Surgical outcomes after laminoplasty for cervical spondylotic myelopathy in patients with renal dysfunction and/or aortic arch calcification

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OBJECTIVE The authors recently reported that the presence of chronic kidney disease (CKD) and/or extended abdominal aortic calcification was associated with significantly worse clinical outcomes after posterior lumbar interbody fusion. CKD is one of the highest risk factors for systemic atherosclerosis. Therefore, impaired blood flow due to atherosclerosis could exacerbate degeneration of the cervical spine and neural tissue. However, there has been no report of a study evaluating the deleterious effects of CKD and atherosclerosis on the outcomes after decompression surgery for cervical compression myelopathy. The purpose of this study was thus to examine whether CKD and systemic atherosclerosis affect surgical outcomes after laminoplasty for cervical spondylotic myelopathy (CSM).

METHODS The authors analyzed data from 127 consecutive cases involving patients who underwent laminoplasty for CSM and met their inclusion criteria. Stage 3–4 CKD was present as a preoperative comorbidity in 44 cases. Clinical status was assessed using the Japanese Orthopaedic Association (JOA) cervical myelopathy evaluation questionnaire before surgery and 2 years postoperatively. As a marker of systemic atherosclerosis, the presence of aortic arch calcification (AoAC) was assessed on preoperative chest radiographs.

RESULTS AoAC was found on preoperative chest radiographs in 40 of 127 patients. Neither CKD nor AoAC had a statistically significant deleterious effect on preoperative JOA score. However, CKD and AoAC were significantly associated with reductions in both the JOA score recovery rate (mean 36.1% in patients with CKD vs 44.7% in those without CKD; 26.0% in patients with AoAC vs 48.9% in those without AoAC) and the change in JOA score at 2 years after surgery (mean 2.3 points in patients with CKD vs 3.1 points in those without CKD; 2.1 points for patients with AoAC vs 3.2 points for those without AoAC). A multivariate regression analysis showed that AoAC was a significant independent predictor of poor outcome with respect to both for the difference between follow-up and preoperative JOA scores and the JOA score recovery rate.

CONCLUSIONS CKD and AoAC were associated with increased rates of poor neurological outcomes after laminoplasty for CSM, and AoAC was a significant independent predictive factor for poor outcome.

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KEY WORDS chronic kidney disease; aortic arch calcification; cervical spondylotic myelopathy; laminoplasty; surgical outcomes

WE have recently reported that the presence of chronic kidney disease (CKD) and/or extended abdominal aorta calcification (as a marker of systemic atherosclerosis) was associated with significantly worse clinical outcomes after posterior lumbar interbody fusion.⁶ Among hyperlipidemia, hypertension, dia-

betes mellitus, and CKD, CKD has been reported to be the highest risk factor for systemic atherosclerosis.⁷ Impaired blood flow due to atherosclerosis could exacerbate degeneration of the spine and neural tissue. Therefore, CKD and systemic atherosclerosis might affect clinical outcomes after decompressive surgery for cervical compression my-

ABBREVIATIONS AoAC = aortic arch calcification; CKD = chronic kidney disease; CSM = cervical spondylotic myelopathy; eGFR = estimated glomerular filtration rate; JOA = Japanese Orthopaedic Association.

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elopathy. However, to the best of our knowledge no study evaluating the deleterious effects of CKD and atherosclerosis on such outcomes has previously been reported. The purpose of the present study was thus to examine whether CKD and systemic atherosclerosis affect surgical outcomes after laminoplasty in patients with cervical spondylotic myelopathy (CSM).

Methods

Patients

At our institution, patients with CSM are treated with cervical laminoplasty unless they have cervical kyphosis $\geq 15^\circ$ and a single-level anterior lesion without a narrow spinal canal, in which case they are good candidates for anterior decompression and fusion. We searched our records to identify all patients who underwent laminoplasty for CSM between January 2010 and September 2013 and had at least 24 months of follow-up. Our initial search identified 191 patients with at least 24 months of follow-up. We excluded cases involving patients with spinal cord injury, ossification of the posterior longitudinal ligament, rheumatoid arthritis, cerebral palsy, or Stage 5 CKD requiring hemodialysis, as well as those who underwent laminoplasty combined with spinal fusion using instrumentation and those who had undergone previous cervical spine surgery. After exclusion of 64 cases based on these criteria, we were left with 127 cases for analysis. The 127 patients included 70 men and 57 women, and their mean age at the time of surgery was 71.3 years (range 45–89 years). Three surgeons performed only bilateral open-door laminoplasty with interpositional autologous bone grafts and/or hydroxyapatite spacers in 57 patients according to surgeon preferences (double-door laminoplasty). Three other surgeons performed only unilateral open-door laminoplasty using interpositional autologous bone grafts and/or hydroxyapatite spacers in 70 patients according to surgeon preferences (single-door laminoplasty). The surgically treated levels were as follows: C3–6 in 69 patients; C3–7 in 40; C4–6 in 7; C4–7 in 4; C3–T1 in 3; C3–5 in 3; and C5–7 in 1. For the first 2 weeks after surgery, all patients wore a soft collar. No significant differences in age at the time of surgery, duration of follow-up, or scores on the Japanese Orthopaedic Association (JOA) cervical myelopathy questionnaire³ before surgery and 2 years after surgery were seen between patients treated with double-door or single-door laminoplasty. Diagnostic criteria for Stage 3–4 CKD were proteinuria persisting for at least 3 months and/or an estimated glomerular filtration rate (eGFR) < 60 ml/min/1.73 m² for at least 3 months. Stage 3–4 CKD was diagnosed in 44 of the 127 patients before surgery. The study was approved by the institutional review board of Kansai Rosai Hospital.

Clinical and Radiological Evaluation

As a marker of systemic atherosclerosis, the presence of aortic arch calcification (AoAC) was assessed on chest radiographs² before surgery by radiologists, and the radiologists' notes were reviewed for this study. AoAC was defined as the presence of apparent calcium deposits on the walls of the aortic arch on chest radiographs.

The neurological status with respect to cervical myelopathy was assessed using the JOA score before surgery and at 2-year postoperative follow-up.

Differences between the JOA score obtained before surgery and 2 years after surgery, the recovery rate of the JOA score (defined below), and the change in JOA score (JOA score at 2 years after surgery minus the preoperative JOA score)⁴ were analyzed, and group means were compared for patients with CKD, patients with AoAC, and patients without either comorbidity.

Statistical Analysis

Statistical analysis was performed using JMP 5.0.1 software (SAS Institute). Univariate analyses were performed to identify correlations between neurological outcomes 2 years after surgery and possible predictive factors. The Mann-Whitney U-test was used. Values of $p < 0.05$ were considered significant. Variables with $p < 0.05$ on univariate analyses were entered into the multivariate regression analysis (ordinal regression analysis).

The JOA score recovery rate, as described by Hirabayashi et al.,¹ is calculated as $(b - a)/(17 - a) \times 100$, where b is the patient's postoperative JOA score and a is the preoperative score (17 is the JOA score of an individual with no impairment due to CSM).

Results

Aortic Arch Calcification

AoAC was found on preoperative chest radiographs in 40 of the 127 patients. Patients with AoAC were significantly older than those without AoAC (75.8 ± 9.2 years vs 69.3 ± 9.3 years, $p = 0.00033$). Patients with CKD had a significantly increased risk of AoAC ($p = 0.0050$), as previously reported,⁷ and patients with CKD were also significantly older than those without CKD (74.9 ± 6.6 years vs 69.5 ± 10.5 years, $p = 0.0025$).

Neurological Outcomes

There was no significant between-groups difference in preoperative JOA scores when patients were stratified by either the presence of Grade 3 or 4 CKD or the presence of AoAC (Tables 1 and 2). In contrast, the presence of Grade 3 or 4 CKD and the presence of AoAC were both

TABLE 1. Comparison of clinical outcomes in patients with and without Stage 3–4 CKD*

Parameter	CKD Stage 0–2 (n = 83)	CKD Stage 3–4 (n = 44)	p Value†
Preop JOA score	10.2 $\pm$ 2.7	10.8 $\pm$ 2.1	<0.05
JOA score at 2 yrs after surgery	13.3 $\pm$ 2.3	13.1 $\pm$ 1.8	<0.05
JOA score recovery rate at 2 yrs after surgery (%)	44.7 $\pm$ 26.3	36.1 $\pm$ 24.7‡	0.040
Change in JOA score at 2 yrs after surgery	3.1 $\pm$ 2.3	2.3 $\pm$ 1.7‡	0.047

* Means are presented $\pm$ SD.

† Mann-Whitney U-test.

‡ Significantly lower than Stage 0–2 group.

TABLE 2. Comparison of clinical outcomes in patients with and without AoAC*

Parameter	Pts w/o AoAC (n = 87)	Pts w/ AoAC (n = 40)	p Value†
Preop JOA score	10.6 ± 2.5	10.0 ± 2.6	<0.05
JOA score at 2 yrs after surgery	13.8 ± 1.9	12.0 ± 2.0‡	0.000026
JOA score recovery rate at 2 yrs after surgery (%)	48.9 ± 24.6	26.0 ± 21.8‡	0.0000028
Change in JOA score at 2 yrs after surgery	3.2 ± 2.1	2.1 ± 2.0‡	0.00070

Pts = patients.

* Means are presented ± SD.

† Mann-Whitney U-test.

‡ Significantly lower than the group without AoAC.

independently associated with reduced postoperative improvement in JOA score both in terms of the raw change in score and the percentage improvement (Tables 1 and 2).

Given these results, a multivariate regression analysis was performed, using age at surgery, CKD, and AoAC as potential predictive factors for neurological outcomes after laminoplasty in patients with CSM. Ordinal regression analysis showed that AoAC was a significant independent negative predictive factor both for the recovery rate of the JOA score and the achieved JOA scores after surgery (Table 3).

Discussion

This study investigated whether CKD and AoAC (a marker of systemic atherosclerosis) affect surgical outcomes after laminoplasty in patients with CSM. As the parameter for evaluating surgical outcomes, many previous surgeons used the JOA score and its recovery rate. However, as Machino et al. suggested, the most crucial limitation of the recovery rate of the JOA score is that actual surgical outcomes in patients with the same recovery rate can differ according to the JOA scores before surgery, and thus it is important to consider not only the recovery rate but also the change in JOA score in evaluating surgical outcomes in CSM patients.⁴ According to their suggestions, in the

TABLE 3. Results of multivariate regression analysis for factors related to poor outcome after laminoplasty for CSM

Variable & Factor	p Value
JOA score recovery rate	
Age at time of surgery	0.085
Stage 3–4 CKD	0.92
AoAC	0.00050
Change in JOA scores	
Age at time of surgery	0.41
Stage 3–4 CKD	0.29
AoAC	0.0010

present study, group differences in the JOA score both before surgery and at 2 years after surgery, the recovery rate of the JOA score,¹ and the change in JOA scores⁴ were compared between the patients with CKD, the patients with AoAC, and patients with neither condition.

In the present study, CKD and AoAC resulted in significant decreases in both the recovery rate of the JOA score and the change in JOA score at 2 years after surgery. Among age at the time of surgery, CKD, and AoAC, multivariate regression analysis showed that AoAC was a significant independent negative predictive factor both for the recovery rate of the JOA score and the change in JOA scores after surgery. The finding of AoAC on chest radiographs represents systemic atherosclerosis and is a strong independent predictor of cardiovascular events.² Moreover, in a study of acute ischemic stroke, a high proportion of patients were reported to have AoAC, which was associated with lower rates of favorable outcome following endovascular treatment.⁵ Given these results, lack of blood flow to the spinal cord due to advanced systemic atherosclerosis in patients with AoAC may result in poor neurological recovery after decompression of the spinal cord by laminoplasty.

Conclusions

The presence of CKD and/or AoAC was significantly associated with a worse JOA score recovery rate and less improvement in JOA score at 2 years after laminoplasty for CSM. Multivariate regression analysis showed that AoAC was a significant independent negative predictive factor.

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Disclosures

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author Contributions

Conception and design: all authors. Acquisition of data: Sakaura.

Analysis and interpretation of data: Sakaura. Drafting the article: Sakaura. Critically revising the article: all authors. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Sakaura. Statistical analysis: Sakaura. Study supervision: Ohwada.

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