Transverse Diameter of Cervical Spinal Cord on Pantopaque Myelography

MANSHO T. KHILNANI, M.D., AND BERNARD S. WOLF, M.D.

Department of Radiology, The Mount Sinai Hospital, New York, New York

Gross changes in the size of the cervical spinal cord as a result of an expanding intramedullary lesion or marked atrophy usually can be recognized by simple inspection of Pantopaque myelograms. When changes are of a minor degree, however, recognition may be difficult. In such instances, knowledge of the extent of the variation in the size of the normal cervical spinal cord would be of great value. Because of technical problems, however, consistent and reproducible measurements are difficult to obtain.

Porter, in a study of 63 normal Pantopaque myelograms, measured the distance between the points of emergence of the nerve roots from the cord at the 4th and 6th cervical levels only. These measurements varied between a minimum of 1 cm. and a maximum of 1.7 cm., with an average width of 1.4 cm. It is difficult to relate these figures to the total transverse diameter of the cord. Wood described in detail the appearance of the cervical cord as seen on spot films. According to this author, the cervical spinal cord occupies the central two-thirds of the cervical subarachnoid space and the "width of the spinal cord is approximately one-half the interpediculate distance except at the level of the maximum cervical enlargement at C-5, where the spinal cord occupies almost two thirds of the vertebral canal." Standards for the sagittal diameter of the cervical spinal cord on air myelography were reported by Lowman and Finkelstein.

Measurements derived from conventional spot films made during cervical myelography are subject to criticism on several bases. To a limited but unknown degree, the factors of magnification vary from patient to patient and are dependent upon the particular geometrical factors incorporated into the equipment used for the examination. An additional complicating factor is introduced when the neck is hyperextended in order to prevent opaque material from entering the cranial cavity. With hyperextension, the upper cervical segments, particularly C1, C2 and the cervicodorsal region, form a large angle with the plane of the film. As a result, factors of magnification for different regions of the cervical spine are not identical. In actual practice, this effect often is lessened by decreasing the hyperextension when the tilt-table has been restored to a nearly horizontal position before spot views are taken. While the introduction of an adequate amount of opaque material (12 ml.) in the subarachnoid space ensures accurate measurements of the cord at most levels, complete filling in the upper cervical and upper dorsal regions frequently is difficult to achieve. Since Pantopaque cervical myelography ordinarily is performed with the patient prone, the posterior portion of the subarachnoid space is devoid of opaque material and the sagittal diameter of the cord cannot be ascertained. As a result, for practical purposes, the transverse diameter is the only reliable measurement of the cervical spinal cord.

Method and Material

Despite the obvious lack of mathematical exactness, it nevertheless was thought desirable to measure the transverse diameter of the cord and the transverse diameter of the subarachnoid space on spot films taken during routine cervical myelography. All examinations were done in conventional fashion, utilizing a tilt-table equipped with a spot device.

Eighty normal myelograms of the cervical
region were studied. Of this group of patients 41 were males and 39 were females. The ages ranged from 30 to 70 years. Myelography was performed in these patients primarily for complaints in areas other than the cervical region, such as sciatic or low-back pain. No abnormality in the cervical region was suspected or detected. Cases in which there were unfavorable characteristics, such as osteoarthritic ridging, segmentation of the opaque column or poor visualization of the spinal cord, were excluded.

All measurements were made directly from the spot films and no effort was made to correct for magnification. The table utilized had a target table-top distance of 20 inches and the film in the spot device could be elevated to a maximum of 18 inches above the table-top. It was estimated that in the majority of instances the column of Pantopaque in the mid-cervical region was located about 8 inches above the table-top and that magnification of the spinal cord was between 1.25 and 1.35. No attempt was made to measure the cord at the 1st or 2nd cervical levels and only a limited number of measurements could be made in the upper dorsal region.

The method of determining the measurements is illustrated in Fig. 1. The subarachnoid space shows scalloped lateral contours as the result of the root pouches at each level. The minimal transverse diameter of the column of Pantopaque about midway between the pouches at each vertebral level was marked by crosses and these crosses were connected by straight lines to indicate the lateral limits of the subarachnoid space. At each vertebral segment, the distance between these longitudinal lines was measured at a level at or just below the pouches. The width of the spinal cord was measured at the same level as the transverse diameter of the subarachnoid space. There was little difficulty in identifying the lateral margins of the spinal cord in the films selected for measurement. However, this margin is not as sharply outlined as the subarachnoid space and small errors, up to a millimeter, in the measurement of the transverse diameter of the cord were unavoidable.

Figure 1. Spot film taken during the course of cervical myelography. The opaque material has been pooled in the cervical region and the table has been repositioned horizontally. The patient is prone with the head extended moderately. C5-T3 refer to the vertebral bodies. The transverse diameter of the column of Pantopaque narrows slightly between the nerve pouches. These points, marked with crosses, are connected to form longitudinal lines which serve as the lateral boundaries of the subarachnoid space. At each level, a measurement is taken just below the corresponding nerve-root pouches between these lines, e.g., A B at the C6 level. The longitudinal dashed lines indicate the spinal cord. The width of the cord is measured at the same level as the subarachnoid space, e.g., C D at the C5 level.

Results

As might be expected, there was considerable variation in the transverse diameter of the spinal cord as well as in the ratio of this diameter to the transverse diameter of the subarachnoid space from patient to patient. A representative average curve (Fig. 2A) could be plotted which corresponded in shape rather closely to the usual upper limits of the interpediculate measurements of Elsberg and Dyke (Fig. 2B). In the thoracic region, this relationship does not apply, as the slope of the Elsberg-Dyke curve is considerably steeper.

Values were determined also for the differences between the diameters at adjacent vertebral levels (Fig. 3). These figures in-
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**Fig. 2.** (A) Absolute measurements of transverse diameter of spinal cord between C3 and T3 in mm. Curve AV represents the estimated average while the adjacent curves (MAX. and MIN.) represent the maximum and minimum measurements found in the group studied. These measurements were taken directly from spot films during the course of cervical myelography.

(B) Curve AV. is identical to the average figures given in (A). Curve PED. is of the usual upper limits of the interpediculate measurements according to Elsberg and Dyke. The mm. scale for this curve is on the right. The lowest curve (%) gives the average ratios of the width of the cord to the width of the subarachnoid space at each level expressed in percentages.

Dicated that the maximum diameter of the cervical spinal cord was usually at the level of C5. The diameter of the cord decreased on the average of 1 to 2 mm. per segment for each of the two segments both above and below C5. These findings indicate that the cervical enlargement is not as sharply marked as frequently suggested in anatomical illustrations. Moreover, in 15 of 69 cases (Fig. 3), the diameter of the cord at C6 exceeded that at C5 although rarely by more than 2 mm. In 4 out of 80 cases, the width of

![Bar graphs](image-url)

**Fig. 3.** Series of bar graphs illustrating the differences in mm. between the widths of adjacent segments of the spinal cord in the cervical and upper dorsal region. The figures on the ordinate and on each bar indicate the number of cases. The first bar graph indicates that in 1 instance the transverse diameter of C3 exceeded that of C4 by 1 mm., in 17 instances there was no difference, in 34 instances C4 exceeded C3 by 1 mm., in 13 instances C4 exceeded C3 by 2 mm. and in 3 instances C4 exceeded C3 by 3 mm. The other bar graphs are interpreted in similar fashion.
the cord at C4 exceeded that at C5 but by no more than 1 mm. In 1 patient, aged 68, the diameter of the cord at C3 exceeded the diameter at C4 by 1 mm. In no instance was the transverse diameter of the cord at the level of C7 greater than the diameter at C6. At all levels from C6 to T3, the cord showed either no significant difference between adjacent segments or showed a progressive decrease in diameter. In general, any difference greater than 3 mm. between adjacent segments should be considered suspicious of an abnormality. The only exception to this was C7-T1. At this level, C7 exceeded T1 by 4 mm. in 6 of 49 cases.

An effort to exclude the variations introduced by magnification was made by calculating at each level the ratio of the transverse diameter to the subarachnoid space. This appears to be a logical approach since expansion of the cord in the early stages of a space-occupying lesion occurs at the expense of the subarachnoid space and since in atrophic lesions the cord occupies a small fraction of this space. Unfortunately, however, this percentage shows considerable variation from patient to patient, ranging from 53 to 78 per cent. An average figure of 67 per cent was found at C6 and 68 per cent at C5. This figure corresponds quite closely to the "two-thirds" figure given by Wood. The average figure at the level of C3 was 63 per cent; at T1, 64 per cent. The curve of average values of the percentages corresponded rather closely to the curve of the absolute values (Fig. 2B). This finding is the result of the fact that the transverse diameter of the subarachnoid space measured in the fashion described above is relatively constant throughout the cervical region. In the upper thoracic region, the subarachnoid sleeve is smaller than in the cervical area and the ratio of the transverse diameter of the cord to that of the subarachnoid space in a particular individual therefore is greater (Fig. 4). However, the range of percentages in the upper thoracic region was not greatly different from that in the cervical area. These results would suggest that any ratio above 80 per cent is likely to be indicative of cervical-cord enlargement while any ratio below 50 per cent is likely to indicate spinal-cord atrophy.

In actual practice, it ordinarily is sufficient by visual inspection to note that the maximum diameter of the cord is at C5 or C6 and that the decrease in diameter above and below is smooth and progressive. If the subarachnoid sleeve appears narrow at any level, calculation of the ratio between the diameter of the cord and of the subarachnoid space should be done. Any suspicion of localized enlargement (Fig. 5) can be confirmed by plotting the diameters at each of the levels and comparing the resulting curve with the shape of the standard curve. Actual differences between any questionable level and adjacent levels also may be compared with
those found in the present group of cases (Fig. 3). Calculation of ratios or percentages is essential whenever there is a suspicion of diffuse enlargement of the cervical cord (Fig. 5) since this will not be shown by plotting the curve of the actual measurements. While the values found for differences in absolute values in this series apply only to the specific technique used, it is likely that there will be no great variation in factors of magnification unless there is a wide departure from conventional myelographic methods.

Discussion

While the figures derived in this report have been found to serve a useful function, small deviations suggesting an abnormality must be confirmed by additional clinical evidence. If such evidence is not available, re-examination after an interval with repetition of the same measurements is indicated. It should be emphasized that widening of the transverse diameter of the spinal cord as seen in the anteroposterior projection is not necessarily caused by an intramedullary expanding lesion. Osteoarthritic spurs or epidural masses compress the cord and may widen it from side to side. In these instances, the lateral projection will clarify the nature of the pathological change.

Summary

Eighty normal cervical Pantopaque myelograms were reviewed in order to determine normal ranges of the width of the cervical spinal cord, differences in the width of the cord at adjacent levels, and ratios of the width of the cord to the width of the subarachnoid space. The findings are presented graphically. It is suggested that any difference between adjacent cervical segments of more than 3 mm. and a diameter of the cord greater than 80 per cent or less than 50 per cent of the diameter of the subarachnoid space are highly suspicious findings.

References