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Is surgery for cervical spondylotic myelopathy cost-effective? A cost-utility analysis based on data from the AOSpine North America prospective CSM study

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Object. Surgical intervention for appropriately selected patients with cervical spondylotic myelopathy (CSM) has demonstrated favorable outcomes. This study evaluates the cost-effectiveness of this type of surgery in terms of cost per quality-adjusted life year (QALY) gained.

Methods. As part of a larger prospective multicenter study, the direct costs of medical treatment for 70 patients undergoing surgery for CSM at a single institution in Canada were retrospectively obtained from the hospital expenses database and physician reimbursement data. Utilities were estimated on the entire sample of 278 subjects enrolled in the multicenter study using SF-6D–derived utilities from 12- and 24-month SF-36v2 follow-up information. Costs were analyzed from the payer perspective. A 10-year horizon with 3% discounting was applied to health-utilities estimates. Sensitivity analysis was performed by varying utility gain by 20%.

Results. The SF-6D utility gain was 0.0734 (95% CI 0.0557–0.0912, $p < 0.01$) at 12 months and remained unchanged at 24 months. The 10-year discounted QALY gain was 0.64. Direct costs of medical treatment were estimated at an average of CaD $21,066. The estimated cost-utility ratio was CaD $32,916 per QALY gained. The sensitivity analysis showed a range of CaD $27,326–$40,988 per QALY gained. These estimates are within the limits for medical procedures that have an acceptable cost-utility ratio.

Conclusions. Surgical treatment for CSM is associated with significant improvement in health utilities as measured by the SF-6D. The direct cost of medical treatment per QALY gained places this form of treatment within the category deemed by payers to be cost-effective.

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Key Words • **cervical spondylotic myelopathy** • **cost utility** • **quality of life** • **spinal cord injury**

Cervical spondylotic myelopathy is a progressive, degenerative disease and the most common cause of spinal cord dysfunction worldwide.[34] Narrowing of the spinal canal is caused by disc protrusion, ossification of the posterior longitudinal ligament, thickening of the ligamentum flavum, or osteophytes, and leads to compression of the cervical spinal cord and nerve roots. Depending on the severity of the disease, symptoms can include neck pain, loss of hand dexterity, gait difficulties, and impotence.[5,26,34] Over time, progressive CSM may lead to tetraparesis or tetraplegia.[9,27]

Previous studies have demonstrated that CSM can severely reduce a patient's health-related quality of life.[12,31] Patients with CSM are often treated surgically to halt or reverse the progression of myelopathic symptoms.[10,21] Surgical intervention has been shown to significantly improve functional status, decrease neurological symptoms, and reduce overall pain.[8,17,30,31]

Despite the frequent clinical occurrence of CSM and the widespread use of surgery for this condition, the cost-effectiveness of this intervention has not been previously assessed. We therefore sought to address this knowledge

Abbreviations used in this paper: CSM = cervical spondylotic myelopathy; mJOA = modified Japanese Orthopaedic Association; QALY = quality-adjusted life year; SF-6D = 6-dimensional Short Form Health survey (derived from the SF-36); SF-36v2 = 36-Item Short Form Health Survey, version 2.

gap. This study reports the results of a cost-utility analysis of surgical intervention for the treatment of CSM at a single Canadian institution. Further, we compare the cost utility of CSM surgery to that of other common medical interventions.

Methods

Study Design

Between January 2006 and September 2007, patients entering treatment for CSM in the Division of Neurosurgery in the Toronto Western Hospital of the University Health Network were prospectively recruited for this study, which was part of a larger multicenter AOSpine North America CSM study examining the outcomes of surgical treatment of CSM. The research ethics board governing Toronto Western Hospital approved the study, and all patients gave their informed consent in writing.

Ninety-three patients undergoing surgery for symptomatic CSM were enrolled in the study and were followed up for 24 months. Symptomatic CSM was defined as experiencing one or more of the following symptoms: numb or clumsy hands, impairment of gait, bilateral arm paresthesia, Lhermitte phenomenon, and weakness. Furthermore, the patient had to demonstrate one or more of the following: corticospinal distribution motor deficits, atrophy of hand intrinsic muscles, hyperreflexia, a positive Hoffman sign, upgoing plantar responses, lower-limb spasticity, or a broad-based unstable gait. Patients were excluded from the study if they had asymptomatic cervical cord compression, if they had undergone previous surgery for CSM or were not referred for surgical consultation or if they had concomitant symptomatic lumbar stenosis, an active infection, neoplastic disease, rheumatoid arthritis, or ankylosing spondylitis.

Table 1 describes patient demographic characteristics. Of the 93 participants, 10 (11%) withdrew before study completion, 13 (14%) did not complete follow-up, and 70 (75%) completed the required 24-month follow-up.

TABLE 1: Summary of demographic and clinical characteristics of study participants treated at Toronto Western Hospital (n = 70)*

Characteristic	Value
sex	
male	49 (70)
female	21 (30)
surgery	
anterior	45 (64)
posterior	18 (26)
anterior & posterior	6 (9)
mean age	55.25 ± 10.81
mean no. of levels treated	3.44 ± 1.16

* Values represent numbers of patients (%) unless otherwise indicated. Means are given ± SD.

Outcome Measures

The effectiveness of the intervention was evaluated by measuring the change in utilities using SF-6D utility values derived from SF-36v2 scores. The SF-36v2 has been proven to be valid and reliable in patients with CSM.[11] The SF-6D is a health state classification measure that is based on 7 of the 8 domains of the SF-36v2 questionnaire, combining physical functioning, emotional and physical role participation, social functioning, bodily pain, mental health, and vitality. The SF-6D describes 18,000 health states. These are accompanied by a set of standard gamble–derived preference weights obtained from a sample of the general population. The preference weights range from 0.0 (worst health state) to 1.0 (best health state) and are used in cost-utility analyses.[3,35] Patients were asked to complete the SF-36v2 questionnaire before treatment and at 6, 12, and 24 months following surgery. The SF-6D health utility gains were derived from the entire multicenter study sample by calculating the difference between baseline and 12-month follow-up values. Of the 278 patients enrolled in the multicenter study, 17 withdrew consent and 1 died of an unrelated cause prior to 12 months' follow-up. Follow-up data were available for 222 (85.4%) of the 260 eligible patients. The SF-6D utilities at the Toronto site were consistent with the utilities in the overall CSM–North America study. A 10-year horizon with 3% discounting was applied to health utilities to determine the number of QALYs gained by the intervention. A QALY provides an estimate of the number of months or years of a reasonable quality of life a patient can expect to gain from treatment. For example, if the patient's health state was 0.6 before treatment and 0.8 after treatment, the annual gain is 0.2 QALYs.[22]

Health outcomes were also evaluated using the Neck Disability Index, the mJOA scale, and a modified version of the Nurick Scale. The original Nurick Scale is a 6-grade system (0–5) that does not include a classification for asymptomatic patients.[24] Our modified version is a 7-grade scale (0–6), where Grade 0 represents no root or cord symptoms and Grades 1–6 are equivalent to Grades 0–5 of the original Nurick scale.

Medical Costs

Direct medical costs of treatment for each patient comprised hospital inpatient costs and physician reimbursement costs obtained from the hospital's Case-Costing Database and from the Ontario Schedule of Benefits for Physician Services (Table 2). Direct medical costs comprised all inpatient services provided in the 24 months following surgery, including ward costs, medication, instrumentation, and in-hospital services and procedural costs, as well as any treatment for peri- and postoperative complications including reoperations occurring within 24 months following the index surgery. Outpatient costs consisted of pre- and postoperative MRI studies and 3 follow-up visits, which were completed as per protocol and reflect the standard of care at Toronto Western Hospital. Postoperative MRI is used to ascertain the adequacy of decompression after surgery.[3] Indirect costs, such as disability losses and foregone productivity, were not included. Also not included were costs of loss of quality of life.

TABLE 2: Direct costs of medical treatment for surgical decompression in patients with symptomatic CSM

Item Billed	Average Cost (CaD $)
clinic	
special surgical consultation	144.75
preadmission surgery admission unit	182.56
follow-up visits (including radiography)	364.92
imaging	
preop MRI	262.95
postop MRI	262.95
procedure	
spine surgeon billing	3,393.56
anesthesia billing	1,220.71
inpatient costs*	15,234.04
total	21,066.44

* Inpatient costs include cost of hospital room, food, medications, implants, laboratory testing, and administration for index surgery and any rehospitalization.

Statistical Analysis

The cost-effectiveness of the surgery was analyzed from the perspective of health care payers. Dividing the mean cost of treatment by the mean number of QALYs gained provides an estimate of cost utility measured in cost per QALY. A sensitivity analysis was performed by varying utility values by 20%. Data analysis was generated using SAS/STAT software, version 9.2 of the SAS System for Windows (SAS Institute, Inc.).

Results

Patients exhibited significant improvement in all measured health outcomes at 12 months following surgery (Table 3). The SF-6D utilities improved significantly by a mean of 0.0734 (95% CI 0.0557–0.0912, $p < 0.01$) at 12 months and remained unchanged at 24 months. Patients experienced a mean discounted gain of 0.64 QALYs over the 10-year period.

The mean estimated value (± SD) for the direct costs of medical treatment was CaD $21,066 ± $14,759 (range CaD $14,494–$148,197). The range in surgery costs was due to different types of surgical approaches, emergency surgeries with after-hours premiums, and/or the inclusion of a second surgery within 24 months of the primary surgery.

The estimated cost-utility ratio was CaD $32,916 per QALY. The sensitivity analysis showed a range of $27,326–$40,988 per QALY gained, based on a 20% variation in utility values.

Discussion

Our analysis suggests that surgical treatment for CSM is a cost-effective intervention by conventional standards. The cost-utility ratio for CSM surgeries is CaD $32,916/QALY, which is below WHO benchmarks that suggest that programs be considered highly cost-effective if life years are purchased at a cost of less than gross domestic product per capita, which was US $45,110 (CaD $46,012 by midyear exchange rate in 2008).[36] Table 4 lists the cost utility of other accepted surgeries, indicating that the cost per QALY gained for CSM surgery falls within the range of surgical procedures deemed to be cost-effective.

Cervical spondylotic myelopathy often affects people over the age of 50 years, and as our population ages, the frequency of surgeries in cases of CSM is expected to rise.[25,37] This study demonstrates that surgical decompression and fusion can induce a clinically relevant improvement of health-related quality of life in patients with CSM, findings which are consistent with earlier CSM studies.[11,32,35] Previous CSM studies have also demonstrated that symptoms rarely improve with conservative management of CSM.[7,14,33] In patients with CSM that is left untreated, symptoms often worsen, and a subgroup of patients may even progress to tetraplegia.[13]

Strengths of this study include the use of prospectively accrued data, a large sample size, the use of a validated outcome measure, and a thorough analysis of all direct medical costs. In addition, the demographics of the participants at our center were very similar to participants at all other 11 study centers in the US.[10] Cost-effectiveness

TABLE 3: Changes in neurological severity and functional and health outcomes in the entire multicenter sample (n = 222)*

Outcome Measure (score range)	Mean Score		Mean Change	p Value
	Baseline	12 Mos		
mJOA (0–18)	13.01 ± 2.63	15.74 ± 2.52	2.74 ± 2. 94	<0.0001
modified Nurick Scale (0–6)†	3.11 ± 0.96	1.51 ± 1.48	−1.60 ± 1.43	<0.0001
Neck Disability Index (0–100)	41.76 ± 21.03	30.39 ± 22.94	−11.34 ± 18.43	<0.0001
SF-36v2				
PCS (0–100)	36.60 ± 9.67	41.88 ± 11.66	5.28 ± 9.26	<0.0001
MCS (0–100)	40.09 ± 10.87	45.30 ± 11.67	5.21 ± 9.87	<0.0001
SF-6D (0–1)	0.575 ± 0.131	0.648 ± 0.148	0.073 ± 0.126	<0.0001

* MCS = Mental Component Summary; PCS = Physical Component Summary.
† Includes a classification for patients with no root or cord symptoms (see *Methods*).

TABLE 4: Cost per QALY of common surgical interventions

Intervention	Cost Utility (US $/QALY)	Authors & Year
cataract surgery	2,020	Busbee et al., 2002
hip replacement	6,668	Lavernia et al., 2011
knee replacement	30,695	Lavernia et al., 1997
	28,100	Losina et al., 2009
gastric bypass surgery	35,600	Craig & Tseng, 2002
primary liver transplantation	52,000	Landman et al., 2011
laminectomy w/ noninstrumented fusion	56,500	Kuntz et al., 2000
revision decompression & fusion	62,955	Adogwa et al., 2011

analyses have some inherent methodological limitations, including the assumptions made in deriving QALYs from health outcomes. While there is a debate over the use of EQ-5D (developed by the EuroQol Group) versus SF-6D utility values, this study uses SF-6D values to calculate QALYs gained, which is a validated approach in cost-utility analyses.[29] In choosing a 10-year horizon for health outcomes, we have assumed that the benefits of surgery remain 10 years postoperatively, an assumption that is supported by anecdotal rather than empirical evidence. To further address this issue, we have discounted utilities by 3%, effectively reducing the value of long-term gains.

Additional limitations of this study include an incomplete analysis of all costs associated with CSM surgery. Costs were calculated from the health care payers' perspective and therefore include only reimbursements for direct hospital treatment. While the reimbursements are not necessarily the same as the costs for provided treatment, our approach follows similar methodology to other cost-utility analyses.[1,18,22,28] Furthermore, we did not compare the costs of surgical versus conservative treatments and have not subtracted the avoided costs of conservative disease management. Thus it is possible that surgical treatment is more cost-effective than our results suggest.

Our cost data reflect costs in the Canadian health care system. The extent to which these data apply in other countries depends on the actual costs of similar services.

Conclusions

Surgical intervention for patients with CSM leads to significant improvement in health utilities measured by SF-6D preference-based utility scores. The cost per QALY gained is within the range of values considered cost-effective. Allocation of hospital resources should focus on creating awareness of this condition at the primary care level, allowing for rapid triage, imaging, assessment, and treatment.

Disclosure

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