

BACK PAIN IN RELATION TO THE NERVE SUPPLY
OF THE INTERVERTEBRAL DISC

BY
GUNNAR WIBERG

The problem of the genesis of pain in the back is as interesting as it is difficult. In view of the remarkable frequency of the different pains in the back, it is surprising that the problem has not been more studied than it has. But this becomes perhaps more understandable, when one approaches the subject more closely and discovers all the difficulties connected with this problem.

Although pain occurs in all parts of the back, it is most common in the lumbo-sacral region, and I will confine my remarks to this region. Our recently acquired knowledge of sciatica and disc prolapse may shed some light on the subject and is a further reason for confining discussion to this part of the back.

The pain may arise from a number of tissues. Muscles, ligaments, intervertebral discs, intervertebral joints, and perhaps even the bone itself may be the origin of the pain. An earlier much advocated theory proposed a myalgic origin for the pain, and I need only mention *Folke Lindstedt's* big work on the subject. We have, however, gradually abandoned this explanation, which, though the possibility of a muscular origin cannot be entirely excluded, now seems less likely. For instance, night pain may occur and even waken the patient, and it does not seem likely that a resting muscle would cause such pain.

Leriche and *Jung* were able, in a number of cases of back pain and reduced disc space, to make the pain disappear and the disc space increase by the injection of local anaesthetic

round the vertebral bodies. They considered that this would be satisfactorily explained if the pain arose from the ligamentous coverings of the disc, and caused a contracture and narrowing of the disc. They do not discuss whether the pain should be regarded as arising directly from the nerve fibres in the ligament, or whether its real origin was the muscle contracture due to the irritation.

Meanwhile, it seems that a study of the nerve supply to this part of the back might be of some value in this question, and *Luschka* and *Hovelaque* and, more, recently *Roofe* have studied this aspect.

Luschka was the first to demonstrate a special nerve which arose just distal to the spinal ganglion, joined a sympathetic branch and passed into the spinal canal where it split up into branches. He called it the sino-vertebral nerve. Some of the end branches ended at the base of the neural arch, and he believed that they probably entered the bone. Other branches followed the vessels, and others were distributed in the space between the dura and the ligaments of the spinal canal.

Hovelaque made similar anatomical investigations, but came in part to different conclusions. He, however, gave no information about the part of the back, which is in this connection of most interest, namely, the lumbar region; one may perhaps assume that this region does not differ from the thoracic and sacral regions. *Hovelaque*, like *Luschka*, believes that the sino-vertebral nerve is formed by a cerebro-spinal and a sympathetic root, although sometimes there may be two roots of the same type. The roots either unite early, so that a single stem passes through the intervertebral foramen, or later, within the spinal canal. The common stem, when well inside the canal, breaks up into end branches, which end as fine fibres in the dura, the outer surface of the vertebral bodies, the ligaments and the vessels. *Hovelaque* did not confirm *Luschka's* findings that the sino-vertebral nerve divided into proximal and distal branches which anastomosed with the nerve above and below.

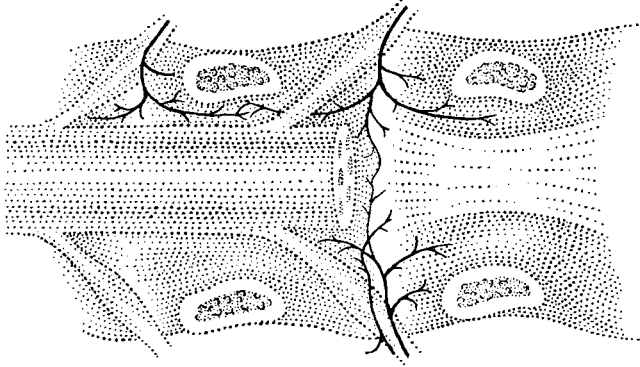


Fig. 3.

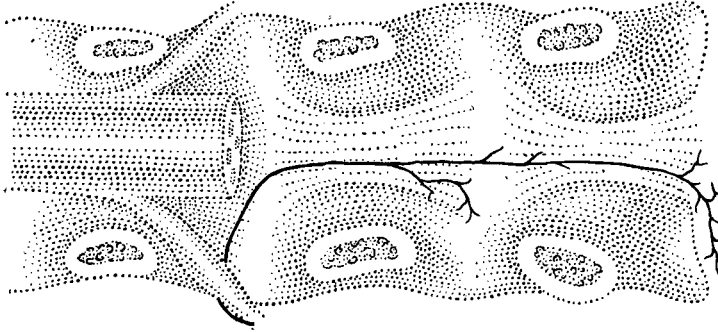


Fig. 2.

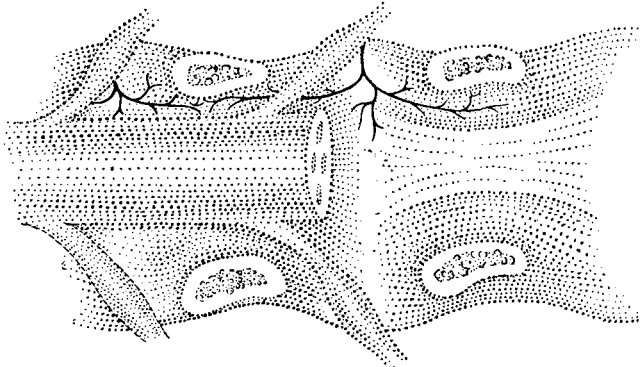


Fig. 1.

The course and division of the recurrent nerve (sino-vertebral nerve) according to
1. *Luschka*. 2. *Roofe*. 3. The author.

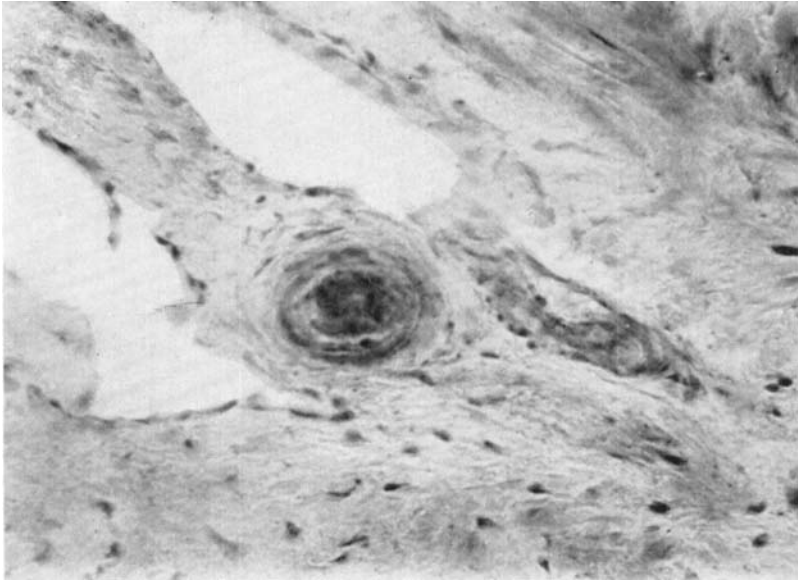


Fig. 4.

Longitudinal section of nerve fibre in outer layer of the ligamentous covering of the intervertebral disc. (silver staining according to *Gross-Schultze*).

The American worker, *Roofe*, (1940), found that a recurrent branch was given off just distal to the ganglion, ran into the spinal canal through the intervertebral foramen, and passed down as a main stem to be distributed in the ligaments one or two vertebral levels below its entrance.

In order to form my own opinion on these macroscopic findings I have dissected a number of specimens of the lower lumbar vertebrae and sacrum. The posterior skeletal parts (the spinous processes, the vertebral arches and the intervertebral joints) were removed, and the dural sac and the nerve roots leaving it were exposed. It was found that it was easier to make the dissection on quite fresh material, which had not been hardened in formalin, and 14 peripheral nerve roots and spinal ganglia have been dissected out in this way. It was often difficult to distinguish between the very fine

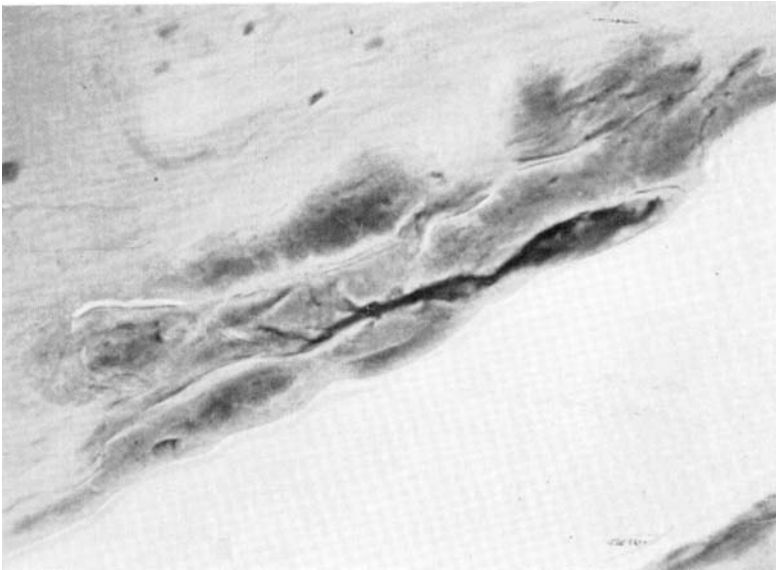


Fig. 5.

Transverse section of nerve in the ligamentous covering of the intervertebral disc. (silver staining according to *Gross-Schultze*).

nerve fibres and the vessels, and in some instances their real nature had to be determined later histologically. Usually I found that a nerve ($\frac{1}{2}$ -1 mm. thick) arose distal to the ganglion, passed back through the intervertebral foramen, and immediately divided in the spinal canal into end branches, which ran toward the base of the spinous process and the ligamentum flavum. In some cases there was also a smaller nerve arising distal to the ganglion, which joined with a branch from the sympathetic. This combined nerve also passed through the intervertebral foramen into the spinal canal, where it soon broke up into branches to the ligamentous tissues, particularly in the neighbourhood of the disc.

The dissection of the fine terminal branches in the skeleton is sometimes particularly difficult, and I think this is the reason for the different findings of different workers. It seems at any rate to be certain that a recurrent branch arises distal

to the ganglion and is joined by a branch from the sympathetic chain (in most cases). The branching of the nerve may vary considerably, and the different branches may join each other.

It was necessary to supplement these macroscopic findings by microscopic examinations, paying particular attention to the disc and the ligamentous connections between the vertebral bodies.

Jung and *Brunschwig*, two of *Leriche's* pupils, investigated the intervertebral disc and the nerve supply of the surrounding ligaments. They came to the conclusion that the nucleus pulposus and annulus fibrosus contain no nerve tissue, but that there are nerves in the surrounding fibrous ligaments. The anterior border of the disc would have a particularly plentiful nerve supply, i.e. in the attachments of the anterior longitudinal ligament to the annulus fibrosus, while the lateral, and even more the posterior, borders would be less well supplied. The nerve branches always appeared to end in the inner part of the connective tissue layer of the ligament, and these workers were not once able to find nerve branches in the outer layer of the annulus fibrosus. They also thought that the nerves contained sympathetic fibres.

My own histological studies on the innervation of the intervertebral discs were made on specimens taken from adults and from full term foetuses, the lumbar discs being examined. In the first series 6 discs were sectioned. After fixation in 10 % formaldehyde, frozen sections 20-30 mm. thick were made. The sections were silver-stained according to *Gross-Schultze's* method, which stains the axis cylinders of the nerves. In 2 of the 6 cases, nerve fibres could definitely be demonstrated; in one there was a longitudinal and in the other a transverse section of the nerve fibre. In both cases the nerve lay in the outer part of the ligament. No nerves were seen in the annulus fibrosus or nucleus pulposus. In 6 adult cases the vertebral bodies and their ligaments were also examined, and in these cases the specimens were decalcified after fixation in 10 % formaldehyde, embedded in paraffin

wax and stained by *Bodian's* method. No nerves were seen in the vertebral bodies, or in the ligamentous coverings.

This part of the investigation was particularly difficult, since the decalcification appeared to be a very harsh treatment for the nerves' delicate structure. For this reason, the series of foetal preparations is being studied, in the hope that more positive findings will be obtained after the less harsh treatment which they require. These investigations are not yet complete.

It is certainly desirable to supplement these examinations of the macro- and microscopical nerve supplies of the intervertebral disc by studies of living material, and one would expect operations for disc prolapse to provide a satisfactory opportunity. It should be possible to discover by palpation how pain originates in the different parts of the back. There are, however, practical difficulties, since palpation affects more than one part (intervertebral disc, vertebral body, nerve root, ligament, intervertebral joint, etc.). It is not possible to know whether palpation of one part, e.g. the surface of the vertebral body, may not cause pain from the intervertebral disc, due to movement.

However, during the last 3 years, various tests have regularly been made at operation, in spite of these drawbacks; and generally speaking I can agree with *Spurling* and *Grantham's* findings, that palpation of an intervertebral disc causes pain in the back; and I think that the results of palpation can even be more exact. The operations are now performed under a local anaesthesia (confined to the skin, subcutaneous tissues and muscles), which has no action on the nerve roots; this can be demonstrated by palpation of the root, which always causes acute root pain.

Touching the ligamentum flavum caused no sensation; this is well known to all surgeons of disc prolapse, as the ligament can be divided without any anaesthesia. In most subjects, firm pressure on the posterior surface of the vertebral body caused no pain, and in the few, among 200 operated cases, who felt pain, it could be explained as arising from a

change in the relative positions of the vertebral bodies causing pain from the intervertebral disc. On the other hand, touching the disc itself caused pain of lumbosacral distribution in nearly all cases, and the patients stated that it felt as if the pain was inside the back. In some cases it was possible to palpate the disc without a preliminary anaesthetic injection of the nerve root, but in most the root had to be anaesthetised before the posterior part of the disc could be exposed for palpation. No difference between the results of these two groups was found, and in view of our knowledge of the recurrent nerve branches this must be interpreted as evidence that the disc has a nerve supply in addition to the recurrent nerve, since no pain could pass through the anaesthetised root. There are two possible explanations; either, in accordance with *Roofe's* studies, a branch of a recurrent nerve supplies lower discs, or the pain is transmitted by the recurrent nerve of the opposite side. Naturally, one does not often have the opportunity to extend the examination and anaesthetise most of the nerve roots on one or even both sides. In some cases, however, I have been able to do this, and have tried to produce pain when two roots on the same side have been anaesthetised. Pain could still be elicited from both the segmental intervertebral discs, and no conclusions can be drawn. The explanation may be one of those suggested above, either the recurrent nerve branch supplies the intervertebral disc two vertebrae lower, or the recurrent branch from the opposite side transmits the pain.

In some cases an elevator was inserted into the intervertebral disc after the prolapse had been removed, to find whether touching the surface of the vertebral body facing the disc caused pain; the result was always negative.

Although these anatomical, histological and clinical investigations do not form a definite proof that pain in the back arises in the intervertebral disc, or, more accurately, in its ligamentous coverings, one may venture to say that there are considerable points in favour of this hypothesis. Disc degeneration causes a certain instability between the vertebrae, and thus there arises the possibility of strain on the ligamentous

covering of the disc. Distraction, which is impossible under normal conditions, may occur, causing pain in the nerves in the ligament.

In this connection I should like to put forward a further idea, which may perhaps be regarded as support of this conception.

The condition is well-known in which a patient with acute lumbago, a few hours, or perhaps a few days, later gets a true sciatic pain which is found at later operation to be due to a prolapse of the intervertebral disc.

It is natural to seek a common explanation for the lumbago and the sciatica, and it remains only to ask whether the lumbago is not also explained by the disc prolapse.

Andersen suggested that when the annulus fibrosus ruptures under strain, bleeding occurs into the tissues and causes pain. *Waldenström* has suggested that when a part of the disc passes through a rupture in the annulus and reaches the surface, it first meets the nerve fibres in the periphery of the root, and it is the irritation of these which causes the lumbago. If the rupture extends further the deeper fibres within the root are compressed, and sciatic pain results.

For myself, I think that it is conceivable that the ruptured disc which is found in disc prolapse from whatever cause (awkward movement, severe strain), shifts forward to the ligamentous coverings and presses on this nerve-containing tissue; this causes a severe pain in the form of an attack of lumbago. If the disc shifts still further, and reaches the nerve root, sciatic pain also develops.

Thus, this conception of the origin of the pain from the ligamentous covering of the disc would explain both the chronic lumbar pain of insufficiency, and its development into a more acute type of lumbago. If we presume this so far hypothetical explanation to be correct, the genesis of back pain is found to be unified.

SUMMARY

The author has dissected preparations of the lumbar and sacral spines, and, like *Luschka*, *Hovelaque* and *Roofe*, was able to confirm the existence of a nerve which arises distal to the ganglion, passes back through the intervertebral foramen into the spinal canal and there divides up. The presence of nerves in the intervertebral disc has also been investigated microscopically, and fibres were found in the ligamentous coverings of the disc. Examinations made at disc operations showed that pain could be caused by touching the surface of the disc, but not by touching the surfaces of the vertebra or the ligamentum flavum. Like *Leriche* and *Jung*, the author believes that it is conceivable that pain arises from the ligamentous covering of the discs.

RESUME

L'auteur a pratiqué la dissection de préparations de la colonne vertébrale lombo-sacrée et comme *Luschka*, *Hovelaque* et *Roofe*, il a pu percevoir un nerf s'éloignant du ganglion et revenant par le trou de conjugaison dans le canal rachidien pour s'y diviser en plusieurs branches. Il a procédé par ailleurs à l'examen microscopique des nerfs qui apparaissent dans les ménisques et il a pu découvrir des filets dans le tissu fibreux recouvrant le disque. Des examens pratiqués à l'occasion d'opérations de ménisques ont prouvé qu'il est possible de déclencher une douleur par la palpation de la surface du ménisque et non par la palpation des surfaces du corps de la vertèbre ou du ligamentum flavum. Comme *Leriche* et *Jung*, l'auteur estime qu'il est probable que le déclenchement de la douleur provient du tissu fibreux recouvrant les ménisques.

ZUSAMMENFASSUNG

Der Verfasser hat Sezierungen am Lumbosakralrücken vorgenommen und konnte, ebenso wie *Luschka*, *Hovelaque* und *Roofe*, einen distal vom Ganglion abgehenden Nerven

feststellen, der via foramen intervertebrale in den Spinalkanal zurückkehrt und sich dort verzweigt. Weiterhin wurden mikroskopische Untersuchungen über das Vorkommen von Nerven in den Zwischenwirbelscheiben durchgeführt. Nervenfasern konnten in den ligamentösen Bekleidungen der Scheiben nachgewiesen werden. Untersuchungen im Zusammenhang mit Diskusoperationen haben erwiesen dass eine Schmerzauslösung durch Berührung der Scheibenoberfläche aber nicht durch Berührung der Wirbeloberfläche oder lig. flavum geschehen kann. Verfasser ist der Meinung ebenso wie *Leriche* und *Jung*, dass die Schmerzauslösung wahrscheinlich von der Ligamentbekleidung der Zwischenwirbelscheiben aus geschieht.

REFERENCES

- Andersen, T.*: Nord. Med. 1943, 2295.
Badgley, C.: Journ. of Bone and Joint Surg. 23, 1941, 481.
Craig, W. and Walsh, M.: Journ. of Bone and Joint Surg. 23, 1941, 417.
Le Fort, R. and Ingeltrans, P.: Revue d'orthop. 17, 1930, 705.
Güntz, E.: Schmerzen und Leistungsstörungen bei Erkrankungen der Wirbelsäule. Ferd. Enke. 1937. Beilageheft zur Z. f. Orthop.
Hovelacque, A.: Ann. d'anat. pathol. 2, 1925, 435.
Jung, A. et Brunshwig, A.: La Presse medicale Febr. 1932, 316.
Leriche, R.: La Presse medicale Mars 1930, 417.
— et *Jung, A.*: La Presse medicale April 1931, 561.
Poirier, P. et Charpy, A.: Traité d'anatomie humaine. Paris 1899.
Renant, J. et Regaud, Cl.: Revue générale d'histologie.
Roofe, P.: Arch. of Neurol. and Psych. 44, 1940, 100.
Smith, R.: Brit. Journ. of Surg. 18, 1930, 358.
Spurling, R. G. and Bradford, F.: J.A.M.A. 113, 1939, 2019.
— and *Grantham, E.*: Arch. of Surg. 40, 1940, 375.
Waldenström, H.: Acta Chir. 91, 1944, 11.