Decreases in Blood Pressure and Sympathetic Nerve Activity by Microvascular Decompression of the Rostral Ventrolateral Medulla in Essential Hypertension

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Background—Neurovascular compression of the rostral ventrolateral medulla, a major center regulating sympathetic nerve activity, may be causally related to essential hypertension. Microvascular decompression of the rostral ventrolateral medulla decreases elevated blood pressure.

Case Description—A 47-year-old male essential hypertension patient with hemifacial nerve spasms exhibited neurovascular compression of the rostral ventrolateral medulla and facial nerve. Microvascular decompression of the rostral ventrolateral medulla successfully reduced blood pressure and plasma and urine norepinephrine levels, low-frequency to high-frequency ratio obtained by power spectral analysis, and muscle sympathetic nerve activity.

Conclusions—This case suggests not only that reduction in blood pressure by microvascular decompression of the rostral ventrolateral medulla may be mediated by a decrease in sympathetic nerve activity but also that neurovascular compression of this area may be a cause of blood pressure elevation via increased sympathetic nerve activity. (Stroke. 1999;30:1707-1710.)

Key Words: decompression • hypertension • sympathetic nervous system

The rostral ventrolateral medulla (RVLM) contains neurons that are the major tonic source of supraspinal sympathoexcitatory outflow,1,2 and thus this area is considered to be an important center for the regulation of sympathetic and cardiovascular activities. Since the first report by Jannetta et al.,3 several clinical studies have indicated a possible association between neurovascular compression of the RVLM and essential hypertension.4–8 Using MRI, we found that the incidence of neurovascular compression of the RVLM in an essential hypertension group was significantly higher than that in a secondary hypertension group and in a normotension group, although the stage of hypertension did not differ significantly between the 2 hypertension groups.9,10 Some investigators have reported that microvascular decompression (MVD) of the RVLM improves or normalizes raised blood pressure (BP).8,11–13 We have found that pulsatile compression of the RVLM activates local neurons14 and elevates BP in rats.10 These observations together suggest that neurovascular compression of the RVLM may elevate BP.

In addition, we reported10 that pulsatile compression of the RVLM elevates BP by increasing sympathetic outflow and that this response is normalized after cessation of the compression in rats. Thus, considering that chemical or electrical stimulation of the RVLM increases sympathetic nerve activity (SNA), which in turn elevates BP,1,2 we assume that in humans neurovascular compression of the RVLM elevates BP via sympathetic activation, while MVD of the RVLM decreases raised BP via sympathetic suppression. However, no human data support our assumption, because SNA has not been measured in patients with neurovascular compression of the RVLM or those who have undergone MVD of the RVLM. Herein we describe the first investigation of SNA in a hypertensive patient before and after MVD of the RVLM.

Case Report
A 47-year-old man with a 4-year history of essential hypertension was admitted to our hospital in July 1998 for left hemifacial spasms. His family history was unremarkable. The patient was 169.5 cm in height and weighed 76.5 kg. BP was 152/110 mm Hg, and heart rate was 64 beats/min under treatment with 5 mg amlodipine, 10 mg quinapril, and 2 mg doxazosin. neurological physical examination revealed nothing abnormal except the left hemifacial spasms.

Initial laboratory evaluations showed normal renal function: serum urea nitrogen was 13 mg/dL and creatinine was...
0.80 mg/dL. Creatinine clearance was 67.9 mL/min. Electrocardiograms and echocardiograms were normal. MRI of the medulla oblongata showed neurovascular compression of the RVLM by the left vertebral artery (Figure 1A). The left facial nerve was seen just proximal to the left vertebral artery, and thus neurovascular compression of the facial nerve was also suspected. We decided to apply MVD to the facial nerve and RVLM.

At surgery, a left lateral suboccipital craniectomy was performed with the patient in the lateral position. The cerebellum was retracted gently to expose the left facial nerve. Because we found compression at the root-entry zone of the facial nerve by the vertebral artery, the artery was moved away from the nerve, and a shredded Teflon felt (CR Bard Inc) was inserted into the space between the nerve and the artery. Consequently, the hemifacial spasms were improved just after the MVD. The RVLM was also released from compression by the vertebral artery, which was later confirmed by MRI (Figure 1B).

This case provided an opportunity to study the effects of MVD of the RVLM. The patient was followed up for 5 months after the MVD. BP, hormone levels, power spectral analysis, and muscle SNA were determined before and after the MVD. All examinations were approved by the ethics committee of Kyoto Prefectural University of Medicine, and informed consent was obtained for them from the patient.

### Study of MVD Effects

#### Methods

**BP Measurement**
BP was measured with the patient in the sitting position after resting for at least 5 minutes with use of a standard mercury sphygmomanometer.

**Hormone Analysis**
Plasma levels of norepinephrine, epinephrine, renin activity, and aldosterone and urine levels of norepinephrine and epinephrine were estimated before and 1 month after MVD while the patient was admitted and on a fixed-sodium diet of 120 mmol/d. The patient had not received antihypertensive agents for 1 week prior to hormone studies, and fasting peripheral blood was drawn via indwelling catheter at 7:30 AM with the patient in the supine position after 30 minutes of rest.

![Figure 1. Serial axial MRI scans. A, before; B, after MVD. In panels A, the left vertebral artery obviously compresses the RVLM. In B, the vertebral artery is relatively separate from the RVLM. Slices are arranged from the rostral to caudal side. V indicates vertebral artery; FN, facial nerve; VN, vagal nerve; R, rostral ventrolateral medulla; and Ant, anterior side.](image)

![Figure 2. Clinical course of the patient. Hormone analysis, power spectral analysis, and muscle SNA analysis were performed at the times indicated by the white arrows. sBP indicates systolic blood pressure; dBP, diastolic blood pressure; Sept, September; Nov, November; and Jan, January.](image)
Results

**Effects of MVD on BP**
BP decreased slightly and gradually after MVD of the RVLM (Figure 2). Three months after MVD, the patient complained of occasional dizziness. Measurement in our outpatient clinic demonstrated that BP was lowered to 90/70 mm Hg, so we decreased the antihypertensive regimen. Five months after MVD, BP was recorded at 108/74 mm Hg under treatment with only 5 mg quinapril. We are currently attempting to discontinue the quinapril if BP remains low.

**Effects of MVD on Hormone Values**
Plasma levels of norepinephrine, epinephrine, renin activity, and aldosterone and urine levels of norepinephrine and epinephrine were all substantially reduced after MVD (Table).

**Effects of MVD on Power Spectral Analysis**
The low-frequency to high-frequency ratio showed a decrement after MVD (Table).

**Effects of MVD on MSNA**
Both average burst rate and burst incidence were clearly decreased after MVD (Figure 3 and Table).

**Discussion**
In the present case, BP values were lowered with concomitant decreases in plasma levels of norepinephrine, epinephrine, renin activity, and aldosterone and urine levels of norepinephrine and epinephrine, low-frequency to high-frequency ratio by heart rate power spectral analysis, and muscle SNA after MVD of the RVLM. Plasma and urine norepinephrine values reflect SNA, whereas epinephrine values are viewed as indicators of adrenal medullary activity. Increased SNA stimulates the renin-angiotensin-aldosterone system, and the low-frequency to high-frequency ratio by power spectral analysis is considered to be an index of SNA, which exhibits a circadian rhythm similar to that of plasma norepinephrine. Muscle SNA measured microneurographically reveals direct, precise, and reproducible sympathetic neuronal responses.

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### Functional Examinations

<table>
<thead>
<tr>
<th></th>
<th>Before MVD</th>
<th>After MVD</th>
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<tr>
<td><strong>Hormone analysis</strong></td>
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<tr>
<td>Plasma</td>
<td></td>
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<tr>
<td>Norepinephrine, nmol/L (normal range, 0.89–3.37)</td>
<td>0.95</td>
<td>0.30</td>
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<tr>
<td>Epinephrine, nmol/L (&lt;0.93)</td>
<td>0.22</td>
<td>&lt;0.05</td>
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<tr>
<td>Renin activity, nmol/L/h (0.15–2.08)</td>
<td>0.31</td>
<td>0.08</td>
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<tr>
<td>Aldosterone, nmol/L (0.05–0.36)</td>
<td>0.43</td>
<td>0.27</td>
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<tr>
<td>Urine</td>
<td></td>
<td></td>
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<tr>
<td>Norepinephrine, mmol/d (0.06–0.24)</td>
<td>0.52</td>
<td>0.39</td>
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<tr>
<td>Epinephrine, nmol/d (5.5–76.4)</td>
<td>83.5</td>
<td>26.2</td>
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<tr>
<td><strong>Power spectral analysis</strong></td>
<td>Low-frequency to high-frequency ratio</td>
<td>3.74</td>
</tr>
<tr>
<td><strong>Muscle sympathetic nerve activity</strong></td>
<td>Burst rate, bursts/min</td>
<td>32.6</td>
</tr>
<tr>
<td>Burst incidence, bursts/100 heart beats</td>
<td>44.1</td>
<td>23.4</td>
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**Power Spectral Analysis**
Power spectral analysis of the R-R intervals was performed before and 1 month after MVD from continuous 24-hour ECG (SM-28, Fukuda Denshi Inc., Ltd.) recordings. The low-frequency domain was obtained by integration of the power spectrum in the range of 0.04 to 0.15 Hz. The high-frequency domain was calculated in the range of 0.15 to 0.40 Hz. The average low-frequency to high-frequency ratio was calculated as an index of sympathovagal balance.

**Microneurographic Analysis**
Muscle SNA was recorded from the tibial nerve before and 1 month after MVD, as described elsewhere. In brief, a tungsten microelectrode was inserted percutaneously with the patient in the supine position. After identifying the muscle SNA, the microneurogram was amplified and monitored. During the microneurographic recordings, BP was monitored continuously from the middle finger by a servocontrolled pressure measurement device (Finapres). Average burst rate (bursts/min) and burst incidence (bursts/100 heart beats) were calculated from 20-minute recordings with the patient at rest in the supine position.

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**Figure 3.** Representative tracings of resting muscular SNA. A, before MVD; B, after decompression.
discharge from the peripheral nerves.\(^2\)\(^3\) Considering that the RVLM is a major center regulating supraspinal sympathetic outflow,\(^1\)\(^2\) our data strongly indicate that MVD improved compression-induced increases in the sympathetic nerve-renin-angiotensin-aldosterone system to thereby reduce BP in our patient.

Removal of a pheochromocytoma immediately reduces elevated levels of catecholamines and BP.\(^2\)\(^3\) In contrast, in the present case, MVD of the RVLM decreased BP gradually. The reason for the discrepancy remains unknown. We suppose that existence of target organ damage by hypertension might have inhibited reduction of high BP even after MVD of the RVLM in our patient. However, this remains only speculative and further studies are expected to resolve this issue.

Also needing to be discussed in this case is whether decreases in BP and SNA were due to MVD of the facial nerve but not of the RVLM. Jannetta et al\(^1\)\(^1\) reported that in patients with hypertension and neurological disorders such as trigeminal neuralgia and hemifacial spasms, MVD of the cranial nerves did not reduce BP, Geiger et al\(^2\) reported that in hypertensive patients, MVD of only the RVLM itself decreased BP. Although SNA was not measured in these studies, we suppose that in our case MVD of the RVLM but not of the facial nerve may have decreased BP and SNA.

This case suggests not only that the reduction in BP by MVD of the RVLM may be mediated by a decrease in SNA but also that neurovascular compression of this area may be a cause of BP elevation via increased SNA. To confirm this assumption, however, further studies in a larger series of patients like ours are needed. In addition, a correlation assumption, however, further studies in a larger series of hypertensive patients who do not show BP decrement despite MVD of the RVLM and normotensive patients despite neurovascular compression of the RVLM are to be investigated.

References

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