MEASUREMENT OF THE SPINAL CANAL BY DIAGNOSTIC ULTRASOUND

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A method is described of measuring the lumbar spinal canal by pulsed echo ultrasound. It is simple, safe and has a high degree of accuracy. The lumbar canal has been measured in over 800 subjects including 100 mining recruits and fifty nurses between the ages of fifteen and eighteen years. Ultrasound can demonstrate the degree and extent of bony stenosis. It may have value in preventive medicine, identifying the subject at risk.

The size of the spinal canal has attracted increasing interest since Scheslinger and Taversas (1953) and Verbiest (1954, 1955) described some of the effects of the narrow canal. The bony canal, however, is not easy to measure, especially in the clinically most significant midsagittal diameter. Rothman and Simeone (1975) state that it can only be measured accurately by direct measurement at operation. Jones and Thomson (1968) and Eisenstein (1977) have described methods of measuring the midsagittal diameter from a lateral radiograph, but in practice this is not always easy.

Myelography is probably the best method of demonstrating the constraint the canal places upon its contents, but its limitations have been well documented by Ehni (1969), Williams (1975), Jacobson (1976) and McIvor and Kirkaldy-Willis (1976). There can be significant reduction in the cross-sectional area of the canal from exaggeration of the trefoil shape, with an apparently adequate anteroposterior and lateral diameter. This oblique narrowing may not be recognised by myelography. Sheldon, Sersland and Leborgne (1977) have shown that computed transverse axial tomography will demonstrate this bony encroachment.

This paper presents a method of measuring an oblique sagittal diameter of the lumbar spinal canal by pulsed echo ultrasound. It is simple, safe and has a high degree of accuracy.

METHOD

An oblique diameter of the spinal canal was measured by pulsed ultrasound using a Nuclear Enterprise Ltd Diasonograph, a machine now widely used in obstetric diagnosis (Fig. 1). Olive oil was used as a coupling medium between the transducer and the skin. A 1.5 megahertz transducer was placed one centimetre from the midline of the lumbar spine, inclined at 15 degrees to the sagittal plane, and moved longitudinally at the same inclination from the first lumbar vertebra to the fifth (Fig. 2). With repeated movements and slight
Two-dimensional display showing echoes reflected from five lumbar vertebrae and laminae.

A-scan display showing three major echoes from the posterior and anterior surfaces of the lamina, and from the posterior surface of the vertebral body.

Figure 5—Mean values and percentiles for 100 young asymptomatic males. Figure 6—Mean values and percentiles for fifty young asymptomatic females.
alteration of the transducer's lateral position, it was possible to obtain echoes reflected from the laminae and from the posterior surfaces of the vertebral bodies as shown in Figure 3. The Diasonograph permits a simultaneous A-scan display of echo amplitudes as a function of time, which itself is related to the depth of the reflecting surface below the skin. Three major echoes were demonstrated: from the posterior and the anterior surfaces of the lamina and from the posterior surface of the vertebral body at any one vertebral level (Fig. 4). Slight alteration of the position of the transducer made the amplitudes of these echoes as great as possible and spurious echoes were removed by electronic filtering. The time interval between the second and third echoes from the canal boundaries is related to the distance between the reflecting surfaces, and is measurable in millimetres on a digital read-out. This is facilitated by electronic calipers positioned at the apex of the second and third echoes on the A-scan, and simultaneously displayed on the B-scan identifying the vertebral level of the echoes. The identity of the reflecting surfaces of the three major echoes was confirmed by immersing cadaveric vertebrae in saline, ultrasound and direct measurements being identical.

RESULTS

The lumbar canal has been measured in over 800 subjects, including 100 male mining recruits between fifteen and eighteen years old, and fifty nurses of the same age. The degree of accuracy of measurement of the oblique sagittal diameter of the lumbar canal is shown by the fact that the inter-observer and intra-observer error is only 0.02 centimetre. Difficulty in measuring the canal occurs only in the very obese and, of course, after posterior spinal fusion.

The mean values, and the tenth and ninetieth percentiles for the 100 miners and fifty nurses are demonstrated diagrammatically in Figures 5 and 6. In the oblique sagittal diameter the lumbar canal is widest at the first lumbar level, narrowest at the fourth, and tends to widen again at the fifth level. The mean values of the canals of the young nurses are slightly wider than those of the young miners. Measurements from both the right and left sides of the lumbar spinal canal have been recorded from sixty patients with low backache with or without sciatica. The mean and standard deviation of the differences for each level are shown in Table I.

DISCUSSION

Ultrasonic energy transmitted into the tissues is partially reflected by the boundaries between different structures. This reflected energy is detected as an echo, and the pulsed emission enables the same transducer both to transmit the ultrasound and to receive the returning echoes. Consequently, echoes are received only when reflected from the surfaces at approximately 90 degrees to the axis of the beam. The reflected angle must lie within the solid angle defined by the width of the face of the transducer and the depth of the reflecting surface below the skin. However, the microscopic irregularity of the bony surface ensures that some echoes are received from the vertebral lamina and the posterior surface of the vertebral body, even though the surfaces macroscopically appear oblique to the direction of the incident beam of ultrasound.

Three major echoes on the A-scan are obtained over an extremely narrow band when the transducer is inclined at 15 degrees to the sagittal plane. This band corresponds to the acoustic "window" in the lamina, through which the sound can be transmitted and received. The echoes are lost if the transducer is moved either medially, because of the high absorption of sound by the bony spinous process, or laterally, from absorption by the facet joints and thickened lateral lamina. The "window" of thin bone is entirely covered by the two-centimetre diameter beam of ultrasound and is constant for each individual vertebra (Fig. 7). This probably explains the high degree of reproducibility of the results.

| Table I. Differences between right and left oblique sagittal diameters for sixty subjects with backache, with or without sciatica |
|------------------------|----------------------|
| L1 | 0.035 | 0.041 |
| L2 | 0.042 | 0.045 |
| L3 | 0.046 | 0.062 |
| L4 | 0.073 | 0.113 |
| L5 | 0.055 | 0.074 |

The mean oblique sagittal diameter measured by ultrasound is similar to the midsagittal diameter measurements reported by Eisenstein (1977) (Fig. 8). It is understandable that the oblique measurements are less than the midsagittal. The difference is most marked
at the fifth lumbar vertebra where the canal can be trefoil in shape. This will significantly affect our measurements because of the obliquity of the diameter recorded by ultrasound. The mean values for the female canal were found to be slightly greater than those for the male.

Ultrasound measurement of the spinal canal has several clinical implications. Bony stenosis responsible for symptoms of claudication can be identified in degree and extent. It is fortuitous that ultrasound measures an oblique diameter that is most affected in stenosis when laminar hypertrophy exaggerates the trefoil shape. This bony encroachment may not be detected by myelography when the midsagittal and coronal diameters are measured.

Comparison between mean oblique sagittal diameters measured by ultrasound and Eisenstein's mean midsagittal diameters.

medicne if it can be shown that a narrow canal increases the risk of disabling symptoms from pathological changes in the disc and from degenerative changes. Young subjects at risk could be identified easily and advised against hazardous occupations and recreations.

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REFERENCES


