Accurate CT Measurement of the Spinal Cord Using Metrizamide: Physical Factors

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Accurate CT Measurement of the Spinal Cord Using Metrizamide: Physical Factors

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Computed tomography (CT) using metrizamide is a valuable tool in the neuroradiologic evaluation of the spinal cord, but CT must be used with care when measuring object size because size may vary with different window center (level) settings. A simple method to determine appropriate window center (level) settings during CT object measurement is described. A polystyrene core with a Teflon outer cylinder designed to simulate the spinal column, spinal cord, and subarachnoid space was scanned with varying concentrations of metrizamide with an EMI 1010 unit. Computer printouts of the CT pixel matrix were analyzed and a constant relationship of the phantom cord true size to the CT numbers of the metrizamide concentration and the phantom spinal cord was found. Window center (level) selection greatly influences measurement of cord size, whereas window width does not. The appropriate window center (level) selection is the mean between the metrizamide CT attenuation number and the cord CT attenuation number.

Computed tomography (CT) with metrizamide has provided an excellent neuroradiologic tool for the evaluation of spinal cord morphology [1, 2]. However, Resjo et al. [3] and Isherwood et al. [4] noted the observed cord size may vary at different window center (level) settings. We encountered this when evaluating patients for possible spinal cord enlargement (fig. 1).

Koehler et al. [5] observed that the selection of the level of window center settings has an important effect on the apparent dimensions of structures in the CT image and that these dimensions are relatively insensitive to window width settings. We conducted a study to determine the optimum window settings during CT metrizamide myelography that provide accurate cord measurement under the various metrizamide concentrations used in clinical practice.

Materials and Methods

A phantom was designed using a polystyrene cord to mimic the spinal cord and a Teflon outer cylinder to mimic the bony spinal column (fig. 2). Various concentrations of metrizamide were placed within the phantom cylinder and scanning was performed with an EMI 1010 scanner. Full concentration was 6.75 g metrizamide in 120 ml normal saline, the volume of spinal fluid in an average spinal canal. Computer printouts of the CT pixel matrix were analyzed. A plot was made of the CT numbers in each pixel along a row through the phantom at its center (fig. 3). Various concentrations of metrizamide were tested and the true phantom cord size was compared with its apparent size. A clinical examination was plotted in a similar way.

Results

The profiles of CT numbers are shown in figure 3 and the clinical study in figure 4. In each graph, A and A′ represent the CT attenuation number of the Teflon (phantom spinal column); B and B′, the CT number of the metrizamide

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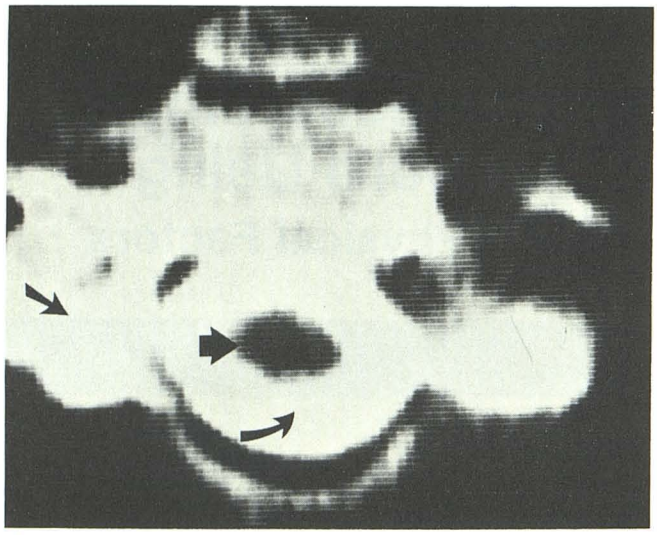
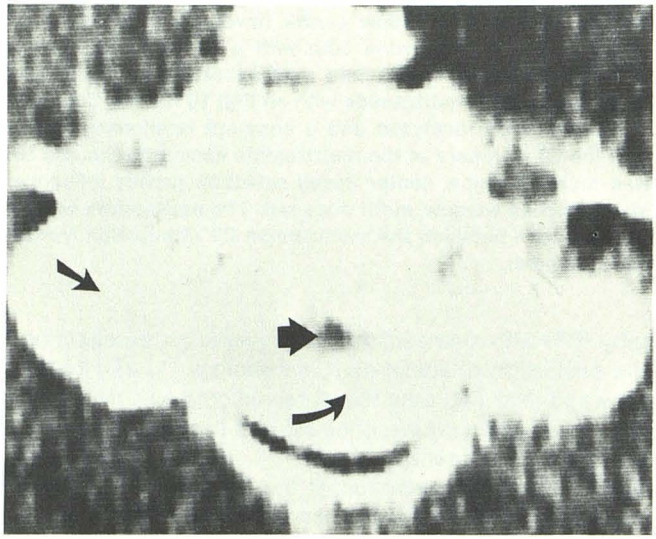


A



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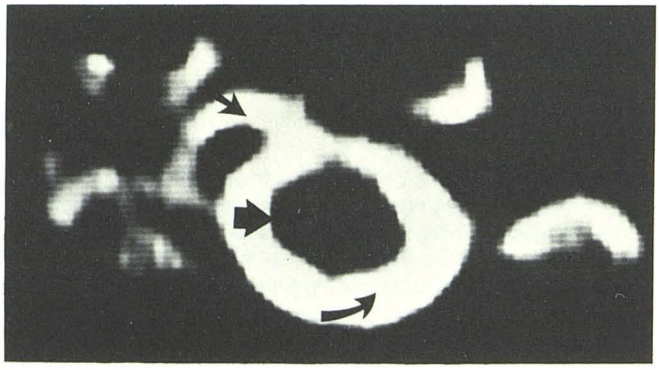

C

Fig. 1.—CT metrizamide myelography at C2 level. Apparent change in size of spinal cord as window (level) center setting and window width vary. **A**, Window center (level) 100 and window width 200; **B**, Window center (level) 50 and window width 100; **C**, Window center (level) 250 and window width 200. Images all of same CT slice. Metrizamide (*curved arrow*); Spinal cord (*large arrow*); Spine (bone) (*arrow*).

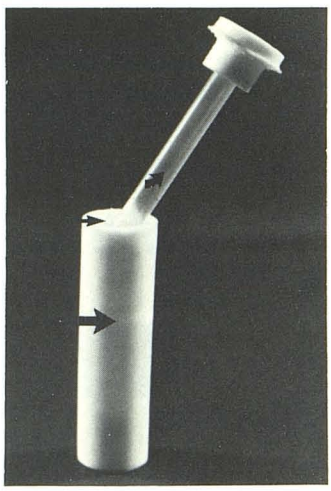

Fig. 2.—Spinal column and spinal cord phantom. Polystyrene cord (*curved arrow*); Teflon spinal column (*arrow*); Space for varying metrizamide solution (*small arrow*).

concentration; and C and C′, the CT number of the polystyrene core. The CT number interval between B and C or B′ and C′ is the uncertain zone for setting the CT window center (level). On each graph, the true polystyrene cord size is indicated at D and D′. E is the area of "overshoot" associated with the reconstruction algorithm of the scanner. A constant relationship was found; the true phantom cord size was at the mean between the CT attenuation numbers of the metrizamide and the phantom cord. This relationship was constant despite varying concentrations of metrizamide solution (table 1). The graph of the clinical study was similar to the phantom study material.

Discussion

As Koehler et al. [5] emphasized, "The optimal window center setting to measure a particular anatomical feature cannot be judged intuitively." Our results provide a guide to reduce error in estimating spinal cord size in CT metrizamide myelography. In practice (fig. 5), CT attenuation numbers of metrizamide and the spinal cord are determined, and the window center is placed at the mean between these two values. It is at this window center placement that the spinal cord can be accurately measured. The attenuation number of the cord is measured in each instance because metrizamide penetrates the cord with time [5, 6], and changes its attenuation number. Varying the window width has little or no effect on the method. Measurements are most accurate with the narrowest window setting, but wider window settings provide a more aesthetic image (figs. 1, 5).

These findings have a direct clinical application. Accurate size estimation of the size of spinal cord cysts is essential for their management (fig. 6). From our studies we conclude that window center (level) selection significantly influences measurement of cord size in CT metrizamide myelography, whereas window width selection does not. The appropriate window center is the mean between the metrizamide CT attenuation number and the cord CT attenuation number. These principles apply to other situations, are recommended

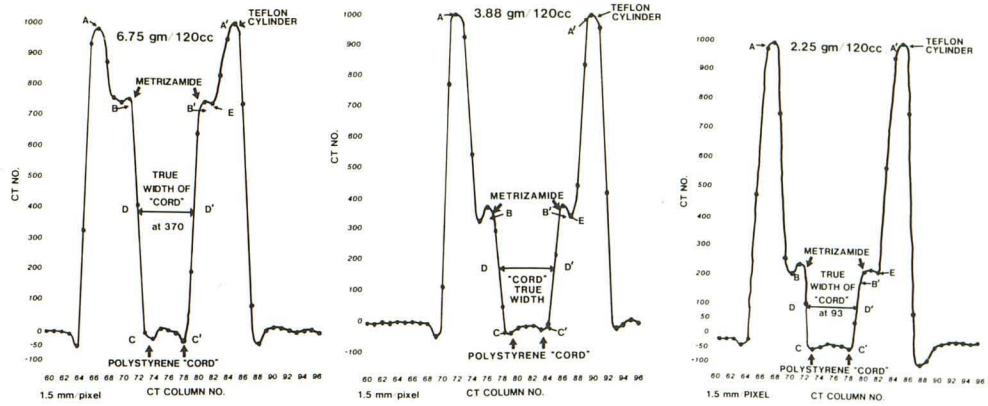

Fig. 3.—Profiles of CT numbers for differing concentrations of metrizamide in phantom. A and A′ represent CT attenuation number of Teflon (spinal column); B and B′, CT number of metrizamide concentration; C and C′, CT number of polystyrene core (spinal cord). Interval between B and C or B′ and C′ represents zone for setting level of CT window center. True polystyrene cord size is indicated at D and D′. E is area of overshoot associated with scanner reconstruction algorithm.

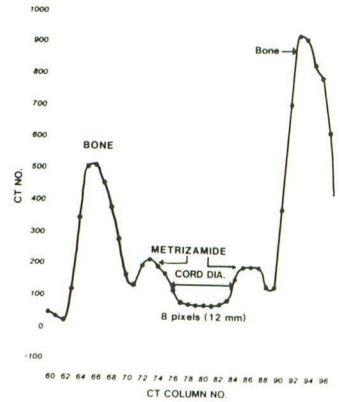

Fig. 4.—*M* Profile of CT numbers from clinical study. Similar to graph of phantom study.

TABLE 1: **Phantom Spinal Cord Size Determined by Mean of CT Numbers**

Metrizamide (g/120 ml)	Metrizamide CT No.	Cord at Two	CT No. True Cord Size (level)	Level/CT No. Mean
6.75	750	−5	370	0.99
3.38	367	−20	170	0.98
1.69	170	−20	75	1.00
2.25	235	−45	93	0.98
1.13	120	−30	45	1.00

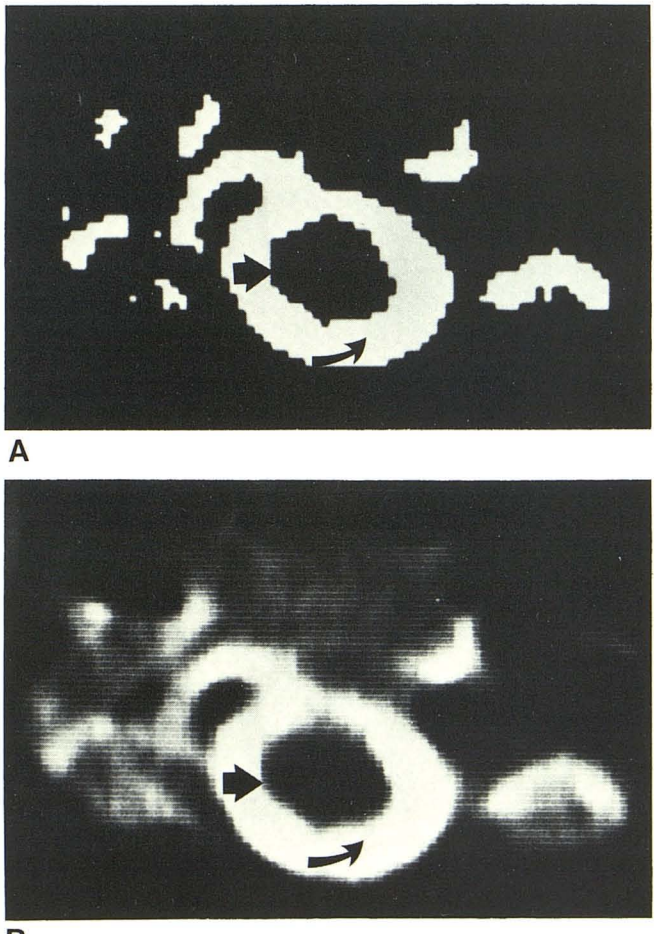

Fig. 5.—**A**, Spinal cord metrizamide study, window center (level) of 250, window width of 1. These are optimum levels for cord measurement. Metrizamide, average CT number (*curved arrow*) was 470. Spinal cord (*arrow*), average CT number was 30. Mean between 470 and 30 is 250. Most accurate window width is narrow window width of 1. **B**, With appropriate center (level) setting, varying window width has no appreciable effect upon object size. Wider window improves aesthetics of image.

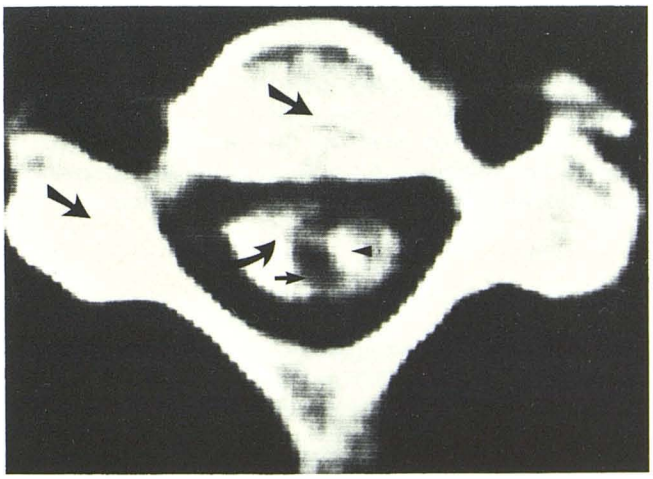

Fig. 6.—CT of spinal cord with metrizamide C5. Vertebral elements (*arrow*); metrizamide (*curved arrow*), average CT number 240; Spinal cord (*small arrow*), average CT number 30; Optimum window center setting (level) is 135 (mean between 240 and 30). Study shows cyst within cord filled with metrizamide (*arrowhead*). Window width of 200 chosen for aesthetics.

for measurement of spinal canal dimensions, lung lesions, liver lesions, etc, and are applicable regardless of scanner type.

REFERENCES

1. Thijssen HO, Keyser A, Horstink MW, Meijer E. Morphology of the cervical spinal cord on computed myelography. *Neuroradiology* **1979**;18:57–62
2. DiChiro G, Schellinger D. Computed tomography of spinal cord after lumbar intrathecal introduction of metrizamide (computer assisted myelography). *Radiology* **1976**;120:101–104
3. Resjo IM, Harwood-Nash DC, Fitz CR, Chuang S. Normal cord in infants and children examined with computed tomographic metrizamide myelography. *Radiology* **1979**;130:691–696
4. Isherwood I, Fawcitt RA, Nettle JR, et al. Computer tomography of the spine. A preliminary report. In: duBoulay GH, Moseley IF, eds. *Computerized axial tomography in clinical practice*. Berlin: Springer, **1977**;322–335
5. Koehler PR, Anderson RE, Baxter B. The effect of computed tomography viewer controls on anatomical measurements. *Radiology* **1979**;130:189–194
6. Isherwood I, Fawcitt RA, Forbes WS, Nettle JR, Pullan BR. Computer tomography of the spinal canal using metrizamide. In: Lindgren E, ed. Metrizamide-Amipaque. The non-ionic water-soluble contrast medium. Further clinical experience in neuroradiology. *Acta Radiol [Supply]* (Stockh) **1977**;355:299–305
7. Winkler SS, Sackett JF. Explanation of metrizamide brain penetration: a review. *J Comput Assist Tomogr* **1980**;4:191–193