THE USE OF MANUBRIOTOMY IN THE TREATMENT OF COMPLICATED INJURY OF THE CERVICOTHORACIC SPINE: CLINICAL CASE REPORT AND LITERATURE REVIEW

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The paper presents a clinical case report and non-systematic review of the literature on the problem of the manubriotomy use in the treatment of complicated injury of the cervicothoracic spine. Approach to surgical treatment of complicated compression-comminuted fracture-dislocation of the cervicothoracic spine was based on preoperative calculation of angulometric characteristics of the injury and individual characteristics of the patient's anatomy, including the Teng criterion. A partial resection of the manubrium of sternum in the area of the jugular notch was performed to ensure safe and stable placement of the cervical fixation plate. Complete restoration of the axis and stability of the spine, and regression of neurological deficit were achieved. The preoperative determination of the Teng criterion in planning cervicothoracic intervention allows, taking into account the anatomical features of the patients, to assess a zone of optimal visualization, as well as to plan caudal expansion of the approach, including by limited U-shaped manubriotomy.

Key Words: manubriotomy, cervicothoracic spine, spinal injury, anterior spinal fusion.

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The term "cervicothoracic spine", denoting the junction area between the mobile cervical spine and more rigid thoracic spine, is confused in the literature and is evaluated by different authors as including C7–T1, C6–T2 or C6–T3 vertebral segments [1, 2]. Fractures at the C6–T3 level account for about 3.5 % of all spinal cord injuries [1, 3]. Meanwhile, a neurological deficit follows in 60–83 % of cases [4, 5]. Foremost, this is due to the relatively narrow spinal canal, the thickening of the cervical spinal cord, and the small reserve spaces in this region.

An anterior approach is optimal for nerve decompression and stabilization of the surgically treated segment in the cervical spine. Due to certain anatomical features, however, an anterior approach to the cervicothoracic spine is a challenging task because of location of the manubrium sterni and significant anatomical structures of the superior mediastinum limiting the procedure, such as the thymus gland, the left and right brachiocephalic veins, the right brachiocephalic artery, the left common carotid artery, the aortic arch, the esophagus, the trachea, and the thoracic duct. Therefore, preoperative preparation requires the surgeon to plan the procedure carefully, have knowledge of anatomy and have adequate experience. Sometimes an anterior approach to the cervical spine can be supplemented with a manubriotomy to decompress nervous structures and stabilize the spine [2]. The uncommon nature of such a case, including the possibility of its planned implementation, enables us to present our own case study.

Patient A., male, 65 years old, was admitted to the Spine Surgery Center of the City Clinical Hospital No. 67 named after LA. Vorokhobov (Moscow), with complaints of pain in the cervical spine, radiating to the shoulders and forearms along the back surface, intensifying with any movement, arm weakness (unable to raise his arms above chest level on his own) and in the hands.

From the anamnesis, it turned out that 10 days ago, the patient fell from a ladder about 2.5 meters at home. When falling, the blow fell on the cervical and thoracic spine. The patient got up on his own, but felt a sharp pain in the neck area, radiating to his hands. A neighbor (a physician) immobilized the neck with available tools. However, the patient's self-referral to the emergency room at the place of residence was in 9 days. Despite the peculiar position of the neck, radiography revealed no data on vertebral injury of the cervical spine (in light of the data in Fig. 1, this should be considered a missed pathology). Due to the persistence of complaints on the 10th day after the injury, the patient called an ambulance team and was admitted to our hospital.

Examination upon admission to the hospital. The cervical spine was immobilized by the Philadelphia neck collar. The patient experienced a sharp pain during palpation in the projection of the C4, C5 and C6 spinous processes. During the neurological examination, the upper paraparesis is up to 4 points, with hyp-

esthesia for the C7 and C8 dermatomes on both sides. CT findings: compression fracture of the C7 vertebral body (type B2 according to the AO Spine Subaxial Classification System) with a decrease in the height of the anterior parts of the body by 1/2 and dorsal dislocation of bone fragments up to 5 mm with the formation of pathological kyphosis at this level (C6–C7); bilateral fracture of the C6 vertebral arch; fracture of the C6 lower articular process on the right; and fracture of the spinous processes of the C5, C6 vertebrae (Fig. 2).

During the examination, attention was drawn to the high location of the clavicle heads and the hypertrophy of the capsule and ligamentous apparatus of the sternoclavicular joints. There was no clinical data (soreness or hematomas) confirming damage to this area. According to CT scans, the filling of the area above the jugular notch of sternum with dense tissues was visualized, which corresponded to the individual anatomical features of the patient and, in turn, could complicate approach to the injured area (Fig. 3a, b).

It was not no doubt that the patient required surgical treatment. Nevertheless, considering the revealed anatomical features, preoperative planning was performed using the Teng criterion [6], identifying the area of the spine that was accessible depending on the level of the upper edge of the sternum. The angle and, accordingly, the Teng criterion were formed as follows: according to the sagittal scan of CT or MRI at the level of the jugular notch of manubrium sterni, a horizontal line was drawn to the anterior part of the vertebral column (Fig. 4, line SA); the second line was drawn from the same starting point to the middle of the anterior border of the C7–T1 intervertebral disc (Fig. 4, line SM). Comparing the features of the obtained angle with the lower zone of the intended procedure (the lowest edge of the healthy vertebra adjacent to the pathology or the mounting area of the spinal fixation system), there are three variants (types) that determine the likelihood of spinal procedures with or without the need for caudal expansion of the surgical approach:

– type A (the angle is located below the procedure area) suggests the possibility of surgical treatment without additional procedures on the sternum;

– type B (the angle is located at the level of the proposed surgery or the lower edge of the healthy involved vertebra is situated at the level of the Teng angle) presupposes the likelihood of resection of the sternum and the willingness of the surgical team for this procedure, including the availability of the necessary tools;

– type C (the angle is located above the boundaries of the abnormal focus) clearly suggests the need for resection of the manubrium sterni.

In our study, the Teng criterion corresponded to type B, which characterized a high probability for manubriotomy to provide approach to the spine (Fig. 4).

Surgery. We used a standard anterior cervical approach along the inner edge of the left sternocleidomastoid muscle. Noteworthy is the location of the sternoclavicular joint, which has already been marked at the stage of preoperative CT: the heads of the clavicle are significantly higher than the upper edge of the sternum. An approach was made to the anterior surface of the C6–C7–T1 vertebral bodies; after reaching the anterior surface of the vertebral bodies, a hematoma was found under the anterior longitudinal ligament at the level of the C7 body. The anterior longitudinal ligament was opened, and the bodies of the C6–C7–T1 vertebrae were skeletonized. The body of C7 was destroyed and disable to support. A discectomy of the C6–C7 and C7–T1 vertebrae and a corporectomy of the C7 vertebra were performed. Therefore, decompression of the spinal canal was done. An ADD telescopic implant was inserted in the C6–T1 interbody space, and its distraction and fixation of the locking screw were performed. During the preventive positioning of the plate for bone fixation on the C6–T1 segments, as expected considering the preoperative calculation, the insertion of caudal screws proved impossible. Thus, it was decided to perform a manubriotomy (Fig. 4). The skin incision was extended downward. The manubrium sterni and the clavicle heads were partially skeletonized. The resection of the manubrium sterni in a 3 × 3 cm area with the preservation of the sternoclavicular joints was performed using an ultrasonic bone scalpel. This maneuver provided an opportunity to mobilize the soft tissues of the superior mediastinum that prevented the screws from passing into the T1 body and successfully fulfil the final fixation of the plate (Fig. 5). The locking screw screwdriver guide is placed directly in the area of resection of the manubrium sterni.

Fig. 1
Radiography of the cervical spine of patient A., male, 65 years old: fracture of the spinous process of C6 vertebra with expansion of the interspinous space C5–C6

Considering the preservation of the anatomical position of the articular processes on the left throughout the injury area as well as the satisfactory axis of the cervical spine, according to the surgical CT findings, it was decided to refrain from additional posterior fixation. In the postoperative period, the patient noted a significant regression of the pain syndrome and an increase in strength in the limbs.

Within two months after the surgery (Fig. 6), full-fledged stability of the C6–T1 anterior fixation was observed without cervical spine deformities, despite the persisting visible fracture line of the C6 arch and the absence of complaints of pain syndrome.

Discussion

There are various types of cervical spine angulometry used both to evaluate its sagittal balance and to define surgical approaches [4, 7, 8]. Meanwhile, the Teng criterion is viewed as simple enough for practical determination of the most caudally achievable vertebra. Accordingly, without setting the task of a comparative study of such techniques, we wanted to prove the possibility of a minimally traumatic maneuver to expand the area of caudal fixation of the plate in a specific case. Nonetheless, the discussion of such maneuvers seems quite interesting.

An anterior approach to the cervical spine, the lower border of which is limited by the cutting of the manubrium sterni, is well known. In most cases, it is adequate to perform decompressn and stabilization surgeries to sufficiently isolate the anterior surfaces of the C7–T2 vertebral bodies [9]. Due to the anatomical position of the neurovascular trunks, soft tissue structures, and organs of the superior mediastinum, the optimal view of the spine may be impeded. In these cases, to ensure the safety of procedures and improve the surgical view, the use of the lower anterior cervical approach can be supplemented with procedures on the sternum and clavicles, for example: sternotomy, unilateral or bilateral manubriotomy, or clavicular excision [10–13].

The techniques for visualization extension for procedures in the lower cervical and upper thoracic vertebrae

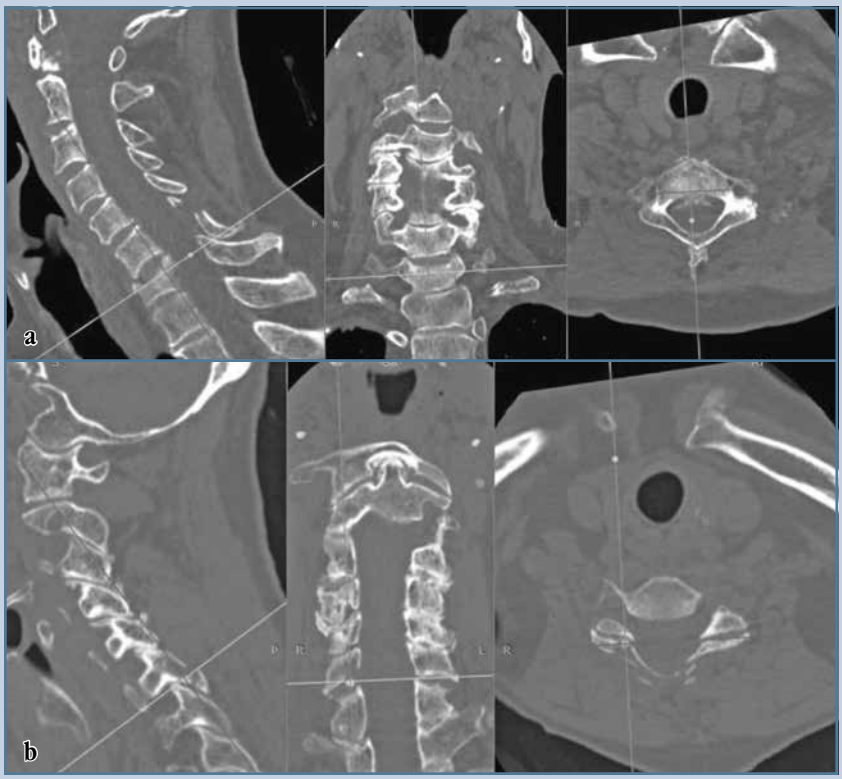

Fig. 2
CT reconstruction at the level of C7 **(a)** and C6 **(b)** vertebrae of patient A., male, 65 years old: fracture of the C7 body with prolapse of the posterior part of the body into the spinal canal **(a)**, fracture of the C6 articular process on the right **(b)**

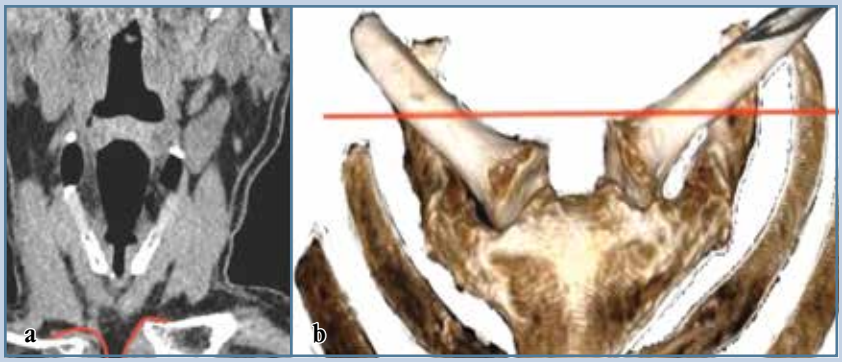

Fig. 3
Coronal CT scan **(a)** and 3D CT reconstruction of the sternoclavicular joints **(b)** of patient A., male, 65 years old: the heads of both clavicles are visualized above the level of the sternum by 16 mm on the right and 18 mm on the left

Fig. 4
Teng criterion: type B

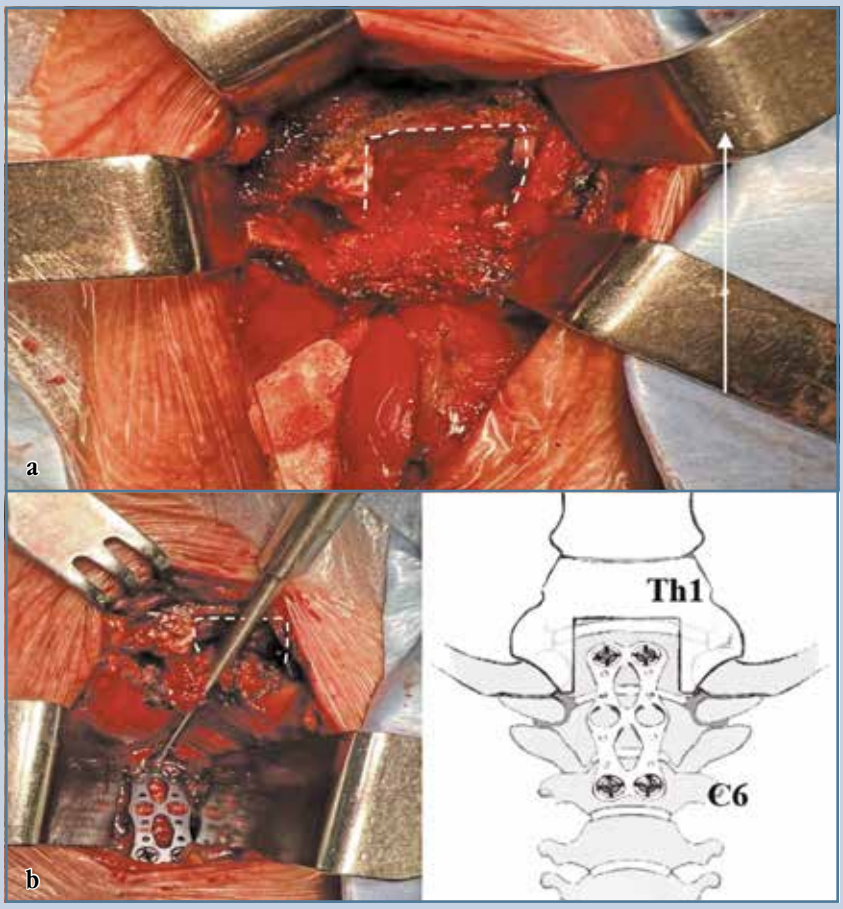

Fig. 5
U-shaped resection of the manubrium sterni, the osteotomy line is indicated by a dotted line **(a)**, intraoperative image and scheme of the final bone fixation C6–T1 **(b)**

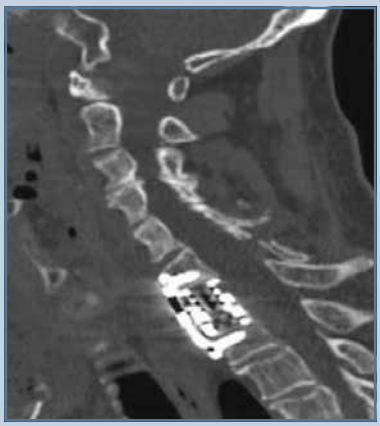

Fig. 6
Postoperative control 2 months after surgery

have been purposefully developed for patients with the so-called "short neck." A median sternotomy was one of the first to be proposed, which, however, appeared to be quite traumatic and associated with the risk of damage to the structures of the superior mediastinum. The authors who applied this technique to 10 patients reported a 40 % mortality rate [14], which subsequently forced them to introduce more detailed limitations on the possibility of performing surgeries using this technique [15].

Another approach was proposed by Sundaresan et al. [16, 17], who performed osteotomy and excised parts of the manubrium sterni and the medial end of the clavicle with a good outcome in 7 patients. According to Charles [18], who evaluated this technique on ten patients, this technique is less stressful and allows a good view of the spine right down to the T3 level. Kurtz et al. [10] modified it by proposing to make the transverse part of the incision only on the approach side. In their opinion, osteotomy of the manubrium is not always justified, and resection of the clavicle should be more adequate.

If an anterior spinal fusion is necessary on the cervicothoracic spine, a surgeon may face a situation where there is lack of space for fixing the caudal screws. Leiblein et al. [19] described the technique of the transmanubrial approach for spinal fusion in a fracture of the C7 vertebra (type B3 according to AO) by forming a small foramen on the manubrium sterni. According to the authors, this technique minimizes the traumatization of a patient, allows to effectively fix the screws, and does not require a more aggressive amount of procedure.

Due to the anatomical features of the patient considered in our study, the anterior cervical approach has provided adequate skeletonization of the anterior surfaces of the C6, C7 and T1 vertebrae. However, the complete mounting of the fixing plate failed, which required a partial manubriotomy. In such circumstances, the approach to the most caudal visible vertebra must be planned by thoroughly studying its linear and angular properties [6]. According to Xu et al. [20], it is difficult to approach the T1 vertebra because of the sternum in the majority of patients. Preoperative planning using the Teng criterion in such a case seems to be the simplest. In our case, this allowed us to avoid unexpected events during the surgery, including abandoning excessive manubriotomy. Standard cervical approach proved adequate for resection of the dislocated C7 body, ensuring mobility of the C6–T1 region, correction of posttraumatic spinal deformity, and replacement of the interbody defect with an ADD telescopic implant. Therefore, for the use of a bisegmental bone plate with

free fixation of the upper base on C6 to insert the screws of the lower base into the T1 body, the angle of instrumental attack was insufficient, which required a limited U-shaped manubriotomy.

Separately, we focus on a widespread mistake made during the radiographic examination of a patient at the initial admission to the hospital. Radiography has low sensitivity in the diagnosis of pathology of the junctional cervicothoracic spine. Therefore, CT or MRI are advisable diagnostic techniques for pathology of this localization [1, 21, 22].

Conclusion

An adequate imaging study and thorough preoperative planning are of particular importance for injuries of the cervicothoracic spine, which are associated with the individual particularities of angulometric indicators in this area. The assessment of the Teng criterion at the stage of surgery planning seems to be quite simple and enlightening to tackle the issue of expanding the surgical approach. Limited manubritomy fully provided repositioning and stabilizing capabilities of the planned surgery, which can be advantageous in the treatment of patients requiring cervicothoracic spine restoration.

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The authors declare that they have no conflict of interest.
The study was approved by the local ethical committee of the institution.
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