FLUID CONTENT OF THE NUCLEUS PULPOSUS AS A FACTOR IN THE DISK SYNDROME*

PRELIMINARY REPORT

BY

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The erroneous term "slipped disk," which is often applied to the disk syndrome by the laity, and unfortunately by a large number of their medical advisers, is derived from an impression that trauma is an invariable concomitant of such lesions, yet in a high proportion of cases the onset is insidious. Armstrong (1952) states that approximately 60% of patients with lumbar disk protrusions give a history of injury initiating their symptoms, whilst Eyre-Brooke (1952), in reviewing a series of cases treated by operation, found a similar history in 13.7%. In a series of 121 cases of cervical disk prolapse I have found injury to be a relevant feature in only 9%. As the alleged injury is often trivial in nature, and previous symptoms are often recounted, we must assume that the injury or strain is a precipitating factor only, and therefore that other factors must play a part in the development of the syndrome. It is suggested that one of the many factors is an increase in the water content of the nucleus pulposus.

Göcke (1932) examined the effect of soaking portions of nucleus pulposus in acid, alkaline, and saline solutions, and noted that swelling resulted from the absorption of fluid. Nuclei removed from young subjects took up fluid equal to 95% of their weight when soaked in saline, while those from adult subjects absorbed 50–60% of their weight of fluid, and less than 25% was absorbed by nuclei removed from aged subjects. The increase in weight was greater when nuclei were immersed in alkaline fluid and less when placed in acetic acid. Such a degree of swelling suggests that a similar change within an intact disk would produce a high internal pressure. This prompted the suggestion (Naylor, 1951) that an initial factor in the development of the disk syndrome was a rise of internal pressure due to increase in the fluid content of the nucleus pulposus. The annulus fibrosus would be stretched, producing cervical or low back pain, depending upon the level affected. Should the annulus be thinned, bulging or actual herniation of the nucleus would occur. Once the herniation has appeared mechanical stress would maintain its extrusion. It is possible that the fluid change in the nucleus may be instigated by some endocrine or metabolic factor, and it is probable that the initial change is a depolymerization of the polysaccharide element of the polysaccharide-collagen complex.

Our measurements of the water absorption by the isolated nucleus confirm Göcke's findings, but there seems to be no linear relationship between the amount of fluid absorbed and the ages of the subject. Vary-

ing degrees of absorptive power were found in disks from subjects of similar ages. The annulus fibrosus will also absorb fluid, but to a less degree than the nucleus. The addition of hyaluronidase to the immersion fluid increases the weight of fluid absorbed by 20%. This is probably due to the depolymerization of the polysaccharides, causing reduction of size of the particles and increase in the osmotic power of the nucleus.

Measurement of Pressure Within the Disk

As an initial step a series of experiments was designed to measure the pressure generated within the disk, and an apparatus (see Diagram) was developed for this purpose. The manometer of the apparatus consisted of a glass

capillary tube (A) fixed to a 20-gauge serum needle (B) by a brass connector; the joints were sealed with a high-vacuum wax. The needle had a series of slots cut in the distal half-inch to allow an even distribution of pressure to the mercury within the needle and to minimize any blockage. It was bent to 90 degrees at its centre so that it could be inserted horizontally into the disk. A mercury reservoir (C) was connected to another capillary tube (D) fixed parallel to the manometer, the latter being joined to the capillary tube by an inverted U-tube containing alcohol. Alcohol was

Diagram of apparatus.

used in preference to water as it has a smaller surface tension, giving ease of flow and facilitating elimination of air bubbles. Initially the apparatus was filled with mercury, the manometer clipped off, and alcohol then drawn into the inverted U-tube. The clip (E) was then opened, the manometer needle being immersed in mercury. By alternately raising and lowering the reservoir a column of mercury is drawn into the manometer. The clip (E) was then closed and the apparatus was ready for use.

Fresh lumbar disks from necropsy subjects were obtained with a thin sliver of bone on each side, this being important to prevent any force being expended on producing bulging of the nucleus. The disk under test was pierced by a hollow needle of the same gauge as that in the apparatus, and the manometer needle was then inserted along the track made. This minimized the risk of blockage by tissue. The specimen was then placed in a glass crystallizing dish and the screw clip (E) opened. The mercury in the reservoir and side tube was levelled and a travelling microscope focused upon the meniscus of the manometer and its scale read, the pressure then being equal to that of the atmosphere. The disk was then immersed in fluid, using water or normal saline. To note the pressure developed, the mercury reservoir was adjusted to bring the meniscus in the manometer to its initial level. The height of the reservoir above the level of the disk is then the pressure required to neutralize that developed within the disk. Initially 20 disks have been investigated in this manner.

*Based on a paper read to the British Orthopaedic Association in October, 1952.

Results

Three experiments were valueless, as blockage of the needle occurred and no readings could be obtained. Of the remaining 17, 11 developed a high, measurable internal pressure, whilst one developed enough pressure to rupture the bone end-plate, and no internal pressure was therefore measured. This disk had been cut with a very thin end-plate, and a complete transverse fracture of this developed, with protrusion of the swollen nuclear material. Simultaneously a disk from the same subject developed a pressure of over 80.2 cm. Hg. It was impossible to raise the mercury reservoir high enough to depress the mercury in the manometer to its normal level, and if the movements of reservoir and manometer meniscus are proportional then a pressure of approximately three atmospheres had developed.

The most significant result obtained was the spontaneous rupture of the annulus fibrosus in one specimen, which developed after 17 hours' immersion in water to which hyaluronidase had been added. At the time of rupture a pressure of 20 cm. Hg was measured, but, despite the production of the rupture, the internal pressure had increased to 80 cm. after eight hours' immersion. The disk bulged extensively, and, on section, the rupture of the annulus and herniation of the nucleus were easily demonstrated.

Two disks from very old subjects registered no rise of pressure, the nuclei being small, brown, and dry on section. Evidently no fluid had been absorbed, and this can be explained by the operation of two factors: (a) decreased permeation as a result of sclerosis of the end-plate; and (b) loss of polysaccharide, which occurs with advancing years.

There is little doubt that a large contribution is made by the latter factor. The absence of water absorption and change of internal pressure in disks of aged subjects is consistent with the known decreased incidence of disk prolapse in that age group. If the polysaccharide content of the nucleus is very much reduced, then fluid absorption, and therefore increase of internal pressure, will be minimal or absent and the potentiality of disk herniation reduced. Sylven (1951), using metachromatic staining methods, showed that the mucoid element in the nucleus was reduced with advancing degeneration. During the course of x-ray diffraction studies of intervertebral disks we have obtained confirmatory evidence of this (Happey, McRae, and Naylor, 1953). *In vivo*, where there is a compression force due to the superimposed body weight, a smaller absorption of fluid would lead to the development of considerable internal pressure.

A compression force was applied to disks, placed in the apparatus previously described, by means of a flat steel bar, weights being added to its ends. With the dry disk a gradual addition of weight was accompanied by a rise of internal pressure, except in those which showed advanced degeneration. The latter had lost their elasticity, and compression caused no rise of internal pressure, while subsequent immersion during maintenance of pressure was without effect. In contrast, a disk from a subject aged 35, compressed by a load of 24 kg., showed a rise of internal pressure from 47 to 119 cm. after immersion in water. Preliminary experiments in which absorption from one or both end-plates is blocked suggested that the fluid reached the nuclei by permeation through the end-plate.

Discussion

The preliminary experiments show that a high pressure can be developed within an intervertebral disk by absorption of fluid, this most probably entering through the bony end-plate. It is postulated that the possible sequence of changes leading to the development of the disk syndrome consists of: (1) depolymerization of the polysaccharides of the collagen-polysaccharide complex in the nucleus pulposus, leading to (2) increased power of water absorption, causing (3) absorption of fluid by the nucleus, the fluid

entering via the end-plate; (4) increase of pressure within the disk. The forces developed by leverage and muscular action would augment this.

It is possible that a return to the *status quo* by a process of polymerization does not occur, but that the internal pressure falls to normal as the depolymerized molecules are absorbed. This process can be repeated with each episode of symptoms, and would explain the gradual development of degenerative change in such disks. A stage is ultimately reached when the disk has degenerated to such an extent—and thereby lost its water absorption power—that prolapse cannot occur. It is possible that a similar process in multiple disks produces attacks of "fibrositis."

Further and more extensive experiments are being conducted to investigate this hypothesis, using modified apparatus to measure the high pressure generated within the disk.

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Medical Memorandum

Thyrotoxicosis Complicated by Thrombocytopenic Purpura

The association of thrombocytopenic purpura with a toxic goitre is rare. The literature reveals approximately twelve such cases (six female and six male). In several the clinical picture may have been complicated by the administration of myelotoxic drugs (Jackson, 1931; Corson, 1942; Fewell *et al.*, 1950; Hart, 1951). In the remainder no such complicating factor is evident (Finochietto *et al.*, 1936; Lavastine and Cachin, 1940; Woodruff, 1940; Bomford and Rhoads, 1941; Bicknel and Dicker, 1942; Conklin and Shank, 1944; Roberts, 1948). In the following case associated drugs, such as bismuth, "sedormid," or thiouracil, were not given before the occurrence of the purpura. The purpuric manifestations were associated with the thyrotoxicosis before treatment. Propylthiouracil was administered pre-operatively after the combination of the two diseases had been noted.

CASE REPORT

A woman aged 62 was admitted to hospital on September 5, 1951. She had been breathless on exertion for years, but this had been aggravated after a three-weeks period in bed for generalized joint pains in January, 1951. Ten days before admission a slight cough and a mild tonsillitis developed. A small haemoptysis occurred with the onset of the cough. Blood had been passed per rectum, and a widespread purpuric rash had developed over the body and limbs and in the mouth. She had bruised very easily and had lost weight over the past year. A mild degree of ankle oedema had been present for years. She had had a right-sided pneumonia with pleurisy forty years before, and several attacks of tonsillitis since. There was no history of rheumatic fever and no relevant family history.

Physical examination revealed a cachectic-looking patient who was dyspnoeic. The mucous membranes were pale, the teeth were decayed, and a mild bilateral tonsillitis was evident. Tremor was marked. The hands were warm and moist. The thyroid gland showed a generalized enlargement of both lobes. Multiple purpuric spots were apparent all over the body and on the gums and tongue. Pulse rate 90. Rhythm regular. The apex beat was displaced laterally. On auscultation the grade II apical systolic murmur was heard and crepitations were present at the bases of both lungs. There was a mild degree of ankle oedema. The liver