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ANALYSIS OF PATIENTS SUBMITTED TO SURGICAL TREATMENT FOR NEUROMUSCULAR SCOLIOSIS WITH AND WITHOUT INTRAOPERATIVE TRACTION

ANÁLISE DE PACIENTES SUBMETIDOS A TRATAMENTO CIRÚRGICO DE ESCOLIOSE NEUROMUSCULAR COM E SEM TRAÇÃO INTRAOPERATÓRIA

ANÁLISIS DE PACIENTES SOMETIDOS A TRATAMIENTO QUIRÚRGICO DE ESCOLIOSIS NEUROMUSCULAR CON Y SIN TRACCIÓN INTRAOPERATORIA

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ABSTRACT

Objectives: To compare the surgical treatment of neuromuscular scoliosis (NMS) with and without intraoperative skull-skeletal traction (ISST) in terms of the degree of curve correction, surgical time, hospitalization time, screw density, use of blood products,and complications. Methods: A comparative retrospective study, in which we analyzed the medical records and radiographs of 17 patients who underwent surgical treatment for neuromuscular scoliosis (NMS). They were divided into two groups, with 9 and 8 patients operated with and without ISST, respectively, at a referral hospital specialized in the treatment of spinal deformitiesfrom 2019 to 2021.The categorical variables were analyzed using the Chi-squared test. Results: Among the 17 patients included in the study, there was a higher prevalence of women in the group without ISST (6 and 2) and of men in group with ISST (5 and 3).The ages of the patients in the two groups ranged from 8-19 years and from 11-29 years, respectively. The screw density used in the traction group averaged 66.33%±8.49 and 82.63%±17.25 in the non-traction group, a statistically significant differencewith a P-value of 0.036. The average percent correction was 76.81%±15.61 in the traction group as compared to an average of 66.39%±12.99 in the non-traction group. In addition, there were complications in 1 patient in each of the groups. Conclusions: Surgical treatment for NMS with ISST allows surgery using fewer blood products to maintain the same hematimetric level in the postoperative period.ISST also allows the use of a lower screw density to correct more severe deformities. ***Level of evidence III; Comparative retrospective study.***

Keywords: Spine; Spinal fusion; Spinal curvatures.

RESUMO

Objetivo: Comparar o tratamento cirúrgico da escoliose neuromuscular (ENM) com e sem uso de tração crânio-esquelética intraoperatória (TCEI), com relação a grau de correção da curvatura, tempo de cirurgia, tempo de internação, densidade de parafusos, uso de hemoderivados e complicações. Métodos: Estudo retrospectivo comparativo, no qual foram analisados prontuários e radiografias de 17 pacientes com ENM submetidos a tratamento cirúrgico, divididos em dois grupos, com nove e oito pacientes operados com e sem TCEI, respectivamente, em hospital de referência de tratamento de deformidades da coluna, entre os anos de 2019 e 2021. As variáveis categóricas foram analisadas através do teste de Qui-quadrado. Resultados: Dos 17 pacientes incluídos no estudo, houve maior prevalência de mulheres no grupo sem TCEI (seis e dois) e de homens no grupo TCEI (cinco e três), sendo a idade dos pacientes entre 8 e 19 anos e 11 e 29 anos, respectivamente. A densidade dos parafusos utilizados no grupo tração foi em média 66,33%±8,49%e82,63%±17,25% no grupo sem tração, diferença estatisticamente significante; o valor de P foi 0,036. A média percentual de correção foi 76,81%±15,61%, em comparação com a média de 66,39%±12,99% em não tracionados. Além disso, houve complicação em um paciente de cada um dos grupos. Conclusões: O tratamento cirúrgico para ENM com TCEI permite a cirurgia com menos usode hemoderivados para manter o mesmo nível hematimétrico no pós-operatório. A TCEI também permite o uso de parafusos com densidade menor para corrigir deformidades maiores. ***Nível de evidência III; Estudo retrospectivo comparativo.***

Descritores: *Coluna vertebral; Artrodese de coluna; Curvaturas da coluna vertebral.*

RESUMEN

Objetivos: Comparar el tratamiento quirúrgico de la escoliosis neuromuscular (ENM) con y sin uso de tracción craneoesquelética intraoperatoria (TCEI), en cuanto al grado de corrección de la curvatura, tiempo quirúrgico, estancia hospitalaria, densidad de los tornillos, uso de hemoderivados y complicaciones. Métodos: Estudio comparativo retrospectivo, en el que se analizaron historias clínicas y radiografías

Study conducted by the Hospital da Baleia de Belo Horizonte, MG, Brazil.
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de 17 pacientes con ENM sometidos a tratamiento quirúrgico, divididos en dos grupos, con 09 y 8 pacientes operados con y sin TCEI, respectivamente, en un hospital de referencia para el tratamiento de deformidades de la columna vertebral, entre los años 2019 y 2021. Las variables categóricas se analizaron mediante la prueba de Chi-cuadrado. Resultados: De los 17pacientes incluidos en el estudio, hubo una mayor prevalencia de mujeres en el grupo sin TCEI (6 y 2) y de hombres en el grupo con TCEI (5 y 3), con pacientes entre 8 y 19 años y 11 y 29 años, respectivamente. La densidad media de los tornillos utilizados en el grupo de tracción fue del 66,33% ± 8,49%en el grupo con tracción y del 82,63% ± 17,25% en el grupo sin tracción, una diferencia estadísticamente significativa; el valor P fue de 0,036. El porcentaje de corrección promedio fue de 76,81%±15,61%, en comparación con el promedio de 66,39%±12,99% en no traccionados. Además, hubo complicaciones en 1 paciente en cada uno de los grupos. Conclusiones: El tratamiento quirúrgico de la ENM con TCEI permite una cirugía con menor uso de hemoderivados para mantener el mismo nivel hematimétrico en el postoperatorio. La TCEI también permite el uso de tornillos con menor densidad, para corregir deformidades más grandes. ***Nivel de evidencia III; Estudio retrospectivo comparativo.***

Descriptores*: Columna vertebral; Fusión vertebral; Curvaturas de la columna vertebral.*

INTRODUCTION

Scoliosis consists of a three-dimensional deformity of the spine with coronal, sagittal, and axial components. It is defined radiographically as a lateral curvature of the spine greater than or equal to 10º, as measured by the Cobb method, with the presence of vertebral rotation.[1-3]

Neuromuscular scoliosis (NMS) is characterized by non-congenital deformity in patients with any type of pre-existing neuromuscular condition such as myopathies (Duchenne muscular dystrophy, cerebral palsy, myelomeningocele, spinal muscular atrophy, Friedrich's ataxia, spinal cord injury). It usually progresses rapidly, at an average of 15-20° per year, with the increase in curvature persisting even after growth has ceased. In addition to presenting spinal deformity, patients may develop various clinical conditions with concomitant changes in pulmonary and cardiac function.[1-6]

Surgical treatmentis an important therapeutic option for NMS, since containment of curvature progression by conservative treatment is difficult. Often, surgeries must be performed early, but must always seek a balance between minimizing the appearance and worsening of deformities without limiting the patient's chest expansion and lung volume.[4]

Intra- and postoperative complications are more prevalent in NMS than in idiopathic scoliosis surgeries.[2] The literature is still inconsistent regarding the best surgical technique to be applied in treatment.[1] The use of intraoperative skeletal traction for the correction of neuromuscular scoliosis has produced significant results.[7,8] Intraoperative halo-femoral or skull-skeletal traction (ISST)has been more of tenreported as facilitating correction in high magnitude scoliotic curves.[7]

There are still no studies with adequate levels of evidence on the use of ISST in the surgical treatment of NMS. Due to the relevance of this pathology, we proposed a study to compare surgical treatment of NMS with and without the use of ISST, analyzing the degree of curvature correction, surgical time, hospitalization time, screw density, use of blood products, and frequency of complications.

METHODS

This study was approved by the Institutional Review Board as opinion number 5.312.891, CAAE 56032622.7.0000.5123.

We retrospectively evaluated the medical records and radiographs of 17 NMS patients submitted to surgical treatment for scoliosis at an in-state referral hospital specialized in deformities. As inclusion criteria, patients with panoramic spinal radiographs taken both preoperatively and at least three months following surgery were accepted. Individuals with incomplete pre- and/or postoperative medical records were excluded.

The patients were followed up with postoperative radiographs for a minimum follow-up period of 15 days and three months of out patient follow-up. All radiographical measurements were performed using the Surgimap® application, which made the evaluation of the Cobb angle, kyphosis, lordosis, sagittal parameters (SP), and pelvic obliquity possible. All these measurements were evaluated by two independent observers and, in the case of discrepancy, a third was responsible for the opinion. All data were duly recorded in the electronic medical records of the institution.

After applying the inclusion and exclusion criteria, the patients were divided into two groups according to the type of surgery performed. Group 1 consisted of ninepatients who underwent surgery with ISST, and Group 2 was made upof eight patients who underwent surgery without traction.

The preoperative radiographic evaluation was conducted using panoramic radiographs of the spinein AP and lateral views, taken with the patient seated and with the patientin the supine position under correction with traction exerted on the upper and lower limbs. The postoperative evaluation was performed using panoramic radiographs also in AP and lateral views.

In all patients, the following parameters were measured in the coronal plane: angular value of the main curve measured from the preoperative radiograph using the Cobb method (Cobb pre), Cobb of the main curve from the postoperative radiograph (Cobb post), and preoperative pelvic obliquity (PO pre). The percentage of postoperative correction was also obtained (Correction = Cobb pre – Cobb pos/Cobb pre x 100).

Surgical Technique

The study patients underwent the surgical procedure under intraoperative neurophysiological monitoring. Intraoperative skull-skeletal traction was performed by positioning a Gardner-Wells tong cranially and Steinmann 4.0 pins in the distal femurs. The patient was placed on a spine support in ventral decubitus, with pads on the elbows, knees, and feet to prevent skin damage. Carewas also provided with eye and breast protection. The patients were submitted to the same anesthetic protocol using total intravenous anesthesia and transamin. After dissection by planes, the implantation of the pedicle screws was performed using the "hands-free" technique. All the patients underwent facet joint osteotomies targeting more flexibility of the curve. Pelvic fixation was necessary in individuals with pelvic obliquity greater than 15°and in those who were not able to walk.

Intraoperative traction was performed in traction group patients with 70% body weight (BW), applied cranially (20% of BW) and traction of the femur was applied caudally (50% of BW – 5 kg), before incising the skin. Neuromonitoring patterns were observed during traction placement, throughout the entire procedure until its completion. Monitoring was performed using soma to sensory evoked potentials (SSEP) and motor evoked potentials (MEP). As a criterion for loss of potentials MEP and SSEP, the value of 50% was defined as an alert signal. The traction load was modified for any decrease in potential during the installation of the traction. After surgery, all patients were transferred to an intensive care unit (ICU) for observation.

Statistics

The variables analyzed were sex, age, weight, surgical time, days in the hospital, Cobb angle, hemoglobin level, use of blood products, complications, and arthrodesis levels.

Statistical analysis was conducted to compare all variables between the participants who had and did not have ISST (Yes or No). The Statistical Package for Social Sciences (SPSS), version 13.0 program was used to assist with the calculations, considering level of significance of 5%. The Chi-squared test was used for the

categorical variables andthe comparison of means for the numeric variables, and the results were presented as absolute and proportional quantities, means, and their standard deviation.

RESULTS

Description of the patients

Seventeen patients with NMS who had undergone surgery, met the inclusion criteria, and had complete medical records were included in this study. The patients were divided into two groups: those who had and those who had not been submitted to surgery with ISST. There was a predominance of women (6 -75%) in the group with traction and of men (6 – 66.7%) in the group without ISST (Table 1). The mean age of the group without traction was 16.88 ± 5.64 years (8-19 years), and of the traction group was 13.78 ± 3.27 years (11-29 years), with no level of significance (P=0.180). Regarding weight (Kg), the ISST group patients weighed less than the non-ISST group, with an average of 30.77 ± 6.92 Kg (Table 1).

Description of the Cobb angle and the arthrodesed levels

The mean preoperative curvature of the Cobb angle was 86.28° ± 25.51 degrees in the traction group and 68.31° ± 13.98 degrees in the group without traction. The mean correction percentage at the end of the procedure was 76.81% ± 29.47 degrees, higher in the group with ISST (Table 2), butwith no significant difference (P=0.169). The corrective arthrodeses implemented ranged from levels T2 to the lumbar region, in addition to 4 iliac fixations.

Surgical time and hospitalization period

The mean difference in surgical time between the two groups of only 24.6 minutes was not statistically significant (P=0.420) (Table 3). Total hospitalization time was greaterin the traction group, though not presenting a significant difference (P=0.407).

The time per instrumented level was evaluated and presented as the mean and standard deviation for the groups with and without ISST, respectively, as19.73 ± 3.08 and 27.15 ± 6.26 minutes.

Differences between pre-, intra-, and perioperative variables

By comparing the hemoglobin (Hb) levels, evaluated by means of a hematimetric examination preoperatively and in the immediate postoperative period at the time of entry to the ICU, we can see a small, final, though not statistically significant differencein between the groups (P=0.335 and P=0.970, respectively, for the pre- and postoperative values).

Table 1. Analysis of the characteristics of patients treated surgically for neuromuscular scoliosis, 2022.

	Traction		
Variables	**Yes n(%) Mean ± SD**	**No n(%) Mean ± SD**	**P-value**
Sex			
Female	6(75)	2(25)	
Male	3(33.3)	6(66.7)	0.081*
Age	13.78±3.27	16.88±5.64	0.180
Weight	30.78±6.92	35.13±8.29	0.257

* LikelihoodRatio.

Table 2. Bivariate analysis comparing the mean descriptive data of patients treated surgically for neuromuscular scoliosis, 2022.

	Traction		
	Yes	**No**	
Variable	**Mean ± SD**	**Mean ± SD**	**P-value**
Postoperative Cobb (angle)	31.93±21.24	23.14±11.24	0.312
Degree of correction	76.81±15.61	66.39±12.99	0.169
Screw density (%)	66.33±8.49	82.63±17.25	0.036
Pelvic obliquity (angle)	14.3±13.81	9.86±9.41	0.457

There was a relative difference in the total use of blood products, considering both the intra- and postoperative periods, between the two groups. In the traction group, 7 patients required them with a mean volume of 285.71 ± 130.17 mL, while, in the group without traction, 4 patients needed them with a mean volume of 540 ± 297.30 mL, indicating a statistically significant difference (P=0.001). (Table 3)

Complications

Among the patients who underwent the surgical procedure to correct NMS, only 2 had complications, with sepsis and infection of the surgical wound, in addition to respiratory changes, without significant difference (P=0.249). (Table 4)

DISCUSSION

In NMS, surgery is the treatment indicated for structural and progressive spinal deformities, as well as for pelvic obliquity that compromises balance or positioning when standing or sitting, aiming for erect posture.[2,9] Considering the different techniques and levels of fixation described in the literature about this treatment, this study analyzed patients who underwent corrective scoliosis surgery with and without intraoperative skull-skeletal traction.

The results showed greater correction of the Cobb angle in the group that used ISST, with a difference of more than 10°, although without statistical significance, probably due to the size of the population studied.

Significant differences were found in the mean density of the screws and the volume of blood products used.

While age was not a decisive criterion in defining the moment of surgery,[9] it was observed that the ISST group was younger and with more severe curves, though without a statistical difference, than the without traction group. The decisive factor for a surgical indication was that the progression of the disease was more severe and earlier, with a high preoperative Cobb angle (86.28° ± 25.51 – ISST vs. 67.15° ± 13.35 – Group without ISST), with mean ages of 13.78±3.27 and 16.88±5.64 years, respectively.

Table 3. Surgical characteristics of the patients treated surgically for neuromuscular scoliosis, 2022.

	Traction		
	Yes	**No**	
Variable	**Mean ± SD**	**Mean ± SD**	**P-value**
Hemoglobin pre	12.31±1.15	13.05±5.25	0.335
Hemoglobin post	9.34±1.54	9.38±1.76	0.970
Surgical time (h)	4.72±1.15	5.14±0.88	0.420
Application of blood products			
Intraoperative (mL)	280±44.72	375±150	0.215
Total volume used (mL)	285.71±37.8	540±134.16	0.001
Hospital stay*			
ICU (d)	5.22±3.8	4±2.24	0.464
Nursing ward (d)	1.22±0.44	1±0.53	0.362
Total hospitalization time (d)	6.44±4.1	5.14±2.61	0.477

*n=16.

Table 4. Analysis comparing the mean iliac fixation and complications data of patients treated surgically for neuromuscular scoliosis, 2022.

	Traction		
Variables	**Yes n(%)**	**No n(%)**	**P-value**
Iliac Fixation			
Yes	2(50)	2(50)	
No	7(53.8)	6(46.2)	0.893*
Complications			
No	8(53.3)	7(46.7)	
Sepsis/Surgical wound infection	1(100)	0(0)	
Respiratory complications	0(0)	1(100)	0.249*

* LikelihoodRatio.

Other studies like ours also reported greater preoperative Cobb angles in the group where ISST was used[7,10,11] for the higher correction potential afforded by the method. The study by Tøndevold et al.[11]also evaluated the correction index, based on preoperative radiographs in flexion, for which they found a statistically significant difference between the two groups. This index was not evaluated in our study, but despite the Cobb correction having been greater in the group with ISST, there was no statistical significance.

Early surgery, associated with less pelvic obliquity, seems to be associated with a higher degree of deformity.[2,9,12] In this study, greater curve correction was observed in the traction group, which had greater pelvic obliquity, though not statistically significant. In this case, however, there is a similarity with the Tøndevold et al. study[11] in which neither group obtained a notable change in pelvic obliquity, which may be explained by the greater rigidity of the curvature in the traction group.[11]

The literature states that surgeries in patients with NMS may have the instrumentation extended either cranially (proximal thoracic spine, normally T1 or T2), to correct thoracic kyphosis, or caudally, which may be limited to the lumbar spine or include the pelvis in cases of increased pelvic obliquity.[2,11] In this study, in the group with ISST, 2 (22.2%) of the 9 surgeries started in T2, but in 8 (88.8%), the arthrodesed levels started in T4, and the fixation did not extend more cranially due to the low kyphosis index. As regards caudal fixation, in the group with traction there was a predominance of lumbar fixation, between L4 and L5 (66.7%) and only 2 iliac fixations (22.2%), agreeing with the surgical indication due to the greater angle of pelvic obliquity present in these cases.[2,9,11,12]

Pelvic fixation may be associated with a slowing of pelvic obliquity progression and a reduction in complications.[13] This type of fixation predominates surgical interventions in patients with NMS. However, current studies offer a new perspective, with instrumentation terminating in L5, constituting a safe method for improving correction regardless of the initial curve.[2,11]

The surgical time data did not show statistical significance but allowed us to observe a shorter surgical time in the group with ISST when compared against the without traction group (4.72±1.15 vs. 5.16±0.94 hours, respectively). The shorter operative time in the traction group may be associated with the greater technical ease of inserting the pedicle screws, since the vertebrae are more anatomically positioned under traction, especially in relation to rotation.

The difference in the length of the hospital stay was one day, longer in the group with traction (6.44±4.1 days vs. 5.14±2.61 days), a variation that was observed based on time in the ICU, since the patients in both groups only spent an average of one day in the nursing unit.

The higher mean density of the screws corresponds to the percentage of screws used in relation to the possible point of fixation of the vertebrae in the curve. In this study, this variable presented statistical significance when comparing the two groups (P=0.036). Other studies reported a statistically significant difference between screw density and scoliosis curve correction.[14,15] It should be noted that the optimum ratio between density and curve correction is important, especially in patients with NMS with a tendency towards reduced lung capacity.[15] Our study demonstrated that under ISST it is possible to achieve greater correction with lower screw density, allowing more correction with less of the neurological and vascular risk inherent in screw implantation, as well as lower cost per surgery.

Complications related to the act of or following surgery are more prevalent in NMS than in idiopathic scoliosis, predominantly blood loss, infections, respiratory and gastrointestinal changes, with the possibility of progressing to death.[2,16,17] This study had a low rate of complications, with only one complication each in both the with and without traction groups (11.1% and 12.5%), the former associated with the surgical wound and the latter with respiratory changes, in line with the literature data. These data differ from those of the study by Rumalla et al.,[17]who reported a complication rate of 40.1% in a review of 2,154 cases of NMS surgery. The presence of pulmonary diseases and greater intraoperative blood loss may be associated with the development of complications.[18] The total volume of blood products showed statistical significance when comparing the two groups of this study (P=0.001), explained by the greater use of more aggressive and complex osteotomiesin search of greater angle correctionin the group without ISST.

This study had limitations with regard to the sample size, which may have been insufficient to statistically evaluate NMS surgeries with or without traction. However, the study is relevant by providing information about the therapeutics applied and the results presented. The data can serve as a basis for further studies, which will broaden the discussion about ISST applied to NMS.

CONCLUSION

This study analyzed the data of patients who underwent surgery for NMS with ISSTas compared to those of patients who were operated without ISST. We observed that the density of the screws and total volume of blood productsassociated with the surgery were statistically significantin a comparison of the groups. The study showed that even though curve correction was greater in the group with traction, the difference was not statistically significant. It is worth noting the low occurrence of complications in this study, in addition to the fact that disseminating the data may contribute tosupporting further discussion about the therapy applied to NMS.

All authors declare no potential conflict of interest related to this article.

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