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Clinical Study

Manual muscle test at C5 palsy onset predicts the likelihood of and time to C5 palsy resolution

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ABSTRACT

The primary objective of this study was to identify time to and prognostic factors of C5 palsy resolution. All patients over a 7 year period who experienced C5 palsy following a posterior decompression and instrumented fusion surgery were retrospectively reviewed. C5 palsy resolution was defined as a recovery of deltoid muscle function equal to or greater than the preoperative condition as defined by the manual muscle test (MMT). Of the 511 patients who met the selection criteria, 8.6% (n = 44) experienced C5 palsy. MMT information was available for 43 patients; 81.4% (n = 35) had full resolution from their condition. Of the 35 patients who resolved, the median MMT score at onset was 3−. Following a discrete-time proportional hazards model, the hazards of C5 palsy resolution increased by 19% for every one-grade increase in MMT score at symptom onset (hazard ratio [HR] = 1.19, $p = 0.005$). Moreover, males displayed a 71% lower hazard of resolution than females (HR = 0.29, $p = 0.003$). Following an adjusted Kaplan–Meier analysis, the median time to C5 palsy resolution was between 6 months and 1 year. In a multiple linear regression, a lower MMT score at the onset of C5 palsy predicted a longer time to C5 palsy resolution (coefficient = −0.19, $p = 0.003$). Time to C5 palsy onset was not statistically associated with hazards of palsy resolution ($p = 0.381$) or time to resolution ($p = 0.121$). A higher MMT score at the onset of C5 palsy statistically significantly predicted a higher chance of resolution and a shorter recovery time. Female sex was also associated with a higher hazard of resolution.

1. Introduction

Palsy of the fifth cervical nerve (C5) is a well-described complication of cervical spine surgery [1–3]. Symptoms typically include paresis of the deltoid and/or biceps brachii muscles [4,5]. Ever since the condition was first described by Keegan in 1965 [6] the prognosis of C5 palsy has been widely debated in the literature. Theories regarding the etiology of C5 palsy span from nerve injury during surgery to nerve root tethering caused by a postoperative spinal cord shift back [3,5,7,8]. Similar to the pathogenesis of C5 palsy, the outcome of this condition has also been a point of contention.

In 2003, Sakaura et al. published a literature review on C5 palsy following cervical decompression and fusion surgeries [5]. Based on their review of limited case series, the authors reported that patients with a lower manual muscle test (MMT) score at the time of C5 palsy diagnosis require significantly longer recovery times than patients with a higher MMT score. They also described a trend toward a lower likelihood of recovery for patients with lower MMT scores, but this was not found to be statistically significant. Although intriguing, these results have not yet been substantiated by formal clinical studies.

In this manuscript, we reviewed 43 patients who experienced C5 palsy following a posterior decompression and fusion surgery to determine the percentage of patients who experienced functional recovery of the deltoid muscle. We evaluated various prognostic factors to determine if they can be used to inform patients regarding the chance and timeline of full recovery from postoperative C5 palsy.

2. Methods

2.1. Data collection

We retrospectively reviewed the records and radiographic imaging of all patients who underwent a cervical posterior

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decompression and instrumented fusion at a single institution over a 7 year period. All operations included the C4–C5 spinal segment for surgical intervention of degenerative spinal diseases. Furthermore, only patients with concomitant instrumented fusions were included in order to standardize the change in lordosis. Operative management for traumatic, infectious, congenital, neoplastic, and metabolic indications were excluded from this study. Circumferential operations were excluded as well. In order to control for confounding factors, exclusion criteria included the laminoplasty procedure, in which the overlay of bone graft may kink the C5 nerve root [9–11]. The direct, mechanical injury may then cause a C5 palsy. Ossification of the posterior longitudinal ligament, another potential confounder, was similarly excluded due to a previously reported association with C5 palsy [5,12].

We identified 511 patients who met these inclusion criteria, and 44 patients experienced a C5 palsy (incidence of 8.6%). MMT information and time to resolution was available for 43 patients. One patient could not be contacted for follow-up and was thus excluded from the study. In accordance with the literature, C5 palsy was defined as a postoperative motor decline of the deltoid muscle function by at least one grade in a standard MMT [5,10,13–15]. Gradations are represented as subsets (+, o, −) within a numerical MMT level (integer values on a 0–5 scale). A decrease in one grade, for example, could be represented as a change from 4+ to 4, 3 to 3−, or 2− to 1+. Patients who presented with bilateral C5 palsy were counted as only one case. Comorbidities, including coronary artery disease, diabetes mellitus, osteoporosis, obesity, ever smoker, chronic obstructive pulmonary disease, hypertension, and depression were ascertained from the medical records. The impact of comorbidity on the surgical management for C5 palsy was assessed with the Charlson Comorbidity Index.

The primary objective of this study was to correlate prognostic factors with the chance of and time to C5 palsy resolution. The primary outcome variable, C5 palsy resolution, was defined as a recovery of deltoid muscle function equal to or greater than the preoperative condition as defined by the MMT.

2.2. Statistical analysis

Summary statistics are reported for 43 patients who experienced a postoperative C5 palsy following a posterior cervical decompression and instrumented fusion (Table 1). Motor function of the C5 nerve root was evaluated at discrete follow-up times, so the data we obtained followed an interval-censored model. Therefore, we utilized a discrete-time approach, in which the MMT measures and the corresponding follow-up time were binned into one of six time intervals: 1 week (time 1), 6 weeks (time 2), 3 months (time 3), 6 months (time 4), 1 year (time 5), and $\geqslant$1 year (time 6). Patients in whom C5 palsy did not resolve were censored at the last follow-up. The hazards of C5 palsy resolution were calculated using a complementary log-log function in a discrete-time proportional hazards model [16]. The constant term was set equal to six discrete baseline hazards corresponding to each of the six time intervals (time 1–6). Predictors of time to C5 palsy resolution were calculated with a multiple linear regression model, in which the outcome reflects discrete-time bins coded as continuous integers (time 1–6). Statistical significance was set at $p < 0.05$. Statistical analysis was performed with STATA (version 12.0, College Station, TX, USA) and Microsoft Excel (Redmond, WA, USA).

3. Results

We identified 511 patients who met these inclusion criteria, and 44 patients experienced a C5 palsy (incidence of 8.6%). MMT information and time to resolution was available for 43 patients.

Table 1
Perioperative characteristics in 43 patients with C5 palsy following posterior decompression and fusion

	C5 palsy
Patients, n	43
Mean age, years	64.3 ± 9.9
Mean follow-up, months	36.0 ± 34.5
Male sex	26 (60.5)
Comorbidities	
Mean Charlson Index	4.0 ± 1.8
Coronary artery disease	4 (9.3)
Chronic obstructive pulmonary disease	4 (9.3)
Ever smoker	7 (16.3)
Diabetes mellitus	10 (23.3)
Hypertension	22 (51.2)
Obesity	1 (2.3)
Osteoporosis	2 (4.7)
Intraoperative parameters	
Number of levels decompressed	4.5 ± 0.96
Foraminotomy	17 (39.5)
Bone morphogenic protein	1 (2.3)
Autograft	32 (74.4)
Allograft	24 (55.8)
Median blood loss, interquartile range	300, 285
Postoperative characteristics	
Mean time to C5 palsy onset, days	3.0 ± 2.3
Mean hospital stay, days	5.4 ± 2.7
Discharge to rehabilitation	7 (16.3)
Deep vein thrombosis	2 (4.7)
Pulmonary embolus	2 (4.7)
Wound dehiscence	2 (4.7)
Surgery infection/dehiscence	2 (4.7)

Data are presented a number (%) or mean ± standard deviation unless otherwise stated.

Of the 43 patients in the study population, the average length of hospitalization was 5.4 ± standard deviation (SD) of 2.7 days, thereby reflecting an ample window of time for immediate diagnosis of new-onset C5 palsy. The mean time to C5 palsy onset was 3.0 ± SD 2.3 days with a median MMT score of 2. The average follow-up time from the onset of C5 palsy to the last relevant patient record was 36.0 ± SD 34.5 months.

The rate of full resolution, which was defined as an MMT score equal to or greater than the preoperative MMT score, was 81.4% (n = 35) in our sample of 43 patients with C5 palsy. Following a discrete-time proportional hazards model, female sex and MMT score at the onset of C5 palsy were statistically significant predictors of C5 palsy resolution (Table 2). Males displayed a 71% lower hazard of resolution than females (hazards ratio [HR] = 0.29, $p = 0.003$) (Table 2). Furthermore, the hazards of C5 palsy resolution increased by 19% for every one-grade increase in MMT score at symptom onset (HR = 1.19, $p = 0.004$) (Table 2). Of the 35 patients who resolved, the median MMT score at onset was 3− (Fig. 1). More specifically, C5 palsy resolution occurred when the MMT score at symptom onset equalled 0 in 17.1% of patients (n = 6), 1 in 11.4% of patients (n = 4), 2−/2 in 20.0% of patients (n = 7), 3−/3/3+ in 28.6% of patients (n = 10), and 4−/4/4+ in 22.9% of patients (n = 8).

Following an adjusted Kaplan–Meier analysis, the median time to C5 palsy resolution was between 6 months and 1 year in our study population (Fig. 2). Of the 35 patients within this population who experienced C5 palsy resolution, 2.9% (n = 1) recovered within 1 week, 14.3% (n = 5) recovered within 6 weeks, 17.1% (n = 6) recovered within 3 months, 14.3% (n = 5) recovered within 6 months, 17.1% (n = 6) recovered within 1 year, and 37.1% (n = 13) recovered in over 1 year (Fig. 3). A multiple linear regression showed with statistical significance that a lower MMT score at the onset of C5 palsy predicted a longer time to C5 palsy resolution (coefficient = −0.19, $p = 0.003$) (Table 3).