SPECT Versus Planar Liver Scintigraphy: Is SPECT Worth It?

H. Daniel Fawcett and Bettye A. Sayle

Division of Nuclear Medicine, Department of Radiology, University of Texas Medical Branch, Galveston, Texas

Five hundred three planar and SPECT hepatic studies were reviewed separately by two experienced observers looking for focal disease. An equivocal reading meant referral to ultrasound or computed tomography (US/CT). The increase in correct readings and decrease in US/CT referrals per 100 positive and per 100 negative SPECT readings were calculated, then the increase in correct readings and decrease in US/CT referrals for various positive rates of liver involvement determined. At our institution, the overall positive rate is ~13% yielding 1.1 and 0.83 more correct readings and 1.8 and 2.0 fewer US/CT referrals per 100 cases for each reader, respectively; a marginal benefit for SPECT over planar scintigraphy.

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For evaluating focal disease of the liver, single photon emission computed tomography (SPECT) has been shown by some investigators to be more sensitive and specific than planar scintigraphy (*1*) while others have found marginal improvement with reader variability (*2, 3*). SPECT systems are presently more expensive than planar systems. Depending on the manufacturer, we found an average variation in cost difference between the two systems of ~$100,000–$150,000. In addition, we found that for the average patient, it takes ~20–25 min longer to perform, process, and interpret SPECT images. Therefore, some index for measuring improvement would be useful in order to determine if these increased "costs" were justified. This study was designed to determine what net increase in correct clinical diagnoses if any would be made by switching from planar to SPECT technique at our institution. We also tried to determine if there would be a decrease in equivocal readings with subsequently fewer referrals to ultrasound or computed tomography (US/CT).

METHODS

All patients referred to the Division of Nuclear Medicine from November 1985 to September 1987 for evaluation of space-occupying disease in the liver were included in the study. Both planar and SPECT images were obtained using an ADAC ARC 3000 (Philips) rotating gamma camera and ADAC DPS 33000 computer system. High resolution collimation was employed. Following administration of 7 mCi (260 MBq) of technetium-99m (^{99m}Tc) sulfur colloid (adult dose), 800K planar images (anterior, right lateral, posterior views) were acquired on a computer using a 128 × 128 × 16 matrix. SPECT images were then acquired in a 64 × 64 × 16 matrix, using a 360° step and shoot circular orbit with 64 stops at 20 sec per stop. Processing of SPECT data included uniformity correction, Butterworth 0.7 filtering with a cutoff of 7, and attenuation correction [Lesions just over 1 cm in a SPECT phantom were identified using these same parameters (Fig. 1)]. Planar and SPECT images were viewed on an ADAC system TV monitor. SPECT slices (1.2 cm) were routinely viewed in the transverse and coronal planes. Sagittal cuts were viewed only when deemed necessary for clarification of questionable abnormalities. Planar and SPECT images of each patient were reviewed at separate sittings by two independent observers without knowledge of the underlying disease. Images were graded on a 1 to 5 system with 1 and 5 meaning definitely negative and definitely positive, respectively, 2 and 4 meaning probably negative and probably positive respectively, and 3 meaning equivocal with referral to US/CT for clarification and final imaging diagnosis. For purposes of data analysis the following assumptions were made.

1. Clinical management would be the same if planar and SPECT agree, whether or not the diagnosis was correct.
2. The scintigraphic diagnosis was considered truth for purposes of data analysis if planar and SPECT agreed.
3. If planar or SPECT diagnoses disagreed or if one was equivocal, the US/CT diagnosis was considered the truth.
4. If US/CT was not available truth was based on followup hepatic scintigraphy.

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For reprints contact: H. Daniel Fawcett, MD, Div. of Nuclear Medicine, Dept. of Radiology, University of Texas Medical Branch, Galveston, TX 77550.

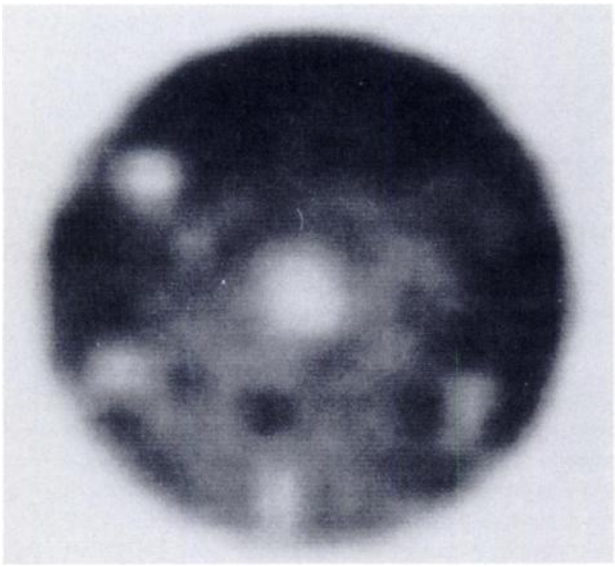

FIGURE 1
Single slice through SPECT phantom. Images were acquired, processed, and displayed using the same technique as hepatic SPECT. The central cold "lesion" was 2.2 cm and the lesion at 4 o'clock was 1.1 cm. A 1.0 cm "lesion" at 2 o'clock was not clearly identified.

RESULTS

Table 1 is a breakdown of patient diagnoses and shows that over 95% of the studies were performed for metastatic disease. Table 2 is a summary of complete and essential agreement between planar and SPECT for both readers. Complete agreement meant the scores given to planar and SPECT images for the same study by a reader were identical. Essential agreement included not only studies with identical scores but also those studies in which the planar/SPECT diagnosis was the same, but one was a definite reading while the other was a probable reading.

Table 3 is a breakdown of these definite/probable readings. Probable readings represented mild concern and were almost always associated with a negative interpretation. Not unexpectedly, the cause for concern was the porta hepatis region, the area of the gallbladder fossa, the renal impression or a thin left lobe. With follow-up available in all but six, it was not surprising that there was only one case in which the diagnosis was incorrect (Reader 2, a 2-1 reading in which CT showed a lesion). This application of SPECT for reduction of this mild degree of uncertainty only affected an improvement in 1.8% and 2.8% of the total number of patients for Readers 1 and 2, respectively.

Table 4 is a summary of planar and SPECT "nonagreement", i.e., disagreement (a 1 or 2 reading with one technique versus a 4 or 5 reading with the other) plus those in which one interpretation was equivocal-3. Table 4 also includes a summary of how well each technique did in the areas of disagreement/equivocal readings plus the calculated net improvement with SPECT for each reader (calculations were extrapolated from patients with followup leading to "fractional patients" in some entries). It is possible for both techniques to be correct if the US/CT from an equivocal reading leads to the same diagnosis as the unequivocal reading. SPECT demonstrated a net improvement of 24% and 19% for nonagreement cases for Readers 1 and 2, respectively. However, nonagreement cases only constituted 4.8% and 4.4% of each readers' total, respectively.

Table 5 is a summary of the improved accuracy normalized to 100 SPECT readings both positive and negative, and the effect on US/CT referrals for each reader. Table 6 is a calculation of the improvement per

TABLE 1
Patient Diagnosis

Diagnosis	No. of studies	% of Total
Breast cancer	196	39.0
Lung cancer	103	20.5
GI tract cancer	76	15.1
Melanoma	27	5.4
Head and neck cancer	19	3.8
Gynecological cancer	10	2.0
Miscellaneous cancer	51	10.1
Other	21	4.1
Total	503	100

TABLE 2
Planar Versus SPECT Agreement in 503 Studies

Agreement	Reader 1	Reader 2
Complete*	463 (92.0%)	467 (92.8%)
(−) Diagnosis	405	411
(+) Diagnosis	56	56
Equivocal diagnosis	2	0
Essential agreement†	479 (95.2%)	481 (95.6%)
(−) Diagnosis	417	423
(+) Diagnosis	60	58
Equivocal diagnosis	2	0

* Identical score.
† Identical score plus definite/probable.

TABLE 3
Probable-Definite Readings*

	P S 2-1	P S 4-5	P S 1-2	P S 5-4	Net SPECT improvement
Reader 1	10	1	1	1	9 (1.8%)
Reader 2	13	1	0	0	14 (2.8%)

* Each column shows the number of patients with the score combination as indicated for each reader. (one normal, two probably normal, four probably abnormal, five abnormal, P-planar, S-SPECT).

TABLE 4
Planar Versus SPECT Disagreement/Equivocal Readings in 503 Studies

Reader	Disagreement	Equivocal	Total	Follow-up
1	5	19	24 (4.8%)	20
2	12	10	22 (4.4%)	20

Reader	Technique	Final Diagnosis +	−	Total
1	SPECT	6/6	16.7/18	22.7/24
	Planar	1/6	16/18	17/24
	Net improvement	5/6	0.7/18	5.7/24 (24%)
2	SPECT	6.9/11	9.7/11	16.6/22
	Planar	4.1/11	8.3/11	12.4/22
	Net improvement	2.8/11	1.4/11	4.2/22 (19%)

100 cases and effect on US/CT referrals, based on different positive diagnostic rates. At our institution, the overall positive rate is about 13% yielding 1.1 and 0.83 more correct readings and 1.8 and 2.0 fewer US/CT referrals per 100 cases for each reader, respectively. Using analysis procedures developed by Grizzle et al. (*4*), the improvement with SPECT was found to be statistically significant for each reader ($p < 0.05$).

DISCUSSION

The decision to switch from planar to SPECT technique for evaluating focal hepatic disease with [^{99m}Tc] sulfur colloid has to be based on the frequency in which the two techniques lead to different interpretations and subsequently to the net increase in correct diagnoses by SPECT. If a difference is seen, then it becomes in part, a philosophical question as to whether the magnitude is worth the increased cost in equipment and time. It is clear from our study of patients being evaluated predominantly for metastatic disease that essential agreement of planar and SPECT readings differ <5% of the time for both our readers. Looking at the overall effect

TABLE 5
Improved Accuracy with SPECT

Reader	SPECT diagnosis	Improvement per 100 SPECT readings	US/CT referrals per 100 SPECT readings
1	(+)	7.5 readings	1.5 more
	(−)	0.16 readings	2.3 fewer
2	(+)	4.1 readings	4.3 fewer
	(−)	0.32 readings	1.6 fewer

TABLE 6
Improvement of SPECT over Planar Imaging at Varying (+) SPECT Diagnostic Rates

Positive rate	Reader	Improvement/100 cases	US/CT/100 cases
10%	1	0.89	1.9 fewer
	2	0.70	1.9 fewer
30%	1	2.4	1.2 fewer
	2	1.4	2.4 fewer
50%	1	3.8	0.40 fewer
	2	2.2	2.9 fewer
70%	1	5.3	0.36 more
	2	3.0	3.5 fewer

(Table 6) there is very little to gain by switching to SPECT in terms of significantly increasing the accuracy unless one is dealing with a population that has a high positive rate. This is not the case at our institution where the rate of positivity is only around 13%. The effect of switching from planar to SPECT on US/CT referrals is insignificant at any disease prevalence. While one cannot draw general conclusions from our study as to how much of an improvement SPECT would have over planar imaging at other institutions with different readers and SPECT systems when evaluating for space-occupying disease using [^{99m}Tc]sulfur colloid, it does indicate that it is not a foregone conclusion that increased accuracy with SPECT will necessarily translate into a clinically significant difference, especially if one uses state of the art planar imaging and display format.

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