Spinal cord tumors in the pediatric population: Diagnosis and management.

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DECLARATIONS

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INTRODUCTION

The occurrence of an intradural spinal cord tumor, wether intra or extramedullary, may affect survival, motor and sensitive development, and spinal stability[1]. The pathological type, the progression-free survival, the spinal deformations, and the rate of recurrence are totally different than in an adult population [2, 3]. Indeed, some tumors may develop from embryonal cells, genetic features are more likely to influence such occurrence, and specific epidemiological considerations must be considered.

Since the patients will grow up, the spine is still evolving, and therapeutic techniques (surgical resection, radiotherapy, chemotherapy) must be adapted. The influence of the surgery on the grow-up, the tolerance of each treatment is different, such as the radiotherapy in the first decade which is usually prohibited.

Then, the post-therapeutic evolution being different, the follow-up needs to be continued even after the tumor control. Indeed, any treatment might influence the grow-up by changing the hormonal status, the neurocognitive development by the radiotherapy, the spinal deformations by the laminectomy, the neurological abilities as walking, sphincter disorders.

We aim to detail the specific considerations of the spinal cord tumor management in the pediatric population, from the suspicion, the diagnosis, to the management and the follow-up.

EPIDEMIOLOGY

Intramedullary spinal cord tumors are a rare cause of neurological deficit in the pediatric population. No exhaustive study describes this incidence, but most of the published series describe less than one hundred patients, and rarely children[3–9]. Indeed, this location is a very small part of the CNS tumors, since it concerns around 5% of all the CNS tumors, both in adult and pediatric population, mostly low-grade gliomas as astrocytomas, and ependymomas, followed by gangliogliomas. Other types of tumors might be diagnosed as other gliomas (including glioblastoma, atypical teratoid/rhabdoid tumor, germinoma) [10–15]. Considering all these pathological types, such tumors concern less than 1/100,000 child/year, including intradural intramedullary and extramedullary spinal tumors[16]. No reported data are available about the incidence of specifically intramedullary spinal tumors in the pediatric population, probably due to their rarity.

Considering the children, from 0 to 19, most of the intramedullary tumors occur in the first decade, with a mean age between 6 and 11[4, 7, 17]. This age highly depends on the histopathogical features of the tumor, since astrocytomas are diagnosed in a younger population than ependymomas (respective mean ages

5 and 12)[18]. Despite the recent advances, from the first clinical symptoms, to the diagnosis, the mean delay remains between 3 to 6 months [3, 4].

At the time of diagnosis, patients are most often complaining at least of spinal pain, and mostly motor or sensitive dysfunction[3, 19]. Since the growth of this population is generally not complete, the occurrence of an intramedullary tumor can cause a delay in neurodevelopment as walking acquisition, or a spinal deformity, before or after the surgical resection[14, 20, 21].

CLINICAL FEATURES

To diagnose a spinal cord tumor in the pediatric population, practicians must be aware of some special considerations in the clinical presentation. Most of the patients, at the diagnosis, are presenting at least a sensitive deficit and/or a spinal pain[15, 19, 22]. Practicians must be aware of such presentation, because, in this specific pediatric population, pain may be expressed through an analgesic attitude as a torticollis, or other spinal pain-related attitude. Walking disabilities, or motor regression under the age of 3, is observed for one third of the patients [3, 15, 19].

Spinal pain is a common presenting complaint, not systematically related to an underlying intramedullary lesion, especially in athletic adolescents. Then, pediatric practicians must be aware of some red flags which must lead to a spinal imaging, including X-rays et MRI, as spinal deformation, nocturnal pain, any neurological disorder, pain longer than 4 weeks[23]. As an example, a quarter of the patients managed for a spinal intramedullary tumor before the age of 3 are presenting a progressive neurogenic scoliosis[22]. Such deformation may be the first symptom of an intramedullary spinal cord tumor and must systematically lead to perform further radiological exams including MR imaging[22, 24].

RADIOLOGICAL FEATURES

When an intramedullary tumor is diagnosed, whether clinically or radiologically, the initial diagnostic must be enforced by an MRI imaging, and full spine X-rays. The whole central nervous system (CNS) must be screened before any surgical consideration. Indeed, some intramedullary tumors may be disseminated or presenting a second location, justifying a whole CNS exploration [25, 26].

The tumors are mostly located in the cervical spinal cord (44%), then in the conus (31%) and in the thoracic (25%) [6, 27–29].

Usually, the diagnosis is performed with classical T1-weighted without and with gadolinium-enhancing and T2-weight MR sequences. The first step is to define the intramedullary characteristic of the tumor. The cord is expanded by the tumor, while an extramedullary tumor pushes it back. Then, the characteristics of the tumor, defining the location, the size, the number of levels, and the MR criteria, help to plan the most adapted management.

Pilocytic Astrocytomas
Intramedullary pilocytic astrocytomas are mostly iso or hypointense on T1-weighted imaging, hyperintense on T2, and mostly enhancing on contrast-enhanced T1-weighted imaging[30]. The boundaries are not always clearly defined, with or without intratumoral cysts. The median size from the top to bottom is usually less than 60 mm[29, 30].

Ependymomas
Ependymomas arise from ependymal cells in the central canal. Their growing is usually slow, explaining the huge size of such tumors at the time of diagnosis. The second reason is probably the adaptability of the CNS of such patients [31]. The margins are usually well-defined, with a hemosidering ring on the bottom or the superior limit, including intratumoral cysts, with or without gadolinium-enhancing[3].

Other Pathological Types
Hemangioblastomas are mostly part of a syndromic von Hippel-Lindau disease. Their margins are well defined, with unique cyst and a small part enhanced on contrast-enhanced T1-weighted imaging on the periphery of the spinal cord, under the pia[32]. Some other gliomas subtypes tumors, as glioblastomas, anaplasic astrocytomas, or spinal cavernomas are very rare. The gliomas' margins are usually less defined, and diagnosis is hardly preoperatively defined.

Spinal Deformity
One of the most important differences between adult and pediatric patients about intramedullary spinal cord tumors, is the occurrence of spinal deformity. Such consequence of intramedullary tumor is almost only diagnosed in this population[33]. Then, we consider mandatory to perform at least a spinal radiographic analysis through at least conventional X-rays in standing up position, or when available, biplanar whole-spine X-rays.

MANAGEMENT

Firstly, every patient needs to be assessed by a pluridisciplinary team including pediatric neurosurgeons, radiotherapist, pediatric oncologist, and pediatricians. After initial diagnosis, IMSCTs management depends on several factors. Since gait impairment, spinal pain, or sensitive deficit are the most frequent presenting symptoms, aggressive management including surgical resection is usually recommended. However, some incidental spinal cord tumors may be discovered without any symptom. It is then recommended to treat such tumors only if they expand or when new onset symptoms appear. Such incidental tumors are mostly diagnosed in patients with genetic syndromes such as neurofibromatosis,

schwannomatosis, or Von-Hippel-Lindau syndrome. [34, 35]

Surgical Resection
When aggressive treatment is decided, the surgical resection is firstly considered. However, when the resection is not completely performed, pathological findings, neurological postoperative status, and age of the child are the key elements to decide wether a second surgical resection must be considered, or radiotherapy, or close follow-up.

For the most frequent tumors, as pilocytic astrocytomas, or ependymomas, complete resection is the most important predicting factor for progression-free and overall survival[8, 9, 27, 36]. Moreover, pediatric patients present a lower morbidity and mortality for this type of surgery. Then, growth-total resection must be aimed as much as possible[37]. When the complete resection is impossible, or for some other tumors, a close follow-up may be sufficient[38, 39].

Adjuvant Radiotherapy
Radiotherapy is usually considered when a residual tumor is growing and second surgical resection is considered impossible, when the disease is disseminating such as some ependymomas or high-grade gliomas. However, the benefit of radiotherapy on intramedullary spinal cord tumors is not clearly defined[38, 40, 41]. Moreover, postoperative medullar radiotherapy is associated with high risk of secondary malignancy, myelitis, and spinal deformation[42–44]. This explains why this treatment is reserved only for tumors which cannot be controlled by surgical resection, even if repeated surgeries are necessary.

Adjuvant Chemotherapy
In 2024, adjuvant chemotherapy are only introduced in high-grade intramedullary tumors, as high-grade gliomas, or some unresectable tumors as some low-grade recurrent intramedullary spinal gliomas[45–47]. About ependymomas, no significant benefit has been described of any know chemotherapy.

Follow-up
Even if children present more frequently low-grade tumors, the risk of recurrence remains high. Then, a close clinical and radiological follow-up is needed. Indeed, ependymomas are at risk of neural dissemination after several years after diagnosis, especially when a subtotal resection has been performed[36].

Moreover, side-effects of the treatment as postoperative spinal deformation can occur a few years after the surgical resection. Some of pediatric patient will even need a surgical instrumentation to correct this deformity, especially when the spinal cord tumor had been resected in the high cervical cord [20, 21]. This postoperative kyphosis may provoke a neurological deterioration, leading to follow the spinal cord for the risk of tumoral recurrence, but also the sagittal balance with full-spine X-rays, to diagnose soon enough to avoid if possible surgical instrumentation and treat with physiotherapy.

CONCLUSION

Intramedullary spinal cord tumors are rare and hard-to-diagnose diseases. Such tumors may occur in the first decade, and be revealed by pain, gait disturbance, torticolis, or even spinal deformity. Their management usually includes a maximal surgical resection, adapted to the anatomical site, the extent in the spinal cord, age, and neurological status. When a gross-total resection, adjuvant radiotherapy may be considered, with a unclearly defined benefit. Gross-total resection, and whatever the pathological findings are, the follow-up must be close, to notice any tumoral recurrence, or post therapeutic side effects as spinal kyphosis. Then, the management of these children must include oncological pediatricians, neurosurgeons, radiologists, and sometimes radiotherapist.

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