Simultaneous measurement of the clearance of damaged red blood cells from the circulation together with splenic scanning may provide a useful information for the assessment of splenic function not only in cases with splnomegaly but also in cases with a spleen of normal size.

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3. DIAGNOSIS OF ABDOMINAL TUMORS BY THE COMBINATION OF ORGAN SCANNING METHODS

Hideo Ueda and Hideo Yamada

Tokyo University

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Abdominal scintiscanning has been used for the diagnosis of the localization of abdominal lesions and for the clarification of the pathophysiology[1] such as detection of hepatic shunt in the disease of the abdominal organs including absorption functions of digestive system[2].

In this report, at first the recent development in radiopharmaceuticals for the organ scanning will be discussed with the demonstration of example of scans obtained in our laboratory. Secondly, clinical cases with abdominal tumor which can be diagnosed by using combination scintiscanning method. Lastly of the first clinical application of Nuclear Image Tube Camera which developed in our laboratory with the colaboration of Shimazu Seisakutio Ltd. will be presented. Both conventional scanner and this newer device will improve and contribute to the diagnostic technique in this field for the coming years.

(1) Radiopharmaceuticals for abdominal scanning.

The radiopharmaceuticals used for the abdominal scanning have made remarkable progress for the past several years. Now many of them are labelled with nucleides with a short half life, low gamma energy and occassionaly no beta, e.g. Au-199, Hg-197, Cs-131 and Tc-99 m.

Since their gamma energies are low, they are easily collimated and shielded by thin lead collimater with high efficienty by small crysla scintigram obtained by such radiopharmaceuticals is much finer than that by nucleides with high gamma energies and would give us more precise information about the lesions. At the same time the short-lived radiopharmaceuticals reduce the danger to the patient and also make possible the large dose administration.

For the diagnosis of the abdominal tumor by scintiscanning, it is desirable to scan organs such as pancreas, spleen, kidney or liver, successively in such a order by several different radioisotopes. Such examination could be performed safely within short period, since now varieties of radiopharmaceuticals are available at our hand.

The radiopharmaceuticals listed in the right side of **Table 1.** shows those which are used in our laboratory at the present time. All of them but Hg-203 MHP and Se-75 Selenomethionin are substances with a physically or biologically short half-life and can be used with radiation safety.

Table 1. Radiopharmaceuticals for Organ Scanning

Liver	^{198}Au Colloid	^{131}I AA ^{125}I AA
	^{131}I Rose Bengal	$^{99m}Tc_2S_7$ (^{199}Au)
Spleen	^{51}Cr RBC	^{197}Hg MHP
	Heated ^{51}Cr RBC	^{203}Hg MHP
	Sensitized ^{51}Cr RBC	
Kidney	^{203}Hg Neohydrin	^{197}Hg Neohydrin
		^{203}Hg Salylgan
Pancreas		^{75}Se Selenomethionin
Perfusion Scan		^{131}I MAA
Blood Pool Scan	RISA, ^{51}Cr RBC	^{99m}Tc Albumin
Bone Marrow		$^{99m}Tc_2S_7$

Liver scintigram of normal and with hepatoma using 99m-Tc-2-S-7 colloid were domonstrated (slides). Tumor in the last case was located in the midportion of the liver and the left lobe seemed enlarged. But spleen scanning by Hg-203 MHP could indicate the presence of duplication of the enlarged spleen on the left lobe of the liver. Since the colloidal materials are also phagocytized by reticuloendothelial cells outside the liver, spleen is often deliniated in liver scintigram in cases with liver diseases, especially liver cirrhosis.

Tc-99m could provides us with many other scanning agents besides Tc_2S_7 colloid for liver and bone marrow sans, such as TcO^{-4} for thyroid scan or brain scan. Tc-Albumin for blood pool scan or lung scan following radioaerosal inhalation[3], $Tc(SCN)_5$ for liver scan, Tc-DNA for kidney scan and others. Therefore it was named as universal scanning agent by McAfee et al[4].

As one of other clinical applications of Tc-99m, Placenta scan using Tc-Albumin was demonstrated in slide. This pregnant woman was suspected placenta previa because of genital bleeding. But placental scanning showed that the placenta was located at the left-anterior side of the uterus. She could be delivered normally without cesarian section.

The six hours half-life of Tc-99m is long enough for scanning and the 140-Kev of gamma energy has satisfactory tissue penetration and yet can be collimated easily. From this point of view it is also said one of the most suitable radioisotopes for scanning.

Spleen scanning has previously performed using heated red cells tagged with Cr-51[6]. Since last year, Hg-203 or Hg-197 labelled 1-mercuri-2-hydroxypropane[7] has been developed in our laboratory with aids of members of Dinabot radioisotope laboratory[8]. Red blood corpuscles simply mixed with MHP are instantly damaged as well as labelled, and are rapidly sequestered by spleen. Therefore the MHP method is a easier way than the Cr-51 method. Spleen scanning was performed chiefly in cases with liver diseases, hematological disorders or abdominal tumor of unknown origin. Some examples were shown in slides. Generally speaking, the size of spleen by the scintigram in splenomegaly was large in a side-view than in front one as shown in slide.

When the spleen increases in size, it enlarges inwards and downward in the frontal plane, and in the sagital plane forward and downward.

Hg-197 Neohydrin with short half-life of 2.7 days, low gamma energy and no beta ray is much more favorable as a Kidney scanning agent than Hg-203 Neohydrin which remains in the Kidney for a long period[9]. However its short shelf-life and high cost did not encourage its wide-spread use in Japan. In this synposium we report briefly the merit of kidney scanning using Hg-203-Salylgan[10] which has a bialogical short half-life, too.

Hg-203-Salylgan was rapidly accumulated in the kidney after intravenous injection. Scanning should be performed between 15 to 60 minutes after administrations in which period radioactivity over the kidney did not change widely. After that, it was rapidly excreted into urine with the half-time of about 90 minutes calculated from the radioactivity decling curve other the kidney (**Fig. 1 a**). Therefore its radiation dosis to the kidney is markedly reduced as compared with Hg-203 Neohydrin and can be used repeatedly with safety. Since its shelf-life is long, it also has an advantage in economical point of view.

In case with renovascular hypertension due to stenosis of the left renal artery, renogram by Hg-203 Salylgan was compared with that by I-131 Hippuran. In normal kidney Hg-203 Salylgan uptake curve reaches to the plateau 30 minutes after injection. While in abnormal side radioactivity revealed slight increase in the initial phase suggesting dilution process, and the further accumulation of Hg-203 Salylgan was not observed (**Fig. 1 b**).

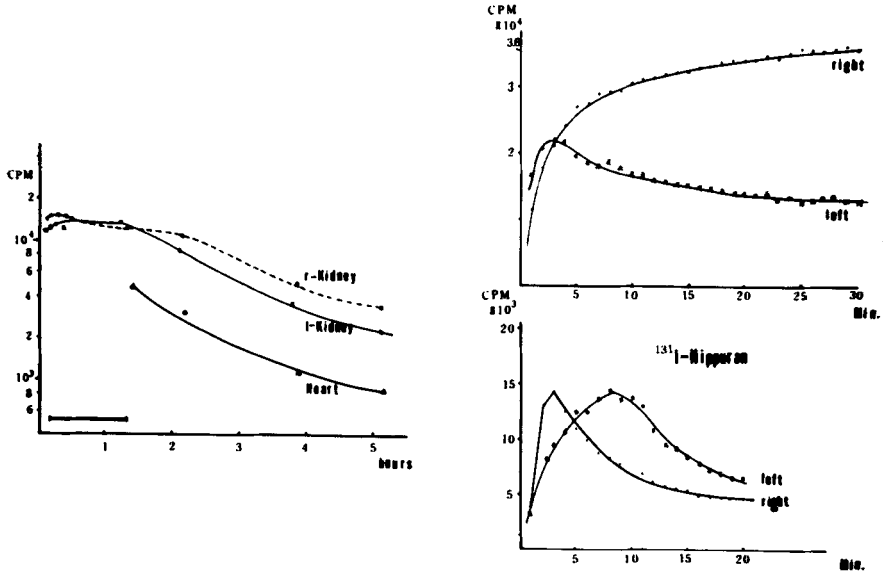
Although excretion phace was not observed in this case, Hg-203 Salylgan uptake curve would differentiate abnormal kidney from normal as well as renogram by I-131 Hippuran. Soon after recording of uptake curve of Hg-203 Salylgan kidney scanning was performed, which could reveal the small left kidney with reduced uptake. Hg-203 Salylgan is able to diagnose the unilateral kidney disease and the degree of its atrophy similar to Hg-197 Neohydrin and with decreased radiation.

(2) Differential diagnosis of abdominal tumor by scintiscanning.

Six cases were demonstrated as examples of the usefulness of scintiscanning method for the

Fig. 1. Radioactivity Curves of ^{203}Hg Salylgan over the Kidney

Left: essential hypertension
Right: renovascular hypertension

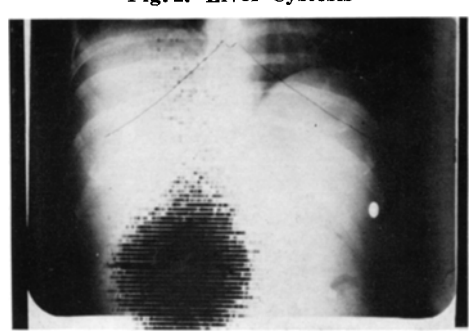


differential diagnosis of abdominal tumor.

Case 1. A 28 year-old woman admitted to the department of internal medicine, Tokyo University Hospital, complaining abdominal tumor and epigastralgia. On physical examination, the tumor shaped like a long ellipse was palpable about 5 cm above the nable. Pancreas tumor was most suspicious. However, Se-75 Selenomethionin scanning showed a pancreas with normal shape and following kidney scanning revealed horse-hoof kidney of which isthmus coincided with tumor.

Case 2. A 42 year-old Woman complaning of abdominal distension and abdominal tumor was diagnosed as no-paracytic liver cystosis by laparoscopic examination. In liver scintigram large defects was observed at right hynochnodrium with functioning liver tissue below the nable (Fig. 2). Another two cases with cystosis showed the same characteristic scintigram similar to this case.

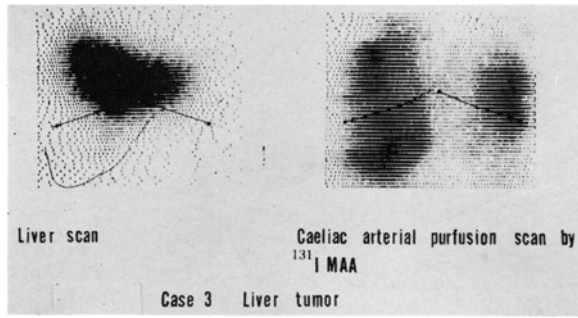
Fig. 2. Liver Cystosis



In this case spleen scanning showed a cucumber type of splenomegaly. Moreover, sequestration of MHP damaged red blood corpuscles of bone marrow revealed the findings compatible with so called hypersplenism.

Case 3. This is a case with liver cancer. Liver scanning by Au-198 colloid showed the rather small and strange shaped liver with defects in the mid portion of the liver and in the right inferior part. Perfusion scanning was performed after introducing I-131 Macroaggregated Albumin (MAA) through selectively inserted catheter into caeliac artery. It revealed the whole silhouette of the liver with increased size. Defects in colloidal radiogold scanning were visualized as at least 5 hot nodules in I-131 MAA scanning. It suggest the existence of tumors rich in arterial blood supply, but without Kupffer's cells (**Fig. 3**).

Fig. 3.



As shown in this example, I-131 MAA developed originally as an agent for lung scanning [11,12,13] can be introduced into various blood vessels and provides us with the information about regional blood perfusion in a certain part of the body. For example we reported the method of intra and extra hepatic shunt detection in liver cirrhosis by liver and lung scanning following percutaneous intrasplenic injection of I-131 MAA (reference).

Case 4. This patient had a large abdominal tumor. Liver scanning showed a normal sized liver without any defect. While kidney scanning revealed a large defect in the left kidney. Perfusion scan by I-131 MAA introduced through the left renal catheter showed the whole silhouette of a huge tumor shaped like a boughnut with a round defect in the center. This was diagnosed cystic tumor of the left kidney. Postoperative diagnosis was a cystic Grawitz's tumor.

Case 5. This 33-year-old man admitted because of left hypochondrial tumor. On physical examination tumor was in the region from epigastrium to left hypochondrium and a hand could not be inserted between the tumor and the left costal arc. Upper gastrointestinal examination revealed the stomach pushed aside by the tumor from median side. Gastric mucosal folds remained regular. No defect nor ulcer was visualized. Liver, spleen and kidney scans were all no contributory. Since the pancreas was covered with the liver, precise reading of pancreas scintigram was impossible. I-131 MAA scanning introduced into caeliac artery by selective catheterzation revealed a doughnut shaped tumor adjacent to both the liver and the spleen (**Fig. 4**). This was diagnosed as cystic tumor with abandant blood supply locating in the region perfused by caeliac artery. Operation revealed Leiomyoma of the stomach with central mecrosis.

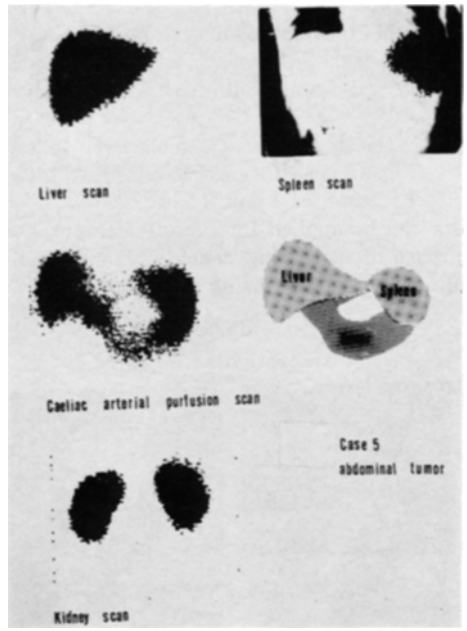
Case 6. This 1.5-year-old male infant had been cyanotic since his birth. The stomach lay on the right as shown by X-ray examination.

Levocardia with situs inversus was known to accompany with various malformation of the heart. Especially, cases with asplenia was reported to be fatal[14].

MHP damaged red blood cells was injected, but the radioactivity did not accumulate in the spleen. Scanning revealed only the heart and liver which had large blood pool. This results indicates asplenia.

Liver was located at the median part and symmetric. This case was suspected belonging to Visceral Hetrotaxy and had various heart malformations such as bilocular heart, transposition of the aorta, pulmonary stenosis and anomalous pulmonary venous return, indicating extremely poor prognosis.

Fig. 4.



(3) Nuclear Image Tube Camera

The widely used scintiscanning system scans mechanically over the patient with shielded and collimated crystal. It takes relatively long time to scan a large organ such as the liver. Moreover it cannot be used when the radioactivity in a certain organ is changing rapidly. Speeding up of scanning period has been devised by the production of a larger crystal scanner and new radionueleides with short half-life such as Tc-99m which makes possible administrating large dosis.

Several new approaches to visualize the distribution of radioisotope in a certain organ without employing the mechanical scanning system were reported. Among them are scintillation camera developed by Anger[15], Autofluoroscope by Bender and Blau[16], Autofluorography by Ter-Pogossin[17], and Spark Chamber Camera by Kellershon[18]. These stationary detector system can visualize the entirety organ at the same time. Since these equipments can record the distribution of radioisotope within a short period, observation of dynamic changes of radioactivity in the organ can be possible.

Based on the principles of Ter-Pogossion, Nuclear Image Tube Camera was developed in our laboratory with the collaboration of members at the Shimazu Seisakusho Ltd. The Nuclear

Fig. 5.

left: by Conventional Scanning
right: by Nuclear Image Tube Camera

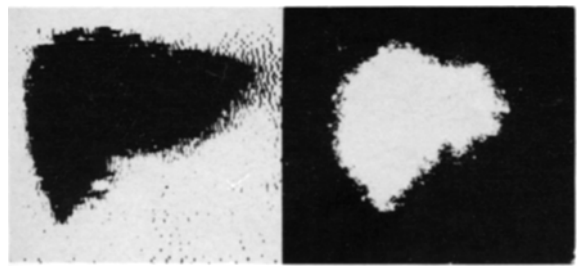


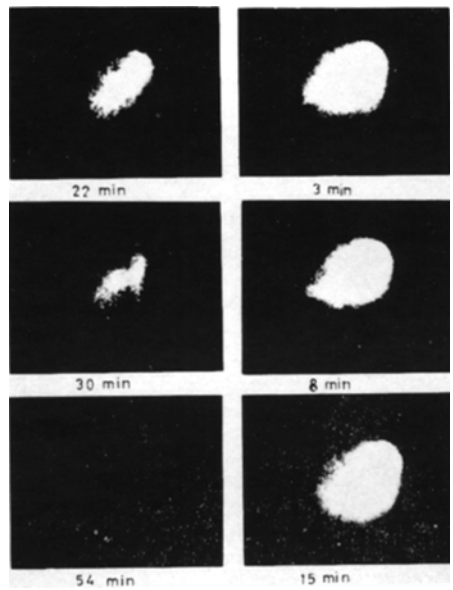
Image Tube Camera consists of a maltihole collomator, X-ray image amplifier illustration of this apparatus and its experimental results will be reported somewhere.

Fig. 5 shows liver image by this camera and liversscintigram by conventional scanner following intravenous injection of 7 mc 99m-Tc_2S_7 in the same person. Conventional scanner takes about 40 min. to scan the liver, while only 5 min. to take a photograph of the liver image by this camera.

Absorption of radioactivity in the stomach was also observed following by peroral administration of 20 mc of 99m-TcO^{-4} (**Fig. 6**). The image was taken at 3, 8, 15, 22, 30 and 5 min. after administration with the exposure time of 1 min.

At this stage, this camera can be applied for the clinical purpose if Tc-99m or Xe-133 is used. However, for the purpose of increasing sensitivity and resolution the improvement of image tube system and collimator are now being performed.

Fig. 6.
Absorption of ^{99m}Tc



Summary

1. For the useful differential diagnosis of abdominal tumor the method of successive organ scanning was reported. Such examination could be performed safely by the recent advancement of various radiopharmaceuticals.

2. Clinical examples of differential diagnosis were shown. I-131 Macroaggregated albumin is proved to be another useful tool for the deliniation of certain abdominal tumors.

3. Nuclear image tube camera and its first application for human beings were demonstrated.