Medialization of Common Carotid Artery Is Associated with Cervical Kyphosis

Motoya Kobayashi, Junichi Ohya, Yuki Onishi, Junichi Kunogi and Naohiro Kawamura

Department of Spine and Orthopedic Surgery, Japanese Red Cross Medical Center, Tokyo, Japan

Abstract:

Introduction: Reportedly, the medialization of the common carotid artery (MCCA) to be a vascular anomaly with a potential risk of intraoperative carotid artery injury. Nevertheless, among spine surgeons, the presence of MCCA has not been well recognized.

Methods: We retrospectively reviewed consecutive patients who underwent cervical radiographs and magnetic resonance imaging (MRI) examinations in a single spine center. Using MRI, the MCCA grade was classified into grades 1 to 3 in order of severity. Radiographic measurement included C2-C7 angles as cervical lordosis, cervical sagittal vertical axis (CSVA), T1 slope (T1S), and T1S-cervical lordosis mismatch. We compared each patient’s background and radiographic parameters between patients with each of the three MCCA grades. The continuous variables were compared using the Jonckheere-Terpstra trend test and the proportions were compared using the Cochran-Armitage trend test to investigate the trend of variables in three grades.

Results: The present study included data from 133 eligible patients (65 males and 68 females) with a mean age of 63.7 (±14.2) years. The details of MCCA grading were as follows: grade 1, n=101; grade 2, n=27; and grade 3, n=5. With an increasing MCCA grade, age (61.9±14.0, 68.2±13.8, and 76.4±9.4 years for grades 1, 2, and 3, respectively, p=0.005) and proportion of female (p<0.001) had an increasing trend, whereas cervical lordosis had a decreasing trend (11.7±13.5°, 7.0±14.5°, and −10.0±19.2° for grades 1, 2, and 3, respectively, p=0.011).

Conclusions: Several patient backgrounds including the female gender, older age, and kyphotic alignment were determined as MCCA risk factors. Careful preoperative neck vasculature assessment would avoid a catastrophic complication during anterior cervical surgery.

Keywords: medialization, common carotid artery, retropharyngeal artery, cervical spine, complication, kyphosis

Spine Surg Relat Res 2021; 5(3): 144-148
dx.doi.org/10.22603/ssrr.2020-0153
traoperative carotid artery injury\(^{(15-22)}\). MCCA awareness would be essential in surgical planning to avoid such a deleterious scenario. For instance, a surgeon can optimize the preoperative decision (e.g., the choice of a left/right-sided anterior approach and anterior/posterior approach) on the basis of the presence of a unilateral MCCA.

Although the MCCA has been described in a few previous studies in the field of otolaryngology\(^{(18-22)}\), the presence of MCCA has not been well recognized among spine surgeons. Additionally, the relationship between the cervical alignment and the MCCA prevalence remains unknown. Therefore, the present study aimed to elucidate the association between the degree of MCCA and cervical alignment in patients who underwent radiographs and magnetic resonance imaging (MRI) of the cervical spine in a single spine center.

**Materials and Methods**

After appropriate Institutional Review Board approval, we retrospectively reviewed consecutive patients who underwent cervical radiographs and MRI examinations of the cervical spines in a single spine center from April 2018 to September 2019. We collected the data from patients’ medical backgrounds and radiographic assessment. Patients who have 1) prior medical history of anterior cervical spine/neck surgery, 2) soft tissue neoplasm or infection, or 3) incomplete carotid vasculature visualization on MRI were excluded in the present study.

MRI was used to evaluate the CCA location at each segment from C2-C3 to C6-C7 bilaterally. According to the previous reports\(^{(21)}\), the MCCA grade was classified into three: grade 1, CCA was located lateral to the foramen transversarium normally at every motion segment (Fig. 1A); grade 2, CCA was situated between the foramen transversarium and the uncovertebral joint at one or more motion segments (Fig. 1B); and grade 3, CCA was found medial to the uncovertebral joint at one or more motion segments (Fig. 1C). Radiographic measurement included C2-C7 angles as cervical lordosis, cervical sagittal vertical axis (C-SVA), T1 slope (T1S), and T1S-cervical lordosis mismatch (T1S-CL) in sitting cervical radiographs.

We compared each patient background and radiographic parameters between patients with each of the three MCCA grades. Mean and standard deviation for continuous variables or number (percentage) for categorical variables were reported. To investigate the trend of variables in the three grades, continuous variables were compared using the Jonckheere-Terpstra trend test, and proportions were compared using the Cochran-Armitage trend test. The threshold for significance was \(p\)-value<0.05. All statistical analyses were conducted using JMP PRO version 14.2.0 (SAS Institute Japan, Tokyo, Japan) except for the Jonckheere-Terpstra and Cochran-Armitage trend tests, which used SPSS software (version 12; SPSS, Chicago, IL, USA).

**Results**

The present study included data from 133 eligible patients (65 males and 68 females) with a mean age of 63.7 (±14.2 SD) years. Each radiographic parameter in this cohort was as follows: C-SVA, 28.6 mm (±17.6 SD); cervical lordosis, 10.0° (±14.5 SD); T1S, 25.4° (±11.6 SD); and T1S-CL, 15.4° (±14.0 SD). The details of MCCA grading were as follows: grade 1, \(n=101\); grade 2, \(n=27\); and grade 3, \(n=5\) (Table 1). When cervical kyphosis was defined as C2-C7 angle<0°, the prevalence of cervical kyphosis was 18.8% (25/133) in the present study.

Table 2 shows the trend test results for variables in each grade. The Jonckheere-Terpstra trend test indicated that, with an increasing MCCA grade, age showed an increasing trend (61.9±14.0, 68.2±13.8, and 76.4±9.4 years for grades 1, 2, and 3, respectively, \(p=0.005\)) and cervical lordosis showed a decreasing trend (11.7±13.5°, 7.0±14.5°, and −10.0±19.2° for grades 1, 2, and 3, respectively, \(p=0.011\)). The Cochran-Armitage trend test, conversely, showed a significant increase in the proportion of females with an in-
increasing MCCA grade (p<0.001).

**Representative Case**

Fig. 2 displays a representative case with grade 3 of MCCA. A 72 year-old female presented with hand clumsiness and gait disturbance. Cervical lateral radiograph in sitting position showed kyphotic alignment (cervical lordosis, −5°) and severe cervical spondylosis (Fig. 2A). Her cervical spine MRI demonstrated that the left CCA was found in front of the C5 vertebral body (Fig. 2B).

**Discussion**

The present study has two interesting findings. First, MCCA (grade 2 or 3) was observed in 24.1% of the patients who underwent cervical MRI for cervical spine disorder examinations. Second, several factors including the female gender, older age, and cervical kyphosis were associated with MCCA. This study is the first to investigate cervical alignment parameters, such as cervical lordosis, T1S, C-SVA, and T1S-CL as potential factors related to MCCA, although only cervical kyphosis was determined as a parameter associated with MCCA.

Although MCCA has been reported as a vascular aberrancy, only one retrospective multicenter study investigated its incidence in the patients with cervical spine disorder, which revealed that the incidence of grade 2 was 9.7% and grade 3 was 2.6% in their study using MRI examination. The MCCA incidence was lower than that in this present study (20.3% for grade 2 and 3.8% for grade 3). Physicians in several departments ordered cervical spine MRI in their multicenter study, whereas the population in our study focused on the radiographic examination taken in a single spine center. We suspected that this discrepancy of the MCCA incidence between two studies was due to the higher proportion of cervical degenerative disorder in the present study compared with that in the previous study. Our study is advantageous in terms of detailed demographic information of patients, which is in contrast to a previous study with no clear description of patient backgrounds such as sex and age. Therefore, considering the association between patient background and the MCCA severity, our study can provide the readers with novel knowledge regarding this vascular anomaly.

It is still unknown whether the radiographic parameters of the cervical spine could predict the MCCA severity. A previous study reported the vascular medialization tended to be found in cases with cervical kyphotic alignment. As the study on cervical deformity became well discussed in this field, several radiographic parameters were established as useful predictors associated with HRQOL. Thus, we investigated several parameters such as C-SVA, T1S, and T1S-CL mismatch as potential factors related to MCCA. As shown by the results of our study, only cervical kyphosis was associated with MCCA, whereas SVA, T1S, and T1S-CL mismatch were not significant. In the clinical practice, grade 3 medialization was observed in cases with local kyphosis or high grade of spondylolisthesis. Since C2-C7 angles could not always reflect local kyphosis or spondylolisthesis, other parameters indicating local kyphosis should be evaluated in further research as potential factors related to MCCA.

The present study found that the female gender and older

**Table 1. Patients’ Demographic Data.**

| Patient’s background | Value |
|----------------------|-------|
| Age (year)           | 63.7±14.2 |
| Sex                  | Male 65/51.0, Female 68/48.9 |
| Radiographic parameters |
| C-SVA (mm)           | 28.6±17.6 |
| Cervical lordosis (degree) | 10.0±14.5 |
| T1S (degree)         | 25.4±11.6 |
| T1S-CL (degree)      | 15.4±14.0 |
| Grade of MCCA       |
| Grade 1 (n=101)      | 101/75.9 |
| Grade 2 (n=27)       | 27/20.3 |
| Grade 3 (n=5)        | 5/3.8 |

MCCA indicates medialization of common carotid arteries; C-SVA, cervical sagittal vertical axis; T1S, T1 slope; T1S-CL, T1S-cervical lordosis mismatch.

**Table 2. Trend Tests for Patients’ Demographic and Radiographic Data in Each Grade of the Medialization of Common Carotid Arteries.**

| Age (years) | Grade 1 (n=101) | Grade 2 (n=27) | Grade 3 (n=5) | P-value |
|-------------|-----------------|----------------|---------------|---------|
| Female (%)  | 39/38.6         | 24/88.9        | 5/100         | <0.001 * |
| C-SVA (mm)  | 28.4±15.7       | 28.0±22.4      | 36.6±28.2     | 0.452   |
| Cervical lordosis (degree) | 11.7±13.5       | 7.0±14.5       | −10.0±19.2    | 0.011 * |
| T1S (degree) | 26.1±11.6       | 24.3±11.3      | 16.6±10.6     | 0.108   |
| T1S-CL (degree) | 14.4±13.4       | 17.3±13.8      | 26.6±23.2     | 0.109   |

C-SVA indicates cervical sagittal vertical axis; T1S, T1 slope; T1S-CL, T1S-cervical lordosis mismatch; * P-value <0.05.

Continuous variables were compared using the Jonckheere–Terpstra trend test, and proportions were compared using the Cochran–Armitage trend test.
Cervical lateral radiograph in sitting position shows kyphotic alignment (cervical lordosis: −5°). (B) Axial MRI shows the severe medialization of the left common carotid artery located in front of the C5 vertebral body (white arrow).
References

1. Quinn JC, Kiely PD, Lebl DR, et al. Anterior surgical treatment of cervical spondylotic myelopathy: review article. HSS J. 2015;11(1):15-25.

2. Emery SE. Anterior approaches for cervical spondylotic myelopathy: which? when? how? Eur Spine J. 2015;24 Suppl 2:150-9.

3. Bronson WH, Moses MJ, Protopsaltis TS. Correction of dropped head deformity through combined anterior and posterior osteotomies to restore horizontal gaze and improve sagittal alignment. Eur Spine J. 2018;27(8):1992-9.

4. Lee SH, Kim KT, Lee JH, et al. 540° cervical realignment procedure for extensive cervical OPLL with kyphotic deformity. Spine. 2016;41(24):1876-83.

5. Ogihara S, Kunogi J. Single-stage anterior and posterior fusion surgery for correction of cervical kyphotic deformity using intervertebral cages and cervical lateral mass screws: postoperative changes in total spine sagittal alignment in three cases with a minimum follow-up of five years. Neurol Med Chir. 2015;55(7):599-604.

6. Wang VY, Aryan H, Ames CP. A novel anterior technique for simultaneous single-stage anterior and posterior cervical release for fixed kyphosis. J Neurosurg Spine. 2008;8(6):594-9.

7. Bertalanffy H, Eggert HR. Complications of anterior cervical discectomy without fusion in 450 consecutive patients. Acta Neurochir. 1989;99(1-2):41-50.

8. Fountas KN, Kapsalaki EZ, Nikolakakos LG, et al. Anterior cervical discectomy and fusion associated complications. Spine. 2007;32(21):2310-7.

9. Frempong-Boadu A, Houten JK, Osborn B, et al. Swallowing and speech dysfunction in patients undergoing anterior cervical discectomy and fusion: a prospective, objective preoperative and postoperative assessment. J Spinal Disorders. 2002;15(5):362-8.

10. Golfinos JG, Dickman CA, Zabranski JM, et al. Repair of vertebral artery injury during anterior cervical decompression. Spine. 1994;19(22):2552-6.

11. Jung A, Schramm J, Lehnerdt K, et al. Recurrent laryngeal nerve palsy during anterior cervical spine surgery: a prospective study. J Neurosurg Spine. 2005;2(2):123-7.

12. Saville P, Vaishnav AS, McNamly S, et al. Predictive factors of post-operative dysphagia in single-level Anterior Cervical Discectomy and Fusion (ACDF). Spine. 2018. doi: 10.1097/BRS.0000000000002865.

13. Smith MD, Emery SE, Dudley A, et al. Vertebral artery injury during anterior decompression of the cervical spine. A retrospective review of ten patients. J Bone Joint Surg Br. 1993;75(3):410-5.

14. Tasiou A, Giannis T, Brotis AG, et al. Anterior cervical spine surgery-associated complications in a retrospective case-control study. J Spine Surg. 2017;3(3):444-59.

15. Muñoz A, De Vergas J, Crespo J. Imaging and clinical findings in patients with aberrant course of the internal carotid artery. Open Neuroimag J. 2010;4:174-81.

16. Paulsen F, Tillmann B, Christophides C, et al. Curving and looping of the internal carotid artery in relation to the pharynx: frequency, embryology and clinical implications. J Anat. 2000;197 Pt 3:373-81.

17. Galletti B, Buccol S, Abbate G, et al. Internal carotid artery transposition as risk factor in pharyngeal surgery. Laryngoscope. 2002;112(10):1845-8.

18. Gupta A, Shah AD, Zhang Z, et al. Variability in the position of the retropharyngeal internal carotid artery. Laryngoscope. 2013;123(2):401-3.

19. Jun BC, Jeon EJ, Kim DH, et al. Risk factors for decreased distance between internal carotid artery and pharyngeal wall. Auris Nasus Larynx. 2012;39(6):615-9.

20. Pfeiffer J, Ridder GJ. A clinical classification system for aberrant internal carotid arteries. Laryngoscope. 2008;118(11):1931-6.

21. Korecky J, Alvi H, Gibby R, et al. Incidence and risk factors of the retropharyngeal carotid artery on cervical magnetic resonance imaging. Spine. 2013;38(2):E109-12.

22. Smith JS, Lafage V, Ryan DJ, et al. Association of myelopathy scores with cervical sagittal balance and normalized spinal cord volume: analysis of 56 preoperative cases from the AOSpine North America Myelopathy study. Spine. 2013;38(22 Suppl 1):S161-70.

23. Tang JA, Scheer JK, Smith JS, et al. The impact of standing regional cervical sagittal alignment on outcomes in posterior cervical fusion surgery. Neurosurgery. 2015;76 Suppl 1: S14-21.

24. Del Corso L, Moruzzo D, Conte B, et al. Tortuosity, kinking, and coiling of the carotid artery: expression of atherosclerosis or aging? Angiology. 1998;49(5):361-71.

25. Liu B, Wu B, Van Hoof T, et al. Are the standard parameters of cervical spine alignment and range of motion related to age, sex, and cervical disc degeneration? J Neurosurg Spine. 2015;23(3):274-9.

26. Martins HPG, Mayer A, Batista P, et al. Morphological changes of the internal carotid artery: prevalence and characteristics. A clinical and ultrasonographic study in a series of 19804 patients over 25 years old. Eur J Neurol. 2018;25(1):171-7.

27. Karabag H, Iplikcioglu AC. The assessment of upright cervical spinal alignment using supine MRI studies. Clin Spine Surg. 2017;30(7):E892-5.

28. Oshima M, Tanaka M, Oshima Y, et al. Correlation and differences in cervical sagittal alignment parameters between cervical radiographs and magnetic resonance images. Eur Spine J. 2018;27(6):1408-15.