Comparison of the Liver's Respiratory Motion in the Supine and Upright Positions: Concise Communication

G. Harauz and M. J. Bronskill

The Ontario Cancer Institute, Toronto, Canada

The effect of the upright position, compared with the supine position, in reducing respiratory motion during liver scintigraphy has been measured in a group of 51 randomly selected patients. Little improvement in spatial resolution can be expected from simply standing the patient upright, and analog motion correction is recommended as much more effective in minimizing respiratory motion artifacts in liver scintigraphy.

J Nucl Med 20: 733–735, 1979

Respiratory motion is a significant limitation in liver scintigraphy. Mettler et al. (*1*) have suggested that the visualization of hepatic lesions is improved in upright views of the liver compared with supine views. This improvement is attributed to a reduction of respiratory motion of the liver in a standing patient compared with a supine patient. Shreiner (*2*), however, has questioned whether general use of liver scintigraphy in the upright position is justified by Mettler's evidence, based as it is on only one or two examples.

An alternative method of reducing respiratory degradation in liver scintigraphy is analog motion correction (*3-5*), which can be used with either upright or supine patients. Such correction has been shown both experimentally and clinically (*6,5*) to improve detection of hepatic lesions. Accurate measurement of the amplitude of respiratory motion of the liver can also be made using an analog motion correction circuit. Using this latter feature, we have investigated the effectiveness of the upright position, compared with the supine position, in reducing respiratory motion of the liver.

MATERIALS AND METHODS

Two large-field-of-view scintillation cameras, each with an analog motion correction circuit, were used for this study. During liver imaging, these circuits produce a correction signal that is proportional to the position of the center of activity of the liver (*5*). A strip-chart recorder was used to plot this signal as a function of time, and a typical record is shown in Fig. 1. The average peak-to-trough excursion of the liver because of respiratory motion (the respiratory amplitude), and also the respiratory frequency, were readily measured from such traces. The signal amplitude was calibrated by moving a small vial of activity across the scintillation camera face in known increments.

A group of 51 patients, chosen at random, was studied. These patients provide a broad spectrum of age, health, and physical fitness, and are representative of the population of cancer patients on whom liver scans are routinely performed at the Princess Margaret Hospital. Each patient was injected with approximately 2 mCi of technetium-99m sulfur colloid. After 10 min, the respiratory frequency and amplitude were measured for both su-

Received Sept. 15, 1978; revision accepted Jan. 9, 1979.

For reprints contact: M. Bronskill, Physics Div., The Ontario Cancer Institute, 500 Sherbourne St., Toronto, Canada M4X 1K9.

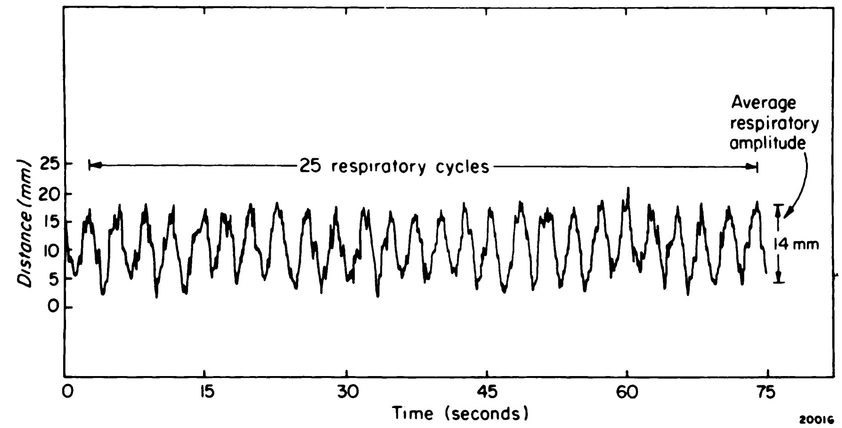

FIG. 1. Position of center of activity of liver, displayed as a function of time. Position signal was obtained from an analog motion-correction signal circuit. Zero positions of both scales are arbitrary. Average respiratory amplitude measured from this trace was 14 mm and respiratory rate was 0.33 Hz (= 20/min). Patient was supine.

pine and upright positions by running traces such as in Fig. 1 for at least a minute. The trace for the supine position was obtained concurrently with the routine anterior liver view. To obtain the trace for the upright position, the camera head was turned 90° and the patient was asked to stand as motionless as possible with his/her chest touching the camera face. Usually the upright trace was obtained first.

RESULTS

The respiratory amplitudes and frequencies measured in the upright and supine positions are shown in Fig. 2. Respiratory amplitude was rounded off to the nearest millimeter in both positions. In 19 patients (37% of those studied) liver respiratory motion in the upright position was greater than or the same as that in the supine position. For the other 63%, the decrease in respiratory amplitude in the upright position was usually only a few millimeters. Most of the patients (69%) breathed more quickly while standing. The observed count rate was unchanged between the two positions.

In 26 patients (51%), a slow downward sag of the liver was observed during the interval of observation in the upright position. The average sag for these patients was 6 mm. For all patients, the trace in the upright position was noisier than in the supine position, indicating more erratic liver and other motions. Both of these observations, illustrated for

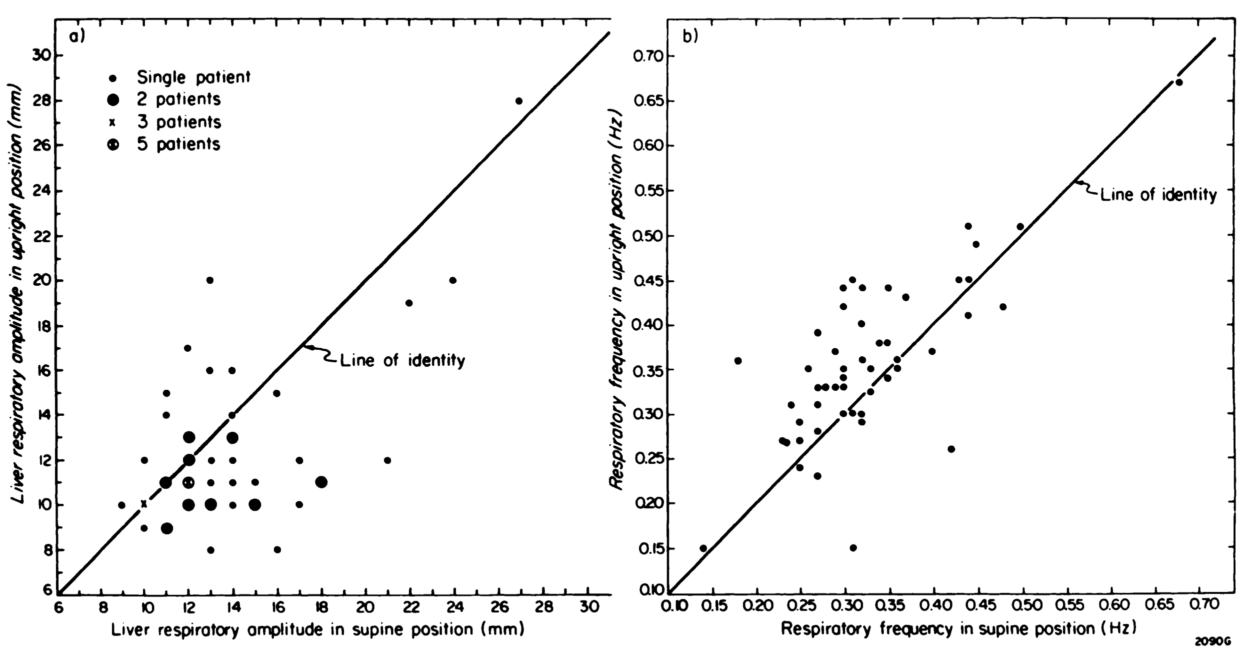

FIG. 2. Comparison of respiratory amplitudes (left) and respiratory frequencies (right) in upright and supine positions. Respiratory amplitudes were rounded off to nearest millimeter. Points above line of identity indicate increase of parameter plotted in upright position compared with supine position.

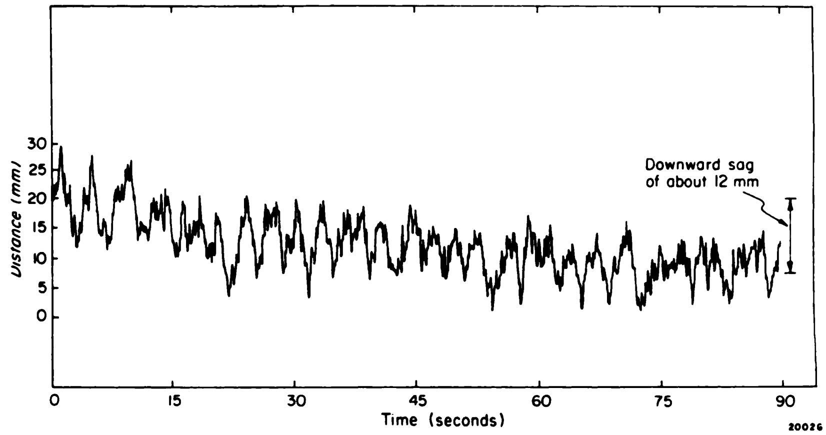

FIG. 3. Position of center of activity of liver displayed as a function of time for a standing patient. Downward sag of about 12 mm is observed in liver position, and trace indicates a more erratic liver motion than in the trace of Fig. 1.

a single patient in Fig. 3, did not depend on whether the standing trace was obtained before or after the supine trace.

DISCUSSION AND CONCLUSION

The observations made with this group of patients indicate that there is little reduction in respiratory amplitude in the upright position compared with the supine. For the entire group of 51 patients, the average respiratory amplitude while supine was 14 mm and it decreased to 12 mm while standing. The histogram of Fig. 4 shows the change in respiratory amplitude from the supine to the upright position for all patients studied.

Eleven patients exhibited *increased* respiratory amplitude in the upright position, as shown by the negative differences in Fig. 4. The average reduction in respiratory amplitude of 1.4 mm is small when compared with the residual respiratory amplitude of 12 mm, and would be offset in most cases by the increased patient motion and downward sag of the liver observed in the upright position.

We believe that little, if any, improvement in spatial resolution can be expected from simply standing the patient upright during liver scintigraphy. A much larger gain in spatial resolution is achieved by using analog motion correction to ameliorate the fundamental problem of the liver's respiratory motion (*5,6*). We also urge caution in advocating changes in procedure without adequate study of the benefits and drawbacks involved (*7*). Especially where sophisticated instrumentation is involved, the quick and the inexpensive are not necessarily good.

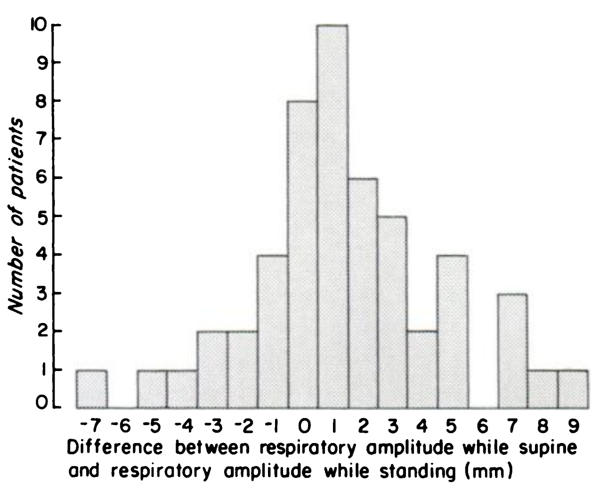

FIG. 4. Change in respiratory amplitude from supine to standing position. Negative differences indicate an increased respiratory amplitude in upright position—i.e., points above line of identity in Figure 2 (left). Average reduction in respiratory amplitude for all patients in group is 1.4 mm.

ACKNOWLEDGMENTS

This work was supported by the Ontario Cancer Treatment and Research Foundation and the National Cancer Institute of Canada. The constructive criticism of Dr. G. N. Ege and Dr. J. L. Yeoh is appreciated.

REFERENCES

1. METTLER FA, SHEA WH, GUIBERTEAU MJ, et al: Improvement in visualization of hepatic lesions with upright views. *J. Nucl Med* 18: 1128-1130, 1977
2. SHREINER DP: Visualization of hepatic lesions with upright views. *J Nucl Med* 19: 563, 1978
3. HOFFER PB, OPPENHEIM BE, STERLING ML, et al: A simple device for reducing motion artifacts in gamma camera images. *Radiology* 103: 199-200, 1972
4. ELINGS VB, MARTIN CB, POLLACK IG, et al: Electronic device corrects for motion in gamma camera images. *J Nucl Med* 15: 36-37, 1974
5. BAIMEL NH, BRONSKILL MJ: Optimization of analog-circuit motion correction for liver scintigraphy. *J Nucl Med* 19: 1059-1066, 1978
6. TURNER DA, FORDHAM EW, ALI A, et al: Motion corrected hepatic scintigraphy: an objective clinical evaluation. *J Nucl Med* 19: 142-148, 1978
7. HENKIN RE: The good, the quick, and the inexpensive. *J Nucl Med* 18: 1131-1133, 1977