NEUROPSYCHIATRIC CONSEQUENCES OF ATOMIC BOMBING AND NUCLEAR TESTS

3.1. Introduction

New era was launched on July 16, 1945 — day of the first A-bomb testing, when humankind faced the possible consequences of atomic energy release. From that day till now the anything related to the nuclear power and ionising radiation application with any purpose is associated in human mind with A-bombing consequences. Table 3.1 shows some events chronology concerning nuclear weapons and nuclear energetic world progress. Radiation medicine and radiation neuropsychiatry in particular was going on in post-war period within situation of two super-states «competition» — USSR and USA with «arms race», «cold war», «space peaceful developing», «nuclear power peaceful application», «struggle fight for peace», «Physicians International Movement for Nuclear War Prevention» and perspective of «nuclear winter».

Several applicable conclusions are resulted from radiation neuropsychiatry *»radioecological»* period (since 1945 till now) historical analysis:

- radiation neuropsychiatry was united with accidental medicine, and the human *radiation psychoneurological pathology* in some cases became combined with *post-traumatic stress disorders;*
- scientific substantiation of *cause-consequence interconnections between pathology and ionising radiation impact* occurred being hostage of political, social and economical situation both in our country and abroad;
- *secret* regimen in the field of ionising radiation biological impact study both in our country and abroad and psychiatric data informational access limitation in the former USSR (its epidemiological aspects in particular) resulted in unfavourable impact on radiation neuropsychiatry progress. This field of medicine being in the border of various sciences was put «out of critics» with exclusion of broad discussion and comprehensive studies in this field.

Professor A.V. Kozlova in Preface to the Russian edition of «Report of Marshall Islands Residents and Americans Accidentally Exposed to Radioactive Fallout Impact and Human Radiation Injury Description» (V.P. Bond, E.P. Cronkite, C.L. Dunham, 1956, 1960) completely impartially noted: «...In spite of significant positive sides of the book one cannot pass by the unwittingly drawing attention tendency for *radioactive fallout injuring effect belittling* towards Marshall islands exposed residents...». Unfortunately many authors cannot avoid tendentiousness and sometimes — speculations in confirmation or denial of one or another radiation effects determination. We consider only the works of Japanese experts being the exclusion here. Deep sorrow for A-bombing victims and such tragic events repeat possibility in future uneasiness prevents radiation effects diminishing by Japanese researchers. At the same time Japanese national traditional cultural peculiarities prevent the speculating conclusions too. That is why the Japanese works concerning A-bombing neuropsychiatric consequences are featured with rather high objectivity. This chapter presents analysis of works reflecting psychoneurological disorders in adults and children — A-bombing survivors. Separate chapter is devoted to the prenatal brain damage problem.

Table 3.1

SOME EVENTS CHRONOLOGY CONCERNING NUCLEAR WEAPONS AND NUCLEAR ENERGETIC PROGRESS

Date	*Event*
1896	First nuclear phenomenon discovery — radioactivity of natural uranium (A Becquerel).
1897	First elementary particle — electron — discovery.
1911	E. Rutherford discovered atomic nucleus and suggested nucleus-planetary atom model.
1913	N. Bor created quantum theory (for hydrogen atom).
1932	Neutron discovery (J. Chadvick). Positron discovery (K. Andersen). First atomic nucleus fission reaction with artificially accelerated protons (J. Cocroft, E. Walton — in U.K., A.K. Valter, K.D. Synelnikov, A.I. Lejpunsky, G.D. Latyshev — in USSR).
December 19, 1938	O. Gan & F. Strassman (Germany) discovered the uranium nuclear fission process.
December 6, 1941	USA adopted the atomic bomb manufacturing plan — «Manhattan Engineer District».
December 1942	Italian physicist E. Fermy launched in USA first in the world nuclear reactor purposed mainly on transuranium i.e. plutonium (^{239}Pu) production and ^{235}U separation as the nuclear explosive.
July 16, 1945	First in the world nuclear plutonium bomb successful testing in the desert Jornada del Muerto («Voyage of Death») in 80 km from Alamogordo, New Mexico, USA.
July 25, 1945	US Air Force Order: «… 509th Complex Brigade 20th Air Forces drop the special bomb ¹1 on the one from four targets — Hiroshima, Kokura, Niigata or Nagasaki — in the nearest time after 3rd of August in appropriate weather…»
July 27, 1945	Leaflets with atomic bombing warning were dropped among the main Japanese cities.
August 2, 1945	20th Air Forces staff in Guam Field Order ¹13 «…20th Air Forces on August 6 will attack the Hiroshima industrial zone – first target in Japan. Time of attack will be 9:30 a.m. …»
August 6, 1945	At 1:30 a.m. the meteorological reconnaissance aircraft took off the US base Tinian island West Pacific. At 2:45 bomber «Enola Gay» with atomic bomb «Little Boy» on board took off followed by reconnaissance planes and dropped the bomb from height 9,480 m at 8:15 a.m. Hiroshima time. Atomic bomb (^{235}U) of 12.5 kilotons power detonated after 43 sec 600 m among Hiroshima. Maximum temperature at the point of explosion reached several million degrees. Fiery ball with 15 m radius was formed within 0.1 msec having temperature 300,000°C. Atomic cloud

	top was of 17,000 m height. The 140,000 people died, 352,000 were injured.
August 8, 1945	Field Order ¹18: «…Kokura will be the first target and Nagasaki — the second one…»
August 9, 1945	At 2:45 a.m. bomber «Bockscar» took off on Tinian to bomb Kokura. But the sky over Kokura was cloudy and course was changed to the second target — Nagasaki. At 10:58 aircraft was in the sky among the Nagasaki industrial zone. Atomic bomb (^{239}Pu) «Fat Man» of 22 kiloton power was dropped from 9,000 m height and detonated at 11:02 a.m. local time 500 m among Nagasaki northern part. The 73,884 people dies, 74,909 received severe injuries, 120,820 were left homeless. The 6,702,300 m^2 of buildings were razed to the ground.
September, 1945	Joint American and Japanese research of Hiroshima and Nagasaki atomic bombings medical consequences research initiation.
Middle 40th	Massive atmospheric releases of approx. 600 kCi ^{131}I from the first-rate industrial nuclear unit in Hanford. No any protective arrangement were applied: thyroid doses in part of the children resident in neighborhood reached 30 Gy. Only 40 years later these data were declassified.
End of 1946	Institute for Biophysics of USSR foundation for radiation sickness research and radiation injuries prophylaxis and management tools working out, studies in the filed of radiotoxicology, dosimetry and radiation hygiene.
1947	Organisation of scientific-research division under leadership of N.V. Tymofeyev—Resovsky on Ural region where convicts, interned Germans (war-prisoners) and Soviet specialists-volunteers in the field of theoretical radiobiology, experimental radioecology, radiotoxicology & radiation dosimetry.
March 1947	Atomic Bomb Casualty Commission (ABCC) founding in Hiroshima by the American National Academy of Sciences under financing of US Atomic Energy Commission.
July 1948	First atomic reactor launch in industrial association «Majak» for weapons plutonium manufacturing in South Ural (100 km from Chelyabinsk city).
December 1948	Radiochemistry plant launch in industrial association «Majak» for plutonium separation.
August 29, 1949	First nuclear device detonation in Semipalatinsk test site.
September 23, 1949	US President Truman announced that the atomic bomb was successfully tested in USSR that was formally enunciated by the TASS information agency only on September, 25.
1949 - 1956	The 76 million m^3 of radioactive wastes with 2.75 MCi total activity were released from the industrial association «Majak» facilities into the Tyecha river. The 124,000 inhabitants were exposed to external and internal irradiation.
January 31, 1950	US President Truman ordered to launch the works for H-bomb creation.
October 3, 1952	First atomic bomb testing in U.K.
November 1, 1952	H-bomb testing in USA.
August 12, 1953	H-bomb testing in USSR.
1953	Radioactive substances release to environment from accidental nuclear rector in US Argonn National Laboratory.
January 21, 1954	USA launched first nuclear submarine «Nautilus».
March 1, 1954	USA tested the H-bomb in Anivetoc test site (Bikini atoll) on Marshall islands. The unexpected change in wind direction immediately after the explosion led to the radioactive substances deposition among populated atolls and warships of United Temporary Group ¹7 that conducted testing. Overall number of exposed — 267 persons. Japanese fishing boat «Fukuryu Maru» (The ¹5 Lucky Dragon) crew (23 fishermen) accidentally present in radioactive fallout sedimentation also was damaged from Bikini radioactive ashes.
1954	First nuclear power plant with 500 kW power capacity was launched in Obninsk city (by I.V. Kurchatov et al.).
1955	The UN Scientific Committee on Atomic Radiation Effects (UNSCARE) was founded on the X session of UN General Assembly.
May 15, 1957	H-bomb testing in U.K.
August 26, 1957	USSR announced of intercontinental ballistic missiles successful testing.
September 29, 1957	Radiation Kyshtym accident on industrial association «Majak» led to 20 MCi radioactivity release. The 270,000 residents of Chelyabinsk, Sverdlovsk and Tyumen provinces were exposed to external and internal irradiation.
October 4, 1957	USSR first in the world launched the space satellite.
October 10, 1957	Accident took place on nuclear reactor in Windscale (U.K.) that resulted in atmospheric releases of approximately 21 kCi radioactivity. The 13 workers of nuclear center died.
End 1957	Launch of Leningrad SRI for Radiation Hygiene of Russian Federation Ministry of Public Health and than — Institute for Medical Radiology of USSR AMS in Obninsk city.
January 31, 1958	USA injected into orbit the «Explorer» satellite.
1958	Catastrophe in Los-Alamos National Laboratory (USA). The 15,272 persons were exposed to internal irradiation from plutonium and general external irradiation.
1959	The first civilian atomic-powered vessel launch — soviet atomic ice-breaker «Lenin».
February 13, 1960	France conducted atomic bomb testing.
October 16, 1964	First testing of Chinese atomic bomb.
Spring 1967	Radiation accident on industrial association «Majak» (Karachai lake) led to 2,700 km^2 contamination and 41,000 people irradiation.
June 17, 1967	First testing of Chinese H-bomb.
August 24, 1968	France accomplished first H-bomb testing on Faungataufa atoll in South Pacific.
September 23, 1969	First subterranean nuclear weapon testing in China.
May 20, 1970	Radiation accident on nuclear power plant Indian-Point-1 (USA).
November 6, 1971	US subterranean testing of 5 Mt nuclear weapon on Amchitka island.
December 1971	Radiation accident on Saxton city NPP. Radioactive gases release to environment constituted $72.89 \cdot 10^{10}$ Bq (19.7 Ci).
May 18, 1974	First subterranean testing of nuclear weapon in India.
April 1975	Atomic Bomb Casualty Commission (ABCC) in Hiroshima reorganized to Radiation Effects Research Foundation (RERF) — binational (Japanese-American) organization designed for research, application and extending of Hiroshima & Nagasaki survivors medical consequences knowledge (year account 4,620 million yen ≈ US$46.2 million in 1993).
June 6, 1975	First French subterranean tests if nuclear weapons in Southern Pacific.
July 1977	USA created «Bomb of elevated radioactivity and decreased destructive capacity» — the neutron bomb.
January 24, 1978	Soviet military satellite «Kosmos – 954» with nuclear reactor on board felt on Earth surface in Northern Canada.
March 28, 1979	Radiation accident on the nuclear power plant Three Mile Island, Pennsylvania, USA — the most serious accident for all the nuclear energetic history before 1986. Sealing and refinement systems provided the substantial decrease of environmental pollution: about $9.25 \cdot 10^{10}$ Bq (2.5 MCi) of noble inert gases and $55.5 \cdot 10^{10}$ Bq (15 MCi) of radioactive

	iodine were released.
August 8, 1981	USA renewed the neutron bomb production interrupted in April, 1978.
March 23, 1983	US President R. Reagan proposed the space protective system creation against soviet intercontinental ballistic missiles.
June 26, 1983	France successfully conducted the neutron bomb testing in Southern Pacific.
June 11, 1984	USA conducted first successful testing of intercontinental ballistic missiles destruction outside the Earth atmosphere.
March 26, 1985	USA proposed Japan and Western states to participate in the Strategic Defence Initiative (SDI).
December 6, 1985	U.K. announced about its decision to take part in SDI.
April 26, 1986	Chernobyl accident that occurred the most wide-scale man-caused radioecological disaster on the planet. As the result 50 – 340 MCi (according to various sources) of radioactive materials were released to environment. In 1986 the acute radiation sickness was diagnosed in 237 patients. From them 29 died in terms from 7 to 96 days. In 1993 according to the law been currently in force about 3 million people were recognized the disaster survivors.
October 1, 1986	Foundation of the All-Union Research Centre for Radiation Medicine (AURCRM) of Academy of Medical Sciences of USSR in Kiev (now — RSRM of AMS of Ukraine).
September 1987	The 249 persons were injured by radiation from the high-active radioactive ^{137}Cs source (1,375 Ci) embezzlement from radiotherapy center in Gojanya city (Brazil) and its further destruction.
October 5, 1989	British International Institute for Strategic Research pointed out in its report «Military Balance» that American and Soviet nuclear forces are actually equivalent and the arms modernisation slowed down.
1995 - 1996	French nuclear weapons tests on Moruroa atolls.
March 12, 1997	Radiation accident on nuclear fuel treatment plant located in approximately 120 km from Tokyo (Japan). Fire occurred on low-activity radioactive wasted bituminization device. Accident was recognised as the most serious one in Japan regarding number of people exposed to radiation impact. However only 35 affected persons were announced in doses less than 0.2% of maximal tolerance year value.

3.2. Hiroshima and Nagasaki Atomic Bombing Consequences

As the result of Hiroshima city A-bombing on August 6, 1945 the 140,000 persons died and 352,000 were injured. Three days later on August 9, 1945 as the result of Nagasaki city A-bombing 73,884 persons died and 74,909 received severe injuries. On March 31, 1995 the 328,629 *hibakusha* (A-bombing survivors) remained alive in Japan.

A-bomb dropped on Hiroshima had the charge of *uranium* and used for Nagasaki — of *plutonium*. Shock wave presented 50% of nuclear explosion energy, thermal radiation — 35% and ionising radiation — 15% respectively. The cloud resulted from atomic explosion consisting from radioactive ashes was released in fallout of «black rain». Momentary radiation dose within 500 m radius from hypocenter in Hiroshima constituted 35 Gy from γ-radiation and 6.04 Gy from neutrons. In the distance of 2 km from hypocenter the respective values constituted 0.07 Gy from γ-radiation and 6.04 Gy from neutrons [A-Bomb Radiation Effects Digest, 1993; Guskova A.K., Yarmonenko S.P., 1995; Radiation: questions and answers, 1996].

Three sources of ionising radiation are considered in nuclear explosion: *primary radiation* from the nuclear explosion center; *radioactive fallout*; *residual* (induced) *radioactivity* of soil and rocks after primary ionising radiation impact. In nuclear explosion the major part of ionising radiation accounts for the primary radiation and other radiation types represent less than one-tenth of total amount (that quite differ nuclear explosion from radiation accident).

Ionising radiation risen in nuclear explosion is mainly presented with γ-radiation and neutrons with quota of the last ones of only 10%. The *neutron component* in Nagasaki excess over that in Hiroshima was registered.

The following can be regarded to Hiroshima and Nagasaki *A-bombing radiation impact peculiarities*:

- ionising radiation energy main part *release instantaneity*;
- *neutron radiation* presence;
- *lack of knowledge* in victims concerning the explosion nuclear nature.

These peculiarities determined the *radiation protection* character being applied with principle of "indirect contra-arrangements" where the arrangement itself is unable to modify the irradiation dose but cam improve the quality of life and thereby decrease probability of irradiation unfavorable effects realization probability [Yamada M. et al., 1991; Mine M. et al., 1991, 1992; Kusumi S. et al., 1993].

Health status studies in adults since 1958 were focused on four groups of survivors survey:

Group I — exposed within range of less than 2,000 m from atomic explosion hypocentre having the acute radiation sickness (ARS) symptoms (4,993 persons).

Group II — exposed within range of less than 2,000 m from atomic explosion hypocentre but having no acute radiation sickness (ARS) symptoms (4,987 persons).

Group III — exposed within range of 3,000 - 3,499 m in Hiroshima and 3,000 - 3,999 m respectively in Nagasaki (4,990).

Group IV — persons been not present in those cities at the time of explosion (4,992 ones).

Irradiation doses reconstruction was conducted in 90% of those persons with application of models presented in Scientific Report DS86 in 1986, with main results shown in Table 3.2 [Kusumi S. Et al., 1993].

Table 3.2

IRRADIATION CATEGORIES DISTRIBUTION DOSE ESTIMATION DS86 IN ATOMIC BOMBING SURVIVORS [by Kusumi S. et al., 1993]

Exposure category	Not in the city	Dose, Gy	Total

		0	0.01–0.49	0.5–0.99	1 and over	
Less than 2 km with ARS symptoms	–	–	968	494	1,042	2,504
Less than 2 km without ARS symptoms	–	9	1,422	4,198	283	2,212
Over 3 km	–	2,941	6	–	–	2,947
Not in the city	2,859	–	–	–	–	2,859
TOTAL	2,859	2,950	2,396	992	1,325	10,522

Honored Professor Masao Tsuzuki — Director of Central Hospital of Japanese Red Cross in Tokyo started the patients examinations in September 1945. In his works (1954, 1964) he marked that clinical signs of injury from A-bomb in Hiroshima and Nagasaki almost completely reduced within first 2 - 3 months and the patients state turned into the *recovery stage*. In some more months after the atomic assault the injuries clinical pattern evolved into the *consequences period*. In 1945 - 1954 the research interests were focused mainly upon the blood diseases study (leukaemia and anaemia), cataract, sexual functions disorders and exposed children development. About 40% of Hiroshima and Nagasaki residents been present within 2 km from hypocentre were found suffering typical radiation cataract (in 84% of people in 2 km zone the radiation sickness signs were registered). Aspermia and amenorrhea were sometimes revealed in survivors. Some physical development disorders were found in exposed children. Author noted that no distinct results were received concerning psychical development disorders in exposed children as the other unfavourable environmental impacts resulted from post-war circumstances could not be excluded.

M. Tuzuki (1954, 1964) described remote consequences as the *chronic radiation sickness* pointing out to the blood capillary disorders as pathogenesis key branch in exposed after A-bombing persons. In clinical pattern of chronic radiation sickness in hibakusha he observed the haemopoietic, endocrine, sexual, nervous and mental functions disorders both with malignant neoplasm and general physical development insufficiency. Author stated that there are many practically healthy people among the atomic bombing survivors, however there are also many of those who easily become tired, lose interest to the life, complain on abnormal physical state and mental working capacity decrease. The dispirited mood, hypobulia, dreaminess, introversion and autism, tendency to the person «narrowing» and «bifurcation», memory absence or decrease were also observed in such persons [Tsuiki S. & Ueno K., 1951].

It is necessary to mark one more time that M. Tsuzuki (1954) proposed to consider the described symptoms as the *chronic radiation sickness*. In another presentation M. Tsuzuki proposed to call these states differing both by non-characteristic subjective symptoms and non-characteristic objective study results as the *«chronic atomic bomb disease»*.

E.E. Prosser et al. (1947) suggested considering the *initial, acute, subacute and chronic* reactions on ionising radiation impact. In their opinion the chronic reaction is the response lasting for several months, years and decades after impact. Professor of Pathology Hiroshima University S. Watanabe (1953, 1955, 1964) suggested his own classification of radiation injury:

A	**Initial damage**	***acute injury***
	1. Acute phase (up to the 2nd week)	
	2. Subacute phase (up to the 5th week)	
	3. Subchronic phase (up to the 2–4th month)	
	4. Chronic phase (after that term)	***chronic injury***
	5. Consequences	
B	**Remote consequences rising several years after**	

S. Watanabe marked further that among the chronic injuries such ones occur that continue rise or remain since initial phase as primary damage consequences both with those related to remote consequences rising after the latent period of several years or generations. Blood diseases, tumours, alterations in gonads and endocrine glands were considered the main injuries under chronic exposure.

Induced by atomic explosions pathologic alterations studies held by S. Amano (1945, 1953, 1964) indicated the testes and adrenal cortex atrophy, thyroid gland alterations. Hypophysis had the signs of atrophy, swelling and degenerative alterations. Author called the registered alterations in endocrine organs as the *polyglandular atrophy in radiation injury*. Small focuses of haemorrhage and degeneration were found in all brain and spinal cord parts under radiation sickness subacute form. Haemorrhage in brain mater with brain tissue emollescence was found in one case.

American researchers on the basis of atomic bombing consequences studies experience concluded the following concerning single general external irradiation (Table 3.3). These data substantially differed from British authors [Taylor D., 1952].

Table 3.3

GENERAL ACUTE IRRADIATION IMPACT ON HUMAN
(Handbook of Atomic Weapons for Medical Officers, USA, 1951)

Radiation dose R	***Injuring effect***

50	No diseases rise. Battle-worthiness is not disturbed.
100	Diseases rise is possible (nausea and vomiting) constituting in a whole 2% within short period. No evacuation is required. No substantial decrease of battle-worthiness.
150	In a few hours amount of sick persons reaches 25%. First definite battle-worthiness decrease. The 50% of injured in this group require evacuation.
200	All exposed are to be evacuated if possible. In one half of cases battle-worthiness is disturbed.
300	Average mortality rate about 20%. All require immediate evacuation and are not to be considered battle-worthy.
450	Mortality rate 50%.
Over 650	Lethal dose but not for all exposed to that.

According to the interpretation of domestic specialists G. Pokrovsky et al. (1957) the injuring impact of various doses single general external irradiation is presented in Table 3.4.

Table 3.4

SINGLE TOTAL IRRADIATION INJURING IMPACT
(by American data, cited by Pokrovsky G. et al., 1957)

Radiation dose R	***Injuring effect***
0 – 25	No noticeable damage.
25 – 50	Blood count alterations possible however without serious damage.
50 – 100	Blood count alterations; radiation injury some signs however without workability lost.
100 – 200	Radiation sickness; workability lost possible.
200 – 400	Radiation sickness; workability lost; lethal exit possible.
400	Lethal exit in 50% cases.
600 and over	Lethal exit.

According to the domestic physiological and pathophysiological concepts the ionising radiation biological effects on organism were considered not only as separate tissues or viscera injuries but the main regulating functions disorder. On these concept background the radiation sickness was considered as *neurodystrophic process* involving all organism [Pokrovsky G. et al., 1957].

In November 1945 — three months after the A-bombing the staff members of Kusu University N. Okumura & H. Hikida (1949) examined 50 hospital patients - atomic bombing survivors. They observed three cases of depressive stupor and astasia in one kid 16-month old. Some patients complained on general weakness, headaches, dizziness, presented depressive symptoms, tachycardia, memory disorders. Authors concluded that symptomatic in survivors after A-bombing was stipulated by ionising radiation general impact both with psychogenic reactions that later in remote period transformed in neurotic states.

Staff member of Japanese Red Cross Central Hospital in Tokyo H. Miyata (1954, 1964) 9 years after the atomic bombings studying 143 hibakusha age 9–69 years revealed that almost all the patients presented *complaints* on: general exhaustion, gums bleeding, headaches, memory disorders, dizziness, palpitations, menstrual flows disorders, sleepiness, appetite lost, night sweating, perception disorders, impotence or predisposition to it etc. However no relation was revealed between those symptoms type and frequency on one side and distance from hypocentre at the time of detonation — on another. Patients were marked having no vital energy reserves (or feel its absence) due to organs functional disorders after radiation injuries, and under various stress situations have high risk of particular chronic disorders rise.

Professor Masucho Konuma and Hiroshima University Psychoneurology Department staff demonstrated (1953–1967) that complaints and symptoms in atomic bombing survivors were stipulated by autonomous nervous system disorders and were of *diencephalic character*. Among clinical symptoms in hibakusha survived from radiation sickness the circulation disorders and vasomotor instability (hyper- and hypotonia, acroparesthesias, acroasphyxias, unstable dermographism, hives, angioneurotic edema, extremities vessels swelling during work) were observed along with metabolic and digestive system disorders (pituitary diabetes and diabetes mellitus, peptic ulcer, diarrhea and constipation, stomachaches attacks etc.), increased secretion (for instance excessive sweating — general, local or half-body), hematuria, thermal regulation disorders, skin alterations (eczema, itching rush, sweating, «goose skin»), general tiredness, tiredness after coitus, sexual anesthesia, impotence, decreased resistance to surrounding (especially towards climate conditions, intolerance of sun shine, cold and warmth), predisposition to all types of haemorrhages, headache, dizziness, insomnia, emotional lability, memory lost and difficulties in intellectual work, endurance absence for mental overstrain. These complaints and symptoms risen after radiation sickness and remaining for 10 years after were qualified as *diencephalosis*. Authors noted in the work that diencephalosis could be induced by direct massive acute hard irradiation, residual radioactive exposure, organism internal medium alterations both with psychogenias. However authors underlined that complaints and symptoms were obviously not only of neurotic nature.

M. Konuma et al. (1953, 1954, 1964) studied blood circulation functional state in survivors suffering radiation sickness. They revealed substantial variability of maximal, minimal and pulse pressure indices, pathologic reactions in orthostatic test, circulation central regulation disorders. Basic metabolism value pathologic elevation for 10% according to the Rid formula, electrocardiogram disorders before and after physical load, cardiovascular tests alterations were marked. Revealed various *circulation disorders* risen after atomic bombing suggest of their direct relation to the atomic bombing impact although no decisive evidence were present.

Electroencephalography studies were conducted in 27 patients suffering autonomous nervous system regulation disorders. *Subcortex dysfunction* was revealed in 77.8% of cases that in 29.6% was of pronounced expression. Multiple peaks amplitude asymmetry in temporal zones and other subcortex disorders were registered in EEG. Revealed neurophysiological deviations were not related to the gender, age, haematological data, cardiovascular tests results and presented complaints degree.

Convincing memory disorders were not revealed in psychological studies. Tiredness and emotional lability in major degree were peculiar to the patients with more severe blood count alterations. In psychogalvanic reaction studies results were received concerning the parameters high variability in exposed persons. On that background the *thalamus elevated irritability* phenomenon presence in survivors was concluded.

M. Konuma et al. (1953, 1954, 1964) concluded that the *diencephalic disorders* and *autonomous nervous system central regulation alterations* in particular are the radiation sickness consequences. However they made no final conclusion about those disorders direct link to the radiation disease.

In another presentation [Kikuchi T., 1953, 1964] the psychiatric study results by professor Miura are presented. The 10 patients from 34 examined A-bombing survivors suffered loss of consciousness after the exposure to explosion. Six of them complained on memory loss, dizziness, emotional excitability and other symptoms often following brain damage. In 5 patients the psychopathological symptomatic was qualified as neurosis.

S. Tsuiki et al. (1958) from Nagasaki University Neuropsychiatry Department in 1956 examined the 7,297 A-bombing survivors in Nagasaki and found among them 533 (7.3%) patients with neurosis-like symptoms, at that 5.5% — in males and 8.9% — in females. Authors concluded that the symptoms were not only psychogenic reactions result but also the ionising radiation organic impact consequence.

T. Nishikawa & S. Tsuiki in 1962 published the paper presenting the own studies held in 1956 reassessment. Table 3.5 shows the psychoneurological disorders structure revealed in atomic bombings survivors in Japan not more than ten years after the A-bombing.

Table 3.5

PSYCHONEUROLOGICAL DISORDERS STRUCTURE IN ATOMIC BOMBINGS SURVIVORS IN JAPAN

(by T. Nishikawa & S. Tsuiki, 1962, Nagasaki)

Disorders	*Cases in males*	*Cases in females*	*Total*
Asthenic	184	312	496
Anxious	4	13	17
Reactive depression (neurotic)	0	6	6
Hysterical	0	5	5
Obsessive-compulsive	2	1	3
Psychosomatic	1	5	6
Schizophrenia	3	3	6
Psychotic depression	0	4	4
Presenile depression	0	2	2
Epilepsy	9	4	13
Epileptiform syndrome	5	3	8
Progressive paralysis	8	2	10
Atherosclerotic dementia	7	3	10
Senile dementia	3	1	4
Unidentified dementia	6	10	16

EEG-studies were applied in thirty patients presenting acute radiation sickness symptoms. In three cases the epileptiform activity with bilateral «peak-» and «polypeak—slow wave» complexes was registered. According to the EEG spectrum analysis in persons survived after radiation sickness the α-range spectral power decrease especially in left hemisphere back parts followed by α-activity slowdown down to 8–9 Hz both with elevation of δ- (2.5–3 Hz) and β- (14–28 Hz) ranges mainly in left hemisphere were observed on the contrary to the not-exposed persons in control [Izumi C., Hayakawa T., 1955; Nishikawa T., Tsuiki S., 1962].

It is remarkable that Japanese psychophysiological works were ahead of time. EEG results interpretation by Japanese researchers was mainly based upon works of G. Moruzzi & H.W. Magoun (1949). Only further the works of T.M. Itil (1972, 1975) were presented where δ- and β-ranges simultaneous elevation both with α-range decrease being characteristic for schizophrenia and persons with high risk for schizophrenia was demonstrated. In studies of P. Flor–Henry (1969, 1973, 1983, 1989), J.H. Gruzelier & N. Hammond (1976), R.C. Gur et al. (1978, 1982) they revealed that the EEG alterations similar to those revealed in atomic bombings survivors reflect the limbic system dysfunction mainly in left hemisphere and are schizophrenia characteristic psychophysiological pattern. One of the present book authors (A.I. Nyagu, 1986) marked that schizophrenia-type symptomatic is observed in brain left hemisphere — temporal — basal damages. In 1986 professors Yoshibumi Nakane & Yasuyki Ohta, Nagasaki University published the epidemiological study results where the extremely high schizophrenia prevalence (6%) was revealed among atomic bombing survivors that in one order exceeded the average-population indices in Japan.

Seven years after the A-bombing N. Izumi (1964), Nagasaki University Pediatrics Department studied the atomic bomb explosion impact on school-age children who were within 2–4 km distance from hypocentre on August 9, 1945. He revealed no any difference in physical strength and fatiguability rate between exposed children and control. However intellect study in children with Tanaka method and their mental development assay with Sakakibara method for mathematics and language *the IQ and mathematics & language giftedness low indices* were revealed in all school forms *in 1952* (Table 3.6).

Table 3.6

INTELLECT AND MENTAL ABILITIES IN PER CENT AMONG EXPOSED CHILDREN FROM SHIROYAM PRIMARY SCHOOL

(by literature data N. Izumi, 1964)

	Intellect		*Mathematics*		*Language*	
	1952	1953	1952	1953	1952	1953
Exposed children	38.1	45.2	34.0	51.5	35.6	40.7
Control group	56.4	53.7	54.8	51.5	54.9	54.1

As shows Table 3.6 the noticeable improvements were noted in 1953 nearly reaching the control values. Author concluded the atomic bombing *effects absence* regarding physical strength, mental development and muscular activity in irradiated children.

In another psychoneurological study S. Tsuki & A. Ikegami (1955, 1964), Nagasaki University Neuropsychiatry Department made attempt to compare the radiation impact in explosion and personality peculiarities. They noted that in spite of 10 years period passed since Hiroshima and Nagasaki A-bombings, the fear and anxiety were still present in minds of survivors. After the pathopsychological study conduction in 52 children from Shiroyam grammar school exposed in nuclear explosion, the so-called *over-strained and self-concentrated personality types with impulsive tendencies* were revealed with Rorshach test in many of them especially those exposed in prenatal period. Personality study results with Miyake method application revealed poor-willed, sensitive, bifurcation, unstable, irascible and weak personality types with clear tendency to *weak-willed* persons number increase. According to intellectual testing data with «Tanaka B» method no any case of high intellectual level was found in exposed kids: majority presented middle-range intellect but *oligophrenia* was registered in 6 cases (11.5%) with radiation symptoms marked in 4 of them.

At the same time T. Ando (1958), Hiroshima University Public Health Protection Department found no significant differences with non-exposed control in physical and psychological state study of 225 children survived in atomic bombing (including the exposed in prenatal period). According to the author's opinion the remaining problems in kids education were of rather more important role in impact on mental development compared to atomic bomb explosion direct effect. Worth to note that so optimistic prognosis found no confirmation in further studies especially regarding children irradiated in prenatal period [Shull W.J. & Otake M., 1993].

Y. Mitani (1953, 1954, 1964), Nagasaki University Obstetrics–Gynecology Department revealed the *menstrual cycle disorders* mainly as menstrual delay in 69.7% of women survived after atomic bombing in Hiroshima. Number of disorders elevated along with more close site to the hypocentre. In further 2–6 months after the restoration to the norm was observed in more than 80% of these cases. No any clear effect of explosion on *menarche* age was marked in healthy persons. Other researchers [Shoji T. & Karia Y., 1947] revealed the average menarche age some delay and menstrual cycle disorders in irradiated schoolgirls that were directly connected to the atomic bomb explosion effect. However Y. Mitani pointed out to the necessity of careful approach in received results interpretation as the mental and physical state changing under the environmental impact could effect the menstrual cycle in contaminated zone.

Autonomous nervous system and neuroendocrine regulation disorders role in radiation injuries consequences pathogenesis was underlined by Professor of Pathology I. Hayaschi (1953, 1964), Nagasaki University. He revealed *specific radiation alterations in adrenals* with no any specific changes in thyroid gland after histological study. I. Hayaschi concluded that adrenal cortex disorders after irradiation in context of «general adaptation syndrome» by H.S elye (1947) lead to diseases rise and deteriorate their prognosis. The unusual hormonal state of irradiated mother rising after adrenal function damage as irradiation remote consequence can probably unfavourably effect the foetus and new-born with diseases, anomalies and malformations risk.

Y. Mitsuyama & T. Yamamoto (1978) explored the 233 brain posthumous preparations (115 female and 118 male) received from Radiation Effects Research Foundation (RERF), Hiroshima. Senile brain alterations increased with the age and were of substantial gender difference that proved endocrine impact on brain. Hypertension clinical manifestations frequency also elevated with age however without gender difference. Authors considered the hypertension substantial role in parenchyma small vessels sclerosis and fibrinoid angionecrosis genesis. Multiple cerebral infarctions were observed more often in the group with hypertension compared to one with normal blood pressure. Cerebral infarctions showed relation to the age and were more frequently observed in males age 60 and over. Vascular or degenerative disorders were revealed in 74% of cases with no any neuropathological alterations found in 20% of them.

Japanese authors themselves noted the clearly insufficient amount of reports and papers in the field of atomic bombings neuropsychiatric effects study [Yamada M., Komada K., Wong F., 1991; Kusumi S. et al., 1993]. Since late 50^{th} – early 60^{th} the attention to the problem decreased in Japan (and USA) probably due to the widespread opinion, concerning nervous system radioresistance. In the available literature quite few works are present devoted to the remote neuropsychiatrical and psychophysiological consequences of A-bombings. However, their extreme actuality is obvious from papers by Y. Nakane & Y. Ohta (1986) demonstrated schizophrenia significant growth in hibakusha.

American researchers followed the direction of nuclear weapon application effects psychologisation. R.J. Lifton — the first American psychiatrist who studied psychiatric consequences of Hiroshima atomic bombing — in his work «Death in the life: survived in Hiroshima» (1967) concluded that disasters induce long-term mental disorders. Such kinds of the disorders were qualified as «survivor syndrome». Psychical state of patients in such cases vary from «zombie-like psychic numbing» and sharp personality alterations in a whole to the reactions corresponding to practically healthy persons psychical adaptation under enough social activity. R.J. Lifton (1974a, 1974b) on the basis of own psychiatric studies results in Hiroshima proposed the new paradigm of human behaviour: the «psychic numbing» process as the result of modern technological violence and absurd death. Author was sure that psychoanalytical theory had to be reviewed in the current historical events context. Paradigm by Freud of sexuality depression is opposed to the unlimited technical violence and absurd death that the today human is faced to. This «numbing process» separated by the author injuries symbolisation and image forming functions and finally leads to the mental disorders. Further R.J. Lifton (1993) presented the post-traumatic stress disorder psychoanalytical concept.

The work «Psychological wounds as the atomic bomb result» [Silberner J., 1982] underlines that demolitions induced by Hiroshima and Nagasaki atomic bombings stipulated remaining psychological problems in survivors. Some of them became homeless, cannot receive employment, suffered from nightmares, depression or anger. In author's opinion these problems are present because the destruction occurred in one moment and razed to the ground all the social structures — family, working places, schools, institutions, hospitals and houses. More than 40% of population died within first three months. Bombings resulted in common psychical numbing. Author selected three reaction levels in survivors: ousting from memory, feeling that they always will be nothing else but bombing survivors; trancedentality.

M.S. Lindee (1994) noted that at the beginning of Atomic Bomb Casualty Commission (ABCC) activity the request on question «If the USA have to redeem their fault for nuclear weapon use and thereby provide medical and social aid to the survivors» was the categorically «No» from majority of Americans including those working in Japan. Whereas further under the public opinion impact they changed their attitude. But the delivered sums amount for research ($ 1 million yearly in 1948 that corresponds to $ 5.2 million in 1992) and medical arrangements ($ 300 thousand yearly) were clearly not enough. But even these costs were delivered by government of President Truman only in 1948 and rather reluctantly. After the «Manhattan Engineer District» Program was partially reorganised into the Programme for Radiation Biological Effects Study (AEC) with centre in Okridge (Tennessee state), the struggle for research in Japan led to the ABCC founding (1948) with three research centres creation: Hiroshima, Nagasaki and Kure (control city). In 1975 ABCC was conversed into RERF (Radiation Effects Research Foundation) with control and financial support on an equal footing with Japan. However since 1989 the US Ministry of Energetic developed new Project «Human Genome» and gradually decreased US part in RERF. RERF Japan-US research activity in Hiroshima regarding radiocerebral effects is focused only on *prenatal brain damage* consequences. Study of the so-called psychological consequences of atomic bombings is held within framework of long-term projects *«Adult health study»* and *«Life span study»* launched in 50th. Study results were expanded in 1986 with dosymetry support from *«Received Doses Dosimetry Estimation System» DS86*.

According to the data of S.T. Seyana et al. (1979) no substantial increase in *internal tumours* incidence was observed among exposed at any age bombing survivors. At the same time L.C. Strong et al. (1979) noted the elevated risk of *brain and spinal cord tumours* rise [Cited U.I. Moscalev (1991)].

M. Otake & W.J. Shull (1982) determined the impact threshold for radiation with low linear energy transfer rate by means of registered ophthalmologic disorders in Hiroshima and Nagasaki atomic bombing survivors. Calculated value constituted 0.6–1.5 Gy.

Y. Nakane & Y. Ohta (Nagasaki University) continued the Nagasaki atomic bombing mental consequences studies initiated in the Neuropsychiatry Department of Nagasaki University Medical School by S. Tsuiki et al. (1958) and T. Nishikawa & S. Tsuiki (1962). Authors since 1960 conduct the Schizophrenia Registry entry in Nagasaki. In 1950 the RERF started in Hiroshima and Nagasaki the long-term Project «Life Span Study» purposed mainly on the ageing process acceleration possibility under the ionising radiation impact. Psychiatric studies results were not included in the Project. In 1978 26,678 persons were identified in Nagasaki within Project «Life Span Study» framework that formed representative study group of Nagasaki residents exposed to the atomic bombing impact. At the same time 1,589 of them were present in the Schizophrenia Registry. Y.Nakane & Y.Ohta (1986) marked some limitations of Schizophrenia Registry i.e. 1) Registry was launched in 1960 but not in 1945 and 2) migration from Nagasaki was not taken into account. These limitations certainly decreased the schizophrenia prevalence index in hibakusha however the revealed values of 6% occurred very high.

Y. Ohta, Y. Nakane, J. Nishihara, T. Takemoto (1992) conducted the study of urbanisation, westernisation, social and financial sates, professional and academic career both with other social factors on the schizophrenia prevalence in Nagasaki. No any statistically significant differences were revealed however the tendency of schizophrenia cases excess in lower social population groups was found.

Professor Y. Nakane in the private dialogue during the Chernobyl disaster neuropsychiatric consequences discussion in Nagasaki (1994) notified that in Japan in the first years after A-bombings almost like as in Ukraine, Belarus and Russia now, the most «acceptable» diagnosis was «organic brain damage» whereas other mental disorders and in particular schizophrenia diagnostic induced the unfavourable social resonance.

In the other studies of neuropsychiatrists from Nagasaki the mortality rate was evaluated in schizophrenia patients exposed to ionising radiation impact after Nagasaki atomic bombing; interdependence between schizophrenia and malignant neoplasm were studied too [Ohta Y. et al., 1991]. The malignant neoplasm incidence was substantially higher in schizophrenia patients exposed to radiation impact than in population but not much higher than in non-exposed schizophrenia patients group. Authors concluded that both schizophrenia and ionising radiation impact are risk factors for malignancy genesis. At that according to the opinion of Y. Ohtathe ionising radiation impact was not of leading role in malignant neoplasm rise among schizophrenia patients. At the same time the WHO [Gulbiant W. et al., 1992] on the background of potential interdependence study between schizophrenia and cancer in three states — Germany, USA (Hawaii) and Japan (Nagasaki) stated that there are no any unambiguous results concerning cancer risk rise or decrease in schizophrenia. That phenomenon is explained by hypothesis of various environmental factors impact with ionising radiation in particular.

On September 28–30, 1992 in Community States Scientific Conference *«Chernobyl NPP Accident Social-Psychological and Psychoneyrological Aspects»* in Kiev the RERF (Hiroshima) staff members S. Kusumi, M. Yamada, K. Kodama, F. Wong and S. Nakamura (Hiroshima University) presented report dedicated to the atomic bombings psychological consequences study. In their opinion based upon own research and above-mentioned long-term

project results summarisation, the incidence of discirculation and peripheral vascular disorders both with psychoneurological symptoms was maximal in persons being most close to the atomic explosion hypocentres and suffering acute radiation symptoms. At the same time no connection between suicide incidence and dose value was revealed and suicides in hibakusha were of the same tendencies as the whole Japanese population.

S. Kusumi et al. (1992) noted that terms *«atomic bomb disease»* and *«atomic bomb neurosis»* widely applied both by physicians and survivors are of definite interest as reflect physical and psychological symptoms induced by the atomic bombs explosions. Term *«atomic bomb disease»* was regarded no only to the ionising radiation impact in the initial period, leukaemia and cancer risen a bit later but also to the non-specific complaints of survivors on tiredness, bodyweight loss in summer, symptoms similar to that in bad cold, gastroenterological symptoms etc. M. Kishikawa, M. Mine, Y. Okumara (1991) marking the contradictions presented in literature issued the following chronological classification of the «atomic bomb disease»:

ATOMIC BOMB DISEASE: EARLY PERIOD		
Stage I		Early stage of the acute phase, *acute phase* in narrow meaning: 0–14 days
Stage II	Stage II A	Middle stage of the acute phase, *subacute phase*: 15–35 days
	Stage II B	Middle stage of the acute phase, *subchronic phase*: 36–60 days
Stage III		Late stage of the acute phase, *chronic phase*: 61–120 days (end 1945)
REMOTE ATOMIC BOMB DISEASE		
		Remote «atomic bomb disease» (in narrow meaning) Prenatal irradiation Other (neoplasm etc.)

Term *«the atomic bomb neurosis»* was used for the states description of leukaemia, cancer and «atomic bomb disease» itself dreads in combination with to such extent elevated anxiousness compared to symptoms risen after irradiation that the normal life style was affected and even person was bedridden. Conducted research led to conclusion that many A-bombings survivors suffered the neurosis-like disorders. In the research results discussion M. Yamada et al., (1991) & S. Kusumi et al., (1993) presented the assumption that symptoms high incidence in survivors been more close to the explosions hypocentre is explained by higher psychological loading and explosions social-economical impact besides the physical injuries presence. Authors agreed with opinion of R.J. Lifton (1967, 1982) — the first American psychiatrist who conducted psychiatric studies in hibakusha — that «... atomic bomb neurosis can be characterised as unstable internal balance between having symptoms necessity and these symptoms troubling link to the death and dying...»

G.W. Beeb (1987) marked that atomic bombings led to the community disintegration, psychological and spiritual stress. Japanese researchers consider that radiation resulted from atomic bomb explosions is the factor of long-term psychological impact. At the same time M. Yamada et al. (1991) & S. Kusumi et al. (1993) were bound to recognise that the last years studies confirmed results of N. Okumura & H. Hikida (1949), M. Konuma et al. (1953–1967), S. Tsuki et al. (1958), T. Nishikawa & S. Tsuki (1962) concerning neurosis-like and autonomous nervous system disorders in hibakusha in remote period of atomic bombings with disorders extent rise along with survivor closeness to hypocentre and expression of acute radiation injury.

Concerning the «atomic bomb disease» possible impact on suicide incidence M. Yamada et al. (1991) & S. Kusumi et al. (1993) not excluding such intercoupling in some cases state that epidemiological studies confirmed no assumption about suicide number rise induction by radiation exposure and further anxiousness.

M. Mine et al. (1991, 1992) demonstrated that own subjective health quality perception in 70-years old atomic bombing survivors is lower than in control. However satisfaction with life and social well-being in hibakusha occurred being higher compared to control. No difference was fixed in mortality rate indices between survivors and control groups age up to 55 years. At the same time mortality incidence in atomic bombings survivors over 60 years old was found being lower than in control. Mortality rate from cerebrovascular diseases in survivors was also lower than in control that in authors opinion can be stipulated by early in-time diagnostic, regular blood arterial pressure control and health protection services effective function in scheduled medical examinations. That is undoubtedly stipulated by wise state policy towards atomic bombings survivors social protection and medical aid providing; at March 31, 1995 the 328,629 of them were alive in Japan.

At the same time M. Mine et al. (1991) marked that in spite of survival rate in exposed to dose range 0.01–1.99 Gy was almost not different from control, those hibakisha exposed to 2–5.99 Gy were peculiar with confidentially lower survival rate. Authors supposed the irradiation in doses exceeding 2 Gy reduces life span.

Up-to-date the ionising radiation impact on mental health and atomic bombings psychological consequences remaining unclear was marked on International Conference *«Radiation Impact on Human after Atomic Bombings»* in Japan, 1992.

L.A. Vasconcelos (1992) noted the complex of interrelated geriatric problems, war consequences and atomic bomb impact in Hiroshima atomic bombing survivors re-adaptation problem study.

Last research results of Japanese authors concerning atomic bombing neuropsychiatric comsequences were presented on International Conference *«Mental Health Consequences of the Chernobyl Disater: Current State and Future Prospects»* in Kiev, May 24–28, 1995. K. Neriishi, M. Yamada, K. Kodama, I. Shigematsu conducted several epidemiological studies of psychological disorders in atomic bombings survivors within framework of RERF Program «Adult health study» using data of examinations held once in two years. The Cornell Medical Index (CMI) was applied — health state questionnaire in 90 questions concerning physical state and in about 30 — concerning emotional and mental state; questionnaire was proposed to 10,522 persons during 1962–1965. Besides that within 1986–1993 the 4,126 persons were questioned in psychological items regarded to life satisfaction in a whole, social activity, own physical well-being estimation and tranquilisers medications use. Results were compared in questioned persons selection depending on distance from nuclear explosion hypocentre and radiation injury acute symptoms presence i.e. epilation, subcutaneous haemorrhages and pharyngitis. CMI-study results demonstrated the questioning integral rank decrease along with hypocentre distance increase that was especially actual, regarding symptoms of cardiac pathology, peripheral vessels and nervous system disorders. More high integral ranks were registered in persons with radiation injury acute symptoms. In this work on the contrary to the previous ones [Yamada M. et al., 1991; Kusumi S. et al., 1993] authors state that psychoneurological status symptoms (anxious, fear, weakness) were identical both in persons within 2 km from hypocentre and over 3 km distance. K. Neriishi et al. (1993) concluded that persons exposed within less than 2 km from hypocentre with radiation injury acute symptoms had the questioning results elevated indices only regarding own physical state estimation and life satisfaction in a whole. At the same time authors noted that range from hypocentre in atomic bombing and radiation damage symptoms are predetermining factors for survivors psychological state even 50 years later.

S. Honda, M. Mine, Y. Imamura et al. (1995) presented the Nagasaki atomic bombing survivors mental health estimation results. They studied 2,000 persons by means of three-stage methodology. Screening test of the 1st stage was the health state questionnaire in 12 positions (GHQ-12). Second stage included Combined International Diagnostic Interview (PHC version), elaborated by WHO and ordered the GHQ-30 application in this stage. Mental disorders were diagnosed in third stage according to IDC-10. Only 80% of patients passed the 2nd and 3rd stages at the time of presentation. Final rank of GHQ-12 among survivors been present most closely to hypocentre exceeds the same parameter in persons cought by nuclear explosion at higher distance.

In spite of atomic bombing neuropsychiatric effects presented above, these effects are actually absent in ABCC/RERF summarised results of remote consequences epidemiological studies of ionising radiation impact on human health. According to the data of I. Shigematsu (1994) and Y. Hasigawa presented on WHO Collaborating Centres 5th Co-ordinating Meeting (Paris, December 5–8, 1994) *the strong connection with irradiation after nuclear explosion* was fixed particularly in growth and development retardation in young age among atomic bombing survivors (excluding those exposed in utero); *weak connection* — in mortality rate from cardiovascular pathology and general mortality rate in doses over 1.5 Gy, in nervous system malignant tumors; *connection absence* — in preliminary ageing. Other neuropsychiatric effects were not studied at all.

In 1992 Hiroshima Medical Council for Radiation Medical Provision the capital monograph «Effects of A-bomb Radiation on the Human Body» was published with 39 authors participation [Guskova A.K., Yarmonenko S.P., 1995]. Monograph authors in particular concluded that *the radiation-induced mortality* was observed in 40–49 years age group 15–20 years after explosion, but in 10–19 years at explosion moment age group — 30 years after. In the group of children younger than 10 years no any malignancies were revealed for all the survey period. Hypothyroidism frequency elevation was noted in dose range 0.01–2 Gy both with *hyperparathyroidism* incidence increase among persons exposed to radiation with doses ≥ 1 Gy. Non-radiation nature of *diabetes mellitus* incidence rise phenomenon was fixed. *Radiation-induced cataract* was not different from age-related one, however both incidence and injury extent were risen in clear dependence upon irradiation dose. *Prenatal brain damage* radiation effects were determined (will be in details presented in the next chapter). No statistically significant *genetic effects* were found (according to the gender ratio, stillbirths, neonatal death rate, and early infant death rate (up to 9 month) both with congenital malformations in newborns or infants age up to 9 months). No *radiation-induced life span shortening* due to non-cancer diseases was observed in last years. However in population group exposed in young age to substantial dose values (≥ 2 Gy) the life span shortening is noted both with diseases incidence rise peculiar to the old age i.e. *cardiovascular pathology*. The weakly expressed effect of death probability elevation was marked due to *heart ischemic disease and cerebrovascular syndrome* in persons exposed to the high doses (> 3 Gy).

However the principally another point of view is present in Japan not coinciding with formal optimistic opinion of the RERF and some other international organisations concerning atomic bombings survivors health state. In the Permanent Public Tribunal (Vienna) on April 12 - 15 the report was presented by K.Furitsu where author underlined that Japanese government both with RERF underestimate and ignore the radiation injuries in atomic bombings survivors, and furthermore now intend to negate and ignore the damages in Chernobyl disaster survivors for the benefit of nuclear policy. According to the data of Atomic bombing survivors research committee from Hannan Chuo (Osaka, Japan) the incidence of *overall health disorders* in A-bomb survivors is in 6–13 times over than in control [Hayakawa N. et al., 1991]. According to K. Furitsu (1996) this fact indicate that overall health disorders are also to be related to radiation effects. At that the RERF recognized that hibakusha been under 40 years at the A-bombing are peculiar with *cardiovascular* diseases (including strokes) and *digestive system* (especially liver cirrhosis) genesis elevated risk [Shimizu Y. et al., 1991].

K. Furitsu et al. (1996) underlined that Hiroshima and Nagasaki were the testing sites for the US nuclear weapons development and the activity of joint Japanese-American research centre ABCC/RERF is directed on underestimation of radiation injuries in atomic bombings survivors aiming nuclear policy progress goals both with radiation protection standards adoption suitable for pro-nuclear groupings. In opinion of these authors the IAEA apply the underestimated radiation effects results from Hiroshima & Nagasaki to underestimate further that in Chernobyl. K. Furitsu et al. (1996) examined 1,233 atomic bombings survivors during 1895 - 1990. Substantial health state deterioration was registered among examined persons compared to the standard Japanese population mainly through the: *lumbago* (revealed in 28.4% of patients i.e. in 3.6 times more often than in respective standard); *hypertension* (23.9% — 1.7-fold); *eye diseases* (18% — 5-fold); *neuralgia & myalgia* (12.3% — 4.7 times); *anaemia & leukopenia* (12.1% — 13.4 times); *gastritis* (9.9% — 4.5 times); *gastro-duodenal peptic ulcers* (9.8% — 4.7 times); *heart ischemic disease* (9.8% — 4.7 times); *liver diseases* (9% — 6.4 times); *diabetes mellitus* (8.2% — 2.7-fold) and also *headaches, physical anergy, arthritis, neck spondylitis* etc. including cancer & leukaemia. In authors' opinion these diseases prevalence elevation is connected with ionising radiation impact.

Many atomic bombings survivors complained in 1985–1990 on weakness, dizziness, palpitations, pain in support-locomotive apparatus. K. Furitsu et al. (1996) explained these complaints with *«Atomic Bomb Chronic Disease»* («Genbaku Bura Bura Disease»), supposing its radiation but not psychogenic genesis. «Genbaku Bura Bura Disease» unites *general symptoms* such as fatigue and weakness, immune system disorders signs (frequent bad cold etc.), *autonomous nervous system regulation disorders* concerning internal organs and blood circulation (dizziness, palpitations etc.), *nervous system disorders* and *support-locomotive apparatus* (headaches, pain in neck and back, lumbago, constraint, numbness etc.). The disease in its early period was more severely presented than now when gained chronic mode. Authors consider that the following data enable to bind the «Genbaku Bura Bura Disease» genesis with radiation impact:

- disease symptoms incidence in atomic bombings survivors is higher than in general population;
- those symptoms are also present among other persons exposed to radiation impact;
- these symptoms frequency is higher in those atomic bombings survivors having acute radiation sickness symptoms (i.e. were exposed in higher doses).

All viscera and system disorders especially peripheral circulation, nervous system and heart most frequent registration was revealed in persons present within 3 km from explosion hypocentre. In spite of that RERF consider these symptoms as psychological disorders as the results of atomic bombing feelings especial experience. The «Genbaku Bura Bura Disease» symptoms incidence is especially high among atomic bombing survivors who suffered the acute radiation sickness, reaching 60-70%. Complaints on weakness and fatigue, headaches and pain in support-locomotive apparatus are of particular clinical importance.

K. Furitsu et al. (1996) consider that «Atomic Bomb Chronic Disease» is the generalised syndrome not available for explanation by any single mechanism. This syndrome is the result of the following multiple alterations interaction in organism after radiation impact:

- *stem cells alteration*: immune reactivity decrease, anaemia, skin diseases and gastro-intestinal dysfunction;
- *central nervous and autonomous nervous system damage*: digestive system dysfunction, circulation disorders, vegetative dysfunction;
- *bone injury*: support-locomotive apparatus damage symptoms;
- other.

Those symptoms according to K. Furitsu et al. (1996) can not been explained only with «stress» however some disorders of neuro-endocrine and autonomous nervous systems stipulated by psychological stress can be the reason of symptoms pointed on above.

K. Furitsu (1996) noted that some psychosomatic symptoms in the Chernobyl disaster survivors qualified by RERF as stipulated by psychological stress and social-economic problems, are rather similar to the «Atomic Bomb Chronic Disease» where correlation is fixed with radiation impact. At that K. Furitsu (1996) paid attention to the health state disorders similarities among Hiroshima and Nagasaki atomic bombings survivors, Chernobyl disaster survivors, atomic energetic and uranium mines workers both with persons resident close to nuclear test sites and various nuclear units.

Thus in spite of more than 50-years-long international efforts for Hiroshima & Nagasaki atomic bombings consequences study the common opinion about A-bombings neuropsychiatric effects genesis is up-to-date absent.

3.3 H-bomb Testing on the Marshall Islands Consequences

After the thermonuclear explosion on Bikini atoll, South Pacific on March 1, 1954 the wide group of people was exposed to sublethal doses of external γ- & β-irradiation both with radioactive materials incorporation. On the contrary in Hiroshima and Nagasaki atomic bombings the radioactive substances uptake was not significant in amount. After the fallout from thermonuclear explosion deposition the most hazardous for humans was ^{89}Sr. Doses on thyroid gland from ^{131}I and other iodine isotopes with shorter half-life period reached up to 1.0–1.5 Sv. The exposition doses from γ-radiation on 267 persons were within range of 20–260 R. Minimal lethal dose for human from fission products after nuclear explosion was shown being 225 R measured in the air whereas in standard laboratory conditions it would constitute 335 R. Marshall islands experience enforced to review the LD_{50} values

from 400–450 R adopted earlier towards lower ones of approximately 350 R of γ-radiation from radioactive fallout [Bond V.P., Cronkite E.P., Dunham C.L., 1956, 1960].

The activity of 0.1–0.2 mCi (for radioactive strontium) is considered as minimal value for radiation sickness rise after radioactivity internal uptake. Radiation sickness in such case is peculiar with following local radiation injuries and long-term chronic flow. In further they noted that radiation sickness any form risen in war-field circumstances is characterised with clinical presentation some peculiarities and first of all — with relative higher severity. That is related to organism general reactivity disorders, its resistance decrease in war situation various circumstances. As the result — in war conditions (and both in *nuclear disasters*) the radiation sickness of 1st severity degree is probable at doses under 100 R (60–90 R) that as a rule is not present in peaceful time [Hempelman L.H., Lisco H., Hoffman J.G., 1952; Kusano N., 1953; Hempelman L.H., Lisco H., Hoffman J.G., 1954; Pokrovsky G. et al., 1957; Molchanov N., 1960].

American researchers [Dunham C.L. et al., 1951; Cronkite E.P., 1951; Bond V.P. et al., 1954 etc.] noted that among the most severely injured persons on Marshall islands the anorexia, nausea and vomiting were observed that were reduced within two days without treatment. In the same persons despite from secondary complications the granulocytopenia and thrombocytopenia were rising slowly in further. In authors' opinion among other radiation injuries only the skin damage and epilation were observed. They noted that central nervous system damage syndrome (doses 6,000 R and over are required [Cronkite E.P. & Brecher G., 1955]) was not observed in Japanese in Hiroshima and Nagasaki and all the more was absent in Marshallese. No any information was found in available literature concerning psychoneurological sphere state in Marshall islands survivors.

Besides Marshall islands population and American navy servicemen the 23 Japanese fishermen were injuries by H-bomb testing on March 1, 1954. Japanese on fish-boat «The No5 Fukuryu Maru» occurred in radioactive ashes deposition zone within 200 km from explosion hypocentre. Further these fishermen have got radiation sickness [Kimura K., 1954; Tsuzuki M., 1964 etc.].

In opinion of M. Tsuzuki (1964) the injury of fishermen was determined as acute radiation sickness from external and internal γ- & β-irradiation. Author noted that combined external and internal irradiation in such significant degree is for the first time registered in humankind history. External irradiation dose for 2-weak stay on boat board reached 200–400 R. All tissues and viscera types were injured depending on their radiosensitivity. Clinical pattern was presented with those injuries combination. However M. Tsuzuki underlined the psychological factor importance and environment impact (raining season and than — hot summer).

According to the reports of physicians Y. Tsuge & T. Ohi (1964) from Jaizu city Municipal Hospital, Sizuoka prefecture the lachrymation, pressure in throat and head, dizziness and nausea rose in «The No5 Fukuryu Maru» crew after ashes sedimentation beginning. In 1– 2 days the complaints on extensive tiredness, appetite loss and vomiting appeared. In a few days some of fishermen complained on stomachache and diarrhea that relived 3–4 days later and fishermen felt severe tiredness and napped in prolonged sleep. According to the Japanese physicians conclusion at March 27, 1945 i.e. 4 weeks after thermonuclear explosion all the crew «was in relative good spiritual mood and had good appetite».

The spermatogenesis severe injuries were marked in Bikini explosion survivors that presented no signs of recovery within 1st year after exposure. Adrenal cortex damage was revealed in many cases both with gonadotropin elevation [Mikamo Y. et al., 1964].

The thyroid atrophy, some pituitary enlargement, brain pia mater moderate swelling, brain slight swelling with brain convolutions hardening; spinal cord posthumous malaxing were revealed under anatomical pathology examination of Aikichi Kuboyama (40 years old) who died from acute radiation sickness complicated with liver function failure and secondary pneumonia on 207th day after radioactive ashes sedimentation. The pituitary basophilic cells excessive vacuolar degeneration, adrenals glomerular zone partial hypertrophy, haemorrhage and demyelination focuses in brain and cerebral tissue malaxing due to vascular alterations were observed in histological study [Miyaki M., Ohashi S., 1964].

No results of neuropsychiatric studies conducted among Japanese fishermen affected by Bikini radioactive ashes were found in available literature.

3.4 Remote Psychoneurological Consequences of Nuclear Tests and Expected Neuropsychiatric Consequences of Nuclear War

H.M. Viner (1983) from Radiation Research Institute, Berkley, California (USA) reported about 11 males (age 43–58 years, two of them died) who were exposed to ionising radiation impact after active participation in American atmospheric nuclear tests. Every examined person had actually identical *complex of asthenic psychiatric symptoms*. Those symptoms content was almost wholly focused upon medical consequences of ionising irradiation that every patient was exposed to. This symptoms complex was summarised in the syndrome. On the background of this syndrome structure and clinical flow the author proposed three hypotheses:

1. Syndrome obviously is the pathological evolution of belief, concerning ionising radiation physical damage based upon self-diagnostic, towards symptoms set in details processing and expressing this belief.

2. Self-diagnosed belief is developed as the solution tool for any medical mysteries concerning human ability to experience ionising radiation impact consequences.

3. Syndrome development is the ionising radiation impact consequence.

Persons who took part or were present close to the nuclear test sites are named in the foreign literature as *atomic veterans*. At present the particular attention is drown to the possible unfavourable consequences study among atomic veterans offspring however the available data are far not enough [Miller R.W., 1995}.

In 1949 the first soviet atomic bomb was detonated and in 1953 — the first soviet H-bomb. Since 1963 only the subterranean explosions were conducted. In surface and air tests more that 10,000 persons were exposed to doses from 0.02 to 1.6 Sv. In many thousand of people resident in surrounding regions to the test site the irradiation dose constituted less than 20 mSv. Both with elevated radioactivity the hazardous substances air content excess over permissible levels, pesticides and cattle-breeding farms wastes presence in drinking water were revealed in Semipalatinsk testing site region. Those ecological factors both with multiple psychogenias and social non-wellbeing stipulated catastrophic medical situation in Semipalatinsk testing site region followed with mortality rate substantial elevation, childbirth with mental retardation [Alexandrovsky U.A., 1993].

T.K. Kuderinov et al. (1993) revealed the *borderline neuropsychiatric disorders* mainly of asthenic circle and *somatic pathology* substantial prevalence approximately in 25 % cases among the residents of region close to Semipalatinsk testing site.

Psychophysiological state study in students from some parts of Altai region revealed definite peculiarities in adaptation processes strain degree depending on gender, age, place and duration of parents and grandparents residence in Semipalatinsk testing site radioactive impact zones [Yastrebov G.G. et al. 1994].

S.M. Suslin (1994) reported about the *autonomous nervous system dystonias* structure study results from wide-mass screening of children resident in regions close to Semipalatinsk testing site. Autonomous nervous system dystonia was revealed with sympathetic branch domination over the parasympathetic one in 76% of cases among study group of 962 children from Loktevsky, Uglovsky and Krasnogorodsky regions of Altai zone. It is important that according to *autonomous nervous system epidemiological studies results* the vegetative dystonia syndrome is found in about 20% of healthy students and in 35–50% of those presenting various complaints. Thus the autonomous nervous system dystonia prevalence rise is obvious in children living near the atomic testing site.

V.A. Gurjeva, K.V. Smirnov and O.V. Lamina (1994) conducted *neurophysiological studies* in women of first and second generations resident close to Semipalatinsk testing site. The 58 females were examined constituting 2 generations: 1st — exposed to ionising radiation impact with integral dose over 250 mSv and 2nd — the children of exposed parents. Neurophysiological studies in women of 1st & 2nd generations enabled to conclude the brain stem — diencephalic structures dysfunction prevalence according to EEG data and the extent vascular disorders according to REG data in females of 1st generation compared to that in the 2nd one. That in authors' opinion was connected to ionising radiation impact consequences on nervous system.

J.A. Alymhanov (1995) presented the *statistical analysis of mental disorders and suicides adjusted prevalence in population inhabiting Semipalatinsk testing site region*. Author reported that persons suffering *oligophrenia* constitute the first rank (49.5%) in identified psychiatric patients structure in involved region. Second rank is occupied by *schizophrenia* (29%) at that the high quota of schizophrenic patients (42.3%) is presented by persons over 40 years of age i.e. those born before first nuclear explosions (in 1949). In this age interval the lowest quota of oligophrenic patients was observed (8.3%). The main part of persons suffering oligophrenia was met within age range from 10 to 30 years (61.2%). These data in author's opinion indicate the patients suffering oligophrenia birth incidence elevation for the last 30 years.

It's worth to note here that according to the data from Scientific Centre for Mental Health of Russia AMS (1994) the oligophrenia was present only in 16.5 - 31.7% of all the psychiatric patients number and that of schizophrenia — in 17.3–23.0% among registered mental disorders prevalence structure for 1965 - 1991. No substantial differences in incidence and prevalence of mental disorders between Kazakhstan and Russia were marked. At the same time in Ukraine where these indices are the most high ones among all the CIS countries, oligophrenia was met in average ~22% from all psychiatric patients' amount and that of schizophrenia — in ~15% among registered mental disorders prevalence structure according to formal data from Ukraine Ministry of Public Health (1991). The non-psychiatric disorders occupied the leading rank (47%). Thus the mental disorders prevalence structure change with clear tendency to oligophrenia and schizophrenia rise is obvious in population resident close to nuclear testing site in Semipalatinsk.

According to data by J.A. Alymhanov (1995) the *epilepsy* prevalence index in studied population was two-fold higher than that in a whole among Kazakhstan. Among various forms of mental disorders in mentioned region population the *suicidal behaviour* sharp elevation was marked. For the last 20 years the suicidal coefficient constituted 20.5 per 100,000 population. At that the suicidal coefficient in population resident no far than 60 km from nuclear testing site reached 87.7, in persons inhabiting zones from 60 to 120 km — 29.1 and in people living more far than 120 km — 17.3 (per 100,000). J.A. Alymhanov concluded the population suicidal coefficient direct correlation with residence distance from atomic testing site.

Expected medical-biological consequences of nuclear war were presented before Chernobyl disaster in *apocalyptic* way [Guskova A.K., Konchalovsky M.V., 1984; Chazov E.I. et al., 1984; Ilyin L.A., 1985]. However after the Chernobyl disaster some authors started to insist that described earlier tragic picture of possible nuclear war consequences was very overstated due to the known political motivations [Antonov V.P., 1987]. The last fact was of enough importance in public distrust forming towards scientific and state power circles during post-Chernobyl period.

History decisively testifies that wars bring destructive consequences for its participants' mental health. Marlow D.H. (1982) [Cited by Mickley G.A., 1987] presented data about neuropsychiatric disorders constituting from 18 to 48% of all sanitary loss during the World War II depending on the battles.

According to the several authors' opinion the psychological reactions on atomic bombings are similar to those in ordinary war or natural disasters [Glas A.J., 1956; Vineberg R., 1965]. Other works point out that such the simplified approach does not take into account the unique nature of stress after ionising radiation impact [Lifton R.J., 1982]. H.M. Vyner (1988) considering ionising radiation the invisible factor of environmental pollution also pointed out to radiation psychological effect peculiarities.

Exposed in the battlefield can occur knowing extremely little or almost nothing about radiation injuries severity. That vagueness and its interpretation in every exact case can alter the working capacity and battle-worthiness. The informed persons themselves can come to conviction about ionising radiation remote consequences rise possibility in them such as leukaemia or genetic disorders. Ionising radiation can directly effect the central nervous system that leads to psychological disorders. Besides that, demolitions caused by nuclear explosion amplify the psychological trauma [Von Greyerz W., 1962].

G.A. Mickley representing Arms Forces Radiobiology Research Institute, Maryland, USA pointed out to the nervous tissue and ionising radiation direct interaction problem being out of sight in nuclear weapons psychological effects studies. Neurones are considered relatively radioresistant ones. However the author underlined, still increasing amount of data indicate that ionising radiation can alter the neurones function in doses substantially lower than those inducing morphological disorders and death. Though the EEG alteration were registered already in doses of 0.01 Gy and behaviour disorders were observed under 0.3 Gy doses impact [Kimeldorf D.J., Hunt E.L., 1965].

One can not exclude that the central nervous system function disorders after ionising radiation direct impact on brain can be basic for nuclear weapons action psychological effects. Those initial alterations can have acute behavioural and psychological correlates through motivations general decrease that in its turn can induce symptoms of lethargy and weakness decreasing thereby general panic probability. Memory and ability to learn disorders can occur. Anxiety and agitation in atomic bombings survivors are obviously higher than in ordinary was victims. At that those symptoms can be amplified under hearsay and doubtful information impact. Phobias and various psychosomatic symptoms are ranked among the remote consequences. Culpability feeling towards personal surviving and own duties execution non-adequacy problem can provide additional contribution to neurotic symptomatic both with physical injuries severity. Psychotic reactions are considered of low probability [Janis I.L., 1951; Ross W.D., 1952; Hachiya M., 1955; Furchtgott E., 1963; Lifton R.J., 1967, 1982; Hersey J., 1981; Mickey G.A., 1987].

In the more late publication G.A. Mickley & V. Bogo (1991) representing the Radiation Research Department of US Air Force Aerospace Medicine School, Texas, presented data for military servicemen radiation-stipulated battle-worthiness alterations prognostics, prevention and management. Published information concerned possible war nuclear conflicts, human irradiation, tactical nuclear weapons psychological effects both with human irradiation animal model. Especial attention authors dedicated to neurophysiological correlates of radiation-induced behavior disorders and so-called *behaviour radioprotection* methods i.e. protection from ionising radiation behaviour consequences.

3.5 Radiation Experiments on Human

This chapter is concluded with one more dark page in nuclear history — *the radiation experiments on humans*. Our decision to mention it in the book was stipulated by extreme social-ethic importance of this problem. In 1993 the «Albuquerque Tribune» newspaper published information that hospital patients in 1945–1947 were experienced to *plutonium experimental injections* [Cited by Miller R.W., 1995]. This newspaper event stimulated the US Energy Department to shed the light also on the further similar experiments in humans. On January 18, 1994 President W. Clinton established the Advisory Committee for Radiation Experiments in Human. On October 21, 1994 the Committee published the intermediate report stated that fact was fixed of about 400 such experiments realisation before up to 1975 both with fragmentary information concerning 1,000 or more additional cases.

Radiation experiment on human were the following ones:

- study of nuclides *biodistribution* (plutonium or other radionuclides injections);
- radiation *biological effects measurement* under general irradiation of patients considered terminally ill;
- *paediatric studies* through labelled atoms method with radioactive calcium in mentally defective children and radioactive iron — for iron metabolism research in «mother-foetus» system;
- experiments in *healthy adults* including testicles irradiation in prisoners;
- *radioisotope studies* for new diagnostic and treatment methods.

Ethic issues of experiments on human problem were matters of discussion on the supreme level. In 1953 the US Defence Ministry Secretary under «Top Secret» stamp established the policy of volunteers involvement for nuclear, biological and chemical weapons testing. History of radiation experiments on volunteers resides in substantial contradiction with widespread public fear towards ionising radiation [Miller R.W., 1995].

Thereby the neuropsychiatric consequences of atomic bombings and nuclear tests are the serious medical-social problem. Spectrum of neuromental disorders described in atomic bombings and nuclear tests consequences structure is extremely wide — from the asthenic-vegetative states and «atomic bomb neurosis» to brain organic damage and schizophrenia. The contradictoriness is drawing attention regarding the ionising radiation and extremal situations psychogenias role in neuropsychiatric effects genesis. That is illustrated by the «chronic radiation sickness» concept «evolution» through the «atomic bomb disease» to the «atomic bomb neurosis». These opinions invalidity is

proved in particular by schizophrenia prevalence substantial elevation in hibakusha more than 40 years after the atomic bombing.