MYXOPAPILLARY EPENDYMOMA OF THE SPINAL CORD IN ADULTS: A REPORT OF PERSONAL SERIES AND REVIEW OF LITERATURE

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SUMMARY – Myxopapillary ependymomas (MPE) of the spinal cord are slow-growing benign tumors most frequently found in adults between 30 and 50 years of age. They arise from the ependyma of the filum terminale and are located in the area of the medullary conus and cauda. The recommended treatment option is gross total resection, while patients undergoing subtotal resection usually require radiotherapy. Complete resection without capsular violation can be curative and is often accomplished by simple resection of the filum above and below the tumor mass. Nevertheless, dissemination and distant treatment failure may occur in approximately 30% of the cases. In this paper, we propose an original MPE classification, which is based upon our personal series report concerned with tumor location and its correlation with the extent of resection. We also provide literature review, discussing surgical technique, tumor recurrence rate and dissemination, and adjuvant treatment. In conclusion, our findings suggest that MPE management based on the proposed 5-type tumor classification is favorable when total surgical resection is performed in carefully selected patients. Yet, further studies on a much broader model is obligatory to confirm this.

Key words: *Myxopapillary ependymoma; Gross total resection; Surgical technique; Tumor classification*

Introduction

Spinal cord myxopapillary ependymoma (MPE) derives from the filum terminale[1], representing the most common tumor of the medullary conus and ac-

counts for nearly 13% of all ependymomas[2-4]. According to the World Health Organization (WHO) classification[5,6], MPE is a slow-growing grade I tumor, which is most often found in adults aged 30-50 years[7]. Although such a tumor is mainly situated in the lumbar spine just below the medullary conus, it may also spread to the thoracic spine, and sacrum[8]. Some of these tumors may become aggressive in spite of their benign histopathology, and they may metastasize
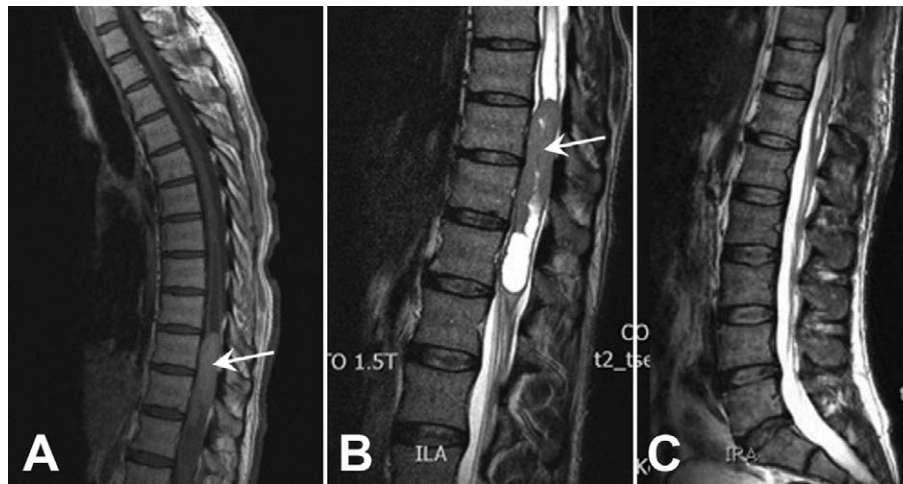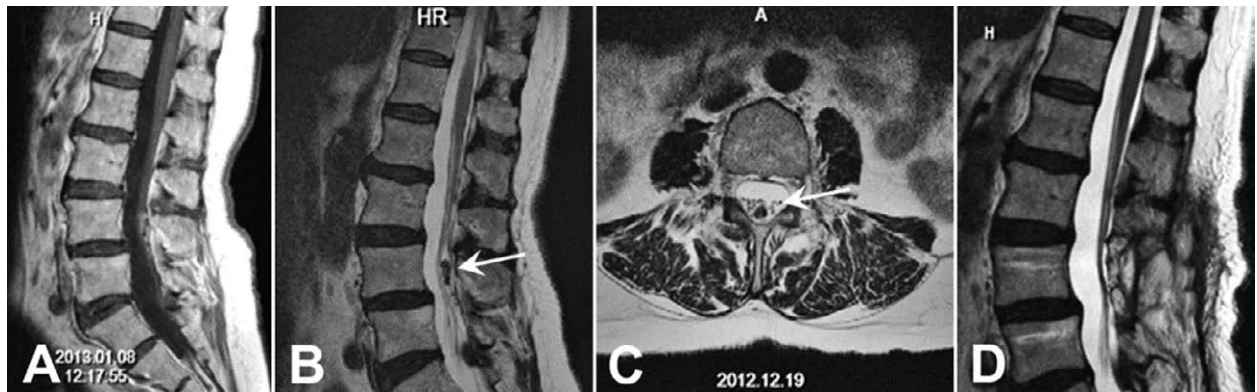
Fig. 1. Preoperative sagittal post-contrast T1-weighted MRI of the spine showing a cystic contrast-enhancing tumor at medullary conus (L1–2) level (arrow) with syringomyelia at T10–12 level (a) and sagittal T2-weighted MRI visualizing the cyst and syringomyelia (arrow) better (b). Postoperative sagittal T2-weighted MRI revealing complete tumor resection with syringomyelia resolution (c).

Fig. 2. Preoperative sagittal T2-weighted spinal MRI revealing spinal cord cystic tumor with intratumoral hemorrhage at L1-L3 level (arrow), and subdural hematoma at S1 level (asterisk) (a). Axial T2-weighted MRI demonstrating the tumor cyst of the vertebral canal ventral part at L1 level (arrow) (b) and subdural hematoma of the dorsal part of the canal at S1 level (asterisk) (c). Postoperative sagittal T2-weighted MRI confirming complete tumor resection, hematoma evacuation, and spinal T12-L3 stabilization (d,e).

along the neural axis to distant cranial and spinal locations, or to local spots after surgery[1,9]. Therefore, gross total tumor resection, accompanied by intraoperative neuromonitoring, remains the best surgical management option available[9-11], while patients undergoing partial (subtotal) resection typically require adjuvant high-dose radiotherapy[12,13]. Complete tumor removal without iatrogenic capsular damage followed by simple resection of the filum above and below the tumor mass is always beneficial, but it may be difficult to ac-

Fig. 3. Preoperative sagittal contrast-enhanced T1-weighted spinal MRI demonstrating an intradural-extramedullary tumor mass at L4 level (a) confined to filum terminale and adherent to the nerve roots (a). Preoperative T2-weighted sagittal (arrow) (b) and axial (arrow) MRI scans (c) visualizing the tumor confined to the filum terminale and adherent to the nerve roots. Postoperative sagittal T2-weighted MRI showing gross total tumor resection (d).

complish. When rupture of the tumor capsule occurs during surgery, brain and whole spine adjuvant radiotherapy is suggested to prevent local recurrence and cerebrospinal fluid (CSF) dissemination[14]. Preservation of sacrococcygeal nerve roots is vital to diminish the incidence of postoperative urinary dysfunction[15]. Nevertheless, neural axis dissemination, distant treatment failure, and tumor relapse may occur in one-third of patients[13].

Herein, we present a 7-case personal series report and propose an original anatomical and surgical MPE classification grounded on tumor location and its correlation with the extent of resection[16]. We also provide a literature review, discussing surgical technique, tumor recurrence rate and dissemination, and adjuvant treatment.

Case Series Report

Case 1

A 45-year-old female was admitted to the hospital due to minor lower-limb motor weakness and urinary retention. A cystic contrast-enhancing tumor at L1-2 level (arrow) with syringomyelia at T10-12 level was identified on preoperative sagittal post-contrast T1-weighted spinal magnetic resonance imaging (MRI) (Fig. 1a). The cyst and syringomyelia (arrow) were well visualized on sagittal T2-weighted MRI (Fig. 1b). According to our classification, the tumor was determined to be type IV B MPE (involving the entire

medullary conus with cystic compartment and signs of syringomyelia in the upper part of the cord). Postoperative sagittal T2-weighted MRI of the spine revealed complete tumor resection with syringomyelia resolution (Fig. 1c) resulting in full neurological recovery.

Case 2

A 43-year-old female presented with acute urinary retention and initial paraparesis. A spinal cord cystic tumor with intratumoral hemorrhage at L1-L3 level (arrow), and subdural hematoma at S1 level (asterisk) were visualized on sagittal T2-weighted MRI of the lumbar spine (Fig. 2a). Axial T2-weighted MRI demonstrated tumor cyst of the vertebral canal ventral part at L1 level (arrow) (Fig. 2b), and subdural hematoma of the dorsal part of the canal at S1 level (asterisk) (Fig. 2c). The tumor was also classified as type IV B MPE (involving the entire medullary conus with cystic compartment hemorrhage). Complete tumor resection, hematoma evacuation, and spinal T12-L3 stabilization with transpedicular screws and rods were accomplished successfully, which was confirmed by postoperative sagittal T2-weighted MRI (Fig. 2d,e) and resulted in full patient recovery.

Case 3

A 72-year-old female complained of low back and bilateral leg pain without any neurological deficit. Preoperative sagittal contrast-enhanced T1-weighted spinal MRI demonstrated an intradural-extramedullary
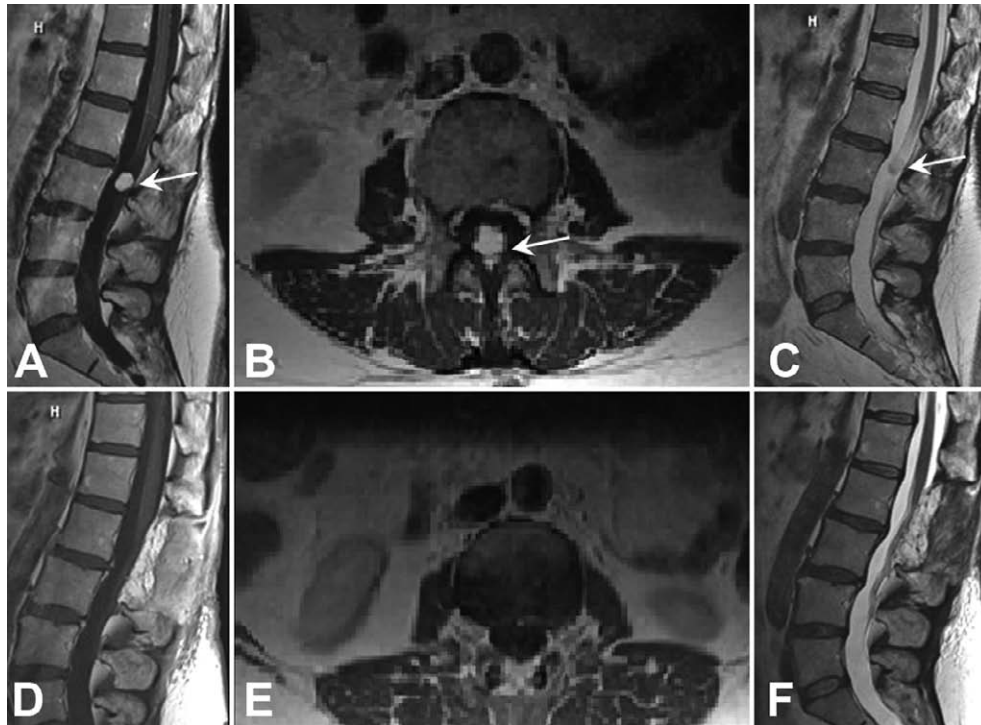
Fig. 4. Preoperative sagittal post-contrast T1-weighted MRI of the lumbar spine showing an enhancing solid tumor at L3 level with engrossment of filum terminale and cauda equina (a), also shown on post-contrast axial T1-weighted (b) and sagittal T2-weighted MRI (c) (arrows). Postoperative post-contrast T1-weighted sagittal (d), axial (e) and sagittal T2-weighted MRI (f) confirming total tumor resection.

tumor mass at L4 level (Fig. 3a). The tumor, which was confined to the filum terminale and adherent to the nerve roots, was also visible on preoperative T2-weighted sagittal (arrow) (Fig. 3b) and axial (arrow) (Fig. 3c) MRI scans. The tumor was classified as type I B MPE (extramedullary conus with lumbar nerve root and filum involvement). Postoperative sagittal T2-weighted MRI demonstrated gross total tumor resection (Fig. 3d). The patient reported no low back and leg pain following surgery.

Case 4

A 56-year-old female presented with low back pain, lower limb numbness, and voiding difficulties. Preoperative sagittal post-contrast T1-weighted MRI of the lumbar spine showed an enhancing solid tumor at L3 level affecting filum terminale and cauda equina (Fig. 4a), which was also shown on post-contrast axial T1-weighted (Fig. 4b) and sagittal T2-weighted (Fig.

4c) MRI scans (arrows). The tumor was classified as type I B MPE (extramedullary conus with lumbar nerve root and filum involvement). Postoperative post-contrast T1-weighted sagittal (Fig. 4d), axial (Fig. 4e), as well as sagittal T2-weighted MRI (Fig. 4f) demonstrated total tumor resection resulting in complete neurological recovery.

Case 5

A 47-year-old female presented with paraparesis, L2 level sensory loss, and bowel incontinence. Preoperative post-contrast sagittal T2-weighted (Fig. 5a) and T1-weighted (Fig. 5b) lumbar spine MRI demonstrated a solid tumor mass at L3 level (arrows). The tumor was classified as type I B MPE (extramedullary conus with lumbar nerve root and filum involvement). Postoperative sagittal T2-weighted MRI confirmed complete tumor resection (Fig. 5c). The patient remained neurologically intact following surgery.
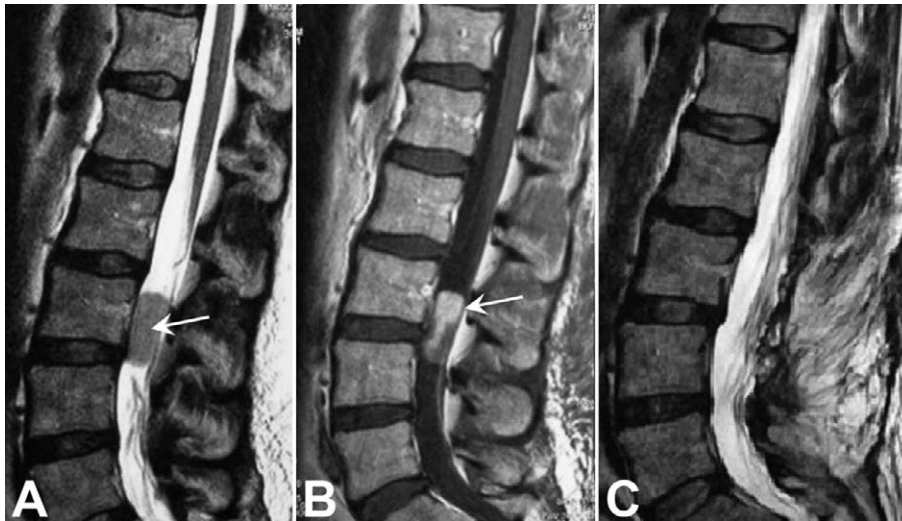
Fig. 5. Preoperative post–contrast sagittal T2–weighted (a) and T1–weighted (b) lumbar spine MRI demonstrating a solid tumor mass at L3 level (arrows). Postoperative sagittal T2–weighted MRI confirming complete tumor resection (c).
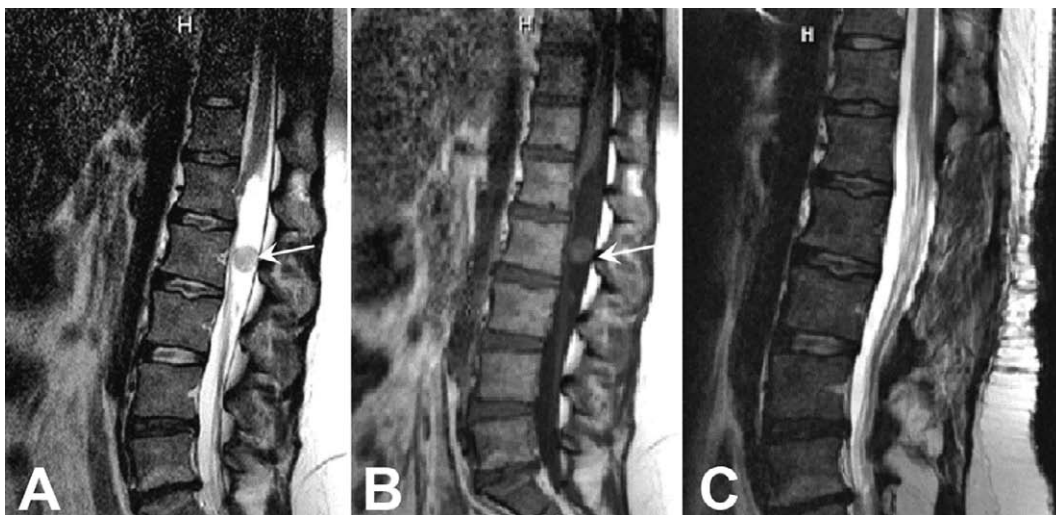
Fig. 6. Preoperative post–contrast sagittal T2–weigted (a) and T1–weighted (b) lumbar MRI revealing a large cystic tumor at L2 level with hydromyelia and involvement of medullary conus. Postoperative sagittal T2–weighted MRI confirming complete tumor resection with cyst drainage and hydromyelia resolution (c).

Case 6

A 35-year-old male presented with severe low back pain and urinary retention. Preoperative post-contrast sagittal T2-weigted (Fig. 6a) and T1-weighted (Fig. 6b) lumbar MRI demonstrated a large cystic tumor at L2 level with hydromyelia and involvement of the medullary conus. The tumor was classified as type IV B MPE (involving the entire medullary conus with cystic compartment and signs of hydromyelia in the upper part of the cord). Postoperative sagittal T2-weighted MRI showed complete tumor resection with cyst drainage and hydromyelia resolution (Fig. 6c). Following surgery, the patient reported no urinary retention or other neurological deficit.

Fig. 7. Preoperative post-contrast sagittal T2-weighted MRI of the lumbar spine demonstrating a large cystic tumor at L1-L2 level with involvement of medullary conus and filum terminale (asterisk) (a). Sagittal T1-weighted MRI revealing two additional lesions at L3 level, and S1 segment as the site of primary seeding (arrows) (b). Axial post-contrast T1-weighted MRI depicting separate tumors at L1 (c) and L3 levels (d) (arrows). Postoperative sagittal T2-weighted (e) and post-contrast T1-weighted MRI (f) confirming total resection of all the three tumors.

Case 7

A 33-year-old male presented with sudden urinary retention and no other symptoms or neurological impairment. Preoperative post-contrast sagittal T2-weighted MRI of the lumbar spine showed a large cystic tumor at L1-L2 level with involvement of the medullary conus and filum terminale (asterisk) (Fig. 7a), while T1-weighted MRI revealed two additional lesions at L3 level, and S1 segment, which was the site of primary seeding (arrows) (Fig. 7b). Axial post-contrast T1-weighted MRI confirmed the separate tumors at L1 (Fig. 7c) and L3 levels (Fig. 7d) (arrows). The tumor was classified as type IV B MPE (involving the entire medullary conus with cystic compartment). Postoperative sagittal T2-weighted (Fig. 7e) and post-contrast T1-weighted MRI (Fig. 7f) confirmed total resection of all the three tumors. Following surgery, urinary retention resolved entirely, and the patient recovered completely. Further MRI screenings excluded secondary seeding.

Discussion

We have proposed an original 5-type MPE classification based on tumor location and its correlation with the extent of resection[16] (Table 1, Fig. 8). Accordingly, extramedullary intradural MPEs incorporating filum terminale only represent type I A, where gross total resection is achievable easily. Type I B stands for extramedullary conus tumors involving lumbar nerve roots together with filum terminale, which are surgically more challenging. Type II represents intramedullary MPEs where conus and filum terminale are involved that could be easily treated by gross total resection. Type III encompasses intramedullary MPEs involving the lower spinal cord, medullary conus and filum, causing the upper lumbar cord enlargement. Type IV A stands for solid or cystic MPEs involving the lower spinal cord, while type IV B represents the entire medullary conus involvement with MPE having a cystic component, and signs of hydromyelia/syringomyelia upon the tumor site, where gross or subtotal resection are management options. Tumors located

Table 1. Classification of spinal cord myxopapillary ependymoma

| Type I A	Filum terminale only
Type I B	Extramedullary conus with lumbar nerve root and filum
Type II	Intramedullary conus and filum terminale
Type III	Upper lumbar cord enlargement
Type IV A	Lower part of spinal cord and medullary conus with solid and cystic component
Type IV B	Entire medullary conus with cystic compartment and signs of hydromyelia/ syringomyelia in the cord upper part
Type V A	Outside the lumbar cord (cervical/thoracic spine)
Type V B	Outside the vertebral canal (intracranial, sacrococcygeal)
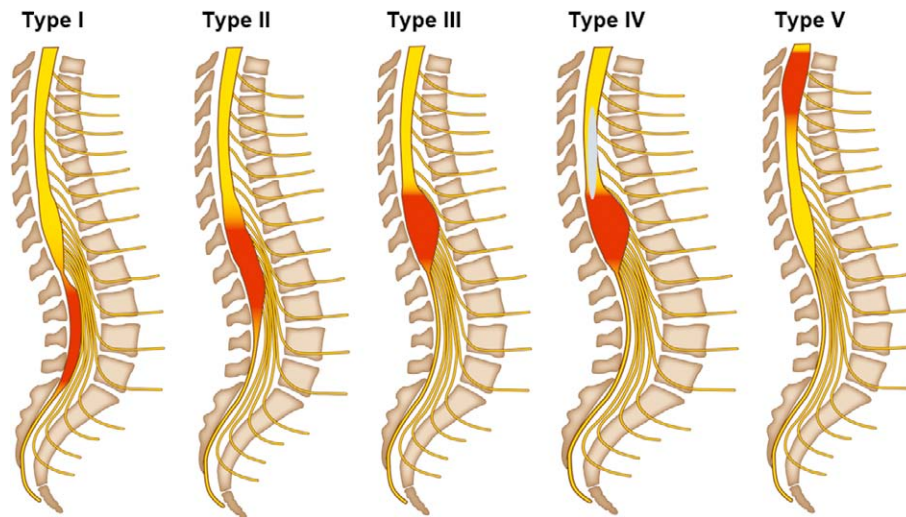
Fig. 8. Schematic drawing of 5-type spinal cord MPE classification.

outside the lumbar cord, but still within the vertebral canal along the thoracic and/or cervical spine represent type V A MPE, whereas those located outside the vertebral canal epitomize type V B MPEs that may be situated at intracranial or sacrococcygeal regions.

Reviewing the literature, we found that the mean patient age at the time of tumor symptomatic occurrence was 36.44 years, and that medullary conus was involved in 28.4% of cases[17], which was less consistent with our results where the mean patient age was 47.28 years and the entire medullary conus was involved in four out of seven (57.1%) patients.

Younger age, preoperative functional capacity, lesser initial neurological deficit, tumor location, size and the extent of resection, as well as adjuvant radiotherapy were identified as significant prognostic factors influencing better outcome[8,13,18,19]. All the patients from our series had minor or lesser degree neurological deficit on admission, and total surgical tumor resection was possible in all of them.

Long-term outcome is also correlated to the extent of tumor resection, as well as to the integrity of the tumor capsule[7,20], since larger tumors may perforate the capsule[14], leading to CSF seeding and dissemination[21]. Hence, an association between capsular damage and tumor relapse was found[22]. Still, surgical morbidity is generally low and postoperative clinical improvement is pretty good, while recurrence rate remains scarce when treatment recommendations and protocols are strictly followed by an experienced neurosur-

geon and other medical staff[7,23]. The same happened with the patients from this series where no surgical morbidity and no tumor relapse or dissemination was observed. Accordingly, Klekamp *et al.* report that gross total tumor resection was achieved in 77.7% of their patients[7], while several studies suggest that it must be combined with high-dose radiotherapy in order to improve the outcome[24-26], and to avoid recurrence, as well as primary and secondary seeding, which remains under-recognized in adults[1,27]. Although tumor benign histologic features are commonly preserved in case of dissemination[28], rostral neuro-axial spread mostly affects the thoracic and cervical spine[29,30]. Then, additional resection or irradiation would be endorsed if metastases become symptomatic[30]. There are single case reports describing the benefits of second- and third-line chemotherapy concomitant with radiotherapy after multiple surgeries of recurrent MPE with disseminated metastases[31,32]. However, this was not the case in patients from our series, since all of them recovered well after total tumor resection. Therefore, the need for repeat surgery or adjuvant therapy was not established and no tumor relapse or dissemination was recorded. Nonetheless, one should still remember the possibility of tumor relapse, primary seeding, and drop metastases; one should also consider the entire craniospinal neuroimaging as part of both the preoperative work-up and postoperative follow-up[1]. Therefore, long-term or lifelong MRI surveillance should be advised[1,16], which is also part of our patient protocol.

In conclusion, having in mind the small number of patients in this personal case series, as well as its retrospective design, our findings suggest that MPE management based on the proposed 5-type tumor classification is favorable when total surgical resection is performed in carefully selected patients, which is well-supported by the literature data. Yet, additional studies on a much broader model are obligatory to confirm these results.

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Sažetak

MIKSOPAPILARNI EPENDIMOM KRALJEŽNIČNE MOŽDINE U ODRASLIH:
PRIKAZ OSOBNE SERIJE I PREGLED LITERATURE

I. Omerhodžić, M. Pojskić, K Rotim, B. Splavski, L Rasulić i K. Arnautovic

Miksopapilarni ependimomi (MPE) kralježnične moždine sporo su rastući, dobroćudni tumori najčešće zastupljeni u odraslih u dobi između 30 i 50 godina života. Nastaju iz ependima filuma terminale, a pretežito su smješteni u području medularnoga konusa i kaude. Kirurško uklanjanje tumora u cijelosti preporučena je metoda liječenja, dok u bolesnika u kojih to nije moguće učiniti u obzir dolazi subtotalna resekcija nakon koje je potrebno zračenje. Potpuno uklanjanje tumora uz očuvanje cjelovitosti tumorske kapsule postiže se jednostavnom resekcijom filuma terminale iznad i ispod tumorske mase, što može dovesti do izlječenja. Unatoč tomu, tumorska diseminacija uzduž neuralne osi može se javiti u oko 30% slučajeva. U ovom radu predlažemo originalnu klasifikaciju MPE koja prosuđuje smještaj tumora i obujam tumorske resekcije, a temeljena je na osobnoj seriji operiranih bolesnika. Također raspravljamo o kirurškoj tehnici, o mogućnostima recidiva i širenja ovakvih tumora, kao i o oblicima pomoćnog liječenja, koristeći se pregledom literature. Zaključujemo kako naši rezultati zagovaraju kirurško liječenje temeljeno na predloženoj originalnoj tumorskoj klasifikaciji, koje može biti uspješno u pažljivo odabranih bolesnika u kojih je tumor uklonjen u cijelosti. Naknadna istraživanja na znatno većem uzorku potrebna su za potvrdu naših rezultata.

Ključne riječi: *Miksopapilarni ependimom; Potpuna resekcija tumora; Kirurška tehnika; Klasifikacija tumora*