Online November 20, 2020
Journal of Neuroendovascular Therapy 2021; 15: 254–259 DOI: 10.5797/jnet.tn.2020-0013

Technical Note

Distal Embolic Protection by Manual Compression of the Vertebral Artery in Subclavian Artery Stenting

Noriaki Tashiro,[1] Hiroto Kawano,[2] Fumihiro Hiraoka,[2] Shuji Fukuda,[2] Yusuke Nakamura,[2] Shigetoshi Yano,[2] Hiroshi Aikawa,[2] Yoshinori Go,[3] Kiyoshi Kazekawa,[2] Yoshihisa Matsumoto,[4] and Shinichi Yoshimura[5]

Objective: There is no established method for preventing vertebral artery embolization in percutaneous transluminal angioplasty (PTA) for subclavian artery stenosis. We manually compressed the supraclavicular fossa outside the sternocleidomastoid muscle to disrupt vertebral artery blood flow and prevent embolism. We report the usefulness of this procedure.

Case Presentations: Between April 2017 and July 2018, three patients with severe stenosis of the subclavian artery of 80% or higher were examined. For these patients, subclavian artery stenting was performed. The approach was via the left brachial artery in one patient and right femoral artery in two patients. After crossing the lesion, the vertebral artery was manually compressed and angiography confirmed that blood flow was blocked. In all patients, stent placement was successfully performed and good dilatation was confirmed by angiography. There were no neurological complications and no findings suggestive of acute cerebral infarction were found on magnetic resonance imaging (MRI).

Conclusion: Prevention of distal embolism by manual compression is simple, does not require multiple catheters, and is useful for subclavian artery stenting.

Keywords ▶ manual compression, vertebral artery, subclavian artery, distal embolic protection, stent

Introduction

As surgical treatment for subclavian artery stenosis, endarterectomy and bypass surgery are available,[1,2] but endovascular procedures, such as percutaneous angioplasty and stent placement have been accepted as alternative treatments.[3,4] The incidence of complications associated with endovascular treatment for subclavian artery stenosis, including transient ischemic attack, was 1.2%–4.5%. The 1- to 10-year patency rate was 78%–89%, and the prevalence of symptomatic restenosis was 7%.[5–7] The method to prevent distal embolism in endovascular treatment of subclavian artery stenosis has not been established. There are reports that treatment is possible without using a distal embolic protection device.[8] However, the usefulness of distal embolic protection using a balloon has also been reported.[9] In subclavian steal syndrome, there is a risk of embolism associated with improvement in the vertebral artery blood flow and the concomitant use of a distal embolic protection device is desirable.[10] The clinical usefulness of manual compression of carotid artery to prevent distal embolism in the treatment of carotid artery lesions has been well documented.[11–13] In our best of knowledge, the usefulness of manual compression of the vertebral artery in the supraclavicular fossa has not been discussed. We prevent embolism by arresting the blood flow at the origin of the vertebral artery by manual compression of the supraclavicular fossa lateral to the sternocleidomastoid muscle (**Fig. 1**). Manual compression is easy to perform and does not require multiple catheters. We report the usefulness of the technique by presenting representative cases.

This study was carried out after approval by the ethical review board of our institution, and after receiving informed consent from the patients and their families.

[1]*Department of Neurology, Fukuoka Neurosurgical Hospital, Fukuoka, Fukuoka, Japan*
[2]*Department of Neurosurgery, Fukuoka Neurosurgical Hospital, Fukuoka, Fukuoka, Japan*
[3]*Go Neurosurgical Clinic, Chikushi-gun, Fukuoka, Japan*
[4]*Department of Neurosurgery, St. Mary's Hospital, Kurume, Fukuoka, Japan*
[5]*Department of Neurosurgery, The Hospital of Hyogo College of Medicine, Nishinomiya, Hyogo, Japan*

Received: January 30, 2020; Accepted: August 12, 2020
Corresponding author: Yoshihisa Matsumoto. Department of Neurosurgery, St. Mary's Hospital, 422, Tsubukuhonmachi, Kurume, Fukuoka 830-8543, Japan
Email: fwip4873@mb.infoweb.ne.jp

Case Presentation

Case 1

Patient: A 70-year-old woman.

Chief complaint: Weakness and numbness of the left upper extremity

Past history: Hypertension, diabetes, dyslipidemia, and paroxysmal atrial fibrillation

Present history: The patient suddenly noted weakness and numbness of the left upper extremity, and was emergently transported to our hospital.

Findings on admission: The patient exhibited clear consciousness and normal orientation. Muscle strength of the left upper extremity was MMT4/5. Sensory disturbance and ischemic symptoms during exertion were noted in the left upper extremity. The left brachial artery was unable to be palpated. The blood pressure in the upper extremity was 172/91 mmHg on the right side and 111/92 mmHg on the left side.

Neuroradiographic findings: Angiography demonstrated the severe stenosis at the origin of the left subclavian artery accompanied by calcification of the outer circumference and antegrade flow in the left vertebral artery. Right brachiocephalic arteriography revealed occlusion of the right vertebral artery at its origin.

Therapeutic approach: Dizziness during exertion was considered to be from insufficient cerebral blood flow due to the severe stenosis of the left subclavian artery and the contralateral vertebral artery occlusion. The patient was previously administered an anticoagulant and an additional antiplatelet drug was prescribed. However, as her symptoms remained, endovascular treatment was selected for symptomatic left subclavian artery stenosis.

Endovascular procedure: Under general anesthesia, a 6Fr GuiderSoftip (Boston Scientific, Natick, MA, USA) was inserted via the right femoral artery and guided to the left subclavian artery (**Fig. 2A**). A CHIKAI-14 (Asahi, Intecc, Aichi, Japan) was guided to the brachial artery across the stenosed lesion. The left vertebral artery was manually compressed in the left supraclavicular fossa and the left vertebral artery was confirmed not to be delineated from the origin by angiography via the left subclavian artery (**Fig. 2B**). Predilation was carried out using a gateway 3.5 mm × 15 mm (Stryker, Kalmazoo, MI, USA) at 6 atm for 2 seconds. Next, an Express Vascular SD stent 6 mm × 14 mm (Boston Scientific) was guided to the site of stenosis and dilated at 8 atm for 2 seconds. The balloon was deflated and blood was aspirated through the guiding catheter. Angiography confirmed satisfactory dilation of the left subclavian artery and improvement in the blood flow of the left vertebral artery (**Fig. 2C**). The duration of manual compression of the vertebral artery was 2 minutes and 10 seconds.

Fig. 1 Location of manual compression for flow arrest in the vertebral artery.

Postoperative neuroradiographic findings: There were no findings due to treatment on postoperative MRI of the head.

Postoperative course: Numbness of the left upper extremity and dizziness on exertion observed preoperatively were resolved, and asymmetry of the blood pressure disappeared (right: 121/67 mmHg, left: 120/66 mmHg).

Case 2

Patient: A 70-year-old man.

Chief complaint: Coldness of the right upper extremity.

Past history: Gastric ulcer, gastric cancer, prostate cancer, dyslipidemia, chronic atrial fibrillation, and angina pectoris

Present history: The patient felt coldness in the right upper extremity and consulted a local hospital. Asymmetrical blood pressure was observed and the patient underwent MRI at the same hospital. As marked stenosis of the right subclavian artery was demonstrated, the patient was referred to us.

Findings on admission: His consciousness was clear and orientation was normal. Paresthesia was noted in the right upper extremity. The blood pressure in the upper extremity was 111/72 mmHg on the right and 132/71 mmHg on the left. No other neurological abnormality was noted.

Neuroradiographic findings: Contrast-enhanced computed tomography (CT) revealed severe stenosis accompanied by calcification at the origin of the right subclavian artery. The right vertebral artery was antegradely demonstrated by right subclavian angiogram but also retrogradely demonstrated by contralateral subclavian angiogram.

Fig. 2 (**A**) DSA of the left subclavian artery showing subclavian artery stenosis. (**B**) DSA of the left subclavian artery showing blockage of the blood flow in the left vertebral artery created by manual compression. (**C**) Sufficient dilation of the left subclavian artery was achieved after stent placement. DSA: digital subtraction angiography

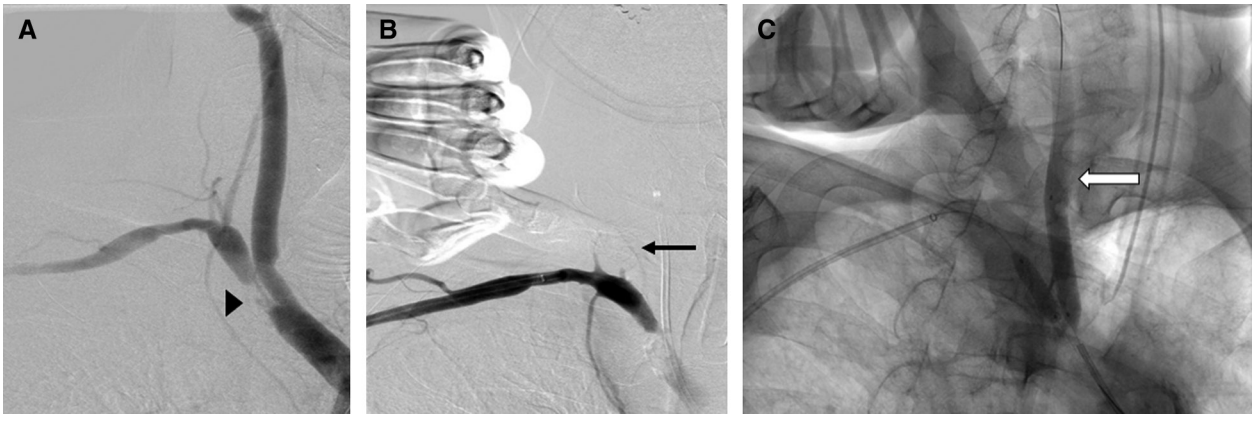

Fig. 3 (**A**) DSA showing right subclavian artery stenosis before stenting (arrow head). (**B**) DSA showing that blood flow in the right vertebral artery was blocked by manual compression (arrow). (**C**) Angiography showing the balloon used to block the right common carotid artery (open arrow). DSA: digital subtraction angiography

Therapeutic approach: As subclavian steal due to stenosis of the right subclavian artery was noted with ischemic symptoms in the right upper extremity, a diagnosis of subclavian steal syndrome was made. The patient was administered one antiplatelet and one anticoagulant for angina pectoris and atrial fibrillation from before treatment, but as the cold feeling in the right upper extremity persisted, endovascular treatment was performed for symptomatic right subclavian artery stenosis. As the site of stenosis was close to the bifurcation of the common carotid artery, prevention against embolism of the common carotid artery was also considered necessary.

Endovascular procedure: Under general anesthesia, a 6Fr Roadmaster (Goodman Co. Ltd, Aichi, Japan) was guided from the right femoral artery to the right brachiocephalic artery. At this point, angiography was performed via the Roadmaster (**Fig. 3A**). Next, a 6Fr Destination (Terumo-Clinical Supply, Tokyo, Japan) was inserted via the right brachial artery and guided to the distal side of right subclavian artery stenosis. The right supraclavicular fossa was manually compressed and the right vertebral artery was confirmed not to be visualized by angiography (**Fig. 3B**). Next, to prevent migration of debris into the right common carotid artery during retrograde angiography of the right subclavian artery through the Destination, a Sterling 8 mm × 40 mm balloon catheter (Boston Scientific) was guided to the right common carotid artery and the blood flow of the right common carotid artery was blocked (**Fig. 3C**). Then, while manually compressing the right supraclavicular fossa, an Express Vascular SD stent 6 mm × 18 mm was guided to the site of stenosis via the Destination. As it was able to be smoothly guided to the most stenosed lesion, the stent balloon was inflated at 6 atm without predilation. The stent balloon was deflated, blood was aspirated through the guiding catheter, and angiography was performed. The right subclavian artery was clearly visualized. The site of stenosis was dilated to a diameter nearly equal to

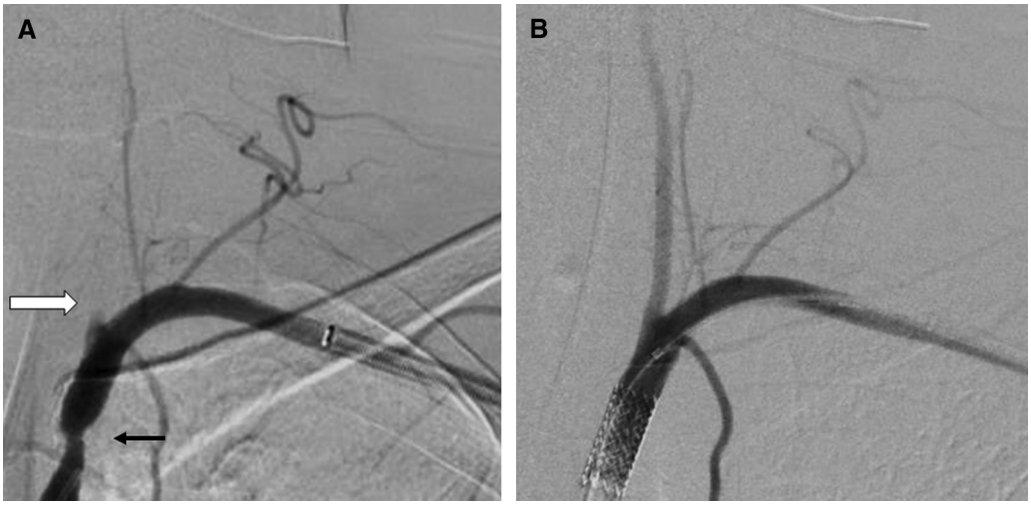

Fig. 4 (**A**) DSA confirming stenosis of left subclavian artery (arrow) and origin of the left vertebral artery (open arrow). (**B**) DSA showing improved left vertebral artery visualization. DSA: digital subtraction angiography

the diameter of the distal right subclavian artery. Postdilation was not performed because antegrade and satisfactory blood flow of the right vertebral artery were confirmed. The duration of manual compression of the vertebral artery was 2 minutes and 30 seconds.

Postoperative neuroradiographic findings: No abnormal findings due to treatment were noted on postoperative MRI of the head. Contrast-enhanced CT demonstrated satisfactory dilation of the right subclavian artery.

Postoperative course: Paresthesia of the right upper extremity observed before procedure was alleviated and completely disappeared after 2 months.

Case 3

Patient: A 70-year-old woman.

Chief complaint: Numbness of the left upper extremity

Past history: Muscle-contraction headache, cervical disc hernia, and cervical spinal canal stenosis.

Present history: The patient exhibited numbness of the left upper extremity. As the maximum systolic flow velocity of the left subclavian artery was markedly increased at 381 cm/sec on ultrasonography, severe stenosis of the left subclavian artery was suspected, and the patient was admitted to our hospital for detailed examination and treatment.

Findings on admission: The patient had clear consciousness and normal orientation. Numbness of the left upper extremity was noted. The blood pressure in the upper extremity was 137/62 mmHg on the right and 112/56 mmHg on the left. No other neurological abnormality was observed.

Neuroradiographic findings: The left vertebral artery was delineated retrogradely by right vertebral arteriography.

Therapeutic approach: As the patient already had taken aspirin, clopidogrel was added as periprocedural antiplatelet treatments. However, the symptoms were not alleviated and endovascular treatment was selected for symptomatic severe left subclavian artery stenosis.

Endovascular procedure: Under general anesthesia, a 4Fr diagnostic catheter (CX catheter; Gadelius Medical, Kanagawa) was guided to the origin of the left subclavian artery via the right femoral artery and angiography was performed. The left vertebral artery was visualized only at its origin (**Fig. 4A**). Via the left brachial artery, a 6Fr Destination was guided to the distal side of left subclavian artery stenosis. Next, an Express Vascular SD stent 7 mm × 15 mm was guided to the site of stenosis, and dilatation was performed at 8 atm while blocking the blood flow of the left vertebral artery by manually compressing the supraclavicular fossa. The balloon was deflated, blood was aspirated through the guiding catheter, and angiography was performed. The left subclavian artery was sufficiently dilated and the left vertebral artery was antegradely visualized (**Fig. 4B**). The duration of manual compression of the vertebral artery was 2 minutes and 20 seconds.

Postoperative neuroradiographic findings: There were no abnormalities due to the treatment on postoperative MRI of the head.

Postoperative course: There were no particular abnormalities and the course was uneventful.

Discussion

We report the usefulness of manual compression of the vertebral artery in the supraclavicular fossa to prevent distal embolism during endovascular treatment for subclavian artery stenosis. After this procedure, no neurological abnormality or MRI abnormality was noted in any of the patients. For this technique, it is important to confirm blockade of the vertebral artery blood flow by angiography before and after manual compression. Regarding distal embolic protection in endovascular treatment for subclavian artery stenosis, there have been reports of embolic protection using a balloon, but this technique has not been established. Balloon embolic protection is difficult to apply to sites near the arterial bifurcation if the balloon is placed on the proximal side of stenosis, and the technique was reported to be somewhat complicated and relatively less reliable.[14] If the balloon is placed on the distal side of stenosis, the risk of intimal damage caused by trapping of the balloon shaft between the narrowed blood vessel and the stent has also been reported.[14] By manual blocking of the vertebral artery, embolism can be prevented without such a risk. In addition, when treating right subclavian artery stenosis, it may be necessary to protect both the common carotid and vertebral arteries from embolism, but this is technically difficult. Manual compression can also be performed readily in such situations without using multiple catheters. Another report found that a balloon guiding catheter is effective for distal embolic protection in endovascular treatment of subclavian artery stenosis, but the procedure was complicated.[15] Manual compression can be performed readily, although it is not as reliable as a balloon guiding catheter.

One problem is radiation exposure of the assistant who performs compression; radiation exposure should be minimized. The radiation exposure dose varies with the duration of angiography, but it is approximately 50 mGy when imaging is repeated several times and does not reach the threshold dose of definite risk. However, radiation exposure should still be minimized using protective hand gear. According to the recommendations by the International Commission on Radiological Protection, the site and dose of irradiation of the skin must be recorded in the chart if the estimated skin dose surpasses 3 Gy in a single procedure or if it surpasses 1 Gy in repeated procedures. In addition, if the dose is ≥3 Gy, a follow-up examination after 10–14 days is mandated and similar management is considered necessary concerning exposure due to this procedure.[16] Although we did not use protective gloves, their use should be considered in the future.

Regarding the site of compression of the vertebral artery, the area that anatomically tolerates compression is affected where the artery enters the transverse foramen in the supraclavicular fossa. The vertebral artery enters the transverse fossa most commonly at the C6 level (93%), followed by C3, C4, C5, and C7 (0.2%, 1.0%, 5.0%, and 0.8%, respectively).[17] At C7, compression may be difficult because of the shortness of the area that can be compressed. Moreover, palpation of the vertebral artery may be difficult depending on the development of muscles, such as the sternocleidomastoid muscle and anterior scalenus muscle, in the supraclavicular fossa. In addition, as the vertebral artery is reportedly more prone to dissection when it arises from the aorta than from the subclavian artery,[18] and this should be remembered when performing compression. Manual compression is not considered suitable for patients in whom compression is difficult for the above reasons, those with a risk of arterial dissection, or those in whom plaque is present diffusely and extends to the vertebral artery.

The strength of compression is recommended to be controlled at the minimum level necessary to arrest the blood flow of the vertebral artery by assessing angiograms. Strong compression is considered to carry a risk of complications such as dissection.

Blocking the blood flow by compression is necessary in procedures that increase the risk of distal embolism, and its timing is recommended to be from before the passage of the guide wire through the stenosed area if stenosis is severe. If there is no sign of marked stenosis, blocking should be started at predilation and maintained until postdilation after stent placement.

In this study, we were unable to quantitatively evaluate the appropriate strength of manual compression of the vertebral artery. We consider it is necessary to control the force of compression at the minimum level required to block the blood flow of the vertebral artery, but strong compression is associated with the risk of complications, including dissection.

During manual compression, thrombus might be formed by flow stagnation at the site of compression and cause distal embolism to cerebral artery or distal upper extremity arteries. In this study, none of the patients exhibited ischemic symptoms of the upper extremity such as pain, coldness, or discoloration, but evaluation by contrast-enhanced CT should be performed if ischemic symptoms are observed in the upper extremity after procedure. The procedure was performed under general anesthesia on all

patients, but treatment under local anesthesia should be considered because monitoring of neurological symptoms is impossible under general anesthesia. In addition, there is insufficient scientific evidence that this procedure reduces thrombosis because of the few number of cases. Assessment of this procedure must be continued further.

Conclusion

Distal embolic protection by manual compression of the vertebral artery is easy to perform and useful for endovascular treatment of the subclavian artery.

Acknowledgment

The authors thank the administration and staff for their dedication to sustainable process improvement and invaluable contributions to this study.

Disclosure Statement

The authors declare no conflict of interest.

References

1) Cinà CS, Safar HA, Laganà A, et al: Subclavian carotid transposition and bypass grafting: consecutive cohort study and systematic review. *J Vasc Surg* 2002; 35: 422–429.
2) Ramirez CA, Febrer G, Gaudric J, et al: Open repair of vertebral artery: a 7-year single-center report. *Ann Vasc Surg* 2012; 26: 79–85.
3) Storey GS, Marks MP, Dake M, et al: Vertebral artery stenting following percutaneous transluminal angioplasty. Technical note. *J Neurosurg* 1996; 84: 883–887.
4) Terada T, Tsuura M, Itakura T, et al: Endovascular therapy for atherosclerotic vertebral and subclavian stenosis. *Jpn J Neurosurg (Tokyo)* 2002; 11: 813–819. (in Japanese)
5) De Vries JP, Jager LC, Van den Berg JC, et al: Durability of percutaneous transluminal angioplasty for obstructive lesions of proximal subclavian artery: long-term results. *J Vasc Surg* 2005; 41: 19–23.
6) Henry M, Henry I, Polydorou A, et al: Percutaneous transluminal angioplasty of the subclavian arteries. *Int Angiol* 2007; 26: 324–340.
7) Sixt S, Rastan A, Schwarzwälder U, et al: Results after balloon angioplasty or stenting of atherosclerotic subclavian artery obstruction. *Catheter Cardiovasc Interv* 2009; 73: 395–403.
8) Takeshita T, Hayashi K, So G, et al: Subclavian steal syndrome treated with balloon expandable stent; reports of two cases. *JNET J Neuroendovasc Ther* 2012; 6: 202–208. (in Japanese)
9) Sadato A, Satow T, Ishii A, et al: Endovascular recanalization of subclavian artery occlusions. *Neurol Med Chir (Tokyo)* 2004; 44: 447–453, discussion 454–455.
10) Ringelstein EB, Zeumer H: Delayed reversal of vertebral artery blood flow following percutaneous transluminal angioplasty for subclavian steal syndrome. *Neuroradiology* 1984; 26: 189–198.
11) Nii K, Nakai K, Tsutsumi M, et al: A manual carotid compression technique to overcome difficult filter protection device retrieval during carotid artery stenting. *J Stroke Cerebrovasc Dis* 2015; 24: 210–214.
12) Kai Y, Morioka M, Yano S, et al: External manual carotid compression is effective in patients with cavernous sinus dural arteriovenous fistulae. *Interv Neuroradiol* 2007; 13: 115–122.
13) Yoshimura S, Enomoto Y, Kitajima H, et al: Carotid-compression technique for the insertion of guiding catheters. *AJNR Am J Neuroradiol* 2006; 27: 1710–1711.
14) Nakahara I, Taki W, Tanaka M, et al: Protective balloon in percutaneous transluminal angioplasty for brachiocephalic arteries. *Jpn J Stroke* 1994; 16: 256–264. (in Japanese)
15) Yamamoto T, Ohshima T, Ishikawa K, et al: Feasibility and safety of distal and proximal combined endovascular approach with a balloon-guiding catheter for subclavian artery total occlusion. *World Neurosurgery* 2017; 100: 709.e5–709.e9.
16) Japan Isotope Association: Avoidance of radiation hazard in IVR. ICRP Publication 85, Japan, Japan Isotope Association, 2005. 35–37.
17) Bruneau M, Cornelius J, Marneffe V, et al: Anatomical variations of the V2 segment of the vertebral artery. *Neurosurgery* 2006; 59: ONS-20–ONS-24.
18) Komiyama M, Morikawa T, Nakajima H, et al: High incidence of arterial dissection associated with left vertebral artery of aortic origin. *Neurol Med Chir (Tokyo)* 2001; 41: 8–11; discussion 11–12.