doi: 10.17116/engneiro201579620-25

Comparative Epidemiology of Adult and Pediatric Intramedullary Spinal Cord Tumors

YU.V. KUSHEL, YU.D. BELOVA

Burdenko Neurosurgical Institute, Moscow, Russia

Intramedullary spinal cord tumors (IMSCTs) occur both in children and adults and are a rare pathology. Our experience shows that tumor characteristics may vary depending on patients' age. Very few studies in the available literature focus on comparative analysis of this type of neoplasms in different age groups. **Objective.** To perform comparative analysis of the main epidemiological characteristics of intramedullary tumors in children and adults using a large surgical series and to identify possible differences. **Material and Methods.** Prospectively collected data about the nature and the main characteristics of intramedullary tumors in 224 pediatric (up to 18 years old inclusive) and 242 adult patients were used for this study, a total of 507 cases of resection of intramedullary tumors. **Results.** Pediatric IMSCTs are more extensive; at admission children are in the worse clinical condition compared to adults. The astrocytoma/ependymoma ratio was 83/17 in children and 21/79 in adults. There were age-related differences in tumor localization. Hence, adults predominantly had tumors of the cervical spine, while children typically had tumors of the thoracic spine and holocord tumors. Conclusions. The revealed differences in epidemiological and clinical characteristics of intramedullary tumors in children and adults have confirmed the fact that diffuse tumors predominate among pediatric patients and specified the astrocytoma/ependymoma ratio in different age groups. The analysis of the size and clinical presentation of intramedullary tumors in children attests to late diagnosis in this age group.

Keywords: *epidemiology, intramedullary tumors, adults, children.*

Intramedullary spinal cord tumors (IMSCTs) belong to the group of rare diseases [1—3]. It is extremely difficult to perform investigations providing the "gold standard" evidence for these cases. In this regard, analysis of personal series will long remain the main source of information on these pathologies. Years of managing IMSCTs patients of different age groups gave the first author a notion of differences between the clinical status in similarly diagnosed children and adults. Some of these differences, including the predominance of astrocytoma in the pediatric subgroup, have already been reported in literature, while others have been not [2—4]. The Medline search did not reveal any studies focusing on comparative analysis of the main epidemiological characteristics of intramedullary tumors in children and adults. The present paper reports the summary statistics on the authors' surgical experience.

Material and Methods

Prospectively collected data on the main epidemiological characteristics of intramedullary tumors

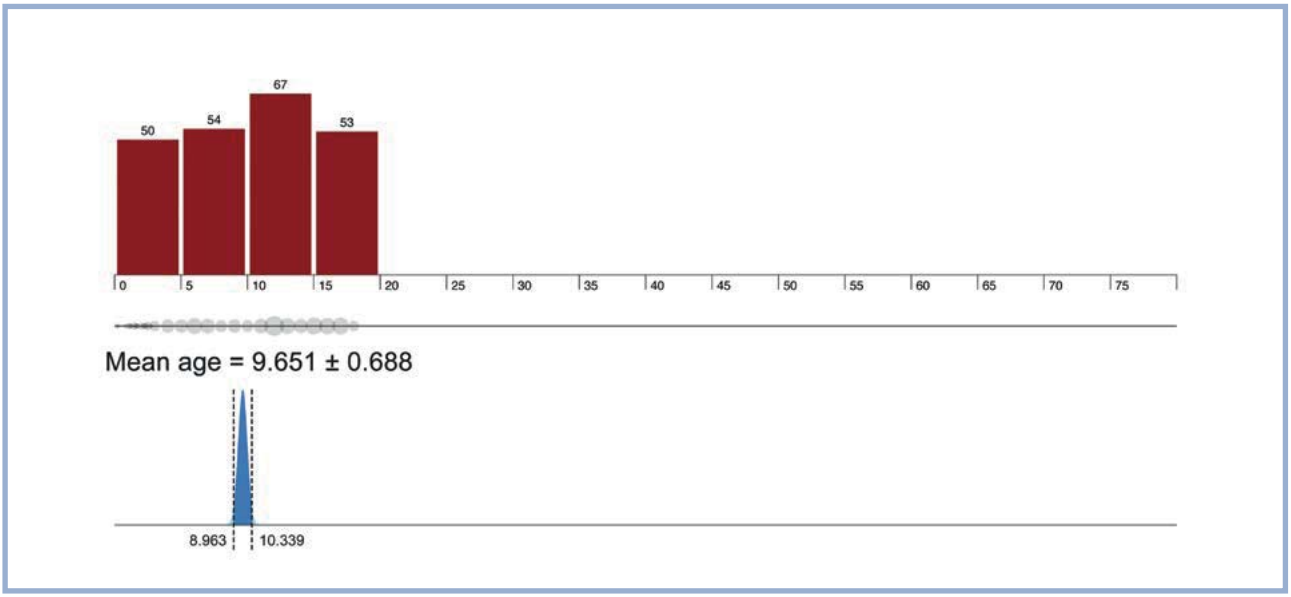


Fig. 1. **Age distribution of intramedullary spinal cord tumors (IMSCTs) in the pediatric group.**

© Yu.V. Kushel, Yu.D. Belova, 2015

e-mail: Kuszel@nsi.ru

from 224 pediatric (up to 18 years inclusive) and 242 adult patients were analyzed. These data represent 507 surgeries on the removal of IMSCTs performed by one surgeon (YK) primarily at the Burdenko Neurosurgical Institute between 2002 and 2015. It is important to note that all of the patients were histologically diagnosed. Quantitative analysis of the data was performed using the standard methods of descriptive statistics and Wizard and Excel software for Mac OS.

Results

The age distributions of patients with IMSCTs in the pediatric and adult subgroups are presented in **Figs. 1** and **2.**

Analysis of the diagrams shows that there is a single maximum of incidence of intramedullary tumors in children aged 12—15 years and two maxima in adults aged 30 and 45—50 years.

Functional status at the time of surgery

In practice, children appeared to be in worse clinical condition than adults, which was confirmed by assessing the patients' functional performance according to the classical McCormick scale [5] and statistical data processing. The analysis showed that a significantly greater number of children are admitted to hospital for surgery when having in the worse functional status corresponding to grades III and IV on the McCormick scale. The revealed difference was statistically significant **(Fig. 3)**.

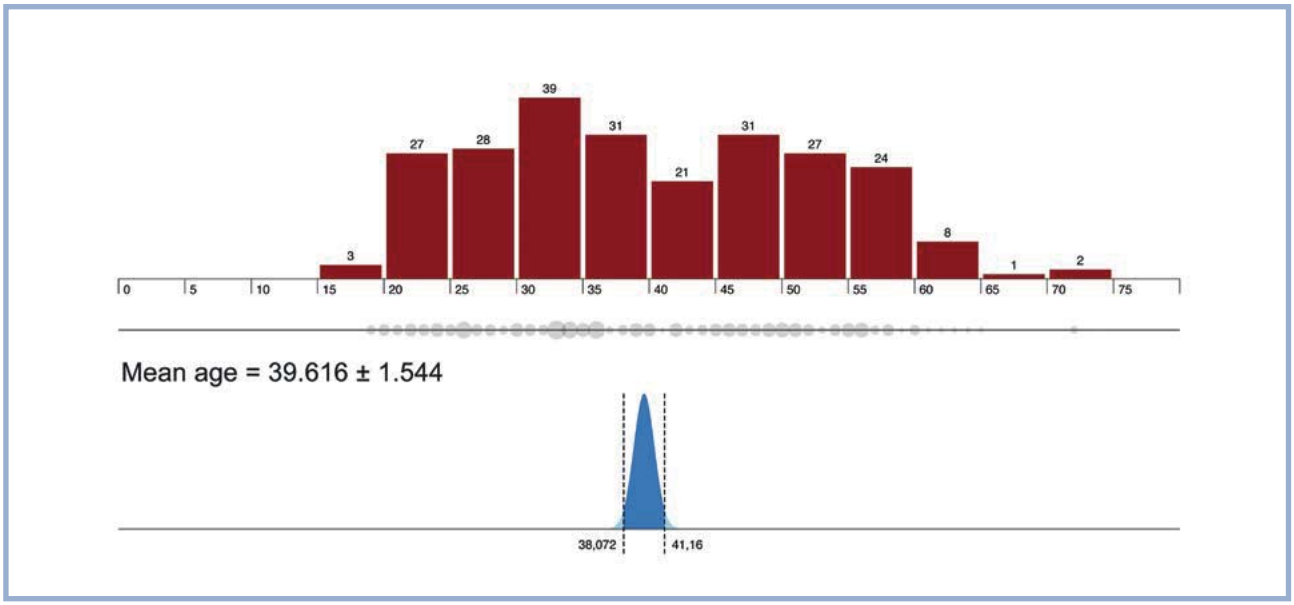


Fig. 2. **Age distribution of IMSCTs in the adult group.**

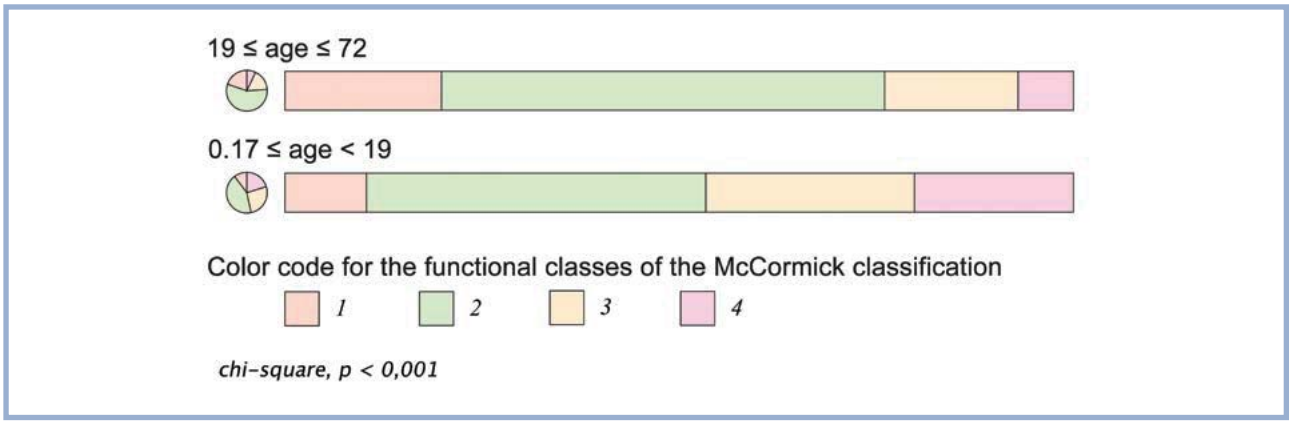


Fig. 3. **Distribution of patients over the functional classes of the McCormick classification for children and adults at the time of surgical treatment.**

Tumor length expressed as the number of vertebrae

As we have been operating on a significant number of patients with intramedullary tumors, we paid attention to the clear predominance of extensive tumors in children **(Fig. 4)**, which was particularly evident when compared to tumors 1—2 vertebrae long that are typical of the adult group **(Fig. 5)**. In our series, the mean tumor length was 3 segments in adults and 5 segments in children. The difference was statistically significant (Mann-Whitney U-test; $p<0.001$). The correlation analysis revealed a negative dependence between the functional status and tumor length; i.e., patients with more extensive tumors mostly belong to the third and fourth functional groups according to McCormick classification **(Fig. 6)**.

Tumor topography

Topographic classification distinguished cervical (C), cervicothoracic (CTh), thoracic tumors (Th), tumors of the medullary cone (L), and holocord (H) tumors. According to the correlation analysis, adults mostly had tumors with cervical localization **(Fig. 7)**, while children were more likely to have thoracic and holocord tumors **(Fig. 8)**. No age-related differences were detected for cervicothoracic tumor localization. Cervicothoracic tumors were most common tumors affecting the spinal cord segments in both age groups.

Histological types of tumors

The astrocytoma/ependymoma ratio was 83/17 in children and 21/79 in adults. Correlation analysis

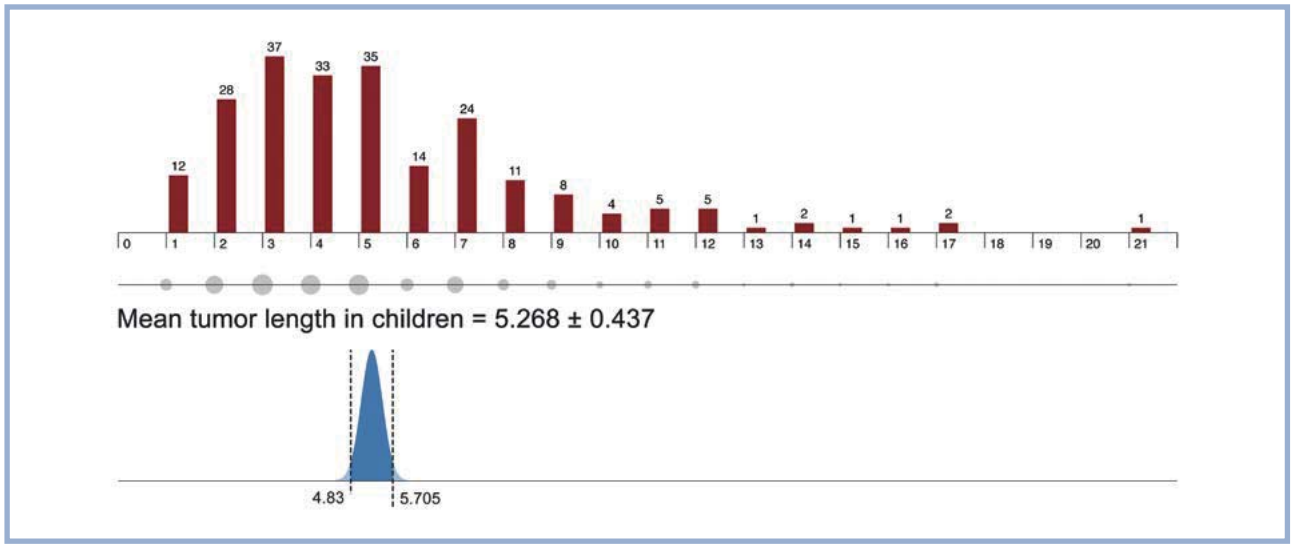


Fig. 4. **Distribution of tumor lengths in children with intramedullary tumors.**

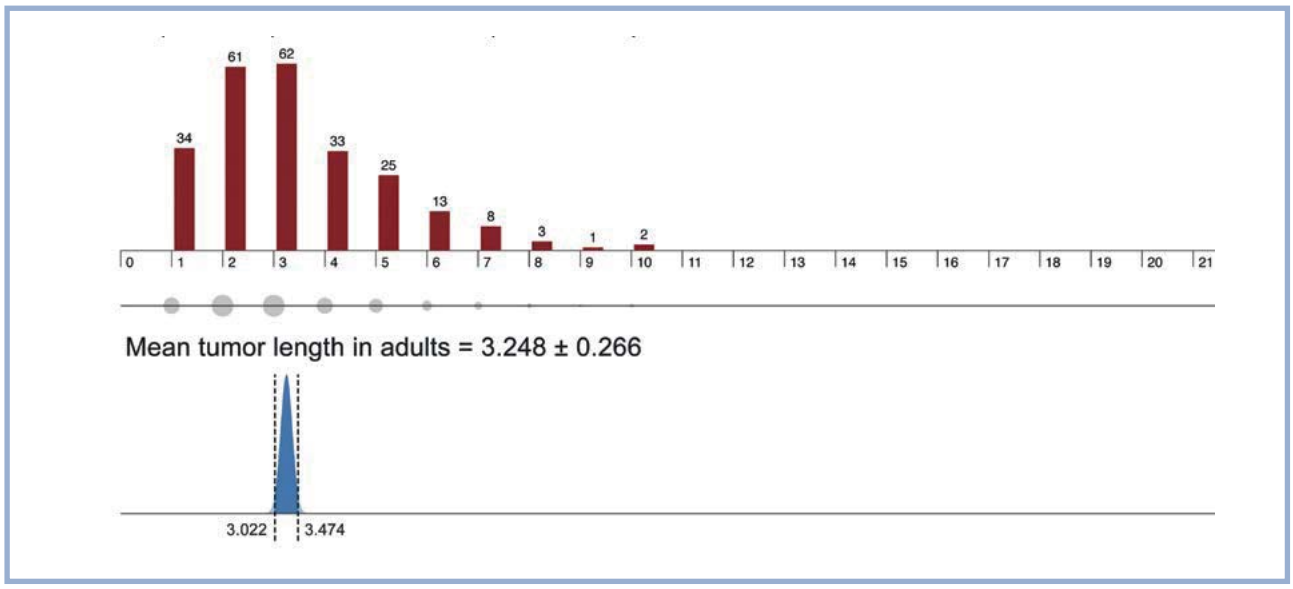


Fig. 5. **Distribution of tumor lengths in adults with intramedullary tumors.**

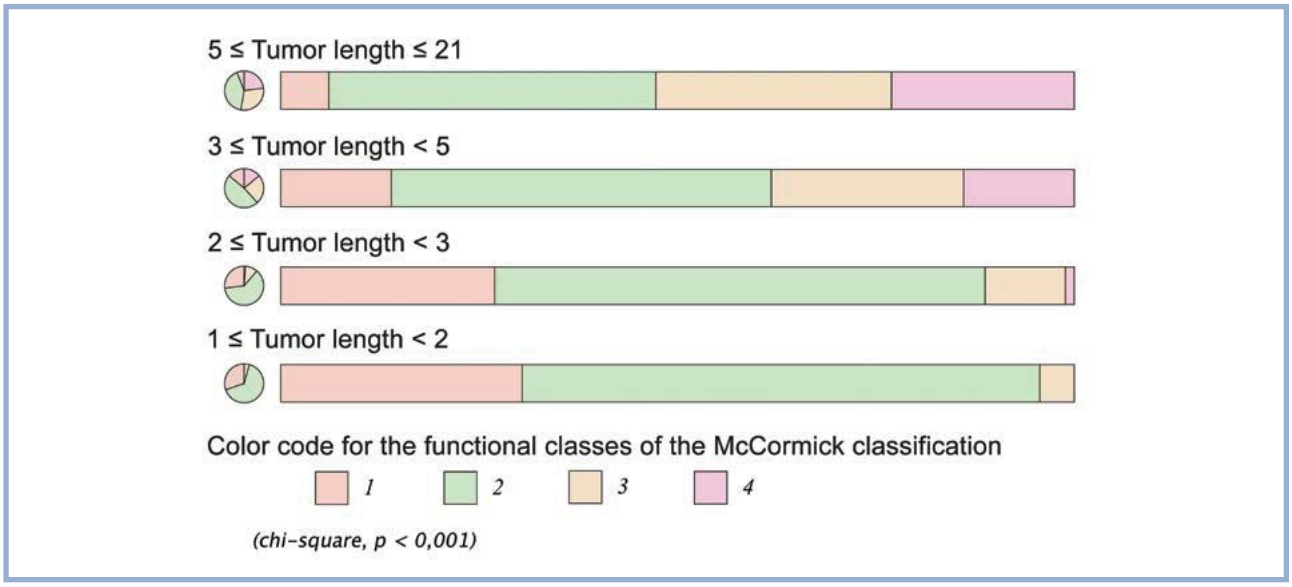


Fig. 6. **Preoperative functional status of patients depending on the level of tumor extension.**

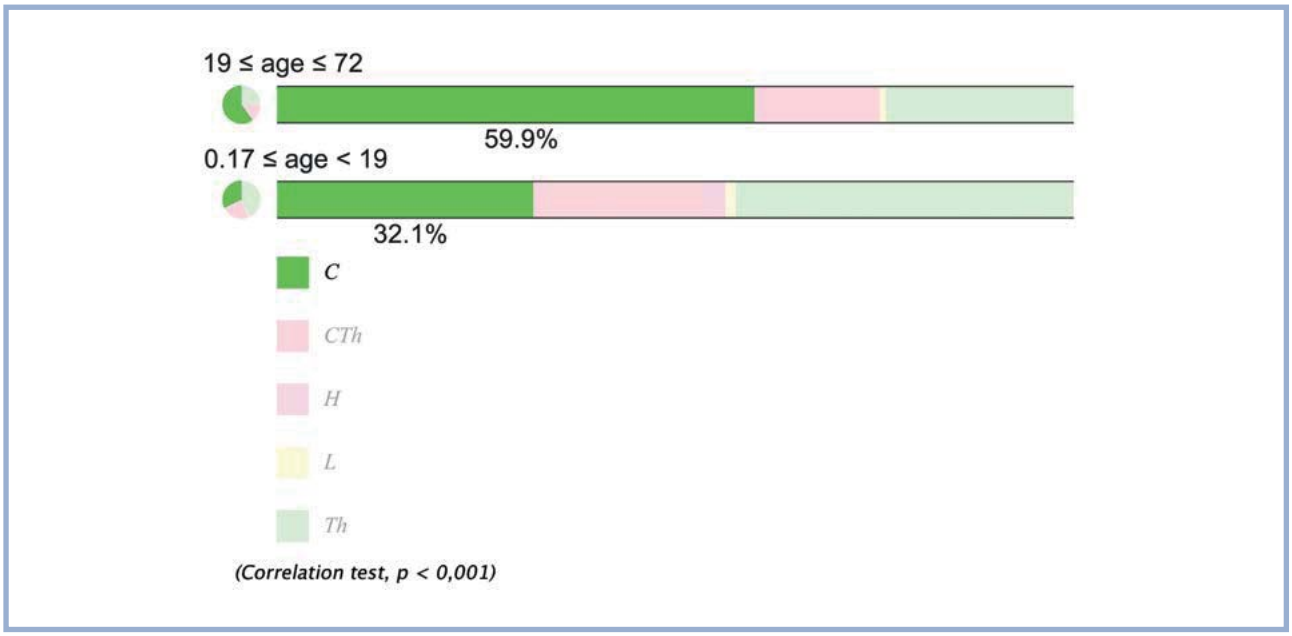


Fig. 7. **The incidence of cervical tumors in different age groups.**

provided the possible relation between histological subtypes and the typical age of their clinical manifestation. Thus, ependymoma was typical of the adult group, while all types of astrocytoma (including glioblastoma), epidermoid and anaplastic ependymomas were more common in the pediatric subgroup. The absence of correlation between age and hemangioblastomas (HAB) was unexpected, since HAB initially seemed to occur more frequently in adults. No correlation was found between the age and the incidence rate of malignant tumors (Chi-square test; p=0.128).

As repeatedly reported in the literature, the incidence rates of astrocytoma and ependymoma were identical in patients older than 60 years. There were 11 patients of this age in our series, including 8 patients with ependymoma. Metastasis, demyelination, and glioblastoma were revealed for the other three patients. Thus, the astrocytoma/ependymoma ratio in the subgroup of patients older than 60 years was 88/12 (i.e., ependymomas were even more predominant than in the entire adult group).

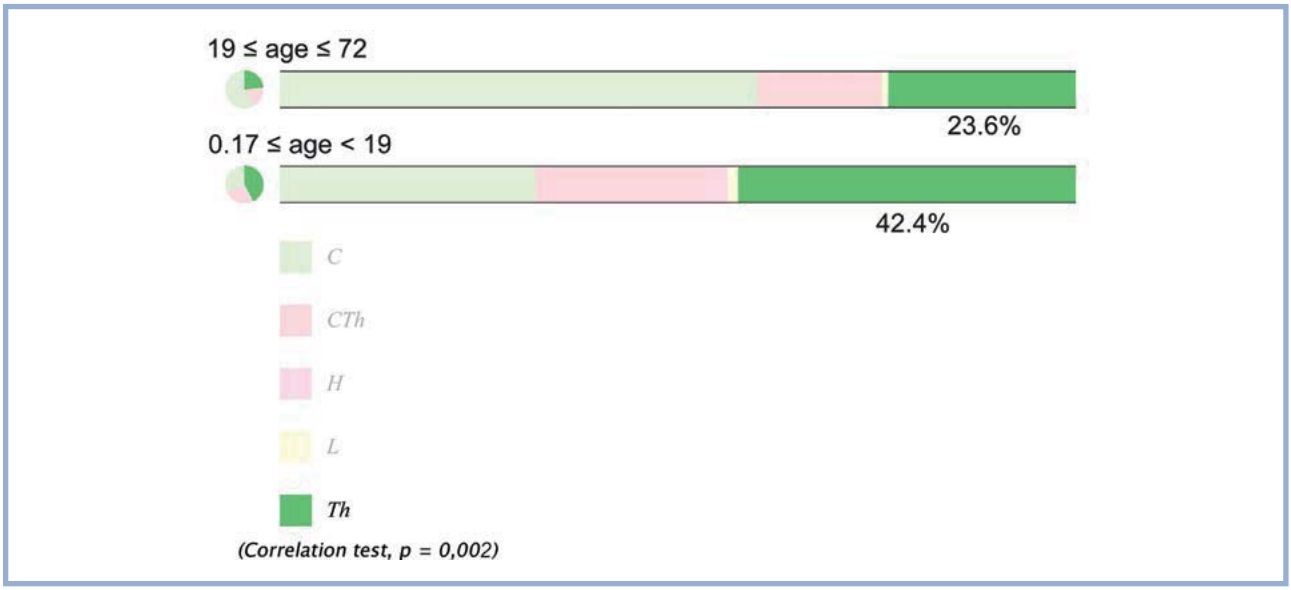


Fig. 8. **The incidence of thoracic tumors in different age groups.**

Discussion

We did not find any available studies focused on comparative characterization of intramedullary spinal cord tumors in children and adults. Our series is unique due to the large number of observations, the almost equal number of patients in both age groups, and the absence of patient preselection. The astrocytoma/ependymoma ratio is the only factor mentioned in the literature as a comparative parameter for pediatric and adult IMSCTs. In most papers devoted to surgery for intramedullary tumors, the reported astrocytoma/ependymoma ratios are 60/40 in adults and 40/30 in children, respectively [3, 6—10]. Our results differ significantly from the previously reported values. The astrocytoma/ependymoma ratio was 83/17 in children and 21/79 in adults.

The prevalence of diffuse and/or poorly circumscribed tumors in children puts additional demands on surgical treatment, including surgeon's experience and technological support, since the motor-evoked potential monitoring is a critical factor for successful surgical outcome.

We revealed some important, yet previously unreported facts. By the time diagnosis is made, children have the more pronounced neurological deficit, the more extensive tumor and the worse functional status. The reason is not so much the nature of pediatric tumors (there is no evident difference in the ratio between malignant and benign tumors in adults and children) but the lack of attention from parents and physicians to the first non-specific symptoms, such as pain, dysesthesia and scoliosis. That is the only reasonable explanation of the fact that tumors in children are twice as more extensive as in adults by the time of MRI diagnosis and that patients have more pronounced neurological symptoms. The correlation analysis demonstrated an evident correlation between the tumor length and the preoperative functional status. Obviously, late diagnosis is a problem in the pediatric subgroup, since MRI is often postponed until there is the full-scale clinical presentation of spinal cord disorder. Adults have the opposite tendency. Along with the high incidence of age-related spinal cord disorders, wide availability of MRI for their diagnosis provides "incidental" or simultaneous detection of IMSCTs and spondylosis during MRI performed to diagnose intervertebral disc herniation.

Conclusion

The revealed differences in epidemiological and clinical characteristics of pediatric and adult IMSCTs confirmed the prevalence of diffuse tumors in children and specified the astrocytoma/ependymoma ratio in different age groups. The analysis of the length and clinical presentation of intramedullary tumors in children indicates that the primary symptoms are ignored by both parents and physicians, resulting in late tumor diagnosis. The broader use of MRI in diagnosis of children with non-specific spinal symptoms, including pain, scoliosis, and forced head position, will undoubtedly improve the current state-of-the-art in diagnostics and the functional outcomes of surgeries.

Authors declare no conflict of interest.

REFERENCES

1. Duong LM, McCarthy BJ, McLendon RE, Dolecek TA, Kruchko C, Douglas LL, et al. Descriptive epidemiology of malignant and nonmalignant primary spinal cord, spinal meninges, and cauda equina tumors, United States, 2004—2007. *Cancer*. 2012;118:4220-4227.
   doi: 10.1002/cncr.27390.
2. Schellinger KA, Propp JM, Villano JL, McCarthy BJ. Descriptive epidemiology of primary spinal cord tumors. *J Neurooncol*. 2008;87:173-179.
3. Tihan T, Chi JH, McCormick PC, Ames CP, Parsa AT. Pathologic and epidemiologic findings of intramedullary spinal cord tumors. *Neurosurg Clin N Am*. 2006;17:7-11.
   doi: 10.1016/j.nec.2005.11.002.
4. Guss ZD, Moningi S, Jallo GI, Cohen KJ, Wharam MD, Terezakis SA. Management of pediatric spinal cord astrocytomas: outcomes with adjuvant radiation. *Int J Radiat Oncol Biol Phys*. 2013;85:1307-1311.
   doi: 10.1016/j.ijrobp.2012.11.022.
5. McCormick PC, Torres R, Post KD, Stein BM. Intramedullary ependymoma of the spinal cord. *J Neurosurg*. 1990;72:523-532.
   doi: 10.3171/jns.1990.72.4.0523.
6. Houten JK, Cooper PR. Spinal cord astrocytomas: presentation, management and outcome. *J Neurooncol*. 2000;47:219-224.
7. Epstein FJ, Farmer JP, Freed D. Adult intramedullary astrocytomas of the spinal cord. *J Neurosurg*. 1992;77:355-359.
   doi: 10.3171/jns.1992.77.3.0355.
8. Hoshimaru M, Koyama T, Hashimoto N, Kikuchi H. Results of microsurgical treatment for intramedullary spinal cord ependymomas: analysis of 36 cases. *Neurosurgery*. 1999;44:264-269.
   doi: 10.1097/00006123-199902000-00012.
9. Jallo GI, Freed D, Epstein F. Intramedullary spinal cord tumors in children. *Childs Nerv Syst*. 2003;19:641-649.
   doi: 10.1007/s00381-003-0820-3.
10. McCormick PC, Stein BM. Intramedullary tumors in adults. *Neurosurg Clin N Am*. 1990;1:609-630.

Commentary

In this work, the authors analyze their own data on the regularities in formation and clinical manifestation of intramedullary tumors in pediatric and adult groups. It is important to note that combining the adult and pediatric groups seems to be not quite justified due to the features in the clinical course of the intramedullary process and histological specificity inherent to different age groups. At the same time, the largest studies on spinal cavernous angioma (over 600 patients operated on at the same center) consolidated patients aged 2—80 years (J. Badhiwala. *J Neurosurg Spine*. 2014 Oct;21.4). The authors' statement about the high evidence level of expert's opinion is also in contradiction to the generally accepted view, since it is expert's opinion that lies at the foundation of the evidence pyramid as opposed to the cohort, representative, multicenter and other evidence-based studies that have the highest level of systematic literature reviews (Haynes et al. *BMJ*. 2006). Of course, the unique experience of the Burdenko Neurosurgical Institute on epidemiology of intramedullary tumors, which are not an orphan disease and have been widely analyzed in literature, requires a comprehensive analysis. Results of these investigations can be comparable to the conclusions drawn by the authors.

The ratio between the histological types of tumors in the pediatric subgroup is quite unconventional. The data of most researchers (A. Menezes et al.) attest to a slight predominance of astrocytic tumors, whereas the authors' series of pediatric tumors predominantly contains infiltrating tumors. Piloid astrocytoma is traditionally the most common tumor type in pediatric population and is followed far behind by fibrillar astrocytomas. In general, as authors fairly noted, the epidemiology of pediatric tumors reveals some unexpected facts, for example, concerning the significant length of intramedullary tumors in children and the degree of disease manifestation according to the McCormick scale. Taking into account the significant predominance of infiltrating tumors, prognosis of total resection of these tumors, as well as the chances of successful functional outcomes are limited.

As a whole, this work provides a representative analysis of cumulative data with justification of age-related, histopathological, anatomical and morphological proliferation of intramedullary tumors in children and adults. The authors' conclusions about the reasons of late tumor diagnosis and surgical treatment in pediatric group and the possible ways to overcome this problem are definitely of great interest. Correlation data analysis of tumor length, the functional outcomes of surgical treatment and technical features of the performed operations may probably be used for future research on this subject.

A.O. Gushcha (Moscow, Russia)