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Lateral Lumbar Interbody Fusion and Neuromonitoring: A Concise Report

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Abstract

Lateral Lumbar Interbody Fusion (LLIF) is a widely used minimally invasive approach providing access to the disc space for interbody fusion via a lateral approach to the spine. The benefits of this procedure include shorter hospital stay and recovery time with minimal blood loss. As the approach for this procedure involves cutting through the psoas muscle, the greatest risk is to the lumbar plexus and femoral nerve which pass through the muscle. The most common post op deficits are hip flexion weakness due to quadriceps weakness and decrease in anterior thigh sensation. Intraoperative neuromonitoring (IONM) using a multi-modality approach has been shown to reduce the risk of neural injury and minimize post op deficits. Though Free run or Spontaneous Electromyography (SpEMG) and triggered EMG are commonly used during these procedures, the IONM protoc ol must be expanded to include Somatosensory Evoked Potentials (SSEP) from Saphenous nerve on the surgical side, peroneal nerve on the non-surgical side in addition to Ulnar and Posterior Tibial Nerve SSEP, Motor Evoked Potentials (MEP) from at least two muscles of the quadriceps and adductors in addition to the other lower lumbar muscles.

Keywords: Lateral Lumbar Interbody Fusion • Spinal Fusion • Neuromonitoring

Introduction

There are different types of approaches to the spine in conditions requiring spinal fusion. The LLIF procedure, also referred as XLIF, utilises a lateral approach to access the anterior disc space via retroperitoneal dissection through the psoas muscle. This is a minimally invasive approach and is associated with shorter recovery time with minimal blood loss. This approach also allows for indirect neural decompression without exposing the nerve roots. It is most used for higher lumbar levels. L5-S1 level is difficult to access due to the presence of the iliac crest. The L5-S1 level also presents an increased risk of nerve and vascular damage as they travel more anteriorly in this location.

To perform the procedure, the patient is placed in a lateral decubitus position with the hip over the break in the operating table. To help maintain position, a beanbag or roll is used. To prevent peroneal nerve compression on the non-surgical side, the lateral aspect of the bottom knee is padded. The leg on the surgical side is bent as much as possible to relax the psoas muscle to aid in dissection. Padding, such as a pillow, is placed between the patient's legs and an axillary roll under the axilla on the contralateral side. Using tape, the patient is secured in placed. The bed is then flexed to help open the lateral disk space on the side of approach. The different stages of the LLIF procedure involve positioning, access to the disc space using retractors, discectomy and then implant placement. The Surgeon approaches the disc space through the psoas muscle using dilators to find a safe pathway (Figure 1) [1-11].

Figure 1. Lateral decubitus position with padding, table flexed at hip and patient is secured with tape.

The positioning places the peroneal nerve at risk of compression on the contralateral side. As the approach for this procedure involves cutting through the psoas muscle, the greatest risk is to the lumbar plexus and femoral nerve which pass through the muscle [10]. The saphenous nerve, which is a sensory branch of the femoral nerve, gives us more specific sensory information [2]. The most common post op deficits are hip flexion weakness due to quadriceps weakness and decrease in anterior thigh sensation. The nerves are at risk not only from direct nerve injury but also from traction injury from retractors [5]. Intraoperative Neuromonitoring (IONM) using a multi-modality approach has been shown to reduce the risk of neural injury and minimize post op deficits [6].

Literature Review

Neuromonitoring

The different stages of the LLIF procedure involve positioning, access to the disc space using retractors, discectomy and then implant placement. Neuromonitoring, using a multi-modality approach, provides information about the effects of the positioning on the patient, helps to identify a safe pathway to the disc space, functional assessment of the lumbar plexus and the status of the lumbar motor roots during the entire procedure [6].

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Though Free run or Spontaneous Electromyography (SpEMG) and triggered EMG are commonly used during these procedures, the IONM protocol must be expanded to include Somatosensory Evoked Potentials (SSEP) from Saphenous nerve on the surgical side, Peroneal nerve on the non-surgical side in addition to Ulnar and Posterior Tibial Nerve, Motor Evoked Potentials (MEP) from at least two muscles of the quadriceps and adductors in addition to the Tibialis Anterior, Gastrocnemius muscles.

The SSEP protocol includes Ulnar nerve and Posterior Tibial Nerve (PTN) responses for general positioning information. Specific to the LLIF procedure are the Peroneal nerve and Saphenous nerve SSEP responses. The Peroneal nerve SSEP responses are recorded from the non-surgical side to monitor for peroneal nerve compression due to the lateral positioning. The most common post op deficit that can be prevented is the development of foot drop. The Peroneal nerve can be accessed at the knee and stimulation does not produce much patient movement. The Saphenous nerve SSEP responses from the surgical side provides more significant information specific to the surgery, as the Saphenous nerve is a sensory branch of the Femoral nerve. The Saphenous nerve is a deeper nerve and can be accessed at the groove between the VM (Vastus Medialis) and Sartorius muscles in the thigh and between the tibia and gastrocnemius muscle in the leg. Since it is a deeper nerve, needle electrodes are most useful in obtaining the responses. Higher stimulation intensities, higher pulse widths up to 1000 microsecs work to provide a better signal. The Saphenous nerve SSEP responses are lower amplitude responses as compared to PTN responses. The PTN provides information about the Sciatic nerve which is not specifically at risk in this procedure. Thus, adding the Saphenous and Peroneal nerve SSEP responses to the IONM protocol is necessary (Figures 2-4) [5].

The critical part of the surgery begins immediately after incision. The most common way the Surgeon accesses the disc space is by using dilators. Nerves are at risk not only from direct nerve injury but also from traction injury from the retractors. The lumbar plexus and the femoral nerve are at risk as we pass through the psoas to access the disc space. SpEMG and Triggered EMG are of importance in finding a safe pathway to the disc space. The muscle of major interest is the quadriceps muscles. At least two of the muscles which include Vastus Medialis (VM), Vastus Lateralis (VL), Rectus Femoris (RF) must be monitored. Adductor longus also should be monitored. Though the levels of innervation, L2-L4, are the same for quadriceps as well as Adductor, the quadriceps are innervated by the femoral nerve while the adductor is innervated by the obturator nerve [3].

Triggered EMG is set to a sweeping intensity between 0-20 mA as the dilators are being placed to identify the lumbar plexus and femoral nerve. Distances are approximated based on the response threshold to help identify a safe pathway to the disc space. Responses are recorded in the EMG muscles. Lower responses indicate closer to the nerve. Once retractors are placed, the four quadrants of the disc space are stimulated to identify any nerve structures in that area. SpEMG is sensitive to identify nerve irritation in real time and mechanical nerve injury from blunt injury but may not identify nerve compression (Figure 5) [6,7].

SpEMG is beneficial in identifying nerve proximity and nerve injury but cannot help in identifying developing nerve root dysfunction. MEP is more specific in identifying developing nerve root dysfunction. For Effective EMG and MEP monitoring, absence of neuromuscular blockade is essential. TIVA (Total Intravenous Anaesthesia) helps in optimising MEP responses. Hence optimal anaesthetic regime should be discussed with the anaesthesia team prior to the procedure. In LLIF procedure the femoral nerve is at risk as opposed to the exiting nerve roots in a traditional lumbar approach. The L2, L3, L4 nerve roots combine to form the femoral nerve in the psoas muscle. Since the approach to the disc space is through the psoas muscle, it places the femoral nerve directly in the path and susceptible to injury [3,4]. The MEP responses from Quadriceps (VM, VL, RF), Adductor longus, Tibialis Anterior should be included along with Gastrocnemius and Abductor Hallucis which monitor the lower lumbosacral trunk. It may be difficult to elicit MEP responses from proximal muscles and monitoring from two or more of the quadriceps muscles increases the probability of obtaining significant responses. A high-grade femoral nerve injury is more debilitating than a single nerve root injury and MEP responses from the quadriceps help significantly in preventing transient as well as permanent neural injury. There may be significant changes in MEP responses with no accompanying changes in SSEP or EMG responses (Figures 6a and 6b) [1,7,8].

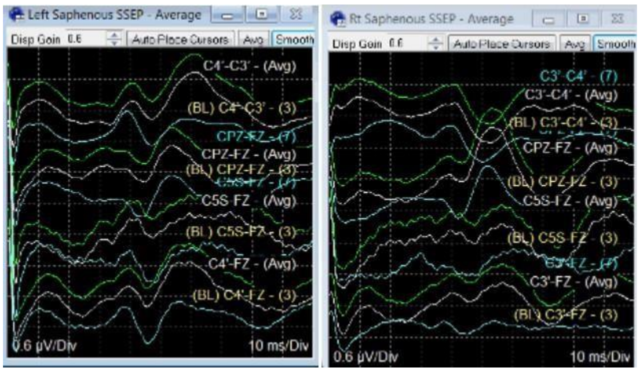

Figure 2. Right and left saphenous nerve SSEP responses.

Figure 3. Peroneal nerve SSEP placement.

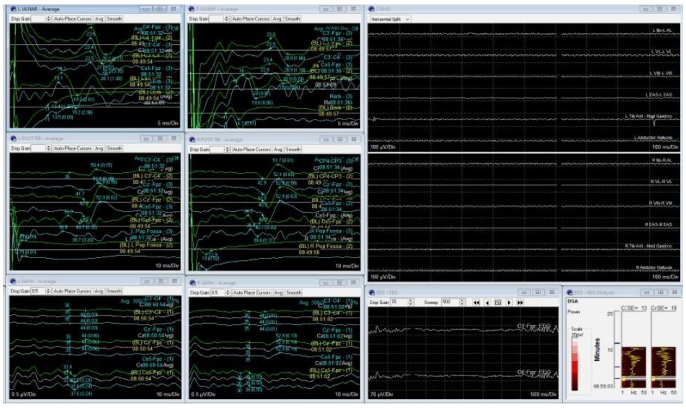

Figure 4. IONM for an LLIF procedure with SSEP, EMG, EEG. highlighting amplitude differences between PTN and saphenous nerve amplitudes.

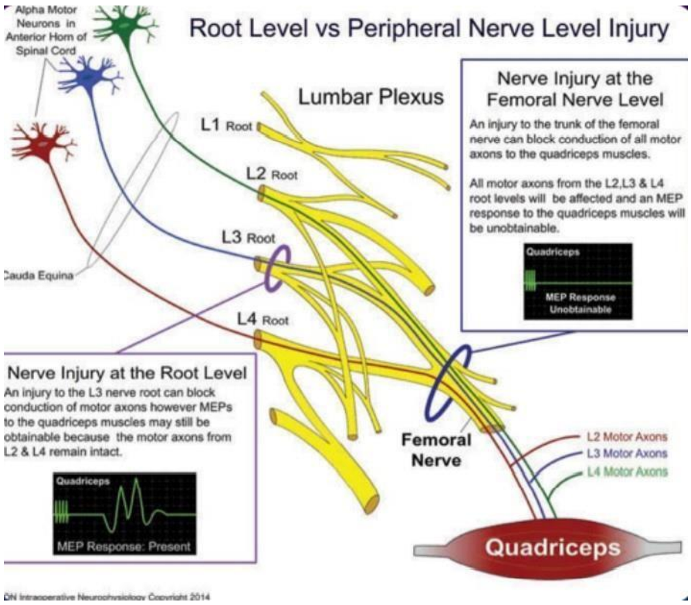

Figure 5. Nerve injury at root level vs. peripheral nerve level. Intraoperative neurophysiology 2014.

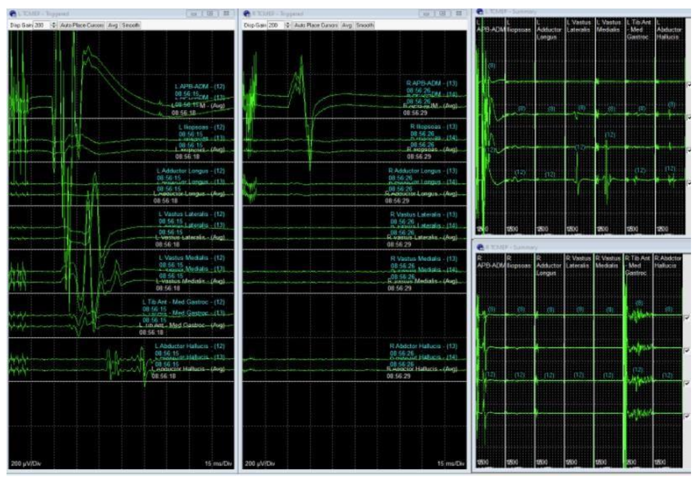

Figure 6a. MEP recordings covering the upper and lower lumbosacral trunk. Significant difference between surgical and non-surgical side. Significant change in responses from baseline to closing. Baseline MEP recordings.

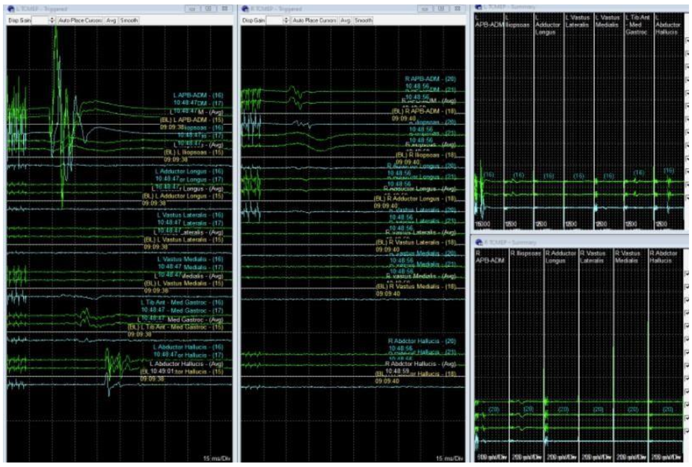

Figure 6b. MEP recordings covering the upper and lower lumbosacral trunk. Significant difference between surgical and non-surgical side. Significant change in responses from baseline to closing. Closing MEP recordings.

Conclusion

To provide the best protection, a multi-modality approach with SSEP, MEP, EMG, Triggered EMG is needed for lateral lumbar procedures. As the approach for this procedure involves cutting through the psoas muscle, the greatest risk is to the lumbar plexus and femoral nerve which pass through the muscle. Saphenous nerve SSEP from the surgical side provides more significant sensory information pertaining to the surgery site as it is the sensory branch of the femoral nerve. Peroneal nerve SSEP are recorded from the non-surgical side to prevent peroneal nerve compression due to the lateral decubitus position. EMG and MEP from the Quadriceps (VM, VL, RF), Adductor longus should be monitored in addition to Tibialis Anterior, Gastrocnemius muscles. EMG and triggered EMG help in identifying a safe pathway to the disc space. EMG can identify blunt nerve injury but is non-specific and cannot help in identifying developing nerve root dysfunction. MEP is more specific in identifying developing nerve root dysfunction. A high-grade femoral nerve injury is more debilitating than a single nerve root injury and MEP responses from the quadriceps help significantly in preventing transient as well as permanent neural injury.

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