Effectiveness and Safety of Microvascular Decompression Surgery for Treatment of Trigeminal Neuralgia: A Systematic Review

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Abstract: Microvascular decompression has been now accepted worldwide as a reasonable treatment for trigeminal neuralgia, yet, as a functional operation in the cerebellopontine angle, this process may be risky and the postoperative outcomes might not be good enough sometimes. To assess the effectiveness and safety of microvascular decompression for treatment of trigeminal neuralgia, we conducted a systematic review. Using the keywords “trigeminal neuralgia”, “microvascular decompression”, or “neurovascular conflict”, manuscripts published in English-language journals and indexed in PubMed between January 1, 2000 and June 1, 2013 on the treatment of trigeminal neuralgia (TN) with microvascular decompression were considered for this study. The success and complications were analyzed. The success in this investigation was defined as complete pain free. Continuous outcomes were summarized using means or medians, and dichotomous outcomes were presented as percentage associated with 95% confidence interval. Twenty-six papers with 6,847 patients were finally enrolled in this review. Among them, the male-to-female ratio was 1:1.4, the left-to-right ratio was 1:1.6, and the pain was located in the innervation of V3 and/or V2 in most of the cases with only 2.3% (0.1–4.7) of V1 exclusively. The average age at surgery was 60.9 years (52.5–64.1) with TN symptoms duration of 24.7 months (6.1–42.1) before microvascular decompression (MVD). Operative findings confirmed the superior cerebellar artery, anterior inferior cerebellar artery, posterior inferior cerebellar artery, and multiple vascular contacts (including veins) as the most common sources of nerve compression. The average follow-up duration was 35.8 months (26.2–56.6). The success rate was 83.5% (79.6–89.1). Complications included incisional infection in 1.3% (0.1–2.5), facial palsy 2.9% (0.5–6.2), facial numbness 9.1% (1.3–19.6), cerebrospinal fluid leak 1.6% (0.7–2.5), and hearing deficit 1.9% (0.2–3.9). The postoperative mortality was 0.1% (0.02–0.2). Accordingly, MVD is the most effective treatment for patients with trigeminal neuralgia. An immediate pain free can be achieved by an experienced neurosurgeon with good knowledge of the regional anatomy. To avoid complications, each single step of the process cannot be overemphasized.

Key Words: Trigeminal neuralgia, microvascular decompression, neurovascular conflict

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Trigeminal neuralgia (TN) is one of the most painful conditions in human clinical practices, which is defined as unilateral disorder characterized by brief electric shock–like pains, abrupt in onset and termination, and limited to the distribution of one or more divisions of the trigeminal nerve.1–3 The incidence of the disease has been reported as 4 to 5 per 100,0004,5 or even higher.6 In 90% of the cases, the symptoms appear in late forties with a bit higher prevalence in Oriental women. The pain might be triggered by daily activities such as drinking, eating, brushing teeth, and so on.

According to the classification of the International Headache Society, the disease can be classified as primary or idiopathic and symptomatic or secondary.7,8 Whatever, most of them are etiologically caused by cerebellovascular compression of the trigeminal root, no matter if directly or indirectly pushed by neoplasms or adhesions in the cerebellopontine angle.9,10 Nevertheless, the pathophysiology of the disease have not been well understood today. It was speculated that an ephaptic transmission occurred at the micro-injury site of the trigeminal nerve fibers compressed by a vessel, which may also result in hyperexcitability of the trigeminal nucleus.11 This ephaptic conduction may be caused by segmental demyelination and artificial synapse formation.12,13 When ephaptic transmission signals from large-diameter partially demyelinated A fibers conducted to small-diameter poorly myelinated A-delta and unmyelinated nociceptive C fibers, it results in paroxysmal facial pain.14 Anyway, we thought the mechanism of the attack could be reduced as ectopic impulses that emerged from the trigeminal nerve fibers at the site of neurovascular conflict, and our preliminary study implied that the sympathetic endings in the adventitia of the offending vessel may trigger those excitabilities.

Speaking of the treatment, the patients would firstly take medications, for example, carbamazepine.15 Thought to relieve the symptoms of some patients in the early stage, those antiepileptic drugs have many side effects and the patient would resist against it with time. The other choices are those ablative procedures, such as glycerol injections,16 radiosurgery (gamma knife),17,18 radiofrequency rhizotomy,19–23 and so on. Partial sensory rhizotomy has now rarely
been performed for TN because of its higher recurrence and intolerable dysesthesia due to nerve damage. Gamma knife radiosurgery is less invasive with 30% to 80% of effective rate, but it takes 1 to 2 months before it works and have 3% to 54% chances of paresthesia and dysesthesia. Regardless of being less invasive, the aforementioned treatments would leave facial numbness at cost and have higher recurrence rates.

Since microvascular decompression (MVD) was first introduced by Dandy and then popularized by Janetta in the last century, it has been thought to be the most reasonable technique to treat TN. Nevertheless, this sort of surgical process is still with risk because of those delicate cerebellopontine structures. Moreover, until now, some of the patients cannot partly or totally relieve their symptoms when they experienced the MVD. Accordingly, we need to be knowledgeable about the effectiveness and safety of MVD.

There are many retrospective cases that have been reported regarding TN treatment with MVD these years. However, no concerted effort has been made to synthesize the totality of date on this topic. Therefore, we conducted this systematic review on the effectiveness and safety for the treatment of TN. We have collected most of the full-text literatures including our experiences with thousands of MVDs which are published in PubMed from 2000 through 2013.

PATIENTS AND METHODS

Information Sources and Eligibility Criteria

Studies that were eligible for consideration in this systematic review were articles published in English-language journals and indexed in PubMed between January 1, 2000 and June 1, 2013 on the treatment of TN with MVD (Table 1). The keywords “trigeminal neuralgia” or “microvascular decompression” or “neurovascular conflict” were used for the primary search. Additionally, the bibliographies of relevant articles were also scanned for additional references.

Data Analysis

The following variables were recorded in a predesigned database, such as: general information (author, year, surgery period, sample size, duration of symptoms, offending vessels, treatment success (before discharge and overall), reoperation, follow-up duration, and adverse events including incisonal infection, facial palsy (permanent and transient), facial numbness, hearing deficit (permanent and transient), cerebrospinal fluid leak, and even mortality. The definition of treatment success was consistent with complete resolution (excellent outcome). Continuous outcomes were summarized using means or medians, and dichotomous outcomes were presented as percentage with the associated 95% confidence interval (CI).

RESULTS

Study Enrolled

An initial search retrieved 122 articles. Those article types of letter, correspondence, case report, or case series with sample size under 8 (n = 28) were excluded and those publications in a non-English journal (n = 48) were also rejected. Of these 46 papers, 14 were rejected due to lack of relevant outcomes and 6 due to a biased cohort of only successful cases. Ultimately, 26 papers representing 6,847 distinct patients treated with MVD for TN were included in the final analysis.

Study Characteristics

Among the 6,847 TN patients, the ratio of male versus female was 1:1.4, left versus right was 1:1.6, and the pain was located in the innervation of V3 and/or V2 in most of the cases with only 2.3% (95% CI: 0.1–4.7) of V1 exclusively. The average age at surgery was 60.9 years (95% CI: 52.5–64.1) with TN symptoms duration of 24.7 months (95% CI: 6.1–42.1) before MVD. Operative findings confirmed the superior cerebellar artery, anterior inferior cerebellar artery, posterior inferior cerebellar artery, and multiple vascular contacts (including veins) as the most common sources of nerve compression. The average follow-up duration was 35.8 months (95% CI: 26.2–56.6).

Success Rates

Because the evaluating criteria varied in different centers, we set the scale of success as complete symptom relief (pain free). Accordingly, we obtained a mean postoperative success rate of 83.5% (95% CI: 79.6–89.1). Approximately 11.1% (95% CI: 4.9–19.1) of the patients with symptom recurrence resorted to repeated MVD during the follow-up period.

Complications

We found transient complications that included incisonal infection in 1.3% (95% CI: 0.1–2.5), facial palsy in 2.9% (95% CI: 0.5–6.2), facial numbness in 9.1% (95% CI: 1.3–19.6), hearing change in 1.9% (95% CI: 0.2–3.9), and cerebrospinal fluid leak in 1.6% (95% CI: 0.7–2.5). The mortality of all the patients is 0.1% (95% CI: 0.02–0.2).

DISCUSSION

Our investigation demonstrated a high success rate that has been obtained by MVD surgery. As the neurovascular confliction theory has been accepted worldwide as the etiology of the disease, this process should give rise to an immediate pain free once the offending vessel was removed from the trigeminal nerve. Nevertheless, the common cure rate was found to be less than 90% in this research, which implied that this process needs to be further refined.

Although it is an effective treatment for TN, MVD has potential risks for delicate cerebellopontine structures in such a small operation room. In this review, we found that MVD may be a cause of death. It is disastrous not only for the patient and his or her relatives but also for the operator, which may frustrate those young neurosurgeons from working on it unceasingly. The main reason for the disaster was cerebellar hemorrhage postoperatively, which often resulted from excessive retraction of the brain or improper management of the petrosal veins. As a matter of fact, MVD is a relatively safe surgery as long as the operator has a very good understanding of anatomy in the cerebellopontine angle. Normally, a surgical corridor is established by a sharp microdissection of the arachnoid and a slow suction of cerebrospinal fluid rather than by using retracting blades. Actually, a narrow suction tube allows more mobility and can actually afford more working space than a wider spatula does during the operation at a moment when a specific region is dissected for one does not need to look everywhere while manipulating in a specific site (but those surrounding anatomical structures should always be in mind). To prevent unintentional tearing of petrosal veins especially at its entry to the superior petrosal sinus, some neurosurgeons would sacrifice them, which was proved to have a risk of delayed intracerebellar hemorrhage. To detour off petrosal veins, we suggest a new entry corridor—a caudorostral approach. After opening cerebellar fissures, the root exit zone could
TABLE 1. Characteristics of Included Studies on MVD for Treatment of TN

<table>
<thead>
<tr>
<th>Study</th>
<th>Period</th>
<th>N (m/f)</th>
<th>Duration, mo</th>
<th>Age, yr</th>
<th>Offending Vessels</th>
<th>Success Rate</th>
<th>Redo MVD</th>
<th>Follow-up, mo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delitala (2001)</td>
<td>1996–2001</td>
<td>34 (NR)</td>
<td>82</td>
<td>62.5</td>
<td>A + V</td>
<td>87.5%</td>
<td>9.6%</td>
<td>24.7</td>
</tr>
<tr>
<td>Ishikawa (2002)</td>
<td>1997–2000</td>
<td>53 (NR)</td>
<td>NR</td>
<td>63.4</td>
<td>SCA 82%, V 8.4%, Non 9.6%</td>
<td>84.9%</td>
<td>9.4%</td>
<td>6–30</td>
</tr>
<tr>
<td>Ashkan (2004)</td>
<td>1991–2001</td>
<td>40 (14:26)</td>
<td>7</td>
<td>&gt;60</td>
<td>A + V</td>
<td>94.1%</td>
<td>5.9%</td>
<td>30–33</td>
</tr>
<tr>
<td>Pamir (2006)</td>
<td>1986–2004</td>
<td>90 (48:42)</td>
<td>7</td>
<td>59</td>
<td>A 92%, V 8%</td>
<td>96.7%</td>
<td>33.3%</td>
<td>&lt;12</td>
</tr>
<tr>
<td>Zhong (2008)</td>
<td>2000–2006</td>
<td>407 (109:208)</td>
<td>NR</td>
<td>64.6</td>
<td>V*</td>
<td>91.4%</td>
<td>8.6%</td>
<td>NR</td>
</tr>
<tr>
<td>Sandell (2008)</td>
<td>1999–2005</td>
<td>135 (64:71)</td>
<td>5</td>
<td>65</td>
<td>A 39.3%, V 18.5%, A + V 37.8%, Non 4.4%</td>
<td>77.3%</td>
<td>NR</td>
<td>38</td>
</tr>
<tr>
<td>Sindou (2009)</td>
<td>1983–1999</td>
<td>330 (165:165)</td>
<td>8.2</td>
<td>28–84</td>
<td>SCA 77%, AICA 6%, SCA + AICA 17%</td>
<td>80%</td>
<td>3.1%</td>
<td>98.4</td>
</tr>
<tr>
<td>Kabatas (2009)</td>
<td>1993–2006</td>
<td>62 (30:32)</td>
<td>&lt;20</td>
<td>21–79</td>
<td>SCA 33.9%, AICA 3.2%</td>
<td>95.2%</td>
<td>11.3%</td>
<td>50.4</td>
</tr>
<tr>
<td>Hong (2011)</td>
<td>2008–2011</td>
<td>15 (1:14)</td>
<td>5.2</td>
<td>55.6</td>
<td>V*</td>
<td>60%</td>
<td>0</td>
<td>19</td>
</tr>
<tr>
<td>Sekula (2011)</td>
<td>2007–2008</td>
<td>36 (11:25)</td>
<td>NR</td>
<td>73</td>
<td>A 33.3%, V 52.8%</td>
<td>86.1%</td>
<td>0</td>
<td>20</td>
</tr>
<tr>
<td>Koopman (2011)</td>
<td>2002–2004</td>
<td>87 (NR)</td>
<td>NR</td>
<td>65.8</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>12</td>
</tr>
<tr>
<td>Kondo (2012)</td>
<td>2006–2011</td>
<td>54 (NR)</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>70%</td>
<td>0</td>
<td>&gt;12</td>
</tr>
<tr>
<td>Zhong (2012)</td>
<td>2002–2011</td>
<td>1,274 (NR)</td>
<td>NR</td>
<td>8–90</td>
<td>SCA 41%, AICA 29%, V 35%, PICA 9%, VA 6%</td>
<td>88.3%</td>
<td>3.6%</td>
<td>36</td>
</tr>
<tr>
<td>Sandell (2013)</td>
<td>1999–2009</td>
<td>243 (98:145)</td>
<td>7.3</td>
<td>63.1</td>
<td>NR</td>
<td>90.3%</td>
<td>0</td>
<td>71</td>
</tr>
</tbody>
</table>

Success rate was defined as completely pain free after the operation.

AICA, anterior inferior cerebellar artery; PICA, posterior inferior cerebellar artery; V A, vertebral artery; SCA, superior cerebellar artery; BA, basilar artery; V*, this study only focused on vein; N (m/f), number (male:female); Duration, history of symptoms (mo); A, artery; V, vein; Redo MVD, reoperation; m, average or range month; y, average or range year; NR, not reported.

be visible directly. Basically, a microdissector assisted by a microsuction tube manipulated by the operator’s both hands are enough to complete all the decompression process, and the forceps (the action of clamping an artery may cause vasospasms) should be avoided. As a functional surgery, an even and smooth postoperative course is required. Those mild complications, such as dizziness, disequilibrium, nausea, and vomiting, also should be avoided as much as possible. It might be attributable to cerebellar laceration or pneumocrania. Therefore, one can never overemphasize each single step of the process. Before dura closure, the cranium should be full of warm normal saline to prevent postoperative low cranial pressure, which could be severe enough to induce a fatal acute epidural hematoma.

To avoid catastrophe, the patient should be closely monitored postoperatively. If the patient was observed awake from the anesthesia late or sleepy with cerebellar signs, an immediate computed tomography scanning is necessary. Usually, cerebellar and ventricular hemorrhages with brainstem shift may be discovered in those patients. In that case, an emergency open-brain surgery should be performed at once. In this time, we suggested to make a postmidline incision followed by a craniectomy covering both sides of cerebellum and extending to the original one. The craniectomy should be big enough to open the foramen magnum. After removal of all the cerebellar hematomas, the tonsils should be raised to remove the hematoma in the fourth ventricle, which may prevent hydrocephalus. With thorough irrigation to make sure there is no bleeding, the dura should be sutured in a watertight pattern, which may avoid potential cerebrospinal fluid (CSF) leak and infection. After the incision was closed, a CSF drainage via the frontal lateral ventricle was suggested.

CONCLUSIONS

With this systematic review, we believe MVD is an effective and safe surgery for treatment of TN, yet one should pay attention to every step of this process. We summarize our opinion as follows:

1. The patient’s head should be put in a proper position to facilitate cerebellar detaching from the petrous bone with its own gravity and without the use of retracting spatulas;
2. The craniectomy should be lateral enough to the transversal sinus;
3. A sharp microdissection of the arachnoid with slow suction of CSF is recommended before approaching the trigeminal root;
4. Petrosal veins should be saved as much as possible;
5. Opening cerebellar fissures makes the root exit zone visible directly;
6. Before dural closure, the surgical field should be irrigated thoroughly and be full of warm normal saline;
7. The dura must be sutured in a watertight pattern at the end of the operation.

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