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COMPARISON OF PATHOLOGIC CHANGES IN INTERVERTEBRAL DISCS AND INTERSPINOUS LIGAMENTS OF THE LOWER PART OF THE LUMBAR SPINE IN THE LIGHT OF AUTOPSY FINDINGS

By

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Low back pain is very common in modern man. The etiological factors in these painful conditions are very diversified, but in the majority of cases they are caused by degenerative changes in the intervertebral discs and interspinous ligaments or by prolapse of the disc. The literature contains numerous detailed descriptions of the different forms and the occurrence of disc degeneration, viewed from various aspects. Detailed reports are available also on disc prolapses, especially on their clinical picture, patho-physiology, mechanism of production, and treatment. Studies of pathological changes in the interspinous ligaments of the lumbar spine during life have also been published. On the other hand, the present writer has not found pathoanatomical studies in which changes in the intervertebral discs and in the corresponding interspinous ligaments were examined at the same time. There has been need of a study of this kind, especially since it has been suggested that rupture of the interspinous ligaments may possibly have significance in the genesis of disc prolapse (*Newman 1952, Hackett 1957, Kallio 1958, 1960, Rissanen 1960*).

MATERIAL AND METHODS

The study was carried out on autopsy material from 30 male and female subjects in the age range 30-70 years. This age group was chosen deliberately since the greatest percentage of pathological changes and

ruptures in the interspinous ligaments occur during these years (*Rissanen* 1960).

The intervertebral discs and interspinous ligaments of the LIII-LIV, LIV-LV and LV-SI spaces were examined. Thus a total of 90 intervertebral discs and the same number of interspinous ligaments were studied. The lower part of the spine from the third lumbar vertebra to the sacrum, including the spinous processes, was detached and examined macroscopically. The specimens for microscopic study were fixed in 10 per cent neutral formalin and decalcified by the EDTA method (ethylene-diamine-tetra-acetic acid, disodium salt: *e.g.*, *Dotti et al.* 1951, *Sreebny & Nikiforuk* 1951) at 37° C and pH 7.2–7.4 of the solution. The sections were stained by the Weigert-van Gieson technique (*Romeis* 1948). In addition, Sudan IV (*Gatenby & Painter* 1946), Kossa's silver (*Romeis* 1948), Alcian blue (*Lison* 1954) and toluidine blue staining was performed for more detailed examination of the different changes.

RESULTS

Macroscopic Changes

For comparison of observed changes in the ligaments and discs they were classified into three groups on the basis of the gross observation: (1) no macroscopic changes from the normal structure, (2) mild degenerative changes, (3) pronounced degenerative changes. The criteria for mild changes were some degree of thickening of the ligament, clearly visible to the naked eye, with the loose connective tissue distinctly proliferated but the true tendinous tissue decreased, and possibly, in addition, small beginnings of cavitation in the center of the ligament. In the group of pronounced degenerative changes I included the cases with a large cavity within the ligament which gave it the external appearance of marked thickening, and furthermore the cases in which a partial or complete rupture was demonstrable in the interspinous ligament.

The intervertebral discs placed in group 2 were those in which the nucleus in the cross section of the disc was abnormally firm and the disc showed pigment aggregation, distinct fissure formations and possibly small incipient cavity formations within the disc. In group 3 I included the cases with large fissures and cavities within the disc, either in the nucleus or the annulus, ruptures in the annulus, and considerable changes in the macroscopic structure of the disc as a whole.

The interspinous ligaments examined were distributed as follows between the different groups:

	<i>No Changes</i>	<i>Mild Degenerative Changes</i>	<i>Pronounced Degenerative Changes</i>
LIII-LIV	16	7	7
LIV-LV	3	13	14 (2 ruptures)
LV-SI	6	9	15 (7 ruptures)

The discs examined were distributed between the different groups as follows:

	<i>No Changes</i>	<i>Mild Degenerative Changes</i>	<i>Pronounced Degenerative Changes</i>
LIII-LIV	18	7	5
LIV-LV	8	9	13
LV-SI	9	9	12

Comparison of the gross changes and their degree of severity in the interspinous ligaments and the intervertebral discs definitely reveals in 70 out of 90 cases the same degree of severity in the disc and in the corresponding interspinous ligament. A slight inconsistency was found in 20 cases between the changes in the ligament and the disc, the disc changes being interpreted in nearly all cases as less marked than the changes in the corresponding interspinous ligament.

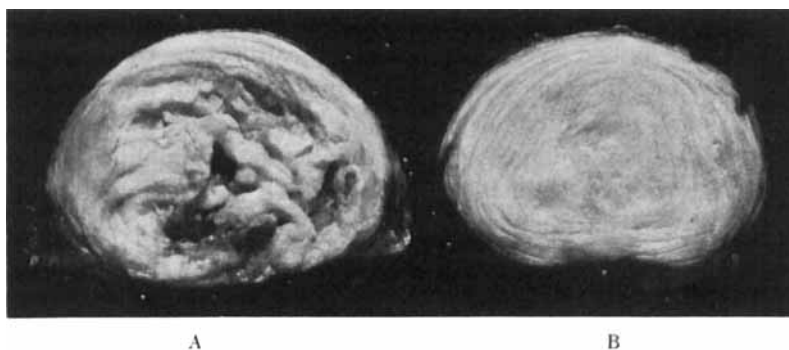


Fig. 1.

Photograph of the intervertebral discs of the LV-SI (A) and LIV-LV (B) spaces in a woman aged 32. Pronounced degenerative changes and total rupture were found in the interspinous ligament of the LV-SI space, but the ligament in the LIV-LV space was intact. The disc of the LV-SI space appears to be degenerated and shows ruptures and defects in the area of both the annulus and the nucleus pulposus, whereas the disc of the LIV-LV space appears normal to the naked eye.



Fig. 2.

Intervertebral disc of the LV-SI space in a woman of 61. There were total rupture and pronounced degenerative changes in the corresponding interspinous ligament. The disc shows pronounced degenerative changes, ruptures and defects in the annulus.

The changes and their uniformity in the ligament and the corresponding disc were very distinct in the majority of the cases (Fig. 1). When highly pronounced degenerative changes had occurred in the interspinous ligaments, giving rise to a large cavity in the ligament, with almost complete disappearance of the true ligament tissue, the disc also showed ruptures in the annulus and fissure and cavity formation.

The material studied contained 2 pathological ruptures in the interspinous ligaments of the LIV-LV space and 7 in the ligaments of the LV-SI space, making a total of 9 ruptures. The corresponding intervertebral disc was very markedly degenerated in all these cases. Each revealed major or minor ruptures in all the layers of the annulus throughout the disc. Cavities and defects of various sizes were found inside the discs (Figs. 1 and 2). However, I did not encounter a single clearly definite disc prolapse among these 9 ruptures, either protrusion of the nucleus pulposus or of the annulus, even if one of these cases displayed a slight and indistinct local bulging of the outermost fibres of the annulus, which could not definitely be regarded as a manifest prolapse. However, all these cases had so many ruptures and fissures

in the area of the annulus fibrosus that prolapse of the disc probably could have occurred under suitable conditions. Such ruptures and fissures in the annulus fibrosus were also seen in cases with no true ruptures in the corresponding interspinous ligaments, but the latter were then always markedly degenerated.

Microscopical Changes

Numerous descriptions of the pathological histology of disc degeneration have been published in various countries (*Böhmig* 1929, *Smith* 1931, *Donohue* 1939, *Coventry et al.* 1945, *Alvik* 1950, *Hirsch & Schajowicz* 1952, *Malinsky* 1958, etc.). All the types of disc degeneration described were encountered in the present material in varying degrees of severity. Fatty degeneration was very common in disc degeneration. In cases with gross distinct degenerative changes the fatty degeneration was often very pronounced (Fig. 3), especially in the region of the annulus fibrosus. The fatty substances usually accumulated as foci adjacent with other degenerative changes.

In the cases in which no definitely degenerative changes were seen



Fig. 3.

Sudan IV staining of the intervertebral disc of the LV-SI space in a man of 57. The disc was degenerated and the corresponding interspinous ligament showed marked degenerative changes and partial rupture. A site of heavy lipid staining is seen in the area of the annulus.



Fig. 4.

Alcian blue staining of the intervertebral disc of the LV-SI space in a man of 52. The disc was degenerated and the corresponding interspinous ligament was ruptured. A typical cystic formation filled with a homogeneous mass, staining bluish-green is seen in the middle of the fibres of the annulus.

grossly, the microscopic examination revealed a decrease in the number of nuclei and weakening of the stainability of the tissue components by the van Gieson technique. When the disc degeneration was visible to the naked eye, the changes brought out by this staining were also pronounced. Here and there were areas of completely necrotized tissue, leaving minor or major defects in the microscopic picture. The largest of them could be seen grossly as cavities in longitudinal sections. More marked aggregation of fat was often revealed by Sudan IV staining in the tissues around these microscopic cavities.

Microscopically, the degenerated discs showed here and there areas of very homogenous appearance, and in places either longish or oval cystic formations filled with an amorphous or slightly granular mass. These formations stained metachromatically with toluidine blue and blue-green with Alcian blue (Fig. 4). These homogenous-looking areas and the fissure and cyst formations thus contained substances of the mucopolysaccharide group.

Marked proliferation of small-calibre blood vessels was very often demonstrable in the degenerated discs, especially inside and on the margins of gross cavities. Since a normal disc has no blood vessels, this phenomenon was even more pronounced by contrast (Fig. 5). Prolife-

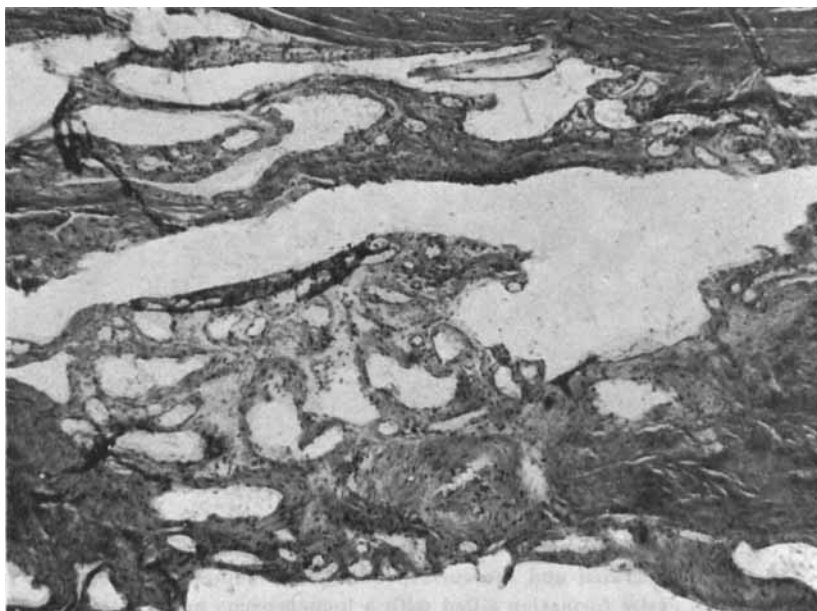


Fig. 5.

Weigert-van Gieson staining of the intervertebral disc of the LV-SI space in a man of 46. A rupture was present in the corresponding interspinous ligament. Photomicrograph shows part of the margin of a cavity in the disc, containing numerous small-calibre blood vessels and new cell formation.

ration of the cell components of granulation tissue was seen around the capillaries. A mesothelium-like lining was seen here and there at the cavity margins. Tissue distinctly similar to hyaline cartilage was occasionally demonstrable; this tissue resembled articular cartilage.

All the degeneration phenomena described above were of exactly the same type in the microscopic picture of degeneration and pathologic ruptures in the lowest interspinous ligaments of the lumbar spine. Ligaments with a grossly degenerated appearance in lipid staining revealed accumulations, often large ones, of a fatty substance, here and there tissue necrotization, proliferation of small-calibre blood vessels, metaplasia of tissue into tissue simulating hyaline cartilage, cavities resembling joint cavities, and accumulation of mucopolysaccharides into tissues in the area of degeneration partly diffusely, partly as cystic degeneration. The histologic and histochemical pattern of degeneration thus seems to be similar in both the disc and the corresponding interspinous ligament and usually to progress at the same rate.

DISCUSSION

In 70 out of 90 cases the degenerative process in the interspinous ligament was accompanied by a change of similar degree in the disc. The degenerative changes in the two structures thus seem to be concurrent and not consecutive in time. The manifestations of degeneration were similar in both tissues. It is probable that owing to the special structure of man these two tissues, the interspinous ligaments and the intervertebral discs, are subjected in the lumbar part to heavy mechanical strain. This explains in a great measure the common occurrence of the degenerative changes, but it does not account for them fully. Sometimes even old persons display only insignificant degenerative changes in the interspinous ligaments and the discs. Mechanical stress naturally varies in different persons, but many other factors such as hormones and vitamins may certainly have a role, not yet fully known to us.

In some cases the interspinous ligaments displayed somewhat more pronounced changes than the corresponding discs. More marked lumbar lordosis was distinctly evident in at least some of these cases. The spinous processes were consequently brought closer to each other and the interspinous ligaments between them were subjected to heavier wear than usual, which might well account for the disproportion in question.

Nine pathological ruptures were encountered in the interspinous ligaments of the series studied. Pronounced degeneration was always demonstrable in the corresponding intervertebral disc, with greater or smaller ruptures in the annulus fibrosus. On the other hand, in none of these cases was there definite protrusion of either the nucleus pulposus or annulus. However, it must be held in mind that this was an autopsy material and that prolapse of the disc is an acute or subacute event in which remission may occur spontaneously in the course of a few weeks. Hence a study based on autopsy material warrants no definite conclusions concerning the role of pathologic ruptures of interspinous ligaments in the etiology of disc prolapse. In all cases of partial or total rupture of interspinous ligaments there were pronounced degenerative changes in the corresponding intervertebral discs, with ruptures and defects in the annulus fibrosus. Hence the preconditions for disc prolapse did exist. However, similar defects in the annulus were also established in the cases with no true rupture in the corresponding

interspinous ligament, although it displayed pronounced degenerative changes.

The investigation as a whole gave the impression that disc degeneration and degeneration of interspinous ligaments are concurrent changes that are similar in type and that possibly may also have the same etiology. Subsequent minor violence would thus be often the only condition required to produce disc prolapse and rupture of the interspinous ligaments, both of which occur in degenerated tissues. The subjects were not examined roentgenologically in the present work, but it has been shown convincingly in an extensive material (*Friberg & Hirsch 1949*) that pronounced disc degeneration can exist without being detected roentgenologically.

SUMMARY

An autopsy material was examined for pathologic changes in the intervertebral discs and the interspinous ligaments of the LIII-LIV, LIV-LV and LV-SI spaces. The observations in the two structures were compared. The series comprised 30 subjects aged 30–70; hence there were 90 discs and an equal number of interspinous ligaments. For comparison the degenerative processes seen in the discs and ligaments were classified by three degrees of severity. The conclusion was drawn that in nearly 80 per cent of cases there is degeneration of a similar degree in the interspinous ligament and the corresponding intervertebral disc. In the present series there were 9 cases of pathologic rupture of interspinous ligament, and the corresponding intervertebral disc revealed ruptures, cavities and pronounced degeneration of the annulus but in no instances a definite prolapse. Degenerative features of exactly the same type, *i.e.*, fatty degeneration, changes in staining properties, tissue necrosis and total disappearance of tissue, proliferation of small-calibre blood vessels, and cystic degeneration, were observed microscopically in the intervertebral discs and interspinous ligaments.

The conclusion reached by the author was that disc degeneration and degeneration of the interspinous ligaments are changes of the same type and concurrent development. It was not established that ligamentous changes, for instance pathologic ruptures, precede the disc changes.

RESUME

Un matériel d'autopsie a été examiné pour étudier les modifications pathologiques des disques intervertébraux et des ligaments vertébraux

des espaces entre les vertèbres lombaires III et IV, IV et V et entre la vertèbre lombaire V et la vertèbre sacrée I. Il a été établie une comparaison entre les deux structures. La série d'observations porte sur 30 sujets âgés de 30 à 70 ans. Il y avait 90 disques et un nombre égal de ligaments vertébraux. Pour établir la comparaison, les processus dégénératifs constatés dans les disques et les ligaments ont été classés selon le degré de gravité de l'altération. La conclusion tirée est que dans presque 80 % des cas il existe une dégénération d'un degré similaire du ligament vertébral et du disque intervertébral correspondant. Dans la présente série d'observations, il y avait 9 cas de rupture pathologique des ligaments avec, dans les disques intervertébraux correspondants, des ruptures, des cavités et une dégénération prononcée de l'anneau, mais dans aucun cas une véritable hernie discale. Des éléments dégénératifs exactement du même type, par exemple dégénération du tissu graisseux, altération des propriétés à la coloration, nécrose des tissus et disparition totale des tissus, prolifération des vaisseaux sanguins de petit calibre et dégénération cystique, ont été observés au microscope dans les disques intervertébraux et les ligaments vertébraux.

La conclusion de l'auteur c'est que la dégénération du disque et des ligaments sont des altérations du même type qui se développent conjointement. Il n'a pas été établi que les altérations des ligaments, par ex. les ruptures pathologiques, précèdent les altérations des disques.

ZUSAMMENFASSUNG

Ein Autopsiematerial wurde unter Hinblick auf pathologische Veränderungen der Zwischenwirbelscheiben und der ligg. interspinosa der Räume L3-4, L4-5 und L5-S1 untersucht. Die Beobachtungen welche an beiden Strukturen gemacht wurden, wurden verglichen. Die Untersuchungsreihe umfasste 30 Personen im Alter von 30-70 Jahren. Es handelt sich daher um 90 Scheiben und um eine gleiche Anzahl von ligg. interspinosa. Zum Vergleiche wurden die an den Scheiben und Bändern gesehenen degenerativen Prozesse in drei Schwerheitsgrade eingeteilt. Man kam zu der Schlussfolgerung, dass in fast 80 % der Fälle eine Degeneration von ähnlicher Ausgeprägtheit in den ligg. interspinosa wie in den Scheiben zu finden ist. In der gegenwärtigen Reihenfolge waren 9 Fälle von pathologischen Rupturen der ligg. interspinosa vorhanden, und die entsprechenden Zwischenwirbelscheiben wiesen Rupturen, Hohlräume und ausgesprochene Degeneration des Annulus, aber keinen sicheren Prolaps auf. Degenerative Zeichen von genau der

gleichen Art, d.h. fettige Degeneration, Veränderung in Färbungseigenschaften, Gewebnekrose und vollständiger Gewebsschwund, Proliferation von kleinkalibrigen Blutgefäßen und cystische Degeneration wurden mikroskopisch an Scheiben und ligg. interspinosa beobachtet.

Die Schlussfolgerung des Verfassers ist, dass die Degeneration der Zwischenwirbelscheiben und der ligg. interspinosa Veränderungen der gleichen Art und gleichzeitiger Entwicklung sind. Es konnte nicht festgestellt werden, dass Bandveränderungen, z.Bsp. pathologische Rupturen, den Scheibenveränderungen vorangehen.

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