Original Article
Relevant influential factors and therapeutic efficacy evaluation of microvascular decompression for hemifacial spasm

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Abstract: To evaluate the clinical therapeutic effect of microvascular decompression (MVD) for hemifacial spasm (HFS) and to analyze the potential influential factors relevant to the therapeutic efficacy of MVD. A total of 198 consecutive patients with typical HFS who underwent MVDs were incorporated in this study. Clinical data of incorporated patients were analyzed retrospectively, including therapeutic efficacy and complications. Logistic regression analysis analyzed relevant factors influencing the efficacy of MVD. There were 149 (75.25%) patients achieved symptoms recovery following MVD, and 40 (20.20%) patients achieved symptoms relief, with a total effective rate of 95.45%. In both the univariate and multivariate analyses, the postoperative findings of clinical outcomes showed that age, intraoperative indentation of the degree of spasticity, and compressive pattern significantly affected clinical outcomes of patients following MVD. Further, recurrence of HFS occurred in 7 cases and 3 cases received re-operation during the follow-up period. The postoperative complications such as facial paralysis, tinnitus and cerebrospinal fluid leakage got recovered, while a part of patients with hearing loss had no improvement during the follow-up period. Collectively, MVD is a safe and effective strategy for HFS patients based on the decompression of the offending vessel as well as the monitoring of AMR disappearance intraoperatively. The present results should be cautiously accepted associated with further investigation including larger sample size and longer follow-up period to verify and broaden the present topic.

Keywords: Hemifacial spasm, microvascular decompression, abnormal muscle response, intraoperative monitoring

Introduction

Hemifacial spasm (HFS) is a relatively rare phenomenon of neuromuscular dysfunction, in other word, a syndrome of facial nerve hyperactive dysfunction, characterized by chronic, irregular, intermittent and involuntary facial muscle contractions on one side of the face [1, 2]. Individuals with spasm are extremely rare on both sides of the face [3]. This disease takes two forms: primary and secondary, of which most cases are classified into primary HFS [4]. Patients who had an arterial compression in the facial nerve at the end of the brain stem were classified or grouped as the primary HFS [5] and patients who had peripheral facial palsy or nerve lesion due to tumors, demyelination, trauma, or infection were on the other side grouped as secondary HFS [4]. HFS affects middle-aged or elderly women more frequently, besides, the prevalence of HFS increases with age, mainly between 40~60 and even higher for senior citizens aged over 70 years [6, 7]. Further, HFS is estimated to be much more common in some Asians [8]. It may be caused by a facial nerve injury, a tumor, or induced without any definite reasons [9]. Three theories exist that may be useful for the explanation of the facial nerve dysfunction in HFS, namely, demyelination or ephaptic transmission; abnormal axons activity at the facial nerve root end zone; or the increased excitability of the facial nerve nucleus due to feedback from a damaged facial nerve [10, 11]. Mild HFS may be managed with anticonvulsant drugs including carbamazepine, which has been shown to have a relatively poor effect on the relief of the HFS symptoms [12], and local botulinum toxin injection [13;

importantly, microsurgical decompression is the current main treatments used for HFS especially if above mentioned drugs treatment choices are not effective [14, 15].

Microvascular decompression (MVD), using the Jannetta procedure, is a conservative method aiming at decompressing offending vessels and also at freeing the entire root to the trigeminal root entry zone [16, 17]. MVD appears to be the most popular surgical treatment at present and is suggested to be a commonly neurosurgical procedure treating trigeminal neuralgia and HFS [15, 18, 19]. The procedure of MVD may contribute to the relief of pressure on the facial nerve, which is exactly the predominant cause of most HFS cases [20]. Clinically, excellent to good results are reported in a majority of HFS cases following the management of MVD, associated with a relatively higher cure rate [21]. Nevertheless, the spasm still remains following MVD, which has still been reported in some cases, even when performed by experienced surgeons [22]. These include cerebellar haematoma or swelling, blocking of the blood vessel of the brain stem, cerebral infarction resulting from a disturbance in the blood vessels supplying blood to the brain, as well as subdural haematoma [9]. Death or permanent disability such as hearing loss can also occur in a few of patients with HFS [23]. With respect to the above interpretation, this study was designed to evaluate clinical outcomes of MVD for HFS and to analyze potential influential factors relevant to the therapeutic efficacy of MVD.

Materials and methods

Patients' selection

From March 2008 to June 2010, a total of 198 consecutive outpatients with typical HFS who underwent MVDs at the Second Affiliated Hospital, Qiqihar Medical College were incorporated in this study. Diagnosis criteria of HSF were listed as follows: (1) Symptoms of patients: involuntary, painless, clonic convulsions of face muscles on one side, and majority of patients started from eyelid downward gradually to the mouth in the course of the disease; twitch duration prolonged gradually (from a few seconds to a few minutes), with interval time shortened and symptoms fluctuated gradually. (2) Combined with the mentioned clinical typical symptoms, the diagnosis of HFS was confirmed

with a conventional complete neurological examination, including magnetic resonance imaging (MRI) and computed tomography pre-operatively to rule out other diseases such as tumors and secondary HFS. Further, all patients underwent pre-operative 3D-TOF MRI scan to make clear the relationship between the facial nerve and the suspicious vessels. In addition, facial electromyograms and brainstem auditory evoked potentials were recorded with surface electrodes from the orbicularis oculi muscles using Viking IV EMG equipment (Nicolet Biomedical. Instrument, Madison, WI, USA). Inclusion criteria: (1) patients who had a definite diagnosis of HFS; (2) no positive signs of nervous system characteristics were found in the preoperative examination except the symptom of facial spasm; (3) patients who received MVD treatments and could provide complete clinical information records. Exclusion criteria: (1) secondary HFS patients due to malignant tumors attack and/or who had a previous administration history of certain drugs; (2) patients who had serious systemic diseases; (3) patients who underwent re-operation were also excluded from this study. According to the investigation [24] regarding the criteria of spasticity classification, the degree of intensity in HFS patients before and during the operation was divided into the following five stages: (1) grade 0, no spasm; (2) grade I, external stimuli lead to blink increase or mild hemifacial fibrillation; (3) grade II, eyelid hemifacial spontaneous tremble slightly without dysfunction; (4) grade III, spasm showed a slight impairment; (5) grade IV, severe spasticity and functional impairment that influence daily life and work. All included patients were diagnosed with at least grade II HFS.

Data collection

Follow-up information of patients who meet the above selection criteria were retrospectively analyzed in this study. Account for the specific informed consent of the study was introduced to the patients and their family members. Registration of patients' general information, chief complaint, present illness, past history and preoperative physical examination was conducted preoperatively carefully. Recording of the severity of HFS, routine physical examination results, preoperative and postoperative type of responsibility vessels, postoperative results and follow-up, and the occurrence of

complications was also performed timely during and after the operation. Contents of follow-up information including HFS symptom remission (healing, delayed healing, recurrence and invalid), complications (paralysis, cerebrospinal fluid leakage, tinnitus, deafness, hearing loss, intracranial hematoma, cerebral infarction, etc.) were carefully collected for the evaluation of the operative curative effect.

Operative procedure

Via a lateral retrosigmoid suboccipital approach, MVD was performed in accordance with the referred standardized procedures, as it has been well described previously in the literature [25, 26]. All surgeries were conducted at our institution by single surgeon at a single medical center. Under general anesthesia, patients were informed to keep in their lateral decubitus position. After opening the bone window (~3 cm) in the posterior auricular region with a sub occipital straight incision, the dura mater was further opened after the identification of the edge of the sigmoid sinus. Subsequently, with the opening of the dura mater and the arachnoids, the cerebellum was gently retracted to expose the entire intracranial facial nerve that was compressed by the arteries/veins. The vessel that compressed the facial nerve was recorded as the compressing vessel. Isolation of facial nerve and peripheral nerve was then performed to locate and separate the responsible vessels. Five to ten soft Teflon felt and thread (DuPont, Wilmington, DE, USA) were inserted between the facial nerve and the offending vessel. As a result of the operative procedure, the facial nerve was freed from the offending vessel.

Before anesthesia intubation, a preoperative abnormal muscle response (AMR) monitoring was performed to confirm if AMR could be induced successfully. The latency, amplitude and stimulus parameters of AMR were recorded as baseline reference values. Further, intraoperative monitoring of AMR was achieved from the mentalis muscle by electrical stimulation of the temporal branch of the facial nerve and from the orbicularis oculi muscles by stimulation of the marginal mandibular branch, with an evoked potential system (Medtronic Keypoint 4, Dantec, Denmark). Electrical stimulation and electromyographic recordings were filtered through a 5 Hz to 3 kHz band pass (gain:

500 mV/division; analysis time: 50 ms). Usually, a stable AMR was recorded at a stimulation intensity level of 5e15 mA. To avoid nerve fatigue, the AMR was evoked and recorded with a 5-min interval before dura opening. Once the dura was opened, the AMR was recorded continuously until the end of the operation. In the identification and management of possible responsible blood vessels, continuous stimulation mode was applied. When the AMR was found to be persistent despite decompression had been done, any other suspected underlying causes such as possible compression by another vessel were further looked for until the confirmation that there was no further neurovascular confliction in the entire nerve root course.

Outcome evaluation

Postoperative outcomes evaluation was performed by a specialized nurse practitioner, who was uninformed with the all the patients' intraoperative findings. Telephone interview and outpatient follow-up were used. Postoperative 1 week curative effect meant a short-term effects after MVD management. Postoperative long-term follow-up review was available for 24 to 48 months in 93.94% of the patients (186/198) with a median period of 28 months. The postoperative result was judged according to the Cohen classification on the degree of spasticity: (1) recovery, the degree of spasticity was decreased from grade II~IV to 0; (2) remission, spasm disappeared but there was no obvious degree decreasing into grade 0; (3) no relief, decrease in spasms was unchanged; (4) recurrence, the symptoms of the patients appeared again after the disappearance of those symptoms at least 3 months after the operation. Total effective rate = recovery rate + remission rate.

Statistical analyses

All data were analyzed using SPSS program (version 17.0 SPSS Inc., Chicago, IL, USA) and simple descriptive statistics of patients' baseline characteristics were reported. Age, gender, spasm side, preoperative symptomatic period, compressive pattern by offending vessel, and clinical outcome at each time of follow-up were all investigated and further compared using the χ^2 test. Univariate and ordinal muticategorical logistic regression analyses were used to

Table 1. Basic information and univariate analyses of the variables evaluated for the association with the clinical outcomes in hemifacial spasm patients received microvascular decompression

		N	Clinical efficacy			χ^2	P
			Recovery	Remission	Ineffective		
Gender	Male	92	65 (70.65%)	25 (27.17%)	2 (2.18%)	-1.146	0.252
	Female	106	84 (79.25%)	15 (14.15%)	7 (6.60%)		
Age	22~40 years	99	65 (65.66%)	30 (30.30%)	4 (4.04%)	6.448	0.040
	41~60 years	74	62 (83.78%)	9 (12.16%)	3 (4.06%)		
	> 60 years	25	19 (76%)	4 (16%)	2 (8%)		
Diseased region	Left	112	86 (76.78%)	23 (20.54%)	3 (2.68%)	-0.710	0.477
	Right	86	63 (73.25%)	17 (19.77%)	6 (6.98%)		
Course of disease	1~3 years	88	65 (73.86%)	20 (22.73%)	3 (3.41%)	0.285	0.867
	4~6 years	72	54 (75%)	14 (19.44%)	4 (5.56%)		
	> 6 years	38	30 (78.95%)	6 (15.79%)	2 (5.26%)		
Preoperative degree of spasticity	Stage II	30	22 (73.33%)	6 (20%)	2 (6.67%)	117.250	0.726
	Stage III	53	38 (71.70%)	13 (24.53%)	2 (3.77%)		
	Stage IV	115	89 (77.39%)	21 (18.26%)	5 (4.35%)		
Postoperative degree of spasticity	Stage II	36	30 (83.33%)	6 (16.67%)	0 (0%)	33.424	< 0.001
	Stage III	24	19 (79.17%)	5 (20.83%)	0 (0%)		
	Stage IV	22	7 (31.82%)	6 (27.27%)	9 (40.91%)		
	0	116	93 (80.17%)	23 (19.83%)	0 (0%)		
Compressive pattern	With contact	127	96 (75.59%)	26 (20.47%)	5 (3.94%)	-0.205	0.838
	Without contact	71	53 (74.65%)	14 (19.72%)	4 (5.63%)		
Intraoperative indentation	With	117	107 (91.45%)	9 (7.69%)	1 (0.86%)	-6.363	< 0.001
	Without	81	42 (51.85%)	31 (38.27%)	8 (9.88%)		
Offending vessels numbers	Single vessel	153	115 (75.16%)	33 (21.57%)	5 (3.27%)	-0.138	0.890
	Multiple vessels	45	34 (75.55%)	7 (15.56%)	4 (8.89%)		
Intraoperative AMR monitoring	Disappearance	163	129 (79.14%)	33 (20.25%)	1 (0.61%)	-3.268	0.001
	Appearance	35	20 (57.14%)	7 (20%)	8 (22.86%)		
Postoperative 1 week curative effect	Recovery	121	93 (76.86%)	23 (19.01%)	5 (4.13%)	4.881	
	Remission	63	49 (77.78%)	11 (17.46%)	3 (4.76%)		0.087
	Ineffective	14	7 (50%)	6 (42.86%)	1 (7.14%)		

Note: AMR, abnormal muscle response. Intraoperative degree of spasticity was confirmed based on the criteria mentioned by Shorr N, Seiff SR and Kopelman J, all included patients were diagnosed with at least grade II degree of HFS. Compressive pattern subgroup was divided based on the existence compression of facial nerve during operation. Postoperative 1 week curative effect meant a short-term effects after MVD management. Indentation: the degree of indentation of facial nerve during operation; Compression: the relationship of possible responsible blood vessels with facial nerve. The comparison of parameters including age, gender, spasm side, preoperative symptomatic period, compressive pattern by offending vessel, and follow-up outcomes were performed using the χ^2, $P < 0.05$ showed statistical difference.

assess the relevant variables that affect the clinical outcome of HFS patients after MVD. The level for statistical significance was a probability value of less than 0.05.

Results

General data

In view of the included eligible subjects, there were a total of 72 males and 126 females (female-to-male ratio: 1.75:1), with an average age of 48.8 years old (ranging from 22 to 75 years old). The right side was affected in 112 patients and the left in 86 cases. The length between onset and surgical operation ranged from 1 to 28 years (mean time of 4.9 ± 3.4 years). Among the 198 incorporated consecutive patients with typical HFS who underwent MVD in this study, a total of 149 cases (75.25%) of patients achieved symptoms recovery following MVD, and 40 cases (20.20%) of patients achieved symptoms relief, with a total effective rate and inefficiency rate of 95.45% and 4.55%, respectively. The detailed distribution of the variables evaluated for the association with the clinical outcomes were given in **Table 1**.

Logistic analyses regarding prognostic factors

In the univariate analyses, the postoperative findings of clinical outcomes showed that

Table 2. Muticategorical regression analysis of variables for the association with the clinical outcomes in hemifacial spasm patients received microvascular decompression

	β	Std. Error	Wald	df	P	95% Confidence Interval	
						Lower Bound	Upper Bound
Age	1.025	0.569	3.250	1	0.071	-0.089	2.140
Course of disease	0.381	0.569	0.448	1	0.503	-0.734	1.496
Preoperative degree of spasticit	0.322	0.333	0.931	1	0.334	-0.331	0.975
Postoperative degree of spasticit	1.222	0.303	16.294	1	< 0.001	0.629	1.816
Gender	-1.831	0.701	6.820	1	0.009	-3.205	-0.457
Desease region	0.935	0.562	2.770	1	0.096	-0.166	2.035
Compressive pattern	1.525	0.646	5.572	1	0.018	0.259	2.792
Intraoperative indentation	-0.320	0.418	0.585	1	0.444	-1.138	0.499
Offending vessels numbers	0.227	0.637	0.128	1	0.721	-1.021	1.476
Intraoperative AMR monitoring	1.267	0.688	3.388	1	0.066	0.082	2.616

Note: Std. Error, standard error; df, degree of freedom; AMR, abnormal muscle response. Multiple logistic regression analysis was applied to search for relevant prognostic factors. $P < 0.05$ was considered as statistical significance.

patients' gender, spasm side, preoperative symptomatic period, degree of spasticity, compressive pattern by offending vessel, and the number of offending vessels all showed none apparent association with the clinical efficacy of patients after MVD (all $P > 0.05$). In contrast, patients with age over 60 years, with intraoperative severe indentation of the root exit zone of the facial nerve, as well as accompanied with the disappearance of AMR were on the other side showed evident influence in the clinical efficacy of patients following MVD, rather than age less than 60 years, without or with minimal indentation and the presence of AMR. Above results suggested that senior ages, visible severe indentation of the root exit zone of the facial nerve intraoperatively and AMR-disappearance were all associated with better clinical curative effect in the follow-up period (all $P < 0.05$) (seen in **Table 1**).

As presented in **Table 2**, in the multiple logistic regression analysis, all variable parameters, including age, gender, diseased region, course of disease, intraoperative degree of spasticity, compressive pattern, intraoperative indentation of the root exit zone of the facial nerve, offending vessels numbers, and intraoperative AMR monitoring, were further analyzed to confirm the relationship with clinical short-term outcomes (postoperative 1 week curative effect) of microvascular decompression for hemifacial spasm. The results indicated that age and intraoperative indentation of the degree of spasticity, and compressive pattern could significantly affect the clinical outcome of

patients following MVD (all $P < 0.05$). Yet there was no significant association of age, diseased region, course of disease, intraoperative indentation of the root exit zone of the facial nerve, offending vessels numbers, and intraoperative AMR monitoring with the clinical outcome of patients following MVD (all $P > 0.05$).

Complications

During the period of follow-up for 24 to 48 months, recurrence of HFS was estimated to occur in 7 cases (3.5%), and 3 cases underwent re-operation again. Postoperative spasm was observed to be relieved in patients at different degrees, but only 1 cases were finally cured. No mortality or severe complications occurred early postoperatively except facial paralysis in 25 cases, hearing loss in 17 cases, tinnitus in 9 cases, and cerebrospinal fluid leakage in 3 cases. Further, the recovery of facial paralysis, tinnitus and cerebrospinal fluid leakage were all achieved during the follow-up period with the exception of 3 cases of hearing loss who still had hearing impairment.

Discussion

Root exit zone compression of the facial nerve is the predominant pathogenesis and electrophysiological basis of HFS [27]. Due to a long-term vascular compression of the nerve root, the loosening of sheath structure and the degeneration of myelinated axons may lead to the degeneration and hyperfunction of nerve roots [28]. Besides, abnormalities in neural cir-

cuitry may eventually result in abnormal discharge in the neurons [29]. At present, it has been suggested that MVD is one of the major means for the treatment of HFS. For example, Sekula RF Jr and his colleagues found in their experiment that twenty-six (96.3%) elderly patients and 93 of 104 (89.4%) young patients reported a spasm-free status during the period of follow-up following MVD treatment [6]. In the present study, the total effective rate was 95.37% in HFS patients after treatment with MVD, which was in line with the above report.

Univariate analyses supported that the intraoperative indentation of the root exit zone of the facial nerve and disappearance of AMR were major variables that might have significant association with the clinical outcome of HFS patients following MVD management. With respect to the severity of intraoperative indentation of the root exit zone of the facial nerve, as has been proved in our study, it can predict the clinical outcomes. Our result indicated that patients with severe indentation of the root exit zone of the facial nerve had rather better outcomes than those patients with no or mild indentation of the root exit zone, highlighting the value of finding the optimal site for decompression of the root exit zone for surgeon. Generally, the target of MVD should be anterior inferior cerebellar artery or posterior inferior cerebellar artery in root exit zone [30]. The presence of indentation of the root exit zone of the facial nerve intraoperatively might be a direct evidence supporting that the facial nerve was compressed by vascular [31]. In accordance with our results, Jin Y and his colleagues supported in their findings that indentation of the root exit zone might be one of the critical factors for the prediction of possible prognostic outcomes in MVD treated patients [31]. In addition, Kim HR cooperated with the other researchers demonstrated that intraoperative identification of root exit zone indentation did help greatly to physicians regarding the determination of clinical outcomes in patients with HFS following MVD [32]. However, multivariate analyses failed to illustrate such relationship; besides, as for compressive pattern, even though patients showing a contact of offending vessels with the facial nerve postoperatively was suggested to be related to the clinical outcomes of HFS patients in the multivariate analyses, there were no apparent associations in the univariate analyses and multivariate analy-

ses of the preoperative statistical analysis. In any case, whether there was a contact of offending vessels with the facial nerve should be carefully detected before, during and after the operation to exclude the possibility of compression by veins and arteriole or distal compression.

Also importantly, with respect to the AMR monitoring, the disappearance of AMR was found to have a closely association with the removal of the offending vessels. In this study, intraoperative monitoring of AMR was all most disappeared, with which a relatively higher total effective rate was found when compared to the patients without the disappearance of AMR. Intraoperative AMR monitoring therefore might be helpful for the prediction of HFS prognostic outcomes after MVD management and the decrease of intraoperative complication incidence. As has been described in other reports, intraoperative AMR monitoring, a major electrophysiological features in HFS patients, has been widely applied for the identification of the offending vessels, and the confirmation of the compression/decompression situations of the facial nerve [33]. Generally, AMR disappearance after decompression might suggest a successful identification of the offending vessel as well as the isolation of the offending vessel and facial nerve for the elimination of the spontaneous activities [22]. Accordingly, after interposition of Teflon balls, the AMR-disappearance was also shown in our experiment, which in turn suggested a successful decompression of the offending vessels. Nevertheless, in some case, AMR did not disappear after the isolation of facial nerve and offending vessels [22, 34, 35], which precluded the identification of real offending vessels, there might be multiple offending vessel that were overlooked; or just due to the insufficient nerve decompression, or incorrect padding of cotton Telfon. After further examination and treatment, the monitoring of AMR-disappearance can contribute a lot to the guidance of right offending vessels and contribute to identifying the location of facial nerve compression, and eventually, to ensure an adequate decompression of the causative nerve. However, cox multivariate analyses of this study failed to prove the possible relationship between disappearances of AMR and the clinical outcome of patients following MVD, which might associated with the restriction of the included subjects, future large sample size

investigation should be involved to confirm the role of AMR monitoring.

In conclusion, MVD is a safe and effective strategy for HFS patients based on the decompression of the offending vessels, compression patterns as well as the monitoring of AMR disappearance intraoperatively. Further longer duration of follow-up postoperatively is required in order to predict the outcome of MVD for HFS and to include more relevant parameters that may have an influence in the prognostic outcomes of patients. However and importantly, the results of the present study should be accepted cautiously since clinical outcomes related to AMR and indentation or other factors were difficult to support the given high rate of surgical success comprehensively. The efficacy of MVD in the management of HFS regarding the decompression of the offending vessels and AMR monitoring should be verified by a large amount of future large sample size studies urgently.

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Disclosure of conflict of interest

None.

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