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PATHOLOGICAL FINDINGS IN THE FATAL CASE (THE LATE MR. KUBOYAMA) OF THE RADIATION SICKNESS CAUSED BY BIKINI ASHES

(An Intermediate Report)

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The autopsy of Mr. Kuboyama was performed on 24 September 1954, between 0010 and 0330 hours at the dissection room of the First Tokyo National Hospital, 5 hours and 14 minutes after death. The autopsy was attended by Higashiichi Kuriyama, Vice President of the hospital; Dr. Tochiku, Professor emeritus of Tokyo University; Professor Shimizu, of Tokyo University; Dr. Omura, Chief of the Hospital Section, Bureau of Medical Affairs, Ministry of Welfare; the group of physicians who treated the patient; Professor Miyake of the Pathology Department, Tokyo University, and the members of his class, Messrs. Saito, Fukushi, Fukuda, Okuhira, Otsura, etc; Honsen [sic] Chief Pathologist of the 406th Corps, United States Army; Dr. Kusano, Assistant Professor of Pathology in communicable diseases; Dr. Katsuda; Oishi Eto, Chief Pathologist of the Koto Premedical Department, and others interested in this case.

CLINICAL DATA

Prior to the autopsy Dr.Koyama, Chairman, Department of Internal Medicine and Dr. Kumatori, Chief Physician gave a full one-hour report on the clinical progress. A summary of this report is given below:

Aikichi Kuboyama: age, 40; sex, male.

Clinical diagnosis: radiation sickness.

Mr. Kuboyama was exposed to radioactive ash near Bikini on 1 March 1954. He spent two weeks as chief radio operator aboard the ship following the exposure, arrived at Yakizu Port, Shizuoka Prefecture, and was hospitalized at the Internal Medicine Department of the First Tokyo National Hospital on 28 March. At that time he was treated for radiation dermatitis in the neck, the lateral cervical region, and the legs. The white cell count was 1,000 in mid-April and 3,000 toward the end of April. His temperature rose to 39.3 degrees but fell gradually and remained slightly above normal until about 7 May. The white cell count rose to between 5,000 and 6,000 toward the end of May but the number of nucleated cells in the marrow did not increase much: 9,000 was the minimum and the count was generally below 50,000. The red cell count was 3 million when he was first hospitalized; blood platelets were between 30,000 and 40,000. Later, following blood transfusions, the red cell count increased to between 4 million and 5.3 million, and the number of blood platelets rose to about 300,000. A condition of anemia was noted at

about 300,000. Toward the end, the white cell count increased to about 20,000; marrow cells and nucleated red cells were seen in peripheral blood and leukemic reaction was observed.

The liver on palpation was somewhat more indurated than at the time of initial hospitalization. Liver function also was impaired and BSP (30 minute value) was 50 percent toward 20 June. Jaundice was observed around 24 June and the jaundice index by Meulengracht's method was 60 between the end of June and the beginning of July; it fell to 15 toward the end of July but rose to 30 early in August. BSP (30 min to value) was 20 percent on 11 August and the patient's general condition was good; but the patient lapsed into a coma on 31 August and remained so until about 2 September. The jaundice index was 226 on 2 September. The patient regained consciousness about 3 September and began to recover. But pneumonia symptoms appeared from about 17 September and the patient's heart declined gradually until his death on 23 September.

During this time the hospital tried 11 blood transfusions of 200 cc each and 51 treatments with dry blood plasma 100 cc each, until the beginning of June.

PATHOLOGICAL AND ANATOMICAL FINDINGS

This report is based on the autopsy records filed in the Pathology Department of the First Tokyo National Hospital.

Ohashi was the spokesman for the group who performed the autopsy and Mori recorded Ohashi's remarks.

During the autopsy Dr. Okamoto, Chief of the Radiation Department, First Tokyo National Hospital, performed radiation measurements on the viscera. For further radiation tests certain portions of the viscera were sent to Dr. Okamoto and to Dr. Eto, Chief Pathologist, Koto Premedical Department, and other portions were sent to Dr. Jo of the Virology Department, Koto Premedical Department for the detection of virus in the liver and blood. Part of the liver, kidney, lung, bone, etc was sent to the Kimura Laboratory, Chemistry Department, Tokyo University for radiochemical analysis. Tests are being conducted in every field by experts and some results are now published. The autopsy findings in the case of Mr. Kuboyama are as follows:

MATERNAL DATA

Height: 157 cm; Weight: 52 kg.

Slight malnutrition; intensive yellow pigmentation over the entire skin, particularly on the palm and sole. Marked rigor mortis in the inferior maxillar joint but not in the large joints of the upper limbs, and only to a slight extent in the large joints of the lower limbs. Slight necrosis in the back. Pupils moderately dilated; the right and left pupils were the same size and perfectly round. Sclera was yellow of medium intensity and capillaries were slightly congested. Slight swelling in the abdominal region, being more pronounced in the upper abdominal region. Abdominal circumference was 78 centimeters at the navel; navel very shallow. Edema on bilateral insteps by impressions; impression remained on the anterior tibiae, but not so prominently. Slight edema at the internal femoral region but somewhat more on the external femoral region. Slight edema of the scrotum. Dilation of

cutaneous veins not so prominent; slight dilation from the lower part of right cervical region to the upper lateral chest region. Cervical circumference was 37 centimeters at the eminence of larynx. About ten subcutaneous punctiform extravasations in the scapular region. About ten extravasations, the size of a millet grain or red bean, from the left shoulder to the upper part of the chest. Penis showed slight phimosis. Old scars in the right and left inguinal regions, the left being about 6 centimeters and the right 5.5 centimeters. Old appendectomy scar in the right iliac region of the abdomen. Several traces of puncture in the left fossa ilica partly covered by scabs. Scar from vein incision about 6 centimeters long, closed with four sutures. Skin on the lower part of left lateral abdominal wall desquamated from slight abrasion, supposedly the result of artificial respiration. Six scars from cardiac puncture beside the left nipple and about 9 scars from narrow puncture from the manubrium. A somewhat black-colored pigmentary deposit followed the dermatitis caused by the radioactive ash from the neck region to the lateral cervical region, and there was a depilated region about 3 centimeters wide caused by the radioactive ash from the lower part of the occiput to the nucha; the surrounding hair did not come out when pulled slightly. Inside the center of the crest of lower left tibia were small cicatrices of brown pigmentation 2.5 x 2.5 cm and 3 x 2 cm; at the right was one cicatrix one square centimeter long and at the outside was another 0.5 x 0.5 cm. At the upper lateral side of the sura was a cicatrix the size of a green pea. On the inner side of the great toe and the dorsum pedis was a long, irregular, gray region about 4 x 2 cm. On the dorsum of the right foot, in the region corresponding to the center of the first metatarsal was a discolored region 1.5 x 2 cm and in the area nearer to the tarsals was another, one centimeter square. All skin changes were the marks of radiation dermatitis. Slight bilateral pigmentary deposits were noted in the areolas. No serious deformation was observed in the toes. There were no bedsores on the nates, which indicates that the patient was well cared for. No swelling was observed in the cervical lymph nodes or the fossa axillaris on either side.

POSITION OF INTERNAL ORGANS

Subcutaneous fat was somewhat diminished. Subcutaneous muscle tissue was red and moist. When the abdominal cavity was opened, the ascitic accumulation rushed out in the form of a yellow fluid in which even the bubbles appeared yellow. The fluid was wholly transparent and the total quantity was 2,000 cc. Apparently the ascites was exudative. The greater omentum was adhered to the inside of abdominal wall at points along the appendectomy scar, forming a fibrous belt about 7 cm long. This area was appropriately marked by a considerable quantity of newly-formed blood vessels communicating with the abdominal wall. The greater omentum was rolled at other places and covered the transverse colon along the major curvature. The stomach was prominently inflated and the inflation in the region of the major curvature reached a point about 5 finger's breadth below the xiphoid process. The inflation of the stomach depressed most of the transverse colon and the small intestines toward the pelvic cavity. With the stomach removed, the left lobe of the liver was exposed at one finger's breadth to the left of and below the xiphoid process; the right lobe, about three finger's breadth above the line of the right sternum line; the left lobe was about one finger's breadth above the left sternum line. The liver appeared granular and grey-brown in color. The marginal region was thin and was indurate and elastic in palpation.

The diaphragm was level with the fourth rib at the right and the fourth intercostal space at the left. Most of the small intestines were floating above the ascites; the abdominal wall was extremely thin and transparent. Lineal or irregular maculae supposedly from extravasation of mucous membranes were seen at places in the corium. The peritoneal side of the frontal abdominal wall was smooth and there was a belt-shaped adhesion about 5 cm long, accompanied by new blood vessels, between the sigmoid colon and the outside, in the left fossa ilica. The peritoneum of the pelvis minor was moderately adipose; the capillaries were prominently dilated and the lymphatics were slightly enlarged. The outside of the mesentery was slightly flocculated. The congested portions of the mesenteric capillaries reached the periphery of the left kidney. There was moderate edema in the fat tunic around the kidney; it appeared gelatinous and was capped by a beautiful lineal blood vessel. The peritoneal side of the rear abdominal wall was moderately edematous. With the sternum removed, no enlargement of mammaria interna was noted on the dorsal side of the sternum. The thymus had become adipose and the parenchyma was scarcely recognizable. In dissection something assumed to be parenchyma was observed near the upper extremity. Upon opening the pericardium, 115 cc of liquid, dark brown in color and somewhat flocculated, was observed. The heart was in slightly transverse presentation (about 45 degrees from the longitudinal axis). The right atrium was prominently enlarged. Short villi were seen on the outer surface of the epicardium (innermost portion of the pericardium), at the front of the right ventricle and on the side of the left ventricle. Ten similar villi were observed inside the pericardium, which was generally congested to a moderate degree. An extravasated area of some 3 cm was observed inside the muscle layer near the third left intercostal region; the intercostal muscle was moist and light red in color. The upper lobe of the left lung showed complete fibrous adhesion. The lower part of the lower lobe was not adhered, and a pleural cyst containing 14 cc of light yellow liquid was observed. The lower lobe, from the side to the back, was adhered. The left pleura from the side of the spinal column to the rear of the apex of the lung was also adhered. The whole right lung appeared fibrous and pleuritic but closer examination revealed that certain parts at the front and on the outside were adhered. The front of the upper lobe showed fibrous adhesions; the lower lobe was adhered to the diaphragm and the dorsal sections were also adhered. Somewhat above this was a cystic portion which was not adhered; the cyst was about the size of a fist and contained 17 cc of yellow liquid mixed with gelatinous fibrin.

THORACIC ORGANS

HEART. Weight, 320 g. The heart was not so large as the fist of the cadaver. The apex of the heart consisted of the left ventricle and was on the median line of the clavicle. The front and the back of the left ventricle were fibrinous and furred. There was a moderate amount of fatty tissue below the epicardium. A few small hemorrhage points were seen at the rear and bottom of the heart below the epicardium. At the front of the right ventricle was a triangular area which was assumed to be a fresh macula. Other than this, nothing extraordinary was externally observed. The left and right ventricles were almost empty. The myocardial layer was soft, somewhat brown, and flocculated. Diffused extravasations were observed below the endocardium of the left ventricle. The valve of the aorta and the inside of the origin of the aorta were prominently jaundiced. There was a slight congestion in the capillary

vessels of the endocardium of the left atrium. The mitral valve was also prominently jaundiced and some congestion was observed near the base. The right atrium was moderately enlarged and the endocardium was flocculated. The tricuspid valve was also moderately jaundiced. The thickness of the myocardium was measured as follows:

Left ventricle, 2 cm; left atrium, 1.8 cm; right ventricle, 0.8 cm; right atrium, 0.6 cm. (All measurements were made at the thickest part.)

LUNGS. Weight: left, 540 g; right, 840 g. The adhesion of the pleura has been noted. Pressure on the lungs produced a turbid yellow secretion from the main bronchus. Right lung: most of the upper lobe was indurated. The pleura was edematous. In section there was a focus of infection larger than a goose egg in the regions of S_1 and S_2 of the right apex of the lung, reminiscent of grey hepatization. Other regions were highly edematous; the air content was low and the blood supply was not very great. Left lung: there was an indurated area larger than a hen's egg in the region of S_3 below the clavicle. The pleura was edematous, and furry fibrinous areas were seen here and there. The places where adhesions were peeled off were especially brilliant red. In section, this part of the upper lobe presented a focus presumably sarcoid with granular or clustered necrosis the size of the tip of the thumb. This focus was the center of a heavy congestion. A long, old, grey, sarcotic focus the size of the little fingertip was observed at a place near the back about 3 cm above the lower margin, at the side of the pleura of the lower lobe; the surrounding stroma had increased to the size of a goose-egg and there was a cluster of foci assumed to be those of interstitial pneumonia, spreading to the circumference. Beneath the pleura, at the lower exterior part of the lower lobe were old light grey-white foci of pneumonia about the size of the tip of the thumb or little finger. There was a distinct rib trace on the surface of the pleura in this area. (See photograph No 3.)). The other lung areas were prominently edematous, with almost no air and a great quantity of exudate. It is noteworthy that all pneumonia foci were apparently of the type caused by mold, such as a filamentous fungus.

LYMPH NODES

The lymph nodes at the bifurcation of the trachea were the size of 2 or 3 red beans and grey-red in color, showing slight deposits of coal dust. The lymph nodes of the lower left bronchus were the size of the tip of the little finger, flat, with a grey-red cortex, and showing coal dust deposits. The lymph nodes of the left lateral trachea were scarcely perceptible. There were two lymph nodes on the left bronchus and they were respectively the size of a soy bean and a red bean. The cortex showed deposits of coal dust and the other parts were grey-red, but not of a medullar shape. There were several lymph nodes on the left lateral trachea, as large as beans and light red in color. The two lymph nodes at the arch of the aorta were respectively the size of a long soy bean and a red bean. The larger one showed coal dust on the cortex and the smaller one at the center. These were light red in section and not of a medullar shape. It is noteworthy that the lymph nodes below the basin of the lungs were rather atrophic.

THYMUS. As above. Weight, 12.5 g.

ABDOMINAL ORGANS

SPLEEN. Weight, 90 g. Size, 9.5 x 7 x 3 cm. The tunic was tense, grey-red, elastic and soft. In section it showed no swelling; there was abundant blood and the organ presented a watery appearance. The trabeculae lienis were prominent. The lymphatic follicles were few and not so prominent, but recognizable. In section, the parenchyma could easily be distinguished.

LIVER. Weight, 850 g. Size, 20 x 14.5 x 7.5 cm. The weight was considerably reduced. The liver was shrunken and the tunic formed slight folds. The surface was grey-brown to green and not prominently granular but slightly uneven. The shape did not differ greatly from normal, and no formation of nodes was observed. Toward the left side of the right lobe and at the front of the left lobe were irregular cicatrices. The lower side of the liver showed some fibrinous striation from the margin toward the center. The organ was indurated and elastic. In section it was yellow grey-green and appeared to be moving toward cirrhosis. The appearance of the lobules was erratic and the Glisson's capsule was wide and irregular, with hrmorrhages around the circumference; punctiform hemorrhagic foci were seen here and there; these were assumed to be hemorrhagic gangrene and were prominent in the right lobe. It appeared as though a transformation from subacute atropy to cirrhosis were in process. The lymph nodes of the hepatic port were not swollen. (See phogograph No 2.)

GALL BLADDER. The bile tested positive and was thick, dark brown. Gallstones were not observed on palpation. The gall bladder contained bile with dark brown mucus; gallstones were not observed. The tiny plicae of the mucous membrane were not clear, there was heavy capillary congestion in the mucous membrane, and the area near the neck was prominently tinted with bile. The common bile duct contained a small quantity of thick bile. There was no calculus and the mucous membrane was tinted yellow. Inside the biliary canaliculi, the major pancreatic duct opened at a spot 5 mm above the papillary region, and the minor pancreatic duct at a spot 8 mm above the papillary region.

SUPRARENAL BODIES. Weight: left, 8.0 g; right, 7.5 g. Right and left bodies were about the same shape. There were small fat tunics and a few spots of cortical lipoid substance were visible through the fibrous tunic. The capillary vessels of the fibrous tunic were dilated at points. In section the thickness of the cortical substance was almost normal; there were few cortical lipoid spots. The pigment layer was visible. The medullary substance was somewhat thin. The blood vessels of the medullary substance were clearly tense.

KIDNEY. Weight: left, 220 g; right, 190 g. Size: 12 x 7 x 5 cm (left). 11.5 x 7.5 x 4 cm(right). Above the right kidney, and at the rear, was an extravasation. The shape of the right and left kidneys was about the same. The surface was smooth, the kidneys were greatly swollen and extremely soft. The tunic was slightly adhered in places, but generally exfoliated easily. The surface was varicolored: brown-grey-green. In section the color was the same; swelling and turbidity were extreme; the shape of the cortical substance was indistinct; and the boundary of the medullary substance was also obscure. The cortical substance was rather thick and murky brown. Green islands were observed here and there.

The medullary substance was somewhat yellow; the pelvis renalis showed many punctiform hemorrhages and the fat tissue of the pelvis was gelatinous.

PANCREAS. Weight, 120 g. Size, 13 x 4.5 x $\begin{matrix}5\text{ cm (head region)}\\4\text{ cm (central region)}\end{matrix}$. The surface was light grey-yellow, rough, and apparently foliated. At the surface of the central region, were about ten areas of fat gangrene, the size of millet grain. The lower part of the pancreas, at the gastro-pancreatic ligament, also presented one spot of yellow fat gangrene the size of a millet grain. Slight congestion was observed near the gangrenous part on the surface of the pancreas; one extravasated macula the size of the tip of the thumb was noted at the rear of other tail areas. The organ was indurated and ligamental, suggestive of an increase in stroma. In section it was moderately turbid. The gangrene nidi in section were limited to the head and central regions, and did not appear in the tail region.

STOMACH. The stomach was inflated. The interior was deficient in plica and the mucous membrane highly atrophied. The surface was covered by a large quantity of thick grey-white mucus; at the front curvature of the antrum pylori was an area of furring about 2 cm square (white thrush); and a furred area about the size of the head of a hatpin caused by green, irregular filamentous fungus was observed on the magenstrasse one cm away. White masses of maculae, presumably from filamentous fungus, were noted in places at the lower part of the cardia. The mucous membrane generally was moderately edematous; the capillaries of the magenstrasse were prominently swollen and inflamed. Signs of extravasation were seen below the mucous membrane. Most of the matter which had inflated the stomach was relatively nonoffensive gas; the aforementioned mucus was mural and sparse.

INTESTINAL TRACT

DUODENUM. Contents: grey mucous liquid, about 5 cc; moderate capillary congestion in the mucous membrane. Vater's papilla was clearly eminent but not enlarged. Small Intestine. Contents: thick yellow mucus. At various places on the ridges of the plicaewere hemorrhages in or under the mucous membrane about the size of the tip of the little finger. The mucous membrane in general was moderately edematous; the lymphatic tissue was not very distinct. Large Intestine. Prominent edematous swelling in the mucous membrane. Contents: soft feces full of light yellow mucus with small specks of red blood in places. The thickness of the wall was about 0.7 cm at the transverse colon.

LYMPH NODES. The lymph nodes of the mesentery were all smaller than a pea and flat, grey-white and light red in color. The appearance in section was watery. The lymph nodes of the lateral abdominal aorta were smaller than the tip of the little finger and spherical; they were grey-brown in section.

PELVIC ORGANS

BLADDER. The urine in the bladder measured about 60 cc, it was brown and thick. The mucous membrane of the bladder was heavily jaundiced. The mucous membrane of the triangle was slightly edematous; there was capillary congestion and hemorrhage. The prostate was not thick. Pressure on the seminal vesicle did not produce a gush of semen.

RECTUM. The mucous membrane was moderately edematous.

TESTICLES. Weight: left, 6.0 g; right, 7.0 g. The sclerotic was strongly jaundiced and generally atrophied. In section it was yellow. Slight filaments were withdrawn by pincette.

PENIS. Slight phimosis. A spot about 2 cm left of the tip of the prepuce was black over an area the size of a pea.

SPERMATIC CORDS. Along the right spermatic cord was a punctiform hemorrhage assumed to be from a diffuse hemorrhage of a venous plexus.

BLOOD VESSELS. The inside of the coxa artery was prominently yellow.

LYMPH NODES. The lymph nodes of the right and left inguinal regions were the size of a red bean and spherical, grey-white in section.

SYNOVIAL MEMBRANE. The synovial membrane of the right knee was extremely yellow.

ORGANS OF THE NECK

PAROTID (Gland). Weight: left, 21 g; right, 22 g; no eminent change.

TONGUE: Wholly covered by a thin grey-yellow fur except at the apex and the outer lateral part. The papillae were not very prominent. The lymphatic tissue of the radix linguae was atrophied; its mucous membrane was red or jaundiced.

PALATE. The mucous membrane of the soft palate was turbid; processes in the shape of lymphatic follicles were seen in places.

TONSILS. Both tonsils were the size of the tip of the little finger and were strongly flushed. On the left tonsil, in the fossa glandulae, was something resembling a purulent plug.

LARYNX. The mucous membrane near the larynx was slightly edematous. At the left rear of the larynx was a foul yellow-green secretion. Extremely slight glottal edema was observed. A similar foul mural secretion was noted on the larynx, the origin of the trachea, and the front of the epiglottis. The Morgagni's fossa on the left side was edematous and shallow.

TRACHEA. The mucous membrane of the trachea was prominently yellow; moderate edema was noted. Sporadic, irregular annular hemorrhages were seen along the cartilage, extending from a point about 5 cm from the upper part of the tracheal fork to the bronchi bilaterally.

ESOPHAGUS. The mucous membrane was moderately jaundiced. The vein at the right rear part of the lower end of the esophagus was distended, forming a varicocele. Between the left rear lateral section, corresponding to the tracheal fork and the aorta was an extravasation about 5 cm long; the connective and fatty tissues near the extravasation were prominently edematous and the fatty tissue was gelatinous. This hemorrhage surrounded the branch of the vagus nerve which runs near it.

THYROID. Weight, 17.5 g; Size: left lobe, 5.5 x 3.0 x 1.5 cm; right lobe, 4.5 x 2.0 x 1.3 cm; isthmus, 3.0 x 1.5 x 0.5 cm. The gland was somewhat atrophied; the colloid material was sparse.

ORGANS IN THE HEAD AND THE SPINAL CORD

Hemorrhages about the size of the head of a hatpin were observed in the skin of the head at the right parietal region and in the fatty tissue of the corium.

MENINGES. The dura was very prominently yellow. No edema was seen in the pia.

CEREBRUM AND CEREBELLUM. Weight, 1,430 g. Slight swelling was observed. The cerebral gyri seemed rather flat. The cerebrospinal fluid was somewhat yellow, and there was not much increase in quantity.

HYPOPHYSIS. Weight, 0.75 g; size, 1.45 x 0.95 x 0.45 cm. Appeared a bit heavy.

SPINAL CORD. Removing the portion from the first encephalon to the cauda equina, we observed some post-mortem softening in places. Moderate congestion was noted in the blood vessels of the pia.

BONE MARROW

LEFT FEMUR. The head was completely of fat marrow. The epiphysis was red marrow, but somewhat fibrous; its center, was somewhat medullary, depending upon position. The diaphysis was yellow gelatinous fat marrow.

RIGHT FEMUR. The part near the epiphysis was red and fibrous; the center was medullary in places. The diaphysis was fat marrow, red tinted in places, and yellow gelatinous. There was less fat marrow than in the left femur; it extended a point 17 cm upward from the lower end of the femur. Part of fat marrow was jaundiced. (See photograph No 1.)

SPINAL COLUMN. The lumbar vertebral section was red; the center was medullary and slightly grey. Red medullary substance extended toward the cortex; the consistency was thin. The central marrow showed signs of proliferation; but the proliferation was not extensive toward the edges. A similar condition was observed in the marrow of the thoracic bones.

STERNUM. Red, slightly medullary, somewhat brown and proliferate.

RIBS. Red, fibrous marrow; the center was medullary in places.

ILIUM. Not much different from the sternum, but fibrous marrow and deep red.

PATHOLOGICAL AND HISTOLOGICAL ITEMS

A. Results of the research conducted by the Pathology Department of the First Tokyo National Hospital and partly by the Pathology Department of Tokyo University up to 1 November 1954 were presented in a slide report by Dr. Chashi at the first medical meeting of the Investigation and Liaison Council on Countermeasures for Atomic Bomb casualties

in the auditorium of Toichi Hospital on 2 November 1954. The following is the summary of the report:

1. The marrow of the femur, sternum, and ilium showed some regeneration at the center; but there was capillary enlargement. Necrotic cells were observed near the diaphyses. Mature and immature growth was still observed in the leukocyte system and giant marrow cells. Part of the last-period leukemic shape reaction can be explained by the regenerative phenomenon of this central part, but it is still a problem for study.

2. The lymph nodes of the mesentery, armpit, neck, and pancreas head were all atrophic; embryonic nuclei were not observed. The lymphatic sinuses were ample and the reticulo-endothelial cells showed some prominent mobilization. The mobilized endothelial cells presented the picture of hemosiderosis and phagocytosis in the red blood corpuscles or nuclei; on the other hand, degeneration and multinucleation were observed in the endothelial cells, and adhesion of a glassy substance was noted in the cortex. (See photograph 9.)

3. The testicles appeared to be considerably atrophied; the stroma was sparse and edematous. The basal membrane of the seminiferous tubules was conspicuously swollen. There were very few spermatocytes and they were scarcely in evidence at certain places. Spermatozoa were difficult to find either in the seminiferous tubules or in the epididymis. In short, spermatogenesis was greatly impeded. Sertoli's cells and Leydig's cells were easily recognized. (See photograph No 10.)

4. Changes in the skin did not include excessively horny lesions; the stratum germinativum was thin. Partial vacuolation of the epidermis was observed. The stratum germinativum extended somewhat toward the corium at places where there was pigmented dermatitis lesion; the cells in such places were heavily pigmented with melanin. The auxiliary organs of the radix pili and skin were atrophied at certain places. There was slight degeneration in the blood vessels of the stratum papillare and corium; the areas around the blood vessels showed infiltration of lymphocytes.

5. Degenerative necrosis was severe in the liver cells and the primary center was assumed to lie in the lobuli hepatis; but centers occurred also in the Glisson's capsule, which was irregular, and these new locations were similar to the findings at the time of red-yellow atrophy. At this old necrotic site, the latticed fiber had increased and some had turned to gelatinous fibrils; the new part showed degeneration of the latticed fiber. When the nidus of the necrosis was extensive, the liver cells were partly regenerated; binuclear liver cells were observed. There was a tendency toward the formation of pseudeo-lobules; these little tubers again turned to fat from the circumference inward, in places, became necrotic, or developed into Mallory bodies. The area around the necrotic nidus showed proliferation of the biliary canaliculi. In places, giant hepatic cells were observed with as many as seven nuclei. Biliary plugs were also comparatively numerous and were assumed to arise from degenerative obstructions caused by necrosis of the liver cells or inflammatory cell infiltration into the Glisson's capsule; the biliary plugs occurred mostly in the necrotic nidus near the capsule. The Glisson's capsule showed moderate inflammatory cell infiltration by

neutrophiles, monocytes, lymphocytes, and plasma cells; fibrous cells were also noted. Between the fibers of the liver cells were also monocytes and neutrophiles but the hematopoietic nidus could barbly be recognized.

The liver cells in general were badly discolored, inflamed, and swollen; the protoplasm was vacuolated. The adipose development involved chiefly the liver cells in and around the necrotic nidus; the nuclei were swollen. The distribution of chromatin was uneven; it was concentrated in places and there was a tendency to overconcentration in the nuclear membrane. The fibers of liver cells separated from the necrotic nidus showed areas of giant multinuclear hepatic cells. The Kupffer's stellate cells were mobilized, fatty, and granular and had gormandized the hemosiderin or bile pigment; the nuclei were deeply colored and some were small. The liver cells were especially prominent around the necrotic nidus and showed gormandization of bile pigment and hemosiderin; the giant multinuclear hepatic cells also absorbed these pigments.

These findings are somewhat similar to the picture in abnormal progressive hepatitis, but we are now studying it in the light of new developments in radiation hepatitis. (See photographs No 4 and 5.)

6. The cavum of the spleen was prominently enlarged. Certain areas of the surrounding tissue had become slightly fibrous, and the medullary cells were few in number. The lymph nodes were atrophic and many of them were small. The central arteries were exposed in places and the walls of many of them were indistinct. Embryonic nuclei were not seen anywhere in the lymph nodules. In places, some adhesion of a glassy substance was evident. Degeneration was observed in the intima of the central artery. No hematogenic nidus was observed. (See photograph No 6.)

7. The kidneys showed severe cholemic nephrotic degeneration. Bile pigment and hemoisiderin had entered the Bowman's capsules and the uriniferous tubules. The epithelial cells of the main part of these pigments were gormandized and slight fatty development was noted in the epithelium of the uriniferous tubules. This was assumed to indicate impediment in the metabolism of iron. (See photograph No 8.)

8. The heart showed severe atrophic degeneration in the myocardium and the effusion within the stroma was vast. The myocardiac connective tissue had become fibrous and the lining membrane of the left ventricle was badly hemorrhaged. Extensive changes in the myocardiac layer were noted especially near the endocardium. (See photograph No 7).

9. Foci of pneumonia were observed in the upper and lower lobes of the left lung and in the upper lobe of the right lung. As the result of research by Mr. Okuhira of the Pathology Department of Tokyo University, it was demonstrated bacteriologically that there was mixed infection of Aspergillus fumigatus in the pneumonia nidus. Many emphysematous lung cells were found in other parts of the lungs and congestion and edema were observed in places. Catarrh was observed in the mucous membrane of the bronchus.

10. The mucous membrane of the stomach and the intestines was degenerative and atrophic. Degeneration was observed in the gland cells but

the proliferation picture was scarcely encountered. There were inflamed areas in places. Lymph nodules were few, especially in the intestines; they were atrophic and hemorrhagic in places. Mr. Okuhira has also demonstrated that the mold from the furring in the gastric mucosa corresponded to the macroscopic impression: Candida albicans and Aspergillus fumigatus.

11. The parenchyma of the pancreas presented regressive degeneration in the form of turbid swelling; the stroma was slightly increased. Occasional fatty development in the parenchyma and hemosiderin gormandization were recognized. Spotty adipose necrosis foci accompanied small, slight infiltrations of lymphocytes.

12. The gland cells of the hypophysis and the cells of the suprarenal cortex were also degenerative. There was a highly atrophied part in the glomerule layer, together with a strongly regenerative part. The blood vessels of the two organs were dilated. The thyroid gland presented the picture of functional decline.

13. In one part of the oesophagus there was degenerative excoriation of the epithelial cells; in another part the deeper cells of the stratum germinativum had proliferated and reached to the surface. The lower layer of the mucosa was atrophic with slight infiltration of lymphocytes and plasma cells; the capillaries were dilated.

14. The epithelial layer of the bronchial mucosa was mostly degenerated and exfoliated; the area below the mucosa was extremely edematous, and platelets, neutrophiles and tissue cells were observed in places. The blood vessels presented a picture of stasis, and degeneration of vacuoles of the cartilaginous cells and was observed together with concentration of nuclei. Cholemic degeneration was seen in the brain.

B. Dr. Ohashi, technical expert at the departmental conference, reported as follows on 16 November 1954 at the second medical meeting of the Investigation and Liaison Council on Counter-measures for Atomic Bomb casualties, at Tokyo University, and these data were made public on the same day by Dr. Tochiku, chairman of the medical meeting:

Pathological Diagnosis of The Late Mr. Kuboyama
(Intermediary Report)

1. Partial recovery picture in bone marrow from general myelopathia.

2. Atrophic degeneration of the lymph nodes.

3. Dysfunction of spermatogenesis; swelling of the basal membranes of the seminiferous tubules.

4. Atrophy of the liver inflammatory cell infiltration and slight cirrhosis (830 g).

5. Atrophic spleen with congestion.

6. Severe cholemic nephrosis of the kidneys (left 220 g, right 190 g).

7. Atrophic degeneration of the myocardium and effusion in the stroma (320 g).

8. Pneumonia with mixed infection of Aspergillus fumigatus of the upper and lower lobes of the left lung and the upper lobe of the right lung.

9. Degenerative atrophy of the gastrointestinal mucosa and partial acute inflammation.

10. Turbid swelling of the pancreas (120 g) with fat necrosis.

11. Exudation in the thorax (left 14 cc, right 17 cc) and ascites (2.6 liters).

12. Extreme yellow turbidity and partial hemorrhage of the skin and mucosa.

13. Dermatitis scars in the neck region, the legs, the insteps, etc, caused by the Bikini ash.

14. Moderate edema bilaterally at the insteps.

CONCLUSION

We have obtained these data as the result of intermediary study. The generative and retrogressive changes in the medulla of the mesenchyme system and the lymphatic system, which are especially sensitive to radiation, and the changes in the testicles, which derive from the mesoderm system, are assumed to be the results of radiation. Skin changes are mainly caused by exposure to beta radiation. Changes in other organs are thought to be partly caused by radiation and partly caused by cholemia, which is deuteropathic, or by the fungus infection of the last stage; but these require further careful investigation. The occurrence of fungus and virus infections in radiation sickness is another important problem.

The crucial problem is the changes in the (endoderm) liver which took Mr. Kuboyama's life. The liver is ordinarily said to be resistant to radiation, but this is true mainly in cases of external exposure. But the main factor in the Kuboyama case was not so much the external radiation as the internal exposure via mouth, lungs, or skin during the 2-week period around the exposed ship, which resulted in degenerative necrosis and cirrhosis, with inflammatory cell infiltration in the liver. Virus hepatitis might have occurred following the blood and plasma transfusions he received.

In any event, the radiation sickness resulting from both external and internal radiation damaged the liver directly and to a great extent. At the same time, the possibility of virus hepatitis or its aggravated form was duly considered and this is one of the main points of study.

However, in this case, an entirely new development like radiation hepatopathia is the main problem and should be considered from the time when the patient first suffered.

The report which shows that zirconium 95, columbium 95, cerium 144, praseodymium 143, yttrium 99, strontium 89, strontium 90, and other fission products were found in the liver of Mr. Kuboyama was submitted

to the Kimura Laboratory of Tokyo University; it amply describes the possibility of radiation hepatopathia. The distinction between this and hepatitis is very difficult and we expect to make further study through animal tests.

Mr. Kuboyama contracted acute radiation sickness from the Bikini devastation. His hematopoietic functions were gradually recovering, thanks to the careful and enthusiastic efforts of his doctors, when he unfortunately succumbed to liver dysfunction and pneumonia caused partially by mold, etc, on the 207th day after exposure. This case teaches us how a patient died from the Bikini radiation.

In conclusion, we pray for the soul of Mr. Kuboyama and we express our deepest appreciation to those members of the Investigation and Research Council who witnessed the autopsy all through the night; to Mr. Sakaguchi, Chief of the Toichi Hospital; Mr. Kuriyama, Vice President of the Toichi Hospital; Mr. Omura, Chief of the Hospital Section, Ministry of Welfare; the doctors in charge; Mr. Shioda, Chairman of the Investigation, Research, and Liaison Council on Countermeasures for Atomic Bomb Casualties; Mr. Tochiku, Chairman of the medical meeting of the Council, and others of the Council; Mr. Miyake of the Pathology Department of Tokyo University, and those of the class; and to all others concerned, who have given us constant guidance.

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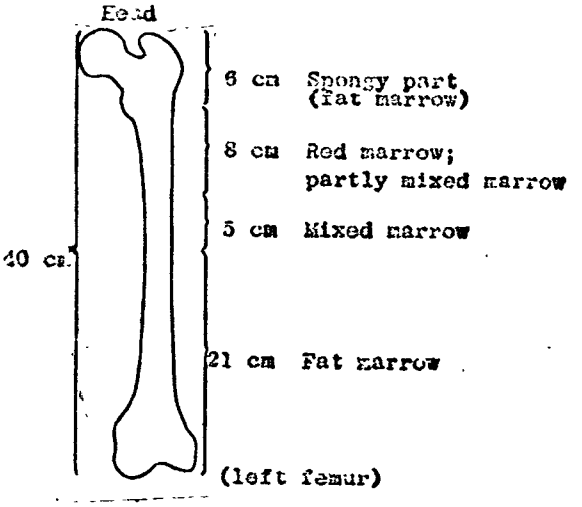

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