## Performance of Scintillation Cameras

A recent letter by Hine and Paras (*1*) deserves a word of comment because it omits important data on Baird-Atomic's "System Seventy." The System Seventy is the only multicrystal camera—indeed, the only scintillation camera—with published performance specifications for count-rate and deadtime correction (*2,3*). The operating count-rate range for the System Seventy extends up to 200,000 observed and retrievable counts per second, obtained with up to 33 mCi of $^{99m}$Tc and the 1.5-in.-thick collimator. This observed rate corresponds to a true input-event rate of up to 400,000 events per second. The standard 2.5-in.-thick collimator resolves 2.8-mm bars at the surface of the collimator and has a FWHM of 3 mm. In the scan mode the multicrystal camera has no intrinsic spatial resolution component, this resolution being defined only by the collimator response (*2*). For example, using the 4-in.-thick collimator, 3-mm bars are resolved at 4 inches from the surface of the collimator.

High count-rate capability and accurate deadtime correction, as well as invariance of the spatial resolution with increasing count rate, are absolute necessities in any system required to perform quantitative dynamic studies such as radionuclide cardiography.

RAYMOND P. GRENIER
Baird-Atomic, Inc.
Bedford, Massachusetts

REFERENCES

*1.* HINE GJ, PARAS P: Performance of scintillation cameras. *J Nucl Med* 16: 1206–1207, 1975

*2.* GRENIER RP, BENDER MA, JONES RH: A computerized multicrystal scintillation gamma camera. In *Instrumentation in Nuclear Medicine*, Hine GJ, Sorenson JA, eds. New York, Academic, 1974, vol 2, pp 101–134

*3.* JONES RH, LIDOFSKY L, BUDINGER T, et al: Instrumentation. In *Quantitative Nuclear Cardiography*, Pierson RN, Kriss JP, Jones RH, MacIntyre WJ, eds. New York, Wiley, 1975, pp 231–253

## Measurement of Serum Triiodothyronine Concentrations

For the past 14 months we have used the commercial resin-strip technique for the measurement of serum triiodothyronine ($T_3$) concentration as described by Burman et al (*1*) in the July 1975 issue of this journal. From our experience we think that several aspects of the technique should be emphasized.

Although we have been unable to achieve the remarkably small coefficient of variation [CV = (standard deviation/mean) × 100%] claimed by the manufacturer, we find that the precision of the method is much better than that observed by Burman et al (Table 1). Our procedure differs from that of the Burman group only in minor details. We feel that careful attention to pipetting and to draining the resin strips when they are removed from the reaction vials makes triplicate samples unnecessary. Our samples are all analyzed in duplicate, using glass chemical micropipets (Lang–Levy) for each critical pipetting step (patient serum, standard, and antibody solutions), and the resin strip is rotated at room temperature, usually 23–26°C. We have consistently obtained CVs of 9–10% over a period of 9 months, using 13 different lot numbers of reagents and involving 77 assays of frozen and thawed pooled serum by five different analysts. We do not use commercial lyophilized control serum since lyophilized controls are often less reproducible than laboratory-prepared frozen pooled serum.

Our initial "normal range" (74–153 ng/dl), determined on 25 healthy volunteers, agreed remarkably well with that of Burman et al. Our normal values were somewhat lower than those suggested by the manufacturer and certainly lower than those reported by most research laboratories using various other antibodies with unknown cross-reactivity with thyroxine ($T_4$). As most clinical laboratories are forced to do, we used volunteer technologists and students as normal subjects. This biased the normal range to describe best the 20–30-year-old population. When this "normal range" was applied to the general hospital population, a great many euthyroid patients over 50 years of age were misclassified as being hypothyroid. Similarly, many elderly patients, clinically hyperthyroid, were included in the "normal $T_3$ concentration range."

A brief survey of the literature revealed numerous reports that $T_3$ concentrations in serum, in contrast to $T_4$, are highly age-dependent (*2–4*). Thus, to speak of a single "normal range" without specifying the ages of the subjects is clinically meaningless. Based on the observations of Brunelle and Bohuon (*2*) that $T_3$ concentrations decline 5 ng/dl for each decade of life, we established our normal range using only 20–30-year-old subjects (79–150 ng/dl) and then constructed the nomogram shown in Fig. 1. Since the precision of the assay in our laboratory was ±10%, one standard deviation was added and subtracted from the extremes of the normal range to indicate "borderline values." The validity of the nomogram was confirmed by reviewing the clinical records of patients with previously determined $T_3$ values; we found a much better correlation with clinical status when we used the age-dependent nomogram than when the single "normal range" was used for all subjects.

Our experience, supported by that of many others, has been that $T_3$ determinations are of great value in the diagnosis of developing hyperthyroidism (when $T_4$ concentrations are often still within the normal range) and in monitoring the dosage of exogenous thyroid medication required for replacement therapy. Caution must be employed, however, in using the $T_3$ analysis to evaluate the possibly hypothyroid patient. The sensitivity of the resin-strip method is not sufficient to allow separation of the low-normal elderly patient from the hypothyroid population, if sensitivity is defined as the smallest concentration of hormone distinguishable from zero. In addition, the $T_3$ concentration in the serum cannot be assumed to reflect thyroid status in patients with severe liver disease (*5*). As the liver is the major site of extrathyroid deiodination of $T_4$ to $T_3$, patients with severely com-

**TABLE 1. INTERASSAY VARIATION OF $T_3$ RESIN-STRIP METHOD**

| Laboratory | No. of analysts | n | Mean (ng/dl) | Standard deviation | Coefficient of variation (%) |
|---|---|---|---|---|---|
| Manufacturer | ? | 4 | 120.6 | 2.8 | 2.3* |
| Burman et al | ? | 13 | "Normal" | ? | 18.7 |
| N. C. Baptist Hospital: | | | | | |
| Pool No. 2 | 5 | 12 | 103.3 | 9.9 | 9.6 |
| Pool No. 1 | 5 | 77 | 104.1 | 10.1 | 9.7 |

* Calculated from mean and standard deviation as reported in package insert, RIA-MAT Circulating T3 I-125 Kit, Mallinckrodt, Inc., St. Louis, Mo.

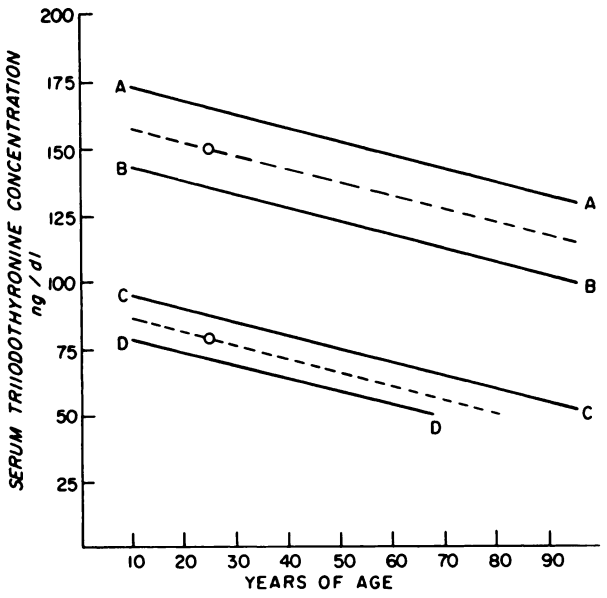


**FIG. 1.** Nomogram relating age to normal concentration of serum triiodothyronine. Normal range was determined for 20–30-year-old population, and line with slope —5 (ng/dl)/10 yr was extrapolated (dashed lines). When using nomogram to interpret serum triiodothyronine concentrations, values falling in area between lines A and B are considered borderline-elevated; between B and C, normal; between C and D, borderline-low. Values above line A are clearly hyperthyroid and values below line D indicate low values for subjects less than 65 years of age.

promised liver function will often have normal concentrations of $T_4$ and reduced $T_3$ levels. Such patients are usually not clinically hypothyroid and can be identified by the reduced concentrations of total serum proteins, albumin, or thyroxine-binding globulin (or elevated $T_3$ resin uptake).

C. M. HEISE
Bowman Gray School of Medicine
Wake Forest University
Winston Salem, North Carolina

## REFERENCES

*1.* BURMAN KD, WRIGHT FD, EARLL JM, et al: Evaluation of a rapid and simple technique for the radioimmunoassay of triiodothyronine ($T_3$). *J Nucl Med* 16: 662–665, 1975

*2.* BRUNELLE P, BOHUON C: Decrease of triiodothyronine in serum of senescent persons. *Clin Chim Acta* 42: 201–203, 1972

*3.* RUBENSTEIN H, BUTLER V, WERNER S: Progressive decrease in serum triiodothyronine concentrations with human aging: Radioimmunoassay following extraction of serum. *J Clin Endocrinol Metab* 37: 247–253, 1973

*4.* HANSEN JM, SKOVSTED L, SIERSBAEK-NIELSEN K: Age dependent changes in iodine metabolism and thyroid function. *Acta Endocrinol* 79: 60–65, 1975

*5.* NOMURA S, PITTMAN CS, CHAMBERS JB, et al: Reduced peripheral conversion of thyroxine to triiodothyronine in patients with hepatic cirrhosis. *J Clin Invest* 56: 643–652, 1975

## Reply

We thank Dr. Heise for her comments and we are gratified that her observations are consistent with ours. We agree that each laboratory must determine its own "normal range" and that these "normal ranges" should serve only as guidelines to suspected clinical illness and should not be interpreted strictly. Indeed, a given serum measurement may lie within the "normal range" and still be abnormal for an individual patient. Given these limitations of the "normal range," it is not surprising that serum $T_3$ measurements may be normal in clinically hypothyroid patients. Fortunately, other methods may be utilized to aid in the diagnosis of hypothyroidism, e.g., thyrotropin or thyroxine measurements and the patient's clinical state. We agree that $T_3$ levels decline with advancing age; this decrement may be related to decreased conversion of thyroxine to triiodothyronine (*1*). Besides the two groups of patients mentioned by Dr. Heise (the elderly and patients with liver disease), $T_4$-to-$T_3$ conversion may also be decreased in patients receiving glucocorticoids (*2*), lithium, or propylthiouracil (*3*); in fasting patients (*4*); and in newborn infants (*5*).

Conversely, serum $T_3$ levels may be increased in pregnancy or after ingestion of estrogens, heroin, or methadone, since these conditions involve elevated levels or capacities of thyroxine-binding globulin (TBG). A high TBG level may also have a hereditary basis. All these patients will tend to have normal free $T_3$ levels and to be clinically euthyroid. Alterations in total and free $T_3$ levels may also be found in euthyroid patients receiving anabolic steroids, in certain patients with various nonthyroidal diseases, and in patients with a hereditary decrease in TBG. That such alterations in binding produce changes in serum $T_4$ has been appreciated for several years. We must now apply the lessons learned so well