

Neurological Recovery after Posterior Spinal Surgery in Patients with Metastatic Epidural Spinal Cord Compression

Noriyuki Watanabe^a, Yoshihisa Sugimoto^{a*}, Masato Tanaka^a, Tetsuro Mazaki^a, Shinya Arataki^a, Tomoyuki Takigawa^a, Masaki Kataoka^a, Toshiyuki Kunisada^b, and Toshifumi Ozaki^a

Departments of ^aOrthopaedic Surgery, ^bMedical Materials for Musculoskeletal Reconstruction, Okayama University Graduate School of Medicine, Dentistry and Pharmaceutical Sciences, Okayama 700-8558, Japan

Metastatic epidural spinal cord compression (MESCC) is a common complication in patients with a malignant tumor, but it is difficult to decide the proper time to perform the necessary surgery. Here we analyzed the prognostic factors for postoperative walking ability. We retrospectively reviewed the cases of 112 MESCC patients treated surgically at our institute and divided them into ambulatory (n = 88) and non-ambulatory (n = 24) groups based on their American Spinal Injury Association (ASIA) Impairment Scale grades at the final follow-up. We also classified the patients preoperatively using the revised Tokuhashi score. We assessed the correlation between preoperative or intraoperative factors and postoperative walking ability in both groups. Of the 10 patients classified preoperatively as grade A or B, 2 (20%) were ambulatory at the final follow-up. Of the 102 patients classified preoperatively as grade C, D or E, 86 (84%) were ambulatory at the final follow-up ($p < 0.001$). There were no significant differences between the groups in the average total Tokuhashi score. Our analysis revealed that the severity of paralysis significantly affects neurological recovery in patients with MESCC. Patients with MESCC should receive surgery before the preoperative ASIA Impairment Scale grade falls below grade C.

Key words: metastatic epidural spinal cord compression, American Spinal Injury Association Impairment Scale, Tokuhashi score, walking ability, prognostic factor

Spinal metastasis occurs in 30-60% of patients with a malignant tumor [1-3]. Metastatic epidural spinal cord compression (MESCC) is a common complication in patients with malignant tumors occurring in 5-14% of all cases [4-7]. There are a variety of options for the treatment of MESCC. Some patients are treated nonsurgically by radiotherapy or chemotherapy, while others undergo surgical treatments such as posterior decompression with or without instrumentation or total en bloc spondylectomy [8-11].

Several authors have reported that radiotherapy is as effective as decompressive surgery in preserving neurological function and pain control [4,12-14]. However, decompressive surgery was shown to be superior to radiotherapy in preserving neurological function [15,16]. Although the goals of surgery for MESCC are to improve the patient's prognosis and quality of life, it is difficult to decide the proper time to perform the surgery. In this study, we analyzed MESCC patients who underwent surgery, and we determined the prognostic factors for postoperative

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*Corresponding author. Phone: +81-86-235-7273; Fax: +81-86-223-9727
E-mail: sugi.ort@gmail.com (Y. Sugimoto)

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walking ability.

Patients and Methods

This study was approved by the ethical review board of our hospital (ID 1604-503). From 1987 to 2014, 112 consecutive patients with MESCC (73 men and 39 women) underwent surgery at our hospital. The average age was 61.5 years (range 14-83 years). The average period from the onset of symptoms (local back pain, radicular pain and neurological deficit) to surgery was 99.4 days (range 1-1100 days). The average follow-up time after surgery was 17.0 months (range 0.5-84 months) (Table 1).

Using the American Spinal Injury Association (ASIA) Impairment Scale [17], we classified these 112 patients preoperatively as grade A in 2 patients, B in 8, C in 59, D in 36 and E in 7 patients. The ASIA Impairment Scale grades are defined as follows: grade A, no sensory or motor function is preserved in the sacral segments; grade B, sensory but not motor function is preserved below the neurological level and includes the sacral segments; grade C, motor function is preserved below the neurological level, and more than half of key muscles below the neurological level have a muscle grade < 3; grade D, motor function is preserved below the neurological level, and at least half of key muscles below the neurological level have a muscle grade \geq 3; grade E, sensory and motor function is normal.

The surgical indications are neurological deficit, severe pain and possibility of spinal vertebrae collapse. We chose a posterior procedure to achieve decompression of the spinal cord. We performed instrumentation surgery if the patient had spinal instability. Seven patients underwent decompression surgery alone, and 87 patients underwent decompression surgery with posterior fusion. Five patients underwent both anterior and posterior approaches, and 11 underwent total en bloc spondylectomies.

Table 1 Patients characteristics (n = 112)

Age*	61.5 (14-83)	years
Sex (male/female)	73/39	patients
The time from the onset until operation*	99.4 (1-1,100)	days
Follow-up time after surgery*	17.0 (0.5-84)	months

*average (range)

We classified the 112 patients preoperatively using the revised Tokuhashi score [18]. There were 57 patients whose total Tokuhashi scores were 0-8, 52 whose total scores were 9-11, and 13 whose total scores were 12-15. The revised Tokuhashi score consists of 6 items thought to affect the outcome (general condition, number of bone metastases other than spinal metastases, number of spinal metastases, type of primary lesion, presence or absence of metastases to major organs, and state of paralysis). The survival period is predicted to be \leq 6 months when the total score is 0-8, \geq 6 months when the total score is 9-11, and \geq 1 year when the total score is \geq 12.

The primary tumors in these patients included lung (n = 25), prostate (n = 13), kidney (n = 12), breast (n = 12) and thyroid (n = 10) (Table 2). Sixteen responsible lesions were located in cervical vertebrae, 76 in thoracic vertebrae and 20 in lumbar vertebrae. Of the 112 patients, 16 (14%) had multiple spinal compression lesions.

We performed a retrospective review and divided the patients into 2 groups based on their ASIA Impairment Scale grades at the final follow-up. There were 88 patients (58 men and 30 women) in the ambulatory group and 24 patients (15 men and 9 women) in the non-ambulatory group. The average age was 60.6 years (14-83 years) in the ambulatory group and 64.6 years (40-78 years) in the non-ambulatory group. The types of primary tumors found in the ambulatory group were lung (n = 21), breast (n = 10), prostate (n = 10), thyroid (n = 8) and kidney (n = 6). The patients in the non-ambulatory group had kidney (n = 6), lung (n = 4), prostate (n = 3), thyroid (n = 2)

Table 2 Sites of primary tumors

Primary tumors	Ambulatory	Non-ambulatory	Total
Lung	21	4	25
Prostate	10	3	13
Kidney	6	6	12
Breast	10	2	12
Thyroid	8	2	10
Gastric	3	1	4
Rectum	2	1	3
Liver	2	1	3
Osteosarcoma	3	0	3
Others	21	3	24
Unclear	2	1	3
Total	88	24	112

and breast (n = 2) tumors (Table 2).

The ambulatory group had 15 lesions located in cervical vertebrae, 55 in thoracic vertebrae and 18 in lumbar vertebrae, whereas one lesion was located in cervical vertebrae, 21 in thoracic vertebrae and 2 in lumbar vertebrae in the non-ambulatory group. As for the preoperative impairment scale grades, there were 2 patients with grade B impairment, 44 with grade C, 35 with grade D and 7 with grade E in the ambulatory group. In the non-ambulatory group, there were 2 patients with grade A impairment, 6 with grade B, 15 with grade C and one with grade D. Grade C was most prevalent in both groups. As for the revised Tokuhashi score, there were 44 patients whose total scores were 0–8, 33 whose total scores were 9–11 and 11 whose total scores were 12–15 in the ambulatory group. In the non-ambulatory group there were 13 patients whose total scores were 0–8, 9 whose total scores were 9–11, and 2 whose total scores were 12–15.

We assessed the correlations between preoperative or intraoperative factors and the patients' postoperative walking ability in both groups, using the Mann-Whitney *U*-test and Fisher's exact probability test. We regarded a value of $p < 0.05$ as significant.

Results

Of the 10 patients classified preoperatively as grade A or B, 2 (20%) were ambulatory at the final follow-up (Table 3). In contrast, of the 102 patients classified preoperatively as grade C, D or E, 86 (84%) were ambulatory at the final follow-up ($p < 0.001$). The probability of a patient being able to walk after surgery was 0% for those with a preoperative impairment scale grade of A, 25% for grade B, 75% for grade C, 97% for grade D and 100% for grade E (Fig. 1).

The average amount of intraoperative bleeding was 960 ml (range 20–3,420 ml) in the ambulatory group and 1,230 ml (range 230–3,090 ml) in the non-ambulatory group. The average length of surgery was 199 min (range 60–975 min) in the ambulatory group and 259 min (range 100–685 min) in the non-ambulatory group. There was no significant difference between the groups in bleeding ($p = 0.35$) or duration of surgery ($p = 0.78$).

The rates of improving by one grade at the final follow-up on the ASIA Impairment Scale were 63%

(55 of 88 patients) in the ambulatory group and 25% (6 of 24 patients) in the non-ambulatory group (Table 4). The average total Tokuhashi scores were 8.4 points in the ambulatory group and 7.8 in the non-ambulatory group. There were no significant differences between the 2 groups in the average total Tokuhashi score ($p = 0.35$) or the average score for each of the 5 measured Tokuhashi parameters, except for the state of paralysis. The average survival period was 12 months in both groups.

Table 3 ASIA impairment scale grade at final follow-up based on preoperative ASIA impairment scale grade

Preoperative ASIA impairment score	Ambulatory (grade D,E)	Non-Ambulatory (grade A,B,C)	Total
grade (A, B)	2pts	8pts	
A	0	2	2
B	2	6	8
grade (C, D, E)	86	16	102
C	44	15	59
D	35	1	36
E	7	0	7
Total	88	24	112

ASIA, American Spinal Injury Association; Ambulatory group, ASIA impairment score grade D and E at the final follow-up; Non-Ambulatory group, ASIA impairment score grade A, B and C at the final follow-up. pts: patients

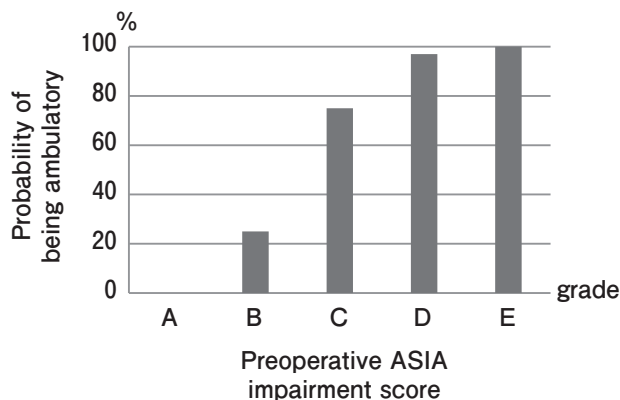


Fig. 1 Probability of being ambulatory after surgery depending on the preoperative ASIA impairment score. A severe preoperative ASIA impairment score was observed to reduce the probability of being ambulatory. ASIA, American Spinal Injury Association.

Table 4 Change of ASIA impairment scale grade before and after surgery

Preoperative ASIA impairment score	Postoperative ASIA impairment score				
	A	B	C	D	E
A	1		1		
B		1	5	1	1
C	1	2	12	41	3
D			1	30	5
E					7

Improved
 No change
 Worse

ASIA : American Spinal Injury Association

Discussion

Our findings revealed that the severity of the preoperative paralysis greatly affected the final walking ability in MESCC patients. Patients with MESCC should receive spinal surgery before their ASIA Impairment Scale grade falls below grade C. In our study, 10 patients had preoperative impairment scale grades of A or B, and 2 of these patients (20%) were ambulatory by the final follow-up.

We graded 102 patients as C, D or E, and 86 (84%) recovered their ability to walk. Several authors reported that the level of preoperative paralysis was associated with postoperative ambulation [4-7,14,16,19-25]. Helweg-Larsen *et al.* reported that ambulatory function before surgery was the main determinant for postoperative gait function [16]. Chaichana *et al.* also showed that the preoperative ability to walk was associated with ambulatory status at the time of the last follow-up [6].

In the present study, the rates of improving by at least one grade on the ASIA Impairment Scale at the final follow-up were 25% in the non-ambulatory group, 63% in the ambulatory group, and 54% for all patients. Several groups showed that the improvement rate was worse for patients who were non-ambulatory before surgery compared to those who were ambulatory [25-27]. Hirabayashi *et al.* reported a 39% (9 of 23 patients) improvement rate of at least one grade on the Frankel scale for patients in their non-ambulatory group, 89% (31 of 35 patients) in the

ambulatory group and 69% (40 of 58 patients) overall [26]. Chong *et al.* reported improvement rates of at least one Frankel grade in 11% (2 of 19) of preoperative non-ambulatory patients, 43% (19 of 44) of ambulatory patients with a Frankel grade less than E, and 33% (21 of 63) of all patients with a Frankel grade less than E [25].

Other than the paralysis parameter, our results showed no association between postoperative ambulatory status and Tokuhashi score or type of primary tumor. Several research groups have reported relationships between the preoperative Tokuhashi score and postoperative ambulatory function or survival [7,22]. Park *et al.* showed that the preoperative Tokuhashi score was significantly associated with longer overall survival, but it was not prognostic of postoperative ambulation [7]. Moon *et al.* demonstrated that the Tokuhashi scoring system was not a significant prognostic predictor for postoperative ambulatory function or survival [22].

Our present findings suggest that the average intraoperative blood loss and operation time are not associated with postoperative ambulatory function. Few studies have demonstrated any correlation between average intraoperative blood loss or operation time and postoperative ambulatory ability, but several authors described other prognostic factors for postoperative ambulatory function in patients with spinal metastasis [6,7,22,25].

The limitations of this study include the short follow-up period after surgery and the exclusion of a discussion on whether radiotherapy or chemotherapy was performed in the patients.

In conclusion, our analysis of 112 consecutive patients with MESCC showed that the severity of their paralysis significantly affected their neurological recovery. Patients with MESCC should undergo surgery before the preoperative ASIA Impairment Scale grade falls below grade C.

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