

## MICROSURGICAL TREATMENT OF LUMBOSACRAL PLEXUS INJURIES

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### SUMMARY

Surgical treatment of lumbar and sacral plexus lesions is very rarely reported in the literature.

The incidence of the involvement of these nervous structures in traumatic lesions of different etiology is probably much higher than believed, and surgical treatment should be taken in consideration in much more cases.

In this paper the experience derived from the surgical treatment of 15 cases is reported. Different surgical approaches have been employed, owing to etiology, to the level of nerve lesion and to concomitant lesions of other organs.

Patients who suffered a lesion in the lumbar or sacral plexus may have a very severe problem with deambulation since the leg may not be stable or may be unable to withstand the weight of the body. Pain syndrome in these patients may be a very severe obstacle to rehabilitation programs and to deambulation and daylife activity.

Microsurgical nerve treatment in the retroperitoneal space is demanding, both for the surgeon and for the patient, but neurolysis and grafting procedures are possible also in this district. The resulting improvement of motor performance and the relief of pain, are strong arguments in favor of this choice. The most beneficiary muscles are the gluteal and the femoral ones, more far distant muscles, and particularly the anterior tibial nerve dependent ones will gain minimal benefit from surgery. The relief from pain is relevant in all cases.

### INTRODUCTION

Injuries to lumbar and sacral plexuses are very rarely reported in the literature, and their incidence is estimated to be very low (25, 29). Probably the incidence of this pathology is underestimated, and this is due to the difficulty of such a diagnosis and also to the possible lack of awareness that such a lesion may exist.

Analogous nerve lesions in the upper limb are very well understood and very well approached all over the world thanks to an enormous amount of anatomical, experimental and clinical studies. Not so much attention has been paid to lumbosacral plexus injuries, for the reasons that I am going to discuss.

These patients are often simultaneously affected by damage to several soft, parenchymatous and bony tissues, and this may make neurological diagnosis a difficult task. This is particularly true for patients who in emergency receive treatment by general, urological, or obstetrical surgeons. In other cases diagnosis may be hindered by the superimposition of symptoms due to pathology of other organs, or by the interposition of a long time span between injury and specialistic clinical examination. This long time interval may be accompanied by a sketchy clinical history and by incomplete or superficial surgical reports. A different situation is that of iatrogenic nerve lesions, which may remain longly misunderstood or underestimated. Surgery for nerves in the abdominal retroperitoneal district is rarely performed both because of the aforementioned problems and because of technical difficulties due to the deep location of nerve structures, which are reached by a laborious approach with risk of haemorrhage and infection. For neurosurgeons this is an unusual anatomical district.

In the literature surgical treatment is reported to have been done in small series of patients: 14 cases had been published during last years. Recently Kline and Hudson have presented their wide experience, with the first relevant series of surgically treated cases.

In this paper a revision of the personal casistic is given, with some comments on surgical approaches.

### ANATOMICAL CONSIDERATIONS

A careful anatomical study has been performed on 12 adult cadavers, in order to collect informations on microsurgical anatomy of the region and to verify surgical possibilities.

Lumbosacral plexus is composed by nerve roots L1 to S2. As for brachial plexus, also in this anatomical district nerve roots located anteriorly provide flexor functions, and posterior ones extensor functions.

Lumbar and sacral plexuses are to be considered separately because of the completely different destiny of their terminal branches, and because of the differences in topographical anatomy which entail different surgical approaches.

The lumbar plexus originates from the spinal roots L2, L3 and L4 and receives contributions from L1 and L5 roots.

Its location is in the corner between vertebral bodies and lateral apophyses. It is covered by ascending iliac and cava veins and by aorta and common iliac arteries on the right side and by iliac arterial and venous plexuses on the left. Posterior to these structures is psoas muscle which covers entirely the plexus. In the space between psoas muscle and the spine, together with the plexus, lumbar arteries and lumbar and azygos veins which form the ascending lumbar vein, are met.

While the most cranial nerve roots and trunks have a fairly horizontal direction, the more caudal ones are obliquely oriented and in the plexus are located posterior to the more cranial ones.

Several terminal branches take origin from the lumbar plexus: iliohypogastric, ilioinguinal nerves, nervous branches to psoas and ileus muscles, genitofemoralis, lateral femorocutaneous, obturatorious, obturatorious accessorius, and femoral nerves.

Three of these nerves, namely iliohypogastric and ilioinguinal proximally and femorocutaneous more distally, emerge from the lateral border of psoas muscle, and run on the posterolateral muscular wall of abdomen. Genitofemoralis nerve on the contrary emerges from the anterior surface of psoas muscle, in a virtual septum between minor and major psoas and runs subfascial on this muscle. Obturator nerves remain in a hidden position, behind psoas belly, running parallel to lumbosacral trunk.

Thus the subserved muscles are: abdominal, psoas, iliac, pectineus, sartorius, quadriceps femoris, and adductors of the thigh.

The sacral plexus originates from the spinal roots L5 - S1 - S2 and S3; some fascicles coming from L4 contribute to this plexus, joining L5.

Sacral plexus lies on the sacroiliac junction, and on piriformis muscle; it is located medially to psoas muscle, between it and the column.

Hypogastric artery intermingles the nerve trunks, and ascending veins cover the plexus. Nerve fibers have a fairly vertical orientation, and go deep in the pelvis following the bony profile. Most caudal components are located posteriorly to the most cranial ones.

The radicular components from L4 and from L5, coming together, form the lumbosacral trunk. Receiving fascicles by S1, S2, and S3 roots, lumbosacral trunk contributes to the formation of common peroneal and tibial nerves, which may unite to form sciatic nerve or remain independent and parallel all the way to the popliteal fossa. From the sacral plexus also superior and inferior gluteal nerves, and motor branches to quadratus femoris, biceps and semitendineous muscles take origin.

Thus the subserved muscles are: major, middle and minor gluteal, obturator, piriform, gemelli and quadratus, the muscles of the posterior aspect of the thigh; anterior tibial and peroneal muscles, abductors and extensors of the foot; triceps surae and plantar flexors of the foot.

### PATIENTS AND METHODS

#### - Patients

This paper reports our surgical experience on 15 patients operated on from 1987 to 1994. Some of these patients made the object of previous reports (5, 6). The mean age was 30; nine were males, six female.

In seven patients the lesion was due to road or work injuries; five out of these were males. In other 4 cases (all males) the lesion was due to bullets, while in 4 females the lesion was the consequence of abdominal or gynecologic surgery.

Patients features are detailed on table 1.

#### - Diagnostic methods

All patients where referred because of the diagnosis of lumbosacral plexus lesion at distance from the lesional event. EMG recordings and Sensory Evoked Potentials were regularly repeated monthly in order to monitor the clinical evolution and get an understanding of the possibilities of

spontaneous recovery.

EMG signs of disfunction in muscles innervated by different terminal branches were

studied to make a map of the possible site of damage; SEP recordings from specific cutaneous areas were analyzed in order to identify possible root damage.

As indicated by Harris and some other Authors myelography and TC Myelography were performed in cases in which a suspicion of root avulsion was present because of the mechanism of the injury: palsies associated with lumbar, sacral or pelvic fractures which may entail stretch injury to the nerves. Starting from the third month after injury patients were studied also by CT and/or MR imaging. These imaging tools provided informations about alterations of anatomy, about the presence of bone displacements or fibrotisation in the retroperitoneal space, and about muscular atrophy.

#### - Surgical methods

The approach to the lumbosacral plexus area may be a difficult matter because of the deep location of nervous structures, which in the retroperitoneal space are covered by major arteries, veins, and venous plexuses. Fibrotisation following retroperitoneal haematomas and traction - distortion lesions may become very compact herein, because of the frequent participation of bone repair processes, and because of the involvement of thick muscles with very numerous tendinous insertions.

Owing to the level of lesion three different approaches have been described in the literature:

- anterior extraperitoneal via a lumbotomy, for reaching L2-L3-L4 roots and lumbar plexus

- anterior transperitoneal via a xifopubic incision for reaching L5-S1-S2 roots and sacral plexus

- posterior via L5 laminectomy and sacrectomy for reaching the nerve roots and the deep intrapelvic origin of sciatic nerve from sacral plexus.

Combined anterior and posterior approach is described only by a theoretical point of view: I could not find in the literature reports about patients treated by this double approach.

Millesi has recently realized a very new approach, which goes along the inner and outer bony surface of iliac bone, and enlarges the margins of foramen ischiaticus, in order to expose the sacral plexus and sciatic nerve at the passage through the foramen.

In this series of 15 patients surgical approach was chosen following the forecited criteria, and also considering the previously performed surgical operations, which in some cases imposed the transperitoneal approach.

After neurolysis, nerve grafting procedures were performed in 2 of the lesions due to trauma, in all the four which were due to bullet, and in 1 of the four iatrogenic lesions.

#### - Surgical procedures

##### 1 - The anterior extraperitoneal approach :

The patient lies on lateral decubitus on the healthy side, with the bed forming a 30 degrees angle corresponding to the lumbar area. The arm on the affected side is kept elevated over the head.

A lumbotomic incision is performed: the arciform skin incision and section of obliqui muscles gives exposure of the peritoneal sac, which is gently retracted medially and downwards. The kidney is visible on the cranial limit of the operative field, on the posterior abdominal wall. Attention must be paid to the ureter, which runs inside a duplication of the peritoneal wall and must not be hurted in dislocating the peritoneum. By this way the plane of psoas and ileum muscles is exposed; femorocutaneous, femoral and genitofemoral nerves are easily identified and the needed microsurgical procedures can be performed. Tracing posteriorly the femoral nerve, we usually elevate the psoas muscle by a strong retractor, in order to reach L2, L3, and L4 roots at the foramina. In this point electrical stimulation is given while evoked cortical potentials are recorded for demonstrating the absence of root avulsion. Distally the terminal branches of the lumbar plexus are followed up to their way out of the pelvis. If needed femoral nerve is neurolysed by dividing the ligamentum inguinale on the lacuna musculorum, and coming into the Scarpa's triangle in the thigh.

The same can be done for the femorocutaneous nerve by dividing the ligamentum inguinale laterally, close to the anterior superior spina iliaca, and opening the fascia lata.

The obturator nerve can be traced distally : it is medial to the psoas muscle, and lateral and posterior to the iliac vein, and goes towards the canalis obturatorius.

In this series this approach has been utilized in 5 cases. In 3 out of these the target was a lesion of L3 and/or L4 roots. This site of lesion was associated with femoral nerve involvement in patient n°7, and with femoral, obturator and femorocutaneous nerves lesion in patient n° 9.

Microsurgical treatment consisted in neurolysis in 2 cases, which showed that grafting procedures were needed in patients

##### 2 - The anterior transperitoneal approach:

The patient lies on its back, the bed forming a 20 degrees angle corresponding to the lumbar area. A long xifopubic skin incision allows bringing apart the two recti abdominis muscles. The anterior wall of the peritoneal sac is opened and bowels are retracted. For maintaining a central free space we have employed a circular autostatic spreader which can retract bowels in any direction without danger.

The posterior peritoneal wall is opened and major vessels are exposed. Once the vessels are gently retracted, the promontorium, that is the body of L5 vertebra and L5-S1 disk, can be palpated. This is the landmark for identifying L5 nerve root. Nerve roots L4 and L5 can be

reached medial to the psoas muscle, and their fusion in the lumbosacral trunk is exposed by partial resection of the muscle from medial to lateral. S1 root can be brought in vision more distally. Surgical procedures on its junction to the sacral plexus become extremely difficult; we believe that only neurolysis is possible at this level. Up to some millimeters exposure becomes impossible because of the very deep location and the presence of not movable vascular structures. So this is the distal limit of the surgical field. This is why more distal lesions at the passage from the pelvis to ischiadic foramen are to be approached by the posterior route.

Out of our 15 patients this approach has been used in nine cases. In 3 the target was a lesion located in L5 root and in more distal roots. In other complex lesions in which L5 root was involved together with the upper roots composing the lumbar plexus, the choice was in favour of this approach rather than the extraperitoneal one.

In four patients the choice for this surgical approach was dictated by preexisting abdominal scar, even if the goal was to reach the lumbar plexus and its terminal branches.

##### 3 - The posterior approach :

The patient lies prone, with the legs maintained in hip and knee flexion as for lumbar disk surgery. This position allows sacrectomy and L5 emilaminectomy, careful muscular resection from sacral insertions and intrapelvic plexus exposure. Also sciatic nerve exposure distal to the foramen ischiaticus underneath gluteal muscles is easily performed by a distal separate approach.

After medial lumbar skin incision, L5 and S1 roots are exposed by laminectomy and sacrectomy followed by foraminotomy. The paravertebral muscles are to be partially sectioned in order to gain a lateral extension of the surgical field and exposure of the retroperitoneal

space. Neurolysis can be performed by this approach and if needed nerve grafting can be performed with connection to the sciatic nerve at foramen ischiaticus. Nerve grafts are brought beneath the gluteal muscles, outside the pelvis.

This approach was employed in only one case, in which the sciatic trunk was lesioned in the pelvis, and had to be repaired by grafts.

## RESULTS

We had no complications from surgery, all postoperative courses were uneventful.

The follow up in our series of patients is at seven years for 3 cases, three years for 2, two years for 4 and 18 to 12 months for 6. In table 2 the legend "postoperative picture" refers to the situation as observed at present, after the mentioned follow-up period after surgery.

EMG recordings have demonstrated that gluteal muscles have regained a significantly useful innervation in neurolysis cases, and in graft cases also. Particularly medium gluteus muscle, which is an important stabilizer of the articulation, has regained useful activity within one year after surgery.

Muscles of the thigh showed an analogous improvement.

In general most proximal muscles have regained much more than the more distal ones. Among these the muscles subserved by Anterior Tibial nerve

have had the worst results.

The woman treated by grafting because of a surgical lesion of the obturator nerve has had a very good recovery, probably because of the clearcut lesion, and of the correct timing for reconstruction.

Among graft cases one does not show improvement 18 months postoperatively. We can not exclude that a root avulsion is in cause in this failure, but since the L5 component of the lumbosacral trunk was the repaired structure, we think that more time is needed for definitive evaluation of this case.

For all patients surgery has allowed improvement in pain sensation; for the great majority pain has disappeared, and this result is achieved almost immediately in the postoperative period.

It is ascribed to neurolysis which gives resolution of ischemia.

## CONCLUSIONS

Patients who suffered a lumbosacral plexus lesion may have a very severe problem with deambulation, since the leg may not be able of withstanding the weight of the body. Also in cases of partial lesion the impairment of various muscles from the gluteus to the foot will engender problems for motion. Moreover the pain syndrome which follows nerve lesions will be exacerbated by posture and will hinder walking and rehabilitation programs.

As for any peripheral nerve lesion, the entity of damage may vary greatly from trunk to trunk and even inside a single nerve structure. Neurolysis, either as a first step procedure for studying the lesion, or as a per se complete treatment, will be a useful procedure, which will facilitate nerve regeneration and contend neurogenic pain.

The problem in lesions of lumbar and sacral plexuses is the relevant distance to the depending muscles. Only some muscle groups are near enough to be reached by nerve regeneration in a sufficiently short time to prevent postatrophic fibrotisation. The muscles which have obtained the best results are the gluteal ones, and the medium gluteus in particular. This muscle is very important for standing and walking since it gives stability to the hip joint.

In the lumbar plexus is concerned psoas and iliopectineus muscles are the most proximal ones: psoas muscle will be reinnervated by branches of lumbar plexus coming directly to it by L2 and L3, while iliopectineus muscle will receive regrowing fascicles through the femoral nerve.

In the sacral plexus is concerned gluteal muscles and muscles of the posterior aspect of the thigh can be reinnervated via gluteal nerves and via the specific short branches of the sciatic nerve.

The improvement of function of these muscular masses which comes from neurolysis or from nerve grafting of more severe nerve lesions will give the patient the enormous advantage of regaining strength for the leg. The possibility of standing on it, without external support will be the basis for starting again walking. Great enthusiasm of the patient, who enjoys also the reduction of pain, will facilitate also the rehabilitation program.

All the other more distal muscles of the inferior limb are too far distant and we should not expect useful reinnervation of this district when planning nerve grafting for lumbosacral plexus lesions. Anyway posterior tibial depending muscles have shown significant degrees of reinnervation.

Neurolysis has proved to be a useful procedure in the retroperitoneal district, since it has allowed gaining 1 or 2 M points, making deambulation possible without external support, and since it has almost completely eliminated pain in all cases.

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