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The Use of ^{125}Iodine for Precordial Counting[3]

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The physical characteristics and particular advantages of ^{125}iodine have been extolled in the literature of the past several years (1-3). With the development of more economical production methods, this isotope has been found useful in application to various diagnostic procedures (3-9). Determination of cardiac output by precordial counting of this soft gamma emitter has not been previously described. This communication reports the use of ^{125}iodine labeled albumin for this purpose.

METHOD

Radioiodinated (^{125}I) human serum albumin, which has a half-life of about 57 days and emits a 27.4 kev x-ray and a 35.4 kev gamma ray, was obtained from E. R. Squibb and Sons or Volk Radiochemical Company. Each day some of the sterile stock solution was diluted to 40 μc/ml. It was rapidly injected into an antecubital vein in doses of 0.5 ml (20 μc) for the first and 1.0 ml (40 μc) for a second determination.

For precordial counting of blood flow through the heart, a Nuclear-Chicago Corporation Model DS8-21 Miniature Scintillation Detector was used. It contains a thallium activated sodium iodide wafer crystal 2 mm thick and 18 mm in diameter which is reported to be at least 98 per cent efficient for 30 kev energies (1, 3). The crystal is covered by a beryllium window 0.005 inch thick which allows low energy radiations to pass without appreciable loss. The instrument includes also a short lucite light pipe, a photomultiplier tube (Dumont K1692) and a small preamplifier. The whole detector has dimensions of 10 x 1 inches and weighs 175 grams.

With a patient in a comfortable supine position, the detector, supported by a ring stand, was centered over the heart (third or fourth intercostal space,

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1 cm to the left of the sternal border) with its long axis perpendicular to the chest wall. Time concentration curves representing cardiac (and pulmonary) transit of the ^{125}I albumin bolus were counted on a conventional linear ratemeter (Nuclear-Chicago 1620 CS) and a milliammeter recorder (Texas Instruments, Inc.). The procedure for exponential extrapolation and calculation of cardiac output from curve area and equilibrium level is the same as for ^{131}I albumin and has been described in detail previously (10, 11). Total blood volume was measured in conjunction with the first cardiac output in each patient.

In 16 patients, some of whom had heart disease, results of ^{125}I albumin determinations were compared to those with ^{131}I albumin (10-20 μc per dose). The latter required conventional 2 inch detectors with lead shielding and narrow angle (20°) collimation (Nuclear-Chicago Corp. DS-5). Four determinations—two with each method—were generally carried out in alternating sequence. In 10 patients, this was started with ^{125}I albumin; in the other 6 individuals, ^{131}I albumin was used first. All determinations in a patient were completed within one hour. Both indicators contributed to background radioactivity levels counted with either detector in subsequent determinations in an individual. This was of no consequence, however, because the calculations are based on relative changes in precordial count rates following each dose.

The ^{125}I and the ^{131}I values for cardiac output were compared in each patient to calculate the correlation coefficient and "p" value. The older, established ^{131}I albumin method was used as the basis of comparison.

RESULTS

Enough soft energy photons from ^{125}I albumin in blood within the heart were detected by the small external counter to record adequate indicator dilution curves. With intravenously injected doses of 20-40 μc, well defined curves were repeatedly observed with peak concentration levels 2,500–20,000 cpm above preinjection baselines (Fig. 1). Qualitative inspection revealed these curves to be similar in each individual to those obtained by the ^{131}I method which included narrow angle collimation. For instance, the peaks of the two curves in Fig. 1 were formed with marked similarity, as were the downslopes and the manner in which recirculation began. While these two curves were recorded with the same shape, their overall size is different. This is, however, a function of the dose, the ratemeter sensitivity setting, and certain geometrical relationships. In Fig. 2 the curves are alike in the height reached as well as in overall shape.

Cardiac output values for the 16 patients are listed in the Table. While there was generally good agreement between the technics, in some patients there was considerable variation in the four consecutive cardiac output determinations. Despite precautions to provide comfort and rest, variation in blood flow of this magnitude may well occur within an hour in unsedated patients. The arithmetic mean of the differences between ^{125}I and ^{131}I results in each individual was + 0.013 liters/min indicating the absence of any systematic difference. Also, there was good correlation of the ^{125}I output values against the ^{131}I results ($r = 0.734$). The "p" value for this correlation coefficient was less than 0.001, strongly suggesting that the two techniques were measuring the same variable.

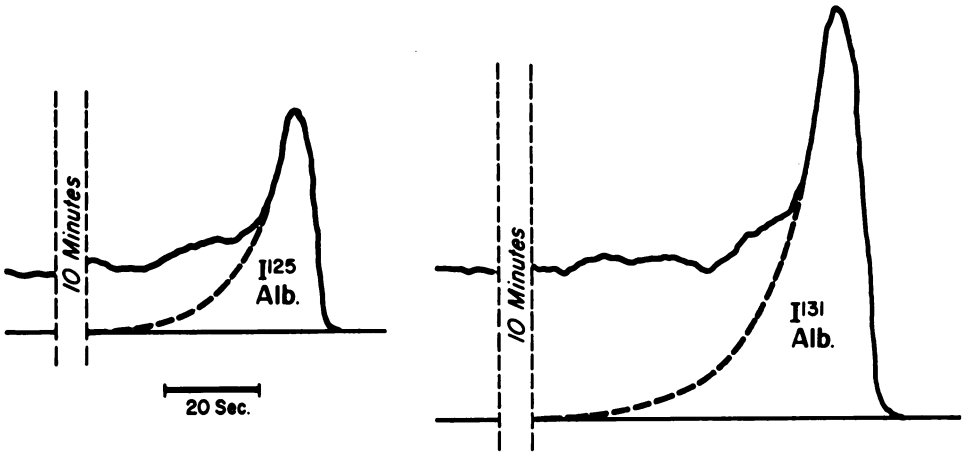

Fig. 1. Consecutive precordial indicator dilution curves on patient H.E. Curve on right: Ten μc ^{131}I albumin; meter setting 50,000 cpm full scale deflection; peak concentration 38,500 cpm above baseline; cardiac output 8.0 L/min (cardiac index 3.9 L/min/M^2). Curve on left: Forty μc ^{125}I albumin; meter setting 30,000 cpm; peak 14,500 cpm above baseline; cardiac output 7.7 L/min (cardiac index 3.7 L/min/M^2).

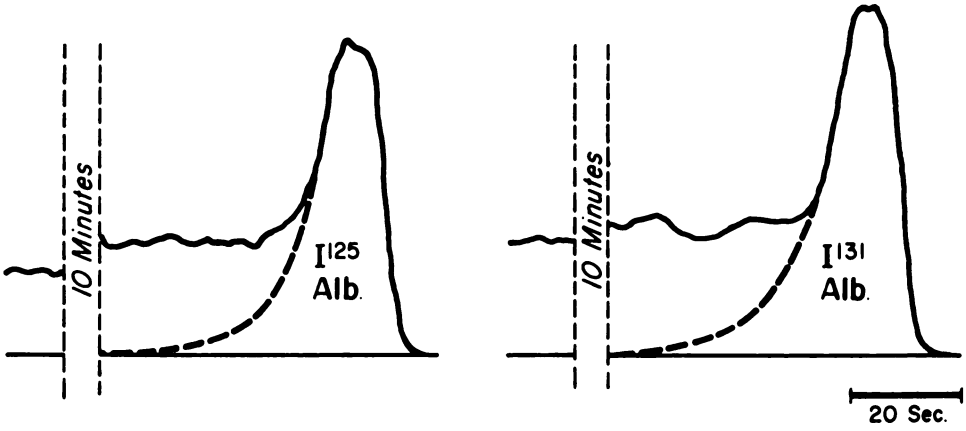

Fig. 2. Consecutive precordial dilution curves on patient W. H. Curve on left: Forty μc ^{125}I albumin; meter setting 30,000 cpm full scale deflection; peak concentration 18,000 cpm above baseline; time constant 2 sec; cardiac output 8.2 L/min (cardiac index 4.2 L/min/M^2).

Curve on right: Fifteen μc ^{131}I albumin; meter setting 100,000 cpm; peak 60,000 cpm above baseline; time constant 2 sec; cardiac output 8.7 L/min (cardiac index 4.4 L/min/M^2).

DISCUSSION

This study is, to our knowledge, the first evaluation of the use of ^{125}I albumin and small uncollimated detectors for the determination of cardiac output. The physical characteristics of ^{125}iodine provide several advantages over other isotopes used previously for precordial counting. Energy emission in the form of a 35.4 kev gamma ray (2) permits efficient detection by small scintillation crystals such as the 2 mm thick wafer used in this study. This small, light detector has very low background counting rates.

On theoretical grounds, external counting of the 35.4 kev gamma emission might not have turned out to be feasible. Body tissues would be expected to provide an effective filter for ^{125}I activity as indicated by its broad-beam half-thickness of one inch in cheese (2). It seemed unlikely that enough radioactivity would survive transit through the cardiac and thoracic walls to permit the use of doses within reasonable limits. In practice, however, 20 μc of ^{125}I for the first and 40 μc for the second determination were sufficient to produce well defined precordial counting curves in patients varying considerably in body size and cardiac output.

Furthermore, the particles of energy which do survive transit through the thorax to reach the external detector probably travel in straight lines. It is unlikely that significant amounts of scattered gamma radiation from ^{125}I reach the detector. This can be substantiated by recalling three lines of evidence. First, without narrow angle collimation the ^{131}I albumin-precordial counting method provided values for cardiac output significantly different from those obtained

TABLE

Patient	^{125}I *Albumin Cardiac Output (L/min)*	^{131}I *Albumin Cardiac Output (L/min)*
G.H.	5.0	5.4
	4.6	4.4
T.W.	7.7	8.5
L.A.	8.8	9.9
	7.2	7.7
O.N.	8.0	6.6
	8.1	5.8
W.T.	7.0	5.5
	6.0	4.7
F.H.	5.4	5 3
	4.3	4.3
W.H.	8.0	8.6
	8 2	8.7
J.S.	6.5	5.2
	6.4	4.9
W.G.	5.4	5.3
	5.0	5.5
T.W.	6.9	6 4
	6.1	7.1
T.T.	4.3	5.1
	5.9	5.4
H.E.	9.0	8.0
	7.7	7.3
W.S.	6.9	9.4
	7.7	7 8
W.J.	6.1	10.3
	7.7	7.6
R.B.	4.0	3.7
	4 9	4.5
H.C.	5.1	4.9
	5.0	4.7

with the longer established and accepted dye-arterial sampling and Fick principle technics (12). Second, after narrow angle collimation was added to minimize the contribution of scattered radioactivity emanating from extracardiac blood vessels (13, 14), cardiac output results were similar to those obtained by catheter-arterial sampling methods (14-24). Lastly, in the present series of comparisons, the ^{131}I method with narrow angle collimation and ^{125}I with uncollimated detectors gave similar values. Therefore, it seems logical to assume that only emanations from ^{125}I in the heart which travel in straight lines reach the precordial detector. This precludes the need for shielding and narrow angle collimation.

Fortunately, also, doses of ^{125}I are well within the acceptable range. Total body radiation from 60 μc of ^{125}iodine albumin (two determinations of cardiac output) was 29 millirads. Duplicate measurements with ^{131}I albumin in each patient (30 μc) resulted in about 54 mr. The absence of β radiation from ^{125}I is responsible for this difference. The longer shelf-life is an additional convenience.

SUMMARY

Precordial counting of ^{125}iodine albumin with small, light weight detectors for determination of cardiac output is reported for the first time. The system works well in human subjects with an unshielded and uncollimated wafer scintillation crystal. Radiation exposures are lower than with comparable doses of ^{131}I albumin. In 16 patients (62 determinations), including some with heart disease, cardiac output values measured with ^{125}I albumin and with ^{131}I albumin showed a high degree of correlation.

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