Medialization of Common Carotid Artery Is Associated with Cervical Kyphosis

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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 (C-SVA), 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

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Introduction

Surgical treatment is the gold standard for patients who developed cervical myelopathy and an indication of two approaches, namely, anterior or posterior, selected according to pathology, location, and cervical spine alignment. Anterior surgery has a crucial advantage of directly decompressing the compressive elements such as the disc hernias, osteophytes, and ossification of the posterior ligament through fascial planes with preservation of the musculature[1,2]. Moreover, with the recent increasing trend of patients with cervical spine deformity, soft tissue release, correction, and fusion technique through the anterior approach become more crucial and indispensable[3-6].

Although the advantages of anterior cervical surgery have become well recognized, high rates of approach-related complications, such as persistent dysphagia (1.7%-67%), dysphonia (0.9%-8.3%), and major vessel injury (0.3%-0.5%)[7-14], have been reported. Common carotid artery (CCA) injury is rare but is a catastrophic complication that should be avoided, as it can cause blood transfusion, potential cerebral infarction, and even death. Although CCA is typically located lateral to the foramen transversarium, it can be identified medially toward the retropharyngeal space in some patients. The medialization of CCA (MCCA) has been reported as a vascular anomaly with a potential risk of in-

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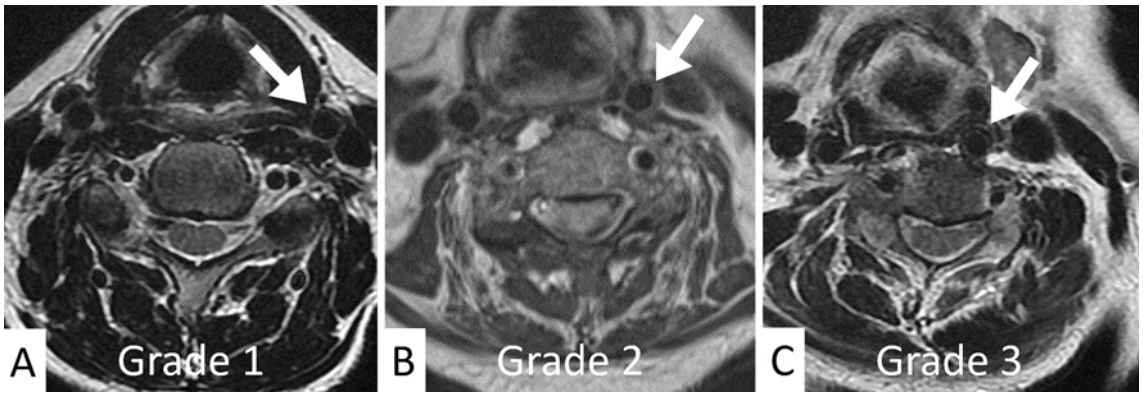

Figure 1. A–C. Representative images of the medialization grading of the common carotid arteries (white arrows). Grade 1: common carotid artery (CCA) is found lateral to the foramen transversarium normally at every motion segment (A). Grade 2: CCA is situated between the foramen transversarium and the uncovertebral joint at one or more motion segments (B). Grade 3: CCA is located medial to the uncovertebral joint at one or more motion segments (C).

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. 1 C). 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 angles≤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-

creasing 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.

Table 1. Patients' Demographic Data.

Patient's background	
Age (year)	63.7±14.2
Sex	
Male (n/%)	65/51.0
Female (n/%)	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	
Grade1 (n/%)	101/75.9
Grade2 (n/%)	27/20.3
Grade3 (n/%)	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

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[21]. 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[21] 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[21]. As the study on cervical deformity became well discussed in this field, several radiographic parameters were established as useful predictors associated with HRQOL[22-25]. 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 2. Trend Tests for Patients' Demographic and Radiographic Data in Each Grade of the Medialization of Common Carotid Arteries.

	Grade 1 (n=101)	Grade 2 (n=27)	Grade 3 (n=5)	P-value
Age (years)	61.9±14.0	68.2±13.8	76.4±9.4	0.005 *
Female (n/%)	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.

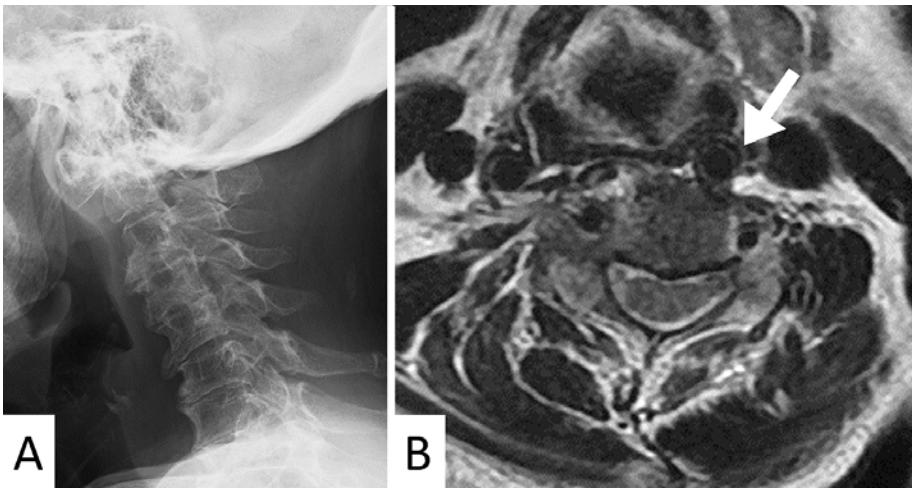

Figure 2. A, B. Example of a left-sided Grade 3 anomaly in a 72 year-old female. (A) Cervical lateral radiograph in sitting position shows kyphotic alignment (cervical lordosis: −5°). (B) Axial MRI shows the severe medialization of the left common carotid artery located in front of the C5 vertebral body (white arrow).

age had a significant trend related to increasing MCCA grades. As in the previous study[21], MCCA tended to occur in the elderly, indicating that the occurrence of MCCA may be due to age-related degenerative changes. As revealed by Del corso et al., atherosclerosis, hypertension, and aging might play an essential role in producing carotid abnormalities[24]. Degenerative vessels with low elasticity can cause MCCA in elderly patients, which is consistent with the results in our study of increased MCCA prevalence among older patients. Moreover, we found that females tended to have MCCA. Martins et al. examined the prevalence and demographic characteristics of morphological change of the internal carotid artery such as kinking, coiling, or looping using an ultrasonographic image, which revealed that morphological changes of the internal carotid arteries were associated with the female gender. They speculated that the alteration in vessel wall elasticity in women might also be related to post-menopausal hormonal process[26]. Furthermore, as reported by previous studies that the cervical alignment in women was more likely to be kyphosis[25], higher rates of kyphosis (C2-C7 angles≦0°) in females than those in males (25.0% vs. 13.8%) were determined in the present study. Although these demographic data have a potential association with cervical alignment, we could not adjust the confounder between variables in this study because of the small sample size. Further larger-scale studies with the adjustment of potential confounders are needed.

The present study has several limitations. First, the number of cases in this study is small. As mentioned above, small sample size could not allow us to adjust the confounder between patient background and cervical spine parameters.

Second, the difference in patients' posture between MRI in supine position and radiographs in sitting position may affect the results of this study. Previous reports have revealed that a significant difference exists between upright cervical x-ray examination and supine cervical MRI in cervical sagittal parameters including C2-C7angle. Karabag et al. measured the cervical alignment of patients with cervical disorders using different methods and estimated C2-C7angle (in plain radiography)=C2-C7angle (in MRI)×0.489+7.13[27]. Conversely, Oshima et al. showed the significant C2-C7 angle difference between imaging modalities only existed in cases of cervical lordosis but not in cases of cervical kyphosis[28]. Thus, the impact of cervical alignment on the change of C2-C7 angle according to imaging modalities can affect statistical results in the present study.

Third, the inclusion criteria that focused on patients who underwent cervical radiographs and MRI examination in a single spine center have potential selection bias. Hence, the results of the present study are not applicable to the general population. Despite these limitations, this study presents informative data that are useful in clinical practice, especially for spine surgeons who perform anterior cervical surgery.

Conclusion

Several patient backgrounds including the female gender, older age, and kyphotic alignment were determined as MCCA risk factors. A catastrophic complication during anterior cervical surgery could be avoided through careful preoperative neck vasculature assessment.

Conflicts of Interest: The authors declare that there are no relevant conflicts of interest.

Ethical Approval: Approval code is 748, which issued by the institutional review board (IRB), and Japanese Red Cross Medical Center granted the approval.

Author Contributions: Motoya Kobayashi, MD wrote and prepared the manuscript, and all of the authors partici-

pated in the study design.

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