distinguish the functional nerve tissue from the filum terminale, and the evoked potentials obtained by direct touch to the tissue in the surgical area were recorded. During the release of the filum terminale, in all cases, monopolar probe was used to determine the nerve tissue (Figure-1). During the operations, MEP, SEP, free-run EMG and sphincter MEP records were evaluated by the neurophysiology team and information was given when asked by the surgeon. Preoperative and postoperative neurological findings and intraoperative neurophysiological findings were evaluated in our study.

RESULTS

Twenty of the cases were male and 10 were female (Table-1). The mean age was 9.03 (minimum 7 months- maximum 36 years) (Table-1). Twenty of the patients had thick streched filum terminale and low conus medullaris (Table-1) (Figure-2). The other

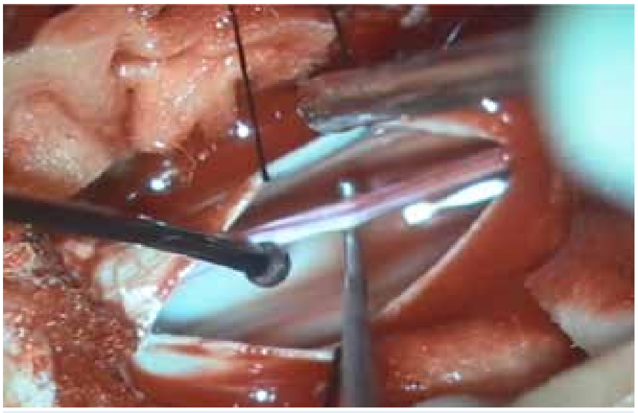

Figure-1: Direct monopolar probe nerve stimulation before filum terminale excision in tethered cord syndrome (TCS).

Figure-3: The appearance of electrodes that are attached to tibialis posterior and anterior, hallucis and external sphincter regions for recordings of MEP, SEP and sphincter MEP records and the surgical incision line in a 1-year old case with TCS.

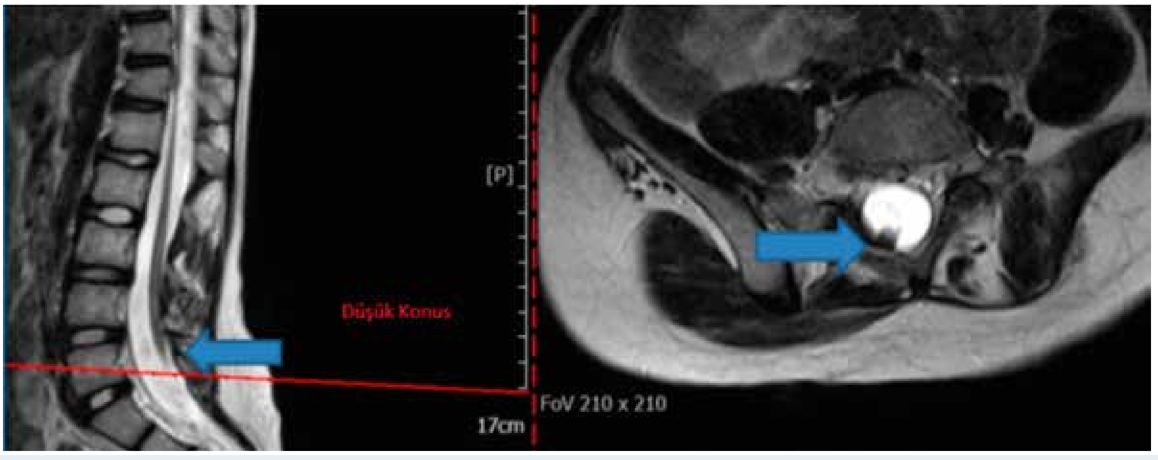

Figure-2: Low conus medullaris and thick tight filum terminale at L5 level can be seen at T2-weighted axial and sagittal MRI preoperatively in one of our cases.

10 patients also had an additional bone spur or fibrous band causing a split cord (Table-1). Ten patients were previously operated for spina bifida and were diagnosed with tethered cord syndrome at follow-up. There were no previous spinal surgery history in 20 patients. When the results of IONM used during the operations were evaluated; SEP values at the end of the procedure were not reduced according to basal SEP values in any of the cases. In one case, SEP values were increased compared to basal values (case number 6, Table-1). In 2 cases, there was a decrease in MEP values according to basal values during surgery; it was temporary in 1 case and reached to basal MEP values at the end of the operation (cases number 17 and 25, Table-1). Additional neurological deficits were observed postoperatively in 3 of the cases. The neurological deficit in one of these cases recovered after 48 hours and was transient (case number 1, Table-1). In the other two cases, the course was permanent (cases number 10 and 25, Table-1). A permanent decrease in MEP values was observed in IONM in one of two cases with persistent neurological deficits (case number 25, Table-1). In other cases, MEP values remained the same as baseline values. No differences were observed at potentials during IONM in other cases except these cases.

DISCUSSION

IONM, one of the many methods developed to protect nerve tissue during surgical procedures, has been widely used for the last 20 years. Although IONM basically records SEP and MEP potentials, it is recommended that sphincter MEP, free-run EMG, and bulbocavernous potentials are also recorded (5). In our study, MEP, SEP, free-run EMG and direct probe stimulation potentials were used in all cases during recordings. Somatosensory evoked potentials (SEP) is the potentials obtained by stimulation of peripheral nerves and dermatome nerves (6). Electrodes are attached to the median nerve and ulnar nerve traces for upper extremity monitoring, and to tibialis posterior and peroneal region at lower extremities. Motor evoked potentials (MEP) is the potential to measure the function of motor nerves. It is an effective method to protect structural and functional integrity. It should be preferred because it allows quick response to the surgeon (1,6). Electrodes should be attached to abductor policis brevis for upper extremity records, tibialis anterior and abductor hallucis for lower extremity records, and external sphincter muscle for sphincter tonus (5) (Figure-3). In our study, records were obtained by attaching electrodes to the tibialis anterior and posterior, abductor hallucis, and external sphincter muscles in all cases.

Although there is a 5% chance of developing permanent neurological deficit in the postoperative period in TCS surgery (7), this rate increases to 10% if transient deficits are added (4,8). In our study, permanent neurological deficit was detected in two cases when we looked at the persistent deficit rate from these rates, and the rate was 6.6% in our study.

When the literatüre was reviewed, Paradiso et al. (9) in their study with 44 cases found that SEP values had high sensitivity and specificity when the postoperative neurological deficits and intraoperative neurophysiological changes were evaluated. In our study, SEP values were not significantly different from baseline values in patients with additional postoperative deficits.

When we evaluated the MEP potentials in our study, although there was additional deficit in the postoperative period in 3 cases, there was a permanent decrease in the MEP values in only 1 of these. This suggests that a false negative result may be seen in the IONM procedure (10). On the other hand, when the MEP and SEP records were evaluated together, in the IONM process, the specificity of the process is 92% and sensitivity is 99% (11). It was thought that the false negative result, which is no change in IONM values despite neurological damage, may be due to the bipolar cautery used during surgery whcih may affect the potential records, or to the effect of anesthetic agents and deepening of muscular relaxants (10,12).

Beyazova et al. (1), in their study, with 10 patients who were operated for tethered cord syndrome were selected using IONM, and no change in MEP and SEP values were determined according to the results. It has been emphasized that the stimulation obtained by direct touch with the probe to the nerve tissue is effective in recognizing and protecting the normal nerve tissue during the surgical procedure. In our study, in all cases, immediately before excision of the filum terminale, stimulation was applied by touching the possible filum terminale with a monopolar probe and direct nerve stimulation was performed; excision was performed if response was not obtained from the nerve tissue (Figure-1). The basal potential values taken at the time of excision of the filum terminale did not change after the excision.

Kothbauer et al. (13) pointed out in another study that the MEP values were effective in providing immediate information, and the direct probe nerve stimulation potentials particularly facilitated the operation.

When the present values and findings are examined, although the results of our study are close to the literature, the potentials obtained with the direct stimulation in the IONM, especially with the probe, is helpful to the surgeon in maintaining the neurological function.

CONCLUSION

The IONM procedure allows you to plan a safe surgical procedure in TCS cases with adequate equipment, an experienced surgeon, an experienced anesthesiologist and an experienced neurophysiologist. The evaluation of SEP and MEP values together in the IONM procedure increases the sensitivity and specificity of the process. It is suggested to use sphincter MEP, free-run EMG values and potential values obtained by direct stimulation of the nerve tissue with probe to minimize the possibility of neurological damage during surgery.

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