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THE ANATOMICAL BASIS FOR LOW BACK PAIN

Studies on the presence of sensory nerve endings in ligamentous, capsular and intervertebral disc structures in the human lumbar spine.

By

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Clinical Introduction.

In spite of numerous clinical and patho-anatomical studies during the past there are still different opinions concerning the interpretation of low back pain. The site of the underlying pathology has been focused on two areas; the discs and the vertebral joints. Degenerative changes in the lumbar discs have in many centres evidently been accepted as the main source of low back pain as ruptures in the posterior part of the annulus are often the cause of sciatica.

Sensory nerve endings have hitherto not been found elsewhere in discs than in the long back ligaments and at the site of junction of the posterior longitudinal ligament with the annulus fibrosus, *Hovelaque* 1925, *Jung & Brunschwig* 1932, *Tsukada* 1938, *Roofe* 1940, *Ehrenhaft* 1943, *Wiberg* 1949. Low back pain was therefore explained as a disorder where the posterior longitudinal ligament was mechanically affected.

Attempts to measure the amount of deformation at the outer borders of normal and degenerative interspaces proved that differences in deformation between normal and pathological discs were very small, *Hirsch* 1954, 1956. When, however, the intradiscal pressure was increased by injection of normal saline or contrast material for radiographic purposes, low back pain of clincal identity could be reproduced, *Lindblom* 1948, *Hirsch* 1948. The intradiscal pressure has been studied by *Nachemson* 1960. Normally the nucleus follow hydrodynamic laws. In degenerated discs the pressure distribution varies. Measurements and mechanical analyzes illustrated that the annulus could be subjected to considerable stress.

When degenerated discs were studied histologically, it was often noted that great numbers of blood vessels had grown between the ruptured and deteriorated collagenous annulus bundles, *Hirsch & Schajowicz* 1952. The areas where granulation tissue could be found were thought likely sites of sensory nerve terminations. However, nerve endings have not as yet been observed in this location.

While it has been easy to find evidence of pathology in discs but difficult to illustrate sensory nerve endings to explain the symptomatology the reverse is true of the vertebral joints. *Ghormley* in 1933 coined the facet syndrome, to which *Badgley* 1941 concluded: The anatomical possibilities for the articular facets to play a more or less active part in the production of low back pain are obvious, but pathological evidence is not yet sufficient to make this statement a fact.

Pedersen, Blunck & Gardner 1956 determined the distribution of the lumbosacral posterior rami and the sinu-vertebral branches of spinal nerves. The posterior rami, in addition to their cutaneous and muscular distribution, give sensory fibers to fascia, ligaments, periosteum and intervertebral joints. Adjacent divisions overlap in their area of supply. Interspinous ligaments are supplied mainly by branches from the next cranial level. Sinu-vertebral nerves supply posterior longitudinal ligament, dura mater, periosteum and blood vessels, show intersegmental anastomoses and contain sensory fibers.

The pattern of low back pain is complex. A variety of symptoms present different types of clinical pictures even in the same patient over a period of time. It is possible that the disc pathology may affect the function of joints and ligaments in interfering with a functional anatomical unit or that we have to accept more than one localization of the pathology. It has been suggested that clinically a painful stimulus to any deep structure in this region is poorly localized and can give rise to a common symptom complex, *Pedersen, Blunch & Gardner* 1956.

It is, hovewer, felt that studies on the pattern of sensory nerve endings and their modalities in the different structual elements in the lumbar spine may offer further neuro-anatomical explaination for lumbago.

The anatomy of the lumbar spine.

The basic anatomical and functional unit of the vertebral column is the articular triad consisting of the fibrous intervertebral joint and the two synovial vertebral joints. This articular triad is stabilized at the joints of the extremities by a ligamentous apparatus and permits movements in the spine by the action of a complex coordination of muscle function and gravity.

The details of the fibrous intervertebral joint have long been well known and the synovial intervertebral joints have recently been restudied by *Lewin, Moffett & Viidik* 1961.

The fibrous intervertebral joint is formed by two adjacent vertebral bodies and the intervertebral disc. The disc consists of the annulus fibrosus and the nucleus pulposus. The annulus shows a complex system of fibers forming lamellae or bundles. Part of the outer lamellae, which run parallel to the long ligaments, is connected by means of a preparatory calcified zone with the marginal bone edge of the vertebral body, *Erdheim* 1931. The inner and the largest part of the annulus fibers run obliquely into the cartilaginous plate of the vertebral body and become attached to the subchondral bony layer. The nucleus pulposus which consists of a three-dimensional network of collagen fibrils enmeshed in a mucoprotein gel is situated in a cavity in the centre of the annulus fibrosus.

In the lumbar synovial vertebral joints the superior articular processes are in contact with the inferior articular processes of the superior vertebra. The superior joint facet is faced medially and backwards and is gently concave. The inferior one is therefore convex and faced laterally and forwards. The joint capsule is attached close to the dorsal and ventral margins of the joint but at the superior and inferior ends there are fatfilled articular recesses. Ventrally and dorsally the capsule is reinforced by direct contacts with surrounding ligaments and tendons. Where the fatfilled recesses communicate with the joint cavity the adipose tissue terminates as a synovial fat pad. The adipose tissue of the superior recess is continuous with that around the spinal nerve in the intervertebral foramen. The adipose tissue deep to the multifidus muscle extends into the inferior recess of the joint. The multifidus muscle covers the lumbar vertebral synovial joints on all sides except ventrally, where the joints are in direct contact with the ligamenta flava.

The ligaments of the vertebral bodies are the ventral and dorsal longitudinal ligaments. According to *Beadle* 1931 and *Hirsch & Schajowicz* 1952 the ventral ligament consists of dense fibrous connective tissue in close union with the annulus fibrosus, while the posterior ligament is thinner and consists only of a series of fanlike bands, which are not particularly firmly attached to the disc.

The ligaments of the vertebral arches are the interspinous, including

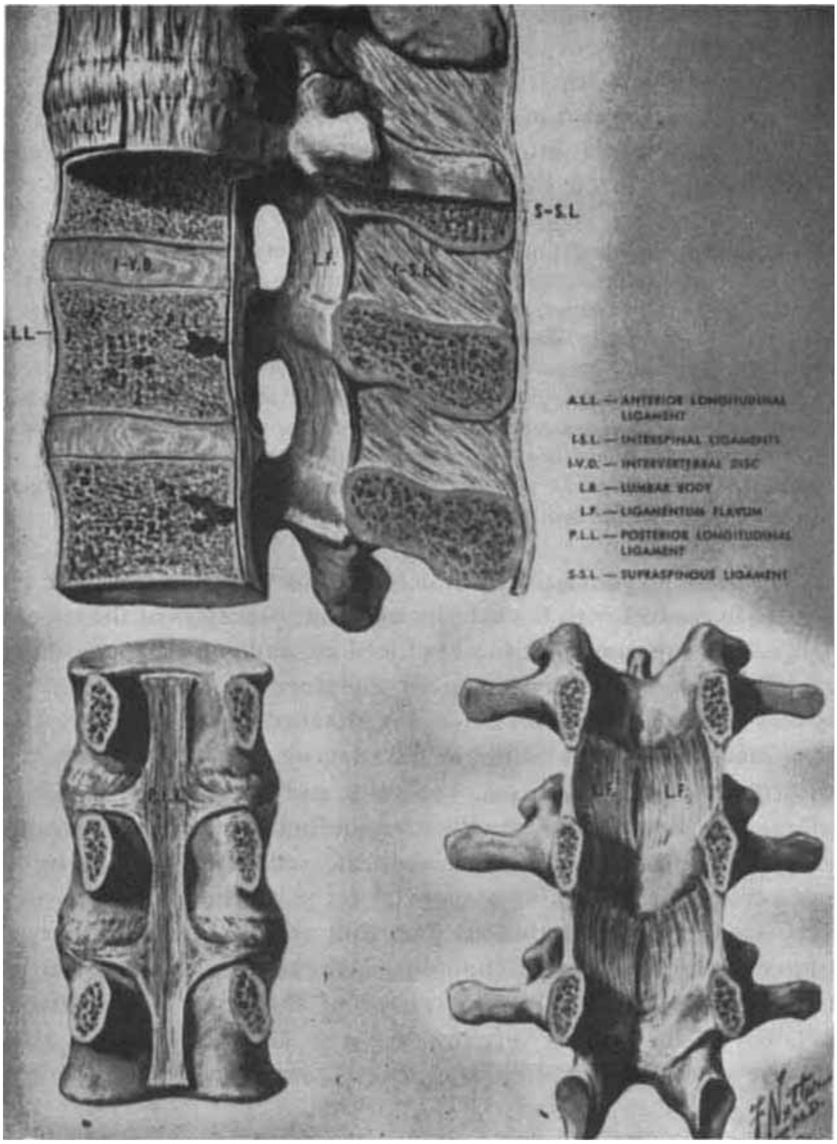

Fig. 1.
The ligaments of the lumbar spine.

the supraspinous group, the intertransverse, and the ligamenta flava. Of these the interspinous ligament is a true ligament.

The flavum ligament has the structure and function of a ligament but it also acts as a fibrous capsule on the ventral surface of the lumbar synovial joint and as an elastic band keeping the spinal nerves free from compression when passing through the inervertebral foramen during movements in the lumbar spine. The intertransverse ligaments appear more as a part of the lumbo-dorsal fascia than as true ligaments.

Besides the multifidus muscle, which seems to be a so-called articular muscle for the synovial intervertebral joints, the muscles of the lumbar region are the sacrospinalis muscles. They are attached to the posterior surface of the sacrum and the iliac crest and insert lateral of the angulus of the ribs. The multifidus muscle covers the intervertebral joints in its run from the mamillary process to its insertion on a spinous process on a level one to two vertebrae above.

The blood vessels of the lumbar spine are branches of the lumbar arteries, which run on the lateral aspect of the vertebral bodies and pass close to the intervertebral foramina. At this level they give off branches to the structures of the vertebral canal, the vertebral arches with their joints and muscles of erector trunci.

The nerve supply is to some extent still unknown. The vertebral arches and the structure posteriorly to them get their nerves from the dorsal ramus of the spinal nerves. This ramus is running in the groove formed by the junction between the transverse and superior articular processes. Thus it is first found on the lateral aspect of the superior articular process and then on the medial aspect of the inferior articular process. During this course it gives off branches to the intervertebral joints and the erector muscles.

The basic articular unit of the vertebral column is, as mentioned above, the two synovial vertebral joints and the associated fibrous intervertebral joint. A movement in anyone of these three joints influences and is influenced by the other two joints in the triad.

During flexion and extension of the spine, the lumbar articular processes exhibit bilateral sliding movements in the sagittal plane while the nucleus pulposus undergoes displacement either dorsally or ventrally. The lumbar vertebral joints appear anatomically designed to facilitate such movements in that their contact surfaces are parallel to the sagittal plane. They allow the mobility which is necessary to accommodate displacements of the nucleus pulposus and at the same time lend lateral stability to the spine. Lateral bending of the spine occurs by means of similar sliding movements in the vertebral joints. On the flexed side each articular process moves into its articular recess.

If any rotation occurs at the lumbar synovial joints, it takes place not through an articular mechanism but by means of the slight degree of elasticity which is found in articular tissues.

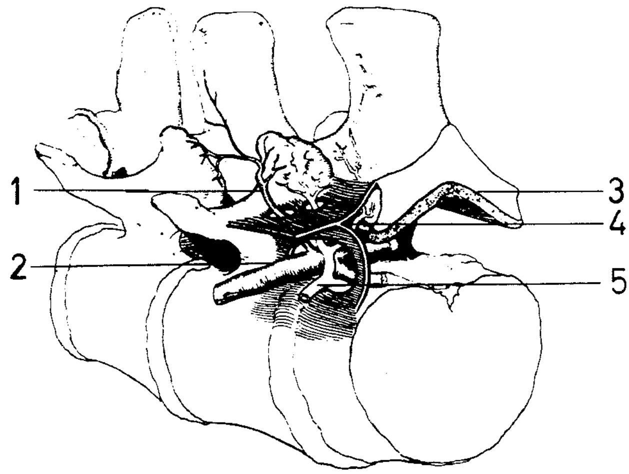

Fig. 2.
A drawing showing some of the topographical relationships in the lumbar spine. 1. Dorsal ramus of spinal nerve. 2. Spinal nerve. 3. Lig.flavum. 4. Intertransverse ligament. 5. Lumbar artery.

Methods of studying nerve endings.

Nerve endings may be demonstrated histologically by either heavy metal impregnation of formalin fixed tissue, or by intravital staining with methylene blue. In anatomical regions such as in ligaments or joint capsules or in other deeply located fibrous structures, nerve terminations are relatively scarce as compared with the more richly innervated cutaneum. The use of methylene blue methods is particularly useful for the study of deep fibrous structures, as large areas of tissue may be stained and studied. Entire joint capsules or broad expanses of ligaments or tendons may be stained either by perfusion or immersion with methylene blue and the nerve endings can be visualized and photographed. Methylene blue has the added advantage of staining very small fibers and with experience one may readily differentiate between nervous and connective tissues.

With heavy metal technics (staining with gold or silver impregnation methods) one is limited to a study of much smaller areas of tissues as sections must be made, and it is often very difficult to stain or mark

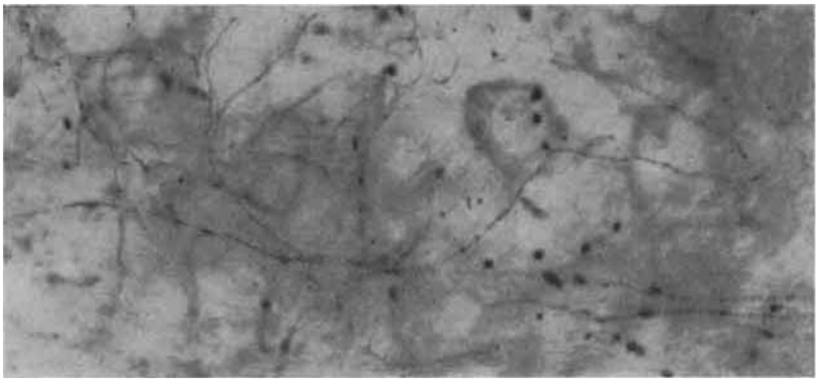

Fig. 3
Free fiber endings in the intervertebral joint capsule of a lumbar intervertebral synovial joint. × 250.

Fig. 4.
Nerve endings associated with two small groups of fat cells in the interspinous ligament between two lumbar vertebrae. × 250.

the finer fibers or endings and the problem of connective tissue and nervous tissue differentiation is always present.

In our experience we have had very good results with the use of both methylene blue perfusion or immersion technics, *Miller* et al. 1958, *Miller & Kasahara* 1959 a; 1959 b; *Ralston* et al. 1960; *Miller* et al. 1960.

We have been able to demonstrate nerve fibers and endings in the ligamentous and joint capsular structures of the lumbar back by use of the methylene blue immersion technic. The lumbo-dorsal fascia, the supraspinous and interspinous ligaments, the ligamenta flava, the

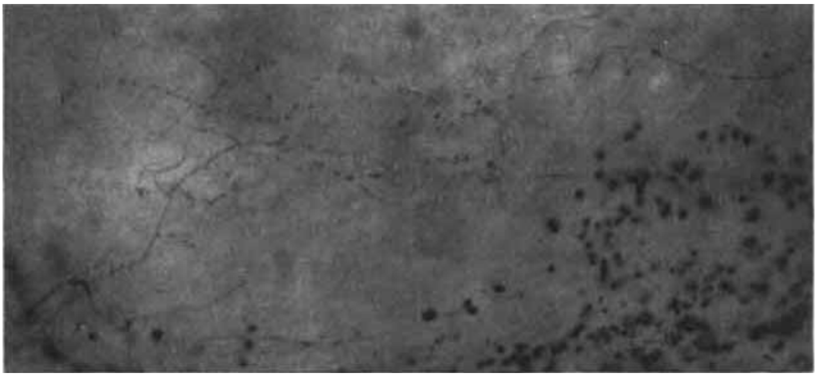

Fig. 5.
Free fiber endings in the outermost layers of the annulus fibrosus just below the posterior longitudinal ligament in the lumbar area. × 250.

vertebral discs have been obtained fresh from surgery and stained by methylene blue immersion. These structures as well as the anterior and posterior longitudinal ligaments and deeper portions of the annuli fibrosi have been studied in relatively fresh cadaver material (four hours post-mortem). Because living tissue is required when using the methylene blue technic, surgically obtained tissues are more satisfactory than autopsy material.

TECHNICAL DATA

Our immersion staining technic consists simply in laying a freshly (usually within one hour after removal from the patient) removed piece of tissue in a 0,005 per cent solution of medical grade methylene blue (may be National Aniline U.S.P. Medicinal C.I. 922; British Drugs, Methylene Blue, B.D.H. Standard; or Chroma, Methylenblau med.) in physiological saline to a liter of which 8 ml. of 0.3 N HCl has been added. Staining is carried out at room temperature for 20 or 30 minutes depending on the thickness of the tissue. After removal from the stainings solution, the tissue is rinsed gently in saline and then aired for 5 to 10 minutes on moist gauze or filter paper. The tissue is subsequently fixed in chilled (8°C) 8 per cent ammonium molybdate for 6 to 12 hours. After fixation the tissues are thoroughly washed in tap or distilled water and then dehydrated in 95 per cent and then absolute alcohol. To facilitate microscopy, the tissues are flattened between two glass plates held together by paper clips or clamps during the period of dehydration. For relatively thick pieces of tissue such as the intervertebral ligament, washing requires approximately two hours, and dehydration an equal length of time. Following thorough dehydration, the tissues are cleared in xylene and then benzyl benzoate. The tissues are stored and studied in the latter medium.

The sensory nerve endings in human lumbar tissues.

As has previously described for many areas of human tissues (see above citations), three types of sensory nerve endings of myelinated nerve fiber origin are found in most areas of the human organism. These are: 1) endings of small (usually less than 3 μ in diameter) myelinated fibers terminating as single branches, 2) complex unencapsulated endings which are nerve terminations derived from medium sized myelinated fibers (5 to 12 μ in diameter) and varying greatly in form from small Golgi-type tendon organs or Ruffini-like endings, to very large and complexly branched, but nevertheless, unencapsulated endings, and 3) encapsulated endings which vary in form from small Golgi-Mazzoni like bulbs to large Pacinian corpuscles.

In the fibrous structures associated with the lumbar spine we have seen some of the above type nerve endings in the following anatomical locations.

A) Lumbo-dorsal fascia
    Fine free fiber and complex unencapsulated endings
B) Supraspinous ligaments
    Fine free fiber and complex unencapsulated endings
C) Interspinous ligaments
    Fine free fiber and complex unencapsulated endings

In almost all anatomical situations, the fine terminals of the complex unencapsulated endings terminate intimate association with bundles of collagenous fibers. Between collagenous bundles of the interspinous ligaments lie occasional small groups of fat cells. The terminations of complex unencapsulated nerve endings have been observed disposed about the walls of the fat cells. A similar situation has been described by *Polaček* 1954 in the joint capsule of the hip joint of the rat. In our opinion, the location of nerve terminals on fat cells implies utilization of the small fatty pads as a mechanical device to register tissue deformation.

In addition to the above types of nerve endings derived from myelinated fibers, we are able to visualize an unmyelinated nerve fiber network associated with blood vessels. While the great majority of the unmyelinated fibers associated with the vasculature are the terminations of post-ganglionic sympathetic fibers, it is probable that some unmyelinated fibers are autonomic afferent in function. From our experience and according to our interpretation, we do not recognize an autonomic ground plexus of afferent nerve fibers. We have observed what may be the terminals of unmyelinated fibers in deep fibrous structures, unassociated with blood vessels, but the exact structual relationships and the function of these nervous elements remains undetermined.

D) Ligamenta flava

We have seen fine free fiber endings on the outermost layer of the dorsal surface of the ligamenta flava, but never in the deeper substance of this structure.

E) Anterior and posterior longitudinal ligaments

Both these structures are innervated by fine free fiber and complex unencapsulated endings. The posterior longitudinal ligament seems to have a greater number of endings, however.

F) Annuli fibrosi

Only on the very outermost layers of the annuli fibrosi, directly adjacent the under surface of the posterior longitudinal ligament we have found free fiber endings. It is probable that these fibers and their endings belong to the same system of nerves supplying the posterior longitudinal ligament. Other than in the most superficial layer of the annulus fibrosus, we have not found nerve fibers nor their terminations. Likewise, the nucleus pulposus is devoid of nerve terminals.

In a few cases of prolapsed nuclei pulposi we have observed a few fine free fiber endings on the outer surface of the prolapse. The latter endings were related to the outermost layers of the annulus or to the adherent posterior longitudinal ligament and had not penetrated the substance of the nucleus pulposus. We have not yet had the opportunity of observing whether blood vessels entering a degenerating intervertebral disc provide entry for nerve fibers or nerve endings. That such occurs is probable, as we observed small myelinated nerve fibers entering opened cartilage spaces in the articular cartilage of arthritic bones. In the latter cases, the nerve fibers were seen entering the opened cartilage spaces along with small blood vessels from the trabecular sub-chondral region.

G) The intervertebral joint capsules

These capsules are innervated by the full triad of nerve endings: fine free fibers, complex unencapsulated, and small encapsulated endings. In this respect, these joint capsules differ in no remarkable manner from any other joint capsule, *Ralston* et al. 1960; *Stilwell* 1957.

H) Vertebral periosteum

Both fine free fiber and complex uncapsulated endings are found in this tissue.

I) The lumbar vertebrae

While so far our techniques have not permitted us to visualize the nerves or nerve endings in the trabecular bone of the vertebrae, it is highly probable that these structures are well innervated as we have been successful in demonstrating both small myelinated and unmyelinated fibers (not associated with blood vessels) in the subchondral bony trabeculae of the femoral head and condyles, in the metatarsal bones, and in the navicular and talus bones of the foot (unpublished). Further, *Stilwell* 1957, has demonstrated that nerve bundles enter the many vascular foramina in the lumbar vertebrae of monkeys.

It is significant that our findings of the nature and distribution of the nerve endings in the ligamentous structures of the human lumbar spine are in close agreement with the findings of *Stilwell* 1957 in the monkey.

In addition to the endings of myelinated fibers described above, we have found unmyelinated fibers and endings associated both with blood vessels and among the connective tissue fibers (not close to blood vessels of all the ligamentous structures of the lumbar spine.

Clinical interpreparation.

The presence of many cartilaginous and ligamentous connections between vertebrae illustrate a complex functional unit. In all these elements sensory nerve-endings of various types have been found. It is, however, imperative to point out that there is no correlation between structure and function of these sensory elements. We merely assume that unmyelinated free fiber endings may be associated with pain or thermal perception, complex unencapsulated endings with tissue position or joint sense, and encapsulated endings with pressure perception. Besides the possibility that some types of nerve endings may be specialized to respond more readily to certain types of stimuli, there is evidence that sensory perceptions may be the result of different types of nerve endings and fibers functioning together, and/or certain types of nerve endings may be concerned in the perception of more than one sensory modality.

In analyzing the clinical picture of lumbago it is well recognized that it consists of a variety of symptoms including changes in posture. These symptoms might be explained by different types of sensory nerve reactions.

Since all cartilaginous and ligamentous tissues have sensory nerve endings, theoretically pathology affecting any of these elements might cause clinical symptoms. If the observations of differences in modality are accepted it would mean that the disc and its longitudinal ligaments would respond with pain only, while the joint-capsules and ligaments would add loss of joint sense and posture control. It is also possible that disturbances at one place could interfere with the function of sensory reactions in other areas, resulting in a greater variety of symptoms.

Since on the other side very little is known about the function of the sensory endings in these structures one cannot accept this theory unless studies have been made on how the patient responds when the disc, the joints and ligaments are subjected to irritation.

This subject was touched upon by *Kellgren* 1938, 1939 and by *Lewis & Kellgren* 1939. They injected 6 per cent saline into interspinous ligaments and other deep structures and studied the distribution of pain. The importance of lesions in posterior intervertebral ligaments as a cause of low back pain was claimed by *Kellgren* in 1942. *Lewis & Kellgren*'s assumption was doubted by *Sinclair* et al. in 1948. Their injection of hypertonic saline into interspinous ligaments did not cause referred pain.

Studies on pain following injections of hypertonic saline in discs, joints and ligaments in the low back.

In order to check the different cartilaginous and ligamentous elements as to the symptoms they may cause, when subjected to irritation, hypertonic solution of saline (11 per cent) was injected in the following way. One thin long needle was introduced between the spinous processes transdurally into the fourth or fifth, or both lumbar discs in patients with low back pain. Another needle was placed on one of the lower intervertebral joints. Positions were checked by X-ray in AP and lateral views. The patients were in a prone position and were not under any anaesthesia. Less than 0.3 ml. was injected to the vertebral joint. Pain occurred after a few seconds and was very annoying. The patients could locate the pain to a distinct area. It had some similarity with a low back attack. After a while the pain was distributed along the sacro-iliac and gluteal areas and then spread out to the greater trochanter. It disappeared after a few minutes. 0.3 ml. was then injected into the disc. After a few seconds a very severe pain occurred, identical to a real lumbago. The patients could not locate the site. They felt a deep aching across the low back. Under X-ray control the needle in the midline was withdrawn to the level of the flavum ligament. A new injection of the same amount of saline gave a very moderate reaction. The patients told us that they could spot some pain in the midline of the back. When the same manoeuvre was repeated with the needle in the interspinous and supraspinous ligaments a slightly more pronounced reaction appeared. The patients were able to say where the pain came from. In the dorsal fascia the reaction was stronger but was still felt as a local affair.

These experiments seem to support the conclusion that the disc is the most sensitive area for low back pain. The vertebral joints may come into consideration. Posterior ligamentous structures do not give clinical evidence of lumbago.

SUMMARY

The presence and pattern of sensory nerve endings have been studied in discs, joints and ligaments in the lumbar spine. In tissues removed at surgery and from fresh autopsies sensory nerve terminals have been demonstrated by intravital staining with methylene blue.

Fine free fibers and complex unencapsulated endings have been found in the lumbo-dorsal fascia, supra- and interspinous ligaments, vertebral periosteum and anterior and posterior longitudinal ligaments.

The intervertebral joint capsules are like other joints and innervated by the full triad of nerve endings, fine free fibers, complex unencapsulated and small encapsulated endings.

In ligamenta flava fine free fibers have been seen on the outermost layer of the dorsal surface, but never in the deeper structure.

Only in the very outermost layers of the annuli fibrosi, directly adjacent to the posterior longitudinal ligament have we found free fiber endings. The nucleus pulposes is without nerve terminals.

Although very little is established between structure and function of these sensory elements it is assumed that free fiber endings will be associated with pain, complex unencapsulated endings with tissue position and joint sense and encapsulated elements with pressure perception.

Hypertonic saline injection into ligamentous, capsular and disc structures in clinical cases have supported the histological findings of painfibers and even illustrated differences in response. A full low back pain syndrome appeared from the annulus fibrosus, some similarity was obtained from the intervertebral joints while the posterior ligamentous structures only caused very localized pain.

The pattern of the sensory nerve supply of the lumbar spine widens the basis for analyzing the various components in different types of low back pain syndromes.

RESUME

On a étudié la présence et la distribution des arborisations terminales des nerfs sensitifs dans les disques, les articulations et les ligaments de la colonne lombaire. Dans des tissues prélevés au cours d'opérations ou d'autopsies fraîches, on a établi la présence d'arborisation terminale de nerfs sensitifs par coloration intravitale au bleu de méthylène.

Des filets libres et des arborisations terminales sans gaîne ont été trouvés dans le fascia lombo-dorsal, les ligaments supra et interépineux, le périoste vertébral et les ligaments longitudinaux antérieur et postérieur.

Les capsules des articulations intervertébrales sont comme celles des autres articulations; elles sont innervées par toute la série d'arborisations terminales, de filets libres, d'extrémités sans gaîne et enveloppées de gaîne.

On a également observé des filets libres dans la couche extérieure de la surface dorsale des ligaments jaunes, mais jamais dans les structures plus profondes.

C'est seulement dans les couches superficielles de l'anneau fibreux, directement adjacentes au ligament longitudinal postérieur que nous

avons trouvé des bouts de filets libres. Le noyau pulpeux n'a aucune arborisation terminale de nerf.

Bien que l'on n'ait pas des connaissances étendues sur les rapports entre la structure et la fonction de ces éléments sensitifs, on suppose qu'il faut associer le bout des filets libres à la sensation de la douleur, l'arborisation terminale sans gaîne à la sensation de la position des membres et l'élément enveloppé de gaîne à la sensation de la pression.

Des injections salines hypertoniques effectuées en clinique dans les ligaments, les structures capsulaires et discales ont appuyé les trouvailles histologiques de ces fibres douloureuses et elles ont illustré aussi la différence des réactions. Un syndrome prononcé de douleur dans la partie inférieure du dos partait de l'anneau fibreux. Quelque chose de similaire a été observé par rapport aux articulations intervertébrales, alors que les structures du ligament postérieur ne provoquent que des douleurs fortement localisées.

La distribution des nerfs sensitifs dans la colonne vertébrale élargit la base de l'analyse des éléments variés que constituent les différents types de syndromes douloureux dans la partie inférieure du dos.

ZUSAMMENFASSUNG

Das Vorhandensein und die Verteilung von sensiblen Nerven in Zwischenwirbelscheiben, Gelenken und Ligamenten in der Lendenwirbelsäule wurden untersucht. In Geweben, die anlässlich chirurgischer Eingriffe entfernt worden waren und an frischem autoptischen Materiale wurden sensible Nervenendigungen mittels intravitaler Färbung mit Methylenblau nachgewiesen.

Feine, freie Fasern und komplexe nicht eingekapselte Endungen wurden in der lumbo-dorsalen Fascie, den ligamenta supra- und interspinosa, dem Wirbelperiost und den ligamento anteriora und posteriora gefunden.

Die intervertebrale Gelenke werden wie andere Gelenke durch die dreifache Art von Nervenendigungen versorgt, nämlich von freien Fasern, komplexen nicht eingekapselten und kleinen eingekapselten Nervenendigungen.

In den ligamenta flava wurden feine, freie Fasern in der äussersten Schichte der dorsalen Oberfläche aber niemals in den tieferen Lagen gesehen.

Nur in den äussersten Lagen der annuli fibrosi, die dem ligamentum

longitudinale posterius direkt anliegen, haben wir freie Fasern gefunden. Der nucleus polposus hat keine Nervenendigungen.

Obwohl sehr wenig über den Zusammenhang von Struktur und Funktione dieser sensiblen Element bekannt ist, nimmt man doch an dass freie Faserendigungen mit dem Schmerz, komplexe nicht eingekapselte Endigungen mit Gewebspostion und Gelenksgefühl und eingekapselte Elemente mit Druckgefühl in Zusammenhang stehen.

Injektion von hypertonischer Kochsalzlösung in Bänder, Gelenkskapseln und Zwischenscheiben in klinischen Fällen haben die histologischen Befunde von Schmerzfasern unterstützt und sogar Verschiedenheiten in der Reaktion aufgezeigt. Ein volles Lumbagosyndrom wurde vom annulus fibrosus ausgelöst, ähnliche Symptome wurden von den intervertebralen Gelenken erhalten, während an den posterioren Bandstrukturen nur sehr ortbundener Schmerz hervorgerufen werden konnte.

Die Anordnung der sensiblen Nervenversorgung der Lendenwirbelsäule erweitert die Basis für die Analyse der verschiedenen Komponenten bei unterschiedlichen Typen des Lumbagosyndromes.

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