Transient long thoracic nerve injury during posterior spinal fusion for adolescent idiopathic scoliosis: A report of two cases

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ABSTRACT
We present the transient long thoracic nerve (LTN) injury during instrumented posterior spinal arthrodesis for idiopathic scoliosis. The suspected mechanism of injury, postoperative course and final outcome is discussed. The LTN is susceptible to injury due to its long and relatively superficial course across the thoracic wall through direct trauma or tension. Radical mastectomies with resection of axillary lymph nodes, first rib resection to treat thoracic outlet syndrome and cardiac surgery can be complicated with LTN injury. LTN injury producing scapular winging has not been reported in association with spinal deformity surgery. We reviewed the medical notes and spinal radiographs of two adolescent patients with idiopathic scoliosis who underwent posterior spinal arthrodesis and developed LTN neuropraxia. Scoliosis surgery was uneventful and intraoperative spinal cord monitoring was stable throughout the procedure. Postoperative neurological examination was otherwise normal, but both patients developed winging of the scapula at 4 and 6 days after spinal arthrodesis, which did not affect shoulder function. Both patients made a good recovery and the scapular winging resolved spontaneously 8 and 11 months following surgery with no residual morbidity. We believe that this LTN was due to positioning of our patients with their head flexed, tilted and rotated toward the contralateral side while the arm was abducted and extended. The use of heavy retractors may have also applied compression or tension to the nerve in one of our patients contributing to the development of neuropraxia. This is an important consideration during spinal deformity surgery to prevent potentially permanent injury to the nerve, which can produce severe shoulder dysfunction and persistent pain.

Key words: Long thoracic nerve, neuropraxia, posterior spinal fusion, scoliosis, spinal deformity, correction, winging

INTRODUCTION
The long thoracic nerve (LTN) derives from the anterior branches of C5, C6 and C7 nerve roots. It runs behind the clavicle to reach the first rib and then descends along the lateral thoracic wall to the eighth to ninth ribs and supplies the serratus anterior muscle. Serratus anterior arises from the external surfaces of the first 8 ribs and attaches to the costal surface of the scapula. It has an important role in upper limb abduction and elevation and acts as accessory muscle during inspiration. LTN paralysis results in medial scapular winging and occasionally shoulder dysfunction.

Scoliosis correction in children often involves a posterior spinal approach to allow use of instrumentation and bone graft. To the best of our knowledge, this is the first report of LTN injury occurring during posterior spinal deformity surgery. We present 2 patients who developed LTN neuropraxia following posterior scoliosis correction.

CASE REPORTS
We reviewed 429 patients who underwent posterior correction of idiopathic scoliosis since 2004 under the primary author and identified 2 patients who developed temporary LTN injury (0.5%). Both patients had no medical co-morbidities and a normal preoperative magnetic resonance imaging of the spine. Spinal surgery was performed using pedicle screw/rod instrumentation and iliac crest bone and was uneventful. No procedure...
involving the thoracic cage was performed. Intraoperative spinal cord monitoring recording cortical and cervical somatosensory and upper/lower limb motor evoked potentials was stable throughout. Postoperative neurological examination was normal in the upper and lower limbs.

Case 1
A 12.5-year-old girl with adolescent idiopathic double thoracic scoliosis (Lenke 2A-) underwent posterior arthrodesis T2-L4 [Figure 1]. Four days after surgery, she noted medial winging of her right scapula without shoulder dysfunction or pain. Patient made a good recovery and the LTN neuropraxia resolved spontaneously 8 months following spinal fusion.

Case 2
A 17-year-old girl with adolescent idiopathic primary thoracolumbar compensatory thoracic scoliosis (Lenke 5CN) underwent posterior arthrodesis T9-L3 [Figure 2]. Six days after surgery, she was noted to develop medial winging of her right scapula with good shoulder function and no pain. Patient made a good recovery and the LTN neuropraxia resolved spontaneously 11 months following scoliosis correction.

**DISCUSSION**

Neuropraxia can develop due to nerve compression, ischemia or traction injury. Due to its long, superficial course the LTN is susceptible to injury through direct trauma or tension. Traction injury is more likely to occur when the patient’s head is flexed, rotated and tilted laterally away from the involved shoulder while the arm is raised overhead as this pulls the LTN anteromedially whilst the serratus anterior moves posteroinferiorly exerting a pathological stretch on the LTN. LTN neuropraxia can develop when patient is under anesthesia due to lack of synchronous coordination of serratus anterior with other shoulder girdle muscles, especially with passive abduction or extension of the shoulder. There are also anatomic variations in the position of the LTN, which can increase the risk of intraoperative injury. This produces medial scapular winging, which becomes most prominent when the arm is lifted forward or when patient pushes the outstretched arm against a wall and may not be evident until the trapezius stretches enough to reveal the injury several weeks later. In contrast, lateral scapular winging is generated by paralysis of the trapezius (spinal accessory nerve) or rhomboids muscles (dorsal scapular nerve). Both patients of this study developed scapular winging with translation of the entire scapula in a more medial and superior position when compared to the normal contralateral side and this took 4-6 days to become clinically evident. Both patients underwent electromyographic testing in the immediate postoperative period, which showed decreased resting potentials, reduced motor unit recruitment and polyphasic motor unit potentials during volitional activity. Nerve conduction studies of the LTN were delayed.

We perform posterior spinal procedures on a Jackson table with our patients positioned prone on a Montreal mattress. The arms are placed overhead at 90° to the trunk and the head is supported on the head rest in a neutral position in terms of rotation and flexion/extension. However, in both patients the head was rotated approximately 30° toward the left side with the neck slightly flexed in order to facilitate attachment of the endotracheal tube to the anesthetic machine. In retrospect, we believe that a traction injury to the LTN may have occurred on the contralateral right side following the mechanism previously described. Placement of heavy wound retractors during surgery may have applied

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**Figure 1:** Posteroanterior and lateral radiographs of the spine in patient 1 before surgery (a and b) and at recent followup (c and d). These show satisfactory scoliosis correction from 60° to 15° for the left upper thoracic and 95-15° for the right low-thoracic curve with good global sagittal balance of the spine.
additional tension, which could have contributed to the development of neuroparoxia in patient 1. None of our patients had a concomitant procedure to the rib cage, such as rib osteotomies or a thoracoplasty, which could have been the cause for an injury to the LTN.

LTN injury can occur in association with infection, exposure to toxins, trauma, surgery and sports.\textsuperscript{4,6-11} Surgical procedures that incur greatest risk of LTN injury are radical mastectomy involving removal of axillary lymph nodes and first rib resection for thoracic outlet syndrome. LTN dysfunction may take up to 2 years to resolve.\textsuperscript{12} Patients with severe symptoms after failure of conservative treatment can benefit from surgical reconstruction involving transfer of the sternal head of pectoralis major to the inferior angle of the scapula reinforced with fascia or tendon autograft or microneurolysis and decompression.\textsuperscript{12,13} Complete recovery occurred in our patients at 8 and 11 months indicating a transient injury. In the presence of a normal shoulder position and function at that stage, we decided not to repeat the electromyographic testing and nerve conduction study.

LTN neuroparoxia can be a potential complication of posterior spinal deformity surgery. Meticulous patient positioning avoiding head flexion, rotation and tilting as well as arm overextension in conjunction with careful placement of the surgical retractors are necessary to prevent a complication, which can result in permanent scapular and shoulder disability.

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