Asymptomatic lipomas of the medullary conus: surgical treatment versus conservative management

Clinical article

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Object. The goal of this study was to compare long-term results of surgery with the outcomes of conservative treatment in patients with asymptomatic lipomas of the conus medullaris.

Methods. The parents of 56 consecutive children with a diagnosis of asymptomatic lipoma of the conus medullaris underwent detailed neurosurgical consultation. The pros and cons of both prophylactic surgery and conservative treatment were carefully presented. Both options were offered, and the parents were free to choose the preferred management. A total of 32 children underwent surgical treatment, and 24 were conservatively treated. Afterward, all patients entered the same protocol of serial neurological and urological follow-up at the Centro Spina Bifida. The mean follow-up periods were 9.7 years in the surgical treatment group and 10.4 years in the conservative treatment group.

Results. Permanent surgical morbidity was 3.1% (1 patient). During follow-up, tethered cord syndrome occurred in 9.7% of the surgically treated patients (3 of 32 patients) and in 29.1% of the conservatively managed children (7 of 24 patients). This difference did not result in statistical significance, but a clear trend in favor of surgery emerged. Young age at surgery and a cord/sac ratio < 50% appeared to be determining factors in the prevention of subsequent tethered cord syndrome.

Conclusions. The small size of this series does not provide enough statistical evidence that surgical treatment can really improve the natural history of asymptomatic lipomas of the conus medullaris. Nevertheless, surgery appears at least advisable since it reduces by 75% the odds of TCS (p = 0.067), which is quite close to statistical significance. (http://thejns.org/doi/abs/10.3171/2014.5.PEDS13399)

Key Words • conus medullaris • lipoma • natural history • pediatric neurosurgery • spinal dysraphism • tethered cord syndrome • spine

Lipoma of the conus medullaris (LCM) is the most common occult spinal dysraphism. It may be wholly asymptomatic, or symptoms may occur, mainly depending on cord tethering even though other factors such as the compression of neural structures may play a role. The tethered cord syndrome (TCS) consists of an association of neurological deficits in the lower limbs, sphincter disturbances, and orthopedic deformities. The symptoms and the severity may be highly variable, the onset of the syndrome may be insidious, and the course is usually slowly progressive.

The natural risk of LCM is not completely understood, and a lively debate exists about the indications for treatment. There is a relative general consensus that symptomatic patients with LCM require surgical treatment, but there is quite a difference of opinions regarding the best treatment for asymptomatic children. On one hand, some authors have reported that the surgically managed asymptomatic patients would have so high a probability of deterioration during the follow-up that they should be conservatively managed and undergo surgery only in case of deterioration. On the other hand, other authors believe that the risk of spontaneous worsening is so high and that postoperative improvement is so rare in patients who become symptomatic that prophylactic surgery would be the only way to ameliorate the natural history of this disease. Indeed, there is...
no randomized controlled trial, and therefore the question about the indications for surgery in asymptomatic LCM patients remains unanswered.

In the past, we considered all patients with LCM as surgical candidates. However, since 1996, we started to contemplate the nonoperative option. Following a detailed consultation with an experienced neurosurgeon, the parents of our asymptomatic LCM patients were offered 2 options: prophylactic surgery with subsequent follow-up for possible late TCS or a protocol of serial clinical observations and instrumental controls with immediate surgery performed only in case of later deterioration. We report our experience in this paper.

Methods

During the period 1996–2008, a total of 56 pediatric patients with asymptomatic LCM were managed at the Neurosurgical Department of the Niguarda Ca’Granda Hospital of Milan, Italy. Patients who underwent treatment after 2008 were not included to allow for more adequate follow-up studies. In all cases, the diagnosis of LCM was confirmed by MRI of the entire spinal cord. Patients with filar lipomas, strictly subdural lipomas, presacral lipomas, and/or other spinal dysraphisms (split cord malformations), as well as patients with severe neu-ro-orthopedic deformities (such as clubfoot or worsening scoliosis) were not included in this study. None of these patients had previously undergone surgery for removal of the lipoma, even though 2 patients had undergone “esthetic” surgery at other hospitals with only partial removal of the more superficial lesions.

These 56 patients were considered asymptomatic following a protocol of neurological and urological examinations, motor and sensory evoked potentials, and urinary ultrasound. Some patients were also studied using electromyography, bladder manometry, urodynamic studies, and/or urography. Once the assessments were completed, the parents of these patients underwent counseling with the senior author who explained in detail the pros and cons of both surgical and nonsurgical management. Every effort was made to provide neutral and impartial information and to exert no influence. In particular, the parents were informed that international scholars are not in agreement about which treatment is more appropriate and were reassured that accurate follow-up would be planned in either case. Afterward, the parents were completely free to choose between surgical or conservative treatment.

The parents of 32 patients (57.1%) chose surgical treatment, while the parents of the remaining 24 patients (42.9%) opted for conservative treatment.

Surgical Treatment Group

A total of 32 patients underwent surgery (14 males and 18 females, M/F ratio 0.77). Patient age ranged from 1 week to 15 years (mean 1.9 years). Basing on MRI findings, the LCMs were classified according to the modified Chapman’s classification:3,19,21,30 as terminal (4 cases [12.5%]) (Fig. 1), dorsal (6 cases [18.7%]) (Fig. 2), and transitional (22 cases [68.8%]) (Fig. 3). In 4 of the 22 tran-
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Conservative Treatment Group

A total of 24 patients underwent conservative treatment (10 males and 14 females, M/F ratio 0.71). Age ranged from 1 week to 15 years (mean 3.1 years). Based on MRI findings, the LCMs were classified as terminal (2 cases [8.4%]), dorsal (4 cases [16.6%]), and transitional (18 cases [75%]); 4 (16.6%) of the 18 transitional cases presented components of the lipoma ventral to the neural plaque (“chaotic-like” lesions).21

These 24 patients directly entered the aforementioned multidisciplinary follow-up protocol for outpatients at the Center for Spina Bifida. The periodic specialist visits and assessments were practically the same as those of the surgically treated group.

Statistical Analysis

All variables were submitted to descriptive statistics. Cross-tabulation between categorical variables was analyzed using the Fisher’s exact test. The development of TCS was used as a binary end point in univariate logistic regression models. A further bivariate logistic model was considered, taking into account only the significant or near-significant regressors. A propensity analysis was also carried out to verify possible trends in arm allocation. The time-to-event analysis for TCS and the survivals were evaluated using the Cox regression model and the log-rank test. Finally, the Kaplan-Meier curves were drawn, taking into account the patients’ age and considering the development of TCS as the end point.

Results

Surgical Treatment Group

Postoperative Results. There were no deaths in the

![Fig. 2. Initial axial (A) and sagittal (B) T1-weighted MR images showing a dorsal lipoma in a female newborn. Two months later, she was referred to us and was scheduled for surgery. New axial (C) and sagittal (D) T1-weighted images show enlargement of the lipoma. The patient was still asymptomatic, and immediate surgery was chosen. The pathological diagnosis was lipoma without any atypical features. Postoperative axial (E) and sagittal (F) T1-weighted MR images obtained 4 days after surgery, showing the abundant but not total removal of the lipoma. However, a significant amount of CSF is visible between the reconstructed cord and the overlying dura (arrow). The lipoma removal was performed through a laminoplasty with final replacement of the laminar elements (arrowheads). Five years after surgery, this patient was completely asymptomatic.](image-url)
surgical group. Permanent morbidity was reported in 1 patient (3.1%) who experienced postoperative severe motor weakness and sphincter deficit due to the acute development of a syrinx cranial to the operated level (Fig. 5). Four years later, at the last follow-up visit, this patient was able to walk with ankle-foot orthoses, but the sphincter deficit persisted. Transitory morbidity was reported in 2 patients (6.2%) who experienced postoperative urinary retention, which completely resolved within 1 week and 1 month. A total of 5 patients (15.6%) developed subcutaneous CSF collection (4 cases) or CSF leakage (1 case). In all cases, these complications were resolved by conservative measures without any further surgical treatment.

The amount of lipoma excision was evaluated by comparing the postoperative MR images with the preoperative images. In 19 cases (59.4%), the residual lipoma was less than 10%, and its removal was considered subtotal (Figs. 1, 3, and 5). In 12 cases (37.5%), the residual lipoma ranged from 10% to 30%, which indicated a partial removal (Figs. 2 and 4). In 1 case (3.1%), the remnant was about 40%, and the removal was defined as limited. The cord/sac ratio was less than 50% in 27 patients (84.3%) (Figs. 1, 3, and 5), whereas it was greater than 50% in the remaining 5 patients (15.6%).

**Long-Term Results.** One patient was lost to follow-up. The remaining 31 patients are still undergoing follow-up as outpatients. At the time of article preparation, follow-up ranged from 4 to 16 years (mean 9.7 years). During this period, 28 patients (90.3%) had a smooth postoperative course and did not present with any symptoms or signs of TCS. However, 2 of these patients experienced some bouts of urinary tract infections that always resolved using antibiotic therapy and that appeared quite unrelated to clear sphincter dysfunctions. In both cases, the neurological state and the urodynamic studies remained unaffected.

A total of 3 patients (9.7%) presented with symptoms or signs of TCS. All 3 patients had transitional LCMs (with “chaotic-like” aspects in 2 cases) that could not be subtotally excised. In all cases, the TCS occurred within 2 years of surgery. The first patient was a 9-year-old boy. One year after partial lipoma excision, he experienced progressive gait and sphincter impairments, with fasciculation in the lower limbs and signs of active denervation on electromyography. He underwent detethering of scar adhesions, but, following a transitory improvement, the TCS recurred and he required an additional detethering procedure. Three years after the third operation, he walked with orthoses and required intermittent bladder catheterization, but his clinical situation appeared stable. The second patient was a 6-year-old girl who had undergone limited lipoma excision 18 months earlier (just about half of the lipoma had been removed). On readmission, she presented with urodynamic changes associated with urinary tract infections, mild motor weakness, and progressively worsening scoliosis. Accordingly, scar detethering was performed. Four years later, the patient required intermittent catheterization, but she can walk without orthoses and the scoliosis had stopped progressing. The third patient was a 2-year-old boy whose LCM
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had been partially removed at the age of 3 months. He progressively developed sphincter dysfunction with fatigue on walking. Five years after scar detethering, he required intermittent catheterization and could walk with distal orthoses.

In sum, varying degrees of neuro-/urological disability remained in a total of 4 (12.5%) of 32 patients (1 with surgical morbidity and 3 with TCS), who also required intermittent catheterization.

Conservatively Treated Group

**Long-Term Results.** All 24 patients in the conservative treatment group remained in our outpatient protocol. Follow-up ranged from 4 to 16 years (mean 10.4 years). A total of 17 patients (70.9%) presented with neither neurological nor urological deficits throughout the follow-up. However, 7 patients (29.1%) experienced symptoms and/or signs of TCS. Sphincter disturbances consisting of difficult or urgent micturition, incomplete voiding, and/or urinary infections always associated with constipation were present in all cases, and a combination of hypertensive bladder and vesico-sphincter dyssynergia was always confirmed by the urodynamic studies. Other manifestations were motor impairment with altered walking (5 cases), amyotrophy (3 cases), back and leg pain without radicular distribution (2 cases), pyramidal signs (1 case), initial development of an equino-varus deformity (1 case), and sciatica (1 case). The TCS occurred in 2 dorsal lesions and in 5 transitional lesions (2 cases with “chaotic-like” aspects). When the 7 patients developed the TCS, their age ranged between 5 and 11 years (mean 7.8 years).

**Surgery in Patients Who Experienced Deterioration.** Surgical detethering was offered to all 7 patients who experienced symptoms and/or signs of TCS. In 1 case, the parents opted for surgery at another hospital. The remaining 6 patients underwent surgical treatment with the aforementioned techniques. The lipoma was subtotally excised in 3 cases and was partially removed in the remaining 3 cases.

Surgical morbidity consisted of 1 case of postoperative subcutaneous CSF collection that completely resolved with conservative measures. During the subsequent follow-up (range 1–10 years, mean 5.1 years), 5 patients remained stable, whereas 1 required a second detethering procedure 1 year later. Urinary disturbances remained unchanged in all cases. Regarding motor impairment, some mild improvements were observed only in subjective weakness and pyramidalism; painful symptoms improved in all cases. We learned that the patient who underwent surgery at another hospital had walking difficulties and needed intermittent catheterization 6 years after surgery.

To sum up, varying degrees of impairment remained in a total of 7 (29.1%) of 24 patients with TCS; these patients continued to require intermittent catheterization.

**Statistical Results**

There was no association between the type of lipoma and surgical or conservative treatment (Fisher’s exact test, \( p = 0.975 \)). This result was confirmed even if the LMCs were subdivided into complex (transitional and chaotic) versus simpler (dorsal and terminal) forms (\( p = 0.767 \)). The only actual difference was in the mean age at diagno-
sis, which was significantly younger in the surgical group than in the conservatively treated group (Mann-Whitney U-test, \( p = 0.0441 \)).

In the univariate logistic analysis, the odds of TCS decreased by 75% in the surgical group in comparison with the conservatively treated group (\( p = 0.067 \)). Moreover, in the surgical group, the age at the enrollment was not significantly (\( p = 0.313 \)) correlated with the risks of developing subsequent TCS, but each increase by a month in age meant a 2% increase in the odds of TCS developing (\( p = 0.031 \)) (Tables 1 and 2). The propensity analysis by age trend showed a possible trend favoring surgical intervention in younger subjects (\( p = 0.090 \)).

Although the odds of TCS decreased by 74% in patients undergoing subtotal excision (\( p = 0.098 \)), the overall risks of TCS and an unfavorable outcome were not significantly influenced by the complexity of the lipoma and by the amount of removal. Conversely, the odds of TCS significantly decreased by 91% (\( p = 0.017 \)) when a cord/sac ratio < 50% was achieved (Table 1). However, in the bivariate logistic model, the significance of cord/sac ratio < 50% disappeared when adjusted for the occurrence of TCS; on the contrary, the TCS maintained its significance even when adjusted for the cord/sac ratio.

The cross-tabulations versus unfavorable outcome did not show any association with treatment (surgery or not), with simple or complex forms of lipoma, and with partial or subtotal lipoma removal. Conversely, the results were significantly influenced by the cord/sac ratio: the proportion of patients with favorable outcome was 81.3% when the cord/sac ratio was < 50% versus 33.3%, when the ratio was > 50% (Fisher’s exact test, \( p = 0.031 \)) (Table 2).

The time-to-event analysis for the 10 patients with TCS showed that the total time at risk for the cohort from surgery to TCS was 6340 patient-months, and thus the incidence rate of TCS was 0.0009 per 1 patient-month in the surgical group and 0.0025 in the conservatively treated group (log-rank test, \( p = 0.163 \)) (Table 3). The Kaplan-Meier curves showed no significant differences in the symptom-free time between the 2 groups, even though a trend favoring surgical intervention was evident (Fig. 6).

**Discussion**

**Epidemiology and Natural History**

Asymptomatic LCMs have been reported to have an incidence of 4–8 per 100,000,\(^{26,30}\) but this is probably underestimated; MRI and autopsy studies have reported higher rates of patients reaching adulthood with undiagnosed lesions.\(^{6}\) It is known that the number of asymptomatic patients declines stepwise with age.\(^{4,5,10–12,17}\) However, most of the arguments about the evolution of asymptomatic LCMs are derived by extrapolations from only observed patients and should be considered as merely speculative.\(^{5,6,14,22}\) Perhaps the natural history could be better understood through a randomized clinical trial, but the diversity of expert opinions about treatment makes such a study unlikely.\(^{4}\)

Indeed, the spontaneous evolution of asymptomatic LCMs has been rarely investigated.\(^{3,14,30}\) The most reliable series is that from L'hôpital Necker-Enfants Malades, in Paris,\(^{14,23,24,29,30}\) where 100 asymptomatic patients with LCMs underwent follow-up for 10 years; one-third of these patients experienced deterioration during childhood, and 14% of them presented with irreversible neurological deficits.

Loss of neurological function has been classically ascribed to cord adhesions with progressive conus tethering due to axial growth spurts.\(^{8,12,20,26}\) Nevertheless, Zerah et al.\(^{30}\) hypothesized that such adhesions could represent only an additional contributing factor while the major role in deterioration would be played by the underlying myelo-dysplasia. This hypothesis has been criticized by Pang et al.\(^{22}\) because it would not explain the worse results reported in patients with incomplete surgical removal and inadequate untethering.\(^{3,24}\)

**Indications for Treatment**

There is general consensus for performing surgery when symptoms occur,\(^{26}\) because further deterioration is considered unavoidable.\(^{22}\) Deterioration usually occurs quite slowly,\(^{7,8,29,30}\) which means that a conservative protocol management with careful and close controls should be theoretically adequate to warrant prompt surgery only when this is really needed. However, the slow pace of worsening, the absence of pain, the paucisymptomatic initial motor impairment, and the difficulties in recognizing a clear incontinence may lead to delayed diagnosis and treatment.\(^{7}\) Moreover, it has been reported that neuropathic bladder and sensorimotor deficits rarely recover even after surgery.\(^{8,11,15,17,18,22,24}\) In our series, the odds of unfavorable outcomes were heavily affected by the occurrence of TCS, which was the most significant determinant of bad results. Namely, if TCS occurred, unfavorable results were invariably reported. Advocates of prophylactic surgery recommend it in all cases because of the rel-

<table>
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<td>0.013–0.649</td>
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Intraoperative monitoring is important but should be not overemphasized. We agree with those authors who think that the amount of removed lipoma with the aid of modern techniques well described by others. We never attempt- ed a really radical removal, but, in all cases, we tried to remove as much of the lipoma as possible by extending the excision as close as possible to the neural plaque. We did not observe any case of subsequent TCS in patients with subtotal removal (at least 90%), but we did not find a statistically significant influence of the amount of fat removal on the risk of TCS, and all surgical morbidities occurred in these patients. Accordingly, the risk/benefit ratio of extended excisions must be carefully weighed. In our practice, we were not able to see a clear influence on the amount of removed lipoma with the aid of modern monitoring. We agree with those authors who think that intraoperative monitoring is important but should be not overemphasized.

In general, surgical treatment should cause as little tethering scar as possible. Generous lipoma removal, neural tube reconstruction, and dural sac widening aim to create a large CSF space well around the reconstructed neural tube thus limiting cord-dural adhesions. It has been calculated that greater the cord/sac ratio, the higher the probability of TCS. We never seen TCS when the cord was well surrounded by the sac. Undoubtedly, this was sometimes indispensable, but when we felt confident that there was enough space to provide a well-bathed cord, we preferred to perform direct dural repair (Fig. 3). In fact, all cases of CSF leaks or CSF collections occurred when we used a dural graft.

It has been calculated that greater the cord/sac ratio, the higher the probability of TCS. All our patients with postoperative TCS had high cord/sac ratios, and we have never seen TCS when the cord was well surrounded by the CSF (Fig. 4). In the univariate logistic analysis, a cord/sac ratio < 50% was statistically significant in reducing the risk of TCS. However, the TCS is such an important factor in determining bad outcome that, in the bivariate analysis, a cord/sac ratio < 50% was unable to prevent unfavorable outcomes in cases of TCS. In other words, this ratio could reduce the risk of TCS but could not prevent permanent neurological impairment, should TCS occur.

**Surgical Techniques**

Classic surgical treatment of LCMs consists of partial removal to minimize the risk of neurological damage. However, it has been reported that partial resection would trigger more scar formation and would expose the cord to a higher risk of retethering. Recently, Pang et al. described a technique to accomplish total/near-total resection with very low morbidity. Removal of the lipoma may be relatively easy in purely dorsal and terminal forms, but it may be quite difficult in transitional and chaotic LCMs, when the demarcation between fat and neural tissue may be quite variable and unpredictable and the neural plaque is rotated with asymmetrical roots.

In the present series, we used classic surgical techniques well described by others. We attempted a really radical removal, but, in all cases, we tried to remove as much of the lipoma as possible by extending the excision as close as possible to the neural plaque. We did not observe any case of subsequent TCS in patients with subtotal removal (at least 90%), but we did not find a statistically significant influence of the amount of fat removal on the risk of TCS, and all surgical morbidities occurred in these patients. Accordingly, the risk/benefit ratio of extended excisions must be carefully weighed. In our practice, we were not able to see a clear influence on the amount of removed lipoma with the aid of modern monitoring. We agree with those authors who think that intraoperative monitoring is important but should be not overemphasized.

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**Operative Complications**

Postoperative transitory urinary and/or motor deficits have been reported in about 6% of patients, with high chances of complete clinical and instrumental regression within 6 weeks. Minor local complications (including wound breakdown and CSF leakage) usually do not contribute to long-term or permanent morbidity but may affect up to 25% of cases and may be responsible of 3% of reoperations.

In our series, the rates of overall neurological and urological morbidity and local complications were negligible, but permanent morbidity remained only in 1 patient (3%). In this regard, we do not believe that the development of a postoperative acute cord cyst (Fig. 5)
was a consequence of the maneuvers of neurulation. Since this patient was the only one to be managed using a laser beam, we wonder whether the laser energy could have played a role. Regardless, different opinions exist regarding the usefulness of laser in lipoma surgery.\textsuperscript{17,18,21,22}

**Long-Term Results**

Postoperative TCS generally occurs 3–8 years after the initial surgery, and its rate is undoubtedly related to the length of the follow-up.\textsuperscript{1,5,6,8,10,12,26} A higher risk of postoperative TCS has been reported in transitional lipomas,\textsuperscript{8} while young age at surgery would be a good prognostic factor according to some authors,\textsuperscript{22} but it has not been confirmed by others.\textsuperscript{20} In our material, we found no statistically significant difference in the risk of TCS between different types of LCM, whereas a trend favoring surgery in younger patients was suggested by a nearly statistical significance (p = 0.074). Each month that surgery was delayed appeared to correlate to a small increment of the odds of TCS, and thus we can hypothesize that earlier operations could decrease the risk of TCS.

In 1997, the Parisian authors\textsuperscript{24,30} found that one-half of their patients experienced neurological deterioration within 5 years of surgery. Accordingly, they stopped offering routine surgery to asymptomatic patients,\textsuperscript{16,20,30} and, subsequently, they reported no difference in the long-term outcome between surgically and nonsurgically treated patients.\textsuperscript{16,24} This viewpoint is in conflict with the opinions of other authors,\textsuperscript{15,17,22} who reported quite better progression-free probability in surgically treated patients. Pang et al.\textsuperscript{2} compared the nonoperated Parisian patients\textsuperscript{11} with their own historical patients who had undergone partial lipoma resection and with their current patients undergoing radical resection; partial treatment had worse results than no treatment, but radical resection appeared to be the best option.\textsuperscript{22} However, satisfactory long-term results have also been reported in series of partial resection.\textsuperscript{15}

**Surgical Treatment Versus Conservative Treatment**

Most LCM series include both asymptomatic and symptomatic patients, both pediatric and adult cases, both new and recurring cases, and even both conus and filum lipomas.\textsuperscript{17,18,21,22,29,30} We do realize that ours is just small series, but it is quite homogeneous and includes only asymptomatic pediatric patients without any previous lipoma treatment, and with a follow-up length of at least 4 years. Moreover, to our knowledge, our paper is the first to report a semiprospective series comparing the long-term outcomes of operated and nonoperated asymptomatic pediatric patients from the same center. In general, comparisons between surgical and nonsurgical treatment have been conducted either by comparing recent versus historic series from the same center\textsuperscript{28,30} or by analyzing the results from different centers with different policies.\textsuperscript{22}

In the present study, all patients were monitored by a multidisciplinary team that included several professional figures in addition to the neurosurgeon. Clearly, the study remains nonblinded, but the results of both surgical and conservative treatment were evaluated and confirmed also by other health care workers, such as physiatrists, urologists, pediatricians, nurses, and physiotherapists, who had no preference regarding surgical or conservative treatment. Furthermore, the study is also nonrandomized. Theoretically, the parents were free to choose between operative and nonoperative treatment. We honestly tried to be impartial, but some involuntary influence could have been given, and perhaps we were more persuasive toward surgery in the simpler forms of LCM and for the younger patients. Nevertheless, the statistical analysis showed that the 2 groups were relatively homogeneous including that which concerns the LCM complexity. The only difference was that surgically treated patients tended to be younger, and we found better surgical results in younger patients. However, this was applicable only within the surgically treated patients, and if the age discrepancy played a role, this would be in favor of conservative management. In fact, the age difference influenced only the Kaplan-Meier curves of the TCS-free interval, where the statistical significance in favor of surgery could not be reached only because of the older patient age in the conservatively treated group. Perhaps the present gap between the Kaplan-Meier curves (Fig. 6) would become significant with longer follow-up periods and larger groups of patients. We found an evident but not statistically significant reduction in both the risks of TCS and in unfavorable final outcome within 5 years of surgery. According to the statistical analysis, the risk of TCS was not significantly different among the various types of LCM. Moreover, the amount of lipoma removal did not result in statisti-
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cally significantly lowering the odds of TCS. Conversely, the risk of TCS was significantly reduced when a favorable cord/sac ratio could be achieved. In the surgically treated group, the TCS occurred only in cases of transitional lipomas that underwent partial removal and had an insufficiently wide dural sac. Favorable results could be achieved even in patients with more complex lipomas provided that a wide dural sac was fashioned (Fig. 4). Conversely, in the conservatively treated group, the TCS occurred regardless of the type of lipoma. In other words, if we take into account only terminal and dorsal lesions, long-term unfavorable results occurred only in unoperated patients. Therefore, we have now changed our policy. We presently offer prophylactic surgery to all patients with nontransitional LCMs.

Satisfactory results may also be achieved in transitional lesions without “chaotic” features, whereas the outcome of patients with “chaotic-like” lipomas appeared scarcely improved by surgery. Perhaps better patient selection may further improve the results.

Conclusions

The natural history of thoroughly asymptomatic patients with LCMs consists of a significant probability of deterioration over time. Prophylactic surgery has been advocated to reduce the risk of long-term unfavorable results, but, in our series, statistical analysis failed to prove the superiority of surgery over the natural history. Nevertheless, the favorable role of surgery appeared at least borderline. If surgical treatment is to be considered, it should be performed as soon as possible, since each additional month of age significantly increases the hazard of TCS by 2%. The fat removal should be adequate to allow for neural tube reconstruction (neurulation) and an adequately wide dural sac. The risk of TCS significantly decreases by 85% if a well-bathed neural tube is obtained and is completely surrounded by the CSF; obtaining a well-bathed neural tube was more important than obtaining a subtotal lipoma removal, which decreased the risk of TCS by 75% but did not reach the significance and could be even risky.

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Disclosure

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author contributions to the study and manuscript preparation include the following. Conception and design: Talamonti, Redaelli. Acquisition of data: Debernardi, Picano, Redaelli. Analysis and interpretation of data: Talamonti, D’Aliberti, Nichelatti, Redaelli. Drafting the article: Talamonti, D’Aliberti, Debernardi. Critically revising the article: all authors. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Talamonti. Statistical analysis: Nichelatti. Study supervision: Talamonti, D’Aliberti.

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