

CHAPTER II.

Clinical Course of the Atomic Bomb Injuries.

Both at Hiroshima and Nagasaki, just at the moment of the explosion of the atomic bomb, darkness and confusion suddenly spread. Devastation of houses, destruction of lives; its terrible scene could never be expressed by either tongue or pen. At Hiroshima, the explosion occurred on August 6th, 1945, at 8:15 a.m., south of the West Parade Ground. At Nagasaki, the explosion occurred 3 days later, on August 9th, 1945, at 11:00 a.m., over the center of the north factory district of the city. The damages in the two cities were not quite the same, on account of the difference of their geographical situation and city conditions. The casualties of the human beings, however, especially the outbreak and course of the atomic bomb injuries were just about the same in both cities.

It would be convenient to understand the clinical course of the atomic bomb injuries, if they are divided into the following 4 periods, with medical consideration of the results of the investigation.

(1) The First Period (the early stage)

From directly after the explosion to the end of the second week. This was the period of the most terrible casualties; various violent energies which were produced simultaneously just at the time of the explosion, acted in a combined form, consequently the damages resulted in various symptoms respectively. About nine-tenths of the victims, who would be expected to die of atomic bomb injuries, actually did so in this period. The majority (ca 90%) of the injured persons who were treated at the medical rescue organizations within several days after the explosion were recorded mainly as burned patients.

(2) The Second Period (the middle stage)

From the beginning of the third week to the end of the eighth week. In this period there prevailed many patients with atomic bomb radiation injuries in moderate degree. About one-tenth of the victims who were destined to die, died in this period. Therefore, the 1st and 2nd periods are to be called "the acute period", according to the condition of the clinical course of the atomic bomb injuries.

(3) The Third Period (the late stage)

From the beginning of the third month to the end of the fourth month. In this period, the symptoms of all sufferers were progressing toward recovery, even though the speed or degree of their recovery did not coincide. Few persons died finally, nevertheless, on account of various severe complications. However, it may be at the end of the fourth month, i.e. in the beginning of December, 1945, at both cities, almost all the sufferers had recovered from the physical damages of the atomic bomb. The clinical course of the atomic bomb injuries themselves, therefore, may be said generally to have come to their end.

(4) The Fourth Period (the after stage)

After the fifth month. This is a period of sequelae, various remaining symptoms, due to burns or mechanical wounds (deformities, contractures, keloids etc.), various remaining symptoms caused by the damage of the blood or blood forming organs after the radiation injuries

(anemia, nervousness etc.), various remaining symptoms of disturbances of the sexual organs (male and female sterility). These sequelae and symptoms appeared more manifest since the beginning of this period and have already been partly clarified by our investigation, but most of them are to be studied continuously in the future.

In the following chapters, the course of the atomic bomb injuries in each period will be described.

1) Genesis and Course of the Atomic Bomb Injuries in the First Period (The Early Stage).

The first period is a time from directly after the explosion to the end of the second week, that is, at Hiroshima from August 6th to about the 19th, at Nagasaki from August 9th to about the 22nd.

Tremendous numbers of deaths were recorded by the injurious action of various kinds of unimaginably powerful energy. According to statistical surveys, about 90% of the dead victims are estimated have been killed within 2 weeks. If the total deaths at Hiroshima be calculated provisionally as about 100,000 90% of them - about 90,000 persons lost their lives in this period.

Immediate deaths are blasted, burned, crushed, drowned etc. The ratio of the immediate deaths (including the deaths within 1 - 2 days) was estimated at 30 - 100% in the area of a radius of 500 m from the ground center, 50 - 80% in the area of a radius of 500 - 1,000 m. Among the cadavers of the immediate deaths, there were many cases with severe generalized burns (charred necrotic skin flaps were loose and hanging), general blast injuries and crush deaths under devastated houses etc. Some severely crushed wounded were burned to death by fires. Besides these, there were found also some cadavers which had apparently no wounds on the surface of the body. They were immediate deaths due to the blast action. It has been argued for a long time that the eye sacks or intestines could be prolapsed simply by a blast action. We have understood that by blast action of an ordinary bomb, a prolapse of eye sack or intestine will not occur without accompanying mechanical wounds. The blast pressure of the atomic bomb, however, is so tremendously strong, therefore lacerations or wounds of the surface tissues would combine with the injuries of internal organs. Medical personnel who worked with rescue organizations told us that few cadavers had true prolapse of internal organs, especially of intestines. The cadavers which appeared as though they had prolapse of the internal organs might have been those with skin flaps torn by hyperthermal blast, combined with complicated open wounds. The alleged prolapse of eye sacks was also probably due to edematous changes of the palpebrae or postmortem prolapse of the palpebral mucous membrane. We can refer to an official report from the KURE Naval Station (the 3rd official report, dated on August 11), which said that there were absolutely no cases of prolapse of intestines or eyes, no hemortysis, even in the central district, a description in the previous report that there were some cases, based upon false observations on complicated wounds or postmortem changes.

Even in the central area a few persons survived just at the inner corner of a cave (a sideway type, covered by a layer of soil 3 m thick).

Some were also safe in a well covered inside room of a strong concrete building. Some persons escaped from their wooden houses, even in the area of a radius of 500 - 1,000 m from the ground center. Of course their houses were destroyed totally, but they had tried to escape by their own effort from the devastated ruin without any serious mechanical wounds before the fires destroyed their houses.

All persons who were at the time of the explosion within 4 km of the ground center, had burn injuries, except those who were in some shadow. Within a radius of 1 km severe burns, in the area of a radius 1 - 2 km moderate burns, in 2 - 4 km slight burns were observed.

Among the severely burned patients who suffered in the central district, there were many immediate deaths or nearly so, due to direct heat damage of internal organs. Their shirts and single clothes (YUKATA - Japanese summer cloth) were burned or scorched and blown off by the subsequent blast pressure, uncovered areas of skin were burned severely, torn off or left hanging in strips and flaps. The persons with thicker clothes escaped from severe burning in a large area, but these patients died without exception if the ratio of the severely burned area of skin was over 20%.

Every report of the Rescue Corps of the Army and Navy at that time said: "the mortality of the burned patients was very high, among the burns which were treated from the night of the day of bombing to the second day, the mortality was estimated at 20 + 40%". All early reports pointed out that the mortality was relatively high, considering the local appearance of the burned wounds. It was also reported that in several hours after the bombing, many burned patients complained of fever, thirst, vomiting etc. These symptoms were due on the one hand to the effects of radioactive energy and on the other hand to poisonous substances produced in the central area after the explosion. These burned patients showed various different symptoms from pure effects of heat. In the area in which radioactive energy is strongly applied: that is, within a radius of 2 km from the ground center, all burned patients who received a primary burn (flash burn), would expect to have radioactive damage also. Therefore, the burns within a radius of 2 km possessed special characteristics of the so-called "Atomic Bomb Burn".

In the area within a radius of 2 - 4 km, there were observed many patients, burned mainly by radiant heat and light rays. Within 2 - 3 km, there were many cases of scorch burns, due to scorching of their clothes, also many cases of contact burns, due to heating of their clothes. Within a radius of 3 - 4 km many cases of slight flash burn were observed.

The so-called "Atomic Bomb Burn", cases which were caused by the direct impact of both radiation and emission forces, had very poor prognosis. Among about 20,000 cases which were treated in a rescue hospital of the Japanese Marine Corps at UJINA-MACHI, Hiroshima City, 2,623 deaths were recorded, most of them were severe burn cases. About 75% of the deaths died by the end of the first week. Over 90% of the cases died within 2 weeks.

How were the radiation injuries in the first period? In the central area, within a radius of 1 km, the persons who were outdoors had severe effects from radioactive energy and severe burns. Almost all of these

persons lost their lives therefore either immediately or shortly thereafter, as it was explained in the chapter on burn. If a person was in a sufficient shadow, to be protected from heat rays, he had no burn. But he received severe effects of radioactive energy. It has been discussed many times, immediate death or not. The note of Dr. NAGAI's, Assistant Professor of Radiology, Nagasaki Medical College said: "the patients died within several hours, changing the skin into black colour." There may be therefore a possibility of an immediate death (death within several hours after the bomb), due to direct effects of the radioactive energy alone. But it is not sure, for death might be caused partly by the blast action.

Some persons were outdoors in shadows, so they had severe effects of the radioactive energy, but no severe burn. These persons complained immediately of extreme fatigue, nausea and vomiting, and within a few days various hemorrhagic symptoms such as hemoptysis, hematemesis, hematorrhoea, hematuria etc. occurred. Many of them died finally of general exhaustion. Some persons were within the area of a radius of 500 m from the ground center, but escaped from immediate death, as they were in covered trenches or strong buildings. Some were in wooden houses in the area of a radius of 500 - 1,000 m, and were not killed immediately. These persons complained in several days or in 2 weeks, of fever (38 - 39°C) continuously) and hemorrhage (hematemesis, hematorrhoea, gingival bleeding etc.) Almost all of them finally died. Among these persons, there were many patients who had mucous bloody stools and died. It was thought, therefore, at that time that there prevailed an epidemic outbreak of dysentery like disease. Bacteriological examinations revealed that the majority of these cases proved negative. But at that time, there were really a few cases of true dysentery and typhoid fever. These cases of dysentery and typhoid fever were treated under such confusing circumstances as cases of the atomic bomb injuries. On the occasion of surveys, it was difficult to determine positively secondary radiation injuries (caused by induced radioactive energy), for there were many rumours reported through careless talk.

Many persons in the central district, were effected with vomiting, diarrhoea, anorexia etc. These symptoms may be explained as early symptoms of radiation injury. In the Hiroshima districts the citizens believe firmly the following stories. These various symptoms occurred after the explosion and were caused by aspiration of some gas-like substances or by drinking water, in which these substances were dissolved. We can not thoughtlessly deny these stories, because we have not enough evidence that these stories are to be negatived. Nevertheless, we have had until now no positive data upon which to support these stories.

2) The Course of the Atomic Bomb Injuries in the Second Period (The Middle Stage).

The second period extends from the beginning of the third week to the end of the eighth week, that is from about August 20th to the beginning of October, 1945, the period of about 6 weeks, both at Hiroshima and Nagasaki. This period can be divided into two sub-periods, according to the clinical course of the patients; the early sub-period (the 3rd, the 4th and 5th week - from about August 20th to September 10th) and the late sub-period (the 6th, the 7th and 8th week - from about September 10th to the beginning of October.)

The majority of the cases which had severe atomic bomb burns, lost their lives during the first period. Therefore, the burned patients surviving until the early sub-period of the second period, were moderately or slightly affected cases. The persons who were within a radius of 2 km from the ground center, had flash burns, combined with scorch - contact - or flame burns. These burn wounds were all of the 3rd degree, the damage penetrating into the deep layer of the skin. Therefore, the demarcation of the necrotic tissue takes a longer time. These patients also suffered from radioactive sickness. According to the alternation of the tissue reactions, the healing process of the wounds were prolonged. The less resistance against infection caused severe suppuration of the burned wounds. The shortage of medical rescue organizations and medical supplies was also a detrimental influence upon the healing of the wounds. Many patients had suffered from severe cicatrization, which would be ground for the further formation of contracture or keloid. On account of the suppuration and disturbance of the healing of the burned wounds, some patients had fallen into a general weakness and showed a poor prognosis. There were observed many slight flash burn cases in the area of a radius of 2 - 4 km, especially at a distance over 3 km, many of these burned cases were just superficial flash burns, which had been almost cured within early subperiod.

Among those wounded mechanically, many severe cases had died in the first period. Slightly wounded cases had been cured for the most part by the end of the late subperiod. The burned cases also healed without suppuration, when they were affected slightly in the area of a radius of 2 - 4 km, glass wounds had also healed very quickly without suppuration, when it occurred in the area of a radius of 2 - 4 km.

On the other hand, those wounded in the houses, within a radius of 2 km, were affected severely and tended to be infected. Healing was prolonged. It should be understood that these patients were affected at the same time by the radioactivity and had radiation injury.

The persons who were outdoors and yet in some shadow, or who were in wooden houses within a radius of 1.5 km from the ground center, had neither burn nor wounds, but they were affected moderately by the radioactivity. Many of them complained, as above mentioned, of vomiting in several hours after the bomb and of anorexia for several days. These persons were, however, becoming better and recovered within several days. Some of them could work at rescue labor. Almost all persons who were within a distance of 1 km from the ground center, were becoming ill in the 3rd or 4th week. Epilation, fever, hemorrhage, necrosis, mucous bloody stools etc. About $\frac{1}{2}$ of the cases died in the course of one week. About $\frac{1}{4}$ of the cases died of complications later.

About one half of the persons who were affected at a distance over 1 km up to 2 km became ill in the 4th and 5th week. They showed epilation, fever, hemorrhage etc. Some of them died of complications in the late subperiod. These patients often became ill without apparent reason, but some of them marked their onset by: overwork, cold, digestive disturbance etc.

In the late subperiod, there occurred some complications of radiation injuries. Many cases were observed, in which some hemorrhagic and necrotic foci were combined with infections: cellulitis, pneumonia, abscess of lungs, gangrene of lung, empyema, enteritis, and especially colitis gravis etc. With these infectious complications the general condition of

the patients again became worse. The occurrence of these complications was based upon the weakened resistance against infection, due to the radiation injuries. On account of the alteration of tissue reactions against an infection, the symptoms of these complications appeared very often in a strange atypical style.

At the end of the late subperiod of the second period, many patients in severe condition showed some signs of recovery. The destructive processes of the atomic bomb injuries ceased at the end of the second period. At that time the clinical course of the atomic bomb patients was going into a recovery stage, the 3rd period.

3) The Course of the Atomic Bomb Injuries in the Third Period (The Late Stage).

The third period is from the beginning of the third month to the end of the fourth month, that is from the beginning of October to the beginning of December. All damaged conditions of the human body took the course of recovery in this period. Even the mechanical wounds or burns which had showed prolonged healing until this time, showed a remarkable healing tendency demonstrating the recovery of function of the blood and internal organs. These wounds had mostly healed by the end of the third period and by that time various sequelae were observed: contracture of the scar, formation of keloid, aneurysms etc. It has not been determined yet, if these sequelae are especially common in atomic bomb patients. We are interested now in the question as to whether those severely wounded by other types of bombs have such a high rate of sequelae. Further experience may give us answer.

The symptoms of the atomic bomb injury also improved in this period: The symptoms of epilation had ceased since the late subperiod of the second period. In many epilation cases, the growing of some thin sparse hairs was observed at the beginning of the third period.

Slight cases of epilation had almost recovered by the end of the third period. In severe cases of epilation, new hair was finally growing.

The damage to blood also recovered in this period. The clinical examinations revealed that leucocytes recovered first. By the end of the fourth month, the number of white blood corpuscles generally returned to the normal value. Some of them even showed somewhat of a leucocytosis. In these cases the recovery of granulocytes was more remarkable than that of lymphocytes. Many cases were observed, who showed a comparative increase of eosinophilic granulocytes. Eosinophilia is a temporal symptom, which is used to indicate a better prognosis.

The observations in the first and second periods revealed to us that the damage to red blood corpuscles was slighter than that of white blood corpuscles. Some cases showed a severe damage to red blood corpuscles in the third period, especially in the cases which had general weakness, caused by the prolonged healing of burns, or in the cases which had some general disorder, caused by complications. In all these cases it was proved that the damage to red blood corpuscles proceeded further in this period.

Put on the whole, the damage to red blood corpuscles also recovered in the third period. The condition of recovery of red blood corpuscles, generally speaking, followed that of white. Even in the fourth month, some cases had not yet returned to the normal value. There still remained many cases of anemia.

Bone marrow showed a proliferative picture, both in granulocyte and erythrocyte systems.

Many patients recovered in the third period. The typical appearance of the face, observed in the second period - anemic, edematous and cachectic features - gradually faded away. An active vivid appearance came back to the face of the patients. A few patients could not, however, completely get back their general healthy condition, because of the prolonged wound healing and the occurrence of the complications, especially suppurative ones.

On this occasion, we would like to touch upon a special feature of some patients, which are provisionally called, "a cachectic condition". This cachectic condition of patients is characterized by a progressive consumption, a dryness of mucous membrane, often sub-icterus, an edema of the various parts of the body, sometimes an ascites, severe diarrhea etc. They usually have distinct anemic features. Disturbances of the function of the liver and the kidneys also occurred. These patients had neither incurable wounds nor suppurative complications. If they had some wounds, their local conditions became worse and they had no tendency to heal. The patients who had such severe symptoms, did not respond to treatment and passed away finally. Among 141 cases of severe atomic bomb injuries who were treated at the SHINKOZEIY Hospital, Nagasaki, there were observed 15 cases of typical cachectic condition and 7 cases of tendency to it in October and November, 1945. This condition looked like mal-nutrition, so some investigators said, due to a disharmony of nutrition. The fundamental basis of this condition should be damage of the functions of internal organs, due to atomic bomb injury. We would like to consider an atomic bomb injury as a wound in a wide sense, therefore we called this condition provisionally "a cachectic condition" in the same meaning as "a wound cachexia", which is given to a condition, occurring in the course of severe wounds. These cachectic conditions are curable in cases of not too severe a grade. Recovery occurs when the function of internal organs comes back with the elapse of time.

It is a well known fact that the sexual organs are affected remarkably by the radioactive energies. A study in the third period at Hiroshima revealed the following results: Out of 124 investigated cases, it was shown that in 43 cases (34.7%) the number of spermocytes in the ejaculated sperm was under 5,000 in one cubic mm (absolutely sterile), 10 cases (8.1%) 5,000 - 10,000 (relatively sterile) and 71 cases (57.1%) over 10,000 (normal). About 1/3 cases of all investigated persons were estimated therefore to be in a sterile condition. A reformation of the spermocytes occurs in one month, so the recovery of damage to spermocyte formation will be delayed more than that of the damage of white blood cells. The shorter the distance, the more severe was the damage. The damaging influence on the number of spermocytes was observed in the area within a radius of 3 km from the ground center. Within a radius of 2.5 km there appeared some sterile cases, within a radius of 1.5 km one half of the cases showed sterility.

The results of an investigation of the menstruation of the females at Hiroshima was as follows: Among 399 women in the ages of sexual maturity, 121 cases (30.3%) had normal menstruation even after the bomb, the other 278 cases (69.7%) showed some disorders of menstruation, mostly amenorrhoea. The nearer the distance, the higher the ratio of menstrual abnormality. According to the further studies on the cases which had some abnormality of menstruation, over 80% of the cases of temporal amenorrhoea recovered in 2 - 6 months and they again had normal menstruation. Moreover, several cases had already been recognized as pregnant.

We consulted 35 pregnant women, who were over the 2nd lunar month at the time of the explosion. Among them 2 abortions were reported, one case on the day after the explosion, another after 3 weeks, the latter probably due to diarrhoea. The other women have been getting along well. 14 cases have delivered already without any particular abnormality throughout both labour and puerperium. In new borns, we have noticed nothing abnormal. As to the endometrium of amenorrhoea cases, the estimated phase at the bombed time did not correspond to the actual phase shown by the curetted specimens. Many of them showed the beginning or middle stadium of post menstrual phase. The endometrium itself was generally thin and atrophic. In the recovered cases, the estimated phase and the phase diagnosed by the curetted specimens corresponded well.

4) Sequelae of the Atomic Bomb Injuries in the Fourth Period (The After Stage).

Both at Hiroshima and Nagasaki, in the fifth month, i.e. in the beginning of December, 1945, the effects of the atomic bomb upon the human body had almost all passed away. Therefore, after the fourth period, the few remaining sequelae are to be studied.

The sequelae of burns and mechanical wounds are contractures and keloids of the scars, disorders after the injuries of peripheral nerves, aneurysms of the blood vessels etc. In some rare cases we might consider the possible genesis of cancerous changes in the scars of burned wounds. The rate of the formation of these sequelae will become clear by further observations. We have not yet received any reports which reveal some distinct differences in the atomic bomb wounds compared with the sequelae after the damage caused by ordinary bombs.

Among the symptoms of radiation injuries, all the epilation has recovered. The hair began to grow again, at the latest by the beginning of the fourth period. The regrowing hairs seem to be generally thin and sparse. Further study will tell us how completely the damage of hairs will recover and for how long recovery will occur.

The damage to blood recovered almost completely by the end of the third period, as above mentioned. There remains even yet some cases of anemia (hemoglobin content around 50%) and leucocytosis (around 15,000). The cases who showed leucocytosis in this period, were mostly outside of a radius of 2.5 km from the ground center at the time of bombing.

In the further studies, it was proved that the anemia recovered very slowly. There may occur, therefore, some disturbance in the form of anemia.

A condition of leucocytosis is thought by many investigators as a

phenomenon of temporal regeneration, but in bone marrow a remarkable picture of proliferation was seen, consequently it is necessary to watch the further course, until it comes back to a normal condition. It is noteworthy that one sufferer at Nagasaki (at 1 km from the ground center) died with acute leukemia after 3 months. The patient was a male student, 19 years of age. In the end of August he had the clear symptoms of radiation injury. His white corpuscles were counted at 650 as a minimum. He was treated at the University Hospital, FUKUOKA, and recovered fortunately in one month. In the beginning of November, after a heavy harvest labor in a 3 day period he became suddenly ill with high fever and severe hemorrhage. The white count was 390,000. He died in 5 days. Clinically he was diagnosed as an acute monocytic leukemia and it was proved by autopsy (cf. the report of Dr. MISAOKA's, Medical Clinic, Kyushu Imperial University). Since then we have not yet heard of any similar cases, but we shall not assume that this case might be an accident one.

As far as the symptoms of the atomic bomb radiation injuries are concerned, many investigations were done from various points of view: biochemical and immunological studies on blood, studies on the status and functions of the digestive tract, studies on the functions of liver and kidney, studies on functions of blood capillaries etc. All these features had some disorders more or less after the bomb, but most of them recovered by the end of the third period. Nevertheless, these features showed a little abnormality or deficiency in their characters, conditions or functions, so the function of an organism as a whole, in other words, the resistance power of the whole body shall be estimated in a less functional condition. We must follow up this condition in some period as an after effect of the atomic bomb injuries and not forget to give suitable care.

On the psychological side, the situation may be similar. Social mal-effects have not yet been reported, but we must be always very careful about neurosis-like complaints in connection with the present social circumstances. This aspect has, of course, some close relation with the anemia as well as lower resistance of the whole vital power of the patients.

The damage of the sexual functions was described already, the latest survey revealed that the abnormality of menstruations of the females recovered almost entirely, and that the recovering of the decreased number of spermatocytes in males is a little slower. A further study has been requested.

The women who were in an early stage of pregnancy, have taken a normal course since the bombing. New born must be carefully checked upon, in order to make clear, how they come along, because they were given a relatively large dose of radioactive energy in their earliest fetal life.

It is already experimentally proved both in botany and zoology that there is a possibility of producing a malformation of descendants, when the sexual cells are affected in some degree by radioactive energy. The question, if this fact is applicable to the human beings or not, will be made clear by the further observations. We have already clear evidence that the human sexual cells are also affected by the atomic bomb injuries. There is a possibility of malformation of the descendants, if the sexual cells should be affected selectively, without any severe damage to the other organs or tissues. In the survey of spermatocytes, it was noticed that they

decreased not only in their number, but they showed also some structural abnormalities. This problem must be, therefore, taken up and carefully followed further. Moreover, if necessary, it shall be discussed also in the field of study of heredity and eugenics.