CASE NOTE

Monitoring placement of high thoracic pedicle screws by triggered electromyography of the intercostal muscles

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Pedicle screw–based constructs provide a stronger basis for spinal instrumentation and fusion than hooks. Placement of the screws within the pedicles is a technically challenging procedure. The orientation of the pedicles with respect to surface landmarks changes along the length of the spine and may be abnormal in the scoliotic spine. In fact, some pedicles may not even have a cancellous core. The medial wall of the pedicle forms one side of the spinal canal, and intrusion of the screw into the canal can lead to major neurologic damage. Breaches in the other pedicle walls can also cause neurologic deficits by irritating or damaging spinal nerve roots.

It is possible to assess the screw hole within the pedicle electrophysiologically.[1] Pedicle screw stimulation involves the passing of an increasing current between a probe in the hole or the screw itself and a return electrode, usually a needle placed in a contralateral paraspinal muscle. The neuromonitorist observes the electromyograph and reports the threshold (lowest current) at which a muscle twitch occurs. If a muscle response is observed below 11 mA of stimulation current, this is taken to indicate a possible breach in the wall of the pedicle, which warrants further surgical exploration.[1,2] There are published guidelines for the stimulation thresholds to be used in assessing the lumbosacral vertebrae.[1–3] Shi and colleagues[1] report the use of similar guidelines for thoracic vertebral instrumentation. In their series of 87 screws, they placed 10 in the T1–T3 vertebrae, 3 in T7 and more than 10 in each of T9–T12. However, they detected none of their breaches in the higher thoracic vertebrae. Shi and colleagues[1] recommend using the intercostal muscles to monitor the higher thoracic vertebrae.

When performing multiple levels of instrumentation, as might occur during surgery for scoliosis, it is impossible to monitor every vertebra directly with a muscle that is innervated by that spinal level. We present evidence from a single case in which we detected breaches in the pedicle wall of a high thoracic pedicle by monitoring the intercostal muscles.

Case report

A 14-year-old boy with Down syndrome was admitted to hospital for planned multilevel posterior instrumentation and fusion (T2L1). We maintained anesthesia with propofol, remifentanil and ketamine, but administered no neuromuscular blocking agents. We used a Cascade Elite system (Cadwell Laboratories) for electrophysiological monitoring, with a technologist and neurophysiologist present in the operating room. Subdermal needles recorded electromyograph activity. We tested pedicle integrity electrically by connecting a custom-made clip to the pedicle probe or screw and using a return electrode placed in a paraspinal muscle contralateral to the side of screw insertion. We placed electrodes in the muscles of the third and fifth

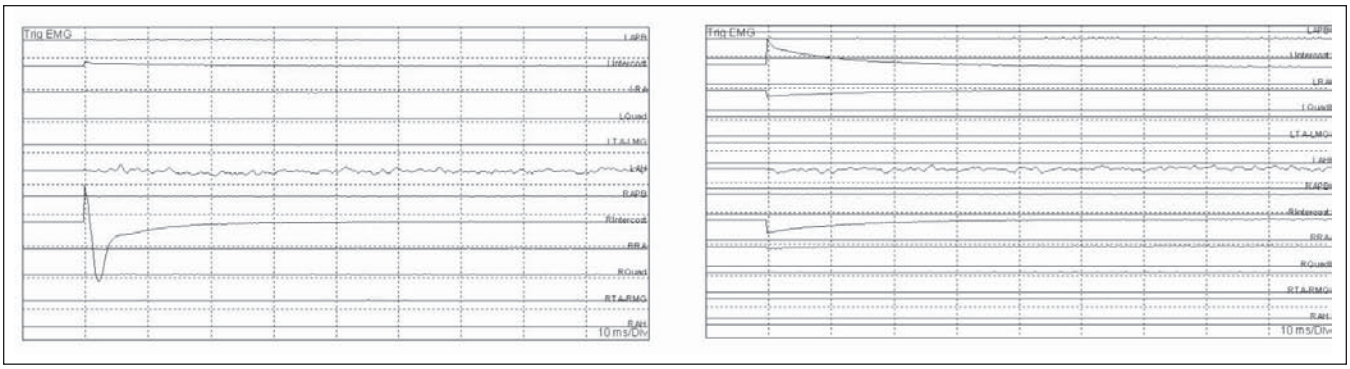

Fig. 1. Triggered electromyographic response to 6.1 mA of stimulation applied to a probe in the right T5 pedicle. (**Left**) The response in the right intercostals is clearly visible. (**Right**) After redirection of the hole in the pedicle, stimulation at 18 mA through the probe does not evoke any muscle response.

intercostal spaces in addition to the rectus abdominus muscle.

In many of the screws tested, even 20 mA of stimulation did not trigger detectable electromyographic activity. However, in one of the higher thoracic (right T5) screws, stimulation amplitudes below 6 mA evoked large muscle twitches in the intercostal muscles. Reinspection of the pedicle walls revealed breaches in both instances. Retesting of the screw after reinsertion along a different tract did not produce an electromyographic response below 19 mA. In Figure 1 (left) we show the response to stimulation of the pedicle probe at 6.1 mA with a large muscle response visible in the right intercostals. Figure 1 (right) shows the response to stimulation of the probe after redirection of the track at a current of 18 mA.

Discussion

Our patient's case illustrates the utility of electrophysiologically monitoring upper thoracic screws using the intercostal muscles as recording sites. As yet, however, it remains unclear where best to place and orient the recording electrodes when monitoring close to the heart. Placing the electrodes equidistant from the heart minimizes the amplitude of the electrocardiogram activity that is recorded, but may also minimize the spread of spinal levels that are adequately monitored. A wider spread of electrodes enables more muscles, and hence spinal levels, to be monitored, but means that the detection system (software or human) must be readily able to distinguish between cardiac interference and electrically triggered muscle twitches. A recent study recorded electromyography triggered thresholds in the intercostals and correlated the position of the screw on postoperative computed tomography with the threshold.[4] In this study, we manually palpated the pedicle and repositioned the screw if a breach was found in the pedicle wall. Screw stimulation testing of pedicles is a useful adjunct to manual palpation of the pedicle wall in detecting breaches of the pedicles, even in higher thoracic levels.

Competing interests: None declared.

References

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