COMPARISON OF ^{131}I, ^{99m}Tc, AND ^{113m}In FOR LIVER SCANS

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The optimum base-level settings were derived experimentally from the line-spread function for the three radionuclides, ^{113m}In, ^{131}I, and ^{99m}Tc. The scans of liver slice phantom obtained with these radionuclides showed that the image quality and detectability of lesions were better with the optimum settings than with the conventional 100-keV window. Indium-113m appeared to be superior to the other radionuclides in its efficiency for detection of a lesion in a phantom.

We have compared the efficiency for detecting lesions in a liver scan of the three most commonly used used radionuclides: ^{131}I (as rose bengal), ^{99m}Tc (as sulfur colloid), and ^{113m}In (as colloid).

Sanders, Cohen, and Kuhl (*1*) as well as Beck and others (*2*) have studied the effect of pulse-height selection on imaging to establish an optimum window setting for ^{99m}Tc in brain scanning. The asymmetric window suggested by them is now well accepted. We have followed Beck's method of using the statistically derived quality factor (figure of merit, Q) to establish the optimum window setting in our studies. This window setting was further confirmed as the most appropriate by comparing scans of liver phantom with different settings. The scans of liver phantom obtained at these "most optimum" settings with the above three radionuclides were then studied for their relative efficiencies for detecting the lesions of different sizes implanted at various depths in the phantom.

METHOD

The scanning system consisted of a 5 × 3-in. probe with a 5-in. focus and ½-in. resolution Picker collimator connected to a Picker magnascanner. Line-spread functions (LSF) at different baseline settings (BLS) and at the focal plane of the collimator were obtained in air as well as in a scattering medium (8 cm front scatter and 2 cm backscatter). The modulation transfer functions (MTF) were obtained from these LSFs. The photopeak efficiency, χ, was also measured at different BLS and the figure of merit, Q, was obtained at various BLS by using the following relationship (*2*),

$$\frac{QI}{Q} = \frac{(MTF_{AIR})/(MTF_{SC})}{\chi}$$

in which QI is the figure of merit for an ideal imaging system. The optimum BLS is given by the setting for which Q is closest to QI. Using this procedure, the optimum BLS were obtained for ^{131}I, ^{99m}Tc, and ^{113m}In.

The liver slice phantom used in these studies was a locally fabricated triangular Perspex box measuring 15 cm in breadth and length and 8 cm in thickness. It had two sets of cylindrical lesions (3 cm in length, 0.5, 1.0, 1.5, 2.0, 2.5 cm in diam), one placed at the bottom and the other fixed at the top. The box is filled with radioactive solution through the holes on the top.

The scans of the phantom were obtained after filling the phantom with an amount of radioactivity which is normally used for liver scans in our department, e.g. 1.7 mCi ^{99m}Tc, 100 μCi ^{131}I, and 1.8 mCi ^{113m}In. The information density and speed were adjusted to give film density of 1,400 corresponding to the maximum darkness on the film.

RESULTS

The optimum BLS, the conventional 100-keV window settings, and QI/Q for all the three radioisotopes are shown in Table 1. Figure 1 shows the corresponding scans obtained at optimum and conventional settings. The optimum settings improved the quality of the image remarkably, especially in the case of a low-energy radionuclide like ^{99m}Tc.

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TABLE 1. ASYMMETRIC WINDOW SETTINGS AND QI/Q VALUES FOR THREE RADIOISOTOPES

Radioisotope		Conventional PHS of 100 keV window	Optimum PHS	Photopeak efficiency	QI/Q at
Name	Energy (keV)	E_c (keV)	E_{opt} (keV)	at E_{opt}	E_{opt}
^{99m}Tc	140	90	120	0.94	1.39
^{131}I	364	314	327	0.93	1.30
^{113m}In	390	340	355	0.94	1.23

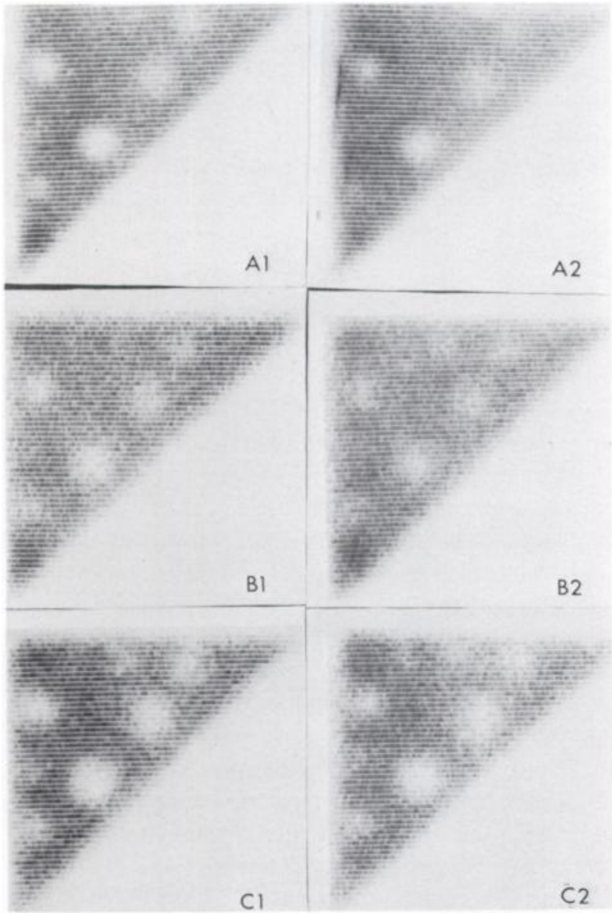

FIG. 1. Comparison of liver slice phantom scans with ^{99m}Tc (A1, A2), ^{131}I (B1, B2) and ^{113m}In (C1, C2). Scans A1, B1, C1 are made with optimum BLS while A2, B2, and C2 are with conventional 100-keV symmetric window. Indium-113m scan (C1) with optimum setting shows better lesion detectability and better contrast than ^{99m}Tc scan (A1) with optimum setting.

The efficiency for detecting the "cold areas" in the phantom was best in the optimum ^{113m}In scan (C1 in Fig. 1). The ^{99m}Tc scan failed to visualize deeply situated lesions (A1 in Fig. 1). The ^{131}I scan was intermediate in this respect (B1 in Fig. 1).

The size of the lesion was closest to the true size with ^{113m}In. The ^{99m}Tc scan showed some reduction in the size of the lesions. The higher Q value for ^{113m}In resulted in good contrast in the scan.

COMMENTS

All the scans were made with a single high-energy collimator, and it may appear that a low-energy collimator would have improved the detectability in ^{99m}Tc scans. The long-focused ^{99m}Tc collimator (2114B) available with the Magnascanner has poorer depth response compared with the collimator (2111) used in this study (*3*), and hence such a low-energy collimator would have improved Q value but would not have enhanced the detectability of deeply situated lesions.

In all the three radionuclides, the image quality improved with the optimum settings derived experimentally, pointing out the desirability of determining the figure of merit (Q) from the line-spread function for a scanning system instead of blind acceptance of 100-keV conventional window settings. The improvement in the image quality was most marked in the case of ^{99m}Tc. The low energy of ^{99m}Tc produces a large degree of coherent scatter which is not effectively eliminated in the conventional settings. The ^{99m}Tc scan failed to show "true-to-life" size of the lesions, again probably because of the degradation of the image due to scatter.

In respect to the efficiency of detection of lesions, ^{113m}In was superior to ^{99m}Tc and ^{131}I. Technetium-99m failed to show the lesions situated at depth. In clinical practice, this shortcoming of ^{99m}Tc is overcome by taking multiple views.

The results obtained in this study are of particular value to us in India and probably in other developing countries which do not have the scintillation camera and the only instrument available for scanning is a single-head rectilinear scanner which is not as fast as many current in the market and which does not have more than one collimator. Multiple views are frequently not taken because either there are too many patients or they are too sick to permit many views with a relatively slow scanner.

On the basis of the studies reported here, ^{113m}In appears a sound choice for imaging large organs like the liver in a situation where best results are desired from a single view with a single collimator on a simple rectilinear scanner.

REFERENCES

1. Sanders TP, Cohen TD, Kuhl DE: Optimizing the window of an Anger camera for ^{99m}Tc. *J Nucl Med* 11: 703–706, 1971

2. Beck RN, Suhuh MW, Cohen TD, et al: Effect of scattered radiation on scintillation detector response. In *Medical Radioisotope Scintigraphy*, vol 1, Vienna, IAEA, 1968, pp 595–616

3. Hine GJ, Tsialas SP: Evaluation of focussed collimator performance. In *Medical Radioisotope Scintigraphy*, vol 1, Vienna, IAEA, 1968, pp 487–507