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ORIGINAL ARTICLE **CME**

Urgent Magnetic Resonance Imaging for Malignant Spinal Cord Compression

SSM Lo, KY Kwok, CW Siu, WK Wong, CM Chan, KW Tang, YL Cheung, SCH Chan

Department of Radiology and Imaging, Queen Elizabeth Hospital, Hong Kong

ABSTRACT

Objectives: *Malignant spinal cord compression is an uncommon complication in patients with cancer. It is frequently diagnosed late and causes irreversible damage to spinal cord. Malignant spinal cord compression is an oncological emergency, requiring a prompt imaging diagnosis and immediate treatment. Magnetic resonance imaging has a vital role in the management of such patients. Our audit was to assess whether patients with malignant spinal cord compression were recognised, investigated, and treated appropriately in our hospital. Large international audits of malignant spinal cord compression, such as clinical resource and audit group, were used as our reference standards. We also compared the level of spinal cord compression inferred clinically and based on magnetic resonance imaging findings, and evaluated whether localised spinal magnetic resonance imaging based on clinical assessment as adopted in our routine magnetic resonance imaging protocol was appropriate.*

Methods: *From January to December 2008, 1087 patients underwent magnetic resonance imaging scans of the spine in our hospital. Of these, 106 patients presented with clinical features suspicious of malignant spinal cord compression and urgent magnetic resonance imaging spine was performed. The demographic factors, primary tumour pathology, Tokuhashi score, clinical symptoms, clinical suspicion of the level of cord compression, magnetic resonance imaging findings, treatment response, and prognosis were assessed retrospectively from the medical records, the electronic Patient Record, and imaging reports from the Radiology Information System.*

Results: *Among the patients with a clinical suspicion of malignant spinal cord compression, prevalence rates were higher in males (61%) and older persons (mean age, 63 years; standard deviation, 14 years). Lung cancer was the most common responsible primary tumour in males (38%), whereas breast cancer was the most common primary tumour in females (32%). Spinal cord compression was the initial presentation of malignancy in 6 (8%) patients. Most patients showed evidence of bone metastasis (53%) and metastasis in major internal organs (51%) prior to the clinical presentation of malignant spinal cord compression. The most common clinical symptoms of malignant spinal cord compression were back pain (77%), limb weakness (94%) and numbness (90%). Of the 106 patients, 43% showed a low Tokuhashi score (<5) during admission. 77% of patients with a clinical suspicion of malignant spinal cord compression had magnetic resonance imaging spine in our hospital within 24 hours; the upper thoracic spine was the most common level of cord compression among these patients, and multi-level compression occurred in 8% of them. There was considerable discrepancy between the level of spinal cord compression inferred clinically and that determined by magnetic resonance imaging (57%); the average level of discrepancy being 5 vertebral bodies (95% confidence interval, 4-6). A greater degree of discrepancy was evident in patients with multiple spinal metastases ($p < 0.05$). 89% of patients with a clinical suspicion of malignant spinal cord compression had received steroids. The mean time required for starting definitive treatment after confirmation of the diagnosis by magnetic resonance imaging was 1.3 (standard deviation, 0.5) days; 74% were treated within 24 hours of the imaging. Patients with malignant spinal cord compression had an unsatisfactory survival rate of 75% at hospital discharge; the median survival time from first clinical presentation was 37 days (range, 9-884 days). The majority (57%) of patients showed clinical improvement after radiotherapy.*

Correspondence: *Dr Sherman Lo, Room 115, Block K, Queen Elizabeth Hospital, 30 Gascoigne Road, Kowloon, Hong Kong. Tel: (852) 2958 2698; Fax: (852) 2958 6048; Email: shermanlo@hotmail.com*

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Conclusion: *Patients with malignant spinal cord compression in our hospital were recognised, investigated, and treated appropriately. Our results were comparable to those reported in the literature. We found a great discrepancy between the level of spinal cord compression inferred clinically and by magnetic resonance imaging, particularly when multiple spinal metastases were present. We concluded that localised magnetic resonance imaging of the spine based on clinical findings was inadequate. Our magnetic resonance imaging protocol for malignant spinal cord compression patient was modified based on the results of this study.*

Key Words: *Magnetic resonance imaging; Metastasis; Prognosis; Spinal cord compression; Spinal neoplasms*

中文摘要

惡性脊髓壓迫綜合症的緊急磁共振成像

羅尚銘、郭啟欣、蕭志偉、王旺根、陳智明、鄧國穎、張毓靈、陳慈欽

目的：惡性脊髓壓迫綜合症（malignant spinal cord compression，MSCC）是癌症病人一種少見的併發症。由於確診經常較遲，對患者的脊髓會造成永久性損傷。MSCC屬腫瘤急症，必須要有及時的影像診斷及即時治理，而磁共振成像（MRI）在其中扮演很重要的角色。本研究的目的是評估本院在檢測、診斷及治療MSCC患者時是否恰當。我們把大型國際MSCC審核（如Clinical Resource and Audit Group；CRAG）作為參考標準，並把分別從臨床及MRI診斷得出的脊髓壓迫位置作比較，來判斷我們慣常使用的MRI設定模式（即按醫生的臨床判斷而作MRI局部脊髓掃描）是否恰當。

方法：本院在2008年內共有1087名病人進行脊髓MRI掃描，其中106名病人因懷疑出現MSCC症狀而進行緊急脊髓MRI。我們在這些病人的病歷紀錄、電子病歷及放射科信息系統內的影像報告中找出有關患者的人口學資料、原發性腫瘤病理、Tokuhashi分數、臨床症狀、臨床估計的脊髓壓迫位置、MRI結果、治療反應及預後。

結果：臨床疑診MSCC患者中，男性（61%）及年齡較大的病人（平均63歲；標準差14歲）有較高患病率。原發腫瘤方面，男性病人最常見的是肺癌（38%），而女性病人則是乳癌（32%）。6名病人（8%）脊髓壓迫為首發的腫瘤病症。大部分病人在出現MSCC臨床症狀前有骨轉移瘤（53%）及主要內臟器官的轉移瘤（51%）。最常見的MSCC臨床症狀為背部疼痛（77%）、四肢無力（94%）和麻木（90%）。有43%患者入院時都有低Tokuhashi分數（即少於5）。疑診MSCC患者中有77%於24小時內進行脊髓MRI。上胸椎是最常見的脊髓壓迫位置，而8%患者出現多重壓迫位置。從臨床診斷及MRI診斷得出的脊髓壓迫位置有很大的差距（57%），平均相差5個椎體（95%可信區間：4-6）。多重脊髓壓迫患者的臨床及MRI診斷脊髓壓迫位置差距較大（$p < 0.05$）。疑診MSCC患者中，有89%服用類固醇。被MRI確診的MSCC患者中，從確診至開始治療的時間平均1.3天（標準差0.5天）；有74%病人於MRI檢查後24小時內得到治療。MSCC患者直至出院為止的生存率並不理想，只有75%。從首次病發至死亡的生存中位數為37天（介乎9-884天）。大部分病人（57%）接受放射治療後臨床情況有好轉。

結論：本研究的結果與其他文獻相似，本院恰當地檢測、診斷及治療MSCC患者。研究結果亦顯示從臨床及MRI診斷得出的脊髓壓迫位置有較大的差距，尤其在脊髓多發轉移瘤的患者。所以只按臨床診斷而進行MRI脊髓局部掃描涵蓋範圍未必足夠。根據本研究的結果，我們醫院對MSCC患者所進行的MRI檢查設定有所更改。

INTRODUCTION

Malignant spinal cord compression (MSCC) constitutes an oncological emergency, which can result in significant morbidity and mortality to the patient.[1-4] Consistently, studies have demonstrated that MSCC is diagnosed late, which causes significant morbidity and mortality in patients with cancer.[5,6] The National Institute for Health and Clinical Excellence

(NICE) has recently published a clinical guideline for metastatic spinal cord compression,[7] where key priorities were identified to implement early clinical recognition, whole spine magnetic resonance imaging (MRI) within 24 hours, and urgent (<24 hours) access to radiotherapy for MSCC patients.

The aim of our study was to document the process of diagnosis, clinical management and clinical outcome of MSCC patients in Queen Elizabeth Hospital, and to compare the findings with those from international studies. We also wanted to determine whether our standard MRI protocol entailing localised spinal MRI to limited levels of the spine according to clinical findings was justifiable in patients presenting with MSCC. We specifically set out to identify any delays in clinical diagnosis, MRI examination, and appropriate treatment for MSCC patients.

The Tokuhashi score has been shown to have the highest correlation between predicted and actual survival outcomes in patients with MSCC.[8] We therefore determined the Tokuhashi score in every patient and correlated the scores with the prognosis of our studied patients.

METHODS

The results of the audit conducted by the Clinical Resource and Audit Group (CRAG[9]) for diagnosis, management, and outcome of malignant cord compression were chosen as the benchmark for the current audit.

A total of 1087 patients who underwent MRI scans of the spine (RIS codes 8201-8210) in our hospital from 1 January 2008 to 31 December 2008 were retrospectively reviewed. 106 patients gave a clinical history of suspected MSCC and were included in this study; 27 (25%) were excluded, as details of their presentation and referral were not verified.

The medical records, electronic Patient Record, and the Radiology Information System were consulted for demographic factors, primary tumour pathology, clinical presentation, level of spinal cord compression, MRI findings, treatment response and prognosis. The Tokuhashi score was calculated based on information in the medical records. All MRI examinations were performed using a Seimens Avanto 1.5 T MRI machine in our hospital. The spinal MR images of suspected MSCC patients were performed according to our usual routine protocol, which consisted of a sagittal T1-weighted turbo spin echo sequence (TR/TE 571/12 ms, 4 mm slice thickness, 2 signal averages) and a sagittal T2-weighted turbo spin echo sequence (TR/TE 3000/92 ms, 4 mm slice thickness, 1 signal average). At the level of suspected spinal cord compression, axial T1-weighted spin echo and axial T2-weighted fast spin echo sequences were obtained to assess the degree of spinal cord compression. Additional T1-weighted images following intravenous gadolinium contrast were obtained if intramedullary or leptomeningeal tumour was suspected. The level of coverage was determined by the clinical findings, and subdivided into cervical, upper thoracic, lower thoracic, and lumbosacral regions.

MR images were retrospectively reviewed by 3 of the authors to assess the presence and location of vertebral body metastases, collapsed vertebral bodies, extradural disease, and spinal cord compression. If whole spine MRI was not performed, localiser-sagittal T1-weighted turbo spin echo sequence (TR/TE 300/11 ms, 3 mm slice thickness, 1 signal average, FOV 450 mm, voxel size 2.1 x 1.1 x 3.0 mm, 9 images) was used to access the rest of the spine for any gross bone pathology and cord compression.

Spinal cord compression was defined as the presence of a mass that displaced, indented, or led to complete loss of definition of the spinal cord or cauda equina.[10] When the spinal cord compression extended more than 1 vertebral level, it was recorded as one site of compression, and the most narrowed site was recorded as the site of compression.

We noted the inherent discrepancy of cord level and vertebra level lesions due to cord length — vertebral length differences — before conducting this audit. We designed our audit so that a 2-level vertebral body difference had to be present before we count it as a significant discrepancy. We also counted all cord compression below T10 as lumbar / cauda equina compression rather than lower thoracic compression. If the clinician found the patient had a cauda equina syndrome and the MRI showed a T11 cord compression, we count it as concordant.

RESULTS

There were 79 patients (48 male and 31 female) aged 30 to 89 (median, 60) years in the study population. Their demographic data are summarised in Table 1.

There was a higher proportion of males (61%) and older persons (mean age ± standard deviation [SD], 63 ± 14 years) in our series. The commonest primary tumour was located in the lungs in males (38%), and breasts in females (32%). Spinal cord compression was the initial presentation of malignancy in 6 patients (8%). Most patients had a previous diagnosis of bone metastases (53%, 42/79) and major internal organ metastases (51%, 40/79) before presenting with MSCC.

Back pain (77%), limb weakness (94%), and numbness (90%) were the most common clinical presenting features (Table 2). Only 20% (16/79) of the patients were ambulant and 42% (33/79) were urinary catheter free at the time they had their MRI. The median period to make a clinical diagnosis of MSCC following presenting symptoms was 5 days (range, 1-214 days). An overall low Tokuhashi score (≤5) [43%, 34/79] was noted in the majority of patients at the time of presentation; only 20% (16/79) had a score of ≥9 points (Figure 1).

All clinically suspected MSCC patients had MRI of the spine after admission. Spinal X-ray (72%, 57/79), computed tomography (CT) [3%, 2/79], or bone scans (4%, 3/79) were performed in some of the patients before the MRI study. The majority of patients (77%, 61/79) had their MRI performed within 24 hours of admission, whereas 18 (23%) had it done after 24 hours. The reasons of such delays in performing an MRI could be classified as due to clinical, radiological, and patient factors — the most common reason was clinical (39%, 7/18) due to failure to appreciate spinal cord compression symptoms, followed by delays in radiological assessment (33%, 6/18) that were mostly related to requests for 'urgent' MRI being turned down by radiologists.

All patients showed one or more vertebral body metastases, and all yielded MRI features of spinal cord compression. The upper thoracic spine was the most commonly affected site (46%). A further 23% occurred in the lower thoracic region, 15% in the lumbosacral region, and 9% in the cervical region. In all, 8% of the patients were identified as having MSCC in more than one region of the spine (Table 3).

There was a significant discrepancy (of more than 2 vertebral body levels) between clinical and MRI findings as to the level of spinal cord compression (Figure 2) in 57% (45/79) patients. The average discrepancy was 5 vertebral bodies (95% confidence interval, 4-6) among those with significant discrepancy in level assessment. Greater discrepancies were

Table 1. Patient characteristics of the study group.

	Male (n = 48)	Female (n = 31)	Total (n = 79)
Median age (range) [years]	61 (37-89)	60 (30-88)	60 (30-89)
Primary site of tumours			
Bronchus	18	5	23
Breast	0	10	10
Nasopharynx	6	3	9
Colon	2	6	8
Prostate	7	0	7
Unknown	4	2	6
Liver	4	0	4
Others	7	5	12

Table 2. Presenting symptoms.

Presenting symptoms	No. (%)
Back pain	61 (77)
Weakness (upper or lower limbs)	74 (94)
Numbness	71 (90)
Bladder dysfunction	46 (58)
Bowel dysfunction	24 (30)

Table 3. Levels of spinal cord compression assessed clinically versus indicated by magnetic resonance imaging (MRI) findings.

Level of cord compression	Clinical (n = 79)	MRI (n = 79)
Cervical	5	7
Upper thoracic	16	36
Lower thoracic	35	18
Cauda equina	21	12
Multiple	1	6
Unknown	1	0

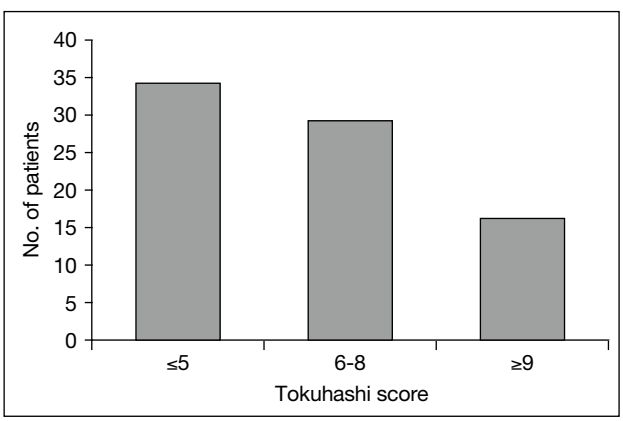

Figure 1. Tokuhashi scores in our study population at the time of presentation.

encountered in patients with metastases in more than 1 vertebral body, of which the finding was statistically significant ($p < 0.05$) [Table 4].

The median (range) time from the onset of symptoms to treatment was 23 (range, 1-730) days. Of those patients with a clinical suspicion of MSCC, 70 (89%) received steroids. The average elapsed time before starting definitive treatment (i.e. radiotherapy or surgery) after the MRI was 1.3 (SD, 0.5) days; 87% (69/79) of whom received palliative radiotherapy, and 11% (9/79) received symptomatic care. Only one patient received surgical spinal decompression for MSCC. Among the patients treated with radiotherapy, 74% (51/69) received radiotherapy treatment in the first 24 hours after their MRI.

In our series, the overall prognosis of MSCC patients was poor; 25% died during their first admission, and the median survival from first clinical presentation with MSCC was 37 (range, 9-884) days, whereas the median survival time from MRI confirmation of MSCC was 28 (range, 4-469) days. More than half of the patients (57%, 40/70) showed clinical improvement after treatment (radiotherapy or surgery); 49% (34/70) experienced pain relief and 23% (16/70) enjoyed improved ambulation.

DISCUSSION

In this audit of our patients, the demographic features and sites of spinal cord compression were consistent with findings from the prospective audit conducted by the CRAG in Scotland.[9] Lung and breast cancers were the commonest malignancies giving rise to MSCC, and the thoracic spine was the most common affected location (68%, 54/79). In our series, MSCC associated with nasopharyngeal carcinoma (NPC) and hepatocellular carcinoma (HCC) were 11% and 5%

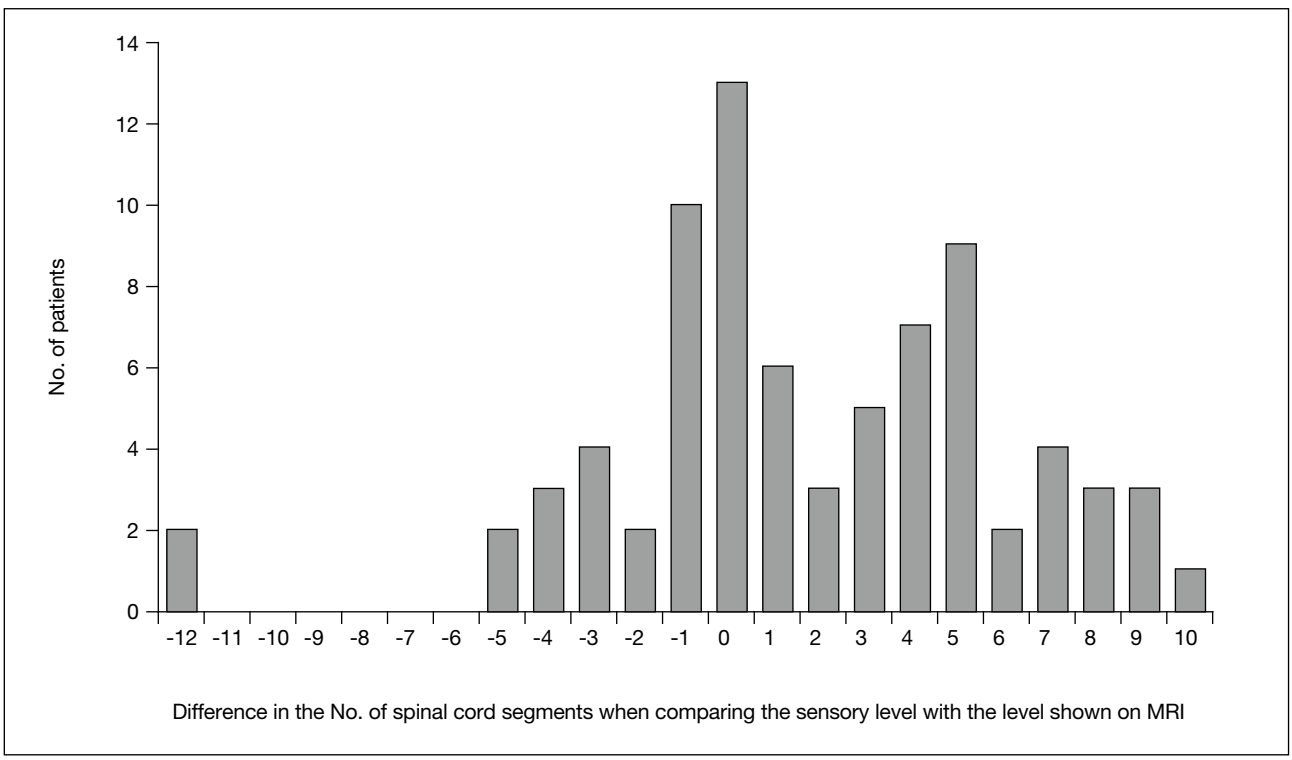

Figure 2. Relationship between clinical sensory levels and magnetic resonance imaging (MRI) levels of cord compression.

Table 4. Correlation between clinical and magnetic resonance imaging findings in levels of spinal cord compression in patients with metastasis in one and more than one vertebral bodies.

	Concordant (n = 34)	Discordant (n = 45)	p Value
>1 vertebral bodies metastases	14	30	0.039
≤1 vertebral body metastasis	20	15	-

respectively which were more frequently observed in the current study compared with the CRAG audit. This could be explained by a higher incidence of NPC and HCC in our locality.

Back pain, limb weakness, and numbness were the most common primary presenting symptoms in our MSCC patients, and were usually present for several days or months before the diagnosis was made. The majority of the delays were due to lack of symptom recognition by the patient and diagnostic delays in the clinical setting. By itself, pain was not an independent predictive factor.[1,11] Pain was usually described as sharp, shooting, deep or burning, and it was precipitated by coughing or bending.[12] The site of the pain and sensory levels did not predict the actual site of spinal cord compression, there being a great discrepancy between the clinical manifestations and MRI findings. In only 43% of the patients did the pain or sensory level correlate with the level of compression noted on MRI. The proportion of patients with a clinically significant discrepancy (57%) was greater than that reported in a previous study (27%).[13]

A wide range of investigations — including plain radiology films, bone scintigraphy, CT, and MRI scans — were used to investigate our study population presenting with symptoms of spinal cord compression. Plain films have been shown to be insensitive and yield a false-negative rate of 10 to 17% for detecting bone metastasis and locating the level of cord compression[11]; 50% bone loss is required for detection on X-ray films.[11] Moreover, 25% of patients with spinal cord compression have no bone destruction.[12] Bone scintigraphy was also shown to be insensitive for detecting the presence of cord compression.[12] Plain films or bone scintigraphy were performed in 75% (59/79) of our patients before the MRI study. Time spent waiting for bone scintigraphy in particular had probably contributed to the delay in management, and in many cases added little to establish the level of spinal cord compression.

MRI of the spine is now widely accepted as the gold standard for diagnosing epidural disease, spinal cord compression, and for guiding radiotherapy or surgical treatment planning.[1,13] The NICE has recently published a clinical guideline for metastatic spinal cord compression management.[7] It recommended all patients with spinal pain suggestive of spinal metastases, and the presence of neurological symptoms or signs suggestive of MSCC, should undergo whole-spine MRI. This should be performed as soon as possible within 24 hours in those needing emergency surgery. Urgent (within 24 hours) access to radiotherapy was also required for all such patients. MRI was shown to have a high sensitivity (93%), specificity (97%), and overall accuracy (95%) in revealing spinal cord compression.[14] Husband et al[15] recommend that whole-spine MRI be performed in all patients with suspected MSCC before radiotherapy commences, as the additional information gleaned might alter the management plan.

All of our patients suspected to have MSCC had MRI of their spine performed (vs 90% in the CRAG audit). The CRAG prospective audit did not review the delay in MRI performance, as the NICE recommendations were published years after that audit. 77% of our patients had MRIs within 24 hours of presentation of their neurological symptoms or signs which were suggestive of MSCC. In our hospital, the routine MRI protocol entailed T1-weighted and T2-weighted sagittal images, targeted at the level of pain or clinically detected sensory deficits. Our results demonstrated great differences between the clinical manifestations versus MRI findings, and also demonstrated that the presence of multiple (more than one level) vertebral body metastases would increase the discrepancy between the clinical and MRI findings to a statistically significant extent ($p < 0.05$). These results confirm the uselessness of site of pain and the sensory level in predicting the site of compression, and provide further support for whole-spine rather than localised MRI for patients with suspected MSCC.

We underestimated the actual number of multiple-level spinal cord compressions or spinal cord metastases, as some of the whole-spine MRIs were reviewed only as localised images. The low imaging resolution and low signal-to-noise ration of the localiser images result in suboptimal evaluation of underlying bone metastases and cord compression.

Two randomised controlled trials demonstrated the benefit of steroids for emergency treatment of malignant extradural spinal cord compression and promoted post-treatment ambulation.[14,16] Another study, however, demonstrated that high-dose dexamethasone was associated with a higher incidence of serious adverse effects than the use of moderate doses,[17] and that patients treated with radiotherapy

without steroids showed greater ambulatory improvement.[18] The optimal dose of dexamethasone remains to be determined in further large randomised studies.[19] Although there are discrepancies in steroid treatment efficacies, and a variety of different recommended dosages for steroid treatment in the literature, 89% of our patients were nevertheless given steroids (vs 93% in the CRAG audit).

The majority of our patients diagnosed as having MSCC (87% vs 87% in the CRAG audit) were treated with primary palliative radiotherapy, but only one (1% vs 5% in the CRAG audit) underwent surgical spinal decompression. The great majority of MSCC patients were treated by radiotherapy in our hospital, and there was a tendency to move away from surgical decompression owing to associated morbidity.[18,20] In our series, the mean time interval between the MSCC diagnosis and commencement of radiotherapy was 1.3 (SD, 0.5) days; 74% (vs 70% in the CRAG audit) were given palliative radiotherapy within 24 hours, which was slightly higher than that in the CRAG study.

The Tokuhashi score was shown to have the highest accuracy in predicting survival outcome in patients with MSCC.[8] We have calculated the modified Tokuhashi score to determine the prognosis in our study population. This score contains 6 parameters — 5 of them were rated 0 to 2, and the remaining parameter (primary site of tumour) was rated 0 to 5 — contributing a total score ranging from 0 to 15. A high Tokuhashi score (≥9) is associated with longer survival and a high degree of functional independence, whereas low scores (≤5) indicate likely survival of 3 months or less.[21,22] 43% of our study population showed a low Tokuhashi score (≤5) on admission, which may explain the low survival rate (75%) up to hospital discharge.

Our audit had several limitations. Firstly, although our hospital is one of the major oncology centres in Hong Kong, the number of patients with MSCC we recruited was relatively small. A large number (25%) were excluded due to lack of detailed and accurate clinical data. Secondly, the data were collected retrospectively, which might not have as accurately documented the level of cord compression leading to the great discrepancy between clinical and MRI findings in the current study. In some patients, clinical notes did not provide a complete account of the care provided, which also affected the calculation of management delay. Some of the plain films or bone scintigraphy tests were performed for reasons other than symptomatic back pain, and could also have biased our analysis. Thirdly, we relied on the MRI performed with whole-spine localiser images to determine other levels of spinal involvement, which may have underestimated the rate of multiple spinal metastasis and multi-level cord compression. Finally, although we took measures to define the meaning of 'significant discrepancy of cord compression' and counted all compression below T10 as lumbar / cauda equina compressions, the inherent cord level discrepancy may still exist, especially at lower thoracic region. Our results indicated that the average discrepancy was 5 vertebral bodies and that the maximum discrepancy was 12 levels. Such results could not be explained simply by an inherent cord level discrepancy.

RECOMMENDATIONS

This audit identified several weak points within the whole multi-disciplinary team in relation to management of patients with MSCC. Recommendations are summarised as follows:

(1) Guidelines for referral, investigation, and management of patients with suspected or diagnosed MSCC should be developed.
(2) Clinical awareness of symptoms and signs of MSCC in patients with primary tumours should be enhanced among frontline clinicians.
(3) Referral guidelines for urgent MRI of patients at risk of MSCC should be formulated between radiologists and frontline clinicians.
(4) The MRI protocol for MSCC patients in our hospital should be modified to include whole-spine sagittal T1-weighted coverage in all patients.

These recommendations are now being taken forward to our hospital management.

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