Neurosurgical treatment of glossopharyngeal neuralgia: analysis of 103 cases

Yi Ma, MD, Yan-feng Li, MM, Quan-cai Wang, MM, Bin Wang, MM, and Hai-tao Huang, MM

2nd Department of Neurosurgery, Liaoning Provincial People's Hospital, Shenyang, People's Republic of China

OBJECTIVE The object of this study was to investigate the immediate and long-term follow-up results of glossopharyngeal nerve rhizotomy (GPNR) with or without partial vagus nerve rhizotomy (VNR) for treating glossopharyngeal neuralgia (GPN).

METHODS A retrospective review of the case notes of patients who had undergone surgery for GPN in the authors' department between 2008 and 2013 was performed to investigate baseline characteristics and immediate outcomes during the hospitalization. For the long-term results, a telephone survey was performed, and information on pain recurrence and permanent complications was collected. Pain relief meant no pain or medication, any pain persisting after surgery was considered to be treatment failure, and any pain returning during the follow-up period was considered to be pain recurrence. For comparative study, the patients were divided into 2 cohorts, that is, patients treated with GPNR alone and those treated with GPNR+VNR.

RESULTS One hundred three procedures, consisting of GPNR alone in 38 cases and GPNR+VNR in 65 cases, were performed in 103 consecutive patients with GPN. Seventy-nine of the 103 patients could be contacted for the follow-up study, with a mean follow-up duration of 2.73 years (range 1 month–5.75 years). While there were similar results (GPNR vs GPNR+VNR) in immediate pain relief rates (94.7% vs 93.8%), immediate complication rates (7.9% vs 4.6%), and long-term pain relief rates (92.3% vs 94.3%) between the 2 cohorts, a great difference was seen in long-term complications (3.8% vs 35.8%). The long-term complication rate for the combined GPNR+VNR cohort was 9.4 times higher than that in the GPNR cohort.

There was no operative or perioperative mortality. Immediate complications occurred in 6 cases, consisting of poor wound healing in 3 cases, and CSF leakage, hoarseness, and dystaxia in 1 case each. Permanent complications occurred in 20 patients (25.3%) and included cough while drinking in 10 patients, pharyngeal discomfort in 8 patients, and hoarseness and dysphagia in 1 case each.

CONCLUSIONS In general, this study indicates that GPNR alone or in combination with VNR is a safe, simple, and effective treatment option for GPN. It may be especially valuable for patients who are not suitable for the microvascular decompression (MVD) procedure and for surgeons who have little experience with MVD. Of note, this study renews the significance of GPNR alone, which, the authors believe, is at least valuable for a subgroup of GPN patients, with significantly fewer long-term complications than those for rhizotomy for both glossopharyngeal nerve and rootlets of the vagus nerve.

<http://thejns.org/doi/abs/10.3171/2015.3.JNS141806>

KEY WORDS microvascular decompression; glossopharyngeal neuralgia; rhizotomy; peripheral nerve

GLOSSOPHARYNGEAL neuralgia (GPN) is a cranial nerve hyperactivity pain syndrome leading to paroxysmal attacks of facial pain lasting from a fraction of a second to minutes and experienced in the ear, base of the tongue, tonsillar fossa, or beneath the angle of the jaw. The pain is usually described as sharp, stabbing, and severe and is precipitated by swallowing, chew-

ing, talking, coughing, and/or yawning. It is a rare clinical entity, representing only 0.2%–1.3% of facial pain syndromes.^{4,8} The overall incidence of GPN in the general population is estimated to be between 0.2 and 0.7 case per 100,000 people per year,^{16,18,21,23} although this incidence is probably underestimated due to insufficient awareness of this condition.

ABBREVIATIONS GPN = glossopharyngeal neuralgia; GPNR = glossopharyngeal nerve rhizotomy; HFS = hemifacial spasm; MVD = microvascular decompression; NVC = neurovascular compression; TN = trigeminal neuralgia; VNR = vagus nerve rhizotomy.

SUBMITTED August 14, 2014. **ACCEPTED** March 3, 2015.

INCLUDE WHEN CITING Published online September 4, 2015; DOI: 10.3171/2015.3.JNS141806.

In 2004 the International Headache Society proposed a subclassification of GPN that includes the classic and symptomatic forms.¹² In the classic type, the pain is only intermittent with no underlying cause or associated neurological deficit. The symptomatic type includes the same characteristics as the classic form, although the aching pain can persist between neuralgic episodes and sensory impairment can be found in the distribution of the above nerve because of structural lesions.

Because of the rarity of GPN and its overlap with other cranial nerve hyperactivity syndromes, such as trigeminal neuralgia (TN), superior laryngeal neuralgia, and nervus intermedius neuralgia, the diagnosis of GPN, not uncommonly, is challenging. The diagnosis is mainly established on comprehensive clinical grounds, as there is no specific test for this condition. Sometimes patients suspected of having GPN should also be seen by an ear, nose, and throat physician to exclude other diagnoses. High-resolution MRI or CT scanning is valuable in finding vascular compression, tumors, demyelinating lesions, or an elongated styloid process involving the glossopharyngeal nerve.

The first-line treatment for GPN is pharmacological and consists mainly of anticonvulsant medications such as carbamazepine, gabapentin, oxcarbazepine, or pregabalin.^{5,9,12,13} In addition, some antidepressants such as amitriptyline can be helpful either alone or in combination with the anticonvulsant medications.¹¹ Drug intolerance, inefficacy, allergies, and/or unbearable side effects associated with medical therapy are indications for surgical treatment.

At this time, a variety of surgical options are available for treating GPN, including intracranial procedures (craniotomy with microvascular decompression [MVD] or nerve rhizotomy), percutaneous procedures (radiofrequency rhizotomy, trigeminal tractotomy, and/or nucleotomy), and, more recently, Gamma Knife radiosurgery. Nevertheless, controversy still exists about the efficiency and potential risk of each procedure owing to the paucity of relevant literature and the limited number of patients included in the majority of studies.

With this paper, we present our experience and investigate the immediate and long-term follow-up results of patients treated with glossopharyngeal nerve rhizotomy (GPNR) alone or in combination with vagus nerve rhizotomy (VNR) for GPN.

Methods

Patient Population

Approval for this study was obtained from the institutional ethics committee of Liaoning Provincial People's Hospital. Between 2008 and 2013, after giving written informed consent, 103 consecutive patients, who conformed to the diagnostic criteria of the International Headache Society (Table 1)¹² for classic GPN, underwent surgery at Liaoning Provincial People's Hospital after medical therapy had failed.

A retrospective review of the case notes for these 103 patients was performed to investigate the baseline characteristics and immediate outcomes during the hospitalization. Pain relief was defined as no pain or no need

TABLE 1. International Headache Society diagnostic criteria for classic GPN^{*12}

1) Paroxysmal attacks of facial pain lasting from a fraction of a second to 2 minutes & fulfilling criteria 2 and 3
2) Pain has all of the following characteristics:
a) unilateral location
b) distribution w/in the posterior part of the tongue, tonsillar fossa, pharynx or beneath the angle of the lower jaw &/or in the ear
c) sharp, stabbing, & severe
d) precipitated by swallowing, chewing, talking, coughing, &/or yawning
3) Attacks are stereotypical in the individual patient
4) There is no clinically evident neurological deficit
5) Not attributed to another disorder†

* The International Headache Society has divided GPN into the classic and symptomatic types. In symptomatic GPN, the description is as in classic GPN with the proviso that aching pain may persist between paroxysms and sensory impairment may be found in the distribution of the glossopharyngeal nerve.

† Other causes have been ruled out by history, physical examination, and/or special investigation.

for medication, while any other results, including partial pain relief, were defined as treatment failure given that no quantitative measure, such as a visual analog scale, was used to analyze patients.

For the long-term follow-up results, an independent interviewer other than the operating surgeons performed a telephone survey. Information on pain recurrence and permanent complications was collected. Pain relief meant no pain or medication, while any pain returning during the follow-up period was considered to be pain recurrence.

For a comparative study, the patients were divided into 2 cohorts: patients treated with GPNR alone or with VNR.

Operative Technique

Under general anesthesia, patients were placed in the park bench position. A keyhole retromastoid craniotomy was performed to expose the inferior cerebellopontine angle. After opening the arachnoids around the glossopharyngeal-vagal complex, the glossopharyngeal and vagus nerves were observed carefully. If there was a distinct distance equal to or larger than the width of the glossopharyngeal nerve between these 2 nerves (Fig. 1A), the GPNR procedure alone was performed (Fig. 1B); otherwise, GPNR+VNR was performed. Usually, approximately 20%–30% of the vagus nerve was sectioned (Fig. 1C and D).

The main reason we preferred rhizotomy over MVD as our therapeutic option is attributed to the lack of experience in the MVD technique at the beginning stages of the study period. In the later stages, encouraged by the accumulation of experience learned from MVD for TN and hemifacial spasm (HFS), we began to explore the root entry zone of the glossopharyngeal and vagus nerves. In a small series of patients, microvascular decompression of the glossopharyngeal and vagus nerves was tried in addition to the rhizotomy procedure in the hope of achieving a higher treatment success rate, and the decompression was easily performed.

FIG. 1. Intraoperative photographs. **A:** There is a distinct distance between the glossopharyngeal and vagus nerves, which is larger than the width of the glossopharyngeal nerve. **B:** The glossopharyngeal nerve is sectioned, while the vagus nerve remains intact. **C:** Glossopharyngeal and vagus nerves mingle as a complex. The glossopharyngeal nerve will be sectioned. **D:** Glossopharyngeal nerve and upper rootlets of the vagus nerve are sectioned, and the posterior inferior cerebellar artery (PICA), compressing the root entry zones of the glossopharyngeal and vagus nerve complex, is decompressed by inserting a small amount of Teflon felt. 1 = glossopharyngeal nerve; 2 = vagus nerve; 3 = PICA; 4 = Teflon felt.

For patients with a combined hyperactive dysfunction syndrome of the cranial nerves, we usually preferred to deal with the glossopharyngeal and vagus nerve complex first, then to explore the trigeminal or facial nerve and decompress the offending vessels related to them.

Statistical significance was defined as $p < 0.05$ for comparing the demographic data of the 2 patient cohorts.

Results

The baseline characteristics of these 2 patient cohorts are outlined in Table 2 and can be summarized as follows (GPNR vs GPNR+VNR): mean age (years), 57.95 (range 34–79) versus 58.14 (range 39–76); mean preoperative duration of symptoms (years), 5.5 (range 0.17–20) versus 4.8 (range 0.08–10.75); right side/left side, 16/22 versus 34/31; sex (female/male), 23/15 versus 38/27; combined TN syndrome (case number), 18 versus 21; combined HFS syndrome (case number), 1 versus 1; neurovascular compression (NVC) at the glossopharyngeal and vagus nerves seen during surgery (case number), 7 versus 28. All of the variables except NVC were comparable between the 2 groups.

A total of 103 procedures were undergone by the 103 patients, including GPNR alone in 38 patients and GPNR+VNR in 65 patients. Seventy-nine of the study patients could be contacted for the follow-up data, with a mean follow-up duration of 2.73 years (range 1 month–5.75 years). Detailed information on immediate and long-term

TABLE 2. Demographic data on 2 patient cohorts treated with GPNR or GPNR+VNR

Characteristic	GPNR Group	GPNR+VNR Group	p Value
Age (yrs)			
Mean	57.95	58.14	0.924
Range	34–79	39–76	
Preop duration of symptoms (yrs)			
Mean	5.51	4.85	0.433
Range	0.17–20.00	0.08–10.75	
Side			
Lt	22	31	0.317
Rt	16	34	
Sex			
Female	23	38	0.502
Male	15	27	
Comorbidities			
TN	18	21	0.095
HFS	1	1	0.604
NVC	7	28	0.009

outcomes for the 2 patient cohorts is presented in Table 3. While there were similar results in immediate pain relief rates (94.7% vs 93.8%), immediate complication rates (7.9% vs 4.6%), and long-term pain relief rates (92.3% vs 94.3%), a great difference was seen in long-term complications (3.8% vs 35.8%), which meant that the long-term complication rate for the GPNR+VNR cohort was 9.4 times higher than that for the GPNR cohort.

There was no operative or perioperative mortality. Immediate complications were seen in 6 cases, consisting of CSF leakage in 1 case, which was successfully controlled by lumbar drainage for 4 days; poor wound healing in 3 cases, which subsequently healed after debridement of the wound; and hoarseness and dystaxia in 1 case each. Permanent complications were seen in 20 (25.3%) of the 79 patients contacted during the follow-up period and included coughing while drinking in 10 cases, pharyngeal discomfort in 8 cases, and hoarseness and dysphagia in 1 case each.

Because the more common complications related to paralysis of the glossopharyngeal and vagus nerves, such as coughing when drinking and pharyngeal discomfort, were investigated only in the follow-up period, a higher complication rate was presented in the long-term follow-up period.

Discussion

To our knowledge, this is the third larger series investigating the surgical treatment of GPN, which consisted of 103 consecutive patients. The results achieved in both patient cohorts—immediate pain relief rates of 94.7% and 93.8%, perioperative complication rates of 7.9% and 4.6%, long-term pain relief rates of 92.3% and 94.3%, and long-term complications rates of 3.8% and 35.8% in the GPNR

TABLE 3. Immediate and long-term outcomes in 2 patient cohorts

Parameter	No. (%)		p Value
	GPNR	GPNR+VNR	
Immediate outcomes			
No. of patients	38 (100.0)	65 (100.0)	0.852
Pain relief	36 (94.7)	61 (93.8)	
Treatment failure	2 (5.3)	4 (6.2)	
Complications			
CSF leakage	0 (0.0)	1 (0.0)	0.493
Poor wound healing	2 (0.1)	1 (0.0)	
Hoarseness	0 (0.0)	1 (0.0)	
Dystaxia	1 (0.0)	0 (0.0)	
Total	3 (7.9)	3 (4.6)	
Long-term outcomes			
No. of patients	26 (100.0)	53 (100.0)	0.727
Pain relief	24 (92.3)	50 (94.3)	
Recurrence	2 (7.7)	3 (5.7)	
Complications			
Cough while drinking	0 (0.0)	10 (0.2)	0.002
Pharyngeal discomfort	1 (0.0)	7 (0.1)	
Hoarseness	0 (0.0)	1 (0.0)	
Dysphagia	0 (0.0)	1 (0.0)	
Total	1 (3.8)	19 (35.8)	

CSF = cerebral spinal fluid.

and GPNR+VNR cohorts, respectively—are roughly in line with those reported by others who have treated GPN with nerve rhizotomy either alone or in combination with MVD.^{3,8,13–15,19,23,26} The mean follow-up duration was 2.73 years. There was no surgical mortality or life-threatening complications throughout the study period.

In reviewing the literature, we found the first larger series published by Rushton et al. in 1981,²³ which consisted of 217 patients with GPN who had been treated medically and surgically at the Mayo Clinic between 1922 and 1977. In that study, 129 patients had undergone surgical procedures for GPN, which included extracranial avulsion of the glossopharyngeal nerve in 4 cases, intracranial section of the glossopharyngeal nerve at the jugular foramen in 71 cases, intracranial section of the glossopharyngeal nerve and the upper rootlets of the vagus nerve in 44 cases, and section of the fifth cranial nerve plus intracranial section of the glossopharyngeal nerve and upper rootlets of the vagus nerve in 10 cases. Subsequently, 110 patients obtained good pain relief and 13 patients did not. Seven patients (5%) died in the immediate postoperative period. These authors reported that the most common postoperative complications were related to swallowing; that is, 25% patients had difficulty swallowing, and many complained of an unusual feeling, such as a foreign body in the throat, a tickling, or a drawing sensation in the pharynx.

In the Taha and Tew study published in 1995,²⁷ all 12 patients who had undergone intracranial rhizotomy of the glossopharyngeal nerve and upper rootlets of the vagus

nerve (4 with and 8 without MVD) had a good outcome during the long-term follow-up (mean duration of 10 years).

Our results, which showed enhancement of the rhizotomy outcome, are comparable with those documented in a series with MVD as the therapeutic procedure.^{7,8,10,15,17,19,22,23,26} In 2002, Patel et al.²² reported on another larger series, which was composed of 217 patients with GPN who had undergone MVD at the University of Pittsburgh between 1973 and 2000. In that study population, MVD for the treatment of GPN afforded complete immediate relief for 67% of all patients, and an additional 25% obtained partial relief, whereas 8% of patients experienced no significant change in symptoms after surgery. Long-term results were collected from 50 patients who could be contacted for these data. Among these patients, long-term relief was noted in 58% of patients and partial relief in 18%. Surgery-related death occurred in 5.8% patients, with all instances in the earlier stages of their practice between 1973 and 1987, whereas the percentage of patients with specific complications in each time period significantly decreased across quartiles from remote to most recent (from 15.4% to 5.9%).

In 2004²⁴ Sampson et al. described their series of 47 consecutive patients who had undergone MVD for the treatment of GPN; 46 (98%) patients had immediate symptom relief. More than 10 years' (median 12.7 years) long-term follow-up data were available for 29 (62%) of these 47 patients. Symptom relief was still present in 97% of these patients, while permanent neurological deficits (> 6 months) attributed to the surgery were seen in 5 (11%) patients, including mild hoarseness or dysphagia or both in 4 cases and moderate (Grade II/VI) facial nerve paresis in 1 patient.

Of particular interest in our study is the finding that 38 of 103 patients were treated with GPNR alone instead of GPNR+VNR. For the 2 patient cohorts, it was shown that most of the variables were comparable, except for long-term complication, which was 3.8% versus 35.8%, respectively. Because this study was retrospective and uncontrolled and because some baseline variables were not statistically matched, it did not have statistical power; nevertheless, a 9.4 times difference between long-term complication rates seemed to imply a tendency for more long-term complications with the GPNR+VNR procedure.

Looking back on the history of surgical treatment for GPN, we found that severe pain in the distribution of the glossopharyngeal nerve was first reported in 1910 by Weisenberg, in a 35-year-old male with a right cerebellopontine angle tumor.²⁸ In 1920, Sicard and Robineau described 3 patients with a similar syndrome, and they introduced extracranial nerve avulsion as the first surgical option for the treatment of GPN.²⁵ However, their approach was aborted because of its high morbidity and pain recurrence due to a lack of supraganglionic ablation. After Adson¹ in 1924 first described the basic intradural approach of sectioning the glossopharyngeal nerve based on cadaveric dissection, Dandy⁶ in 1927 was the first to report sectioning of the glossopharyngeal nerve intradurally. Later it was noted that even though short-term results were good after these procedures, long-term pain recurrence was frequent and the sectioning of certain rootlets of the vagus nerve might improve long-term outcomes.^{2,20} Since

then, the combined procedure of GPNR+VNR became the main treatment for GPN, until it was gradually replaced by the MVD procedure in recent years.

Although many series have advocated rhizotomy of the upper rootlets of the vagus nerve in addition to rhizotomy of the glossopharyngeal nerve, we failed to find a satisfactory explanation for the rationale underlying this option. It seems that this option may be considered an anecdotal therapeutic procedure, with its main support based on limited series with fewer patients.^{2,20}

The limited experience obtained from our series is obviously not enough to advocate GPNR alone as a reliable procedure for the treatment of GPN; however, the promising outcomes obtained encourage us to speculate that the option is at least valuable for a subgroup of patients with GPN.

Conclusions

In general, our study indicates that GPNR alone or in combination with VNR is a safe, simple, and effective option for treating GPN. We assume that this option may be especially valuable for patients who are not suitable for the MVD procedure and for surgeons who do not have much experience with the MVD technique. Moreover, as its major purpose, our study renews the significance of GPNR alone, which we believe is at least effective for a subgroup of patients with GPN.

References

- Adson AW: The surgical treatment of glossopharyngeal neuralgia. *Arch Neurol Psychiatry* **12**:487–506, 1924
- Bohm E, Strang RR: Glossopharyngeal neuralgia. *Brain* **85**:371–388, 1962
- Ceylan S, Karakuş A, Duru S, Baykal S, Koca O: Glossopharyngeal neuralgia: a study of 6 cases. *Neurosurg Rev* **20**:196–200, 1997
- Chawla JC, Falconer MA: Glossopharyngeal and vagal neuralgia. *BMJ* **3**:529–531, 1967
- Dallessio DJ: Diagnosis and treatment of cranial neuralgias. *Med Clin North Am* **75**:605–615, 1991
- Dandy WE: Glossopharyngeal neuralgia (tic douloureux). Its diagnosis and treatment. *Arch Surg* **15**:198–214, 1927
- Ferrolli P, Fioravanti A, Schiariti M, Tringali G, Franzini A, Calbucci F, et al: Microvascular decompression for glossopharyngeal neuralgia: a long-term retrospective review of the Milan-Bologna experience in 31 consecutive cases. *Acta Neurochir (Wien)* **151**:1245–1250, 2009
- Fraioli B, Esposito V, Ferrante L, Trubiani L, Lunardi P: Microsurgical treatment of glossopharyngeal neuralgia: case reports. *Neurosurgery* **25**:630–632, 1989
- Fromm GH: Clinical pharmacology of drugs used to treat head and face pain. *Neurol Clin* **8**:143–151, 1990
- Gaul C, Hastreiter P, Duncker A, Naraghi R: Diagnosis and neurosurgical treatment of glossopharyngeal neuralgia: clinical findings and 3-D visualization of neurovascular compression in 19 consecutive patients. *J Headache Pain* **12**:527–534, 2011
- Gilron I, Watson CP, Cahill CM, Moulin DE: Neuropathic pain: a practical guide for the clinician. *CMAJ* **175**:265–275, 2006
- Headache Classification Subcommittee of the International Headache Society: The International Classification of Headache Disorders: 2nd edition. *Cephalalgia* **24** (Suppl 1):9–160, 2004
- Jannetta PJ: Microsurgery of cranial nerve cross-compression. *Clin Neurosurg* **26**:607–615, 1979
- Jannetta PJ: Neurovascular compression in cranial nerve and systemic disease. *Ann Surg* **192**:518–525, 1980
- Kandan SR, Khan S, Jeyaretna DS, Lhatoo S, Patel NK, Coakham HB: Neuralgia of the glossopharyngeal and vagal nerves: long-term outcome following surgical treatment and literature review. *Br J Neurosurg* **24**:441–446, 2010
- Katusic S, Williams DB, Beard CM, Bergstralh E, Kurland LT: Incidence and clinical features of glossopharyngeal neuralgia, Rochester, Minnesota, 1945–1984. *Neuroepidemiology* **10**:266–275, 1991
- Kawashima M, Matsushima T, Inoue T, Mineta T, Masuoka J, Hirakawa N: Microvascular decompression for glossopharyngeal neuralgia through the transcondylar fossa (supracondylar transjugular tubercle) approach. *Neurosurgery* **66** (6 Suppl Operative):275–280, 2010
- Koopman JS, Dieleman JP, Huygen FJ, de Mos M, Martin CG, Sturkenboom MC: Incidence of facial pain in the general population. *Pain* **147**:122–127, 2009
- Laha RK, Jannetta PJ: Glossopharyngeal neuralgia. *J Neurosurg* **47**:316–320, 1977
- Love JG: Diagnosis and surgical treatment of glossopharyngeal neuralgia. *Surg Clin N Am* **24**:959–962, 1944
- Manzoni GC, Torelli P: Epidemiology of typical and atypical craniofacial neuralgias. *Neurol Sci* **26** (2 Suppl 2):s65–s67, 2005
- Patel A, Kassam A, Horowitz M, Chang YF: Microvascular decompression in the management of glossopharyngeal neuralgia: analysis of 217 cases. *Neurosurgery* **50**:705–711, 2002
- Rushton JG, Stevens JC, Miller RH: Glossopharyngeal (vago-glossopharyngeal) neuralgia: a study of 217 cases. *Arch Neurol* **38**:201–205, 1981
- Sampson JH, Grossi PM, Asaoka K, Fukushima T: Microvascular decompression for glossopharyngeal neuralgia: long-term effectiveness and complication avoidance. *Neurosurgery* **54**:884–890, 2004
- Sicard R, Robineau V: Algie velo-pharyngee-essentielle: traitement chirurgical. *Rev Neurol (Paris)* **36**:256–257, 1920
- St John JN: Glossopharyngeal neuralgia associated with syncope and seizures. *Neurosurgery* **10**:380–383, 1982
- Taha JM, Tew JM Jr: Long-term results of surgical treatment of idiopathic neuralgias of the glossopharyngeal and vagal nerves. *Neurosurgery* **36**:926–931, 1995
- Weisenberg TH: Cerebello-pontine tumor diagnosed for six years as tic douloureux; the symptoms of irritation of the ninth and twelfth cranial nerves. *JAMA* **54**:1600–1604, 1910

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

Conception and design: Ma, Li. Acquisition of data: Q Wang, B Wang. Analysis and interpretation of data: Ma. Drafting the article: Ma. Critically revising the article: Ma, Li. Reviewed submitted version of manuscript: Ma. Approved the final version of the manuscript on behalf of all authors: Ma. Statistical analysis: Q Wang. Administrative/technical/material support: Huang.

Correspondence

Yi Ma, 2nd Department of Neurosurgery, Liaoning Provincial People's Hospital, No. 33, Wenyi Rd., Shenhe District, Shenyang 110016, China. email: doctormayyi@126.com.