Radiotherapy efficacies for vertebral hemangioma patients with severe spinal cord compression and cauda equina syndrome—case report and literature review

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Background: Although vertebral hemangioma is the most common benign spinal tumor, in rare cases, patients may experience spinal cord compression accompanied by pain and neurological deficits; surgery remains the standard treatment option in such cases. For patients with comorbidities who cannot tolerate surgery, radiotherapy may be an alternative treatment; however, previous studies have suggested that if the spinal canal is aggressively compressed by a vertebral hemangioma, the efficacy of radiotherapy is suboptimal.

Case Description: Herein, we present two patients with vertebral hemangioma who developed spinal cord compression. The first patient, with underlying congenital heart disease, had spinal canal encroachment of 63.4% at the ninth thoracic vertebra. In the second patient, transcatheter arterial embolization for the treatment of total encroachment of the sacral plexus had failed. The first patient underwent radiotherapy with 44 Gy in 20 fractions using helical tomotherapy and fully recovered from severe neurological deficits 5.5 months after completing radiotherapy. The second patient experienced complete neurological symptom relief six months after the completion of radiotherapy with 42 Gy in 21 fractions using the volumetric modulated arc therapy technique.

Conclusions: Our results suggest that radiotherapy with 42–44 Gy in conventional fractions can efficiently cause tumor regression and improve neurological symptoms resulting from vertebral hemangioma-induced spinal cord compression.

Keywords: Radiotherapy; vertebral hemangioma; neurological deficits; case report

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Introduction

Vertebral hemangiomas are the most common benign spinal tumors, with a prevalence rate of approximately 12%. They are enriched with blood-filled cavities and mostly occur in the thoracic and lumbar spine (1,2). Vertebral hemangioma, which causes thickened vertebral trabeculae, is classically characterized by polka dot and corduroy signs on radiographic computed tomography (CT) scans (3). On magnetic resonance imaging (MRI), vertebral hemangiomas often manifest as hyperintense signals in which the signal values are dependent on the composition of adipocytes, edematous tissue, and vascularity of the vertebral hemangioma (4).

Although vertebral hemangiomas are benign tumors, some patients develop spinal cord compression accompanied by pain symptoms and subsequent neurological deficits (1,5). Surgery remains the mainstay of treatment for these patients. However, for patients with comorbidities who are ineligible for surgery, treatment options are limited. Herein, we present two cases of inoperable aggressive vertebral hemangioma with prominent spinal cord compression causing severe neurological deficits in accordance with the CARE reporting checklist (available at https://tro.amegroups.com/article/view/10.21037/tro-23-8/rc). The patients responded to radiotherapy and fully recovered from their neurological symptoms.

Highlight box

Key findings

- Conventional radiotherapy could improve neurological symptoms for patients with inoperable vertebral hemangioma.

What is known and what is new?

- Radiotherapy is an effective alternative treatment of pain relief for patients with inoperable vertebral hemangioma.
- Our case reports showed that two patients with vertebral canal encroachment by hemangioma, accompanied by neurologic deficits, experienced complete regression of neurologic symptoms after completion of radiotherapy with 42–44 Gy in conventional fractions.

What is the implication, and what should change now?

- Radiotherapy could provide clinical benefits for patients with hemangioma-associated vertebral canal encroachment and accompanying neurological deficits.

Case presentation

Patient 1

A 17-year-old boy presented with dysesthesia of the right foot and an unsteady gait that had persisted for one month. Later, he experienced progressive dysesthesia and bilateral weakness in bilateral lower extremities. Neurological examination revealed that his Medical Research Council's scale (MRC scale) for muscle power was four out of five. As symptoms progressed (MRC scale muscle power: 3), the patient became wheelchair-dependent for ordinary daily living activities. The CT scan showed polka dot and corduroy signs at the ninth thoracic vertebra (T9) (*Figure 1A,1B*). MRI revealed a T2-weighted hyperintensity and gadolinium-enhanced T1-weighted hypointensity, with an expansile lesion at T9 which caused spinal cord compression (*Figure 1C,1D*). Based on these classical radiographic findings, the patient was diagnosed with vertebral hemangioma at T9. The patient was unsuitable for surgery due to a cyanotic heart defect and therefore underwent radiotherapy at 44 Gy in 20 fractions using helical tomotherapy and concurrent administration of dexamethasone (*Figure 2*).

Upon completion of radiotherapy, the patient's bilateral lower-limb dysesthesia subjectively improved without treatment-related adverse toxicities. At 5.5 months after the completion of radiotherapy, he fully recovered from neurological symptoms (MRC scale muscle power of the lower extremities returned to five) and returned to normal activities of daily living. Follow-up MRI also showed partial regression of the vertebral hemangioma at T9. The patient remained neurologically deficit-free 34 months after the completion of radiotherapy, and MRI revealed almost complete remission of the T9 vertebral hemangioma (*Figure 3*).

Patient 2

A 36-year-old man initially complained of right buttock numbness for five months. Subsequently, he experienced right leg pain and numbness, accompanied by difficulty with defecation. MRI revealed a T2-weighted hyperintensity and gadolinium-enhanced T1-weighted lesion in the sacrum, which caused cortical destruction and total sacral nerve root encasement (*Figure 4A*). Pathology of the sacral tumor

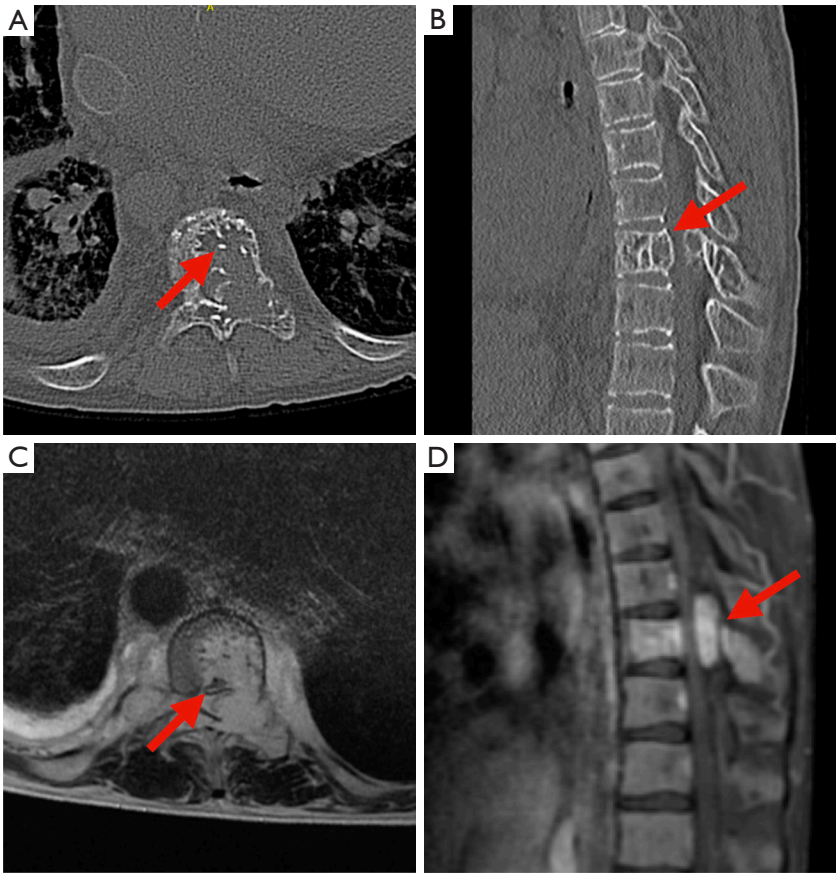


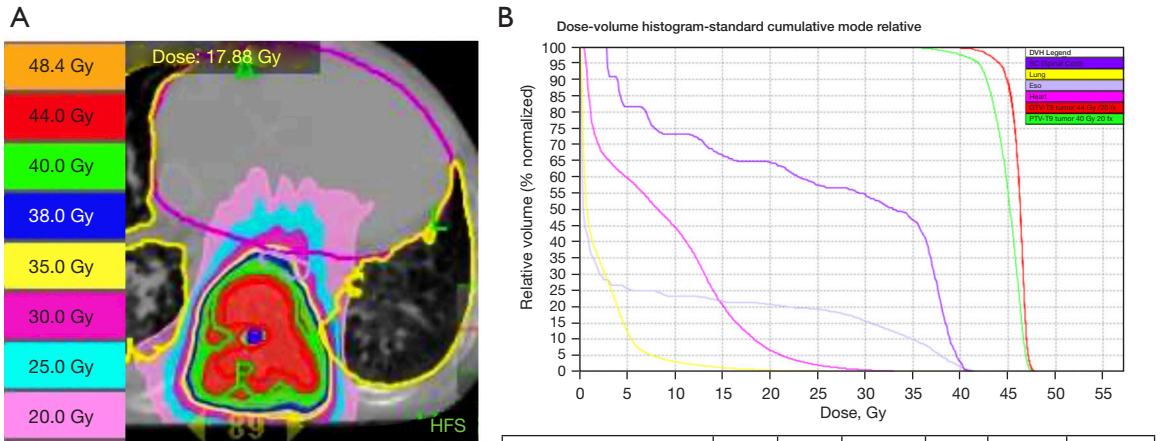
Figure 1 Case 1: spinal hemangioma imaging findings. (A) Axial CT revealing classic polka dot sign at T9 (red arrow). (B) Sagittal CT showing classic corduroy sign at T9 (red arrow). (C,D). Case 1: spinal hemangioma MRI findings. (C) T2WI prior to radiotherapy demonstrating severe cord compression (red arrow). (D) T1WI with contrast disclosing an enhancing lesion at T9 (red arrow). CT, computed tomography; T, thoracic spine; MRI, magnetic resonance imaging; T2WI, T2-weighted image; T1WI, T1-weighted image.

biopsy specimen revealed a hemangioma, confirming sacral hemangioma with cauda equina syndrome. The patient underwent transcatheter arterial embolization (TAE), but his symptoms persisted, with a slightly enlarged tumor after TAE (*Figure 4B*). Hence, the patient underwent radiotherapy for the sacral hemangioma with 42 Gy in 21 fractions, using volumetric modulated arc therapy (VMAT). During radiotherapy, the patient experienced subjective improvement in right leg pain and numbness. Soon after the completion of radiotherapy, he experienced subjective improvement in difficulty with defecation. Grade 1 or 2 dermatitis and fatigue were observed during and after radiotherapy. Six months after the completion of radiotherapy, the patient showed complete recovery of neurological symptoms, including pain, numbness, and difficulty with defecation. Follow-up MRI revealed partial remission of the hemangioma 2 years after completing radiotherapy and good partial remission of the sacral lesion eight years after the completion of radiotherapy (*Figure 4C*).

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the Helsinki declaration (revised version in 2013). Written informed consent was obtained from patient 1's parents and patient 2 for publication of their cases and accompanying images. A copy of the written consent is available for review by the editorial office of this journal.

Discussion

In addition to surgery, previous studies have reported that radiotherapy may serve as an alternative treatment option



Name	Max dose [Gy]	Min dose [Gy]	Median dose [Gy]	Avg dose [Gy]	StdDev dose [Gy]	Physical Vol [cc]
Spinal Cord	41.25	2.78	32.95	25.13	14.33	4.46
Lung	37.91	0.10	0.74	2.24	3.23	1,446.59
Esophagus	42.88	0.06	0.39	7.99	13.63	41.00
Heart	36.88	0.43	8.22	8.79	7.24	1,013.70
GTV-T9 tumor 44 Gy 20 fx	48.06	37.98	46.28	46.02	1.06	22.36
PTV-T9 tumor 40 Gy 20 fx	48.06	34.47	45.21	44.84	1.78	70.38

Figure 2 Case 1: planning of T9 spinal hemangioma treatment using helical tomotherapy. (A) Radiotherapy dose distribution for the T9 spinal hemangioma. GTV is defined as the tumor volume visualized under CT images. PTV is defined as the GTV with a 5-mm expansion. (B) Dose-volume histogram of the T9 spinal hemangioma. GTV was prescribed with 44 Gy in 20 fractions, whereas PTV was prescribed with 40 Gy in 20 fractions. GTV, gross target volume; PTV, planning target volume; T, thoracic spine; CT, computed tomography.

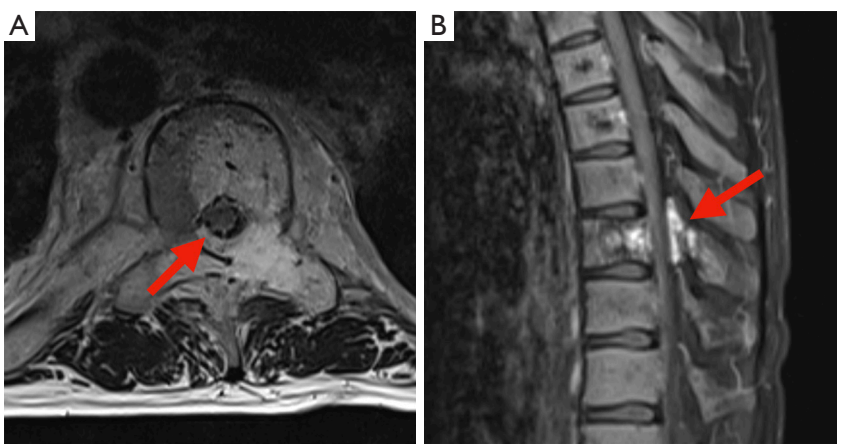


Figure 3 Case 1: MRI of spinal hemangioma after radiotherapy. (A) T2WI 16 months after radiotherapy revealing resolution of tumor in the spinal canal (red arrow). (B) T1WI with contrast 16 months after radiotherapy revealing almost complete remission of the tumor at T9 (red arrow). MRI, magnetic resonance imaging; T2WI, T2-weighted image; T1WI, T1-weighted image; T, thoracic spine.

for vertebral hemangioma (6-14). Rades *et al.* analyzed 117 patients with vertebral hemangioma and categorized them into high-radiotherapy dose (36–44 Gy) and low-radiotherapy dose (20–34 Gy) groups according to the equivalent dose in 2 Gy per fraction (EQD2), in which an α/β ratio of 3 was applied because vertebral hemangioma is a low-proliferative benign disease (6). Rades *et al.* reported that patients in the high-dose radiotherapy

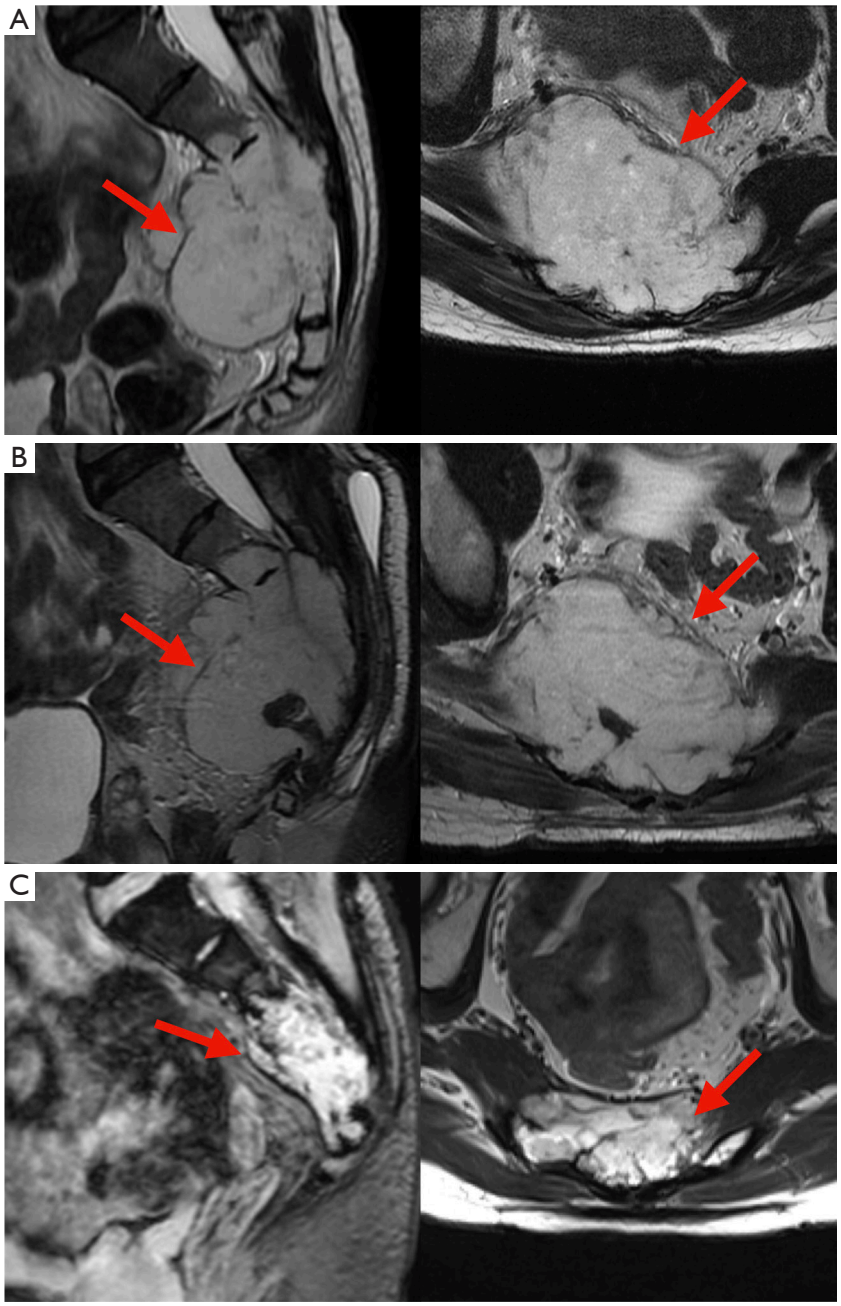


Figure 4 Case 2: MRI of spinal hemangioma. (A) An irregular-shaped lesion with a diameter up to 8.4 cm (red arrows) causing bony destruction and nerve root encasement on T2WI imaging. (B) T2WI showing slightly enlarged lesion (red arrows) with diameter over 9 cm 1.5 months after TAE. (C) T2WI demonstrating significant tumor size reduction (red arrows) without tumor recurrence 8.0 years after radiotherapy. MRI, magnetic resonance imaging; T2WI, T2-weighted image; TAE, transcatheter arterial embolization.

group achieved better symptom control (up to 82%) without experiencing an increase in toxicity (6). Heyd *et al.* recruited 84 patients with symptomatic vertebral hemangioma (82 patients with pain and 24 patients with spinal cord compression accompanied by paresis of neurological symptoms) and showed that radiotherapy with a median dose of 34 Gy (range, 4.5–45 Gy) provided an overall response rate of 90% in pain relief [complete

Table 1 Results of radiotherapy treatment for patients with vertebral hemangioma from different institutions

Series (institution) (Ref)	N	RT (Gy)	Complete pain relief	Neurological deficits improvement	Notes
University Hospital Eppendorf (6)					≥36 Gy resulted in better pain relief
Group A	62	20–34 (2 Gy/fx)	39%	NA	
Group B	55	36–44 (2 Gy/fx)	82%	NA	
Multicenter German Study (7)	84	4.5–45 (median 34 Gy/17 fx)	62%	CR =79%; PR =21%	≥34 Gy resulted in better pain relief
Maria Sklodowska-Curie Center (8)	137	8–30 (81% 24 Gy/12 fx)	64% at 1.5 years	NA	Increase RT dose and fx size resulted in better pain relief
Akdeniz University Hospital (9)	80	30–40 (median 40 Gy/20 fx)	59%	NA	Patients with concomitant musculoskeletal disease had lower pain relief
University of Florida (10)	10	28.8–59.8 (median 45 Gy/25 fx)	NA	NA	90% local tumor control at 30 years
National Cancer Database (11)	56	Mean: 19.36	NA	NA	Overall survival: >35 *vs.* 0–35 Gy; at 50 months: 21% *vs.* 0%, P=0.0073
Peking University Third Hospital (13)	20	40–50 (20–25 fx)	NA	CR =65%	VCE >40% resulted in poor RT response
Maria Sklodowska-Curie Center randomized trial (14)					Exclude patient with hemangioma-related neurological symptoms; CK arm result in better pain relief
CK arm	38	25 (5 fx)	73.7%	NA	
Conventional arm	36	36 (18 fx)	50%	NA	

RT, radiotherapy; fx, fraction; NA, non-analysis; CR, complete response; PR, partial response; VCE, vertebral canal encroachment; CK, CyberKnife.

response (CR), 52 (61.9%); partial response (PR), 24 (28.6%)] (7). Regarding neurological symptom relief (n=20), the authors reported that radiotherapy resulted in an overall response rate of 100% (CR, 79.2%; PR, 20.8%). However, in their study, 20 patients underwent surgical intervention before radiotherapy. It is unclear whether most patients with neurological symptoms underwent initial surgical intervention. In addition, using multiple logistic regression analyses, the authors showed that radiotherapy >34 Gy provided better pain relief than radiotherapy <34 Gy. Furthermore, Heyd *et al.* reviewed the literature on radiotherapy for symptomatic vertebral hemangiomas and reported that radiotherapy resulted in a CR rate of 57.6% (n=200) and PR rate of 27.7% (n=96) for pain relief in a total of 347 cases from 64 published studies (7). A similar radiation dose schedule was also endorsed by two large retrospective studies (8,9) in which the radiotherapy dose was at least 36 Gy in 2 Gy per fraction, which could offer feasible treatment outcomes for patients with vertebral hemangioma, with complete pain relief ranging from 59% to 64% (*Table 1*).

In a follow-up study of 10 patients with symptomatic vertebral hemangioma over 5 years, Parekh *et al.* showed that radiotherapy with a mean dose of 47 Gy provided a 90% tumor control rate and recommended a favored radiotherapy dose of 45 Gy in a 1.8 Gy per fraction schedule for treating vertebral hemangioma (10). In an analysis of the National Cancer Database, searching for hemangiomas between 2004 and 2016, Patel *et al.* identified 102 patients with histologically proven spinal hemangiomas who underwent different treatments, including surgical approaches, chemotherapy, and radiotherapy (11). Patel *et al.* further showed that, among 56 patients receiving radiotherapy, a higher dose of radiotherapy (>35 Gy) was significantly associated with better overall survival (at 25 months, 37.5% *vs.* 10%, P=0.0073) (11). The aforementioned results should be interpreted with caution because the endpoints thereof primarily focused on pain relief but did not specifically describe improvements in neurological deficits, and some patients also underwent

surgical intervention before radiotherapy (*Table 1*).

Another case series conducted by Jiang *et al.* analyzed the treatment outcomes of 29 patients with vertebral hemangioma who had neurological deficits (12), of whom 2 of the 10 patients who received radiotherapy alone required further surgical intervention for progressive neurological deficits. However, the radiotherapy dose was not mentioned in this report (12). Wang *et al.* assessed the clinical outcomes of 20 patients with vertebral hemangioma who had mild neurological deficits (defined as MRC scale for muscle power of greater than three out of five) and were treated with radiotherapy using 40–50 Gy in 20–25 fractions. In their study, 13 patients (65%) achieved complete resolution of neurological symptoms without recurrence after a minimum follow-up of 20 months (*Table 1*) (13). Moreover, among those receiving radiotherapy with 40 to 50 Gy, seven patients who experienced progressive or stable neurological symptoms after radiotherapy had more severe vertebral canal encroachment (greater than 40% at initial MRI examination), whereas 13 patients who responded to radiotherapy had an encroachment ratio less than 40% (*Table 1*) (13). In contrast, our first presented case had a spinal canal encroachment of 63.4% and was completely free of neurological symptoms 5.5 months after completing radiotherapy. The other patient had complete encroachment (100%) of the sacral plexus by the sacral hemangioma and achieved good partial remission of the tumor, with complete recovery from difficult defecation, leg pain, and numbness after completing radiotherapy.

Miszczyk *et al.* conducted a randomized controlled trial that focused on two different radiotherapy schedules for relieving pain at two years in patients presenting with painful vertebral hemangiomas. This randomized trial excluded patients who exhibited hemangioma-related neurological deficits or pain caused by cord compression (14). A total of 74 patients were randomly assigned to two treatment arms: the CyberKnife (CK) arm (25 Gy in 5 fractions using CK) and the conventional arm (36 Gy in 18 fractions using a linear accelerator). When compared to patients in the conventional arm, more patients in CK arm experienced improvement in pain (at 2 years, 73.7% *vs.* 50%, P=0.036), but the percentage of decreased numerical rating scale (NRS) and adverse effects were not significantly different between CK and conventional arms (NRS: 67% *vs.* 50%, P=0.407) (*Table 1*) (14). Although this trial did not enroll patients with vertebral hemangioma with neurological deficits, the hypofractionated radiotherapy regimen provided more subjective pain relief than the conventional radiotherapy regimen. This trial also provided the information that the hypofractionated regimen is likely to substitute the conventional regimen, and most importantly, shorter and more intensive course of radiotherapy could be beneficial for patients with acute neurological deficits. Further exploration of the efficacy of relieving neurological deficits caused by vertebral hemangiomas using hypofractionated radiotherapy regimens (such as 25 Gy in 5 fractions) is warranted.

Wang *et al.* retrospectively analyzed the clinical outcomes of 39 patients with vertebral hemangiomas who presented with neurological deficits or spinal cord compression (Enneking stage 3, S3) and were required to undergo decompression with (n=22) or without (n=17) intraoperative vertebroplasty (15). In their study, postoperative radiotherapy of 40–50 Gy was administered to patients who had a residual vertebral lesion on the 3-month postoperative follow-up images. None of the 22 patients who underwent decompression plus intraoperative vertebroplasty (18 patients without radiotherapy) experienced recurrence. Of the 17 patients who underwent decompression, one of nine patients without radiotherapy developed recurrence and underwent decompression followed by adjuvant radiotherapy. At a median follow-up of 50.2 months (range, 13–134 months), none of the patients had vertebral hemangioma recurrence (15). Wang *et al.* also reviewed the literature regarding the association between different surgical approaches, including decompression surgery, intralesional vertebrectomy, and total *en bloc* spondylectomy, and clinical outcomes for aggressive vertebral hemangioma (at least Enneking stage 3). Their results showed that the aforementioned surgical approaches provided the optimal control rate for aggressive vertebral hemangioma (15). In another retrospective study of 21 patients with aggressive vertebral hemangioma (all with neurologic deficits) who underwent different surgical procedures, including intralesional spondylectomy with reconstruction (n=9), stabilization, decompression, and vertebroplasty (n=9), and decompression and stabilization (n=3), all patients experienced improvement of neurological symptoms; only one patient developed a local recurrence at a mean follow-up of 55.78 months (range, 24–96 months) (16). Considering that the technique of decompression surgery is relatively undemanding and that several studies have shown that vertebroplasty or radiotherapy may prevent local recurrence (15,17,18), decompression surgery and intraoperative vertebroplasty followed by radiotherapy for residual lesions is recommended for patients with aggressive

vertebral hemangioma without comorbidities.

There are few reports describing clinical outcomes and management of vertebral hemangioma from Taiwan. Hwang *et al.* reported that a 55-year-old woman who presented with a mono paresis of the left leg resulting from a T10 vertebral hemangioma, and this patient had neurologic symptoms-free at 6 months after undergoing a T10 laminectomy but without postoperative radiotherapy (19). In the retrospective analyses of 184 patients who underwent surgical approaches for intraspinal tumors, Wu *et al.* showed that the most common histological subtype was Schwannoma (55 cases, 54%), while only 3 patients (3%) of them were histologically proven to be hemangioma (20). In this study, we reported two patients who could not undergo surgical approaches but well responded to the conventional dose of radiotherapy. Although these are the first two case reports of vertebral hemangioma treated by radiotherapy in Taiwan, further studies exploring the treatment efficacies of conventional or hypofractionated radiotherapy alone for Taiwanese patients with inoperable vertebral hemangioma are warranted.

Conclusions

Our study, together with those reported in the literature, demonstrated that radiotherapy with a conventional dose of at least 40 Gy resulted in significant improvements in neurological symptoms. The use of radiotherapy can be an alternative treatment strategy for patients with inoperable vertebral hemangioma, even if the disease manifests as severe spinal cord compression accompanied by neurological deficits.

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Footnote

Reporting Checklist: The authors have completed the CARE reporting checklist. Available at https://tro.amegroups.com/article/view/10.21037/tro-23-8/rc

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://tro.amegroups.com/article/view/10.21037/tro-23-8/coif). S.H.K. serves as an unpaid Associate Editor-in-Chief of *Therapeutic Radiology and Oncology*. The other authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the Helsinki declaration (revised version in 2013). Written informed consent was obtained from patient 1's parents and patient 2 for publication of their cases and accompanying images. A copy of the written consent is available for review by the editorial office of this journal.

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