an iterative convolution technique. A time lag of these lung transport functions was one or two seconds and the distributions of the functions were in a narrow range.

## Measurement of Circulating Blood Volume, Heart Volume, Pulmonary Blood Volume and Blood Volume of Body by Analog Simulation of Radiocardiogram

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Radiocardiograms were performed in 34 normal subjects, 130 patients with cardiac valvular diseases, 11 with obstructive lung disease and 18 with other cardiac diseases. Radiocardiograms were analyzed using an analog computer simulation circuit which represents the mathematical models of the whole circulatory system. Circulating blood volume (CBV) was determined by means of a well-scintillation counter using $I^{131}$-RIHSA and blood volumes of heart, lung and body were calculated as a product of respective mean transit time (sec) and cardiac output (ml/sec/$m^2$) obtained by analog analysis of radiocardiogram.

In normal subjects, CBV was 2496 $\pm$ 241 ml/$m^2$ (mean + SD) and blood volume of heart, lung and body was 268 $\pm$ 43 ml/$m^2$, 272 $\pm$ 45 ml/$m^2$ and 1955 $\pm$ 199 ml/$m^2$, respectively, and the ratio of them to the CBV was 10.8 $\pm$ 1.8%, 10.9 $\pm$ 1.1% and 78.3 $\pm$ 2.3%, respectively. In patients with mitral and aortic valvular diseases, CBV and heart volume increased in proportion to the severity of the disease classified by the criteria of New York Heart Association, but blood volume of body was almost kept constant and the only exception was the case combined with right heart failure in which blood volume of body was also increased. In patients with lung disease, cases with right heart failure showed the increase of CBV and blood volume of body, however, cases without right heart failure showed no increase of them. These results suggest that in patients with mitral and aortic valvular diseases, increased CBV is caused by the increased heart volume but in the case combined with right heart failure increased blood volume of body also contributes to the increased CBV.

## The Determination of Cardiac Output by Radiocardiogram

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In measurements of cardiac output from radiocardiogram, attention must be paid on the following points:

(1) Identical mixing pool both during the primary circulation and at the time of calibration.

(2) Problems of extrapolation.

(1) The curve recorded by a large detector (3 inch in diameter and with 20 cm-long cylindrical collimator), which is placed over the entire region of cardiac shadow, is helpful for quantitative and qualitative diagnosis of cardiac patients. But cardiac output computed from this curve (Curve-A) by our analog simulation method was 35% larger than that measured by direct Fick method (computed CO/Fick CO = 1.35 ± 0.22 (mean ± SD), N = 22). This is because the observed pool has some later components that come into the region after the period of primary circulation, and the final dilution level is falsely high. The liver, spleen, large veins, skin or muscle must have greately contributed to it. When radiocardiogram was recorded by a 2 inch crystal with 9 cm-long collimator, which was placed closer to the chest wall over the second intercostal space at the left sternal margin, cardiac output was only 6% larger than that by Fick method (Curve-B). This shows that the first point (identical mixing pool) is satisfied better in Curve-B than in Curve-A.

(2) Calculation of cardiac output by Mac Intyre's method (M-method) rests on the accurate extrapolation of multichamber dilution curves. But in case of decreased output it is impossible to eliminate recirculation wave from the prolonged left heart slope, and the area of the primary circulation is overestimated. However, our analog simulation analysis is based on the mathematical model, in which recirculation is taken into consideration, and there is less possibility to make such an error (S-method). Therefore, with the prolongation of half time clearance of left heart (T-1/2), the ratio of cardiac output by S-method to M-method increased: RO by S-method/CO by M-method = 1.05 (T-1/2<6 sec.), 1.23 (6 sec.<T-1/2<15 sec.), and 1.64 (15 sec.<T-1/2).

Reference:
Kuwahara, M. et al.: IJBE 1: 13, 1972.

## Analysis of Dilution Curve by Scintillation Camera with Computor processing Data of Congenital Heart Diseases

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With aid of scintillation camera with computor processing of data, we are conducting the analysis of dilution curve of congenital heart diseases, and here we report some of our experiences.

The camera was directed obliquely toward the left anterior aspect of the thorax. $^{99m}TcO4^-$, 10 mCi/1–3 ml was injected into the ante-cubital vein, and immediately with timpe lapse camera as well as with polaroid film by hands, consecutive pictures are taken. Simultaneously, by the scintillation camera time lapse records are taken on video tape recorder. After play back, we obtain dilution curves of regions of interest such as the right heart, left heart, pulmonary outflow, lung and aorta.

While this method affords only an auxiliary diagnosis, it is not only safe but can be repeatedly performed so that as a non-operative examination method, it is an extremely useful method for determining the clinical course and success or failure for-surgical operation.