OBJECTIVE. To assess the potential of using intraoperative rectal ampullar manometry to prevent bladder dysfunction in surgical treatment of the spinal cord conus lipoma.

MATERIAL AND METHODS. The results of surgical treatment of 59 children with lipomas of the spinal cord conus were studied. The presence of urological symptoms (urinary retention or incontinence) was assessed before and after surgery. Intraoperative rectal ampullar manometry was performed in 22 cases with registration of signs of irritation (increased pressure in the rectal ampulla) and depression (decreased pressure in the rectal ampulla) of sacral parasympathetic centers which allowed controlling their proximity and tolerance to the performed manipulations.

RESULTS. Urological symptoms before surgery were detected in 25 (42%) patients: urinary retention in 7 (28%), and incontinence in 18 (72%). Symptoms were significantly more often detected in children older than 3 years (p < 0.05). Intraoperatively, a transient decrease in pressure in the rectal ampulla was noted during bipolar coagulation, and a decrease in pressure in the rectal ampulla was noted during ultrasound disintegration. The most pronounced changes in pressure were observed during manipulations along the borderline between the lipoma and the spinal cord in the zone of localization of sacral parasympathetic centers. Persistent profound changes in pressure (>3 mm Hg) have precluded from the total removal of lipoma in all 22 patients; subtotal or partial lipoma removal and release of the tethered spinal cord were achieved in all cases. None of the patients operated on using rectal ampullar manometry presented urinary retention after surgery, these disorders developed in 12 (32%) children operated on without this procedure (p < 0.05).

CONCLUSION. Paresis or paralysis of the bladder detrusor after removal of the spinal cord conus lipoma may result from direct damage to the parasympathetic sacral centers located at the borderline between the lipoma and the spinal cord. The method of intraoperative rectal ampullar manometry allows protecting the functions of the pelvic organs and determining the safe volume of lipoma resection.

KEY WORDS: spinal cord conus lipoma, lipomyelomeningocele, tethered cord syndrome, surgical treatment, intraoperative monitoring, rectal manometry.


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tion) in terms of its functional permis-
sibility (prevention of neuro-urological
complications).

The objective of this study was to
evaluate whether intraoperative rectal
ampullar manometry can be used to pre-
vent bladder dysfunction after surgical
treatment of spinal cord conus lipoma.

This was a retrospective-prospective
single-center group-control study, with
sequential parallel comparison design.

Material and Methods

The outcomes of surgeries performed
in 59 children with spinal cord conus
lipomas at the Pediatric Neurosurgery
Department of the A.L. Polenov Rus-
sian Neurosurgical Institute (since 2014,
a branch of the V.A. Almazov National
Medical Research Center) in 2004–2018
were analyzed. Patients with dorsal, tran-
sitional, and caudal types of spinal cord
conus lipomas (according to the classi-
ﬁcation suggested by Chapman, 1982)
were enrolled. The age distribution of
patients is shown in Table 1.

Indication for surgery was the diag-
nosis of tethered cord syndrome pre-
senting as a combination of sensory
loss, weakness and lower extremity
deformities, as well as pelvic organ
dysfunction.

It was evaluated whether or not the
patients had urological symptoms (uri-
nary retention or incontinence) before
and after the surgery (Table 2, 3). Only
one factor, postoperative changes in
the urological status (the emergence of
urinary incontinence symptoms), was
analyzed in this study.

The microsurgical technique of
lipoma resection using an ultrasonic
destructor and stimulation mapping of
spinal nerve roots was employed in all
the cases. Until 2015, either total or
subtotal resection was performed (in
37 of 59 analyzed patients). Intraopera-
tive rectal ampullar manometry started
to be used since 2015 (in 22 patients).

The compared groups (patients oper-
ated on using rectal manometry and
without it) were matched in terms of
patient number, patients’ age distri-
bution, and severity of preoperative
urological symptoms.

Manometry procedure. During the
study, a Foley catheter balloon equipped
with a pre-tested pressure sensor (a Cod-
man microsensor to monitor intracra-
niad pressure) was inserted into the
rectal ampulla (Fig. 1a). The depth of
balloon catheter implantation was
determined according to the coronal
MRI data (Fig. 1b). The sensor was cali-
brated by measuring pressure attained
after 5 ml of water had been added to
the balloon under atmospheric pressure
(-531–535 mm Hg). This parameter was
set as the initial pressure level by press-
ing the «P → 0» button on the instru-
ment panel. Next, normal saline bolus (1
ml) was consecutively administered, and
changes in pressure applied to the sen-
 sor were recorded. After the implanta-
tion, the balloon was also consecutively
ﬁlled with normal saline to a level when
dissociation between the volume/press-
ure ratio started to be observed under
atmospheric pressure (the balloon being
placed inside the rectum; Fig. 1c). This
was required to ensure an elastic contact
between the balloon and the rectal wall.

Next, the deviation of pressure from
the value achieved upon elastic contact
between the balloon and the rectal wall
(pressure at the point of dissociation of
the volume/pressure ratio) was taken
into account. The detected intraopera-
tive changes in pressure gave grounds
to suggest either irritation (increased
pressure) or depression (reduced pres-
sure) of the function of sacral parasy-
mpathetic centers, which made it pos-
sible to estimate their proximity and
tolerance to the manipulations being
performed. In all cases, the manipula-
tions were stopped once the initial
pressure values had been attained.
That was how the contractile activity
in smooth muscle of the rectal ampulla
was continuously monitored.

All the intraoperatively applied meth-
ods were approved by the Ethics Com-
mittee of the medical institution; a writ-
ten informed consent was obtained from
all the patients enrolled in this study or
their legal representatives. The effective-
ness of the method was veriﬁed by statis-
tical analysis (Pearson χ² test and Fisher’s
exact test; the p < 0.05 value was consid-
ered statistically signiﬁcant).

Results and Discussion

Pathological urological symptoms were
detected in 25 (42 %) patients: symp-
toms of urinary retention and incon-
tinence were revealed in 7 (28 %) and
18 (72 %) patients, respectively. Children
older than 3 years were signiﬁcantly
more likely to be symptomatic (p < 0.05).
After the surgery, 12 (32 %) of 37 patients operated on without using rectal
manometry presented symptoms of
urinary retention. These disorders were
detected in none of the patients operated
on using rectal ampullar manometry. The
intergroup difference was statistically
signiﬁcant (p < 0.05). Speciﬁcally, the
intraoperative changes in rectal pressure
were multi-directional for bipolar
coagulation and ultrasonic disintegration.
In the former case, pressure was reduced,
while being increased in the latter case.
No correlation between changes in
pressure and motor responses from the
external anal sphincter were observed
(Fig. 2).

The most profound pressure chang-
es were detected upon manipulations at
the lipoma–spinal cord boundary, in the
zone where the parasympathetic centers
of the lateral horns of spinal cord are
located. A persistent profound pressure
elevation (by > 3 mm Hg) made total
lipoma resection infeasible in 22 patients
who had undergone rectal ampullar
manometry. However, subtotal or par-
tial resection allowed one to perform
tethered cord release in all these cases,
resulting in a positive outcome in terms
of the neurological symptoms.

Table 1

<table>
<thead>
<tr>
<th>Age, years</th>
<th>Patients, n</th>
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<td>&lt;1 year</td>
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<tr>
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<td>From 14 to 17</td>
<td>3</td>
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</table>
achieved. Fig. 4 shows the total lipoma resection accompanied by postoperative urological complications.

None of the patients had wound complications (hematoma or suppuration) that could affect the neurological outcome of the surgery. Specifically, the preoperative urological symptoms in children were not changed after the surgery in both groups (Tables 2, 3).

The problems related to surgical treatment of spinal cord conus lipomas in children have been regularly discussed at international meetings of pediatric neurosurgeons. It is worth mentioning that the microsurgical technique of the surgery has been repeatedly described in the literature, while the development of wound complications is comparable in large case series and is not considered to be a reason for focal neurological complications, including the neurogenic pelvic organ dysfunction [3, 4, 6]. Hence, the question of determining the optimal (radical or partial) resection volume of spinal cord conus lipoma in terms of the functional outcome of a surgery remains the most widely discussed issue. Any new data on the putative mechanisms of the development of postoperative complications have a scientific value.

Although the rate of neurological complications in surgery of the spinal cord conus lipoma is ~5% [3, 4, 6], it was found that up to 80% of asymptomatic patients have abnormal bladder dynamics, while postsurgical aggravation in bladder dynamics can be revealed in 20% of patients [14, 15]. The involuntary activity of the bladder and rectum are known to be governed by the reciprocal cross-regulation mechanism. At the segmental level, this regulation is performed by the lumbar sympathetic and sacral parasympathetic centers. The sympathetic centers are responsible for the contraction of bladder and anal sphincters, ensuring the continence of urine and feces; the parasympathetic centers stimulate the contractile activity of the detrusor and rectal ampulla, thus causing micturition and defecation [3]. We believe that the reason for the most frequent complication (paralysis/paresis of the bladder detrusor) is the dysembryogenetic features of formation of spinal cord conus lipomas, since tumor invasion of
the opened neural placode occurs at the level of sacral parasympathetic centers that regulate the pelvic organ function [5, 16, 17]. In our opinion, paralysis/paresis of bladder detrusor after resection of spinal cord conus lipoma may result from direct damage to the centers residing in the lateral horns of the spinal cord rather than spinal nerve roots or the posterior columns of the spinal cord, as it was believed previously [6].

Rectal ampullar manometry allowed one to detect signs of irritation or depression of sacral parasympathetic centers during resection of spinal cord conus lipoma, which presented as an elevation or reduction of pressure applied to the balloon catheter by the rectal wall. Hence, continuous intraoperative monitoring of the function of sacral parasympathetic centers prevented their damage as the surgeons did not perform total lipoma resection. Due to its technical simplicity, rectal ampullar manometry can be considered an efficient method for intraoperative monitoring of the pelvic functions during microsurgical resection of spinal cord conus lipomas in children, thus allowing neurosurgeons to safely perform surgeries without using the unnecessary procedures and expensive monitoring equipment.

Conclusions

Paresis or paralysis of the bladder detrusor after resection of the spinal cord conus lipoma can result from direct damage to the sacral parasympathetic centers located on the spinal cord–lipoma boundary. Their functions can be monitored intraoperatively using rectal ampullar manometry. This method can be used to preserve the bladder and rectal function and to determine the safe tumor resection volume.
The risk of these complications can be reduced only if the spinal surgeons reasonably stop performing total lipoma resection. The use of intraoperative rectal ampullar manometry during these surgeries allows one to intraoperatively control safe volume of lipoma resection, thus preventing postoperative bladder dysfunction. The reasonably safe extent of lipoma resection in this case ensures a better functional outcome than total lipoma resection does.

Limitations of the study

1. This study did not focus on such complications of resection of spinal cord conus lipomas as defecation disorders. Constipation is similar to urinary retention but is not as clinically important and is occult more often. Nevertheless, the similar pathogenesis of these conditions gives grounds for assuming that the proposed method will reduce the risk of these complications as well.

2. The study was not aimed at evaluating the effectiveness of rehabilitation or the long-term outcomes of neuro-urological complications after resection of spinal cord conus lipomas.

3. The multidirectional nature of changes in rectal pressure in response to the manipulations performed using a bipolar coagulator and an ultrasonic destructor are of undoubted interest for further research in the field of functional spinal neurosurgery. In this study, we have only outlined these differences.

The authors are grateful to Professor I.B. Osipov, the Head of the Urology Division of the St. Petersburg State Pediatric Medical University, and Professor S.N. Larionov, the leading researcher of the Neurosurgery Clinical Research Department of Irkutsk Regional Pediatric Clinical Hospital, for their assistance and consultations during manuscript preparation.

The study had no sponsorship. The authors declare that they have no conflict of interest.

### Table 2
Characteristics of patients operated on without using rectal ampullar manometry

<table>
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<th>Patients</th>
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N — without urological symptoms; R — urinary retention; I — urinary incontinence.

### Table 3
Characteristics of patients operated on using rectal ampullar manometry

<table>
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<th>Age, months</th>
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N — without urological symptoms; R — urinary retention; I — urinary incontinence.
References


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