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VERTEBRAL FRACTURES IN CHILDREN DURING THE COVID-19 PANDEMIC

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Background. The COVID-19 pandemic has had a significant influence on the main epidemiological indicators of emergency trauma, as well as on the pediatric population.

Aim. This study aimed to analyze the incidence of compression fractures of vertebral bodies in children between January and July 2020 (the first months of COVID-19 pandemic).

Materials and methods. A comprehensive examination and treatment of 82 children and adolescents aged 3–17 years, who received compression fractures of the vertebral bodies in the period from January 1 to July 31, 2020, was carried out. A group of 96 children of the same age who sustained a similar type of injury at the same time in 2019 was studied as a control. To make a clinical diagnosis, we used methods of traditional research examination for emergency traumatology. The severity of vertebrogenic fractures was determined according to the AO/ASIF classification.

Results. The total number of patients diagnosed with vertebral fractures during the COVID-19 pandemic was 14.58% less than that in the same period in 2019. Patients in the comparison groups were comparable in sex, average age of injury, and age group in which the spine was most often injured. The most frequent mechanism of spinal injuries in patients of the comparison groups was a fall from a height. More often than others, Th_{VI} and Th_{VII} vertebral bodies were broken. The severity of vertebral fractures in all cases corresponded to type A, subtypes A1 and A2. For treatment, conservative methods were used in most cases. During the period of strict self-isolation, in April 2020, no children of the main group had vertebral fracture because they were forbidden to leave their apartments unnecessarily. In May 2020, the number of children with vertebral fractures was half the number in the same month in 2019. In June 2020, the incidence of vertebral fractures was in line with the pre-crisis average.

Conclusion. Strictly following restrictive anti-epidemic measures during a pandemic is an effective method of reducing the number of cases requiring emergency treatment for compression fractures of the vertebral bodies in children.

Keywords: children; vertebral fractures; COVID-19 pandemic.

ПЕРЕЛОМЫ ПОЗВОНКОВ У ДЕТЕЙ В ПЕРИОД ПАНДЕМИИ COVID-19

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Обоснование. Пандемия COVID-19 существенно повлияла на основные эпидемиологические показатели экстренной травмы населения, в том числе в детской популяции.

Цель — провести анализ частоты получения детьми компрессионных переломов тел позвонков в период с января по июль 2020 г., в первые месяцы течения новой коронавирусной инфекции.

Материалы и методы. Проведено комплексное обследование и лечение 82 детей и подростков в возрасте от 3 до 17 лет включительно, получивших в период с 1 января по 31 июля 2020 г. компрессионные переломы тел позвонков. В качестве контрольной исследовали группу 96 детей того же возраста, получивших аналогичный вид повреждений в те же самые сроки 2019 г. Для постановки клинического диагноза у пострадавших использовали традиционные для экстренной травматологии методы исследования. Степень тяжести полученных вертеброгенных переломов у пациентов определяли согласно классификации AO/ASIF.

Результаты. Общее количество пациентов с установленным диагнозом переломов позвонков в период пандемии COVID-19 было на 14,58 % меньше, чем в аналогичный период 2019 г. Пациенты групп сравнения были сопоставимы по половой принадлежности, среднему возрасту получения повреждений и возрастной группе, в которой чаще всего травмировался позвоночник. Наиболее частым механизмом получения травм позвоночника у пациентов групп сравнения было падение с высоты своего роста. Чаще других были сломаны тела позвонков Th_{VI} и Th_{VII}. Тяжесть полученных детьми переломов позвонков во всех случаях соответствовала типу А, подтипам А1 и А2. Для лечения данного вида повреждений в подавляющем большинстве случаев использовали консервативные методы. В период строгой самоизоляции, в апреле 2020 г., когда было запрещено без надобности покидать свои квартиры, не было диагностировано ни одного случая получения детьми основной группы вертеброгенных переломов. В следующем месяце количество детей с переломами позвонков было в два раза меньше, чем в тот же месяц 2019 г. В июне 2020 г. частота выявления переломов тел позвонков соответствовала средним «докризисным» показателям.

Заключение. Строгое соблюдение ограничительных противоэпидемических мер в период пандемии стало эффективным средством, обеспечившим уменьшение количества случаев экстренного обращения детей за медицинской помощью по поводу компрессионных переломов тел позвонков.

Ключевые слова: дети; переломы позвонков; пандемия COVID-19.

The pandemic of Corona VIrus Disease 2019 (COVID-19) radically changed the everyday life of people of all age groups and the functions of all industries and the social sphere [1]. The health care system, being the most important link in the economy, was the first to face the well-known cardinal changes in its functions [2]. Traumatology and orthopedics, medical specialties that largely determine the morbidity, mortality, and disability of the population, have also undergone significant changes [3]. Thus, many medical institutions of traumatology were redesigned into COVID hospitals [4], planned hospitalization of orthopedic patients was completely suspended [5], the number and structure of emergency trauma [6] changed, the volume of emergency traumatological surgeries was reduced [7], telemedicine technologies were widely used for diagnostic purposes [8], some personnel of trauma departments were retrained and transferred to other treatment units [9], and many employees of orthopedic clinics had coronavirus infection [10].

Adult patients are the target group of published scientific papers about the organization of emergency medical care to the population during the COVID-19 pandemic. A few publications, including the works of S. Farrell et al. [11], J.M. Wilson et al. [12], and J. Hernigou et al. [13], are devoted to the pediatric aspects of this topic. The lack of information on specific nosological units of emergency trauma in children and adolescents during the COVID-19 pandemic prompted this study.

Aim. This study aimed to analyze the incidence of compression fractures of vertebral bodies in children between January and July 2020 (the first months of the COVID-19 pandemic).

Materials and methods

The present work is an analytical sample observational cross-sectional study. The main observation group consisted of 82 children aged 3–17 years who received compression fractures of the vertebral bodies from January 1 to July 31, 2020. The control group included 96 children of the same age who received similar spinal injuries from January 1 to July 31, 2019. We used traditional methods of investigation for emergency traumatology: collection of complaints and anamnesis, clinical research according to the generally accepted method, and radiation diagnostics to make a clinical diagnosis in all victims of the main and control groups. Radiation examination of

the spine included a survey radiography, computed tomography, and magnetic resonance imaging of the injured area in all patients. For clinical reasons, related specialists were involved in the examination of injured children.

The type and subtype of vertebral fractures in the studied patients were determined according to the AO/ASIF classification [14].

The dynamics of the epidemiological situation with regard to coronavirus infection in the region was assessed in accordance with the Decree of the Governor of Tyumen Region No. 120-p dated March 17, 2020 "On the introduction of a high alert regime" [15] and the guidelines of Rospotrebnadzor MR 3.1.0178-20 dated 05/08/2020 "Determination of a set of measures, as well as indicators that are the basis for the gradual removal of restrictive measures in the context of the epidemiological spread of COVID-19" [16].

Statistical data processing was carried out using Microsoft Excel 2016 and Statistica 6.0. Qualitative variables were described by absolute and relative (%) frequencies; for quantitative variables, the arithmetic mean and standard deviation (M ± SD) were calculated. The parametric Student's t-test was used to quantitatively compare the groups. In the case of phenomenon values less than or more than 10 in one cell when constructing four-field tables, Chi-square test (χ^2) or two-sided Fisher's exact test (p) was used to qualitatively compare the groups, respectively. For possible multiple outcomes, arbitrary contingency tables were analyzed using the Chi-square test (χ^2), taking into account the degree of freedom of frequency (df).

Results

During the COVID-19 pandemic, the number of children and adolescents diagnosed with vertebral fractures decreased by 14.58% compared with the same period in 2019.

In both comparison groups, males prevailed, with 51 boys (62.19%) in the main cohort and 50 (52.09%) in the control cohort (df = 1, $\chi^2 = 1.842$; $p < 0.05$) and only 31 girls (37.81%) in the main cohort and 46 (47.91%) in the control cohort.

The average age of children in the main group was 9.2 ± 0.3 years, whereas that in the control group was 9.0 ± 0.3 years. In both comparison groups, patients aged 8–12 years prevailed, with 44 (53.65%) in the main cohort and 48 (50%) in the control cohort (df = 1, $\chi^2 = 0.237$; $p < 0.05$).

The mechanism of spinal injuries in children is presented in Table 1.

Data analysis Table 1 shows that the distribution of patients in the study groups by the mechanism of injury was comparable (df = 5, $\chi^2 = 4.391$; $p < 0.05$), and the main causative factor was a fall on the back or buttocks from the height of their own growth.

Patients in the main group suffered isolated spinal fractures in 17 (20.73%) clinical cases and multiple fractures in 65 (79.27%). In the control

Table 1

Structure of the studied groups of children by the mechanism of spinal injuries

Mechanism of injury	Observation group				Significance level of differences
	Main		Control		
	N	%	N	%	
Fall on the back or buttocks from the height of their own growth	32	39	39	41	0.828*
Fall on the back, legs or buttocks from a height of 1 m or more	31	38	36	37	0.967*
Slight axial load on the spine	11	13	16	17	0.547*
Road traffic accidents	2	2	1	1	0.595**
Hit your head on the bottom of a pond when diving into water	3	4	–	–	0.096**
Others	3	4	4	4	1.000**
Total	82	100.0	96	100.0	

*Chi-square test; ** two-sided Fisher's exact test.

Table 2

Number of compressed vertebrae in patients of the study groups with multiple trauma

Number of compressed vertebrae	Observation group				Significance level of differences
	Main		Control		
	N	%	N	%	
Два	15	23	22	29	0.449*
Три	15	23	20	26	0.671*
Четыре	17	26	14	19	0.281*
Пять и более	18	28	20	26	0.857*
Итого	65	100.0	76	100.0	

*Chi-square test.

group, isolated spinal fractures and multiple fractures were recorded in 20 (20.83%) and 76 (79.17%) cases, respectively. The number of compressed vertebrae in one patient with multiple trauma is presented in Table 2.

Analysis of cases of multiple spinal trauma revealed no significant difference in the number of compressed vertebrae in the victims of the main and control groups (df = 3, $\chi^2 = 1.586$).

In general, the main group was diagnosed with compression of 283 vertebrae, with an average of 3.45 injuries in one patient, whereas the control group had 251 vertebrae, with an average of 2.61 injuries in one child. The broken vertebrae were ranked according to the frequency of their damage. In the main group, the bodies of the Th_{VII} and Th_{VI} vertebrae were most often compressed in 31 (10.95%) and 30 (10.6%) cases, respectively. In the control group, the middle thoracic vertebrae were also more often injured, with Th_{VI} in 33 (13.14%) cases and Th_{VII} in 32 (12.74%) cases. None of the observations were diagnosed with vertebral body fractures C_I, C_{II}, and C_{III}.

One case of polytrauma was recorded in the main (1.21%) and control (1.04%) groups. In a child from the main group, vertebrogenic fractures were accompanied by fractures of the third and fourth ribs on the left; thus, this clinical case was classified as multiple trauma. In a patient from the control group, vertebral fractures were obtained simultaneously with a mild concussion; thus, this clinical observation was considered as a concomitant injury.

According to the AO/ASIF classification, all cases of traumatic vertebral injuries in the children of the main and control groups were classified as type A, subtypes A1 and A2 [14]. The severity of the compression of the vertebrae determined the treatment tactics. Of the 82 children in the main group, a conservative method of treatment was used in 80 (97.56%) cases, and surgical stabilization of the injured spinal motion segments was performed in 2 (2.44%) cases. In the control group, conservative treatment was chosen in 95 (98.95%) patients, and surgical treatment in 1 (1.05%) patient. The indications for the surgical treatment of injured vertebrae in children were the severity of compression of the bodies and a high degree of likelihood of mechanical and/or neurological instability.

The frequency of obtaining compression fractures of the vertebrae in children by months during which the coronavirus infection developed was analyzed (Table 3).

As shown in Table 2, vertebral fractures were absent in the children of the main group in April 2020, whereas 10 cases of vertebrogenic fractures were diagnosed in patients of the control group in April 2019. In May, the number of vertebral fractures was also higher in the control group (17 cases) than in the main group (6 cases) (df = 1, $\chi^2 = 4.244$; $p < 0.05$). A statistically significant difference in the frequency of vertebral fractures in the children was also registered in July, but already with a twofold predominance of their occurrence in patients of the main group: 18 cases in comparison with 9 cases in the control group (df = 1, $\chi^2 = 5.436$; $p < 0.05$).

The frequency of vertebral fractures in the children of the studied groups was also analyzed, and it was influenced by the measures taken by the federal and local authorities to reduce the incidence

Table 3

Distribution of children with vertebral fractures by months in 2020 and 2019

Month of year	Observation group				Significance level of differences
	Main		Control		
	N	%	N	%	
January	15	18	20	21	0.671*
February	15	18	10	10	0.132*
March	15	18	13	14	0.386*
April	–	–	10	10	0.002**
May	6	8	17	18	0.045**
June	13	16	17	18	0.742*
July	18	22	9	9	0.022*
Total	82	100.0	96	100.0	

*Chi-square test; ** two-sided Fisher's exact test.

Table 4

Distribution of children with vertebral fractures depending on the restrictive anti-epidemic measures in 2020

Dates, nature of restrictive measures	Observation group				Significance level of differences
	Main		Control		
	N	%	N	%	
01.01–02.04; period of analyzing the situation and making first decisions	45	55	43	45	0.180*
03.04–17.05; strict self-isolation regime	4	5	21	22	0.001**
18.05–31.05; first stage of lifting restrictions	2	2	6	6	0.290**
01.06–31.07; second stage of lifting restrictions	31	38	26	27	0.127*
Total	82	100.0	96	100.0	

*Chi-square test; ** two-sided Fisher's exact test.

and mortality of the new coronavirus infection. Table 4 shows the frequency of vertebral fractures in the studied patients, depending on the restrictive anti-epidemic measures taken by the authorities.

Table 4 shows that the frequencies of vertebrogenic fractures in the children of the study and control groups were 54.87% (45) and 44.79% (43), respectively, from January 1 to April 2, 2020. During the period of strict self-isolation from April 3 to May 17, 2020, 4 (4.86%) cases of vertebral fractures were registered in the main group and 21 (21.87%) in the control group ($p < 0.001$). At the first stage of removal of restrictive measures from May 18 to May 31, 2020, the shortest in duration, the number of detected vertebral fractures was 2 (2.43%) in the main group and 6 (6.25%) in the control group. At the second stage of lifting restrictions from June 1 to July 31 (end of the collection of clinical material), the number of vertebrogenic fractures was 31 (37.84%) in the main group and 26 (27.09%) in the control group.

Thus, statistically significant differences in the frequency of vertebral fractures in children were obtained in April, the first half of May 2020 (at the stage of strict self-isolation).

The average bed-day of a patient's stay in the hospital was 9 in the main cohort and 10.3 in the control cohort. Among the children of the main group, not a single case of COVID-19 was detected throughout the study period.

Discussion

Analysis of the main epidemiological indicators of uncomplicated spinal trauma in children during the coronavirus pandemic showed that the patients of the comparison groups were comparable in gender, average age of injury, and the age group in which the spine was most often injured. Other authors also cited comparisons of traumatized children that are close to our findings on these criteria [17].

The most frequent mechanism of spinal injuries in both groups was falling on the back or buttocks. Children fell either from the height of their growth or from any other height, starting from 1 m and above. The greatest height of the child's fall corresponds to the dimensions of the seventh floor of a residential building [18].

The high frequency of seemingly insignificant traumatic agents (e.g., falling on the back from the height of one's own height) is primarily associated with the so-called "arch-key mechanism" [19]. V.E. Belenky et al. (1984) set up an experiment on biological dummies, reproducing a blow to the spinous processes of the vertebrae in the thoracolumbar region, which often occurs when falling on the back from the height of one's own growth. Experimenters have documented that traumatic force acting on the apex of the spinous process of the vertebra causes compression of the superior vertebrae and stretching of the underlying intervertebral discs. Thus, when a test machine hit the area of the spinous processes of the vertebrae Th_X and Th_{XI}, the pathological and anatomical dissection of biomannequins revealed fractures, including the vertebrae Th_{II} and Th_{III} in one case and the vertebra Th_{III} in the other case [19].

A distinctive feature of the injuries of the patients of the main group was that such mechanisms of damage as jumping on a trampoline and falling from slides and swings in courtyard playgrounds were much less common. In our opinion, this finding can partly be explained by the fact that shopping and entertainment centers, where children most often jump on trampolines, were closed from April to May 2020, during the period of the most severe restrictive epidemic measures. In addition, visiting children's playgrounds, where various play structures were partially or completely dismantled, was not allowed.

From April to July 2020, preschool educational institutions (nurseries, kindergartens), schools, and sports institutions were closed, explaining why children of the main group did not have injuries that could be classified as "school" and "sports." Our findings are consistent with those published by J.T. Bram et al. The authors report an increase in the proportion of injuries sustained by children at home during the pandemic. At the same time, the proportion of sports injuries decreased from 26.0% of clinical observations in March–April 2019 to 7.2% of cases in the same months of 2020. Injuries sustained on children's playgrounds amounted to 9.0% in spring 2019 and 5.2% in the same period in 2020 [20].

Interestingly, the differences in the incidence of isolated and multiple vertebral fractures in children of the studied groups amounted to tenths of a percent, with the prevalence of the frequency of polyfractions by approximately 4 times. Our data on the incidence of multiple fractures in 79.27% (main group) and 79.17% (control group) of cases are closest to the indicators of a similar category of vertebral injuries published by D.B. Franklin 3rd et al. (i.e., 81.1% of clinical observations) [21].

As indicated above, compression of 283 and 251 vertebrae was diagnosed in children of the main and control groups, respectively. In both comparison groups, the Th_{VI} and Th_{VII} vertebral bodies were fractured more often than the others: 61 (21.55%) cases in the main group and 65 (25.89%) cases in the control group. The prevalence of multiple injuries of the middle thoracic region, mainly in patients under 12 years of age, is primarily associated with the anatomical and physiological features of the children's spine. At the age of 3–12 years, the spine in children is a flexible structure. In the vertebrae of the middle thoracic region, the bone beams are located vertically and have short horizontal joints; in the vertebrae of the lower thoracic and lumbar regions, the same beams are closely intertwined in various planes. These structural features of the thoracolumbar and lumbar vertebrae give them greater density and strength in comparison with the thoracic ones [17]. When a traumatic force is applied, the vertebrae located at the apex of the physiological kyphosis are more susceptible to compression than those lying above or below [22].

The severity of vertebral fractures received by children in all cases corresponds to type A, A1 and

A2 subtypes on the AO/ASIF scale. The data obtained coincide with the information published in the literature on the predominant nature of type A vertebrogenic fractures in the pediatric population [23]. For the treatment of this type of damage, conservative methods were used in the majority of cases. Priority to these techniques is given by authoritative domestic experts while focusing on the difficulties of diagnosing and accounting for pediatric patients with spinal injuries [24, 25].

Realizing the goal set in the study, special attention was paid to the analysis of the frequency of diagnostics of vertebral compression fractures in children, depending on the coronavirus infection in the region.

We preliminarily studied comparative analyses of the epidemiological situation in patients with traumatological and orthopedic pathology before and during coronavirus infection. The first articles on this topic appeared in foreign journals in April–May of this year [13, 20, 26]. In the first 5 weeks of the development of coronavirus infection in one of the specialized clinics of Leipzig (Germany), the number of hospitalized patients with injuries decreased by 307 compared with the same period in 2019, with 1.9 million euros of economic losses of the institution [26]. Belgian researchers J. Hernigou et al. reported that for the first 1.5 months of the development of the COVID-19 pandemic, when patients were on self-isolation, the total number of injuries decreased by 32% compared with the same period in 2018 [13]. According to American authors J.T. Bram et al., the number of pediatric patients who presented with fractures during the month of the pandemic decreased 2.5 times (from 22 diagnosed fractures per day in 2019 to 9 in 2020) in their clinic [20]. Such a significant decrease in the incidence of fractures in children led the authors to place the words "Where Have All the Fractures Gone?" The average age of affected children was 7.5 years, whereas this figure was 9.4 years in 2019. Along with a decrease in the number of fractures diagnosed daily, the need for surgical treatment decreased from 2.2 cases per day in 2019 to 0.8 cases in 2020. The authors considered the introduction of restrictive measures as one of the important reasons for the decrease in the number of the above statistical indicators during the 2020 pandemic [20].

Other researchers agree with this statement. For example, Serbian authors M.M. Mitkovic et al. reported a 19% decrease in the total number of diagnosed fractures during the emergency regime [27]. New Zealand scientists G. Christey et al. reported a 48% decrease in the hospital admissions of children for injuries during the pandemic [28].

Our data on the number of vertebral fractures in children during the strict self-isolation in April and the first half of May 2020 also confirmed the trend described above. Within the indicated time frame, only four cases of vertebral fractures were registered, whereas 21 such clinical observations were recorded in the control group ($p < 0.001$, Table 4). In April 2020, no cases of children receiving fractures were recorded; in April 2019, 10 such clinical observations were recorded (Table 3). As the restrictive measures were lifted, especially at the second stage, the number of detected fractures increased; in May and July 2020, more of them were recorded in absolute and relative terms in comparison with the same period of 2019 (Table 4). This result can be attributed not only with the onset of the warm summer months but also with the natural increase in the motor activity of children to "compensate" for the limited mobility during the implementation of anti-epidemic measures.

In general, the impact of coronavirus infection on the body of children is not fully understood [29]. Many authors note that children suffer more than adults not from the physical but from the psycho-emotional aspects of the pandemic and the accompanying harmful effects, such as child labor, early marriage, and sexual exploitation [30].

Conclusion

During the first wave of the COVID-19 pandemic, the frequency of compression fractures of the vertebral bodies in children and adolescents decreased by 14.58% compared with the same period in 2019. Analysis of the main statistical indicators showed that the comparison groups were comparable in terms of gender, the average age of injury, and the age group in which children most often injured the spine. The most frequent mechanism of spinal injuries by patients during the COVID-19 pandemic and in patients in the control group was falling from different heights. The bodies of the vertebrae Th_{VI} and Th_{VII} were usually broken.

A distinctive feature of the injuries received by the patients of the main group was such mechanisms of damage as jumping on a trampoline and falling from slides and swings on children's playgrounds were much less common. The severity of vertebral fractures received by children in all cases on the AO/ASIF scale corresponded to type A, subtypes A1 and A2. In the vast majority of cases, conservative methods of treatment were used to treat this type of injury. During the period of strict self-isolation in April 2020, not a single case of children receiving vertebral fractures was identified. The next month, at the first stage of lifting restrictions, the number of diagnosed fractures was two times less than in the same period in 2019. In June 2020, the frequency of detection of vertebral fractures corresponded to the pre-crisis indicators of 2019.

The COVID-19 pandemic, due to the current lack of pathogenetic-based therapy, is a serious problem for different populations, including the pediatric population. Results show that strict adherence to restrictive anti-epidemic measures during the pandemic has become an effective means of reducing the number of cases of emergency treatment of children for compression fractures of the vertebral bodies.

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Ethical statement. A comprehensive, multifaceted study on the problem of uncomplicated compression fractures of the vertebral bodies in children and adolescents was approved by the Ethics Committee of Tyumen State Medical University (Min No. 59 dated 06/27/2014).

The consent of the patients (their representatives) to the processing and publication of personal data was obtained.

Author contributions

E.G. Scryabin — diagnostics and treatment of patients in the main and control groups, development of the study design, analysis of clinical material, writing the main text of the article.

M.A. Akselrov — diagnostics and treatment of patients in the main and control groups, analysis of clinical material, editing of the text of the article.

P.B. Zotov — search for literary sources, analysis of clinical material, editing the text of the article.

A.A. Kurmangulov — analysis of clinical material and its statistical processing, editing of the text of the article.

A.N. Bukseev — diagnostics and treatment of patients in the main and control groups, editing the text of the article.

All authors made significant contributions to the study and preparation of the article, read, and approved the final version before publication.

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