ASSESSMENT OF HEPATIC RESPIRATORY EXCURSION

Phillip H. Weiss, James M. Baker, and E. James Potchen

Edward Mallinckrodt Institute of Radiology and the Biomedical Computer Laboratory, Washington University School of Medicine, St. Louis, Missouri

Several methods have been proposed to avoid the degradation of hepatic scintillation scan images caused by respiratory motion (*1–3*). To evaluate these methods more precisely, it is desirable to know the magnitude of hepatic excursion. This communication reports our studies of hepatic respiratory excursion.

MATERIALS AND METHODS

Direct estimation of hepatic excursion. Hepatic excursion was studied in a group of 25 patients referred to the Mallinckrodt Institute for liver scans. Scans were performed on a Nuclear-Chicago Pho/Gamma III scintillation camera using a parallel-hole collimator (4,000-hole) after administration of 3.5–5.0 mCi of ^{99m}Tc-sulfur colloid. Three of the scans showed metastatic disease, two showed changes compatible with alcoholic cirrhosis, and the remainder were interpreted as normal.

Excursion was measured in the anterior projection in erect and supine positions. Data collected from the scintillation camera are processed by dual analog-to-digital converters interfaced to a PDP-12 computer. The digitized images are collected in frames of 0.3 sec in a 32 $\times$ 32 format, and the spatial distribution of the data is analyzed to determine the matrix row containing the median count. The data are transferred to another core location with the images adjusted so that the median rows are in the same position using an algorithm developed by Oppenheim (*3*). This produces an image of the liver with motion corrected. These operations are performed before and during the collection of the next data frame so that the motion corrected image is available at the completion of the study. In addition, the uncorrected image is also available at this time.

The position of the median row is interpolated to the nearest half row and displayed on the PDP-12 oscilloscope during the data collection allowing documentation of liver excursion.

Indirect estimation of hepatic excursion. The second group consisted of 30 patients referred to the Mallinckrodt Institute for gastrointestinal and chest radiography. In this group, excursion of the right hemidiaphragm was observed fluoroscopically and recorded with spot films during quiet respiration and deep breathing in erect and supine positions. No patient had chest, abdominal, or neurologic pathology affecting respiration. Recorded diaphragmatic excursion was corrected for radiographic magnification.

RESULTS AND DISCUSSION

Excursions are shown in Table 1. Although diaphragmatic excursion is an indirect estimation of hepatic motion it is reasonable to expect them to be similar. In fact, the data from both methods do not differ significantly. Diaphragmatic movement (measured radiographically) was less in the erect position than in the supine position and the differ-

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For reprints contact: E. James Potchen, Div. of Nuclear Medicine, Mallinckrodt Institute of Radiology, 510 S. Kingshighway Blvd., St. Louis, Mo. 63110.

TABLE 1. HEPATIC AND RIGHT HEMIDIAPHRAGM EXCURSION DURING QUIET RESPIRATION

	Computer-determined hepatic excursion (cm)	Radiographically-determined hemidiaphragm excursion (cm)
Erect	0.8 ± 0.2* (n = 18)	0.8 ± 0.4 (n = 26)
Supine	1.1 ± 0.3 (n = 12)	1.3 ± 0.5 (n = 25)

* s.d.

ences were statistically significant ($p < 0.001$). Hepatic excursion (estimated by the computer) was also less in the erect position than in the supine position ($p < 0.05$). These data are in a similar range to that reported by Wade (*4*) for diaphragmatic excursion measured radiographically during quiet respiration. It is of interest that he observed no significant difference between excursion in erect and supine positions (1.63 ± 0.18 cm erect and 1.70 ± 0.26 cm supine).

With voluntary deep breathing excursion measured by both techniques ranged from 1.2 to 7.5 cm which is similar to that observed by others (*4,5*).

Kranzler, et al (*6*) have studied hepatic pliability with scintillation scans performed with deep respiration and suggest that the presence or absence of pliability may be a useful clinical sign. The computer algorithm used here is based on a model which assumes that hepatic respiratory excursion is a vertical translation without plastic deformation. This appears to be a reasonable assumption. The criterion of pliability as described by Kranzler, et al (*6*) is a flattening of the dome of the liver consequent to the change in contour of the right hemidiaphragm. We observed no change in diaphragmatic contour during quiet respiration, confirming previous observations (*5*). The relatively small excursion during quiet breathing further suggests that it is unlikely that deformation is a significant problem in the majority of liver scans.

The effect of coarse matrices (32×32, and 64×64) in degrading gamma camera images has been discussed by Erickson, et al (*7*), and their studies indicate that computer image representation will require finer matrices (128×128 or finer) and, consequently, larger core capacity. The relatively small hepatic excursion during quiet respiration emphasizes the need for computers with greater capability than are presently available to most clinical nuclear medicine departments if computer correction of motion is to attain wide clinical usage.

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