Original Article

Modified Transclavicular-Transmanubrial Approach to Cervicothoracic Spine: Revisiting and Renovating the Path – Lessons Learned

TS Vasan, Raghavendra M Rao

Department of Neurosurgery, JSS Medical College and Hospital, Mysuru, Karnataka, India

Abstract

Introduction: A thorough knowledge of the vital structures adds to the safety in approaching the cervicothoracic spine junction. The best described method to reach the spine is via viscero-neurovascular space. We present our experience of 10 cases operated at our institute using the modified transclavicular transmanubrial approach to the cervicothoracic spine pathology.As we gained experience we have used various corridors to the operating field and used a new space to approach the lower cervicothoracic junction spine. **Methods:** Between February 2011 to August 2015, 10 patients with disease in upper thoracic vertebral body were admitted and evaluated clinically and radiologically. Neurological status in all cases was graded according to Frankel grading system.Patients were followed up with Histopathological reports and treated accordingly. **Results:** All patients(except metastasis) improved by 1 or 2 grade in post op period. Metastasis patients remained in same grade. **Conclusion:** Anterior approach with its modifications are the better suited biomechanically for exploring the pathology of cervicothoracic spine,its decompression and stabilization. Also it preserves the stability of shoulder girdle with good neurological and cosmetic outcome.

Keywords: *Cervicothoracic spine, transclavicular-transmanubrial approach, tuberculosis spine*

Introduction

Anterior approach to the cervicothoracic junction for corpectomy and instrumentation in spinal surgery has a long tradition and is challenging since decades. Many critical structures hinder the exposure including major vascular, neural, bony, and articular structures in the operative field. A sound knowledge of these vital structures adds to the safety in approaching the cervicothoracic spine junction.[1] The area extending from C7–D4 is considered as the cervicothoracic junction. The best-described method to reach the spine is via viscero-neurovascular space. There are many approaches such as low anterior suprasternal approach, transmanubrial approach, transclavicular-transmanubrial approach, median sternotomy approach, and various other high thoracic anterolateral approaches, posterior and posterolateral approaches. We present our experience of 10 cases operated between 2011 and 2015 at our institute using the modified transclavicular-transmanubrial approach to the cervicothoracic spine pathology. The median follow-up in our series was 14 months. We observed good cosmetic outcome, shoulder stability, and neurological outcome in benign cases with this osseo-musculo-articular preserving surgery. As we gained experience, we have used various corridors to the operating field and used a new space to approach the lower cervicothoracic junction spine.

Materials and Methods

Between February 2011 and August 2015, ten patients with disease in the upper thoracic vertebral body were admitted and evaluated. All these patients underwent diagnostic workup including clinical examination, anteroposterior and lateral radiographs of the cervicothoracic spine, computed tomography scan with three-dimensional reconstruction, and magnetic resonance imaging (MRI) of the cervicothoracic

Address for correspondence:
Dr. TS Vasan,
Department of Neurosurgery,
JSS Medical College and
Hospital, Mysuru - 570 008,
Karnataka, India.
E-mail: coltsvasan@yahoo.co.in

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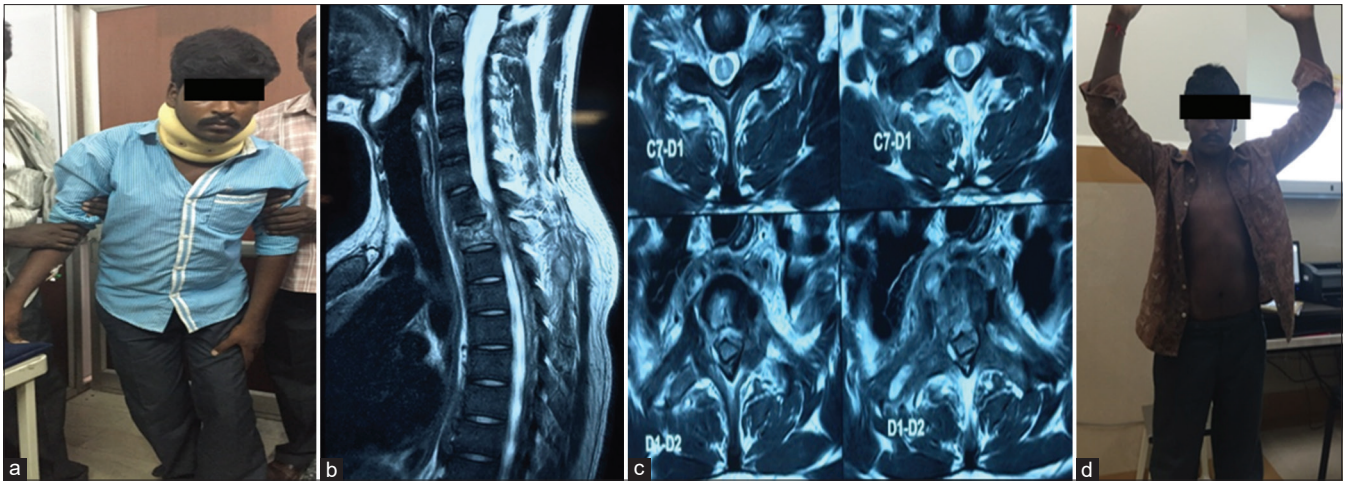

Figure 1: Illustrative case images. (a) Preoperative clinical photo showing need for support to stand. (b) Sagittal T2-weighted image magnetic resonance imaging showing pathological D2 vertebral body with extension to prethecal space and cord compression. (c) Axial T2-weighted image magnetic resonance imaging showing involvement of vertebral body and causing canal stenosis. (d) Postoperative day 7 – clinical photo showing patient standing without support

spine. Diagnosis was confirmed by postoperative histopathological examination [Figure 1]. Neurological status in all cases was graded according to the Frankel grading system [Appendix 1] in the preoperative, postoperative period and during the last visit. The patients were followed up with histopathological reports and were treated accordingly [Figure 1a].

Illustrative case

A 27-year-old man presented with a 2-month history of generalized weakness, upper back pain, night sweats, and loss of appetite [Figure 1b,c]. Over the next month, he noticed weakness of both lower limbs, with progressive weight loss, and could ambulate only with the support of two people. On examination, the patient was febrile with tenderness in the upper dorsal spine region, with Frankel Grade C power in bilateral lower limbs with exaggerated lower limb reflexes, and absent abdominal reflexes. Routine blood and radiological investigations including contrast MRI were done. It showed diseased and collapsed D2 vertebrae with extension of abscess to paravertebral space and prethecal space causing spinal cord compression. He was started on antitubercular treatment [Figure d]. The patient underwent D2 corpectomy with adjacent discectomy and spinal cord decompression with tricortical iliac bone grafting and anterior plate fixation via a modified transclavicular-transmanubrial approach [Figure 2a-l]. The patient had improvement in power of lower limbs on postoperative day 1. On postoperative day 7, the patient was ambulant independently without support (Frankel grade E) and with satisfactory shoulder stability during right shoulder abduction movements. Histopathological examination showed features suggestive of tuberculous pathology. Antitubercular treatment was continued for the next 18 months.

Operative step

All patients were operated under general endotracheal anesthesia in supine position. The head was supported on head ring with the neck in extended position with a wedge under the interscapular region. We preferred to operate all the patients from the right side as it is convenient for a right-handed surgeon although there is a possibility of injury to the right recurrent laryngeal nerve[2,3] but without the risk of injury to the thoracic duct. A horizontal "T-" shaped incision about 3 cm above the manubrium extending from palpable margin of the sternocleidomastoid muscle of either side is made with a vertical incision in the midline starting at horizontal line extending below to reach 3 cm just below sternal angle. The platysma was then incised and retracted with the skin flap. The external jugular vein was identified on the right side and was cut under bipolar cauterization. The deep cervical fascia was divided, and the strap muscles with the sternoclavicular muscles were left attached to the clavicle and manubrium. Subperiosteal dissection of the manubrium sternum, medial third of the right clavicle, and first right costochondral junction was done. Right two-third manubriotomy was performed with limited sternotomy (up to 2 cm below sternal angle) in some cases, followed by middle one-third claviculectomy preserving the attachment of sternocleidomastoid attachment to the clavicle and manubrium. This osseo-musculo-articular complex of the manubrium with medial third clavicle and its joint with preserved sternocleidomastoid muscle is freed from underlying vital structures by digital dissection and retracted superolaterally. Meticulous dissection was done along the areolar plane retracting visceral compartment of the trachea and esophagus medially and neurovascular compartment of the carotid artery and internal jugular vein with vagus nerve laterally. The dissection is continued lower down to delineate the right brachiocephalic artery, its branches, and internal jugular vein to superior vena cava formation. The

Figure 2: Serial images of operative steps. (a) T-shaped surgical incision. (b) Skin flap retracted with platysma and subcutaneous tissue. (c) Exposure of medial third of clavicle and manubrium. (d) Manubriotomy with attached sternocleidomastoid muscle. (e) Right brachiocephalic artery and trachea-oesophagus with tracheoesophageal groove. (f) Left brachiocephalic vein coursing from left to right with subjacent lower medial window. (g) Needle localization of operative field. (h) Corpectomy defect with decompressed spinal cord. (i) Tricortical iliac graft placed in the operative defect area. (j) Overlay plating with screws. (k) Manubrium sutured with steel wire and clavicular plating with preserved sternoclavicular joint. (l) Postoperative X-ray showing metal plate *in situ*

inferior thyroid artery and vein can be ligated if required. The left brachiocephalic vein is seen running from the left to right side along the inferior operative field which is dissected up to its confluence with superior vena cava. Care is taken to avoid injury to the right recurrent laryngeal nerve which arises from the vagus nerve and ascends to course along the inferior thyroid artery and vein. Although ligation of left brachiocephalic vein is described, except for initial 2 cases, we preferred to avoid it by retraction or by utilizing the aorto-superior vena cava window. On deeper dissection with gentle retraction along this corridor, we were able to visualize the prevertebral fascia blending with the endothoracic fascia at D3 vertebral body level. Anteroposterior view X-ray was taken with needle in place to confirm the pathological vertebral body with adjacent disc level. The anterior longitudinal ligament is delineated and incised in the midline. In cases of tubercular abscess, the abscess was drained. In cases of diseased vertebrae,

corpectomy was done along with adjacent discectomy using a high-speed drill. This drilling is continued up to the posterior longitudinal ligament to decompress the spinal cord. In all the cases, tricortical bone graft harvested from the right iliac crest was used as a bony strut graft. The anterior cervical plate was then fixed over the upper and lower vertebral bodies spanning the strut graft with longer screws than in cervical plating. In two cases, there was a need to tap the screws in D4 vertebral body when we used a potential space by retracting the left brachiocephalic vein superiorly and the arch of the aorta inferiorly in the midline which gave direct access to D3 and D4 vertebral bodies. Hemostasis was achieved, and a suction drain was placed in the operative cavity [Table 1]. In two cases, intercostal tube drainage was placed as there was a breach in pleura with hemothorax. Manubrium was sutured using 22G titanium wires or mini plates, and the clavicle was approximated with plates and screws. The wound was closed in layers.

Results

In our series, a total of 10 patients underwent a modified transclavicular-transmanubrial approach for upper thoracic spinal pathology. They were in the age group of 22–60 years, of which 3 were females. Majority of the patients had pathology at the level of D2 vertebral body (n = 8) and D3 level (n = 2) and two patients had two-level pathology. On histopathological examination, 6 patients had tuberculosis, 2 patients had metastasis, 1 with plasmacytoma, and one with vertebral body hemangioma. Intraoperatively, 1 patient had bradycardia and 2 patients had increased airway resistance, but no patient had hypotension. All patients (except metastasis) improved by 1 or 2 grade in postoperative period. Metastasis patients remained in the same grade. Five patients developed hoarseness of voice which improved over 3 months by conservative management. Following breach in right-sided pleura, intercostal drainage (ICD) was inserted in two patients. The average hospital stay was 9 days and average blood loss was 700 ml. The median follow-up in our series was 14 months. Sternal wound dehiscence was seen in 1 patient which healed in 2 weeks with regular dressings. No patient had hardware-related failures. All patients had good right shoulder abduction movements, neurological improvement, and cosmetic outcome at 6-week follow-up.

Discussion

It is by now generally accepted that various structures including parenchymatous, vascular, neural, bony, lymphatic, and visceral structures hinder the anterior approach to the cervicothoracic spine which extends from C7 to D4. Added to this difficulty is the lordotic cervical spine becoming kyphotic thoracic spine. The variety of pathologies involving this area further increase the kyphotic deformity with compression of the spinal cord.[4] We acknowledge the fact that there are considerable discussions as to choose a modified approach to safeguard critical structures and preserve the stability of shoulder girdle in contrast to high anterior transthoracic approach by Hodgson and Stock.[5] Cervicothoracic spine area can be approached via posterior, posterolateral, anterolateral, and anterior approaches.[6] Posterior and posterolateral approaches do not adequately address the anterior column pathologies and are limited by the thick scapular muscles, crowded ribs, deep narrow space, superior mediastinal vessels, and need for retraction of the spinal cord. Anterolateral approaches add to the morbidity and need assistance by a thoracic surgeon. We would like to emphasize that anterior approaches are more feasible, safer, and address the pathology adequately along with reduced operation time, transfusion requirements, early ambulation, without injury to posterior spinous ligament, spinal cord, and segmental nerve roots.[7] The anterior approaches include a low anterior cervical suprasternal approach with additional variants to widen the corridor which includes medial third clavicle resection,[8] manubriotomy, limited upper sternotomy, median sternotomy, and manubriotomy with biclavicular resection.

Le *et al*. demonstrated a transsternal full median sternotomy surgical approach for ventral decompression and fusion of C7–D2,[9] which was further substantiated by a study done by Zengming *et al*.[10] In our patients, we performed a modified transclavicular-transmanubrial approach with preservation of the right sternoclavicular joint and refixing the clavicle. The sternoclavicular joint maintains the stability of the right upper limb by transmitting the upper limb weight onto the axial skeleton. In initial two cases, the left brachiocephalic vein was sacrificed to make space for operative field, but later, this was found unnecessary with experience.

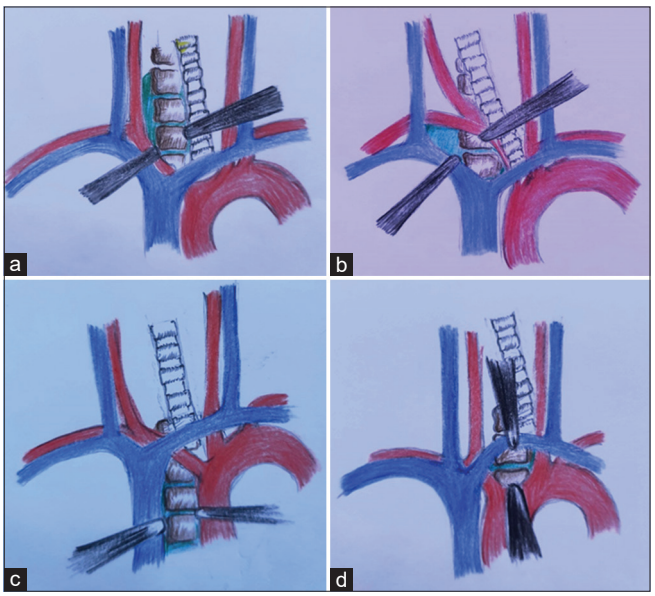

Figure 3: Various corridors to approach the cervicothoracic spine (Pictorial images). (a) Upper medial window (b) Upper lateral window. (c) Lower lateral window. (d) Lower medial window

Table 1: Patient demographic data

Case	Age/ gender	Vertebral body level	Spinal fusion level	Diagnosis	Frankel grade		Complications
					Preoperative	Postoperative	
1	27/male	D2	D1-D3	Tuberculosis	C	E	Nil
2	42/male	D3	D2-D4	Tuberculosis	C	D	Hoarseness of voice
3	27/male	D2+D3	D1-D4	Plasmacytoma	D	E	Hoarseness of voice, hemothorax
4	52/male	D2	D1-D3	Tuberculosis	C	D	Nil
5	39/male	D3	D2-D4	Tuberculosis	C	D	Hoarseness of voice, hemothorax
6	60/male	D2	D1-D3	Metastasis	C	C	Sternal wound dehiscence
7	25/female	D2	D1-D3	Vertebral body hemangioma	C	E	Nil
8	44/male	D1+D2	C7-D3	Tuberculosis	B	C	Hoarseness of voice, bradycardia
9	54/male	D2	D1-D3	Metastasis	C	C	Nil
10	22/female	D2	D1-D3	Tuberculosis	C	D	Hoarseness of voice

With experience, we found that the right brachiocephalic artery and left brachiocephalic vein are the two major structures to be meticulously dissected to perform this approach safely. Once these two structures are dissected, the cervicothoracic spine approaches would become straight forward. In relation to these structures and their crossing over, 4 corridors can be described [Figure 3a-d]: upper medial and upper lateral window on either side of the right brachiocephalic artery above the left brachiocephalic vein. There are two potential spaces below the left brachiocephalic vein on either side of the origin of the right brachiocephalic artery which can be called lower medial and lower lateral window. The lower lateral window is aorto-venacavo-subinnominate space, as described by Cohen, which provides access to D5 and D6 vertebra.[11] We tried to cast light on the lower medial space, which is a potential space seen on retraction of the left brachiocephalic vein superiorly and aortic arch inferiorly in the midline. This space is bordered by the left common carotid artery origin laterally and right brachiocephalic artery origin medially. In two of our cases, this potential space was used to place D3, D4, and upper D5 screws with ease and with minimal retraction of major vessels.

In tubercular abscess cases, the abscess is drained and phlegmon curated with adjacent discectomies. In benign cases, the bone defect is filled with autogenous tricortical bone graft harvested from the right iliac crest. The anterior plate is bent to fit the thoracic kyphosis and is placed over the graft, drilled, and tapped with screws. We found that it is feasible to fix inferior plate screws to D3 and D4 vertebral bodies via the lower medial window. The screws used in the thoracic vertebrae need to be longer than the one used in the cervical vertebrae. It is experimentally proven that instrumentation in tubercular cases is not a contraindication, and all of our cases with tuberculosis have shown postoperative improvement. There were no instrument-related complications such as screw breakage and graft displacement.

Although this procedure is safe, it is not devoid of complications. In literature, complications in relation to vascular injury, recurrent laryngeal nerve palsy, thoracic duct injury, tracheal edema, dysphagia, esophageal injury, Horner's syndrome, dura and spinal cord injury, CSF leak, pseudomeningocoele, sternal wound dehiscence, and nonunion of manubrium have been reported.[12] In our series, we encountered 5 cases with hoarseness of voice which improved at 3 months; 1 patient had bradycardia and 3 had airway resistance intraoperatively which was corrected by release of retraction. In 2 patients, the left brachiocephalic vein was sacrificed with no significant complications.

Conclusions

Anterior approach by a modified transclavicular-transmanubrial approach with preservation of the sternoclavicular joint is better suited biomechanically for exploring the pathology of the cervicothoracic spine and its decompression and stabilization. We emphasize that a sound knowledge of anatomy and meticulous dissection of the right brachiocephalic artery and left brachiocephalic vein and its various possible retractions to explore the potential spaces, gentle retraction of the structures, controlled use of drill, maintaining the continuity of clavicle and sternoclavicular joint integrity, and instrument handling in deep space are the keys to make this procedure safer and for a better neurological outcome with good upper limb stability.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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Appendix 1: Frankel Classification Grading System

Frankel grade	Descriptions
A	Complete motor and sensory loss
B	Complete motor and incomplete sensory loss
C	Incomplete motor loss with useless or non-functional strength
D	Incomplete motor loss with useful or functional strength
E	No motor of sensory abnormalities