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IDEAS AND INNOVATIONS

Peripheral Nerve

Lumbosacral Plexogram: An Aid to Reconstructive Nerve Possibilities in the Lower Extremity

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Summary: The lumbosacral plexus is the network of nerves responsible for the motor and sensory function of the pelvis and lower limb. Our observation is that the anatomy of this plexus is less familiar to surgeons than that of the brachial plexus. Damage to the lumbosacral plexus and its terminal branches may have a significant impact on locomotion, posture, and stability. We have designed a visual representation of the lumbosacral plexus to aid clinicians treating peripheral nerve disorders. The utility is illustrated with a case report in which a patient underwent nerve transfers in the lower limb to restore function. A visual representation of the lumbosacral plexus is a valuable adjunct to a clinical examination and helps make sense of clinical signs. The color-coding of each root level and the arrangement of muscles from proximal to distal helps with visual recall. A clear assessment of complex lumbosacral plexus patients is essential for diagnosis and planning. As with the case described, a sound knowledge of the "plexogram" can identify solutions for complex patients and result in significant functional improvements. We hope it helps advance the field of nerve surgery and, particularly, nerve transfers.
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INTRODUCTION

The lumbosacral plexus is the network of nerves responsible for the motor and sensory function of the pelvis and lower limb. Our observation is that the anatomy of this plexus is less familiar to surgeons than that of the brachial plexus. In recent years, management of brachial plexus injuries has improved with the adoption of nerve transfer surgery, a technique that necessitates a sound understanding of brachial plexus anatomy, and its terminal branches plus spinal nerve root contributions to individual muscles. However, the indications for this technique to the lower limb are not fully explored.[1]

Damage to the lumbosacral plexus and its terminal branches can be through degenerative spinal disease, trauma, resection for the management of malignancy, and as a result of iatrogenic injury. The resulting deficiencies may have a significant impact on locomotion, posture, and stability. We have designed a visual representation of the lumbosacral plexus to aid clinicians treating peripheral nerve disorders. Inspired by the "plexogram" proposed by Felder, we hope that this "lumbo-sacral plexogram" may improve the understanding of lower limb nerve injury and open up the possibility for novel nerve transfers in an area where reconstructive options are currently very limited.[2] (Fig. 1).

We envisage that our visual representation allows for an immediate appreciation of individual motor territories and for those boundary zones where distal nerve branches from different parts of the lumbar plexus lie in close proximity, a prerequisite for successful nerve transfers. The "lumbosacral plexogram" is designed with color-coding corresponding to individual nerve roots (Fig. 1). The utility is illustrated with a case report in which a patient underwent a nerve transfer in the lower limb.

CASE

A 26-year-old woman was referred to the peripheral nerve injury service with left-sided lower limb weakness due to a sarcoma resection necessitating the loss of the psoas muscle, L3-L5 hemi-vertebrectomy with the loss of L3-L5 nerve roots, and partial excision of iliac crest 12 months prior. The defect was reconstructed with a free fibula and a wire cage. This was followed by postoperative radiotherapy and chemotherapy. Her functional status improved with physiotherapy, but she had no femoral

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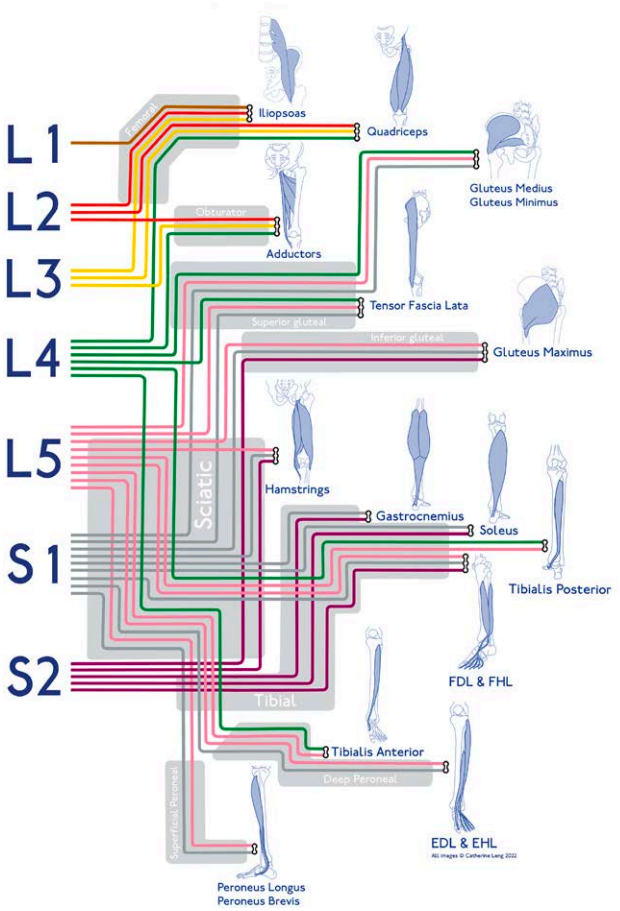

Fig. 1. The Lumbosacral plexogram. The pictorial representation of the muscles of the lower limb from proximal to distal allows the reader to appreciate the proximity of individual muscles relative to each other. The gray boxes indicate the main named nerves of the lower extremity and their respective radicular contributions. Cross referencing this visual proximity with the color-coding of the root-level innervation will help identify potential accessible donors. Knowledge of anatomy is still required for successful operative planning and when considering nerve fascicle transfers more proximally. EDL, extensor digitorum longus; EHL, extensor hallucis longus; FDL, flexor digitorum longus; FHL, flexor hallucis longus.

Takeaways

Question: Is there a way to simplify the lumbosacral plexus to help with the diagnosis and management of lower limb nerve injuries?

Findings: A visual representation of the lumbosacral plexus is a valuable adjunct to clinical examination and helps interpret clinical signs. It provides a representation of the boundary zones where distal nerve branches from different parts of the lumbar plexus lie in close proximity, a prerequisite for successful nerve transfers.

Meaning: This visual representation of the lumbosacral plexogram is a useful aid to the diagnosis and management of lower limb nerve injuries.

nerve and minimal adductor magnus function, resulting in knee instability for which she wore a knee brace. Her hamstrings and gastrosoleus were strong, but there was no tibialis posterior and a flicker of motion in the tibialis anterior, resulting in a foot drop.

She was assessed clinically and with nerve conduction studies/electromyography. These revealed no function in quadriceps, reasonably preserved biceps femoris, and some innervation in semi-membranosus. Gastrocnemius medial and lateral heads showed moderate function and tibialis anterior had fibrillations and positive sharp waves.

She underwent three nerve transfers 13 months after the sarcoma resection. A gastrocnemius nerve fascicle from the sciatic nerve to femoral nerve fascicle to quadriceps for knee extension, as well as medial gastrocnemius branch to deep peroneal nerve to restore ankle dorsiflexion, was performed (Figs. 2 and 3). In addition, flexor digitorum longus to tibialis posterior nerve transfer was undertaken. All nerve transfers were performed end-to-end.

At 15 months after the nerve transfer surgery, after physiotherapy, she mobilized without using a knee brace, as a result of quadriceps reinnervation, and regained some function in her tibialis anterior (MRC 4), which allowed her to stop wearing an ankle-foot orthosis.

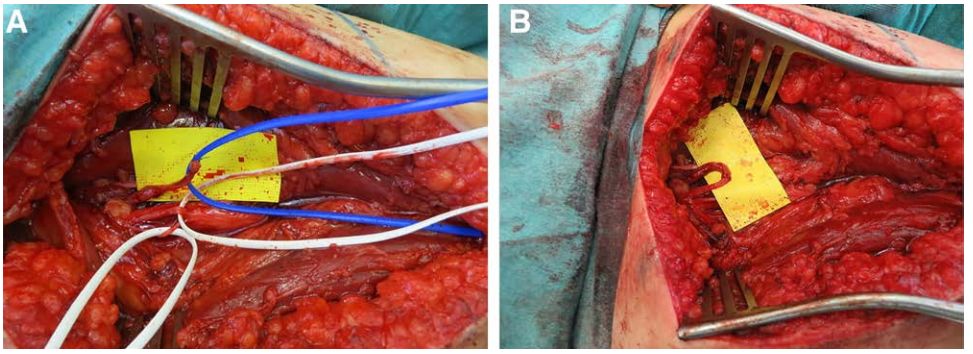

Fig. 2. A, Femoral nerve branches to quadriceps in blue vessel loop delivered from anterior thigh. Gastrocnemius fascicle from sciatic nerve in white loop. B, End-to-end co-aptation of gastrocnemius fascicle and branches of femoral nerve to quadriceps.

Fig. 3. Popliteal approach in lateral position. Medial gastrocnemius nerve fascicle to deep peroneal end-to-end co-aptation.

DISCUSSION

Lower limb nerve injuries can result in profound disability due to the motor and sensory deficits and resulting impact on movement, gait, loss of proprioceptive feedback, and protective sensation. Many options have been described in the literature for managing these injuries, including splints (AFOs), arthrodesis, tendon transfers, nerve grafts, and nerve transfers. Splints are helpful but do not produce active movement and require good compliance from the patient. They are often reported to be uncomfortable, and patient satisfaction is low.[3,4] Nerve graft results have been, on the whole, disappointing due to the long reinnervation distance in the lower limb and the degeneration of motor endplates before reinnervation occurs. In addition, nerve grafts longer than 6 cm are often unsuccessful.[5]

In the upper limb, nerve transfers for some functions are superior to tendon transfers.[3] This is not the case in the lower limb where reliability of nerve transfers is still debated. Tendon transfers in the lower limb, however, have the disadvantage of creating an imbalance between the transferred muscle and the remaining intact muscles.[6,7] Some commonly used tendon transfers are associated with long-term complications such as hindfoot valgus, flat foot deformity, and arthritis.[4]

In the case described above, the nerve transfers were undertaken later than would be recommended (<9 months) for a complete motor loss but still resulted in a significant functional improvement for the patient. The delay is likely related to the infancy of the technique in the lower limb with limited clinician awareness and, hence, delayed referrals.

A detailed knowledge of anatomy is critical for any surgery because it relates not only to "space" and other structures, but also to the topography of nervous plexi, individual nerves, and muscle innervation. This is especially true when considering nerve transfers that rely on a thorough knowledge of innervation pathways from the cord to the periphery. With this plexogram, we hope to help demystify the innervation of the lower limb from the lumbosacral plexus by providing a useful aide-memoire and, in doing so, to advance the cause of lower limb nerve transfers.

CONCLUSIONS

A visual representation of the lumbosacral plexus is a valuable adjunct to a clinical examination and helps make sense of clinical signs. The color-coding of each root level and the arrangement of muscles from proximal to distal helps with visual recall. A clear assessment of complex lumbosacral plexus patients is essential for diagnosis and planning. As with the case described, a sound knowledge of the "plexogram" can identify solutions for complex patients and result in significant functional improvements. We hope it helps advance the field of nerve surgery and, particularly, nerve transfers.

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DISCLOSURE

The authors have no financial interest to declare in relation to the content of this article.

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