The Role of Multi-detector CT Angiography in Surgical Planning for Congenital Cervicothoracic Kyphoscoliosis: A Case Report

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Surgical correction of a cervicothoracic deformity is difficult with a potential risk of vascular injury. Comprehensive preoperative vascular evaluation is important for safe and successful surgery. The use of multi-detector computed tomography angiography (MDCTA) allows a combined display of vascular and osseous structures of the musculoskeletal system. However, no clinical reports have described the use of MDCTA for surgical planning of anterior cervicothoracic surgery in patients with vascular malformation. The case of a 7-year-old girl with congenital cervicothoracic kyphoscoliosis who underwent preoperative MDCTA evaluation and successful correction is presented in this report.

Index words: Spine
Kyphosis
Computed tomography (CT)
X-Ray
Angiography
Spinal Fusion
Child
Musculoskeletal

Congenital cervicothoracic kyphoscoliosis is usually progressive and the disorder is not affected by conservative treatment. Progression of this deformity may lead to paraplegia and cardiopulmonary dysfunction (1). A combined anterior-posterior approach is required to correct severe kyphoscoliosis (2). However, surgery is technically challenging as congenital kyphoscoliotic deformities are mostly accompanied by vascular abnormalities. Intraoperative complications of the anterior cervical decompression mainly include neurovascular injuries involving the nerve root, the spinal cord, and the vertebral artery (3, 4). Especially in pediatric patients, the safety of cervical pedicle screw fixation has not yet been established.

Computed tomography angiography (CTA) has been frequently used to evaluate the vascular anatomy (5). One major advantage of the use of CTA in comparison to conventional angiography is the ability to obtain multiplanar reconstructed images (6). Multidetector CTA (MDCTA) provides higher resolution, three-dimensional vascular imaging as well as excellent bone and soft tissue spatial relationships with short breath-hold duration (7, 8). We present the role of MDCTA in surgical planning for congenital cervicothoracic kyphoscoliosis.
A 7-year-old Turkish girl with congenital cervicothoracic kyphoscoliosis was admitted to our hospital for surgical treatment. The patient complained of neck pain and frequent respiratory difficulty and could not lie on her back during sleep because of a posterior neck 'hump'. A plain radiograph showed severe kyphoscoliosis at the cervicothoracic junction (Fig. 1). T2WI MR and an MR myelogram showed a focal myelopathy with spinal cord compression at the gibbus deformity level (Fig. 2). A CT examination was performed using a 16-detector-row CT scanner (Brilliance Philips Medical Systems, Cleveland, OH USA). To evaluate the variability of the vertebral artery, CTA was performed from the aortic arch to the vertex with 0.5 s gantry rotation speed, 0.75 mm collimator width, 22.5 mm/s table feed/rotation, pitch 0.938, and a reconstruction increment of 0.5 mm. An 18-gauge IV cannula was inserted in the right femoral vein. A high iodine concentration contrast agent, Ultravist (70 mg of iodine/mL; Schering AG, Berlin, Germany) (30 mL) was injected at the rate of 4mL/s. To optimize the enhancement of the arterial vessel and to avoid venous superimpositions, we used a test-bolus approach. The standard scan start delay (10 seconds) was calculated from the peak maximum enhancement at the level of the aortic arch. Arterial-phase images were obtained with caudocranial data acquisition. Following the application of the volume-rendering (VR) algorithm, the staff physicians performed image analysis in real-time.

An abnormal course of the vertebral artery was confirmed by MDCTA. The left vertebral artery ascended towards the C4 defective transverse foramen, while the right vertebral artery ascended towards the C6 defective vertebra.

**Fig. 1.** Preoperative plain anteroposterior (A) and lateral radiographs (B) demonstrate left-side scoliosis and severe kyphosis at the cervicothoracic junction.

**Fig. 2.** A. Sagittal T2WI MR shows that the spinal cord is markedly stretched and angled at the apex of the deformity. B. An axial T2WI MR shows spinal cord compression and a suspicious myelopathy at the gibbus deformity level. C. An MR myelogram shows nearly complete block of thecal sac at the level of dysgenesis.
transverse foramen (Fig. 3). The reformatted 3D VR images showed the detail of the malformed cervicothoracic junction with spina bifida of C5 (Fig. 4A). A large intervening misshapen C6-T3 body mass was confirmed on the sagittal multiplanar reformation CT images (Fig. 4B). Preoperative multiplanar CT reconstruction of the pedicle anatomy was performed for cervicothoracic pedicle screw fixation (Fig. 5). A chest CT revealed congenital stenotic areas in the trachea and left main stem bronchus with parenchymal consolidations in the left lobe (Fig. 6A). The patient also had kidneys with double ureters (Fig. 6B).

We performed combined anterior-posterior-anterior surgery. The spinal cord was decompressed by performing an anterior release with a resection of the dysgenesis segment. Then, pedicle screws were successfully inserted into the pedicles in the cervicothoracic level. Finally, anterior reconstruction using an allograft with anterior plating from C3 to T5 was performed (Fig. 7). There were no iatrogenic neurologic or vascular injuries.

Fig. 3. Volume rendered 3D images of CTA. A. The anteroposterior view shows the course of the vertebral arteries. B. Left lateral oblique images show the left vertebral artery running towards the C4 defective transverse foramen. C. Right lateral oblique images show that the right vertebral artery running towards the C6 defective transverse foramen.

Fig. 4. A. The reformatted 3D volume rendering images demonstrate that the C5 spinous process is split, the left lamina of C6 vertebra is dysplastic, its right lamina is fused to C7 vertebra, and the vertebral body from T1 to T3 was fused. B. The sagittal multiplanar reformation CT images demonstrate a large intervening misshapen C6-T3 body mass (arrow).
Vertebral artery laceration is a rare, but serious complication of anterior cervical decompression (9). Once laceration occurs during surgery, hemorrhage is difficult to control. Therefore, comprehensive preoperative evaluation of the vascular anatomy is essential to conduct safe and successful surgery.

Although CTA provides high-resolution images, a large number of images for the diagnosing physician to review are generated. It also is difficult to use for the identification of veins versus arteries. With recent advances in CT technology, MDCTA has been becoming increasingly popular to use for preoperative vascular evaluation (7, 8). The VR technique is a useful tool to visualize 3D clinical images. Using the VR technique, a true 3D display accurate to each pixel in the data-set can be generated. Depending on the clinical question, a volumetric 3D image can be generated in real time, focusing on the soft tissue, bone, or vascular structures. Postoperative reviews of patients with orthopedic hard-
ware can also be more effective as the use of 3D VR eliminates the vast majority of streak artifacts and clearly delineates the relationship between hardware and bone (10).

In our case, the VR algorithm gave a comprehensive overview of the course and caliber of the vertebral arteries (Fig. 3). A reformatted 3D VR image demonstrated that the C6 vertebra had a dysplastic left lamina and a right lamina fused to the adjacent C7, spina bifida of C5 and multiple level posterior fusion of T1, T2, and T3 (Fig. 4A). After the surgeons had the detailed spatial relationships between the malformed vertebral arteries and the misshapen vertebral bodies, they could safely perform anterior cervical decompression and posterior stabilization.

In conclusion, volume rendered MDCTA is a valuable noninvasive technique for surgical planning of congenital cervicothoracic kyphoscoliosis to prevent vertebral artery injury.

Acknowledgements

The authors warmly thank Song-Woo Shin, In-Kyeong Ha, and Eun-Hee Park for their help in preparing the manuscript and figures.

References

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