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Treatment experiences of thoracic spinal hydatidosis: a single-center case-series study

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ABSTRACT

Objective: Spinal hydatid disease is rare and remains a serious health problem associated with high rates of recurrence. We report our experience in treating patients with thoracic spinal hydatidosis through a single-center case-series study.
Methods: Sixteen patients with thoracic spinal hydatidosis were treated in our center between 1995 and 2017. A total en bloc spondylectomy (TES) was performed in three patients. Five patients were treated with posterior decompression and stabilization after removing the involved elements. The remaining patients underwent curettage and resection of the infected bone. The therapy was completed with medical treatment or radiotherapy.
Results: Of the 16 patients, seven were men and nine were women; their mean age was 38.5 years (range 28–60 years). The infected area was the upper thoracic level in one patient, mid thoracic level in eight patients, and lower thoracic level in seven patients. Four patients had paraplegia and seven had paraparesis before surgery. At the last follow-up, five patients had successfully recovered from the neurological damage. During a mean follow-up of 4.75 years (range 2–12 years), eight patients had local recurrence; however, no patient who underwent TES had recurrence.
Conclusions: An individualized surgical strategy should be decided carefully for each patient in the first intervention. In the early stages of the disease, TES should be considered as a treatment for suitable cases of primary thoracic spinal hydatidosis.

Introduction

Hydatidosis is a rare disease, but is relatively common in the Mediterranean, Middle East, Central Asia, East Africa, and Western China. It may develop in almost any part of the body, although most hydatid cysts occur in the liver or in the lung (Sapkas et al., 1998; Terek et al., 2000; Song et al., 2007; Liang et al., 2014). Bone hydatidosis is rare and accounts for only 0.5% to 4% of all locations (Neumayr et al., 2013a). Approximately 50% of the cases of bone hydatidosis are spinal, and 50% of spinal involvement is seen in the thoracic region (Govender et al., 2000; Neumayr et al., 2013a; Baysefer et al., 1996).

The only curative treatment for osseous hydatidosis is surgery (Zlitni et al., 2001; Neumayr et al., 2013b). The treatment of spinal hydatidosis with different surgical options has been reported in the literature, including simple drainage or debridement, curettage and resection of the infected bone, and posterior or anterior decompression and stabilization (Khazim et al., 2003; Gezercan et al., 2017; Pamir et al., 2002). However, following the occurrence of bone hydatidosis, recurrence is still frequent (Zlitni et al., 2001). The total en bloc spondylectomy (TES) is a surgical technique that is indicated for primary malignant bone tumors, aggressive benign tumors, and infrequently for solitary metastatic lesions (Jones et al., 2018). In hydatid disease of the vertebrae, the parasites

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spread along the bony intratrabecular space, destroying the bone, but intervertebral discs are usually preserved because the disease tends to propagate beneath the periosteum (Baysefer et al., 1996). This makes TES possible in the early stages of the disease.

A total of 16 cases of thoracic spinal hydatidosis were treated at The First Affiliated Hospital of Xinjiang Medical University between 1995 and 2017; these cases represent 46% of spinal hydatidosis and 18% of musculoskeletal hydatidosis treated in our center. Our experience in treating these 16 patients with thoracic spinal hydatidosis is reported here. This study is novel, as no large series or TES for thoracic spinal hydatidosis appear to have been reported previously in the literature.

Patients and methods

Between 1995 and 2017, a total of 16 patients with hydatid disease of the thoracic spine were treated in the Department of Orthopedics, The First Affiliated Hospital of Xinjiang Medical University (Table 1). Seven were male and nine were female, and their mean age at the first surgery was 38.5 years (range 28–60 years). The median duration of follow-up was 4.8 years (range 2–12 years). Plain radiography, computed tomography (CT), and magnetic resonance imaging (MRI) were used in all of the patients to establish the diagnosis and to assess the status of their visceral organs. Laboratory testing for echinococcosis was performed using eight immunodiagnostic tests, including both ELISA and dot immunogold filtration assay (DIGFA). These tests can detect four types of antigen simultaneously, namely *Echinococcus granulosus* crude hydatid cyst fluid antigen (EgCF), *E. granulosus* protoscolex antigen extract (EgP), hydatid cyst fluid native antigen B (EgB), and *Echinococcus multilocularis* metacestode laminated layer extract (Em2) (Liang et al., 2014; Feng et al., 2010). The erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP) level were also determined for the 16 patients.

Treatment

An individualized surgical strategy was decided for each patient, mainly according to neurological symptoms, classification, systemic involvement, and general status of the patient. A total of 29 operative procedures were performed in these 16 patients, including TES, posterior decompression and stabilization after removing the involved elements, and curettage and resection of the infected bone. In the first intervention, TES was performed in three patients (patients 10, 11, and 12), five patients (patients 5, 7, 8, 9 and 16) were treated with decompression and stabilization, and the remaining patients (patients 1, 2, 3, 4, 6, 13, 14 and 15) underwent curettage.

The thoracic spine was exposed posteriorly in all but patient 14 in the first intervention. TES involved four steps: an en bloc laminectomy, posterior stabilization with pedicle screws, and en bloc resection of the vertebral body without rupture of the cyst, followed by insertion of a titanium cage filled with autograft. Due care was taken to avoid spillage of the cyst contents while performing an en bloc resection of the vertebral body. The surrounding surgical field was packed with gauze soaked in 20% NaCl solution to prevent local spillage. The vertebral column was stabilized with pedicle screws, two above and two below the diseased vertebra (Figure 1).

All patients were administered postoperative chemotherapy of albendazole (10 mg/kg/day) for 12 months with close observation of liver enzymes. Nine of the 16 patients received preoperative chemotherapy with albendazole, at least one dose, before the operation. Patients experiencing recurrence were routinely administered anthelmintic chemotherapy; in addition, four patients (patients 3, 8, 13 and 15) also received radiotherapy (total dose 6900 cGy/23 f/30 days).

Results

Twelve out of the 16 patients had typical imaging characteristics, which could be diagnosed preliminarily by MRI. The liver or lung was involved in nine patients (Table 1). Fifteen patients (93.75%) were positive in the eight immunodiagnostic tests. The average ESR was 21 mm/h (range 6–52 mm/h), and the average CRP was 6.4 mg/l (range 3.2–59.4 mg/l). The final diagnosis was confirmed by histopathological examination of the resected tissue.

The infected area was the upper thoracic spine (T1–T4) in one patient, the mid thoracic spine (T5–T8) in eight, and the lower thoracic spine (T9–T12) in seven. In the cases of thoracic spinal hydatidosis, one level was affected in 13 cases and several levels were affected in three cases. According to the classification of Braithwaite and Less (1981), there was one case of type 2 (intradural extramedullary), two cases of type 3 (extradural), nine cases of type 4 (vertebral), and four cases of type 5 (paravertebral).

Table 1
Details of the patients.

Case No.	Age (years)/ sex	Location	Braithwaite and Lees classification	Initial symptom	Frankel's grades	Status of liver and lung	Initial surgical treatment	Initial preoperative chemotherapy	Initial postoperative chemotherapy	Total number of operations	Follow-up (years)	Outcome
1	29/M	T10	Type 2	SCC	B	HI	L + C	No	Yes	1	3	LFU
2	36/F	T6	Type 3	SCC	D	Uninfested	L + C	Yes	Yes	1	4	FOS
3	34/F	T3	Type 3	BP + SCC	D	PI	L + C	No	Yes	3	12	FOS
4	31/M	T9	Type 4	BP	E	Uninfested	L + C	Yes	Yes	1	6	FOS
5	30/F	T7	Type 4	BP + SCC	D	PI	L + PF	Yes	Yes	1	2	FOS
6	48/F	T10	Type 4	BP	E	HI	L + C	No	Yes	3	7	LWD
7	43/F	T9	Type 4	SCC	D	PI	L + PF	Yes	Yes	2	4	FOS
8	37/M	T8	Type 4	SCC	D	Uninfested	L + PF	No	Yes	3	6	LFU
9	42/M	T12	Type 4	BP	E	Uninfested	L + PF	No	Yes	2	3	LWD
10	29/F	T11	Type 4	BP + SCC	B	Uninfested	TES	Yes	Yes	1	3	FOD
11	32/M	T7	Type 4	SCC	C	Uninfested	TES	Yes	Yes	1	2	FOD
12	37/F	T11	Type 4	BP + SCC	D	Uninfested	TES	Yes	Yes	1	2	LFU
13	52/F	T7	Type 5	BP	D	HI	L + C	No	Yes	3	6	LWD
14	60/F	T5–8	Type 5	BP	E	PI	AC	Yes	Yes	1	2	FOS
15	48/M	T4–7	Type 5	BP	E	HI + PI	L + C	Yes	Yes	2	4	LWD
16	28/M	T5–7	Type 5	BP + SCC	C	HI + PI	L + PF	No	Yes	3	10	Died

Abbreviations: M, male; F, female; SCC, spinal cord compression; BP, back pain; HI, hepatic infestation; PI, pulmonary infestation; L, laminectomy; C, curettage; PF, posterior fixation; TES, total en bloc spondylectomy; AC, anterior curettage; LFU, Lost to follow-up; FOS, free of symptoms; LWD, live with disease; FOD,free of disease.

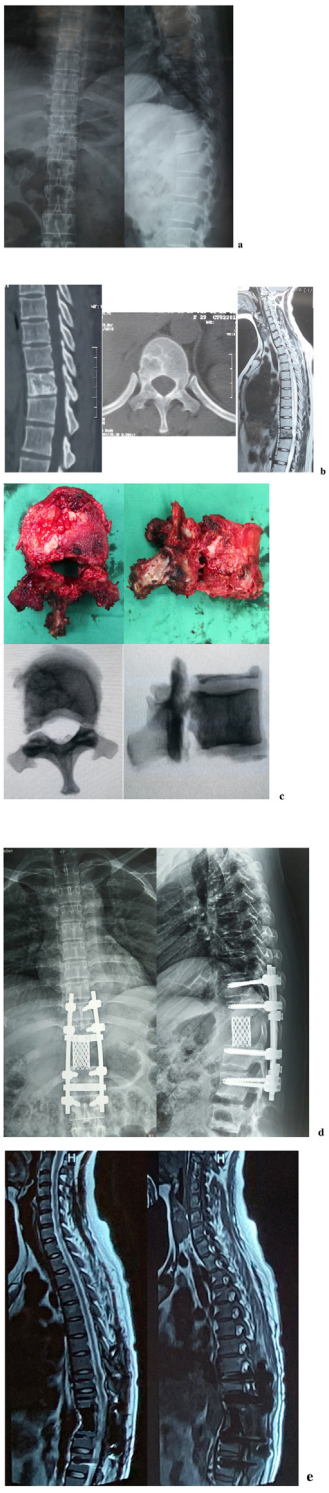

Figure 1. A 29-year-old female with thoracic spinal hydatidosis of type 4 (case 10). (a) Radiograph of the thoracic vertebra before surgery. (b) CT and MRI scans showing an osteolytic lesion in the T11 vertebra and spinal cord compression. (c) Appearance and radiographs of the resected T11 vertebra. (d) Radiograph and (e) MRI performed 3 years after surgery, showing the internal fixation and vertebra in good alignment, with no sign of recurrence.

Clinically, 11 patients (69%) presented with a 2- to 24-week history of back pain, seven patients (43.75%) with varying degrees of paraparesis, and four patients (25%) with paraplegia of the lower extremities at the time of admission to the center.

Fifteen patients were free of pain after recovery from their first operation. No neurological systems became worse. Impending paralysis was prevented in the seven patients with Frankel grade D (useful motor function with or without auxiliary means). The neurological damage recovered successfully in five patients (patients 2, 3, 7, 10 and 12), including one with Frankel grade B (motor complete, sensory incomplete function disorder) who underwent TES and was able to walk autonomously on the first month after surgery.

The follow-up time ranged from 2 to 12 years. The median time of follow-up was 4.75 years. Three patients missed follow-up after the last surgery. Eight patients had a recurrence (50%) and eight (50%) patients were free of symptoms at the last follow-up. The average time to the first recurrence after surgery was 2 years, but no patient who underwent TES had recurrence. One patient died of disseminated disease.

Repeated curettage was necessary in eight cases. One of these eight patients (patient 3) was diagnosed with thoracic spinal hydatidosis and pulmonary hydatidosis after the first curettage in 2006. Six years after initial presentation, there was a recurrence of acute paraplegia. At that time MRI showed dorsal spinal cord compression at the level of T3–T4. The spinal cord was decompressed by laminectomy and stabilization with a pedicle screw–rod system. Neurological recovery was initially complete, but she complained of radiating pain in the left chest 3 years after the second operation. MRI showed narrowing of the spinal canal by extradural hydatid cysts, with expansion into the left intervertebral foramen. Hydatid cysts in the left lower lobe were also evident (Figure 2). Another curettage was performed through the previous laminectomy incision. It was also decided with the thoracic surgeon to remove the pulmonary hydatid cysts during surgery through an anterior approach. The patient's postoperative recovery was uneventful.

Discussion

Bone hydatidosis remains rare, with vertebral locations observed in half of these cases, generally located in a single vertebra (Govender et al., 2000). The thoracic spine is the most commonly affected part of the vertebral column, followed by the lumbar spine, sacrum, and cervical spine (Kafaji et al., 2013; Xia et al., 2019). Braithwaite and Lees (1981) classified spinal hydatidosis into five types: intramedullary, intradural extramedullary, extradural intraspinal, vertebral, and paraspinal. In the series presented here, approximately 94% of lesions were located extradurally, most commonly in the vertebral body, and the most prevalent location was the mid thoracic region (50%), followed by the lower thoracic and upper thoracic regions.

Spinal involvement in hydatid disease usually starts in the vertebral body and grows slowly because of the resistant nature of bone (Ozdemir et al., 2004). There are no pathognomonic signs or symptoms other than the symptoms related to compression of the spinal cord. Weakness of the limbs and paraplegia are reported in 25% to 84% of cases (Charles et al., 1988), and paraplegia is the most serious complication of the disease. Most authors seem to highlight an important rate of paraparesis or paraplegia at presentation (61% to 73%) (Gennari et al., 2016), and the incidence of paraplegia in recurrent disease is also reported to be as high as 45% (Pamir et al., 2002). In our series, the presenting clinical symptoms at the time of admission to the hospital were paraparesis in seven cases (43.75%) and paraplegia in four cases (25%). In the case of recurrent disease, five patients (62.5%) presented with paraparesis or paraplegia.

Although hydatid disease is an infectious disease, its clinical behavior is similar to that of local malignant tumors, so that local control of the disease is almost impossible with chemotherapy

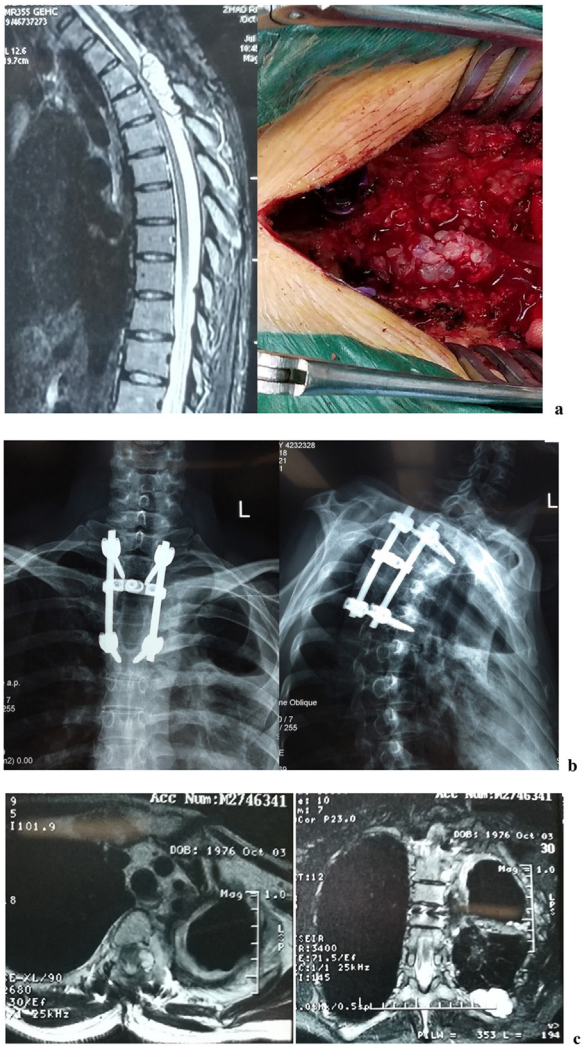

Figure 2. A 34-year-old female with thoracic spinal hydatidosis of type 3 (case 3). (a) MRI and appearance after the first recurrence, showing narrowing of the spinal canal by multiple extradural cysts. (b) Radiograph of the thoracic vertebra after the second surgery. (c) MRI after the second recurrence, showing the cystic lesions located in left intervertebral foramen and left lower lobe.

alone. The only curative treatment for osseous hydatidosis is surgery. The objectives of the surgery include local control of infection, prevention of neurological decline, total removal of the cyst without rupture, and spinal deformity correction (Kaloostian and Gokaslan, 2015). An individualized surgical strategy was decided for each patient, mainly according to neurological symptoms, classification, systemic involvement, and the patient's general status. We have previously reported that internal fixation should not be used in pelvic bone hydatidosis when surgical eradication is uncertain (Liang et al., 2014). However, in many cases of thoracic spinal hydatidosis, the initial symptoms are paraplegia or paraparesis, which require rapid decompression followed by internal fixation to alleviate symptoms and prevent kyphosis.

At present, the posterior decompression approach is recognized as achievable for the majority of spinal hydatidosis cases. Laminectomy has been performed as a routine procedure for years, but it has not significantly affected the outcome of spinal hydatid disease (Sengul et al., 2008). Several authors have used this approach with or without complementary bone fixation. Other authors have performed a posterior fusion with instrumentation after removing the involved elements and an additional anterior approach to perform corpectomy and bone graft (Herrera et al., 2005). Bhojraj and Shetty (1999) suggested that an anterior approach should be avoided to prevent the spread of the disease to the chest and abdominal cavities. In our opinion, the clinical symptoms for lesions situated in the vertebral body are usually absent, and in the majority of cases, the first symptom is spinal cord compression or sensory deficit, which require rapid posterior decompression and stabilization. Therefore, in the series presented here, the anterior approach was only used for curettage in the treatment of recurrence or paravertebral involvement, and this was usually palliative rather than curative.

As thoracic spinal hydatidosis has a high possibility of recurrence and malignant transformation, we recommend that radical excision should be considered first if possible. Khazim et al. (2003) stated that spinal hydatidosis should be considered as a locally aggressive tumor, the treatment of which ideally should be radical excision of all affected tissue with a margin of healthy tissue. Govender et al. (2000) suggested total vertebrectomy to prevent recurrence, even if only a part of the vertebral body is involved. Xia et al. (2019) reported that most surgeries actually consisted of a subtotal resection of hydatid lesions, spinal decompression, and transpedicular fixation, which might have been the main cause of the high recurrence rate. In our opinion, TES may offer the hope of eradication in this situation. At present, TES is well recognized as the most effective and efficient surgical method for both alleviating symptoms and preventing recurrence in patients with vertebral body tumors (Mesfin et al., 2015). It appears that TES as a treatment for thoracic spinal hydatidosis has not been reported previously.

In vertebral tumors, according to the classification of Tomita, TES is best indicated for type 3 and 4 lesions, and is relatively indicated for some advanced type 2 or selected type 5 lesions (Tomita et al., 1994). We believe that the Tomita classification for vertebral tumors is also instructively significant for thoracic spinal hydatidosis, because the vertebral regions (including vertebral body, pedicle, lamina, epidural space, paraspinal area) indicated for disease onset and malignant tumor progression are similar to those of spinal hydatidosis.

However, spinal hydatidosis cannot be fully equated with vertebral tumors. In hydatid disease of the vertebra, the parasites spread along the bony intratrabecular space, destroying the bone, but the intervertebral discs are usually preserved because the disease tends to propagate beneath the periosteum (Gezercan et al., 2017; Ozdemir et al., 2004). Braithwaite and Lees (1981) believed that hydatid cysts in the bone expand relatively slowly, and the remaining bone has smooth, well-defined margins. Govender et al. (2000) also reported that hydatid infestation is usually confined to a single body, owing to the relative resistance to invasion of the disc space. Therefore, even though the type 4 lesion (Tomita classification) extends into the epidural space, we still consider it an intra-compartmental lesion that can be removed by TES. However, patients with extra-compartmental lesions (types 5–7, Tomita classification) are excluded from TES. In our series, no type 1 lesion (Tomita classification) was observed, probably because patients with this type usually have no clinical manifestation. When the bone is breached by the cysts and the extradural space is violated, neurological deficit ensues, and the type 1 or 2 lesions progress to more serious types. Xia et al. (2019) believed that the majority of parasitic lesions in the intraspinal–extradural areas may have migrated from the liver or lung to the spinal canal. Güneçs et al. (2009) reported that the disease usually spreads to the spine by direct extension from a pulmonary or abdominal infestation. Cavus et al. (2018) recommended that the presence of the visceral hydatid cyst should alert the surgeon against the spinal hydatidosis. Patients with visceral hydatid disease may cause spinal hydatidosis, therefore, presence of visceral hydatid cyst may affects the choice of spine surgery. TES was only performed for

primary spinal hydatidosis without any other systemic involvement, and the intra-compartmental lesions had to be located in a single thoracic segment.

The basic technique of curettage for osseous hydatidosis involves exposure of the lesion and protection of the adjacent normal tissue with gauze soaked in 20% NaCl solution. Dexamethasone (10 mg) was injected during the operation to prevent allergic shock (Liang et al., 2014). The surgeon should attempt complete intralesional or marginal if not radical excision of the cyst and avoid spillage of the cyst contents (Khazim et al., 2003; Gezercan et al., 2017). Due care should be taken to avoid dural damage, because dural damage at the time of previous surgery has been suggested as the most plausible mechanism of spread (Jain et al., 2014; Hamdan, 2012). These basic techniques must be followed when the diagnosis of thoracic spinal hydatidosis cannot be ruled out before surgery.

Although surgery is the most effective treatment, adjuvant anthelmintic chemotherapy is essential to control the disease locally, avoid systemic spread, and prevent recurrence (Xia et al., 2019). A literature review has suggested that preoperative chemotherapy with albendazole may prevent anaphylactic shock in the event that an active cyst ruptures, reduce the risk of cystic recurrence, and facilitate the operation by reducing the intracystic pressure, although there is controversy regarding the duration of treatment (Hall, 2015). According to the systematic review by Neumayr et al. (2013b), perioperative treatment with albendazole should be initiated $\geq$4 h before surgery to achieve scolicidal blood levels. However, some authors have treated their patients without preoperative chemotherapy. In a large case series reported by Kafaji et al. (2013), most of the patients had severe neurological symptoms on first diagnosis that required urgent surgery before chemotherapy. Similarly, Thaler et al. (2010) performed immediate surgery without full length preoperative chemotherapy owing to the critical neurological status of their patient. In our series, only nine patients received preoperative chemotherapy because most neurosurgeons and orthopedists had a weak awareness of preoperative pharmacotherapy for spinal hydatidosis before the year 2005, and some patients without typical imaging characteristics were misdiagnosed before the first intervention. We believe that anthelmintic treatment should be given both preoperatively and postoperatively, regardless of whether the spinal hydatidosis is a first episode or a case of recurrence. However, the increased risk of dissemination and recurrence caused by insufficient preoperative chemotherapy must be weighed against the risk of neurological deterioration. For patients with severe neurological damage, clinicians should give priority to urgent surgery rather than full length preoperative chemotherapy to provide the opportunity for neurological recovery, but at least one dose should be administered preoperatively.

Recurrence remains a major problem in spinal hydatidosis and the recurrence rate varies between 40% and 100% (Kafaji et al., 2013). This is because of the difficulty in removing the cyst due to limited access and the presence of vital structures around the vertebra. Another reason for recurrence is rupture of the cyst during removal. Our observation showed a relatively low recurrence rate (50%), probably for the following reasons: first, in thoracic lesions, the nerve roots could be sacrificed to gain a larger access, making radical excision more possible; second, no recurrence was observed at the last follow-up in patients who had been treated with TES, which suggests that TES may provide a longer disease-free interval and even decrease the recurrence rate of thoracic spinal hydatidosis.

In conclusion, the treatment of thoracic spinal hydatidosis is difficult and the surgeon should be aware that the operation sometimes results in disease recurrence or worse conditions. Thus, an individualized surgical strategy should be decided carefully for each patient in the first intervention. We also advocate that total en bloc spondylectomy should be considered as a treatment for primary thoracic spinal hydatidosis in the early stages of the disease.

Author contributions

Qiuzhen Liang and Haibin Xiang contributed to the data collection, data analysis, and writing. Xinghua Song and Jiangtao Chen contributed to the study design and performing the operations. Leilei Xu, Zheng Tian, and Akbar Yunus contributed to providing the patients. Hao Wen contributed to providing the conception of the operations. Chong Wang, Dawei Jiang, and Maimaitiaili Abuduwaili contributed to data acquisition and follow-up. All authors read and approved the final manuscript.

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Ethical approval

This study was performed in compliance with ethical standards.

Conflict of interest

The authors declare that they have no conflict of interest.

References

Baysefer A, Gönül E, Canakçı Z, Erdoğan E, Aydoğan N, Kayalı H. Hydatid disease of the spine. Spinal Cord 1996;34(5):297–300.
Bhojraj SY, Shetty N. Primary hydatid disease of the spine: an unusual cause of progressive paraplegia. J Neurosurg 1999;91(2 Suppl):216–8.
Braithwaite PA, Lees RF. Vertebral hydatid disease: radiological assessment. Radiology 1981;140(3):763–6.
Cavus G, Acik V, Bilgin E, Gezercan Y, Okten AI. Endless story of a spinal column hydatid cyst disease: a case report. Acta Orthop Traumatol Turc 2018;52(5):397–403.
Charles RW, Govender S, Naidoo KS. Echinococcal infection of the spine with neural involvement. Spine 1988;13(1):47–9.
Feng X, Wen H, Zhang Z, Chen X, Ma X, Zhang J, et al. Dot immunogold filtration assay (DIGFA) with multiple native antigens for rapid serodiagnosisof human cystic and alveolar echinococcosis. Acta Trop 2010;113(2):114–20.
Gennari A, Almairac F, Litrico S, Albert C, Marty P, Paquis P. Spinal cord compression due to a primary vertebral hydatid disease: a rare case report in metropolitan France and a literature review. Neurochirurgie 2016;62(4):226–8.
Gezercan Y, Ökten AI, Çavuş G, Açık V, Bilgin E. Spinal hydatid cyst disease. World Neurosurg 2017;108:407–17.
Govender TS, Aslam M, Parbhoo A, Corr P. Hydatid disease of the spine. A long-term followup after surgical treatment. Clin Orthop Relat Res 2000;(378):143–7.
Güneçs M, Akdemir H, Tuğcu B, Günaldi O, Gümüçs E, Akpinar A. Multiple intradural spinal hydatid disease: a case report and review of literature. Spine (Phila Pa 1976) 2009;34(9):E346–50.
Hall WA. Spinal parasites. World Neurosurg 2015;83(1):39–40.
Hamdan TA. Hydatid disease of the spine: a report on nine patients. Int Orthop 2012;36(2):427–32.
Herrera A, Martínez AA, Rodríguez J. Spinal hydatidosis. Spine (Phila Pa 1976) 2005;30(21):2439–44.
Jones M, Holton J, Hughes S, Czyz M. Total en bloc spondylectomy. J Spine Surg 2018;4(3):663–5.
Jain A, Prasad G, Rustagi T, Bhojraj SY. Hydatid disease of spine: multiple meticulous surgeries and a long term followup. Indian J Orthop 2014;48(5):529–32.
Kafaji A, Al-Zain T, Lemcke J, Al-Zain F. Spinal manifestation of hydatid disease: a case series of 36 patients. World Neurosurg 2013;80(5):620–6.
Kaloostian PE, Gokaslan ZL. Spinal hydatid disease: a multidisciplinary pathology. World Neurosurg 2015;83(1):52–3.
Khazim R, Fares Y, Heras-Palou C, Ruiz Barnes P. Posterior decompression of spinal hydatidosis: long term results: Fundacion Jimenez Diaz, Madrid, Spain. Clin Neurol Neurosurg 2003;105(3):209–14.
Liang Q, Wen H, Yunus A, Tian Z, Jiang F, Song X. Treatment experiences of pelvic bone hydatidosis. Int J Infect Dis 2014;18:57–61.
Mesfin A, El Dafrawy MH, Jain A, Hassanzadeh H, Kebaish KM. Total en bloc spondylectomy for primary and metastatic spine tumors. Orthopedics 2015;38(11):e995–e1000.

Neumayr A, Tamarozzi F, Goblirsch S, Blum J, Brunetti E. Spinal cystic echinococcosis—a systematic analysis and review of the literature: part 1. Epidemiology and anatomy. PLoS Negl Trop Dis 2013a;7(9):e2450.
Neumayr A, Tamarozzi F, Goblirsch S, Blum J, Brunetti E. Spinal cystic echinococcosis—a systematic analysis and review of the literature: part 2. Treatment, follow-up and outcome. PLoS Negl Trop Dis 2013b;7(9):e2458.
Ozdemir HM, Ogün TC, Tasbas B. Lasting solution is hard to achieve in primary hydatid disease of the spine long-term results and an overview. Spine (Phila Pa 1976) 2004;29(8):932–7.
Pamir MN, Ozduman K, Elmaci I. Spinal hydatid disease. Spinal Cord 2002;40(4):153–60.
Sapkas GS, Stathakopoulos DP, Babis GC, Tsarouchas JK. Hydatid disease of bones and joints. 8 cases followed for 4–16 years. Acta Orthop Scand 1998;69(1):89–94.
Sengul G, Kadioglu HH, Kayaoglu CR, Aktas S, Akar A, Aydin IH. Treatment of spinal hydatid disease: a single center experience. J Clin Neurosci 2008;15(5):507–10.
Song XH, Ding LW, Wen H. Bone hydatid disease. Postgrad Med J 2007;83(98):536–42.
Terek MC, Ayan C, Ulukus M, Zekioglu O, Ozkinay E, Erhan Y. Primary pelvic hydatid cyst. Arch Gynecol Obstet 2000;264(2):93–6.
Thaler M, Gabl M, Lechner R, Gstöttner M, Bach CM. Severe kyphoscoliosis after primary Echinococcus granulosus infection of the spine. Eur Spine J 2010;19(9):1415–22.
Tomita K, Kawahara N, Baba H, Tsuchiya H, Nagata S, Toribatake Y. Total en bloc spondylectomy for solitary spinal metastases. Int Orthop 1994;18(5):291–8.
Xia Y, Ju Y, Liu JP, Chen LY. Common spinal parasites. Turk Neurosurg 2019;29(3):409–13.
Zlitni M, Ezzaouia K, Lebib H, Karray M, Kooli M, Mestiri M. Hydatid cyst of bone: diagnosis and treatment. World J Surg 2001;25(1):75–82.