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INTRAVERTEBRAL PRESSURES IN PATIENTS WITH LUMBAR PAIN

A Preliminary Communication

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Theoretically, pain in the lumbar area can originate in several different structural elements. In past decades the etiological discussion has been dominated by changes in the morphology, chemistry and function of the intervertebral discs and much information has been collected in this field. However, if we except the apparently clear-cut syndromes with nerve root affection caused by disc herniation, we cannot say that our understanding has gained substantially from this impressive pool of detailed information (Hirsch 1971, Nachemson 1971).

Many experiments have been performed during which the pressure in different structures of the lumbar area has been raised temporarily by injection of fluids. Thus, injections into normal, as well as degenerated discs have occasionally been answered by characteristic low backache (Hirsch 1948, Lindholm 1950, Feffer 1963, Holt 1968), but then very similar effects have been obtained by injection into the intervertebral joints (Hirsch et al. 1963). Localised pain resulted after injections into the interspinous ligaments, the musculature and the dorsal fascia (Hirsch 1966). Experiments with injection into the vertebrae have not been reported.

In patients with coxarthrosis Arnoldi, Linderholm & Müssbichler (1971) observed a state of stasis and hypertension in the intramedullary space of juxtachondral bone. There are strong indications that the aching rest pains, characteristic of severe coxarthrosis, are caused by excessively high intraosseous pressures (Arnoldi, Linderholm &

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Müssbichler 1971, Arnoldi, Lemperg & Linderholm 1971) and that intraosseous stasis and hypertension may be important in the pathomechanism of osseous changes in arthrosis (Brookes & Helal 1968, Arnoldi, Linderholm & Vinnerberg 1971, Arnoldi, Linderholm & Müssbichler 1971). The roentgenological changes in juxtachondral bone in arthrotic joints seem very similar to the spondylotic changes observed in the spinal column in many patients with low back disorders. Further, the aching rest pain of e.g. coxarthrosis seems to be of a quality similar to the aching pain felt in certain types of chronic lumbago. These similarities induced the present investigation of intravertebral pressures in patients with low back disorders.

MATERIAL

65 vertebrae from 20 patients (nine men and eleven women; age 47.2 (31–66) years, mean and (range), with various forms of low back disorders were examined.

In 10 patients X-ray examination of the lumbar spine showed normal vertebrae and no roentgenological signs of disc degeneration. Six of these patients (all women) suffered from general weakness and tiredness of the back (insufficientia dorsi) with occasional periods of slight to moderate pain in the lower lumbar area. These women had no history of sciatica. The remaining four cases (two men and two women) suffered from subacute sciatica of indeterminate localisation, together with slight lumbar pain.

In the remaining 10 patients X-ray examination revealed signs of disc degeneration in one or several segments, together with varying degrees of spondylosis (subchondral and juxtachondral sclerosis and/or osteophytes involving one, several or all lumbar vertebrae). Eight of these patients (seven men and one woman) had a history of intermittent or constant severe low back pain of long standing (lumbago chronica). Two of them had previously had attacks of sciatica. The remaining two patients of this group (both men) suffered from severe lumbar pain together with sciatica, involving the fifth lumbar root. None of the patients suffered from cardio-pulmonar diseases.

METHODS

General procedure. The patient was placed in a horizontal position, lying on his left side. A position was arranged with the spinous processes in the same horizontal plane. The positions of the spinous processes were marked with ink and their identity ensured by means of X-ray examination prior to the pressure measurements.

The skin, subcutanous tissues and periosteum were infiltrated with a few ml of Carbocaine®. Specially constructed needles (made by AB Stille-Werner, Stockholm) 4 cm long, with an external diameter at the tip of 2.00 mm and a lumen measuring 1.40 mm were introduced into the marrow of the spinous process. A penetration of 5 mm was considered suitable (Figure 1). Aspiration of blood by gentle suction ensured the intramedullary position of the tip of the needle.

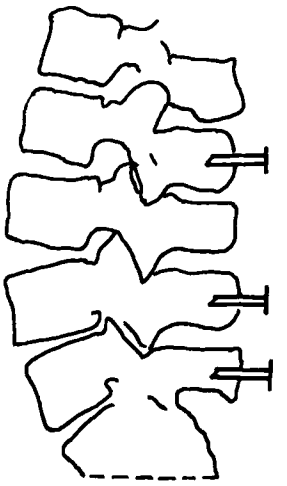

Figure 1. Needles introduced into the bone marrow of the spinous processes of the second, fourth and fifth lumbar vertebrae for measurements of intramedullary pressure. Schematic representation.

Pressure measurements. As a rule, pressures were determined in three vertebrae in each patient. Polyethylene tubes (PE 160) were fitted to the needles in the spinous processes and connected to a system for simultaneous recording of intraosseous pressures by means of a Mingograph (Elema). For technical details, see Arnoldi & Linderholm (1969). The insertion of the fourth left costal cartilage into the sternum was chosen to indicate heart level and all pressures are referred to this level.

Figure 2. Lumbar spine from patient with insufficientia dorsi. Radiologically normal vertebrae. Pressure tracings from this patient are shown in Figure 3.

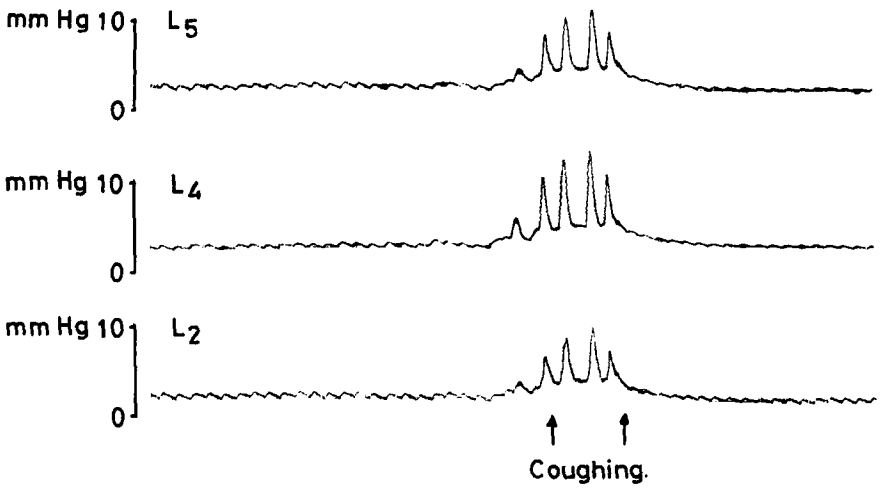

Figure 3. Pressure curves from the spinous processes of the second, fourth and fifth lumbar vertebrae. Same patient as in Figure 2.

Table 1. Measurements of intraosseous pressure of the processus spinosus of the lumbar vertebrae in 20 patients with various forms of low back disorders

Site of measurement	Normal vertebrae			Spondylotic vertebrae		
	n	P_S, mm Hg mean (range)	A, mm Hg mean (range)	n	P_S, mm Hg mean (range)	A, mm Hg mean (range)
L_1	5	8.5 (4.1–11.4)	2.3 (1–3)	–	–	–
L_2	9	9.2 (2.2–12.5)	2.0 (1–3)	2	33.0 (25.3–40.7)	2.0 (2–2)
L_3	5	7.6 (5.9–10.0)	1.8 (1–3)	6	25.2 (15.4–40.6)	3.0 (1–5)
L_4	12	7.5 (4.4–12.6)	1.9 (1–2)	8	28.4 (15.7–46.6)	2.8 (1–5)
L_5	12	8.6 (4.2–12.9)	1.9 (1–3)	6	28.6 (14.3–49.1)	2.7 (1–4)
Total	43	–	–	22	–	–
Mean	–	8.3	1.9	–	28.0	2.7
(Range)	–	(2.2–12.9)	(1–3)	–	(14.3–49.1)	(1–5)

Subscript: n = number of vertebrae. P_S = intramedullary pressure of processus spinosus. A = amplitude of intramedullary pulse pressure.

Figure 4. Lumbar spine from patient with chronic low back pain. Moderate spondylotic changes of 5th lumbar vertebra, slight changes of the 4th and roentgenologically normal appearance of 3rd and 2nd segments. Pressure tracings from this patient are shown in Figure 5.

RESULTS

Intraosseous Pressures in Roentgenologically Normal and in Spondylotic Vertebrae

Roentgenologically normal vertebrae (Table 1, Figures 2 and 3). The intramedullary pressure of the processus spinosus was measured in 43 vertebrae without signs of spondylosis. All the patient groups mentioned under "Material" are represented in this series.

The mean intraosseous pressure was 8.3 mm Hg. The pressure range (2.2–12.9 mm Hg) was within the range expected at this short distance from the heart level. There was no systematic difference between the pressures obtained from different segments (L_1–L_5) (Table 1).

The pressure curves were always pulsatile (Figure 3). The amplitudes of the pulse pressures varied within narrow limits (1–3 mm Hg).

Coughing resulted in an immediate rise of intramedullary pressure (Figure 3) and straining in a gradual increase of pressure at all points of measurement.

Vertebrae with roentgenological signs of spondylosis (Table 1, Figures 4 and 5). Intramedullary pressures were determined in 22 vertebrae with roentgenological signs of spondylosis. Ten patients are represented in this series, two with a history of "lumbago-ischias" and eight with chronic low back pain without sciatica.

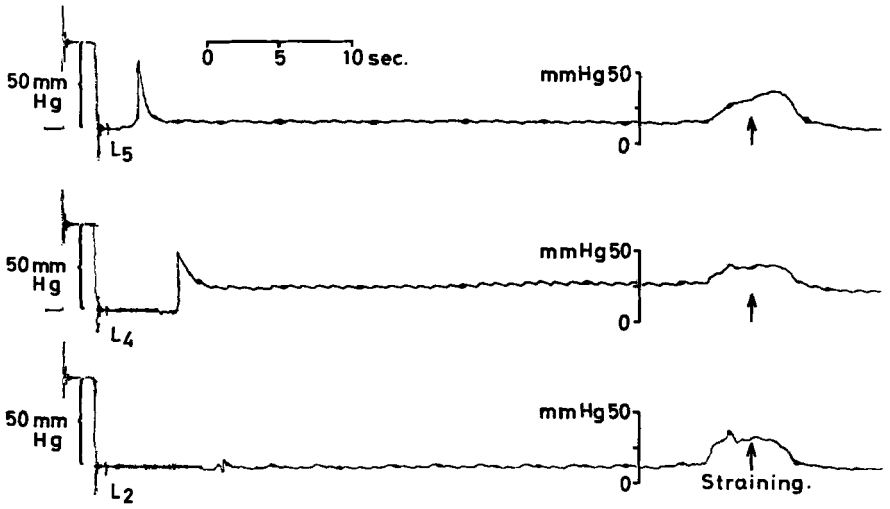

Figure 5. Pressure tracings from 5th, 4th and 2nd lumbar vertebrae from the spine shown in Figure 4. Slightly increased intraosseous pressure in 5th segment, clearly pathological pressure in 4th and normal pressure in 2nd.

The mean intraosseous pressure in the group was 28.0 mm Hg. Range: 14.3–49.1 mm Hg. The mean pressure was significantly higher than the mean pressure of the group with roentgenologically normal vertebrae ($p < 0.01$).

The pressure tracings were always pulsatile. The mean pulse pressure seemed to be higher in this group than in "normal" vertebrae, but

Table 2. Mean and maximum intraosseous pressures in patients with different types of low back disorders (see Material)

Roentgen classification lumbar spine	Clinical classification	n_1	n_2	Mean intraosseous pressure and (range), mm Hg	Maximum pressure, mean and (range), mm Hg
Normal	Insufficientia dorsi	6	20	7.3 (5.4– 9.8)	11.9 (9.8–12.5)
Normal	Subacute sciatica	4	12	7.8 (6.1– 9.7)	11.6 (9.7–12.5)
Spondylosis	Chronic lumbago	8	26	27.3 (25.4–31.8)	38.7 (28.4–46.6)
Spondylosis	Lumbago-ischias	2	7	29.4 (23.8–35.0)	41.4 (33.7–49.1)

Subscript: n_1 = number of patients. n_2 = number of vertebrae examined.

the difference was not statistically significant. As in normal vertebrae, coughing and straining were accompanied by an increase of intramedullary pressure at all points of measurement (Figure 5).

Relationship between intraosseous pressures and the degree of vertebral spondylosis. The pressure was higher in spondylotic than in normal vertebrae (Table 1). There was, however, no distinctive relationship between the degree of spondylosis and the height of intraosseous pressure. Comparatively low pressures were often obtained from vertebrae with severe roentgenological changes, whereas other vertebrae—of the same patient—with moderate or slight X-ray changes showed considerably higher pressures. In other patients the vertebra with the most distinctive X-ray changes was also the segment with the highest pressure.

Mean and Maximum Intravertebral Pressure in Relation to Clinical Symptoms

Table 2 shows mean and maximum intraosseous pressures in patients with different clinical syndromes (see Material). These pressures were low in patients with "insufficientia dorsi" and with sciatica without chronic lumbar pain, whereas they were high in all patients with severe chronic low back pain.

DISCUSSION

Suitability of Spinous Processes as Sites of Measurement

The spinous processes were chosen as convenient sites for simultaneous measurements of intravertebral pressure at different levels because of the minimal risk and discomfort to the patient. It was assumed that the pressure recorded would be representative of, or at least reflect the pressure conditions in the entire intravertebral medullary space.

Earlier experience from pressure measurements in normal cancellous bone indicates that the pressure will be fairly uniform in all parts of the medullary cavity, as long as the arterial supply and the venous drainage from bone are intact (Arnoldi & Linderholm 1971). The medullary cavity of the spinous process is in direct communication with the medullary space of the vertebral body, and the values of pressure obtained from roentgenologically normal bone were of the same order as observed in healthy cancellous bone marrow in other parts of the body, i.e. 2–15 mm Hg above the pressure expected in the

larger extraosseous veins at the same distance from the heart level (Arnoldi & Linderholm 1966, 1971).

Although direct comparison between pressures in the spinous process and the vertebral body has not as yet been performed, there are thus good reasons to believe that the pressure recorded in the spinous process is representative of the intraosseous pressure of the entire normal vertebra.

On the other hand, experience from measurements of intraosseous pressures at various distances from arthrotic joints (Arnoldi, Lemperg & Linderholm 1971, Arnoldi & Linderholm, to be published) indicates that the pressure obtained from the processus spinosus in spondylotic vertebrae is probably lower than the pressure in the sclerotic juxtachondral bone of the vertebral body.

Intraosseous Hypertension a Possible Cause of Low Back Pain?

The number of vertebrae examined and the results obtained from the pressure measurements strongly indicate that spondylosis is accompanied by increased intravertebral pressure. The intraosseous hypertension ranged from a slight elevation to pressures of the same order as observed in severe coxarthrosis with aching rest pain. These findings seem to indicate that intraosseous hypertension may well be one cause of low back pain, just as it seems to be the cause of rest pain in osteoarthritis. However, certain reservations are necessary at the present stage. Firstly, the patient material is small and selected. Secondly, and most important, patients with asymptomatic lumbar spondylosis were not included in the series. Whereas definite conclusions should therefore be postponed, it seems safe to say that the results are interesting and encourage further and more extensive studies along these lines.

SUMMARY

In 20 patients with various forms of low back pain, the intraosseous pressures of 65 spinous processes of the lumbar region were measured. At least three vertebrae were examined simultaneously in each patient.

In roentgenologically normal vertebrae the intraosseous pressures varied within narrow limits (2–13 mm Hg) with a mean value of 8.3 mm Hg. In vertebrae with spondylotic changes in the radiogram the pressure was significantly higher (28.1 (14–49) mm Hg, mean and (range).

A comparison between mean and maximum intraosseous pressures from different forms of low back disorders showed high pressures in the groups with severe chronic lumbago, but low values in women with insufficientia dorsi.

The results of the present limited investigation indicate that high intraosseous pressure may be one cause of low back pain.

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