LUMBOSACRAL LIPOMA: TRACTION BIPOLAR COAGULATION DISSECTION

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Objective. To analyze the technique of traction bipolar coagulation dissection (strip technique), to assess its effectiveness and safety in surgery for removal of lumbosacral lipomas of various types.

Material and Methods. The study involved 39 patients (the follow-up period was 1 year) operated on for removal of lumbosacral lipoma using the method of traction bipolar coagulation dissection. The 3D models of lumbosacral lipomas before and after surgery were created based on neuroimaging data, the neurological status before and after surgery was assessed using the SBNS scale, and the results of intraoperative neurophysiological monitoring were analyzed.

Results. A decrease in the volume of lumbosacral lipomas by 95.0 % was achieved in all patients, the volume after surgery was less than 1 cm^3 ($p < 0.01$). Positive dynamics of neurologic status according to the SBNS scale was observed in 94.9 % of patients ($p < 0.01$). Motor evoked potentials remained unchanged throughout surgery in most patients. No false negative results of intraoperative neurophysiological monitoring were obtained.

Conclusion. Traction bipolar coagulation dissection is an effective and safe method of surgical treatment of lumbosacral lipomas allowing the safest and most complete removal of lipomatous tissue, as well as improving the functional state of patients.

Key Words: traction bipolar coagulation dissection, strip technique, lumbosacral lipoma, tethered spinal cord syndrome.

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Lumbosacral lipomas are benign solid dysembryomas distinguished by development of tethered spinal cord syndrome [1]. Intramedullary tumors are more common among children [2]. The incidence of lumbosacral lipomas is estimated as 0.25–0.50 per 1,000 newborns [3, 4]. Tethered spinal cord syndrome leads to progressive neurological, urological, and orthopedic disorders. In some cases, lumbosacral lipomas are not clinically manifested, while the cosmetic defect is the first to be diagnosed. Manifestations of tethered spinal cord syndrome become more severe with lipoma growth, thus inevitably resulting in a specific deficit [5, 6].

Surgery is the main treatment method for patients with lumbosacral lipomas. The key to successful treatment is safe and complete resection of lipomatous tissue and restoration of normal anatomy [7, 8]. Several methods of surgery for lumbosacral lipomas exist to date. However, none of these methods can guarantee safety and completeness of lumbosacral lipoma removal. A new lipomyelomeningo-radiculolysis technique, namely traction bipolar coagulation dissection (strip technique), was developed by A.A. Sufianov and M.R. Gizatullin [9] at the Federal Centre of Neurosurgery (Tyumen) in 2015. The surgical technique involves stretching the lipomatous tissue with its simultaneous coagulation and dissection within the connective tissue plane (white plane) located at the border of the lumbosacral lipoma and the spinal cord.

The aim of the study is to analyze the method of traction bipolar coagulation dissection as well as assess its effectiveness and safety for various types of lumbosacral lipomas.

Material and Methods

A total of 39 patients (18 males and 21 females) underwent resection of lumbosacral lipomas using traction bipolar coagulation dissection at the Federal Centre of Neurosurgery (Tyumen) in 2015–2019. Patients' age ranged from three months to 48 years (mean age, 4.7 ± 1.9 years). Follow-up period duration for all patients by the time of the study was one year. Patients were divided into groups based on age and lumbosacral lipoma type according to the classification proposed by Oi et al. [10] in 2009. There were six (15 %) individuals at the age of < 6 months, eight (20 %) patients within the range of 6 to 12 months, seven (18 %) 1–3-year old individuals, five (13 %) children at the age of 4–7 years, eight (20 %) patients at the age of 8–13 years, and five (13 %) individuals over 14 years old. According to preoperative MRI data, dorsal lipoma was diagnosed in 10 (26 %) patients, caudal lipomas were found in two (5 %) individuals, mixed lipoma was detected in seven (18 %) children; there were also eight (20 %) and 12 cases (31 %) of filum terminale lipoma and lipomyelomeningocele, respectively. Only two patients had no clinical symptoms. Pelvic organ dysfunction was the most common type of manifestation. A total of 30 % of the patients had pain in the lumbosacral region. Concomitant skin abnormalities (dermal sinus, hemangiomas, hypertrichosis, etc.) in the region of lumbosacral lipoma were found in 30 % of the operated patients.

All patients underwent T1-, T2-weighted and thin-slice MRI of the spinal cord in the pre- and postoperative periods (Fig. 1). Spinal CT with 3D reconstruction, ultrasound examination of the abdominal cavity with determination of the amount of residual urine, examination by a urologist, and assessment of neurological status using the spina bifida neurological scale (SBNS) were also performed. Intraoperative neurophysiological monitoring with analyzing motor evoked potentials were conducted before opening the dura mater, during lumbosacral lipoma resection, and after reconstructive surgery of the spinal cord and dura mater. All patients were operated on under the guidance of intraoperative ultrasonography using a Flex Focus 800 Ultrasound Machine. The tool set used for lumbosacral lipoma resection in the presented group of patients included the following transducers: a High Frequency Linear 8870, a Hockey Stick 8809, and a Craniotomy 8862.

Intraoperative ultrasonography was performed at the following surgical stages:

1) immediately after patient positioning and preparation of the surgical field;

2) during approach to and resection of bone structures;

3) during lipomatous tissue resection;

4) during spinal reconstruction surgery and duraplasty;

5) in the early and late postoperative periods.

The completeness of lipomatous tissue resection was assessed using Osirix software by creating 3D models of lipomas (V, cm3) before and after surgery.

Statistical analysis. Statistical Package for the Social Sciences (SPSS) software version 22.0 was used. The t-criterion was calculated in the following steps: 1) comparison of the mean values of lumbosacral lipoma volume (cm3) before and after surgery; 2) comparison of the dynamics of neurological status using the SBNS scale before and after surgery. Differences were considered statistically significant at a two-sided p level < 0.05. Pairwise correlation analysis using Pearson's rank correlation coefficients ($p < 0.5$ is a weak correlation, $0.5 < p < 0.7$ is a medium correlation, and $p > 0.7$ is a strong correlation) was conducted.

Surgical technique. The surgery is performed under the guidance of neurophysiological and ultrasound monitoring. After the approach, either laminectomy or laminotomy of the lumbar vertebrae is conducted, followed by dura mater dissection under a surgical microscope using microsurgical instruments. The ratio of the lumbosacral lipoma to the spinal cord is then determined. Once a border between them is found in the cranial part of the wound, traction bipolar coagulation dissection of the lipomatous tissue is performed. Traction of lumbosacral lipoma creates tension at the region where the lipomatous tissue transforms into the tissue separating the spinal cord and lumbosacral lipoma, the so-called white plane [11]. This tension creates the conditions for formation of a dissection layer along white plane surface facing lumbosacral lipoma. In these conditions, simultaneous coagulation and dissection using a bipolar coagulator in this layer lead to evaporation and melting of lipomatous tissue, its separation from the white plane, and coagulation of lumbosacral lipoma vessels. Nerve tissue on the opposite side of the white plane remains intact. The liquid part of lipomatous tissue is aspirated, while the surface of the surgical field is irrigated with saline during the operation. The procedure is performed until the lipomatous tissue is completely removed [9].

Further, reconstructive artificial neurulation of the conus medullaris, duraplasty, and reconstruction of the musculofascial layer are carried out. The final stage involves suturing of the wound tightly layer-by-layer (Fig. 2, 3).

Results

Intermediate and control examinations of the operated patients revealed that lipomatous tissue volume decreased by an average of 95 % from the baseline in all groups, with the residual lipoma volume being < 1 cm3. The best result was achieved among the patients operated on for filum terminale lipoma: the lipoma was completely resected in all cases, which was due to the specific anatomy of this type of the spinal dysraphism (Fig. 4, 5). The resulting difference between the volumes before and after surgery is statistically significant ($p < 0.001$).

Intraoperative neurophysiological monitoring revealed only one case of decreased motor evoked potentials during surgery (Table 1). No false negative results of intraoperative neurophysiological monitoring were obtained.

Control examination after 6 and 12 months showed improvement in neurological status (SBNS scale) by an average of one point in almost all (94.9 %) patients (Tables 2, 3). Positive dynamics manifested themselves as improvement of pelvic organ function and partial restoration of reflexes and motor functions of the lower extremities. An exception was the group of patients aged 0–6 months, which is because of the com-

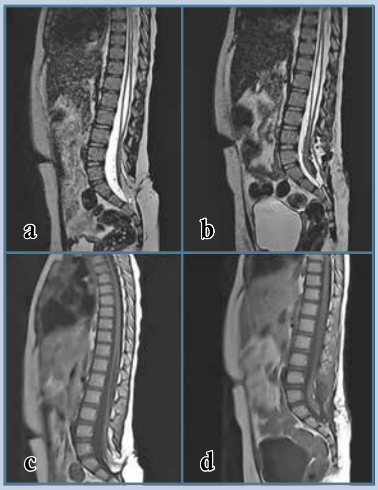

Fig. 1
MRI images of mixed lumbosacral lipoma: **a** – preoperative MRI (thin-slice T2-weighted myelography, sagittal section); **b** – postoperative MRI (thin-slice T2-weighted, sagittal section); **c** – preoperative MRI (T1-weighted, sagittal section); **d** – postoperative MRI (T1-weighted, sagittal section)

plexity of assessing pelvic organ function and the predominance of the mixed type of lumbosacral lipomas and lipomyelomeningocele. The differences were statistically significant in all groups of patients ($p < 0.001$).

Transient complications developed in 5 % of cases in the early postoperative period: two patients had transient urinary retention and transient paresis of the lower limb. There were no complications associated with wound healing in the analyzed groups. No cases of postoperative liquorrhea were noted. Aggravation of neurological deficit estimated using the SBNS scale (a one-point decrease) was observed in a patient with a mixed type of lipoma and a patient with lipomyelomeningocele. Pain syndrome regressed in 42 % of patients.

Discussion

Traction bipolar coagulation dissection is a new surgical method for treating lumbosacral lipoma. Similar techniques (ultrasound-based destruction-aspiration of lipomatous tissue, the use of a CO laser or microsurgical scissors) have a number of disadvantages. These disadvantages include frequent bleeding from lipomatous tissue vessels and risk of injury to the spinal cord and surrounding nerve structures closely adjacent to lumbosacral lipoma. Traction bipolar coagulation dissection allows bloodless, safe, and effective resection of lipomatous tissue, while preserving the structure of the surrounding anatomical structures. The apparent advantage of the method is that it does not require purchasing new microsurgical instruments, thus allowing its widespread use.

Among the key advantages of the surgery for lumbosacral lipoma is complete resection of lipomatous tissue, which allows for an adequate reconstruction of the normal anatomy. Various neuroimaging techniques are used for its assessment. MRI is the most sensitive of them. In addition to visual examination, 3D modeling of lumbosacral lipoma allows for a more objective assessment of resection completeness in terms of quantitative evaluation of the difference in the volumes before and after surgery. Pang et al. [7] was among the first to start actively using this technique in 2008. Lumbosacral lipoma volume decreased by 95 % from the baseline in almost all patients in our study after surgery, which is close to complete resection. Resection completeness depends not only on the surgical technique used but also on the type of lumbosacral lipoma. In this terms, filum terminale lipoma is the easiest one to manage: it requires only resection of the fixed filum terminale, which has been transformed into lipomatous tumor. Dorsal, caudal, and mixed types of lipomas, as well as lipomyelomeningocele, require more complicated approach. In these cases, the spinal cord, spinal roots, and the dura mater are usually involved.

The safety of the technique is assessed based on several parameters: neurological status of patients before and after surgery, data of intraoperative neurophysiological monitoring, and the presence of postoperative complications. The SBNS scale demonstrated good results in assessing the functional status of the nervous, urinary, and musculoskeletal systems [18]. The scale is easy to use. It also allows the most comprehensive evaluation of the nature of the existing deficit. Reliable positive dynamics of the functional state in 95 % of the patients according to the SBNS scale within a year after surgery confirms the effectiveness and safety of the traction bipolar coagulation dissection. We assessed motor evoked potentials during surgery as an

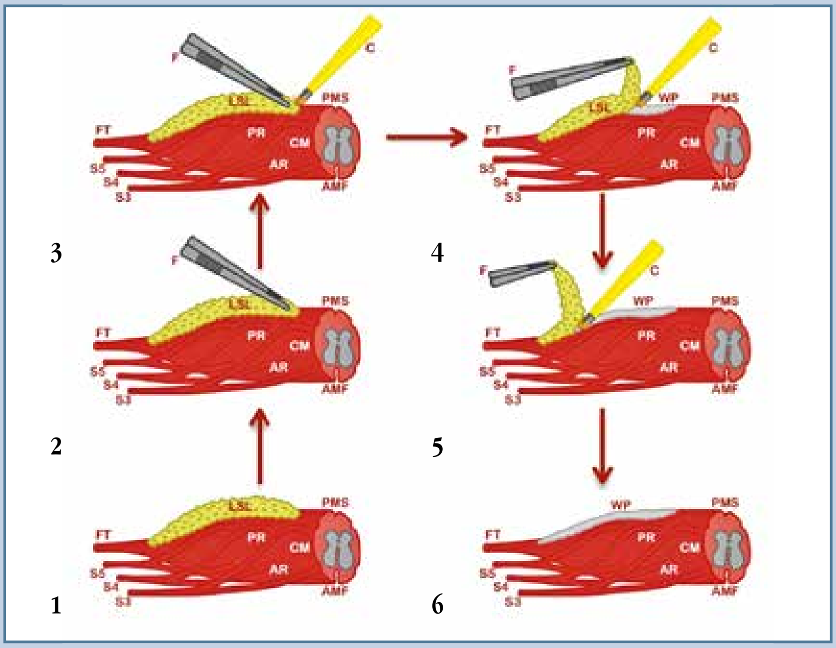

Fig. 2
Schematic representation of the main stages of traction bipolar coagulation dissection: *1* – general view before surgery; *2* –lumbosacral lipoma grip using forceps; *3–5* – lumbosacral lipoma traction using forceps, coagulation using a bipolar coagulator along the white plane border; *6* – general view after surgery (complete resection of lumbosacral lipoma); LSL – lumbosacral lipoma; CM – conus medullaris; AR – anterior roots; PR – posterior roots; AMF – anterior median fissure; PMS – posterior median sulcus; FT – filum terminale; S3, S4, S5 – spinal nerves; C – bipolar coagulator; F – forceps; WP – white plane

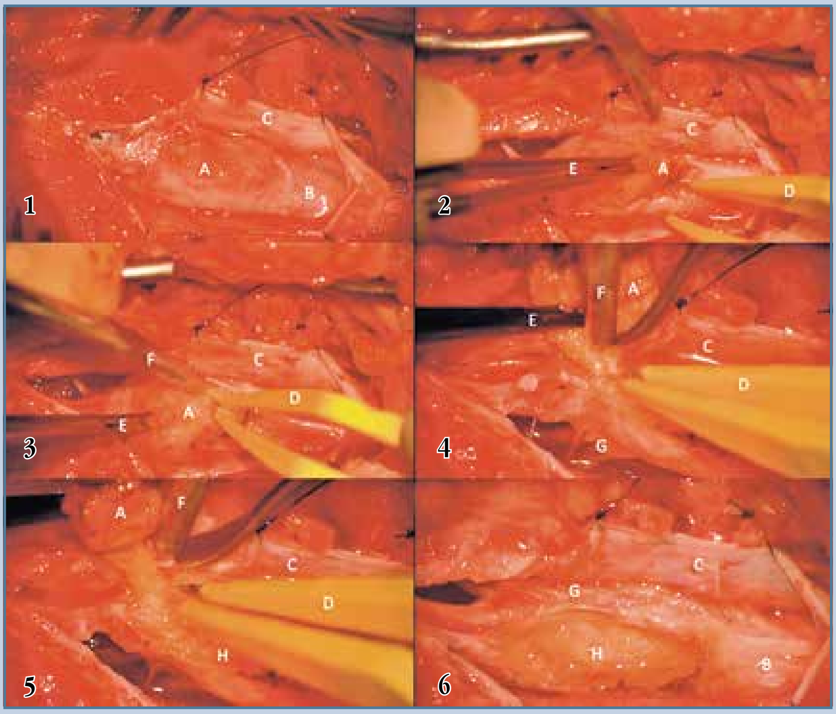

Fig. 3
Stages of traction bipolar coagulation dissection: *1* – general view before surgery; *2* – lumbosacral lipoma grip using forceps; *3–5* – lumbosacral lipoma traction using forceps, coagulation using a bipolar coagulator along the white plane border*; 6* – general view after surgery (complete resection of lumbosacral lipoma); A – lumbosacral lipoma; B – conus medullaris; C – dura mater; D – bipolar coagulator; E – forceps; F – aspirator; G –spinal roots; H – white plane

objective indicator of the method's safety. Stable responses at all stages of the intervention in most patients, as well as the absence of false negative results, confirm that this method of surgery is safe. The percentage of complications in lumbosacral lipoma resection ranges from 0.6 to 30.0 % in the world literature [19–22]. In particular, it concerns postoperative neurological regression (Table 4). Neurological status impairment was observed in only two (5.1 %) patients in our series. A longer follow-up observation of these patients is necessary to establish the disease cause and determine the treatment strategy.

Conclusion

Surgical treatment of patients with lumbosacral lipomas is a crucial issue in modern neurosurgery for spinal dysraphisms. Taking into account that the syndrome of tethered spinal cord progresses, while surgery duration increases with age, it is recommended to perform a surgery immediately after the diagnosis is made. Traction bipolar coagulation dissection is an effective and safe surgical method for treating patients with lumbosacral lipomas. The technique allows resecting lipomatous tissue in the

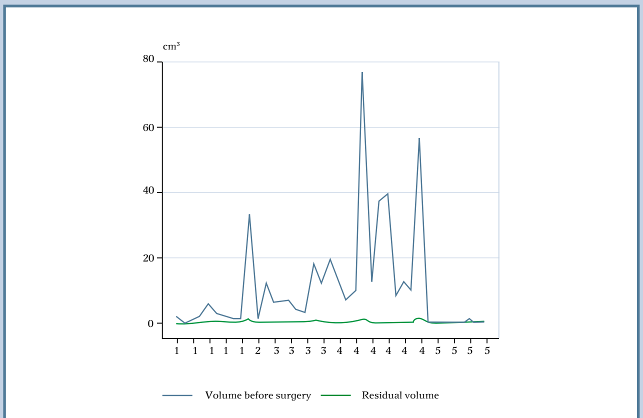

Fig. 4
Lumbosacral lipoma volume before and after surgery based on lipoma type: *1* – dorsal type; *2* – caudal type; *3* – mixed type; *4* – lipomyelomeningocele; *5* – filum terminale lipoma

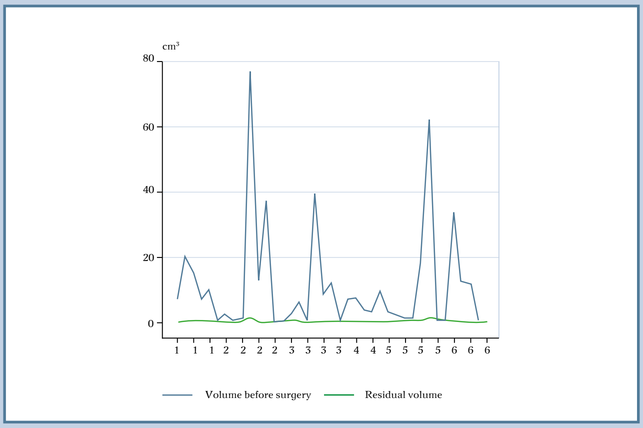

Fig. 5
Lumbosacral lipoma volume before and after surgery in the following age groups: *1* – 0–6 months ; *2* – 6–12 months; *3* – *1–3* years; *4* – 4–7 years; *5* – 8–13 years; *6* –14 years

Table 1

Dynamics of motor evoked potentials during surgery, μV

Muscle	Before opening the dura mater	During lumbosacral lipoma resection	After artificial neurulation	After dura mater suturing
M. tibialis anterior	240.10 ± 20.15	209.40 ± 45.78	189.75 ± 23.45	244.20 ± 49.01
M. gastrocnemius	275.36 ± 34.40	356.17 ± 48.03	268.08 ± 54.30	270.45 ± 46.20
M. sphincter ani externus	42.21 ± 22.64	67.45 ± 37.45	40.87 ± 50.08	74.09 ± 43.10
M. rectus femoris	321.05 ± 32.48	296.67 ± 46.78	255.13 ± 29.70	331.35 ± 27.86

Table 2

Neurological status of patients assessed using the SBNS scale before and after surgery depending on lipoma type, points

Lipoma type	Patients, n	Before surgery		After surgery	
		mean value	standard deviation	mean value	standard deviation
Dorsal	10	11.70000	1.94651	13.00000	2.00000
Caudal	2	10.00000	1.41421	11.00000	0.00000
Mixed	7	11.57140	1.61835	12.14209	1.77281
Lipomyelomeningocele	12	10.00000	1.53741	10.66670	1.77525
Filum terminale lipoma	8	9.62500	1.99553	12.25000	2.91548

Table 3

Neurological status of patients assessed using the SBNS scale before and after surgery depending on the age group, points

Age groups	Patients, n	Before surgery		After surgery	
		mean value	standard deviation	mean value	standard deviation
0–6 months	6	10.83330	0.40825	10.66670	0.81650
6–12 months	8	9.62500	1.84681	11.37500	2.82527
1–3 years	7	10.85710	2.54484	11.71430	3.03942
4–7 years	5	11.20000	1.92354	12.20000	1.78885
8–13 years	8	11.12500	2.10017	12.62500	1.99553
>14 years	5	10.40000	1.94936	12.80000	1.30384

Table 4

Neurological regression rate in patients after surgery (literature data)

Authors	Publication year	Number of patients, n	Regress, % (n)	Follow-up period
Arai et al. [14]	2001	120	5.8 (7)	2–19 years
Kulkarni et al. [15]	2004	100	22.0 (22)	4.4 years
Koyanagi et al. [12]	2008	58	27.6 (16)	7.9 years
Oi et al. [10]	2009	236	3.4 (8)	1 month to 5 years
Dushi et al. [16]	2011	7	14.3 (1)	10 years
Talamonti et al. [17]	2014	32	9.4 (3)	4–16 years
Tu et al. [13]	2016	10	30.0 (3)	8 years

safest and most complete way, as well as improving the patient's functional status. The method of traction bipolar coagulation dissection can rightfully be considered as an alternative to other approaches for the surgical treatment of lumbosacral lipoma.

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