Surgical management for upper thoracic spine tumors by a transmanubrium approach and a new space

Zeng Ming Xiao · Xin Li Zhan · De Feng Gong · Shi De Li

Received: 10 April 2006 / Revised: 15 September 2006 / Accepted: 20 September 2006 / Published online: 17 October 2006
© Springer-Verlag 2006

Abstract The anterior aspect of the upper thoracic spine is a difficult region to approach in spinal surgery. Many vital structures including osseous, articular, vascular and nervous ones hinder the exposure. With increasing frequency, spine surgeons are being asked to provide decompression and stabilization in patients with spinal tumors. The traditional exposure is between the esophagus and trachea medially and the left common carotid or the brachiocephalic artery (BCA) laterally, and the disadvantages were that the ligation and section of the left innominate vein is proposed to reach T4 and the injury of the thoracic duct could occur. The right space of the BCA or the ascending aorta (AA) (the exposure between the right brachiocephalic vein and the BCA or between the AA and superior caval vein) is recommended in exposing the upper thoracic vertebrae; this new space is technically feasible; the exposure is sufficient for vertebral body resection and reconstruction and fixation. Twenty-eight patients with upper thoracic spine tumors underwent surgery by the use of this new space between June 2000 and October 2005. A strut graft was fixed anteriorly after decompression of the spinal cord. Levels C7–T5 can be well exposed through this new space, allowing complete vertebral body removal at level T1–T4. After body removal, the posterior longitudinal ligament is well exposed, allowing complete release of the spinal cord. Curettage was performed in

one case of aneurysmal bone cyst and three cases of bone giant cell tumors. For other tumors, vertebrectomies or sagittal resections were performed. Four patients underwent surgery by a combination of anterior and posterior approach.

Keywords Upper thoracic spine · Bone tumor · Transmanubrium approach · New space

Introduction

The anterior aspect of the upper thoracic spine is difficult to expose, and many techniques have been described [3]. Most of the previously described techniques are extensile and require osteotomy of the clavicle [16] or sternotomy [18]. A thoracic lateral approach requires elevation of the scapula [4] with extensile muscle dissection and rib resection, leading to significant morbidity. A cervical approach [5] does not allow good spinal cord decompression at the levels T1, T2 or T3, because it is not possible to see the posterior vertebral ligament, and osteosynthesis is not easy due to the obliquity of the access. On the other hand, the traditional exposure is between the esophagus and trachea medially and the left common carotid or the brachiocephalic artery (BCA) laterally (Fig. 1), and the disadvantages were that the ligation and section of the left innominate vein is proposed to reach T4 or T5 and the injury of the thoracic duct could occur [4, 7, 9, 11–14, 16, 18]. Our previous study [19] showed that the anterior aspect of the upper vertebral body from C7 to T4 can be easily exposed through the right space of the brachiocephalic trunk [between the right brachiocephalic vein (R-BCV) and the BCA]; our clinical

Z. M. Xiao · X. L. Zhan (✉) · D. F. Gong · S. De Li
Department of Orthopedics,
The First Affiliated Hospital of Gaungxi Medical
University, Nanning, Guangxi, China
e-mail: 3cstar@163.com

Fig. 1 The traditional exposure (*T* trachea, *L-CCA* common carotid artery, *L-BCV* left brachiocephalic vein)

experience showed that T3–T5 can be easily exposed through the right space of the ascending aorta (AA) [between the AA and superior caval vein (SCV)]. We used a transmanubrium approach and the right space of the brachiocephalic trunk or the AA in 28 patients without ligation and section of the left innominate vein and avoiding the injury of the thoracic duct, which made it possible to decrease the morbidity and optimize visualization.

Materials and methods

Patient collective

Twenty-eight patients underwent surgery by the use of a modified transmanubrium approach and the right space of the brachiocephalic trunk or the AA between June 2000 and October 2005. All patients presented with pain and/or neurological deficits and underwent preoperative magnetic resonance imaging (MRI). Neurologic function was graded according to the classification of Frankel et al. [6]. There were eight cases of bone giant cell tumors, four osteosarcomas, two chondrosarcomas, two eosinophilic granulomas, one aneurysmal bone cyst, one non-Hodgkin's lymphoma, one solitary plasmacytoma, one malignant fibrous

histiocytoma, and eight metastatic carcinomas. According to Tomita et al. [17] surgical staging system for spine tumors, the tumors were divided into following types: type I (21 patients), type II (1), type III (3), type V (1), type VI (2).

Operative technique

The patient is placed supine on the operating table under general endotracheal anaesthesia; the neck is hyperextended and turned to the left side (Fig. 2). For a better exploration after sternotomy, a rolled towel is placed between the scapulae. A stomach tube is placed for a better intraoperative identification of the oesophagus; in case of suspected leakage of the ductus thoracicus, this tube can also be used for diagnosis. Intra-venous antibiotics are given; we prefer 48 to 72-h shot with cephalosporine. All areas in contact with the table must be well padded, then the right anterior neck and chest are prepared and draped in sterile fashion. If the C7–T1 is the goal, this approach is combined with the cervical one described by Robinson and Smith [15]. In this case the skin incision starts with a longitudinal cut about 4–8 cm cranial of the jugulum along the anterior aspect of the sternocleidomastoid muscle to the jugulum, then it follows as a midline incision on the sternum to 2 cm caudal of the sternal angle. The platysma muscle is incised, subcutaneous tissue is incised, and the anterior veins may be sectioned. Although the external and internal jugular veins and the medial subclavicular nerve can be retracted, they may be sacrificed if exposure and mobilisation warrant. Then the superficial and deep

Fig. 2 The patient is placed supine on the operating table, the neck is hyperextended and turned to the left. The skin incision of the modified transmanubrium approach

cervical fascia are divided, and the sternocleidomastoid muscle is mobilized, followed by blunt dissection to create a plane between the carotid sheath and the trachea. After subperiosteal exposure of the sternum, retrosternal fat tissue and rests of the thymus are digitally removed from the sternum. Limited sternotomy (2 cm caudal of the sternal angle) and transverse osteotomy of the right splitting sternum at the end of the splitting sternum follows with a sternotome or a sternal saw (Fig. 3). Bleeding from the sternum is stopped by bone wax, and then the retractor is inserted. The sternohyoid and sternothyroid muscles are divided, allowing connection of the region of the lower cervical and the upper thoracic spine. By blunt dissection downward, the brachiocephalic or innominate vein is identified. For better exploration the inferior thyroid artery and vein may be ligated. The esophagus and the trachea and the BCA or the AA were then retracted to the left together with the recurrent laryngeal nerve or vagus nerve, and the R-BCV or SCV were gently retracted to the right. The right space of the BCA (between the R-BCV and the BCA) offers good access to T4 (Figs. 4, 5a, b), assisted by the caudal retraction of the base of the left brachiocephalic vein (L-BCV), no need to ligate and section the left innominate vein. If T5 must be reached, the right space of the AA (between the AA and SCV) is recommended (Figs. 4, 6a, b). A strut graft was fixed anteriorly after decompression of the spinal cord. Levels C7–T5 can be well exposed through this new space, allowing complete vertebral body removal at level T1–T4. After body removal, the posterior longitudinal ligament is well exposed, allowing complete release of the spinal cord. Curettage was performed in one case of aneurysmal bone cyst and three cases of bone giant cell

Fig. 3 Limited sternotomy. The *line* represents the actual sternotomy used

tumors. For 20 patients in type I (17), type V (1), and type VI (2), tumors of which involved the vertebral body, vertebrectomy (resection of the vertebral body) [2, 17] was performed. For four patients in type II (1) and type III (3), tumors of which involved part of the body and part of the arch, sagittal resections (resection of part of the body and the posterior arch) [2, 17] were performed by double combined approach in the same operation. As a body or lesion replacement, different possibilities according to the pathology are described. In case of benign disease we use autogenous bone graft harvested from the dorsal iliac crest, and for malignant bone tumours using bone cement (Fig. 7a–d). To secure the strut, anterior cervical titanium alloy plates can be used until T5 (Fig. 7a–d). Closure is by irrigation, haemostasis and placement of a deep drain. The sternohyoid and sternothyroid muscles are resutured, if they were dissected. The wound closure of the subcutaneous tissue and skin is routine, the neck is closed in two layers, the platysma and skin. A chest tube is not needed until the pleura remains closed.

Radiotherapy and chemical therapy were given accordingly.

Results

Operative findings and postoperative assessment

The right space of the brachiocephalic trunk or the AA offers good exposure and working room from C7 to T5. The operation time is 90–180 min with an average of 116 min and the bleeding during operation is

Fig. 4 A anatomical view: *R-BCV* right brachiocephalic vein, *BCA* brachiocephalic artery, *VN* vagus nerve, *AA* ascending aorta, *SCV* superior caval vein

Fig. 5 **a** Anteroposterior view and **b** horizontal cut. After limited sternotomy, the right space of the brachiocephalic artery offers extensive exposure and working room to T4 (*R-BCV* right brachiocephalic vein, *L-BCV* left brachiocephalic vein, *BCA* brachiocephalic artery, *T* trachea, *E* esophagus)

300–2,000 ml with an average of 400 ml. Postoperative histological examinations showed that four patients underwent intracapsular excision, 14 marginal excision, 10 wide excision. The mean follow-up period was 28.4 months (range 3–60 months). The results were satisfactory with pain reduced (28/28) and the neurological function improved in different degrees (28/28) postoperatively. Sternal union was achieved in all cases.

Complications

Eleven cases of bradycardia and hypotension or increasing airway resistance occurred intraoperatively. Three patients had transient voice hoarse due to laryngeal nerve injury, and the symptoms disappeared 2 months postoperatively. There were no vascular injuries, no infections. Four patients died from general metastasis and failure 10–20 months postoperatively; they included one case of T2 osteosarcoma and three cases of T1–T4 metastatic cancers originated from breast, colorectum and unidentified origin respectively. Two patients with giant cell tumor recurred 10 months postoperatively.

Fig. 6 **a** Anteroposterior view and **b** horizontal cut. After limited sternotomy, the right space of the AA offers extensive exposure and working room to T5 (*AA* ascending aorta, *L-BCV* left brachiocephalic vein, *SCV* superior caval vein, *R-PB* right principal bronchi)

Discussion

With increasing frequency, spine surgeons are being asked to provide decompression and stabilization in patients with spinal tumors. A significant anterior destruction caused by tumors leads to the natural tendency toward kyphosis and anterior collapse with compression of the spinal cord [5]. Surgical treatment should attempt to achieve bony stability, preserve neurologic function and minimize patient morbidity.

While no region of the spine is easily treated, the upper thoracic spine is perhaps the least accessible. It is very difficult to excise such a tumor, because it is not easy to approach the upper vertebral body through a conventional approach such as the posterior or lateral route. The surrounding rib cage provides support, but also acts as an obstacle to plain radiography and surgical access. Different approaches are described in the literature [4, 7, 9, 11–14]. To have sufficient manual working room, the sternotomy approach first described in 1957 [12] is recommended because transpleural approaches to the upper thoracic spine inadequately expose the lower cervical spine; standard

Fig. 7 **a** Preoperative magnetic resonance image with spinal cord compression at level T3. **b** Anterior–posterior view of postoperative X-ray film. **c** Lateral view of postoperative X-ray film. **d** Postoperative sagittal computed tomographic scan reconstruction

approaches to the cervical spine may offer good exposure to T1, but the working room more distally is poor. Another advantage is that it does not interfere with shoulder function like the high anterior trans-thoracic approach by Hodgson et al. [8] or the modified anterior approach to the cervicothoracic junction described by Kurz et al. [10]. Disadvantages are that the operative wound is narrow and deep [1]. Louis [12] in 1985 described a modified approach to the cervicothoracic junction which offers good exposure and working room from C6 to T4. The traditional exposure is between the esophagus and trachea medially and the left common carotid or the BCA laterally, and the disadvantages were that the ligation and section of the left innominate vein is proposed to reach T4 and the injury of the thoracic duct could occur [4, 7, 9, 11–14, 16, 18]. We used a transmanubrium approach and the right space of the brachiocephalic trunk or the AA in 28 patients, no need to ligate and section the left innominate vein. Our previous study [19] showed that the anterior aspect of the upper vertebral body from C7 to T4 can be easily exposed through the right space

of the brachiocephalic trunk (between the R-BCV and the BCA), compared with traditional space. Our clinical experience showed that T3–T5 can be easily exposed through the right space of the AA (between the AA and SCV). On the other hand, because the thoracic duct empties into the systemic venous system from T1 to T2 on the left, we use the right approach in the cervical region, which avoids the injury of the thoracic duct. In short, this transmanubrium approach and the two spaces made it possible to decrease the morbidity and optimize visualization. The dangers to be avoided are esophagus injury, and pleura, and recurrent laryngeal nerve or vagus nerve, and vessel damage; blunt dissection and gentle retraction are recommended. Special attention is that bradycardia and hypotension and increasing airway resistance may occur due to stimulation of retraction; if these things happen, retraction must be removed until normal blood pressure and airway pressure recover.

Vertebrectomy and complete neurologic decompression was performed, because this approach and this new space allows a very good view. The

improvement in the neurologic score postoperatively confirms this good decompression.

Conclusion

The right space of the brachiocephalic trunk offers good exposure and working room from C7 to T4; the right space of the AA offers good exposure and working room from T3 to T5; two of them were less invasive than those previously described. We report no major complications, but this experience is limited and must be confirmed by further surgery.

References

1. Anderson PA (1999) Anterior approach to the cervicothoracic junction. In: Zdeblick TA (ed) Anterior approaches to the spine. Quality Medical Publishing, St Louis, pp 76–80
2. Boriani S, Biagini R, De Iure F, Bertoni F, Malaguti MC, Di Fiore M, Zanoni A (1996) En bloc resections of bone tumors of the thoracolumbar spine. A preliminary report on 29 patients. *Spine* 21(16):1927–1931
3. Daftari TP, Herkowitz HN (1999) Transsternal, transmanubrial, and transclavicular exposures. In: Zdeblick TA (ed). Anterior approaches to the spine. Quality Medical Publishing, St Louis, pp 87–103
4. Fang HSY, Ong GB, Hodgson AR (1964) Anterior spinal fusion, the operative approaches. *Clin Orthop* 35:16–33
5. Findlay GF (1984) Adverse effects of the management of malignant spinal cord compression. *J Neurol Neurosurg Psychiatry* 47:761–768
6. Frankel HL, Hankock DO, Hyslop G, Melzak J, Michaelis LS, Ungar GH, Vernon JD, Walsh JJ (1969) The value of postural reduction in the initial management of closed injuries of the spine with paraplegia and tetraplegia. *Paraplegia* 7:179–192
7. Geiger M, Roth PA, Wu JK (1995) The anterior cervical approach to the cervicothoracic junction. *Neurosurgery* 37:704–710
8. Hodgson AR, Stock FE, Fang HSY, Ong GB (1960) Anterior spinal fusion: the operative approach and pathological findings in 412 patients with Pott's disease of the spine. *Br J Surg* 48:172–178
9. Kirkaldy-Willis WH, Thomas G (1965) Anterior approaches in the diagnosis and treatment of infections of the vertebral bodies. *J Bone Joint Surg Am* 47:87–92
10. Kurz LT, Fischgrund JS, Pursel SE, Herkowitz HN (1997) The modified anterior approach to the cervicothoracic junction. In: Bridwell KH, Dewald RL (eds) The textbook of spinal surgery. Lippincott-Raven, Philadelphia, pp 237–241
11. Lesoin F, Thomas CE III, Autricque A, Villette L, Jomin M (1983) A transsternal biclavicular approach to the upper anterior thoracic spine. *Surg Neurol* 26:253–256
12. Louis R (ed) (1985) *Die Chirurgie der Wirbelsäule*. Springer, Berlin Heidelberg New York, pp 188–195
13. Micheli LJ, Hood RW (1983) Anterior exposure of the cervicothoracic spine using a combined cervical and thoracic approach. *J Bone Joint Surg Am* 65:992–997
14. Nazarro JM, Arbit E, Burt M (1994) 'Trap-door' exposure of the cervicothoracic junction. *J Neurosurg* 80:338–341
15. Robinson RA, Smith GW (1953) Anterolateral disc removal and interbody fusion for cervical disc syndrome. *Johns Hopkins Hosp Bull* 96:223–224
16. Sundaresan N, Shah J, Foley KM, Rosen G (1984) An anterior surgical approach to the upper thoracic vertebrae. *J Neurosurg* 61:686–690
17. Tomita K, Kawahara N, Baba H, Tsuchiya H, Fujita T, Toribatake Y (1997) Total en bloc spondylectomy. A new surgical technique for primary malignant vertebral tumors. *Spine* 22:324–333
18. Turner PL, Webb JK (1987) A surgical approach to the upper thoracic spine. *J Bone Joint Surg Br* 69:542–547
19. Xiao Z-M, Gong D-F, Zhan X-L, Xu F-T (2006) Anatomic basis of the upper thoracic vertebrae and its clinical significance. *Chin J Orthop* 26:183–186