Int J Clin Exp Med 2018;11(7):7208-7215
www.ijcem.com /ISSN:1940-5901/IJCEM0069528

Original Article

Local *vs.* general anesthesia for decompression for thoracic spinal stenosis

Ye Zhao[1], Juan Xu[2]

Departments of [1]Orthopedics, [2]Ultrasound, Cangzhou Central Hospital, Cangzhou, Hebei, China

Received July 30, 2017; Accepted April 9, 2018; Epub July 15, 2018; Published July 30, 2018

Abstract: This research was aimed to assess the safety and efficacy of local and general anesthesia for decompression for thoracic spinal stenosis (TSS). From June 2005 to December 2015, 130 cases receiving decompression for TSS were chosen for a retrospective study. The efficacy and safety of the decompression operation under two anesthetic techniques were assessed by neurological function (JOA score), postoperative efficacy (Mann's standard) and incidence of complications. The incidence of complications (spinal cord injury), operation time, intraoperative blood loss, number of days in hospital and hospitalization costs were significantly lower in the local anesthesia group; the average JOA score at 2 weeks after operation was 7.92±1.09 in the local anesthesia group. The paired t-test showed that all indicators were significantly better in the local anesthesia group as compared with the general anesthesia group ($P<0.05$); For the local anesthesia group, there were 22 cases (33.8%) achieving excellent treatment effects, 32 cases (49.2%) good effects, 10 cases (15.4%) moderate effects, and 1 case (15.4%) poor effects. The excellent and good rate was much higher in the local anesthesia group than in the general anesthesia group ($P<0.05$); Multivariate conditional logistic regression indicated that general anesthesia was the independent risk factor of the operation effect (OR=1.611, P=0.015). Decompression for TSS under local anesthesia has a higher safety, lower incidence of complications and lower cost. Local anesthesia can greatly reduce neurological deterioration after surgery. This approach is ideal and noteworthy for elderly patients with poor tolerance of general anesthesia.

Keywords: Decompression for thoracic spinal stenosis, local anesthesia, efficacy and safety, cohort study

Introduction

Thoracic spinal stenosis (TSS) is the condition of thoracic spinal canal narrowing due to congenital factors, degeneration, endocrine and systemic disorders. This is usually accompanied by spinal cord decompression and (or) poor blood supply to the spinal cord as a result of thoracic spinal degeneration [1-3]. As to the causes of TSS in China, over 80% of the TSS cases are related to ossification of ligamentum flavum (OLF); about 15% of the cases are related to thoracic disc herniation (TDH), and less than 5% of the cases are related to ossification of the posterior longitudinal ligament (OPLL) and other reasons [4-6]. Thoracic spinal cord compression is the presenting symptom. The patients may suffer from pain in the chest and back, unsteady walking, loss of skin sensation, thermohypesthesia, loss of muscle tone, muscular tension, positive pyramidal signs, weakening or loss of tendon reflex, or even paraplegia and incontinence at advanced stage of the disease [7, 8]. Surgery is the only radical cure for TSS so far. TSS, if not timely and properly treated, will cause irreversible damage to the spine and impair patients' physical and psychological health.

Most decompression for TSS is performed under general anesthesia [9], but this anesthesia approach is associated with the risk of neurological deterioration and postoperative cognitive dysfunction (POCD) [10]. Based on different anesthesia approach that was used, TSS cases matched for baseline information were equally divided into local anesthesia group and general anesthesia group, for a retrospective cohort study. The efficacy and safety of local anesthesia for decompression for TSS were assessed based on postoperative neurological recovery.

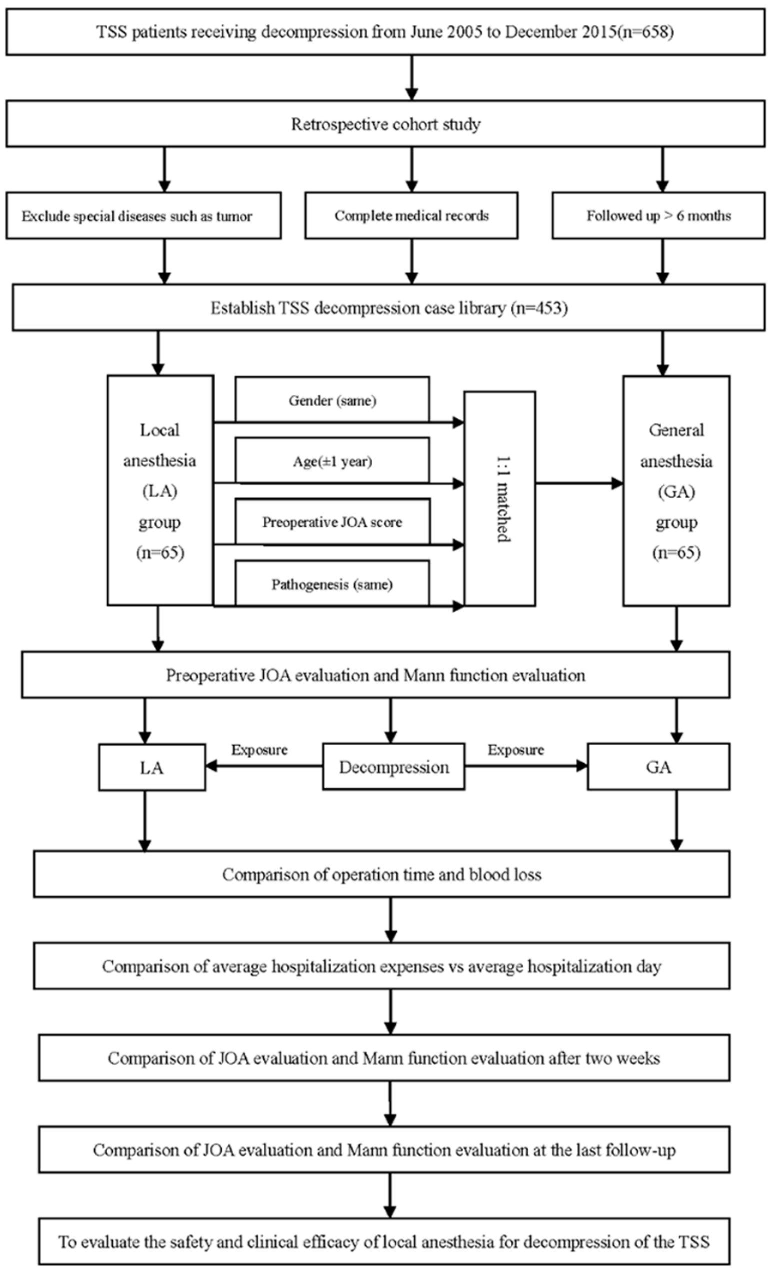

Figure 1. Consort chart showing flow of participants through the trial.

Materials and methods

General data

From June 2005 to December 2015, a total of 130 TSS patients receiving decompression at our hospital were included. All of them were confirmed by clinical presentations and imaging findings (CT, MRI) and also by surgery, according to the diagnostic criteria. The conditions of thoracic spine fracture, tumors, cysts and spinal nerve root injury were excluded. All operations were undertaken by one surgeon. All cases had complete clinical data, physical examination data, baseline information and follow-up data. The study was approved by the Ethics Committee of Cangzhou Central Hospital and all patients were informed consent.

65 cases were included in the local anesthesia group. Equal number of cases who were matched for gender, age (±1 year), preoperative JOA score (±0.5) and etiology received general anesthesia. The retrospective cohort study was performed between these two groups. The research flow chart was seen in the **Figure 1**.

Surgical method

For the local anesthesia group, local infiltration anesthesia was performed using 0.5% lidocaine, and for the general anesthesia group, endotracheal intubation was performed first. For cases with simple OLF, en-bloc removal of the spinal canal via the posterior approach termed as “thinned cap uncovering” was carried out; for cases with simple OPLL and TDH, anterior decompression was performed; for cases of OLF combined with OPLL or TDH, the decompression via the combined anterior-posterior approach and circumferential decompression were performed, respectively.

Both two groups were put under perioperative monitoring, and the drainage tube was kept unobstructed. The patients were inquired of sensation and mobility of the lower limbs every hour, and the neurological functions of the patients were closely observed. Wide-spectrum antibiotics were given to prevent infections, and microcirculation was improved by neurotrophin treatment. The patients took active flex-

Table 1. Comparison of baseline information between the two groups

Factors	LA group (n=65)	GA group (n=65)	X^2/t	P
Gender (n, %)				
Male	34 (54.0%)	34 (54.0%)	-	1
Female	29 (46.0%)	29 (46.0%)		
Pathogenesis (n, %)				
Ossification of the yellow ligament	40 (64.62%)	40 (64.62%)	-	1
Ossification of posterior longitudinal ligament	4 (6.15%)	4 (6.15%)		
Thoracic disc herniation	2 (3.07%)	2 (3.07%)		
Ossification of the posterior longitudinal ligament and ossification of the yellow ligament	10 (15.38%)	10 (15.38%)		
Ossification of the thoracic intervertebral disc with ossification of the yellow ligament	7 (10.77%)	7 (10.77%)		
Age (year)	59.1±9.7	58.4±8.9	0.428	0.668
Preoperative JOA score (score)	4.67±1.81	4.82±2.04	-0.443	0.657
Course of disease (month)	26.3±4.7	25.1±5.6	1.323	0.186

Note: Comparison of observation indicators between the two groups using paired t-test and paired chi-square test.

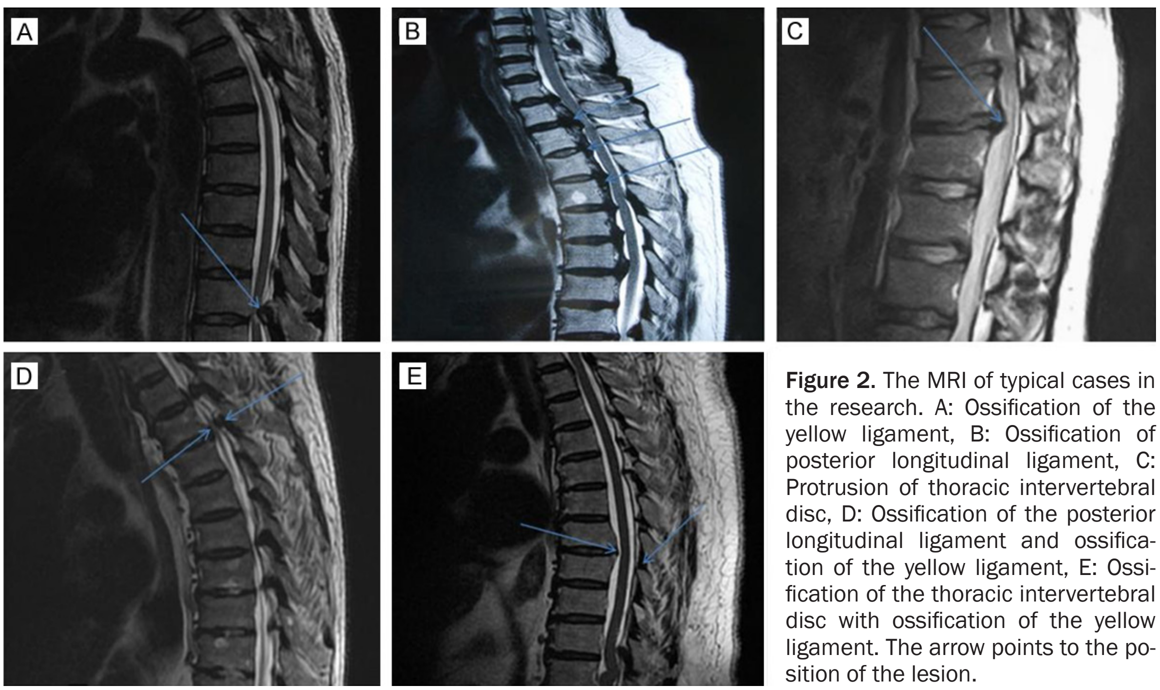

Figure 2. The MRI of typical cases in the research. A: Ossification of the yellow ligament, B: Ossification of posterior longitudinal ligament, C: Protrusion of thoracic intervertebral disc, D: Ossification of the posterior longitudinal ligament and ossification of the yellow ligament, E: Ossification of the thoracic intervertebral disc with ossification of the yellow ligament. The arrow points to the position of the lesion.

ion and extension exercises of the ankles and straight leg raising at early stage postoperatively to facilitate the recovery of muscular strength in the four limbs and to prevent adhesion. The patients were allowed movements out of bed at 2-3 weeks postoperatively, for functional exercises.

Observation indicators

(1) Demographic information; (2) Evaluation indicators: operation time, intraoperative blood loss, expenses and number of days in hospital; (3) course of disease, radiological classification, and preoperative assessment of neurological functions; (4) postoperative assessment of treatment effects, neurological functions and complications.

Treatment effects were assessed based on clinical manifestations and symptoms in the last follow-up using Mann's standard [11]. Excellent efficacy was defined as full or near full recovery of sensation and mobility; good efficacy was defined as significant improvement in sensation and mobility with self-care ability; moderate efficacy was defined as alleviation of clinical symptoms, but without self-care ability; poor efficacy was defined as neither improvement nor deterioration of the symptoms.

Table 2. Comparison of operation indicators between the two groups

Group	Operation time (min)	Blood loss of the operation (ml)	Hospitalization time (day)	Hospitalization expenses (ten thousands RMB)
LA	193.47±32.18	685.16±89.75	8.65±2.45	3.08±0.67
GA	229.84±41.38	804.84±101.29	10.28±3.19	3.79±0.82
T	-5.593	-7.129	-3.267	-5.405
P	<0.001*	<0.001*	0.001*	<0.001*

Note: *P<0.05, compared with the general anesthesia group using the paired t-test.

The Japanese Orthopedic Association (JOA) scoring system of 11 points was used to assess the neurological status [12], which included a preoperative assessment of mobility and sensation of the lower limbs, sensation of the trunk and bladder function, as well as a postoperative assessment of neurological functions at 2 weeks postoperatively and in the last follow-up. All cases were followed up for at least 6 months after surgery, with an average of 29.6 months (6-35 months). The improvement rate of neurological functions was calculated as follows: (postoperative JOA score-preoperative JOA score)/(11-preoperative JOA score) ×100%. The improvement rate ≥75% was considered excellent, 50%-74% good, 25%-49% moderate, and <25% poor.

Statistical analysis

Statistical analyses were performed using SPSS 20.0 software. Measurements were reported as mean ± standard deviation ($\overline{X}$±s). Intergroup comparisons were conducted using paired t-test and analysis of variance. Counts were reported as number of cases (percentages, N (%)), and intergroup comparisons were conducted using paired chi-square test. Multivariate conditional logistic regression was carried out with significance level α set to 0.05.

Results

Baseline information compared between the two groups

The two groups of patients were comparable in gender, age, preoperative JOA score and course of disease (P>0.05). See **Table 1**. Typical cases detected by MRI were seen in **Figure 2**.

Comparison of operation indicators between the two groups

The operation time, intraoperative blood loss, number of days in hospital and medical expenses were significantly lower in the local anesthesia group, as compared with the general anesthesia group (P<0.05). See **Table 2**.

Comparison of JOA score between the two groups

Neurological functions and treatment effects were assessed by postoperative JOA score. The two groups showed significant difference in JOA score before operation, 2 weeks after operation and in the last follow-up (P<0.001). LSD test indicated that the JOA score at 2 weeks after operation and that in the last follow-up were all considerably higher as compared with the score before operation (P<0.001). This means that decompression for TSS is feasible whether under general anesthesia or local anesthesia; all cases achieved a remarkable improvement after the surgery.

The average JOA score in the local anesthesia group at 2 weeks after operation was 7.92±1.09 and that in the last follow-up was 8.23±1.33; the recovery rate reached 56.24% in the last follow-up. The paired t-test showed that the observation indicators in the local anesthesia group were all higher than those in the general anesthesia group (P<0.001). It is apparent that the patients achieved better recovery of neurological function under local anesthesia (**Table 3**).

Treatment effects and complications compared between the two groups

The treatment effect was assessed based on clinical manifestations using Mann's standard. There were 22 cases (33.8%) achieved excellent effect, 32 cases (49.2%) achieved good effect, 10 cases (15.4%) achieved moderate effect and 1 case (15.4%) achieved poor effect in the local anesthesia group; the difference was of statistical significance (**Table 4**).

There were 12 cases suffering from postoperative complications in the local anesthesia

Table 3. Comparison of JOA score between the two groups

Group	Preoperative	Two weeks after the operation	Final follow-up (more than 6 months)	The last follow-up recovery rate (%)	F	P
LA	4.67±1.81	7.92±1.09*	8.23±1.33*	56.24±20.62	122.012	<0.001
GA	4.82±2.04	6.88±1.38*	7.25±1.59*	39.32±23.41	38.92	<0.001
T	-0.443	4.768	3.8155	4.372	-	-
P	0.657	<0.001	<0.001	<0.001	-	-

Note: JOA score within the same group at different time points was compared by variance analysis; LSD test was used for pairwise comparisons; *indicates comparison of JOA score within the same group at 2 weeks after operation and in the last follow-up; *P<0.05, between different groups at the same time point using paired t-test. Recovery rate: postoperative JOA score-preoperative JOA score)/(11-preoperative JOA score) ×100%.

Table 4. Comparison of postoperative treatment effects between the two groups

Curative effect	LA (n=65)	GA (n=65)	X^2/t	P
Excellent	22 (33.8%)	14 (21.5%)	8.102	0.044*
Good	32 (49.2%)	26 (40.0%)		
Moderate	10 (15.4%)	21 (32.3%)		
Poor	1 (1.5%)	4 (6.2%)		

Note: *P<0.05, compared with the general anesthesia group using the chi-square test. Treatment effects were assessed based on clinical manifestations and symptoms in the last follow-up using Mann's standard: Excellent efficacy was defined as full or near full recovery of sensation and mobility; good efficacy was defined as significant improvement in sensation and mobility with self-care ability; moderate efficacy was defined as alleviation of clinical symptoms, but without self-care ability; poor efficacy was defined as neither improvement nor deterioration of the symptoms.

group; the incidence was 18.5% vs. 35.4% in the general anesthesia group (23 cases), indicating significant difference (P<0.05). Only 1 case in the local anesthesia group had deteriorating spinal cord injury after operation, as opposed to 7 cases who showed similar conditions in the general anesthesia group (P<0.05). Under local anesthesia, decompression of TSS can greatly reduce the spinal cord injury and achieve a better safety (**Table 5**).

Multivariate conditional logistic regression for the influence factors of treatment effects

To exclude the confounding factors, the baseline information and anesthesia approach were taken as independent variables; the treatment effect was taken as the dependent variable. Five potential influence factors (anesthesia method, age, course of disease, preoperative JOA score and other concurrent spinal cord diseases) were identified by regression analysis, as shown in **Table 6**. Among them, anesthesia method was the independent risk factor (OR=1.611, P=0.015). The proportion of adverse effects after general anesthesia was 1.611 times as much as that under local anesthesia. This means the decompression of TSS is safer and more effective under local anesthesia.

Discussion

Conservative treatment for TSS can only achieve a moderate effect because of poor supply to the thoracic spinal canal with stenosis. Thus surgical decompression offers the only hope for TSS patients [13, 14]. Much modified decompression has emerged recently to directly address the pathological factors causing spinal cord compression. We compared the treatment effect and efficacy of local anesthesia and general anesthesia for decompression of TSS and found that the JOA score at 2 weeks after surgery and that in the last follow-up were both higher than the preoperative JOA score for either the general anesthesia group and local anesthesia group (P<0.001); the improvement rate of the treatment effect reached 82.0% and 61.5% for the two groups, respectively. This result indicates that decompression is very effective for TSS.

TSS is most common in the elderly people (the average age was 59.1±9.7 in the local anesthesia group), who are usually combined with organ dysfunction. Moreover, the surgery is very challenging because of the small buffer space in the thoracic spinal canal and spinal cord. Different surgical approaches are preferred for different causes of TSS, but no standard has been established yet. For this reason, surgical treatment for TSS may have a high incidence of complications including paraplegia, and the

Table 5. Comparison of postoperative complications between the two groups

Complications	LA (n=65)	GA (n=65)	X^2	P
Total of complications	12 (18.5%)	23 (35.4%)	4.731	0.030*
Damage aggravated of spinal function	1 (1.5%)	7 (10.8%)	4.795	0.029*
Pulmonary infection	4 (6.2%)	3 (4.6%)	0.151	0.698
Leakage of cerebrospinal fluid	5 (7.7%)	7 (10.8%)	0.367	0.545
Nerve root injury	2 (3.1%)	4 (6.2%)	0.699	0.403
Incision fat liquefaction	0 (0.0%)	2 (3.1%)	2.031	0.154

Note: *P<0.05, compared with the general anesthesia group using paired chi-square test.

Table 6. Multivariate logistic regression analysis of postoperative curative effect in patients with thoracic spinal stenosis

	B	S.E	Wald X^2	P	Exp (B)	EXP (B) 95% C.I.	
						Lower Limit	Upper Limit
Age (>65 years)	2.740	0.363	17.088	<0.001	12.492	7.610	13.536
Course of disease (>25 months)	1.856	0.219	10.257	<0.001	5.084	1.457	6.753
Preoperative JOA score (<5 score)	1.090	0.164	8.303	<0.001	2.974	1.324	3.704
Combined with other spinal disorders	0.398	0.159	4.896	0.024	1.467	1.049	2.248
Anesthesia (general anesthesia)	0.477	0.196	5.917	0.015	1.611	1.097	2.367

prognosis is unpredictable [15, 16]. The choice of an appropriate anesthesia technique is very crucial for ensuring the treatment effect and safety of the decompression.

General anesthesia has a higher risk for the elderly patients who are combined with organ degeneration, a decline in physical function and lower tolerance to anesthesia and surgery [17, 18]; besides, the incidence of POCD is also higher after general anesthesia for the elderly patients [19]. Spinal cord injury is another severe postoperative complication after decompression under general anesthesia [20, 21]. Constant efforts are being made to reduce the spinal cord injury caused by surgeries. It is reported that posterior float decompression inner fixation method under local anesthesia can achieve a better effect, with a less risk of spinal cord injury and higher safety as compared with the surgery under general anesthesia (P<0.05) [22]. To confirm this, we assessed the decompression of TSS under local anesthesia.

A retrospective cohort study was performed with equal number of cases randomly assigned to local anesthesia group and general anesthesia group. Univariate regression showed that the average JOA score in the last follow-up was 8.23±1.33 and the recovery rate in the last follow-up was 56.24% for the local anesthesia group; the excellent and good rate was 82.0%. All these indicators were significantly improved as compared with the general anesthesia group. Logistic regression also indicated that general anesthesia was the risk independent factor of the treatment effect (OR=1.611, P=0.015). The incidence of complications, operation time, intraoperative blood loss, number of days in hospital, and hospital expenses were all considerably lower in the local anesthesia group as compared with the general anesthesia group (P<0.05). Only 1 case in the local anesthesia group had spinal cord injury after the operation, while 7 cases suffered similar conditions in the general anesthesia group; the difference in the incidence of complications was of statistical significance (P<0.05). We believe that decompression of TSS is safer and more effective under local anesthesia, with fewer postoperative complications and lower cost. Patients are more responsive to potential spinal cord injury under local anesthesia so that the surgeon can timely shift to safer procedures [23, 24]. This benefit is helpful for reducing postoperative neurological deterioration, especially for elderly patients who are intolerant to general anesthesia.

Before decompression of TSS under local anesthesia, an effective communication with the patients, pulmonary functional training, defecation training, and exercises in prone position are all measures to improve intraoperative cooperation and reduce fear, anxiety, muscular tension and fluctuation in blood pressure. If the patients are very sensitive to pain, a small dose of flurbiprofen with ketamine can be given at 30 min before surgery to enhance local anesthetic and analgesic effects.

In addition to general anesthesia, age, course of disease, preoperative JOA score and other concurrent spinal cord diseases were also found to be the influence factors of the treatment effect. These factors also deserve attention in the decompression of TSS.

Acknowledgements

This work was supported by the Hebei Science and Technology Science and Technology Support Program (1123038ZD).

Disclosure of conflict of interest

None.

Address correspondence to: Dr. Ye Zhao, Department of Orthopedics, Cangzhou Central Hospital, 16 Xinhua Road, Cangzhou 061001, Hebei, China. Tel: +86-317-2075627; Fax: +86-317-2075627; E-mail: zhaoyeczcp@163.com

References

[1] Barnett GH, Hardy RW Jr, Little JR, Bay JW, Sypert GW. Thoracic spinal canal stenosis. J Neurosurg 1987; 66: 338-344.
[2] Hou X, Sun C, Liu X, Liu Z, Qi Q, Guo Z, Li W, Zeng Y, Chen Z. Clinical features of thoracic spinal stenosis-associated myelopathy: a retrospective analysis of 427 cases. Clin Spine Surg 2016; 29: 86-89.
[3] Vleggeert-Lankamp C, Peul W. Surgical decompression of thoracic spinal stenosis in achondroplasia: indication and outcome. J Neurosurg Spine 2012; 17: 164-172.
[4] Jayakumar PN, Devi BI, Bhat DI, Das BS. Thoracic cord compression due to ossified hypertrophied ligamentum flavum. Neurol India 2002; 50: 286-289.
[5] Benvenutti-Regato M, De la Garza-Ramos R, Caro-Osorio E. Thoracic epidural spinal angiolipoma with coexisting lumbar spinal stenosis: Case report and review of the literature. Int J Spine Surg 2015; 9: 67-82.
[6] Shimokawa T, Miyamoto K, Hioki A, Masuda T, Akiyama H, Shimizu K. Trachea-thoracic vertebral body fistula causing spinal cord injury: a case report. Spine 1976; 39: E657-659.
[7] Park BC, Min WK, Oh CW, Jeon IH, Kim SY, Kyung HS, Oh SH. Surgical outcome of thoracic myelopathy secondary to ossification of ligamentum flavum. Joint Bone Spine 2007; 74: 600-605.
[8] Liu X, Sun B, Xu Q, Che X, Hu J, Gu S, Shou J. Outcomes in treatment for primary spinal anaplastic ependymomas: a retrospective series of 20 patients. J Neurosurg Spine 2013; 19: 3-11.
[9] Somri M, Gaitini LA, Vaida SJ, Malatzkey S, Sabo E, Yudashkin M, Tome R. The effectiveness and safety of spinal anaesthesia in the pyloromyotomy procedure. Paediatr Anaesth 2003; 13: 32-37.
[10] Liu FJ, Chai Y, Shen Y, Xu JX, Du W, Zhang P. Posterior decompression with transforaminal interbody fusion for thoracic myelopathy due to ossification of the posterior longitudinal ligament and the ligamentum flavum at the same level. J Clin Neurosci 2013; 20: 570-575.
[11] Mann KS, Khosla VK, Gulati DR. Cervical spondylotic myelopathy treated by single-stage multilevel anterior decompression. A prospective study. J Neurosurg 1984; 60: 81-87.
[12] Kato S, Oshima Y, Oka H, Chikuda H, Takeshita Y, Miyoshi K, Kawamura N, Masuda K, Kunogi J, Okazaki R, Azuma S, Hara N, Tanaka S, Takeshita K. Comparison of the Japanese Orthopaedic Association (JOA) score and modified JOA (mJOA) score for the assessment of cervical myelopathy: a multicenter observational study. PLoS One 2015; 10: e0123022.
[13] Matsuyama Y, Yoshihara H, Tsuji T, Sakai Y, Yukawa Y, Nakamura H, Ito K, Ishiguro N. Surgical outcome of ossification of the posterior longitudinal ligament (OPLL) of the thoracic spine: implication of the type of ossification and surgical options. J Spinal Disord Tech 2005; 18: 492-497.
[14] Yamazaki M, Okawa A, Fujiyoshi T, Furuya T, Koda M. Posterior decompression with instrumented fusion for thoracic myelopathy caused by ossification of the posterior longitudinal ligament. Eur Spine J 2010; 19: 691-698.
[15] He B, Yan L, Xu Z, Guo H, Liu T, Hao D. Treatment strategies for the surgical complications of thoracic spinal stenosis: a retrospective analysis of two hundred and eighty three cases. Int Orthop 2014; 38: 117-122.
[16] Sun J, Zhang C, Ning G, Li Y, Wang P, Feng S. Surgical strategies for ossified ligamentum flavum associated with dural ossification in thoracic spinal stenosis. J Clin Neurosci 2014; 21: 2102-2106.
[17] Ballard C, Jones E, Gauge N, Aarsland D, Nilsen OB, Saxby BK, Lowery D, Corbett A, Wesnes K,

Katsaiti E, Arden J, Amoako D, Prophet N, Purushothaman B, Green D. Optimised anaesthesia to reduce post operative cognitive decline (POCD) in older patients undergoing elective surgery, a randomised controlled trial. PLoS One 2012; 7: e37410.

[18] Zywiel MG, Prabhu A, Perruccio AV, Gandhi R. The influence of anesthesia and pain management on cognitive dysfunction after joint arthroplasty: a systematic review. Clin Orthop Relat Res 2014; 472: 1453-1466.

[19] Rasmussen LS, Johnson T, Kuipers HM, Kristensen D, Siersma VD, Vila P, Jolles J, Papaioannou A, Abildstrom H, Silverstein JH, Bonal JA, Raeder J, Nielsen IK, Korttila K, Munoz L, Dodds C, Hanning CD, Moller JT. Does anaesthesia cause postoperative cognitive dysfunction? A randomised study of regional versus general anaesthesia in 438 elderly patients. Acta Anaesth Scand 2003; 47: 260-266.

[20] Palumbo MA, Hilibrand AS, Hart RA, Bohlman HH. Surgical treatment of thoracic spinal stenosis: a 2- to 9-year follow-up. Spine 1976; 26: 558-566.

[21] Chan AK, Winkler EA, Jacques L. Rate of perioperative neurological complications after surgery for cervical spinal cord stimulation. J Neurosurg Spine 2016; 25: 31-38.

[22] Beems T, van Dongen RT. Use of a tubular retractor system as a minimally invasive technique for epidural plate electrode placement under local anesthesia for spinal cord stimulation: technical note. Neurosurgery 2006; 58: ONS-E177.

[23] Lee SE, Choi RM, Kee R, Lee KH, Jeon S, Jung JW, Kim WJ, Yoon JS. Epidural anesthesia for permanent spinal cord stimulation with a cylindrical type lead: a case series. Korean J Anesthesiol 2015; 68: 179-183.

[24] McLain RF, Kalfas I, Bell GR, Tetzlaff JE, Yoon HJ, Rana M. Comparison of spinal and general anesthesia in lumbar laminectomy surgery: a case-controlled analysis of 400 patients. J Neurosurg Spine 2005; 2: 17-22.