NUCLEOGRAPHY

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In the last ten years, disc herniation has been given increasing attention, operative treatment has been perfected and the operation itself more and more simplified. Also, the operating field has become considerably smaller. Thus the surgeon, having before him only a small area exposed, depends even more on precise localisation of the herniation. Clinical methods of localisation depend upon the patient's statement concerning the distribution of the pain and upon neurological changes in the limbs; they may be supplemented by radiographic evidence, especially contrast-myelography. Nevertheless even a myelogram of good quality will show only indentation, if present, of the dural sac, whereas the actual cause—the disc prolapse itself—cannot be shown.

EXPERIMENTAL STUDIES

Preliminary research to show the nucleus pulposus by radiography began early in 1949 on 200 intervertebral discs removed at necropsy from the lumbar region of subjects between the ages of twelve and eighty-five years. When attempts were made to stain the nucleus pulposus by a watery solution of either eosin or methylene blue injected directly into the nucleus pulposus, the stain showed up only in the nucleus pulposus mass. It was only when, in consequence of the degeneration of the annulus fibrosus, fissures and ruptures directly connected with the nuclear cavity were apparent, that the area of the annulus took the stain too. Larger ruptures were frequently filled by the nuclear mass which could therefore be shown. Thus the spreading nucleus and its channel of diffusion were made visible, but the nuclear mass alone took the stain. Staining was then repeated with a watery solution of 0.4 per cent eosin and 30 per cent potassium iodide. This made the impregnation visible by radiography. In all cases complete agreement was found between the radiographic shadow and the eosin stain, the contours of the stained area being identical with those of the nucleus pulposus and its diffusion (Figs. 1 to 3). In no instance were deposits of stain found in healthy or only slightly degenerated annulus fibrosus. Further experiments were conducted in which an attempt was made to reproduce the conditions of life by subjecting the disc to a pressure of up to 300 kilograms before and after staining. No difference was apparent in these groups. The examination showed the actual nuclear contours and therefore allowed conclusions to be drawn on the state of degeneration of the disc. Five principal disc-forms were apparent, though not all were true to type (Fig. 4). Form 1—The globular nucleus, found mostly in young subjects, denotes a healthy disc without degeneration or herniation (Fig. 5). Form 2—The lobed nucleus, the usual form in adults, shows a few large lobulations. Herniation or protrusion is unlikely. Form 3—The simple branched nucleus shows a central shadow with a few long and narrow branches and predisposes to herniation. Frequently a visible protrusion (Form 3a) if not a real herniation (Form 3b) or a free prolapse (Form 3c) can be diagnosed (Fig. 5). Form 4—The multiple branched nucleus has a small central shadow and several branches in various directions. This is a transitory form of degeneration in which prolapse is likely to occur. Form 5—The spread nucleus shows multiple branches in all directions instead of the central shadow. This form represents the typical degenerated disc and is mostly associated with narrowing of the disc. Herniation must no longer be expected.

The most important types for clinical diagnosis are the simple branched nucleus (Form 3) and the spread nucleus (Form 5). The latter is seen in cases of marked degeneration and is
indicated in the plain radiographs by the narrowing of the disc space. The simple branched nucleus (Form 3) is seen with herniation (Form 3a) protruding only slightly over the vertebral body; in such cases some of the fibres of the annulus fibrosus are still intact and will only be bulged by pressure. In herniation proper (Form 3b) parts of the nucleus are outside the disc and correspondingly the contrast shadow projects clearly beyond the margins of the vertebral bodies. With free prolapse (Form 3c) connection with the central shadow can, in many instances, no longer be demonstrated, and the prolapse shadow, with indistinct contours, is situated beyond the disc. In frontal view a medially situated herniation will be covered by the central nuclear shadow, while a laterally situated hernia will be noticed on its corresponding side. The lateral view will bring out best a medially situated herniation while the lateral prolapse is shown most distinctly at 15 degrees inclination; projection of the central ray obliquely from right ventral to left dorsal shows a prolapse situated on the right, and projection from left ventral to right dorsal shows one situated on the left. Combination of the different projections should make it possible to locate the level, position and size of a prolapse.
RADIOGRAPHIC TECHNIQUE

To take a nucleogram in the living patient a fine lumbar puncture needle or a double cannula of at least 12 centimetres length, an injection syringe, and a needle and syringe for procaine anaesthesia are required. A 50 per cent solution (70 per cent in the case of the fifth lumbar disc) of iodine in water is used.* The films may be taken with the patient sitting or lying. The local anaesthetic is injected as deeply as possible, up to the vertebral bodies beside the spinous processes. While the needle remains inserted, a radiograph is taken for general orientation. The lumbar puncture needle is now inserted half an inch lateral to the spinous process and immediately above the upper margin of the spinous process of the adjacent lower vertebra and is directed upwards and medially (Fig. 6). Thus, the vertebral foramen is by-passed at its lateral angle and the disc reached paradurally (Fig. 7). In the case of the lumbo-sacral disc the needle should be inserted downwards and medially in accordance with the angle of this disc (Fig. 6). The elastic rubbery resistance of the annulus fibrosus must now be felt for and the annulus fibrosus itself pierced. The needle is then pushed 1·5 centimetres farther (not more) thus reaching the centre of the nucleus. The position of the needle is checked by antero-posterior and lateral radiographs. After removal of the stillette the opaque fluid is injected—usually 1 to 2 cubic centimetres is required. This injection requires considerable pressure; lack of resistance means either that the disc is grossly degenerated, or that the

* Marketed under the trade name "Joduron" by Cilag, Schaffhausen, Switzerland.

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Fig. 5
Nucleography at necropsy of subject aged seventy years (with lumbarisation of S.1 vertebra). Discs L.2 to L.5 were injected. Discs L.2 and L.3 are normal and show a normally shaped nucleus (Form 2). Disc below L.4 shows postero-lateral extension (Form 3a); in the lateral view the central shadow is indistinct. Disc below L.5 is similar, but the central shadow is more compact and the posteriorly displaced portion is small. At 15 kilograms pressure the spine showed left lateral protrusion below L.4 and a smaller left paramedian protrusion at L.5. These protrusions were not visible before pressure was applied.

Fig. 6
Position of needles for injection of nuclei. Figure 6—Lateral photograph of dissected specimen with needles inserted. Dotted lines indicate plane of discs. At the discs below L.2, L.3 and L.4 the needle is inserted cranio-medially; for injection of that below L.5, the needle is thrust caudo-medially. Figure 7 shows position of needle in transverse plane.

Fig. 7
Clinical nucleography. Figure 8—After insertion of the needles their position is checked by radiographs. Figure 9—Antero-posterior view after injection of opaque fluid. Nucleus below L.4 corresponds in shape with Form 2; that below L.5 with Form 4. Figure 10—Oblique view. Disc below L.4 shows no prolapse; that below L.5 shows a large prolapse. Figure 11—Lateral view showing free prolapse below L.5 (arrows).
needle has been misplaced into soft tissue. If several discs are to be injected, it is best to insert all the needles first and then to inject the solution into each with as little delay as possible. Sensations in the affected area felt by the patient are additional confirmation of the correct position of the needle. When the needle is being withdrawn it is possible to check, in passing the spinal canal, that the needle has not been passed through the dural sac. After withdrawal of the needle, movements of the trunk should be performed to promote even distribution of the impregnating fluid. The following radiographs should be taken as quickly as possible, for the impregnating agent diffuses rapidly: 1) antero-posterior view; 2) lateral view; 3) right and left obliques with the patient turned at an angle of 15 degrees. Examples are shown in Figures 8 to 12.

![Fig. 12](image)

Clinical nucleography. Lateral view showing distinct prolapse below L.4 (Form 3).

**DISCUSSION**

With this technique it should be possible under normal conditions to remain outside the coverings of the spinal cord. This type of puncture therefore causes little disturbance to the patient. Undesirable sequelae, such as are recognised after injection of oily iodine solutions into the spinal theca, need not be feared.

Material taken from post-mortem specimens has shown that after as little as four hours the solution has diffused to such an extent that it is no longer visible in radiographs. In life absorption is added to diffusion, and the fluid injected at nucleography will disappear completely after a few hours.

If the technique described is followed, none of the opaque fluid can find its way into the dural sac. Moreover it has been shown in several thousand cases of deliberate intrathecal
injection (myelography) that watery iodine solutions will cause no arachnoidal or similar disturbances. The iodine is absorbed from the theca and excreted by the kidney, so that the renal pelvis may be seen in the radiographs. Because of this rapid excretion iodine disturbances will not occur, a fact which has greatly contributed in recent years to the development of myelography with watery solutions in Sweden and Austria. Thus in nucleography by the technique we have described no damage should occur either from the puncture itself or from the effect of the injected solution.

Theoretically it is possible that puncture might facilitate herniation of the disc at the point of entry of the needle. But our pressure experiments at 300 kilograms have never shown this to occur. In any case, nucleography should be restricted to cases in which early operation is contemplated, but in which diagnosis and localisation cannot be made with sufficient accuracy.

It seems to us that myelography and nucleography both have a place. Myelography enables a general examination of the affected area to be made; whereas nucleography allows a more accurate interpretation of changes found in a particular disc by myelography. By nucleography it is also possible to show the shape of a disc herniation which, because of its lateral position or its small size, may not be shown in the myelogram.

SUMMARY

1. The technique of nucleography, in which a radio-opaque watery solution of iodine is injected into the nucleus pulposus for contrast-radiography, is described.
2. The merits of the procedure in demonstrating the shape and condition of nucleus are discussed.