Journal of Radiotherapy in Practice

Journal of Radiotherapy in Practice (2013)
12, 218–225 © Cambridge University Press 2013
doi:10.1017/S1460396912000301

Original Article

A prospective study of patients with impending spinal cord compression treated with palliative radiotherapy alone

L. O'Sullivan[1], A. Clayton-Lea[1], O. McArdle[1], M. McGarry[1], J. Kenny[1], M. Dunne[2], E. O'Shea[1], C. Small[3], M. Moriarty[1], P. Thirion[1]

[1]*Department of Radiation Oncology, Saint Luke's Radiation Oncology Network, Dublin, Ireland,* [2]*Clinical Trials Unit, Saint Luke's Radiation Oncology Network, Dublin, Ireland,* [3]*Department of Radiation Oncology, Galway University Hospital, Galway, Ireland*

(Received 21st November 2011; revised 27th February 2012; accepted 2nd March 2012)

Abstract

Impending malignant spinal cord compression (IMSCC) may be defined as compression of the thecal sac, without any visible pressure on the spinal cord itself. Although there is a perception that IMSCC patients have a better prognosis and less severe clinical symptoms than true malignant spinal cord compression (MSCC) patients, these factors have never been documented in the literature.

Purpose: To record the characteristics, management and functional outcome of a group of patients with IMSCC, who were treated with radiotherapy in our institution, and compare these parameters with similar data on MSCC patients.

Materials and methods: Data (gender, age, primary oncological diagnosis, pain, performance status and neurological status) were prospectively collected for 28 patients. Patients were then followed up post treatment to document their response to treatment and treatment-related toxicity.

Results: The median survival of our group of IMSCC patients is similar to that of an MSCC patient. In addition, the IMSCC group exhibits significant clinical symptoms including neurological deficit.

Conclusion: Although further studies are necessary, we have found that IMSCC patients in this study share similar prognosis and clinical symptoms with MSCC patients. Clinicians should be aware of this when communicating with IMSCC patients and their families, and short-course radiotherapy should be considered.

Keywords: impending spinal cord compression; palliative radiotherapy; spinal cord compression

INTRODUCTION

Malignant spinal cord compression (MSCC) occurs when metastatic disease infiltrates the spinal canal, resulting in indentation and/or displacement of the spinal cord. MSCC is a

Correspondence to: Lydia O'Sullivan, Department of Radiation Oncology, Saint Luke's Radiation Oncology Network at Beaumont Hospital, Beaumont Road, Dublin 9, Ireland. Tel: 353+ 1 704 5577, 353+ 1 852 8625. Fax: 353+ 1 704 5591. E-mail: lydia.osullivan@slh.ie

familiar oncological emergency, affecting between 2·5 and 5% of cancer patients,[1] and despite prompt treatment, median survival is poor—about 3 months.[2,3] MSCC can arise from any solid tumour but most commonly from breast, prostate and lung cancers[4] and has a propensity to develop most frequently at the thoracic spine level, followed by the lumbosacral and cervical levels, respectively.[5] Best-practice guidelines suggest that MSCC patients should be treated within 24 hours of diagnosis,[3,6] with radiotherapy being a common treatment option,[7] should surgery not be possible.

In some oncology departments, the practice is not to distinguish between a compression of the spinal cord itself and a compression of the thecal sac, and to include both in the category of 'MSCC'. However, in other institutions, compression of the thecal sac, without any visible pressure on the spinal cord itself is denoted 'Impending Malignant Spinal Cord Compression' (IMSCC), similar to the definition by Williams et al.[8] The IMSCC phenomenon, when differentiated from MSCC, is commonly considered a precursor to true MSCC.

Much data have been published regarding the natural history and outcomes in the treatment of MSCC,[9–14] allowing an evidence-based approach to clinical investigation and treatment. There is also a clear consensus that an urgent approach is necessary when providing treatment for these patients.[6,15] For IMSCC, however, lack of similar accurate data and a perception that these patients may have a better prognosis may result in less urgent and more varied treatment approaches. This perception may also influence the clinician when discussing prognosis with patients and their families. As surgery has no proven efficacy for IMSCC, the treatment of choice is external beam radiotherapy. In our institution, multiple fractions and a higher total dose are commonly prescribed for IMSCC, with the view that this group of patients may survive long enough to risk the development of an in-field recurrence.

We designed a prospective study to evaluate the presenting symptoms, clinical course and subsequent outcomes of patients with IMSCC. The primary objective of this research study was to prospectively document the demographics, management, functional outcome and survival of IMSCC patients in our institution. The secondary objective was to compare the IMSCC data with similar data for true MSCC patients to provide evidence to support the distinctions and similarities of the two phenomena.

MATERIALS AND METHODS

All patients attending our institution with a diagnosis of IMSCC were eligible for inclusion in the study. The enrolment period was between September 2007 and February 2010. We identified a total of 28 potentially eligible patients, all of whom were included in the study.

Each of the 28 patients with IMSCC included in this study was simulated using a simple two-dimensional technique and treated on a cobalt-60 machine or linear accelerator. Radiotherapy treatment fields typically included the site of IMSCC plus one to two vertebrae above and below. The radiotherapy fractionation varied and was at the discretion of the treating physician. Twenty-seven patients were diagnosed via full spinal magnetic resonance imaging (MRI); the remaining patient had a full spine computed tomography (CT) scan.

Study data included gender, age, primary oncological diagnosis, pain assessment, performance status using the Karnofsky Performance Status (KPS) scale and neurological status, determined by physical examination. Patients were asked to score their pain with a number between 0 and 10 (0 = no pain; 10 = unbearable pain).

Patients were then followed, either by phone or in person, at 1 and 5 weeks post treatment and every 3 months thereafter until their death to document their subsequent neurological status, any treatment-related toxicity and their overall survival. Toxicity was graded using the Acute and Late Radiation Therapy Oncology Group Toxicity Criteria.[16] Overall survival was calculated from the date of diagnosis of IMSCC (date of MRI) to the date of last contact or date of death.

https://doi.org/10.1017/S1460396912000301 Published online by Cambridge University Press

In some cases, some variables could not be obtained because of the difficulty in following up patients in this palliative patient cohort, as is often observed in palliative research.[17,18]

The IMSCC data from this study were compared with similar data on 67 patients with MSCC. These comparative data were drawn from the screening database of an ongoing, randomised Phase III Spinal Cord Compression Trial (The All-Ireland Co-operative Oncology Research Group 05-03 Trial)[19] comparing two fractionation schemes. In this trial, patients were randomised to receive either 20 Gy/5 fractions or 10 Gy/1 fraction.

The worst severity toxicity documented was considered the final toxicity, even if the complication resolved later on.[20] The patient characteristics were compared using Mann–Whitney and χ^2 tests. The Kaplan–Meier method was used to estimate survival times.[21] Survival functions were compared using the log-rank test. All statistical tests were two-sided and assessed for significance at the 0·05 level. All statistical analyses were performed using statistical package for the social sciences (SPSS) version 18 (SPSS Inc., Chicago, IL, USA).

This study has received approval from the local Research Ethics Committee.

RESULTS

Patient data

Table 1 presents the demographics, the site of primary malignancy, the level of compression and the fractionation schedule for both the IMSCC and MSCC patient groups.

For the IMSCC group, the median number of days from diagnostic MRI/CT to the date of first treatment was 1; however, the range was large (0–30 days). The median time from the diagnosis

Table 1. *Patient characteristics, levels of compression and fractionation schedules*

	IMSCC ($n = 28$)	**MSCC ($n = 67$)**
Gender		
Female	15 (54%)	20 (30%)
Male	13 (46%)	47 (70%)
Age (years)		
Mean	59·5	64·2
Range	38–85	29–87
Primary diagnosis		
Breast	7 (25%)	14 (21%)
Lung	4 (14%)	13 (19·4%)
Renal	4 (14%)	4 (6%)
Prostate	3 (11%)	15 (22·4%)
Colorectal	3 (11%)	7 (10·4%)
Other	7 (25%)	14 (21%)
Level of compression		
Thoracic	12 (43%)	41 (61%)
Lumbar	7 (25%)	20 (30%)
Cervical	5 (18%)	3 (4·5%)
Two regions	4 (14%)	3 (4·5%)
Fractionation (Gy/number of fractions)		
20/5	18 (64%)	34 (51%)
10/1	–	33 (49%)
30/10	5 (18%)	–
8/1	2 (7%)	–
10/5	1 (4%)	–
20/10	1 (4%)	–
20/4	1 (4%)	–

Note: Data are for number of patients, unless otherwise specified.
Abbreviations: MSCC, malignant spinal cord compression; IMSCC, impending malignant spinal cord compression.

https://doi.org/10.1017/S1460396912000301 Published online by Cambridge University Press

Table 2. Acute GI toxicity of IMSCC group

Toxicity	Zero toxicity	Grade 1	Grade 2	Data not available
Upper GI				
1 week post RT	19	2	0	Seven missing data
5 weeks post RT	15	2	0	Six missing data Five others had died
Lower GI				
1 week post RT	14	1	6	Seven missing data
5 weeks post RT	12	1	4	Six missing data Five others had died

Abbreviations: GI, gastrointestinal; IMSCC, impending malignant spinal cord compression.

of the primary malignancy and the diagnosis of the IMSCC (date of MRI) was 14 months, range: 0·13–46 months. The most common vertebral level of IMSCC was thoracic, followed by lumbar and cervical spine (Table 1).

At the time of presentation, patient's KPS ranged from 50 to 100, with a median of 60. The KPS distribution was the following: 50–60—13 (46%), 70–80—5 (18%) and 90–100—10 (29%). Pain was reported in all 26 patients (100%) for whom we had Pain data, with 16 of the 26 (62%) reporting a Pain Score of 8–10. Two (7%) patients were affected by urinary incontinence. Ten out of 23 patients (43%) for whom we had neurological data had a neurological abnormality on physical examination. Sixteen (57%) patients were mobile, eight (29%) required a walking aid and four (14%) were bed bound.

Outcome and toxicity of the IMSCC patients

See Table 2 for a description of acute gastrointestinal (GI) toxicity experienced by the IMSCC patients. No notable late toxicity was recorded.

At 5 weeks follow-up, 16 of the IMSCC patients had unaltered mobility status, one had improved, four had deteriorated and five had died (data missing for two patients) At the same time point, 15 of the IMSCC patients experienced improved pain levels, one was stable, one had deteriorated and five had died (data were missing for six patients).

Median survival from diagnosis of IMSCC (date of MRI) was 4·2 months, with a range of 15–826 days (95% confidence interval: 3·1–5·3 months). Median survival times were 5·2 months for those who walked unaided ($n = 16$) at presentation, 3·4 months for those who needed a walking aid ($n = 8$) and 1·1 months for the four patients who were bed bound. There was no statistically significant difference in survival between these three groups ($p = 0·116$). The probabilities of surviving for at least 4 months were 62%, 50% and 50%, respectively. The percentage of IMSCC patients still alive at 9 months was 14% and all of these patients had breast cancer.

Table 3 shows the number of deaths within the study period and the median survival by the primary site of malignancy.

Comparison with true MSCC

It was found that there were a relatively high number of patients with two to three vertebral levels of involvement in the IMSCC group, including the involvement of two to three segments within a specific region. A χ^2 test for independence (with Yates continuity correction) indicated a statistically significant association between number of levels involved and whether the compression was IMSCC or true MSCC ($p = 0·024$, $n = 95$). There were also a relatively high number of patients with cervical spine involvement in the IMSCC patients.

A Mann–Whitney U test revealed no significant difference in the age of those in the IMSCC group (median = 56 years, $n = 28$) and those in the true MSCC group (median = 66 years, $n = 67$), $p = 0·103$.

https://doi.org/10.1017/S1460396912000301 Published online by Cambridge University Press

Table 3. Deaths and median survival of IMSCC patients by primary site

Primary site	Total number of patients	Number of deaths within the study period	Median survival from date of diagnosis of IMSCC in Months (95% confidence interval)
Breast	7	3	6·1 (3·4–8·7)
Lung	4	4	1·6 (0–5·4)
Renal	4	4	1·7 (0–4·2)
Prostate	3	3	3·4 (1·2–5·6)
Colorectal	3	3	2·8 (2–3·6)
Other	7	7	4·2 (1·3–7·2)
Overall	28	24	4·2 (3·1–5·4)

Abbreviation: IMSCC, impending malignant spinal cord compression.

A χ^2 test for independence (with Yates continuity correction) indicated a borderline significant association between gender and whether the compression was IMSCC or true MSCC ($p = 0{\cdot}051$).

DISCUSSION

To the authors' knowledge, this is the first description of the characteristics and outcomes in this group of patients in the literature. From the results of this study, we have shown that, despite IMSCC patients presenting with mid to high KPS, the group has a similar median survival to the MSCC group, significant neurological and clinical symptoms and a poor functional outcome.

Survival

Although a perception exists that IMSCC patients may survive significantly longer than the typical MSCC patients, our results suggest otherwise. We found a median survival of 4·2 months, which is quite similar to the documented median survival of MSCC patients (~3 months).[22] This should have an impact on discussions between patients and their families and their clinicians regarding prognosis. Families should be given the opportunity to discuss making wills and preferences for end of life care; however, these subjects may not be broached if the possibility of limited prognosis is not made clear.

This finding of a similar survival time should also be considered when deciding the radiotherapy fractionation. Despite the poor survival we report here, only two (7%) patients were treated with a single radiotherapy fraction and 25 (89%) patients had at least one full week of treatment. Although no randomised evidence is available to guide treatment prescription in this patient population, single fractions have been used to good effect in both painful bony metastasis[23] and MSCC.[24] Both in terms of resources and patient quality of life, it seems prudent that short-course radiotherapy should be given consideration in this patient cohort. Maximising quality of life is a crucial consideration, especially for those patients who do not have a long life expectancy. Minimising hospital attendances and facilitating discharge from the acute hospital setting to home or hospice care may be the key factors in this.

As stated earlier, a higher total dose and multiple fractions are often thought necessary for IMSCC because these patients may survive to develop an in-field recurrence. In addition to the higher dose, another consideration may be the higher biological equivalent dose (BED) associated with longer course treatment—$\mathrm{BED} = 75\,\mathrm{Gy}_2$ for 30 Gy/10 fractions versus $60\,\mathrm{Gy}_2$ and $40\,\mathrm{Gy}_2$ for 20 Gy/5 fractions and 8 Gy/1 fraction, respectively ($\alpha/\beta = 2\,\mathrm{Gy}$).[25] It appears from the outcome data for patients in the upper end of the survival range in this study that recurrences in long-term survivors should be taken into account [four patients (14%) were alive at 9 months follow-up]. However, when considering the low survival rate in the population as a whole, it would be optimal if it were possible to identify these 'better prognosis' patients at the time of diagnosis of IMSCC. It is not surprising that the patients with a breast primary who developed IMSCC had the longest survival (6·1 months), whereas those with a lung

https://doi.org/10.1017/S1460396912000301 Published online by Cambridge University Press

primary had the shortest survival (1·6 months). Much work has been conducted in developing prognostic scoring criteria for MSCC patients;[26] however, these criteria need to be similarly validated for the IMSCC group. It should also be noted that it has been estimated that clinicians can overestimate survival in 63% of patient cases.[27] This illustrates the importance of providing proven objective indicators to guide treatment prescription.

Clinical symptoms

Despite the fact that IMSCC is often denoted as 'sub-clinical' cord compression, all of the IMSCC patients for whom we have pain data with reported pain at presentation, with a significant proportion (62%) reporting severe pain (scores 8–10). This illustrates the clinical importance of the IMSCC event. It also correlates with reports regarding the incidence of pain in the MSCC patient, one author reporting it as 83–96%.[2] In terms of pain relief, radiotherapy did achieve some positive results—with 15/17 (88%) of patients that survived for 5 weeks follow-up, reporting some improvement in pain.

In addition, 43% of patients had some form of impaired mobility at diagnosis of IMSCC; this appears to be somewhat less than the reported level of two-thirds of patients being non-ambulatory at the diagnosis of MSCC.[1] This record of impaired mobility was in conjunction with our finding of 43% having neurological abnormality on physical examination and 7% (two patients) presenting with urinary incontinence. Although the result was not significant, it was not surprising that there is a trend with IMSCC patients with better mobility living longer, as ambulatory status is a prognostic indicator for MSCC patients.[12] One author investigating the role of MRI in the detection of MSCC found that 4% of their patient population had IMSCC or 'thecal sac compression'.[28] This group suggested that the neurological deficit identified in these patients might have arisen from a vascular cause. Similarly, Rades et al.[24] suggested that the reason why one of the predictors of functional outcome in MSCC is the length of time for developing motor function deficits before treatment start may be the differing mechanisms: fast-growing tumours may irreparably damage the cord's arterial blood supply, whereas slower proliferating tumours may simply temporarily disrupt the venous network.[29] However, regardless of the mechanism underlying IMSCC, it is clear from this study that IMSCC patients have similar clinical symptoms to that of the MSCC patients, although perhaps slightly less severe in nature.

Referral after diagnostic MRI

The wide range in number of days (0–30) from diagnosis of IMSCC to the date of first radiotherapy treatment illustrates the differences in the clinician's opinions relating to treatment urgency. As stated earlier, best-practice guidelines for MSCC suggest that patients should be treated within 24 hours of diagnosis.[3,6] In contrast, in this study, although the median number of days was 1, almost half of our IMSCC patients were not treated in accordance with this guideline. The importance of early detection and treatment in MSCC in terms of functional outcome is well documented, but it is beyond the scope of this study to suggest whether this should apply to IMSCC also. However, this result does clearly show the lack of consensus among clinicians about the treatment urgency in IMSCC.

The role of surgery

As stated previously, patients presenting with IMSCC in our institution were not sent for neurosurgical opinion before commencing radiotherapy because of the lack of evidence for surgical intervention. Patchell[30] showed superior functional outcome and a survival advantage in MSCC patients who had decompressive surgery plus radiotherapy, compared with radiotherapy alone; therefore, perhaps there is a need for similar randomised trials to explore the possible efficacy of surgery in the IMSCC group.

Primary site, gender

In reviews of the MSCC patients, the frequency of MSCC arising from particular primary sites is a function of their tendency to metastasise to bone. This gives rise to a typical distribution of primaries, where breast, lung and prostate each

https://doi.org/10.1017/S1460396912000301 Published online by Cambridge University Press

account for ~20% of the MSCC population.[4] In contrast to this, there was a wide range of malignant primaries in this study of IMSCC patients, which did not fit the typical MSCC distribution. Compared with the distribution of primaries in MSCC, there were a relatively low number of primary prostate IMSCCs detected and a relatively high number of renal IMSCCs.

Similarly, it is interesting to note the finding of a borderline significant gender difference between the groups ($p = 0{\cdot}051$). From the demographics of our ICORG 05-03 MSCC trial, the male:female ratio is roughly 70:30, whereas the ratio for IMSCC is ~50:50. Again, if IMSCC is an event that occurs before full MSCC, one would expect the distributions to be approximately equal. This finding of a difference in the gender distribution may be because of the above finding of a higher proportion of prostate primaries in the MSCC group. However, a larger data set is required to determine whether this borderline difference in the genders is related to the primary cancer site.

In MSCC, the frequency of vertebral compression levels is also well documented. Thoracic spine, lumbrosaccral spine and cervical spine account for ~60%, 30% and 10% of MSCCs, respectively.[5] This is thought to be both an effect of the spine's structural kyphosis and the greater intrathecal cross section.[1] Interestingly, in the IMSCC population, there are a relatively high number of cervical spine IMSCCs and also a relatively high number of multiple levels of involvement.

These findings may simply be because of the small data set used in this single institution study.

CONCLUSION

The results of this study give a preliminary description of a group of patients with IMSCC. Despite the fact that IMSCC patients are perceived as having a better prognosis, their survival is not largely different to that of the MSCC patient. In addition, we have shown that these patients have significant neurological deficits and clinical symptoms. As this is a single institution study with a small number of patients, further studies are needed to substantiate our findings and to provide further information about this patient group. In the absence of such data, the poor survival and functional outcome of these patients should be the impetus for frank clinician–patient conversations regarding prognosis. Clinicians should also consider the role of short-course radiotherapy to palliate symptoms while maximising quality of life for this cohort of patients whose remaining lifespan may be severely limited.

Acknowledgements

The authors thank the Radiotherapy Department, Saint Luke's Radiation Oncology Network, Rathgar for their support to this study. The authors also acknowledge Dr Aoife Shannon and the All Ireland Co-operative Oncology Research Group (ICORG) for their role in the ICORG 05-03 Spinal Cord Compression Trial. This project was supported in part by the Health Research Board, Ireland.

References

1. Prasad D, Schiff D. Malignant spinal-cord compression. Lancet Oncol 2005; 6: 15–24.
2. Abraham J. Assessment and treatment of patients with malignant spinal cord compression. J Support Oncol 2004; 2: 377–401.
3. National Institute for Health and Clinical Excellence, Metastatic Spinal Cord Compression: Diagnosis and Management of Adults at Risk of and with Metastatic Spinal cord Compression. National Institute for Health and Clinical Excellence Clinical Guideline 75. London: National Institute for Health and Clinical Excellence, 2008.
4. Loblaw D, Smith K, Lockwood G et al. The Princess Margaret Hospital experience of malignant spinal cod compression. Proc Am Soc Clin Oncol 2003; 22: 119 (Abstract 477).
5. Schiff D. Spinal cord compression. Neurol Clin 2003; 21: 67–86.
6. Husband D J. Malignant spinal cord compression: prospective study of delays in referral and treatment. BMJ 1998; 3: 18–21.
7. Prewett S, Venkitaraman R. Metastatic spinal cord compression: review of the evidence for a radiotherapy dose fractionation schedule. Clin Oncol 2010; 22: 222–230.
8. Williams M P, Cherryman G R, Husband J E. Magnetic resonance in suspected metastatic spinal cord compression. Clin Radiol 1989; 40: 286–290.

9. Loblaw D A, Perry J, Chambers A, Laperriere N J. Systematic review of the diagnosis and management of malignant extradural spinal cord compression: The Cancer Care Ontario Practice Guidelines Initiative's Neuro-Oncology Disease Site Group. J Clin Oncol 2005; 23: 2028–2037.
10. Rades D, Fehlauer F, Schulte R et al. Prognostic factors predicting functional outcomes, recurrence-free survival, and overall survival after radiotherapy for metastatic spinal cord compression in breast cancer patients. Int J Radiat Oncol Biol Phys 2006; 64: 182–188.
11. Rades D, Fehlauer F, Veninga T et al. Functional outcomes and survival after radiotherapy for metastatic spinal cord compression in patients with cancer of unknown primary. Int J Radiation Oncol Biol Phys 2007; 67: 532–537.
12. Rades D, Rudat V, Veninga T et al. A score predicting post treatment ambulatory status in patient irradiated for metastatic spinal cord compression. Int J Radiat Oncol Biol Phys 2008; 72: 905–908.
13. Rades D, Lange M, Veninga T et al. Preliminary results of spinal cord compression recurrence evaluation (score 1) study comparing short course versus long course radiotherapy for local control of malignant epidural spinal cord compression. Int J Radiat Oncol Biol Phys 2009; 73: 228–234.
14. Rades D, Lange M, Veninga T et al. Final results of a prospective study comparing the local control of short course and long course radiotherapy for metastatic spinal cord compression. Int J Radiat Oncol Biol Phys 2011; 79: 524–530.
15. Poortmans P, Vulto A, Raaijmakers E. Always on a Friday? Time pattern of referral for spinal cord compression. Acta Oncol 2001; 40: 88–91.
16. Cox J D, Stetz J, Pajak T F. Toxicity criteria of the Radiation Therapy Oncology Group (RTOG) and the European Organization for Research and Treatment of Cancer (EORTC). Int J Radiat Oncol Biol Phys 1995; 31: 1341–1346.
17. Grande G E, Todd C J. Why are trials in palliative care so difficult? Pall Med 2000; 14: 69–74.
18. Jordhøy M S, Kaasa S, Fayers P, Øvreness T, Underland G, Ahlner-Elmqvist M. Challenges in palliative care research; recruitment, attrition and compliance: experience from a randomised trial. Pall Med 1999; 13: 299–310.
19. http://clinicaltrials.gov/ct2/show/NCT00968643?term=Spinal+Cord+Compression&rank=1. Accessed on 7th February 2012.
20. Cancer Therapy Evaluation Program, Common Terminology Criteria for Adverse Events, Version 3.0, DCTD, NCI, NIH, DHHS, 2006.
21. Kaplan E L, Meier P. Nonparametric estimation from incomplete observations. J Am Stat Assoc 1958; 53: 457–481.
22. Loblaw D A, Laperriere N J, Mackillop W J. A population-based study of malignant spinal cord compression in Ontario. Clin Oncol 2003; 15: 211–217.
23. Lutz S, Berk L, Chang E et al. Palliative radiotherapy for bone metastasis. Int J Radiat Oncol Biol Phys 2011; 79: 965–976.
24. Rades D, Stalpers L J A, Hulshof M, Zschenker O, Alberti W, Koning C. Effectiveness and toxicity of single-fraction radiotherapy with 1×8 Gy for metastatic spinal cord compression. Radiother Oncol 2005; 75: 70–73.
25. Fowler J F. The linear-quadratic formula and progress in fractionated radiotherapy. Br J Radiol 1989; 62: 679–694.
26. Tang V, Harvey D, Dorsay J P, Jiang S, Rathbone M P. Prognostic indicators in metastatic spinal cord compression: using functional independence measure and Tokuhashi scale to optimize rehabilitation planning. Spinal Cord 2007; 45: 671–677.
27. Glare P A, Virk K, Jones M et al. A systematic review of physicians' survival predictions in terminally ill cancer patients. BMJ 2003; 327: 195–200.
28. Husband D J, Grant K A, Romaniuk C S. MRI in the diagnosis and treatment of suspected malignant spinal cord compression. BJR 2001; 74: 15–23.
29. Rades D, Fehlauer F, Stalpers L et al. A prospective evaluation of two radiotherapy schedules with 10 versus 20 fractions for the treatment of metastatic spinal cord compression: final results of a multicenter study. Cancer 2004; 101 (11): 2687–2692.
30. Patchell R A, Tibbs P A, Regine W F et al. Direct decompressive surgical resection in the treatment of spinal cod compression caused by metastatic cancer: a randomized trial. Lancet 2005; 266: 643–648.

https://doi.org/10.1017/S1460396912000301 Published online by Cambridge University Press