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原著

Balneotherapy for the Survivors of Atomic Bomb Injuries.

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Introduction

So called "chronic atomic bomb disturbances" (1) have been recognized among the people who were in the area where the atomic bomb explosed. These are not necessarily the ones who showed acute irradiation symptoms shortly after the explosion. Some entered the contaminated area for purposes of rescue or to search for relatives after the explosion took place. They are divided into two groups: 1) those showing somewhat objectively recognizable physical disturbances, such as severe anemia, reduced leucocyte count or hemorrhagic diathesis and 2) those with only little evidence of alterations in their physical or laboratory examinations.

In those of the second group, despite the lack of clinical findings, some were unable to perform the daily routine of their lives satisfactorily, complaining of weakness, malaise etc. In addition, there has been a higher incidence of leukemia, aplastic anemia, malignant tumors and severe endocrine disturbances among the residents of Hiroshima and Nagasaki. Fear of these fatal diseases may also have played a contributing role.

It is important, however, to note that this group has a tendency to develop clinically manifested disturbances later, probably supported by some additional factors which are not fully identified as yet.

Since more of these cases were found in an area located close to the center of the explosion, especially within 2km from this center, exposure to the irradiation was considered responsible to some extent. This will be discussed later.

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It was deemed prudent to not only observe these individuals, but that efforts be made in preventing a developement of irreversible disturbances. However, as far as preventive treatment is concerned, there has not been an acceptable method from the standpoint of efficacy and economy.

The purpose of this paper is mainly to advocate treatment by hot spring waters in these cases, presenting the method and results obtained thus far (4, 6, 7, 8, 9).

Material and method

Based on some empirical facts observed in Yunotsu Spring Resort and Beppu Spring Resort, observations were made on 132 cases of 160 subjects who underwent hot spring treatment. The hot springs used are shown in Tab. 1. The treatment consists of the

Tab.1

Used Hotsprings for Treatment

No.	Date of treatment	Number of cases	Hot—Spring	
I	9/7～9/19 (1957)	25 (cases)	Okanoyu	(Simple Hotspring)
II	2/24～3/4 (1958)	22	Shinokanoyu	(〃)
III	3/15～3/29 (1958)	12	Yanagiyu	(Muriated Earthspring)
IV	7/4～7/19 (1958)	16	Shinokanoyu	(Simple Hotspring)
V	7/23～8/2 (1958)	25	Umijigoku	(Saline acidic Hotspring)
VI	7/25～8/8 (1958)	9	Tanoyu	(Simple Hotspring)
VII	9/27～10/9 (1958)	15	Shinokanoyu	(〃)
VIII	11/20～12/4 (1958)	6	Umizigoku	(Saline acidic Hotspring)
IX	3/21～3/12 (1959)	18	Shinokanoyu	(Simple Hotspring)
X	4/15～4/27 (1959)	9	〃	(〃)
XI	5/11～5/23 (1959)	11	〃	(〃)

bathing routine of average Japanese people, usually deep bath-tubs are used being filled with waters of temperature 42°C. The body is immersed up to the neck. Duration of bathing is variable depending on temperature of water, atomosphere, from 5—15 minutes. Close attention was paid dnring the entire period of treatment, particularly to those who had hypertension, cardiac disease, kidney dysfunction etc, thus trying to minimize any side effects of the treatment. Those individuals having active tuberculosis or cancer were excluded from the treatment due to the aggravation of these diseases by hot spring treatment.

*Located in Shimane Prefecture, Japan. Hot, sulphated waters.

**One of the largest hot spring resorts in Japan, located in Oita Prefecture.

There are various types of spring waters available, numbering more than 2,300 spring sources.

A number of laboratory examinations were performed before and after the treatments; erythrocyte count, hemoglobin, color index of blood, hematocrit, plasma protein content, leucocyte count, blood platlet count, methylene blue reduction time, bleeding time, clotting time, petechinometry, B. S. P., Thorn's test, blood pressure, urine analysis, prothrombin time and so on.

The various situations to which individuals were subjected by the atomic bomb explosions are summarized and listed in Tad. 2. and 3.

Tab.2
Distance of the cases from center of Atomic bomb explosion

Distance	case
0.6	1
0.7	1
0.8	1
1.0	17
1.2	9
1.3	6
1.5	18
1.6	1
1.7	1
1.8	6
2.0	20
2.2	1
2.3	1
2.5	11
2.8	1
3.0	5
3.5	3
4.0	5
4.0 Km or others	24
total	132

Tab.3
Conditions of the cases at AB Explosion

Protection	+	66 (cases)
	−	42
	Others	24
Burning	+	30
	−	78
	Others	24
Scar, Keloid	+	14
	−	94
	Others	24

Two types of hot spring waters were used for the treatment; One with simple spring waters having a mild biological effect and the other with acidic "Umijigoku" Spring water with PH 2.0 which contains sulphite and chloride salts in higher concentrations than simple spring waters, and is tonic in the nature of biological effects. The results obtaind, being somewhat different for the two spring waters, will be compared and discussed.

Results

The results of the laboratory examinations are shown in Figures 1 through 20.

General aspect on the effect of the hot spring treatment.

As illustrated in Figs. 1—20, the examined value exhibit the tendency to concentrate within a certain range of values after the treatment, no matter how high or low the values before the treatment, Therefore the standard deviation for values becomes less after the treatment than before. This could be recognized more or less in every respect and is termed "concentration of values in a certain range". Since this approximate the normal range, it is also termed "normalisation" (Tab. 4) which will be discussed elsewhere.

Tab. 4

Concenrating Ranges of Every Examination value after Bathing

Labaratory examination	Concentrating Range
Erythrocyte count	300～500×10⁴
Hemoglobin	75～90%
Colorindex of blood	0.8～1.2
Hematocrit	35～45%
Leucocyte count	5000～8000
Lymphcyte (differential count)	25～50%
Plasma Protein content	7.0～8.0g/dl
Blood Platlet count	9～19×10⁴
Bleeding Time	1′.5～4′.0
Prothrombine Time	30″～40″
Clotting Time Begining	2′.5～4′.5
Clotting Time end	5′.0～8′.0
B. S. P.	2.5～5.0%
MBRT	3′.5～5′.0
Blood Pressure (max.)	100～150mm Hg
Urin Analysis Protein test	normalisation
Urin Analysis Davis's test	〃

Comparison in effect between the mild and tonic spring waters.

Regarding this trend to normalization, the springs differ from each other to some extent as shown in Tab 5. In the case of the Umijigoku Spring, much of the data

Fig. 1

Change of Plasma Methylen Blue Reduction time by the Cure (Simple Hotspring)

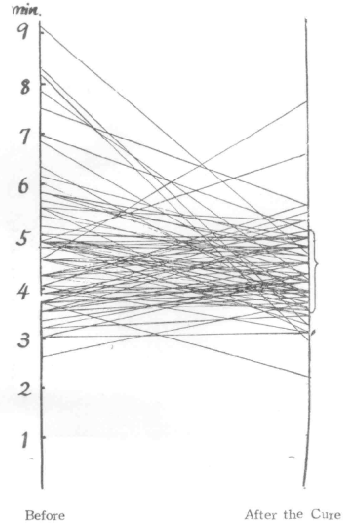


Fig. 2

Change of Methylen Blue Reducion time by the cure (Acidic Hotspring)

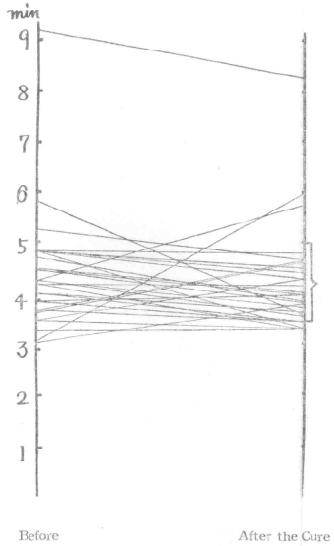


Fig. 3

Change of Hemoglobin by the cure (Simple Hotspring)

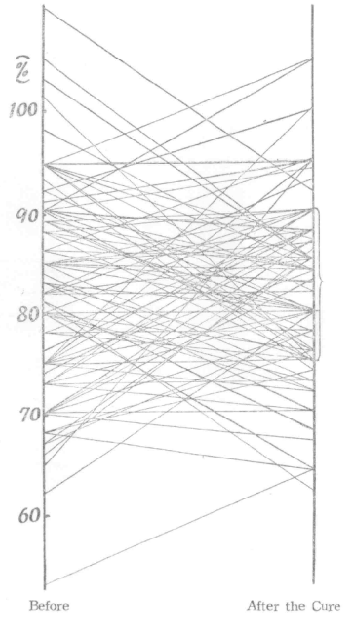


Fig. 4

Change of Hemoglobin by the Cure (Acidic Hotspring)

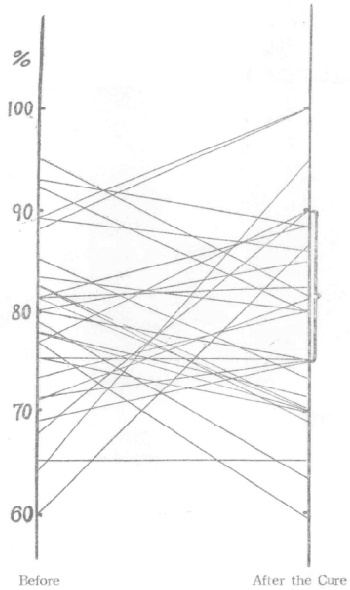


Fig. 5

Change of Erythrocyte Count by the Cure (Simple Hotspring)

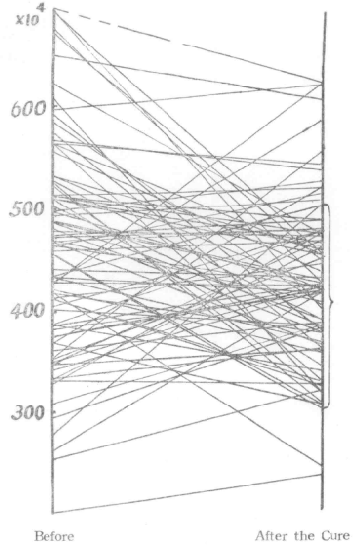


Fig. 6

Change of Erythrocyte Count by the Cure (Acibic Hotspring)

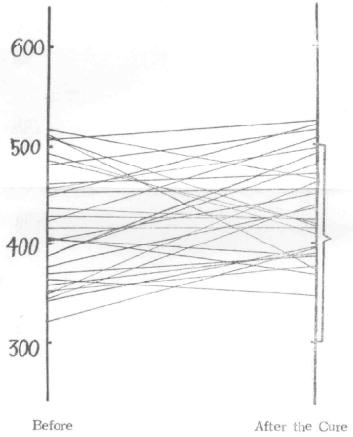


Fig. 7

Change of Blood Platlet Count by the Cure (Simple Hotspring)

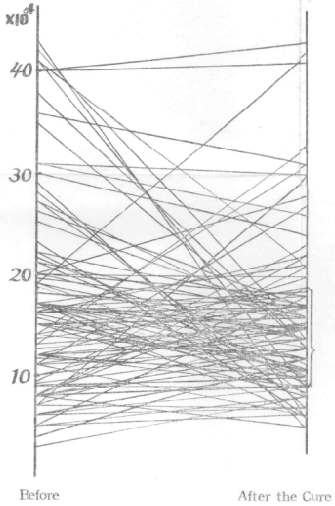


Fig. 8

Chage of Blood Platlet Count by the Cure (Acibic Hotspring)

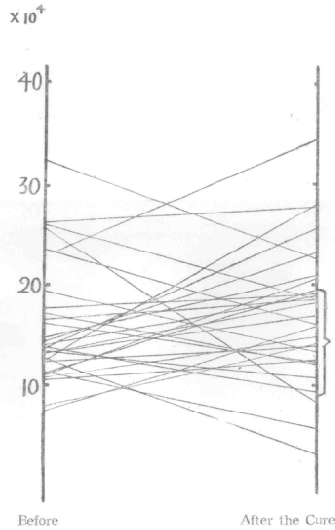


Fig. 9

Change of Clotting time by the Cure (Simple Hotspring)

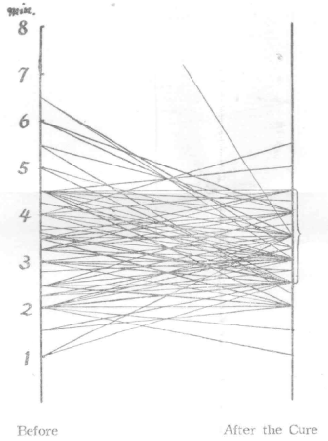


Fig. 10

Clotting time by the Cure (Acibic Hotspring)

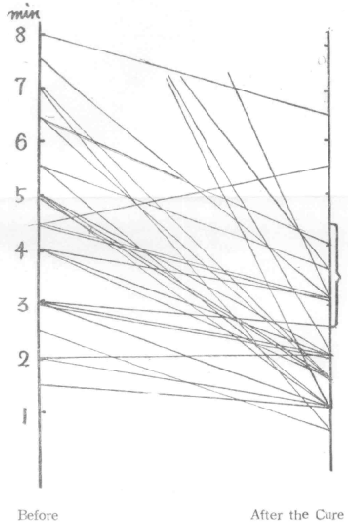


Fig. 11

Change of Plasma Protein Content by the Cure

(Simple Hotspring)

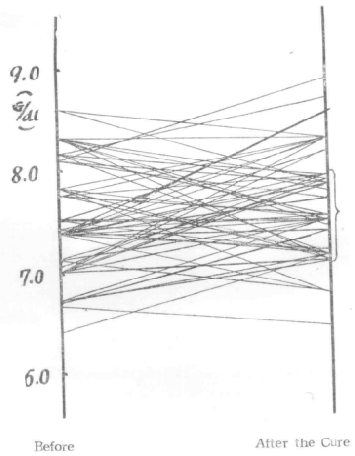


Fig. 12

Change of Plasma protein Content by the Cure

(Acidic Hotspring)

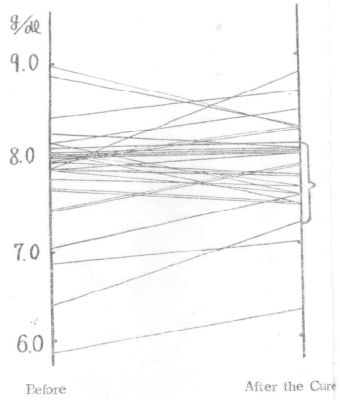


Fig. 13

Change of Bleeding time by the Cure

(Simple Hotspring)

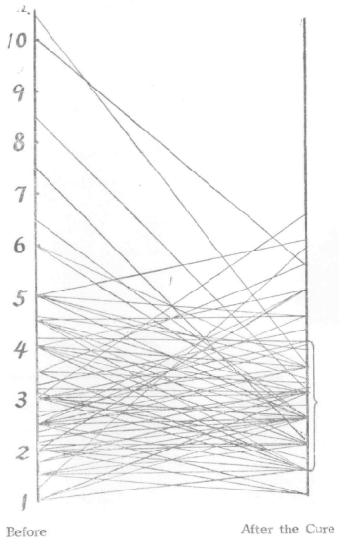


Fig. 14

Change of Bleeding time by the Cure

(Acidic Hotspring)

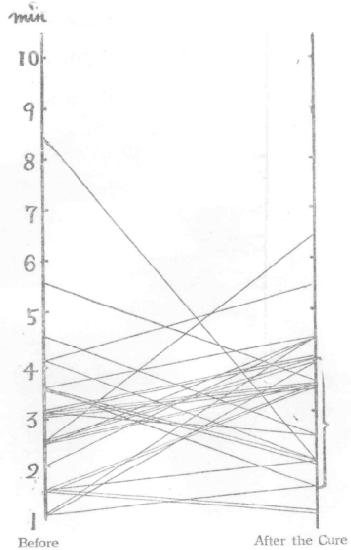


Fig. 15

Change of Leucocyte Count by the Cure

(Simple Hotspring)

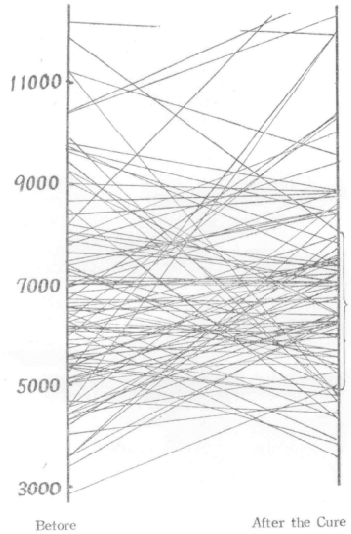


Fig. 16

Change of Leucocyle Count by the Cure

(Acidic Hotspring)

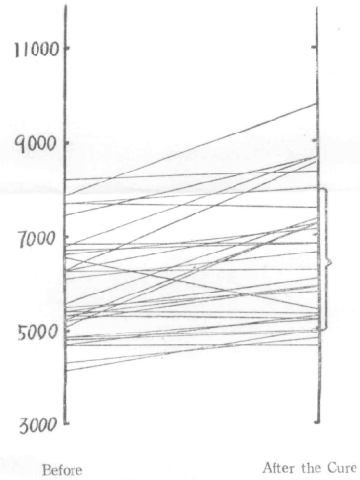


Fig. 17

Change of Blood Pressure (Max.) by the Cure

(Simple Hotspring)

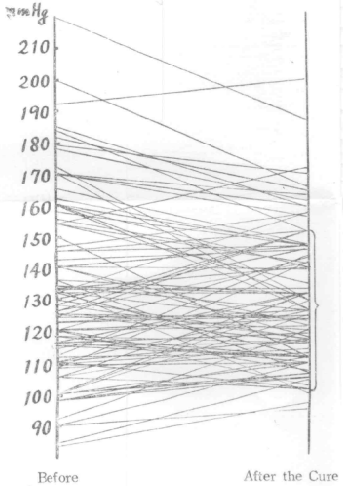


Fig. 18

Change of Blood Pressure (Max.) by the Cure

(Acibic Hotspring)

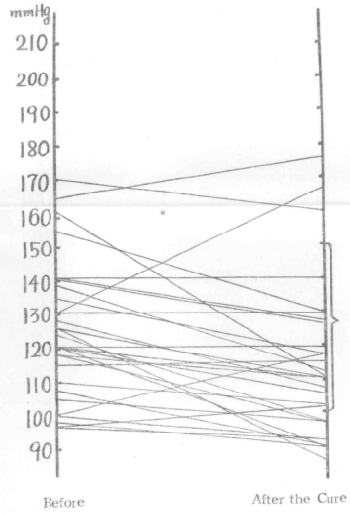


Fig. 19

Change of Hematocrit by the Cure

(Simple Hotspring)

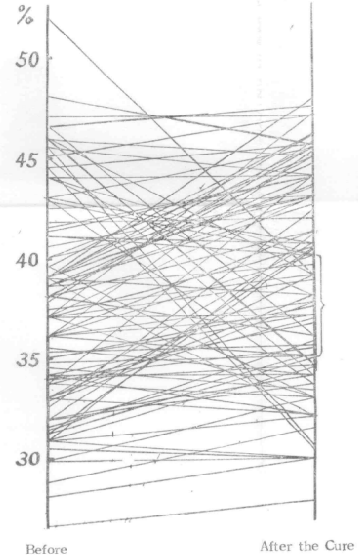
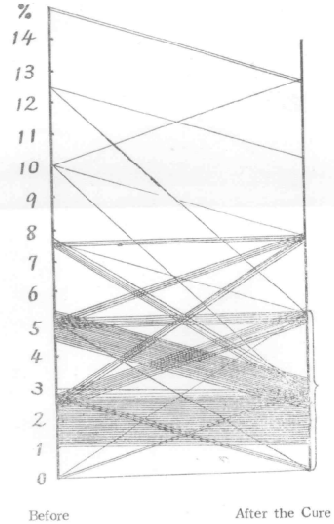


Fig. 20

Change of B.S.P. by the Cure

(Simple Hotspring)



Tab. 5

Standard Deviation of various Examination Values after the Cure

Hotspring / Examination	Simple Hotspring	Acidic Hotspring (Umijigoku)
Erythrocyte count $\times 10^4$	423.32±0.57	435.96±13.55
Hemoglobin %	81.88±9.41	79.46±11.51
Plasma Protein Content g/dl	7.57±0.49	7.79±0.49
Leucocyte count	7251.51±2156	6542.66±1538
Blood Platlet count $\times 10^4$	15.63±0.81	16.85±0.07
MBRT	4′.29″±1′.20″	4′.12″±1′.01″
Bleeding Time	2′.49″±1′.12″	3′.16″±1′.39″
Clotting Time (Begining)	3′.04″±49″	2′.15″±1′.21″
Blood Pressure (Max.) mmHg	128.69±20.2	114.5±22.9

showed considerably larger standard deviation than in the case of the simple spring.

The number of subjects whose examination data fell out of normal range are listed in each instance on Tab 6. of the group treated in the mild spring waters, the deviations

Tab. 6

The Number of Subjects whose Examination Data fell out of normal Range

	Simple Hotspring % (102 cases)			Aeidic Hotspring % (30 cases)		
	Before	After	Residual Case	Before	After	Residual Case
Decreased Erythrocyte count	9.8	2.9	2.0	3.3	0	0
Reduced Hemoglobin	23.5	17.6	7.8	26.7	36.7	3.3
Abnomal color index of Blood	44.1	28.4	11.8	13.3	20.0	0
Reduced Hematocrit	26.5	19.2	10.1	0	40.0	0
Abnormal Leucocyte count	37.3	39.0	13.7	30.0	26.7	13.3
Abnormal Differential Lymphcyte Procent	22.5	12.9	8.9	33.3	13.3	3.3
Reduced Plasma Protein	9.8	3.9	1.0	10.0	3.3	3.3
Decreased Blood Platlet count	21.6	21.6	9.9	6.7	13.3	0
Prolonged Bleeding Time	25.0	13.0	3.0	10.0	20.0	0
Prolonged Clotting Time (Beginning)	10.0	2.0	0	53.3	6.6	3.3
Hypofunction of Liver	16.8	15.8	8.9	20.0	0	0
Prolonged MBRT	23.8	16.8	4.0	10.0	10.0	0
Abnormal Blood Pressure (Max.)	31.7	13.7	11.8	20.0	30.0	13.3
Adrenocortical Hypofunction (Thorn's Test)	61.3	46.9	30.2	40.0	66.6	23.3
Decrease of Capillary Resistance	42.2	42.2	30.4	56.6	50.0	33.3

Residual case: Fell out of normal Range After as well as before the Cure

observed prior to the treatment were somewhat less following treatment. Contrarily, in the case of the Umijigoku group the deviation was greater in many respects after the treatment, i. e., reduced hemoglobin, abnormal color index, reduced hematocrit, decreased blood platlet count, prolonged bleeding time, abnormal systolic pressure and adrenal cortical dysfunction,

It has been well recognized that bathing in tonic spring waters resulted in a much stronger parasympathetic reaction than in the case of simple spring waters. This fact might have a close relationship to the results mentioned above. The results seem to indicate that the Umijigoku spring is less useful than the mild springs.

Miscellaneous observations.

Previous to treatment, hemoconcentration was observed in 16 subjects. Although its etiology was unknown, it was satisfactorily corrected by the treatment.

Remarkable improvement was observed in 3 of 6 subjects who had been shown to have fairly severe anemia over a long period of time before treatment.

Approximate amount of effective radiation was calculated by Shono (Hiroshima Woman-Univ.) according to the geographical location of each place. Of the subjects treated, 3 were suspected to have suffered from calculated radiation of more than 600 rem. The treatment was satisfatory even in these subjects.

Increase of body weight was noted in 70 subjects after the treatment.

In spite of scrupulous care, side effects of the treatment, known as the "hot spring illness", developed in 30 subjects. Judging by the author's experience, this was a surprisingly high incidence and was considered to show reduced resistance to stress. This probably contributed to their disorders as mantioned in the beginning of this paper. There was also an incidence of jaundice and a crisis of tabes dorsalis.

Discussion

It would be difficult to present a definitive picture of the disorder due to variety in symptoms and clinical examinations. However, it might be reasonable to insist upon the entity of disturbance which is considered associated with radiation injury. Some of the reasons for this have already been stated at the beginning of this paper. In addition, though it might be a slight one, the clinical picture frequently found in these subjects was some-what similar in nature to that of the atomic bomb disturbances.

Numerous articles describing the damage to victims of the atomic bomb were mostly concerned with pathologic changes in hematopoietic and endo-crine organs (1, 23). Identical changes have also been observed in experimental animals exposed to large amounts of radiation (24, 29). In our case, the clinical data also showed a high incidence of hematopoietic and endocrine disturbances.

In addition to these organic damages, Tsutsuki (1, 25) pointed out the incidence of functional disturbances in the autonomic nervous system. Unusual serum cholinesterase level found in our subjects might have a relation to this concept (8).

Another report (26) discussed the biochemical changes occurring in subjects with radiation injuries. According to this, irradiation caused several changes in biochemical

processes of wide rariety, ranging from reversible disorders to irreversible fatal damage. Besides extraordinary ionization of water in the body, SH enzymes were pointed out to be one of the most radio-sensitive biochemical processes. It is important to note that reversible biochemical disorders do not necessarily remain in their place but can proceed to irreversible changes under certain circumstances. In these situations, attention should be drawn to the existence of such physiological, biochemical disturbances and an effort should be made to prevent any further aggravations.

A brief consideration will be made about the mechanism of the hot spring bathing treatment concerning its effect on the subject treated. Although it not the purpose of this paper, the characteristic normalization effect of the spring waters will also be discussed here for the benefit of understanding this mechanism.

There has been experimental evidence showing that hot spring water bathing saved the lives of animals previously exposed to lethal doses of x-ray irradiation (27, 28, 29, 30). A protective effect was also observed in other experiments on animals.

The mechanism of this effect has been investigated by the author and is assumed to have resulted from multiple factors. The regulation of the autonomic nervous system, release of the adrenal cortical hormone and increase of SH bound compounds were considered to be the main factors involed.

This concept has been obtained from the fact that the lives of half the mice exposed to the lethal x-ray irradiation were saved by administration of nor-adrenlin, adrenochrom (31), adrenal cortical hormone(32, 33) or SH bound compunds (34, 35, 36, 37, 38).

Thus the biological effect of hot spring waters seemed a complex effect and dus to the nature of its action it has been expressed by the term "normalization". The normalization effect of hot spring waters on abnormally functioning organs has been obseveed by some investigators (10). It was first noted by Neubauer in 1934 (11). He found that both hyperacidity and hypoacidity of stomach juices were successfully normalized after the drinking or hot spring waters. An identical effect has been recognized in cases of those bathing in spring waters.

The exact process involved in this phenomena is still obscure. Favorable alterations in the state of the autonomic nervous system have been recognized and this seemed the first sign of the effects. In experiment performed on the excised toad heart, there was a biphasic effect on heart contractility following the administation of serum derived from rabbits treated by hot spring waters (12, 13). Supporting this biphasic effect of hot spring waters, there is an anatomic evidence; i., e., superior cervical ganglia have a communication with nodal ganglia of the vagus nerve, which was shown by an electrophysiolgoical and histological method (14, 15). This means that stimulus to the skin will result on the one hand a sympathetic and on the another hand a parasympatheitic response.

From these findings, the author believes that hot spring waters act as an adrenalgic and cholinegic agent on the animal's body, depending on the state of autonomic nervous system which existed previous to the hot spring application.

As a part of its sequence, the activity of endocrine organs might be regulated, thus

contributing to the normalization. Adrenal cortical hormone is also likely to play an essential role in this respect (10). Another important factor involved is that mineral constituents exist in hot spring waters (16). Some of them are absorbed into the body through the skin or the gastro-intestinal mucosa and can supplement their deficiencies, if any. This has been proved by isotope technic. Electrolyte imbalance or lack of SH bound compounds are thus corrected. This is also a factor of considerable importance in the normalization effects of hot spring waters.

Clinical and experimental evidence have shown that at least 2 weeks' duration of daily bathing was necessary for a stable normalization to take place (10). In the case of drinking, the duration of treatment was similar.

It has already been mentioned that the grade of normalization effect, especially on the autonomic nervous system, differed depending on the type of hot spring waters used (21). In general, biologically, the more tonic the spring waters, the more parasympathomimetic the effects. Relating to this, much stronger histamine release was observed after bathing in tonic spring waters (10, 22). Therefore, careful consideration is necessary in the selection of the hot spring for its therapeutic use. It should be noted that therapeutic effects are greatly dependent on the state of the individusal subject before undergoing hot spring treatment.

Conclusion

(1) Hot spring treatments were applied to 160 individuals who had skown physical disabilities which apparently resulted from the atomic bomb explosions. Laboratory examinations performed on 132 of these cases showed the following changes; anemia (24.1%), increased or decreased leucocyte count (35.6%), decreased blood platlet count (18.2%), prolonged bleeding time (22.3 %). prolonged clotting time (20.0%). lowered reduction activity of plasma (28.2%), dysfunction of liver (17.0%), and adrenal cortical insufficiency (56.2%).

(2) Hot spring treatment of 2 weeks' duration brought about considerable improvement in many of the findings mentioned above, especially in bleeding time and clotting time.

(3) Statistical analysis of the results showed a difference between mild, simple spring waters and tonic spring waters in their therapeutic effects, indicating a superiority of mild, simple spring waters. Simple spring waters, especially those which also effect an increase in SH bound compounds in the body, might be the best choice of spring in thes case.

(4) The mechanism of hot spring water treatment was discussed.

(5) With reference to the results obtained, hot spring treatmets were considered effective not only in improving the individual's general condition but also in preventing aggravations of his disorders.

(6) A treatment of more than 2 weeks' duration seemed to be necessary to attain a sufficieient therapeutic effect. Pretherapeutic examinations and professional guidance should not be neglected.

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