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ORIGINAL ARTICLE

Safety and resource utilization of anterior cervical discectomy and fusion

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Abstract Degenerative cervical spondylosis (DCS) is part of the aging process and is the most common reason for degenerative changes with the spinal column. Anterior cervical discectomy and fusion (ACDF) is a major option for operative management of DCS in our institution. This retrospective study investigated the frequency of postoperative complications and resource utilization in 145 patients who underwent ACDF procedures from January 2009 to December 2011. Patients with degenerative changes that involved cervical intervertebral levels C1–C2, spinal injury of traumatic origin, spinal tumors, or previous cervical fusion were excluded. Patients were then further classified into two groups: (1) level 1 or 2 disease (Group M) and (2) level 3 or 4 disease (Group S). Measures of mortality, complications after surgery as well as immediate reoperation for any reason were evaluated. Operation time, length of hospital stay, and hospitalization cost were defined as resource utilization. Ninety seven patients met the inclusion criteria and were further reviewed to characterize the sample better. There were no hematomas, airway complications or deaths, except in one patient who developed postoperative hemorrhage that required immediate surgical intervention, and resolved without any neurological deficit or casualty. Resource utilization indicated that the average operation time for Group S was significantly higher than for Group M (4.31 ± 1.25 vs. 2.88 ± 0.90 hours, $p < 0.0001$). There were no significant differences in length of hospital stay and hospitalization cost between the two groups ($p = 0.265$ and $p = 0.649$). Our results indicate that neurosurgical intervention is safe for patients with DSC. Postoperative complication rates associated with these procedures are low. When surgery is considered appropriate for patients with multilevel diseases, these data suggest that ACDF is a safe surgical option.

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Introduction

Anterior discectomy with or without fusion is the most common surgical intervention performed for degenerative cervical spondylosis (DCS), with established literature of its efficacy and natural history [1,2]. When surgery is indicated, the choice of operative approaches including anterior, posterior, and combined procedures becomes a significant part in the optimal management of the disease. Hospital pressure for lower hospitalization cost because of the limited resources offered by national health insurance has always pushed surgeons to come up with innovative ideas to perform surgery. DCS refers to age-related disc degeneration and the population profile in Taiwan is aging, therefore, it is predictable that the resource utilization of patients with DCS will increase with time.

In this study, we report the incidence of postoperative complications and resource utilization for 97 patients undergoing anterior cervical discectomy and fusion (ACDF) for multilevel disease from January 2009 to December 2010. The aim of the study was to investigate factors related to complications, operation time, the associated length of hospital stay, and hospitalization cost.

Patients and methods

All patients undergoing ACDF in the Section of Neurosurgery in our institution between January 2009 and December 2010 were enrolled in the study, and data were collected prospectively and then reviewed retrospectively. The Institutional Review Board approved the study (KMUH-IRB-990271). Based on International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM), all patients included were diagnosed with DCS (diagnosis code: 722.0, 722.71, or 722.91) and scheduled for ACDF (procedure code: 81.02). Patients were excluded based on C1—C2 involvement, trauma, neoplasia, or previous cervical fusion, and then further classified into two groups: (1) level 1 or 2 disease (Group M; patients with clinically mild diseases who might use fewer medical resources); and (2) level 3 or 4 disease (Group S; patients with clinically severe diseases who were supposed to use more medical resources). Cervical degenerative disease levels were defined according to the number of intervertebral discs involved, that is, level 1 or 2 disease indicated pathology of two or three discs, and level 3 or 4 disease involved four or five discs. At present there are no definitive guidelines within the literature as to what delineates the patient population that can be safely and economically managed through ACDF. However, patients with either stenosis or herniated nucleus pulposus involving level 1 or 2 disease are increasingly managed on an outpatient basis [3,4]. In addition, clinical results after level 3 or 4 ACDF are seldom reported in the literature [5].

Information regarding age, sex, medical comorbidity, history of smoking, body mass index (BMI), and surgical details was collected, and routine blood workup, including blood cell count, prothrombin and partial thromboplastin times, and international normalized ratio, were routinely obtained. ICD-9 diagnosis codes were used to generate

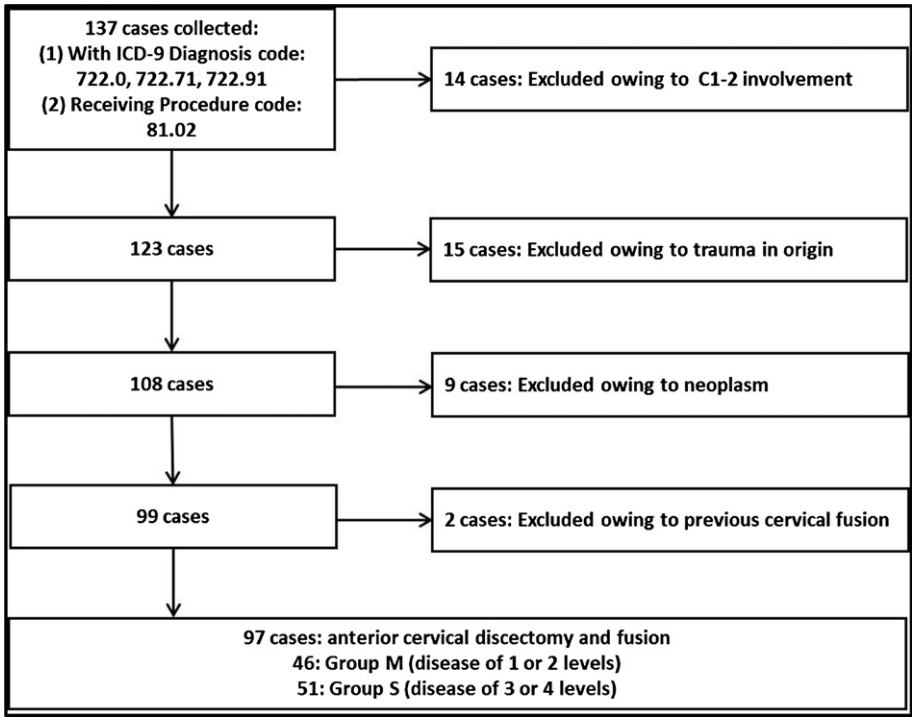

Figure 1. Patient selection flow diagram demonstrating identification of population sample for anterior cervical discectomy and fusion for degenerative cervical spondylosis in Kaohsiung Medical University Hospital from 2009 to 2010. ICD-9 diagnostic code: 722.0 = displacement of cervical intervertebral disc without myelopathy; 722.71 = intervertebral disc disorder with myelopathy, cervical region; 722.91 = other and unspecified disc disorder, cervical region. ICD-9 procedure code: 81.02 = other cervical fusion of the anterior column, anterior technique. ICD9 = International Classification of Diseases, Ninth Revision.

Table 1 Demographic data of the population sample ($n = 97$).

	n/mean ± SD	%/range
Sex		
Female	54	55.7
Male	43	44.3
CCI		
≥ 1	50	51.5
0	47	48.5
Age (yr)	55.44 ± 12.99	22–85
BMI	24.32 ± 3.96	17.58–38.72
Single-level	16	16.5
C3–C4	1	
C4–C5	2	
C5–C6	11	
C6–C7	2	
Two-level	30	30.9
C3–C5	4	
C4–C6	17	
C5–C7	7	
C3–C4, C6–C7	1	
C4–5, C6–C7	1	
Three-level	29	29.9
C3–C6	14	
C4–C7	11	
Others	4	
Four-level	22	22.7
C3–C7	19	
C4–C7–T1	3	
Fusion material		
PEEK cage	67	69.0
Bryan disc	15	15.5
Both	15	15.5

BMI = body mass index; CCI = Charlson Comorbidity Index; PEEK = polyetheretherketone; SD = standard deviation.

Table 2 Demographic information of the study groups ($n = 97$).

	Group M ($n = 46$)	Group S ($n = 51$)	p value
Age (yr)	51.75 ± 13.63	58.77 ± 11.53	0.007
BMI	24.03 ± 3.98	24.58 ± 3.96	0.500
Sex (n; %)			
Female	28 (60.9)	26 (51.0)	0.414
Male	18 (39.1)	25 (49.0)	
CCI (%)			
≥ 1	21 (45.7)	29 (56.9)	0.312
0	25 (54.3)	22 (43.1)	
Fusion material			0.001
PEEK cage	32	35	
Bryan disc	12	3	
Both	2	13	

Student t test was used to derive p value for age and BMI, Fisher's exact test for gender and CCI, and χ^2 test for fusion material. BMI = body mass index; CCI = Charlson Comorbidity Index; PEEK = polyetheretherketone.

a Charlson Comorbidity Index (graded 0 or ≥ 1; categorical variables) for each patient. Outcome variables contained postoperative complications, mortality, and resource utilization, which included operation time, length of hospital stay, and hospitalization cost. Cost data were estimated by using hospital inpatient reimbursement (National Health Insurance) data. Statistical analyses for the study were performed using SPSS for Windows version 12.0. Student t tests and Fisher's exact tests were used to compare the results of the study. Log-linear regression model was used to identify factors affecting resource utilization.

Results

A total of 97 patients underwent elective level 1–4 ACDF procedures during the study period (Fig. 1); 16 patients (16.5%) underwent a single-level procedure; 30 patients (30.9%) a two-level procedure; 29 patients (29.9%) a three-level procedure; and 22 patients (22.7%) a four-level procedure (Table 1). Fifty-four patients (55.7%) were female. Average age of the population sample was 55.44 years (range: 22–85 years) with a standard deviation of 12.99. When analyzing pre-existing medical conditions, 51.5% of patients had at least a chronic disease before surgery. All patients were instrumented, and prosthesis was used. As fusion material, a polyetheretherketone cage was used for 67 patients (69.0%), Bryan® disc was provided to 15 patients (15.5%), and both polyetheretherketone cage and Bryan® disc were offered simultaneously to 15 patients (15.5%). The demographic information about age, BMI, sex, clinical status, and the prosthesis used for the study groups is described in Table 2. There were 46 patients in Group M and 51 in Group S. However, the two study groups had no substantive differences in any variables apart from age. Patients in Group S were significantly older. The type of prosthesis used was significantly related to disease severity.

There was one complication (1.0%) involving postoperative hemorrhage, which required immediate surgical intervention and was resolved without any neurological deficit or casualty. The patient was originally diagnosed with herniated intervertebral discs with stenosis at the C3–C4, C5–C6 and C6–C7 levels. There were no hematomas, airway complications or deaths.

The preliminary results of analysis of resource utilization are shown in Table 3, which demonstrated that the operation time for the population sample ranged from 1.33 to 7.67 hours (mean: 3.62 hours). The operation time for patients in Group S was significantly higher longer than for Group M (4.31 ± 1.25 vs. 2.88 ± 0.90 hours, $p < 0.0001$). The average length of hospital stay for Group M was 8.59 days (range: 4–15 days) and 8.39 days (range: 4–15 days) for Group S. The average hospitalization cost was 3,076.4 USD (range: 713.8–5,693.2 USD) for Group M and 3,261.3 USD (range: 806.4–5,567.1 USD) for Group S. There were no statistically significant differences in length of hospital stay and hospitalization cost between the two groups ($p = 0.265$ and $p = 0.649$). In addition, whether with pre-existing medical conditions or not, the resource utilization of the population sample was not

Table 3 Resource utilization of the population sample.

	All patients ($n = 97$)	Group M ($n = 46$)	Group S ($n = 51$)
Operation time (h; range)	3.62 ± 1.31 (1.33–7.67)	2.88 ± 0.90 (1.33–5.33)	4.31 ± 1.25* (2.50–7.67)
Length of stay (d; range)	8.48 ± 4.44 (4–15)	8.59 ± 5.69 (4–15)	8.39 ± 2.93 (4–15)
Hospitalization cost (USD; range)	$3{,}173.7 \pm 860.5$ (713.8–5,693.2)	$3{,}076.4 \pm 787.0$ (713.8–5,693.2)	$3{,}261.3 \pm 920.8$ (806.4–5,567.1)

Hospitalization cost was adjusted using the 2009–2010 average currency (USD/NTD = 1/31.56) published by Central Bank of the Republic of China. *Indicates significant difference between Group M and Group S ($p < 0.0001$).

significantly different (data not shown). The results of the log-linear regression model for resource utilization revealed that patients in Group S were associated with 43% longer operation time ($p < 0.0001$; adjusted R^2: 0.319) when comparing that of patients in the Group M after controlling for the observed covariates.

Discussion

ACDF was first described by Smith et al in 1958 [6], and until recently, some western studies had revealed that it takes about 14,300–23,400 USD and 1–3 days of hospital stay for patients undergoing ACDF procedures [3,7]. A more recent study using the National Inpatient Sample of Canada demonstrated a much higher cost for the surgery, which was between 36,835 to 57,469 USD [8]. However, local data for Taiwanese population are scanty. To the best of our knowledge, this is the first local study in the literature to examine the issue of both safety and resource utilization in patients undergoing ACDF.

The incidence of potential common complications associated with cervical spine surgery ranges from 2% to 70% [4]. Recurrent nerve palsy, respiratory insufficiency, epidural hematoma, quadriplegia, and pharyngeal injury occurred occasionally, with incidences ranging from 0.2% to 1.1%. However, death was infrequently seen [3,9,10]. Higher complication rates associated with level 3 or higher cervical surgery was noted in some studies [11]. We therefore further classified the population sample into two groups: patients with level 1 or 2 disease (Group M) and those with level 3 or 4 disease (Group S), to draw more valid conclusions regarding disease severity. The initial descriptive analyses demonstrated that the two groups were clinically homogeneous, except that patients in Group S were older. Spondylosis refers to age-related degenerative changes in the spinal column [12], therefore, it was reasonable to presume that the older population would develop more severe disease. However, a wide age distribution was observed in our study, leading to the interesting finding that DCS developed in younger patients in Taiwan when compared to western or Japanese studies [13,14]. Large studies are warranted to clarify the causation of such a difference. The present study described a complication rate of 1.0% for patients undergoing multilevel ACDF. This rate was not higher than those reported in the studies mentioned above. Patients with level 3 or 4 disease in our study were expected to have a higher rate of complications than those with level 1 or 2 disease. However, only one complication occurred in the patients with level 3 or 4 disease, which did not differ significantly from those with level 1 or 2 disease.

This study assumed that disease severity would affect the risk of complications and resource utilization. Resource utilization of length of hospital stay or hospitalization cost was not significantly higher among patients with level 3 or 4 disease compared with level 1 or 2 disease. Instead, the results of a log-linear regression model for resource utilization revealed that patients with level 3 or 4 disease was associated with 43% longer operation time when comparing with patients with level 1 or 2 disease, after controlling for the observed covariates. Many studies have concluded that age and comorbidity are associated with the need for critical care and prolonged hospitalization, which would reflect higher hospitalization costs [15–17]. However, our study results fail to verify this conclusion, partly because operations for various levels of disease are reimbursed with the same payment [e.g., operation fee is reimbursed at the same rate (485.59 USD per ACDF) regardless of whether the procedure is for a single-level or multilevel disease) by the NHI authority in Taiwan. Fusion material is not yet reimbursed comprehensively by the NHI, and so patients must pay for it themselves or wait until payment permission is obtained. To avoid the cost bias of patient-paid, high-tech prostheses, we therefore decided to use hospital inpatient (NHI) reimbursement data for comparison of hospitalization costs. A prospective, randomized controlled study in a more carefully selected population sample is needed to give a definitive clarification.

Limitations of the present study included a lack of prospective randomized design, the small sample size, and limited samples obtained from a single department (neurosurgery) in our institution. A large, prospective randomized study is warranted to determine factors affecting the safety and resource utilization of patients undergoing ACDF.

In conclusion, neurosurgical multilevel ACDF procedures are safe. Among patients with level 3 or 4 disease, compared with patients with level 1 or 2 disease, there was no higher rate of complications, or no higher resource utilization of length of hospital stay or hospitalization cost. However, resource utilization of operation time was significantly higher in this group of patients. These results demonstrate the impact of disease severity on the incidence of complications and outcome differences. When surgery is considered appropriate for patients with multilevel diseases, these data suggest that ACDF should be the operation of choice.

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