

Original Article

Factors affecting C5 nerve root palsy after decompressive anterior cervical surgery

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Abstract: Study Design: Retrospective study. Background: Degenerative cervical spondylosis is a steadily increasing morbidity in the ageing population. Anterior cervical surgery are commonly used in the treatment of cervical spondylosis. C5 nerve root palsy is one of the most serious complications with severe impact on the patients' quality of life. Objectives: To identify preoperative risk factors causing C5 nerve root palsy after decompressive anterior cervical surgery. Methods: From January 2011 to December 2016, 168 patients who underwent anterior cervical decompression surgery were selected. The patients were divided into two groups: C5 palsy (Group A) and nonpalsy (Group B). Age, gender, surgical levels, cervical curvature correction, JOA score, OPLL, APD (anteroposterior diameter) of the C4/5 intervertebral foramen and high signal intensity of spinal cord in T2-MRI at C4/5 were evaluated. Risk factors of C5 palsy were detected by Logistic regression analysis. Results: Of the 168 patients, 9 cases experienced C5 palsy after surgery. Logistic regression analysis revealed that there were no statistic differences in gender, age, preoperative of JOA, high signal intensity of spinal cord and APD of the C4/5 intervertebral foramen. However, cervical physiological curvature correction, surgical levels and intervertebral height variation had significant differences between two groups. ($P < 0.05$). Conclusions: Cervical physiological curvature overcorrection, multilevel decompression, and excessive increase of intervertebral height are correlative risk factors for C5 palsy. Thus proper surgical strategy should be made.

Keywords: C5 nerve root palsy, anterior cervical surgery, risk factor

Introduction

C5 nerve root palsy is one of the most serious complications of cervical decompression surgery, which was first reported by Scoville [1] and Stoops [2]. C5 nerve root palsy is mainly characterized by abnormal motor function of the deltoid muscle and/or biceps brachii with worsening spinal cord symptoms, and it may also be accompanied by intractable pain, numbness, and other sensory abnormalities in the innervation region of C5 nerve root after cervical spinal surgery [3]. At present, the exact cause and mechanism of C5 nerve root palsy remain not fully understood, and relevant literature reports are also lack of adequate evidence-based medical basis. How to determine the influencing factors of C5 nerve root palsy after cervical decompression is still the most direct and fundamental problem that spinal surgeons urgently need to solve. This article is aimed to

investigate the influencing factors of C5 nerve root palsy after anterior cervical decompression and fusion surgery.

Materials and methods

Patients

It adopts retrospective analysis of 168 patients undergoing anterior cervical surgery at Ningbo No. 2 Hospital between January 2011 and December 2016. All operations were performed in a single institution by one senior surgeon. According to whether C5 nerve root palsy appears, it is divided into Palsy Group (Group A) with 9 cases and Control Group (Nonpalsy, Group B) with 159 cases. Group A includes 5 males and 4 females; the average age is 53.2 years (range, 38-73 y); while Group B includes 85 males and 74 females with an average age of 48.7 years (range, 25-82 y). The mean follow-up period was 21.5 months (range, 6-32 mo).

Factors affecting C5 palsy after anterior cervical surgery

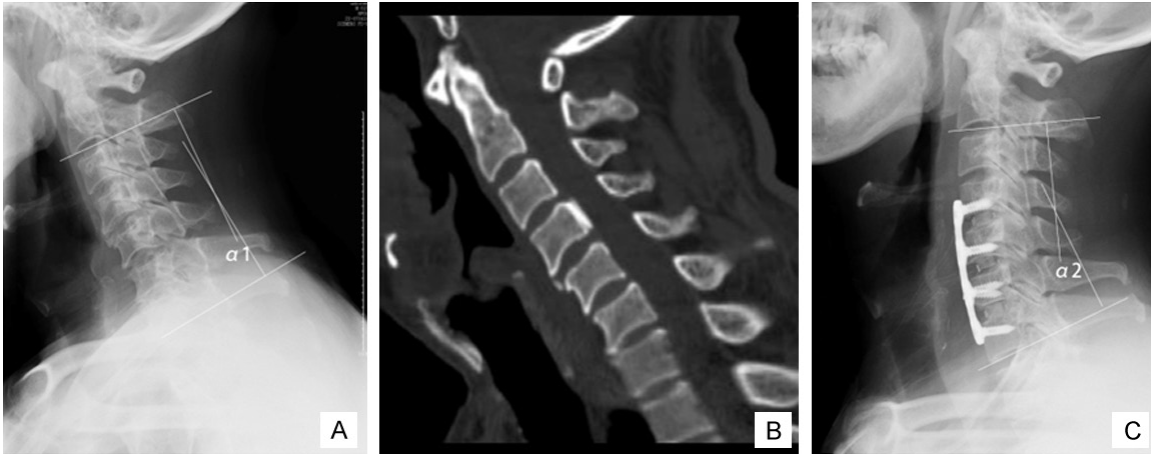


Figure 1. M, 61 Y, cervical spondylotic radiculopathy with cervical spine instability, received ACDF from C4-7. A and C. Show C2-7 Cobb's angle pre and post-operation, $\Delta\alpha = \alpha_2 - \alpha_1$. B. Computed tomography (CT) shows cervical vertebral physiological curvature becoming straight or reverse, with certain degree of degenerative change.

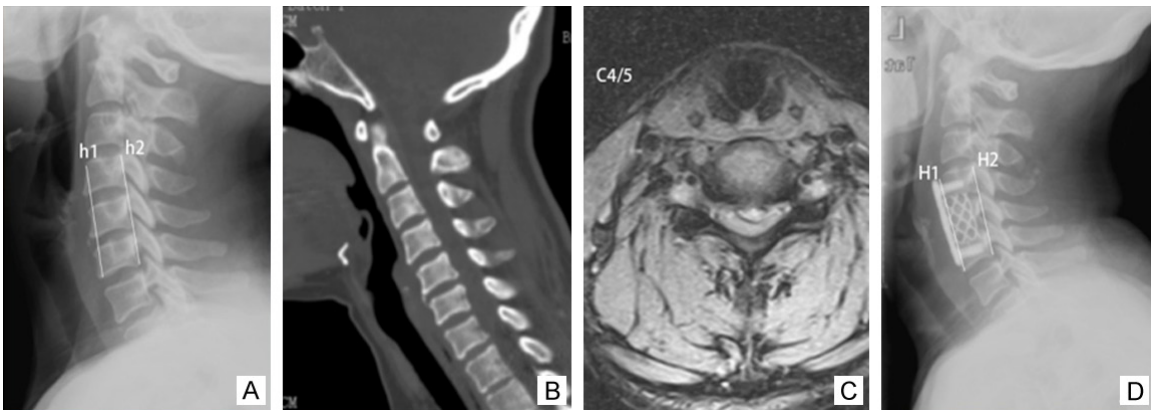


Figure 2. F, 39 Y, Cervical spondylopathy with C4/5 disc herniation. A. Pre-op intervertebral height. $H = h_1 + h_2 / 2$. B. Sagittal reconstruction computed tomography (CT). C. MRI shows C4/5 disc herniation. D. X-ray after receiving ACCF. $H = H_1 + H_2 / 2$.

The difference of general conditions of the two set have no statistics significance ($P > 0.05$).

Inclusion criteria

1. Patients with Cervical Spondylosis or Ossification of Posterior Longitudinal Ligament (OPLL) given anterior cervical decompression and fusion surgery; 2. Complete Imaging Data; 3. Post-operative follow-up is over 6 months. Exclusion Criteria: 1. Post-operative brain complications (such as epidural hemorrhage); 2. History of cervical surgery; 3. Cervical trauma, tumor. This study is approved by the Hospital Ethics Committee, and informed consent is signed by patients themselves. Diagnostic Criteria of C5 Nerve Root Palsy [4]: post-opera-

tive new-onset deltoid muscle and/or biceps brachii palsy (muscle strength < grade 3 or muscle strength decreases by over 1 level after surgery) and skin in C5 innervation region feels pain, numbness, and no significant increase in symptoms of preoperative spinal cord compression.

Surgical methods and post-operative management

Of the 168 patients, 61 patients received single-segment C4/5 Anterior Cervical Discectomy and Fusion (ACDF), 26 patients received dual-segment ACDF (C3-5 or C4-6), and 11 patients received trio-segment ACDF (C3-6 or C4-7). 42 patients received single-segment (C5

Factors affecting C5 palsy after anterior cervical surgery

Table 1. Comparisons between group A (C5 Palsy) and group B (Nonpalsy)

	Group A (n=9)	Group B (n=159)
Age	53.2±18.1	48.7±16.52
Gender (M/F)	5/4	85/74
Operation Level	3.11±0.78	2.08±0.99*
JOA Pre-op	6.67±1.58	6.26±1.66
C2-7 Cobb's angle variation ($\Delta\alpha$)	11.78±6.12	4.84±5.20*
Intervertebral height variation (mm)#	3.92±1.30	2.43±1.56*
C4/5 foraminal APD (mm)	3.56±1.01	3.26±1.29
High signal intensity at C4/5 (T2-MRI)	3/9	11/159*
OPLL (C3-5)	3/9	34/159

*Statistically significant, $P < 0.05$. Independent sample t test, Mann-Whitney U test, χ^2 test and Fisher exact test were used for 2 groups. JOA: Japanese Orthopaedic Association; MRI: magnetic resonance imaging; OPLL: Ossification of the posterior longitudinal ligament. APD: anteroposterior diameter of the C4/5 intervertebral foramen. #Intervertebral height variation = $h-H$. $h = h1+h2/2$. $H = H1+H2/2$ **Figure 1**.

or C4) (ACCF), 18 patients received two ACCFs (C4+5, C3+4), and 10 patients received single-segment ACCF plus ACDF. Post-operative cervical collar is fixed for 3 weeks to 3 months. All patients from the palsy group should get CT and MRI examination immediately to exclude the epidural hematoma. In terms of treatment, they should be given mannitol and methylprednisolone, and neurotrophic drugs, in addition to encouraging patients to take active and passive rehabilitation training. Two of the patients are treated with hyperbaric oxygen therapy. All patients receive regular out-patient visits.

Clinical and radiographic evaluation

1. Muscle strength and sensation of deltoid and biceps brachii;
2. JOA (Japanese Orthopaedic Association) scores of pre- and post-operative neurological function;
3. Operation Level;
4. Ossification of posterior longitudinal ligament (OPLL): Record C3 ~ 5 on the patient's pre-operative spinal CT scan to evaluate if it has OPLL.
5. Radiographic results: height variation of the intervertebral space in the operative segments (show in **Figure 2**), pre-operative spinal cord hyperintensity (whether the MRI T2WI C3~5 level have high signal intensity), Cervical physiological curvature correction (C2-7 Cobb's angle variation, show in **Figure 1**) and APD (anteroposterior diameter) of the C4/5 intervertebral foramen.

Statistical treatment

SPSS 18.0 software was used for statistical analysis. Group A and B use two independent sample t-test and χ^2 test. Multivariate Logistic regression is used for the analysis on related risk factors. $P < 0.05$ is considered statistically significant.

Results

Patients characteristics with C5 nerve root palsy

168 patients were received anterior decompression fusion and internal fixation. Nine patients (5 males and 4 females) developed the symptoms of C5 nerve root palsy after surgery, with an average age of 53.2 years (range, 38-73 y). All patients developed symptoms within 1 week. Among them, there were 4 cases of double-level, 3 cases of triple-level, and 2 case of quadruple-level. At the last follow-up, 5 patients got recovery completely. (Patients characteristics show in **Table 1**).

Imaging parameters

C2-7 Cobb's angle variation ($\Delta\alpha$), operation level, Intervertebral height variation and T2-MRI cord high signal intensity are higher than that of group B ($P < 0.05$). There is no significant statistics difference in OPLL and APD of intervertebral foramina between two groups ($P < 0.05$) (**Table 1**).

Analysis on the risk factors of C5 nerve root palsy

In order to clarify the risk factors of C5 nerve root palsy after anterior cervical surgery, relevant parameters of the two groups were regressed. These parameters include age, gender, pre-operative JOA score, operation level, T2-MRI cord signal, cervical physiological curvature correction, height variation of the intervertebral space in the operative segments, anteroposterior diameter of intervertebral foramina between C4/5 and OPLL. After screening out part of factors, multivariate Logistic regression analysis was performed, and it found that such parameters like age, gender, preoperative JOA score, T2-MRI high signal,

Factors affecting C5 palsy after anterior cervical surgery

Table 2. Logistic regression analysis of C5 palsy risk factors

Variables	Univariate Logistic regression		Multivariate Logistic regression	
	OR (95% CI)	P	OR (95% CI)	P
Age (per 10 yrs)	0.970 (0.588-1.600)	0.906		
Gender (M/F)	0.919 (0.238-3.549)	0.902		
Operation level	2.736 (1.321-5.665)	0.007	2.266 (1.013-5.067)	0.046 ^a
JOA Pre-op	1.168 (0.761-1.794)	0.477		
High signal intensity (T2-MRI)	6.727 (1.478-30.612)	0.014	4.302 (0.723-25.615)	0.109
C2-7 Cobb's angle ($\Delta\alpha$)	1.136 (1.048-1.232)	0.002		0.013 ^a
Intervertebral height variation	1.776 (1.162-2.716)	0.008	1.135 (1.027-1.254)	0.037 ^a
C4/5 foramina APD (mm)	1.193 (0.716-1.988)	0.497	1.860 (1.039-3.329)	
OPLL	1.838 (0.437-7.734)	0.406		

Note: Univariate Logistic regression analysis P < 0.1 independent variables into the multivariate regression analysis model.

^aStatistically significant, P < 0.05.

C4/5 intervertebral foramen antrum are not statistically significant (P>0.05). Operation level, C2-7 Cobb's angle ($\Delta\alpha$), and intervertebral height variation are the risk factors of C5 palsy after decompressive anterior cervical surgery (Table 2).

Discussion

C5 nerve root palsy is one of the complications of anterior cervical decompression and fusion, which usually occurs within 24 hours to 2 months after the surgery. Unilateral symptom is the most common form, with about 92% of patients suffering from unilateral disease and 8% bilateral [5]. The incidence of C5 palsy is affected by the surgical approach, methods, as well as the differences of diagnostic criteria, leading to a various incidence rate. The incidence rates from the literature ranges from 0 to 50%, with the vast majority less than 10% [6, 7]. Although most patients can obtain satisfactory results through conservative treatment, some patients are still left with symptoms including weakened upper limbs, pain, numbness, which seriously affect the early post-operative curative effect assessment and satisfactory degree of patients.

The exact cause and mechanism of C5 nerve root palsy are not fully understood at present, and no adequate clinical and imaging evidence had obtained. Most scholars believe that palsy is the result of a combination of factors [8-12], which mainly include the following five factors: a. Surgery-induced nerve root injury; b. Tethering effect caused by spinal cord drift; c. Spinal

cord ischemia caused by the reduction of nerve root arterial blood supply; d. Regional dysfunction caused by spinal cord lesions; e. Spinal cord ischemia-reperfusion injury.

The clinical follow-up of 168 cases of anterior cervical decompression surgery finds that the incidence rate of C5 nerve root palsy is 5.36% (9/168), which is basically consistent with the previous literature. The number of decompression segments, C2-7 Cobb's angle and intervertebral height variation are the risk factors of this complication. According to this study, it is found that cervical physiological curvature variation (C2-7 Cobb's angle) are larger than that of the control group, inferring that it may be related to the occurrence of C5 palsy. The mechanism may be that the C5 nerve root is short, and C4/5 is the vertex of decompression point; when the cervical physiological curvature correction is stronger, the spinal cord drifts more backward from the spinal canal, which may easily cause C5 nerve root injury (called Tethering Effect) [12]. This is consistent with the results of Yamashita [13] and Shiozaki [14]. Yamashita [13] reports that the average distance between the C4 and C5 levels of the spinal cord in 3 patients with C5 nerve root palsy is 5 mm, which is significantly greater than that of those nonpalsy patients. Shiozaki [14] finds that, after 1 to 3 weeks of the surgery, retrocession of the spinal cord (5.5 mm on average) in patients with C5 nerve root palsy is significantly higher than that of the control group (3.3 mm on average). There is no unified conclusion on whether the number of fusion segments will cause C5 nerve root palsy at present. Kawakami

[15] believes that inappropriate increased anterior column height and excessive surgical segments are related to post-operative cervical axial pain. The multivariate regression analysis of this study shows that the intervertebral height and the surgical segments are related to C5 palsy. Excess decompression segments and relatively large range of operation will stimulate the nerve roots and spinal cord and easily drag the C5 nerve root and cause dysfunction. Although the intervertebral height is increased in both groups after surgery, the height variation in the C5 palsy group is greater than that in the control group, signifying that with the intervertebral height increasing, C5 nerve root palsy is likely to occur. Bai [16] finds that variation in the intervertebral height of the surgical segments after ACDF can lead to the onset of cervical axis symptoms, which directly indicates that height increase will affect the patient's postoperative residual symptoms. The author believes that the increasing height will cause the spinal cord or nerve root to be dragged, which in turn increase the incidence rate of post-operative palsy. Therefore, spinal surgeons need to choose the appropriate Cage according to the height of the patient's cervical intervertebral. However, for some patients with congenital intervertebral space stenosis, even if the minimum one doesn't fit, and it will increase the risk of C5 nerve root palsy after surgery. Most patients with C5 palsy have a good prognosis, and be able to recover within 6 months. However, some patients need up to 2 years for recovery, even suffering from some of the neurological deficits [17-19].

In conclusion, the incidence rate of C5 nerve root palsy is higher in patients with cervical physiological curvature overcorrection, more surgical decompression segments, and excessive increase of intervertebral height in the operative segments. For such patients, spinal surgeons should make reasonable plan to reduce the incidence rate of C5 palsy before surgery. Because of the defects such as small number of cases and retrospective studies, it is unlikely to fully describe the factors related to the occurrence of C5 palsy. Large samples and multi-center prospective studies are needed to reveal the exact factors.

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Disclosure of conflict of interest

None.

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Factors affecting C5 palsy after anterior cervical surgery

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