Early Ambulation Training as Impairment-Driven Rehabilitation in Cancer Patients with Cervical Spine Metastases After Palliative Spine Surgery

Yukako Ishida
Nara Medical University School of Medicine Graduate School of Medicine: Nara Kenritsu Ika Daigaku Igakubu Igakuka Daigakuin Igaku Kenkyuka
Hideki Shigematsu
Nara Medical University School of Medicine Graduate School of Medicine: Nara Kenritsu Ika Daigaku Igakubu Igakuka Daigakuin Igaku Kenkyuka
Shinji Tsukamoto
Nara Medical University School of Medicine Graduate School of Medicine: Nara Kenritsu Ika Daigaku Igakubu Igakuka Daigakuin Igaku Kenkyuka
Yasuhiko Morimoto
Nara Medical University School of Medicine Graduate School of Medicine: Nara Kenritsu Ika Daigaku Igakubu Igakuka Daigakuin Igaku Kenkyuka
Eiichiro Iwata
Nara Medical University School of Medicine Graduate School of Medicine: Nara Kenritsu Ika Daigaku Igakubu Igakuka Daigakuin Igaku Kenkyuka
Akinori Okuda
Nara Medical University School of Medicine Graduate School of Medicine: Nara Kenritsu Ika Daigaku Igakubu Igakuka Daigakuin Igaku Kenkyuka
Shingo Kishi
Nara Medical University School of Medicine Graduate School of Medicine: Nara Kenritsu Ika Daigaku Igakubu Igakuka Daigakuin Igaku Kenkyuka
Hiromasa Fujii
Nara Medical University School of Medicine Graduate School of Medicine: Nara Kenritsu Ika Daigaku Igakubu Igakuka Daigakuin Igaku Kenkyuka
Kanya Honoki
Nara Medical University School of Medicine Graduate School of Medicine: Nara Kenritsu Ika Daigaku Igakubu Igakuka Daigakuin Igaku Kenkyuka
Yasuhito Tanaka
Nara Medical University School of Medicine Graduate School of Medicine: Nara Kenritsu Ika Daigaku Igakubu Igakuka Daigakuin Igaku Kenkyuka
Akira Kido (akirakid@naramed-u.ac.jp)
Nara Medical University Hospital https://orcid.org/0000-0002-7658-3690

Research Article

Keywords: early ambulation, cancer rehabilitation, palliative cervical surgery, cervical spine metastasis.

Posted Date: September 29th, 2021

DOI: https://doi.org/10.21203/rs.3.rs-843585/v1

Abstract

Background

Cervical spine metastasis worsens the quality of life (QOL) of patients with cancer. While the beneficial effects of surgery have been reported, the detailed course of functional recovery remains unclear, especially in the acute phase of rehabilitation. We previously reported on impairment-driven rehabilitation in patients with thoracic or lumbar level metastases. The present study assessed the effects of an impairment-driven strategy on the early recovery of ambulatory function in patients with cervical spine metastasis.

Methods

We retrospectively reviewed 13 consecutive patients with cervical neoplastic spinal compression. The patients were those whose primary impairment with spinal instability identified by a multidisciplinary tumor board who underwent palliative spine surgery. In addition, we examined neurological deficits; ambulation status; pathological fracture, collapse, and postoperative implant failure progress; and Barthel Index (BI).

Results

The average duration of ambulation was 3.75 ± 3.92 days after surgery. One case showed collapse and two showed progressions of paralysis. However, all patients had early ambulation after surgery, except for one patient who developed postoperative cerebral infarction. The BI scores showed an improving tendency; however, the difference before and after rehabilitation was not statistically significant.

Conclusions

We reviewed the recovery course of ambulation in patients with cervical spine metastases who underwent impairment-driven rehabilitation. Combined with surgery and early mobilization, this strategy may improve the QOL of patients with cancer and cervical spine metastasis.

Background

Cancer patients with bone metastases often have multiple impairments due to the primary lesions, as well as metastatic lesions and cancer treatment itself [1]. Owing to the long periods associated with cancer treatment, most survivors do not return to their previous state of well-being [2, 3]. These impairments contribute to a decreased quality of life (QOL), resulting in disability [4]. Many groups have reported that cancer rehabilitation improves physical and cognitive impairments, social participation, and QOL at every stage of the treatment courses for various cancer types [5–11].

Spinal metastases are a skeletal-related oncological condition at an advanced stage that causes pain or neurological disorders [12]. They directly affect the activities of daily living (ADL) and QOL, and also shorten patient life expectancy due to various complications. The treatment methods for spinal metastases include chemotherapy, radiation therapy, and surgical treatment [13]. For patients at this stage, the functional prognosis is as important as life expectancy [14, 15]. Surgical treatment can be a good alternative for patients with particular impairment types [16]. After surgery, immediate rehabilitation is essential as long rest periods may result in a poor prognosis [13]. Thus, early ambulation is as crucial as early surgery. Therefore, these should be considered indivisible treatments.

We recently reported impaired cancer rehabilitation in patients with neoplastic spinal cord compression at the thoracic and lumbar levels after palliative surgery [16]. In 2013, Silver et al. proposed impairment-driven cancer rehabilitation [1]. They emphasized the importance of identifying physical impairments as the interactions among multiple physical impairments frequently drive disability. Furthermore, the authors stressed that an important component of the rehabilitation care continuum should be offered to survivors only after their impairments have been identified, treated optimally, and safety precautions and contraindications have been identified and documented [1]. Based on these findings, we believe that the identification of impairments is of utmost importance in patients with neoplastic spinal compression. In patients with a primary impairment of skeletal instability, spine-fixation surgery allows them to undergo early ambulation training during rehabilitation [16].

The present study focused on the ambulation status of patients with cervical metastasis. While cervical metastasis differs from the other spinal locations because of its higher level of neurological responsibility [17], we believe that the same strategy of impairment-driven rehabilitation could result in good functional recovery. Some groups have reported improved physical function in patients with cervical spine metastasis after palliative surgery [14, 15]. However, the details of functional recovery during rehabilitation are unclear, especially in the acute phase. The prediction of the status of daily recovery would help establish a protocol for training in the acute phase. We retrospectively investigated 13 patients who underwent palliative surgery with immediate rehabilitation after identification of impairments. We investigated their courses of ambulation recovery during training while considering neurological disorders, pathological fractures, vertebral body collapse, and postoperative complications.

Methods

We retrospectively reviewed the data of 13 consecutive patients with neoplastic spinal compression who underwent palliative cervical surgery for spinal metastases and who also received immediate rehabilitation after surgery. Before the surgery, the impairment status was evaluated based on spine-specific and other factors, as previously reported [16]. We also examined neurological deficits, ambulation status, progression of pathological fracture, collapse, postoperative implant failure, and Barthel Index (BI) [18].

Patients

This retrospective study was conducted at Nara Medical University Hospital. The study protocol was approved by the hospital institutional review board. The study was conducted in accordance with the principles of the Declaration of Helsinki and the laws and regulations of Japan. A consecutive cohort of 13 patients with neoplastic spinal cord compression from 2010 to 2018 who met the surgical indications described below was enrolled. The treatment strategies for all patients were assessed by the multidisciplinary tumor board (MDTB) of our hospital. The inclusion criterion was palliative cervical surgery for cervical metastasis during the study period. The follow-up periods averaged 593 ± 643days (range, 60–1872 days).

Multidisciplinary tumor board for skeletal metastasis

An MDTB for the assessment of skeletal metastasis at Nara Medical University Hospital was established in 2010. Since then, the disability/impairment status of each patient has been evaluated. Moreover, treatment plans for approximately 100 patients are evaluated annually. The monthly board meetings are attended by physicians, medical oncologists, radiation oncologists, diagnostic radiologists, physiatrists, orthopedic oncologists, spine surgeons, advanced practitioners, oncological nurses, and clinical support staff. In addition to regular monthly board meetings, web discussions were held for emergency cases selected based on the electronic medical record system of the hospital. The cases eligible for presentation included new or existing outpatients or inpatients with skeletal metastasis. The multidisciplinary tumor board supported the coordination, communication, and decision-making among team members. Based on these board discussions, all patients immediately received intensive and regular adjuvant treatments, including radiation therapy, chemotherapy, palliative care, and rehabilitation.

Surgical indications for palliative cervical surgery

The surgical indications for palliative cervical surgery were comprehensively assessed by the MDTB for skeletal metastasis, based on the following clinical findings:

1. Spinal instability.
2. Radiological spinal compression.
3. Prognosis.
4. Feasibility of the stabilization surgery (presence of multiple spinal lesions).
5. Presence of pain or neurological deficits.

We evaluated spinal instability using the spinal instability neoplastic scale (SINS) score [19]. The SINS is generated by tallying each score from the six individual components (location, pain, bone lesion quality, spinal alignment, vertebral body collapse, and posterolateral involvement of the spinal elements). It SINS showed excellent inter-and intra-observer reliabilities in determining three clinically relevant categories of stability [19]. A score ≥ 7 was classified as potentially unstable or unstable. A 6-point epidural spinal cord compression (ESCC) grading scale was also used [20]. This magnetic resonance (MR) imaging-based grading scale is based on the degree of impingement of the cerebrospinal fluid (CSF) space. The inter-and intra-observer reliabilities were reported to range from good to excellent [20]. After grading, the neurological findings were evaluated. Regarding prognosis, we referred to the Revised Tokuhashi [21] and new Katagiri [22] scores. Patients with an estimated life expectancy of ≥ 3 months were assessed for surgery. Palliative cervical surgery mainly involved posterior fixation. Patients with multiple spinal lesions expanding the vertebra of the planned fixation level were deemed unsuitable for surgery. In addition to fixation, posterior decompression was also performed in tumors occupying only the posterior epidural space and which were not considered hemorrhagic based on radiological and pathological findings.

Rehabilitation

Rehabilitation was started 1 day after the surgery and involved tasks such as sitting, standing, and walking, similar to rehabilitation programs performed after general (non-oncological) spine surgeries.

Outcome evaluations

All patients were hospitalized for surgery. Preoperative measurements were taken at admission, while postoperative measurements were performed at discharge by medical doctors in the Department of Rehabilitation Medicine. The primary outcome evaluations were the BI, neurological deficits using the Frankel Scale (A–E) [23], duration to start ambulation exercises, and overall survival.

The Frankel Scale

The Frankel Scale classifies the extent of the neurological/functional deficits into five grades. Frankel grade A patients show complete motor and sensory lesions, while Grade B patients had sensory-only function below the level of injury. Grade C patients showed some degree of motor and sensory function; however, they lacked retained/recovered motor function. Grade D patients had proper but abnormal motor function below the level of injury. Furthermore, grade E patients showed complete motor and sensory recovery [23].

Duration to the start of ambulation exercises

The duration (days) to the start of ambulation exercise after surgery was obtained from the medical records. We defined the level of mobility achieved during rehabilitation from levels 1 to 5, as described by Kim et al., with some modifications (Table 1) [24].

Table 1
Maximum levels of mobility during hospitalization

Level 1	Therapeutic (in-bed) exercises
Level 2	Bed mobility (supine-to-sit)
Level 3	Transfer training (sit-to-stand/bed-to-chair)
Level 4	Gait training (walk with assistance)
Level 5	Gait training (walk independently)

BI

The BI is one of the most widely used rating scales to measure activity limitations in patients with neuromuscular and musculoskeletal conditions [18]. The BI consists of 10 items that measure a person's daily functioning, including feeding, bathing, grooming, dressing, toilet use, transfers, mobility, and stair use [18]. Previous studies reported high marks for reliability and validity ratings in various reports on the BI [25–27].

Statistical analysis

Statistical analysis was performed using JMP14.0 (SAS Institute, Cary, NC, USA) and G * Power software 3.1 (University of Dusseldorf). Statistical significance was set at $p < 0.05$. As the data using the Shapiro-Wilk test were nonparametric, Wilcoxon signed-rank tests were used to assess the differences in BI scores before and after the rehabilitation intervention.

Results

Patient characteristics

Table 2 shows the patient characteristics. The patients included nine men and four women with a mean age at surgery of 65.5 years (range, 38–84 years). The primary lesions were located in the kidney in two patients (15.4%), colon in 2 patients (15.4%), breast in 2 patients (15.4%), prostate in 1 patient (7.7%), stomach in 1 patient (7.7%), thyroid in 1 patient (7.7%), tongue in 1 patient (7.7%), parotid in 1 patient (7.7%), bladder in 1 patient (7.7%), and schwannoma in 1 patient (7.7%). Frankel's classification of preoperative paralysis was B in 1 patient (7.7%), C in 3 patients (23.1%), D in 5 patients (38.5%), and E in 4 patients (30.8%). The degree of cord compression assessed with the ESCC grading scale included 7.7% for grade 1b, 23.1% for grade 1c, 15.4% for grade 2, and 53.8% for grade 3.

Table 2
Patient Characteristics (n = 13)

Valuable	Value
Sex	
Male	9
Female	4
Age (mean ± SD), years	65.5 ± 13.1
Primary tumor	
Kidney	2
Colon	2
Breast	2
Prostate	1
Stomach	1
Thyroid	1
Tongue	1
Parotid	1
Bladder	1
Schwannoma	1
Frankel classification (pre-operative)	
A	0
B	1
C	3
D	5
E	4
ESCC grade	
1a	0
1b	1
1c	3
2	2
3	7

Table 3. Clinicopathological data and functional prognosis including first ambulation (days) after surgery

Patient no.	Tumor progression classified by Katagiri et al.	ESCC grade	SINs	Frankel classification Preoperative Postoperative	Pathology level	Instrumantation level	BI Preoperative Postoperative	First ambulation training (days after surgery)	Implant failure	Collapse	RT
1	Slow	3	8	C/D	C5-T1	C3-T3	10/55	4	-	-	+
2	Moderate	3	8	C/C	C7.T1	C3-T4	5/10	15	-	-	+
3	Moderate	2	12	D/D	C5.6	C4-T2	50/95	3	-	-	+
4	Rapid	1b	8	D/D	C5,T1-3	C3-T4	0/80	2	-	-	+
5	Slow	1c	11	E/E	C2.3	C2-5	100/100	3	-	-	+
6	Rapid	1c	14	D/D	C4.5	C3-6	100/100	1	-	-	+
7	Rapid	3	10	D/D	C6.7	C3-T2	10/40	1	-	-	+
8	Moderate	2	9	E/E	C7,T5	C4-T2	85/100	1	+	-	+
9	Moderate	3	7	C/B	C4,T11	C2-7	10/30	6	-	+	+
10	Rapid	1c	15	D/D	C6	C3-T1	100/100	1	-	-	+
11	Slow	3	9	E/E	C6	C3-T1	90/95	1	-	-	+
12	Rapid	3	17	B/C	C6	C2-T1	0/50	7	-	-	-
13	Rapid	3	13	E/B*	T7	C3-T3	5/0	NE*	-	-	-

* Patient 13 could not receive the training due to worsening of general condition caused by a cerebral infarction.

Duration to ambulation and functional prognosis after surgery

Table 3 shows the clinicopathological data and functional prognoses, including days to ambulation recovery. Although the spinal cord was highly compressed in almost 70% of patients (15.4% of patients had ESCC grade 2 and 53.8% of patients had grade 3), the mean duration of ambulation was 3.75 ± 3.92 days (range, 1–15 days). One patient could not receive ambulation training owing to a worsening of their general condition caused by cerebral infarction. We also observed one case each of implant failure and vertebral collapse after surgery. The comparison of BI scores before and after surgery showed improvements in nine cases, maintenance in three cases, and worsened status in one.

Neurological recovery on the Frankel scale

Table 4 shows the neurological recovery in terms of the Frankel scale. Neurological deficiency improved or was maintained in 84.6% of patients and worsened in 15.4% of patients.

Table 4
Neurological recovery according to the Frankel scale

Frankel classification	Number of cases before surgery	Number of cases after sugery				
		A	B	C	D	E
A	0	0	0	0	0	0
B	1	0	0	1	0	0
C	3	0	1	1	1	0
D	5	0	0	0	5	0
E	4	0	1	0	0	3

The ambulation status

Figure 1 shows the course of early mobilization after surgery. Most patients achieved progress in ambulation during the early phase. All patients reached level 3 within 15 days after surgery, except for one patient who developed postoperative cerebral infarction.

Changes in Barthel Index (BI) before and after surgery

Figure 2 shows the changes in BI scores after surgery. We found no significant differences in BI score between before and after surgery in the present study.

Discussion

Crevenna et al. reported the importance of rehabilitation with competencies in diagnostic, therapy, and coordination of multi-professional and interdisciplinary rehabilitation teams [9]. They also stressed that cancer rehabilitation must be integrated early into the cancer care continuum [9, 10]. Thus, a multidisciplinary team approach is now advocated as the standard of care for patients with cancer [9–11, 28].

Several studies have reported the effectiveness of surgical treatment with the importance of ambulatory ability in patients with metastatic spinal cord compression. Arrigo et al. reported that preoperative ambulatory status was a significant predictor of survival [29]. Hirabayashi et al. reported that postoperative ambulation was associated with extended survival [13]. We reported a good functional prognosis in patients achieving ambulation within 7 days after surgery [16]. Most recently, in a narrative review conducted by searching MEDLINE and the Cochrane Database of Systematic Reviews, Lawton et al. reported that the prompt diagnosis and treatment of metastatic spinal cord compression could reduce pain and functional loss [30]. Considering the irreversible mechanism of spinal cord injury, the immediate identification of impairments is of utmost importance for starting rehabilitation. As we stressed, surgery and rehabilitation are indivisible treatments under an impairment-driven strategy. Early exercise preserves ambulation ability and supports patient QOL. Furthermore, increased levels of physical activity may prevent patients from experiencing critical events, including cardiac or infectious diseases [31]. MDTB also plays an essential role in the identification of impairment.

Based on Frankel grade evaluation, Younsi et al. investigated the impact of palliative surgery in 101 patients, reporting an improved grade in 61% of patients and that 51% of all non-ambulatory patients (Frankel Grade A–C) regained ambulation [32]. In the present study, 11 of 13 cases (84.6%) showed improved or maintained Frankel grade, while the remaining 2 cases (15.4%). showed worsening. Among these, one patient required reoperation and another developed cerebral infarction after surgery. Although the spinal cord was highly compressed in almost 70% of patients, the mean duration to ambulation was 3.75 ± 3.92 days except for one case who developed postoperative cerebral infarction. These results suggested the feasibility of our impairment-driven strategy. The mean duration of ambulation was 1.63 days in preoperative cases with Frankel grade D or E. Among these cases, five patients could ambulate on postoperative day 1, with four of them walking with assistance on the same day. In addition, patients who developed postoperative cerebral infarction and took 15 days to mobilize did not achieve ambulation. Thus, although it depends on the preoperative neurological status, the onset of early mobilization exercise may reflect the final ADL.

Although the number of cases was small, we believe that the data shown in Fig. 1 regarding the postoperative course of early mobilization provide hope for patients and medical staff confronting these impairments owing to cervical metastases. Furthermore, the data show the daily recovery of patients in ambulation with precise identification of impairments. Thus, we believe that the data will inform the establishment of a training protocol for rehabilitation, which has not been previously reported.

Conclusion

Cervical spine metastasis differs from metastasis of other spinal locations because of its higher neurological level. Therefore, the immediate identification of impairments is of utmost importance in supporting patient QOL, resulting in prolonged survival. In addition, our data on early ambulation training in patients undergoing palliative spine surgery may be useful for establishing a training protocol for impairment-driven rehabilitation.

Declarations

Author contributions

YI and AK conceptualized and designed the study. HS and ST analyzed the results. YM, EI, AO and SK contributed to collecting the cases. HF, KH and YT critically analyzed the manuscript. All authors have read and approved the final manuscript.

Funding

This work was supported by JSPS KAKENHI (Grant numbers: JP18K10753, JP15K01381, and JP20K19383).

Conflicts of interest/Competing interests (include appropriate disclosures)

The authors declare that they have no competing interests.

Availability of data and material (data transparency)

All date used and analyzed during this study are available from the corresponding author on reasonable request.

Code availability: Not applicable

Ethics approval

This study was approved by the Nara Medical University Institutional Review Board.

Consent to participate (include appropriate statements)

Informed consent was obtained through opted-out from all patients.

Consent for publication (include appropriate statements)

Written informed consent was obtained from the patient and legal guardian for publication of these reports.

Acknowledgements

We would like to thank Editage (www.editage.com) for English language editing.

References

1. Silver JK, Baima J, Mayer RS (2013) Impairment-driven cancer rehabilitation: an essential component of quality care and survivorship. CA Cancer J Clin 63:295–317. https://doi.org/10.3322/caac.21186
2. Hewitt M, Rowland JH, Yancik R (2003) Cancer survivors in the United States: age, health, and disability. J Gerontol A Biol Sci Med Sci 58:82–91. https://doi.org/10.1093/gerona/58.1.M82
3. Harrington CB, Hansen JA, Moskowitz M, Todd BL, Feuerstein M (2010) It's not over when it's over: long-term symptoms in cancer survivors-a systematic review. Int J Psychiatry Med 40:163–181. https://doi.org/10.2190/PM.40.2.c
4. World Health Organization (1980) International classification of impairments, disabilities, and handicaps: a manual of classification relating to the consequences of disease, published in accordance with resolution WHA29.35 of the Twenty-ninth World Health Assembly, May 1976. https://apps.who.int/iris/handle/10665/41003. Accessed 13 Jul 2021. World Health Organization
5. Stout NL, Alfano CM, Belter CW, Nitkin R, Cernich A, Lohmann Siegel KL, Chan L (2018) A bibliometric analysis of the landscape of cancer rehabilitation research (1992–2016). J Natl Cancer Inst 110:815–824. https://doi.org/10.1093/jnci/djy108
6. Maltser S, Cristian A, Silver JK, Morris GS, Stout NL (2017) A focused review of safety considerations in cancer rehabilitation. PM R 9:S415–S428. https://doi.org/10.1016/j.pmrj.2017.08.403
7. Smith SR, Zheng JY (2017) The intersection of oncology prognosis and cancer rehabilitation. Curr Phys Med Rehabil Rep 5:46–54. https://doi.org/10.1007/s40141-017-0150-0
8. Stubblefield MD, Hubbard G, Cheville A, Koch U, Schmitz KH, Dalton SO (2013) Current perspectives and emerging issues on cancer rehabilitation. Cancer 119 Supplement 11:2170–2178. https://doi.org/10.1002/cncr.28059
9. Crevenna R, Kainberger F, Wiltschke C, Marosi C, Wolzt M, Cenik F, Keilani M (2020) Cancer rehabilitation: current trends and practices within an Austrian University Hospital Center. Disabil Rehabil 42:2–7. https://doi.org/10.1080/09638288.2018.1514665
10. Crevenna R (2020) Aspects of cancer rehabilitation: an Austrian perspective. Disabil Rehabil 42:1. https://doi.org/10.1080/09638288.2018.1522554
11. Keilani M, Kainberger F, Pataraia A, Hasenöhrl T, Wagner B, Palma S, Cenik F, Crevenna R (2019) Typical aspects in the rehabilitation of cancer patients suffering from metastatic bone disease or multiple myeloma. Wien Klin Wochenschr 131:567–575. https://doi.org/10.1007/s00508-019-1524-3
12. Kanda Y, Kakutani K, Sakai Y, Yurube T, Miyazaki S, Takada T, Hoshino Y, Kuroda R (2020) Prospective cohort study of surgical outcome for spinal metastases in patients aged 70 years or older. Bone Joint J 102–B:1709–1716. https://doi.org/10.1302/0301-620X.102B12.BJJ-2020-0566.R1
13. Hirabayashi H, Ebara S, Kinoshita T, Yuzawa Y, Nakamura I, Takahashi J, Kamimura M, Ohtsuka K, Takaoka K (2003) Clinical Outcome and Survival after Palliative Surgery for Spinal metastases: palliative surgery in spinal metastases. Cancer 97:476–484. https://doi.org/10.1002/cncr.11039
14. Kakutani K, Sakai Y, Maeno K, Takada T, Yurube T, Kurakawa T, Miyazaki S, Terashima Y, Ito M, Hara H, Kawamoto T, Ejima Y, Sakashita A, Kiyota N, Kizawa Y, Sasaki R, Akisue T, Minami H, Kuroda R, Kurosaka M, Nishida K (2017) Prospective cohort study of performance status and activities of daily living after surgery for spinal metastasis. Clin Spine Surg 30:E1026–E1032. https://doi.org/10.1097/BSD.0000000000000456
15. Uei H, Tokuhashi Y, Maseda M, Nakahashi M, Sawada H, Nakayama E, Soma H (2018) Clinical results of multidisciplinary therapy including palliative posterior spinal stabilization surgery and postoperative adjuvant therapy for metastatic spinal tumor. J Orthop Surg Res 13:30. https://doi.org/10.1186/s13018-018-0735-z
16. Ishida Y, Shigematsu H, Tsukamoto S, Morimoto Y, Iwata E, Okuda A, Kawasaki S, Tanaka M, Fujii H, Tanaka Y, Kido A (2020) Impairment-driven cancer rehabilitation in patients with neoplastic spinal cord compression using minimally invasive spine stabilization. World J Surg Oncol 18:187. https://doi.org/10.1186/s12957-020-01964-y
17. Jenis LG, Dunn EJ, An HS (1999) Metastatic disease of the cervical spine. A review. Clin Orthop Relat Res 359:89–103. https://doi.org/10.1097/00003086-199902000-00010
18. Mahoney FI, Barthel DW (1965) Functional evaluation: the Barthel index. Md State Med J 14:61–65
19. Fisher CG, DiPaola CP, Ryken TC, Bilsky MH, Shaffrey CI, Berven SH, Harrop JS, Fehlings MG, Boriani S, Chou D, Schmidt MH, Polly DW, Biagini R, Burch S, Dekutoski MB, Ganju A, Gerszten PC, Gokaslan ZL, Groff MW, Liebsch NJ, Mendel E, Okuno SH, Patel S, Rhines LD, Rose PS, Sciubba DM, Sundaresan N, Tomita K, Varga PP, Vialle LR, Vrionis FD, Yamada Y, Fourney DR (2010) A novel classification system for spinal instability in neoplastic disease: an evidence-based approach and expert consensus from the Spine Oncology Study Group. Spine (Phila Pa 1976) 35:E1221–E1229. https://doi.org/10.1097/BRS.0b013e3181e16ae2

20. Bilsky MH, Laufer I, Fourney DR, Groff M, Schmidt MH, Varga PP, Vrionis FD, Yamada Y, Gerszten PC, Kuklo TR (2010) Reliability analysis of the epidural spinal cord compression scale. J Neurosurg Spine 13:324–328. https://doi.org/10.3171/2010.3.SPINE09459
21. Tokuhashi Y, Matsuzaki H, Oda H, Oshima M, Ryu J (2005) A revised scoring system for preoperative evaluation of metastatic spine tumor prognosis. Spine (Phila Pa 1976) 30:2186–2191. https://doi.org/10.1097/01.brs.0000180401.06919.a5
22. Katagiri H, Okada R, Takagi T, Takahashi M, Murata H, Harada H, Nishimura T, Asakura H, Ogawa H (2014) New prognostic factors and scoring system for patients with skeletal metastasis. Cancer Med 3:1359–1367. https://doi.org/10.1002/cam4.292
23. Frankel HL, Hancock DO, Hyslop G, Melzak J, Michaelis LS, Ungar GH, Vernon JD, Walsh JJ (1969) The value of postural reduction in the initial management of closed injuries of the spine with paraplegia and tetraplegia. I. Paraplegia 7:179–192. https://doi.org/10.1038/sc.1969.30
24. Kim RY, Murphy TE, Doyle M, Pulaski C, Singh M, Tsang S, Wicker D, Pisani MA, Connors GR, Ferrante LE (2019) Factors associated with discharge home among medical ICU patients in an early mobilization program. Crit Care Explor 1:e0060. https://doi.org/10.1097/CCE.0000000000000060
25. Rollnik JD (2011) The early rehabilitation Barthel index (ERBI). Rehabilitation (Stuttg) 50:408–411. https://doi.org/10.1055/s-0031-1273728
26. Castiglia SF, Galeoto G, Lauta A, Palumbo A, Tirinelli F, Viselli F, Santilli V, Sacchetti ML (2017) The culturally adapted Italian version of the Barthel index (IcaBI): assessment of structural validity, inter-rater reliability and responsiveness to clinically relevant improvements in patients admitted to inpatient Rehabilitation Centers. Funct Neurol 22:221–228. https://doi.org/10.11138/fneur/2017.32.4.221
27. Hobart JC, Thompson AJ (2001) The five item Barthel index. J Neurol Neurosurg Psychiatry 71:225–230. https://doi.org/10.1136/jnnp.71.2.225
28. Bongiovanni A, Recine F, Fausti V, Foca F, Casadei R, Falasconi MC, Oboldi D, Sansoni E, Fabbri L, Micheletti S, Severi S, Matteucci F, Zavoiu V, Mercatali L, Amadori D, Ibrahim T (2019) Ten-year experience of the multidisciplinary Osteoncology Center. Support Care Cancer 27:3395–3402. https://doi.org/10.1007/s00520-019-4635-5
29. Arrigo RT, Kalanithi P, Cheng MD, Alamin I, Carragee T, Mindea EJ, Park SA, Boakye J M (2011) Predictors of survival after surgical treatment of spinal metastasis. Neurosurgery 68:674–681. https://doi.org/10.1227/NEU.0b013e318207780c discussion 681.
30. Lawton AJ, Lee KA, Cheville AL, Ferrone ML, Rades D, Balboni TA, Abrahm JL (2019) Assessment and management of patients with metastatic spinal cord compression: A multidisciplinary review. J Clin Oncol 37:61–71. https://doi.org/10.1200/JCO.2018.78.1211
31. Mcphee JS, French DP, Jackson D, Nazroo J, Pendleton N, Degens H (2016) Physical activity in older age: perspectives for healthy ageing and frailty. Biogerontology 17:567–580. https://doi.org/10.1007/s10522-016-9641-0
32. Younsi A, Riemann L, Scherer M, Unterberg A, Zweckberger K (2020) Impact of decompressive laminectomy on the functional outcome of patients with metastatic spinal cord compression and neurological impairment. Clin Exp Metastasis 37:377–390. https://doi.org/10.1007/s10585-019-10016-z

Figures

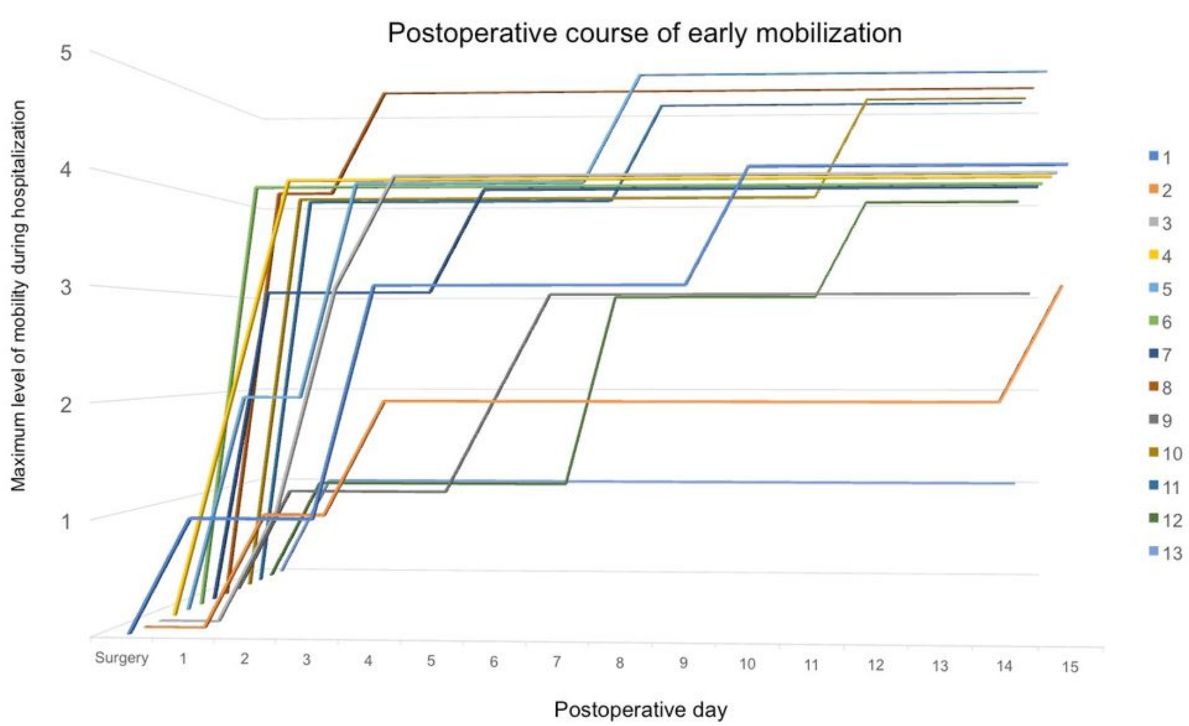

Figure 1

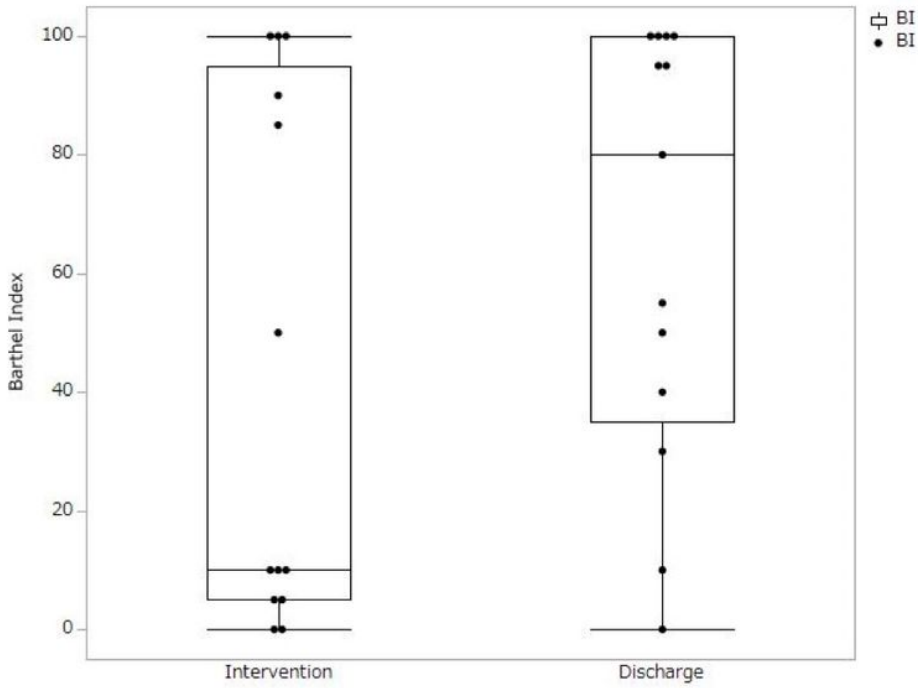

Figure 2

Changes in Barthel Index scores after surgery in patients classified according to clinical prognosis.