Abstract. The study of the back muscles bioelectric activity in 216 children of 10-15 years old showed that the paravertebral muscles total bioelectrical activity on the convex side of the curve top and on the concave side of its caudal part is higher compared with that on the opposite side. Investigation of H-reflex and M-response in 302 patients of 10-15 years old has created a normative database. Its comparison with the totality of the specific patient’s individual electrophysiological parameters makes to determine its progression group possible.

Keywords. AIS, ENMG, back muscles bioelectric activity, H-reflex, M-answer.

Introduction

Electroneuromyography (ENMG) allows to assess the functional state of the nervous-muscular apparatus. However, the use of ENMG for the evaluation of clinical features and predicting the progression of AIS is complicated. Therefore, the main goals were, first, to refine the methodology of the integral assessment of the bioelectric activity of the back muscles depending on the type of scoliosis, location, and size of the curve, second, to evaluate the predominance of cerebral or spinal mechanisms in the formation and progression of deformation using the H-reflex, and third, to reveal the presence and nature of the interdependence of the calculated parameters in the formation and progression of deformation.
Electroneuromyography (ENMG) gives an opportunity to evaluate the functional state of neuromuscular system. However, application of ENMG for the AIS clinical features and prognosis progression assessment is difficult. Therefore, the main goals of our work were: the first - to clarify the methods of back muscles bioelectric activity (BEA) integral evaluation depending on the type of scoliosis, location and magnitude of the curve; the second - to estimate the prevalence of cerebral or spinal mechanisms in formation and progression of the curve using the H-reflex technique; and the third - to identify the presence and interdependence of the surface and stimulation ENMG parameters data to optimize the list of ENMG parameters.

Material-methods I.

Were examined 216 children: 32 healthy children and 184 with the curve 5-100º Cobb angle with right (67%) and left-sided (33%) AIS (the average age 12,6±1,9 years, 93% girls). The curve top was evaluated at the ThVII-X, ThXI-XII, LI-II and was respectively in 47%, 20% and 33% of all cases. The muscles BEA was recorded by bipolar cutaneous electrodes at the electrode distance of 3cm to the right and to the left of the spinous processes (at ThVII, ThXII, LI) paraspinal,
at 3cm and 6cm lateral. Electromyograph "Neyromian" (firm "Medikom LTD", Taganrog) was used. The bandwidth of signal was 10Hz-2kHz. The total BEA (in mV*sec) was recorded three times in a lying posture, duration - 5 seconds, interval - 15 seconds. Data for each point of the recording were averaged, were calculated asymmetry coefficients (AC): the ratio of the BEA average value on the convex curve side to the BEA average on the concave side at symmetric points of registration. Data were processed by «Statistica» 6.0 and 6.1.

Results and Discussion I.

AC рассчитывались по отдельности в группах с правосторонним грудным сколиозом (результаты приведены в таб.1 в качестве примера), правосторонним поясничным, левосторонним грудным и левосторонним поясничным сколиозом.

AC were calculated separately in the right thoracic scoliosis group (Table 1 an example of summarized results), right lumbar group, left-handed or left thoracic lumbar scoliosis group.

Table 1. The asymmetry coefficient (AC) of integral EMG (M±m) in patients with right-sided scoliosis

<table>
<thead>
<tr>
<th>Deformation (Cobb angle)</th>
<th>AC ThVIII IX</th>
<th>AC ThX XI</th>
<th>AC L I II</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Control group. (32 people)</td>
<td>1,09±0,06</td>
<td>0,98±0,05</td>
<td>1,01±0,03</td>
</tr>
<tr>
<td>5-10º (6 people)</td>
<td>1,42±0,16</td>
<td>1,11±0,11</td>
<td>1,15±0,12</td>
</tr>
<tr>
<td>10-25º (27 people)</td>
<td>1,29±0,09</td>
<td>1,23±0,11</td>
<td>1,15±0,11</td>
</tr>
<tr>
<td>25-40º (36 people)</td>
<td>1,48±0,11</td>
<td>1,52±0,16</td>
<td>1,31±0,09</td>
</tr>
<tr>
<td>&gt;40º (18 people)</td>
<td>1,78±0,37</td>
<td>1,67±0,67</td>
<td>1,67±0,28</td>
</tr>
</tbody>
</table>
In calculations held on Spearman correlation method \((p < 0.05)\) was revealed the trend to AC increase as the deterioration of condition and progression process, particularly at the curve top in the 1st point of registration. Patients with the top of the arc at Th_{VII-IX} have the highest correlation coefficients between the AC magnitude at the curve bottom and character of progression, as in the studies [1,4]. In this case the AC at the curve bottom (at LII) is negative. It isn’t observed in the EMG recording at other levels. An AC under deformation degree increase is observed not only in the paraspinal region, where it reflects mainly the muscle-rotators activity. The same pattern is also in the 2nd and 3rd points of registration. In these areas is basically recorded the activity of m.latissimus dorsi, m.trapezius and others, performing a compensatory role of derotators on the convex side of the curve and rotator’s role – on the concave side. Discriminant analysis showed the coincidence of the classification carried out only on the EMG parameters, with clinical and radiological data, depending on the curve size and type of the AIS in 72-90% of cases. It indicates a specific EMG pattern for each of the scoliosis form.
Revealed asymmetric paraspinal muscle EMG changes in the AIS imply asymmetric changes in the activity of spinal motoneurons that innervate these muscles. Therefore, in the second part of the study the possibility of H-reflex and M-response parameters from the soleus (less kortikolise) and gastrocnemius (more kortikolised) [3] muscles to the excitability of motor neurons that innervate the paraspinal muscles change, depending on the severity and nature of progression investigated.

Material-methods II.

Results of the H- and M- responses study for 302 girls of 10-15 years old with the curve top at TThvii,vii (94 children, 31%), Thxvii-L (104 children, 34%), Lvii (105 children, 35%) and 15 healthy children were analyzed (table 4). The average curve value on Cobb for the group was 26,17°±18,91° (5-100°). In the group with progressive form average curve was of 39,1±16,98° (12-100°), in a rapidly progressive form group – 14,24°±7,5°(5-45°), in a non-progressive form group – 6,96°±1,83°(5-12°).

Table 4. The distribution of patients with AIS in the treatment groups by the progression character.

<table>
<thead>
<tr>
<th>Type of scoliotic deformation</th>
<th>Right-side AIS</th>
<th>Left-side AIS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Curve top</td>
<td>Curve top</td>
<td>Curve top Lvii</td>
</tr>
<tr>
<td>Thvii,vii</td>
<td>Thxvii-L</td>
<td>Lvii</td>
</tr>
</tbody>
</table>
Rapidly progressive forms 75 (80%) 44 (42%) 51 (48%)
Progressive forms 16 (17%) 39 (37%) 36 (34%)
Non-progressive forms 2 (2%) 21 (20%) 18 (17%)
Total 93 104 105

Electromyograph "Neuro-MEP-04" (firm "Neurosoft", Ivanovo) was used. The study was conducted in the standard position [7]. Bipolar stimulating electrodes were used. The stimulation of the nerve in a standard single-point rectangular pulses of 0.2 ms, stimulus frequency of 1 in 10 seconds, with a consistently growing up from sub threshold to supramaximal intensity. Signal bandwidth was of 20Hz-10 kHz. The bipolar registration electrode was located in the motor points of the MIM and the SM.

Results and Discussion II.

In general, H/M of MIM and SM in the group of healthy subjects were higher than in the group of children with AIS (tab.5). The analysis held by Wilcoxon test for sub-groups showed a statistically significant asymmetry between convex and concave side of curve only in right-side thoracolumbar scoliosis group and in the left-side lumbar scoliosis group with the non-progressive course (p<0.0046 and p<0.026 respectively).

Table 5. The value of H/M*100% in patients with AIS aged 10-15 years in the whole group.
<table>
<thead>
<tr>
<th></th>
<th>±m</th>
<th>Median</th>
<th>Minimum</th>
<th>Maximum</th>
<th>σ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right IGI</td>
<td>20,9±0,8</td>
<td>17,3</td>
<td>1,2</td>
<td>90</td>
<td>14,5</td>
</tr>
<tr>
<td>Left IGI</td>
<td>20,5±0,8</td>
<td>16,2</td>
<td>1,6</td>
<td>98</td>
<td>14,6</td>
</tr>
<tr>
<td>Right SI</td>
<td>44,3±1,2</td>
<td>43,8</td>
<td>1,5</td>
<td>100</td>
<td>22,0</td>
</tr>
<tr>
<td>Left SI</td>
<td>45,3±1,3</td>
<td>44,2</td>
<td>0,0</td>
<td>99</td>
<td>22,2</td>
</tr>
</tbody>
</table>

Обнаружена асимметрия Н/М на выпуклой и вогнутой стороне дуги в группе пациентов с правосторонними формами сколиоза при величине дуги 5-25° и отсутствие ее при величине дуги более 25°. H/M asymmetry on the convex and concave side of the curve in patients with right forms of scoliosis in the curve magnitude of 5-25° and its absence in the magnitude of the arc of more than 25° were found. Величины Н/М как по правой и левой МИМ, так и по правой и левой КМ во всех исследуемых группах имеют тенденцию к нарастанию по мере утяжеления состояния и характера прогрессирования, особенно в группе правосторонних грудных и грудопоясничных сколиозов. В данном случае наши результаты совпадают с результатами [2] по левосторонним поясничным сколиозам.

The H/M values for both left and right MIM and right and left of the SM all treatment groups have a tendency to grow as the worsening condition and character progression, especially in the group of right-sided thoracic and thoracolumbar scoliosis. In this case, our results are consistent with [2] on the left-sided lumbar scoliosis. В наше исследовании величины Н/М составили по КМ у здоровых детей 55-57%, по правой и левой МИМ (M±m=25,8±3,2 и 22,1±2,9 соответственно) в отличие от опубликованных в литературе [5,6]. Это свидетельствует о преобладании в исследованных нами группах отклонений в деятельности спинных механизмов либо показывает реакцию спинного мозга на уже развившуюся деформацию. In our study H/M amounted to KM in healthy children 55-57%, on the right and left MIM (M±m=25,8±3,2 and 22,1±2,9 respectively) in contrast to published in the literature [5,6]. It indicates the predominance of spinal abnormalities of the investigated groups in either shows the reaction mechanisms of spinal cord on the pre-existing strain.

С использованием критериев Манна-Уитни и Вальда-Вольфовица были выявлены отличия между здоровыми испытуемыми и пациентами с правосторонними формами ИС, а также между право- и левосторонними формами ИС при условии отдельного рассмотрения пациентов в зависимости от локализации вершины дуги.

Using the criteria of the Mann-Whitney and Wald-Wolfowitz were revealed differences between healthy subjects and patients with right forms of AIS, as well as between right- and left-sided forms of AIS in condition of individual
treatment of patients, depending on the location of the curve top. Результаты корреляционного анализа по методам Спирмена, тау-Кендалла и гамма-статистики в группах право- и левосторонних сколиозов в зависимости от вершины дуги и характера прогрессирования уточнялись с помощью дисперсионного и дискриминантного анализа (последний проверен на той же выборке с помощью априорной классификации). Они позволяют говорить лишь о той или иной степени вероятности прогрессирования при нарастании в динамике величины H/M у правосторонних форм ИС по левой МИМ при снижении H/M по правой КМ, у левосторонних форм – при нарастании H/M по правой МИМ в сочетании со снижением H/M по левой КМ.

The results of correlation analysis according to Spearman techniques, Kendall’s tau-and gamma-statistics in groups of right- and left-sided scoliosis, depending on the curve top and progression character were refined using the variance and discriminant analysis (this method was validated on the same sample using a priori classification). All this give opportunity to speak only about the degree of probability of right-side scoliosis progression if H/M on left MGM increase in the dynamics in combination with H/M decrease on the right SM, and of left-side scoliosis progression – if an H/M increase on the right MGM, in conjunction with the decrease of H/M on the left CM.

Conclusion.

В ходе исследования установлено, что на выпуклой стороне вершины дуги и на вогнутой стороне каудальной её части суммарная биоэлектрическая активность паравертебральных мышц выше по сравнению с таковой на противоположной стороне. При этом необходим учет этапности развития процесса деформации. При однократном исследовании процесс прогрессирования отражается в среднегрупповых показателях H/M, однако недопустимо применение лишь соотношения H/M-ответов.

The study revealed that on the convex side of the curve top and on the concave side of its caudal part the paravertebral muscles total bioelectrical activity was higher compared with that on the opposite side. Of great importance is the registration of the stages of deformation processes phases. The progression process is reflected in the mean-group H/M data in a single study, however is inadmissible the use only H/M responses ratio. Сравнение совокупности индивидуальных электрофизиологических показателей пациента с данными, содержащимися в нормативной базе, позволяет
отнести его в ту или иную группу по признаку прогрессирования с достаточно высокой степенью вероятности. Comparison of patient’s electrophysiological individual parameters with data contained in the standard database makes it possible to define the group on the basis of progression with a high degree of probability.
References


