Application of Digital Computer Circuitry to Multi-nuclide Scanning

M. MATSUDAIRA, K. HISADA and T. HIRAKI
Department of Radiology, School of Medicine, Kanazawa University, Kanazawa

Our scanning system MUHC has a wide clinical versatility with four scan recording multi-dot tapper heads and four spectrometers, so that four nuclides can be scanned simultaneously provided that each photopeak of gamma rays from them can be separated satisfactorily by some means. The main purpose of multi-nuclide scanning is the simultaneous visualization of multiple organs which locate in various depths, so that isosensitive scanning is an indispensable part of multi-nuclide scanning technic.

With future clinical practice in mind, ^{198}Au-colloid (0.41 MeV), ^{203}Hg-chlormerodrin (0.28 MeV), ^{75}Se-selenomethionine (0.27, 0.138 MeV) and ^{197}Hg-mercurihydroxypropane (0.077 MeV) were chosen as test nuclide agents. Basic experiment was carried out with Alderson Research Laboratory's organ scanning phantom. Since it contains the hollow phantoms of the liver, kidneys, pancreas and spleen in it, appropriate amounts of each radioactive agents were instilled into the phantoms. The energy spectrum from one nuclide (volume source) overlaps those from others. Generally, most overlapping is seen in the lower energy of spectrum. A complete elimination of this undesired overlapping can be achieved with digital computer technique.

Signals from two opposed detectors were fed into four pulse height analyzers. The output from the four pulse height analyzers were fed directly into a digital computing circuit.

Let A_O represent net counts from ^{198}Au at its photopeak (with channel width of $\pm 10\%$), H_O the counts from ^{203}Hg at its photopeak, S_O the counts from ^{75}Se at its photopeak (0.138 MeV) and M_O the counts from ^{197}Hg at its photopeak respectively. The counts (A) from pulse height analyzer I setting for ^{198}Au photopeak are a sum of net counts (A_O) from ^{198}Au and a contribution ($s_A S_O$) from ^{75}Se. The virtual counts (H) from pulse height analyzer II setting for ^{203}Hg photopeak are a sum of net counts (H_O) from ^{203}Hg and contributions ($a_H A_O$, $s_H S_O$) from ^{198}Au and ^{75}Se. The counts (S) from PHA-III for the lower photopeak (0.138 MeV) of ^{75}Se are a total of net counts (S_O) and countributions ($a_S A_O$, $h_S H_O$) from ^{198}Au and ^{203}Hg. The number of signals (M) from PHA-IV for ^{197}Hg photopeak is a sum total of net counts (M_O) and contributions ($a_M A_O$, $h_M H_O$, $s_M S_O$) from ^{198}Au, ^{203}Hg and ^{75}Se. Thus we have the relationship of simultaneous equations as followings:

$$A = A_O + s_A S_O \quad (1)$$
$$H = a_H A_O + H_O + s_H S_O \quad (2)$$
$$S = a_S A_O + h_S H_O + S_O \quad (3)$$
$$M = a_M A_O + h_M H_O + s_M S_O + M_O \quad (4)$$

where generally z_X is a constant which denotes the ratio of counts due to Z_O at other channel (X) to counts due to Z_O at its own channel (Z). Constants a_H, a_S, a_M, h_S, h_M, s_A, s_H and s_M can be determined under certain experimental conditions respectively.

Equations (1)-(4) are transformed:

$$A_O = A - s_A S_O \quad (5)$$
$$H_O = H - a_H A_O - s_H S_O \quad (6)$$
$$S_O = S - a_S A_O - h_S H_O \quad (7)$$
$$M_O = M - a_M A_O - h_M H_O - s_M S_O \quad (8)$$

The equations (5)-(8) were then related to the assembly of a computing circuit which is attached to scanning system.

Four photopeks were picked up by each pulse height analyzer I-IV respectively and the counts from each pulse height analyzer were corrected by subtraction of undesired counts from the overlapped spectra. Net counts were then recorded on duplicating or mimeograph master sheets. The masters were transferred with different colors in the processing. In this manner, one could get four colored scintiscans of four nuclides simultaneously at one scanning.

Thus, the pictorial quality of multi-nuclide scan has much improved with use of a specially designed digital computing circuit.