

CAPILLARY MICROSCOPIC OBSERVATIONS ON THE SUPERFICIAL MINUTE  
VESSELS OF ATOMIC BOMB SURVIVORS, HIROSHIMA 1972-73

原爆被爆者の表在性細小血管の毛細血管顕微鏡観察  
広島，1972 - 73年

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**SUMMARY**

Microscopic and photographic studies were conducted in 1972-73 at ABCC in Hiroshima on the morphology of superficial blood vessels of A-bomb survivors to determine whether the somatic effects of radiation still existed 30 years after the A-bomb. Control curves representing the relationship between age and score values assigned to morphological changes of the minute blood vessels of the fingernail fold, labial mucosa, and lingual mucosa, which could be regarded as an index of aging, were obtained. These were compared with similar curves obtained from A-bomb survivors with the aim of evaluating the effect of radiation on the aging process of these vessels.

The late somatic effects of irradiation which were demonstrated 10 years after the A-bomb in a previous study (1956-57) were found to persist in the current study (1972-73) conducted 30 years after the A-bomb though not as pronounced as in the earlier study. A significant effect was observed only in the fingernail fold of those exposed to 100 rad or more under the age of 10 at the time of the bomb. A statistically significant difference was not observed for labial mucosa and lingual mucosa because the number of cases available for scoring was small, but a trend was observed for abnormalities of these two sites to be higher in frequency in the 100+ rad group under the age of 10 ATB than that of the control group.

No significant difference was observed between the control and exposed with regard to radiation

**要 約**

原爆後30年を経過しても、体細胞に放射線影響が依然として存在するか否かを観察するために、顕微鏡観察および写真撮影による原爆被爆者の表在性血管の形態的研究が、1972年から1973年にかけて、広島のアBCCで行われた。加齢の指標とみなし得る指爪床部、口唇粘膜、舌下粘膜の細小血管の形態的变化に対する評価値と、年齢との関係を表わす対照曲線が得られた。これらの血管の加齢に対する放射線の影響を評価する目的で、この曲線と原爆被爆者から得られた同種の曲線とを比較した。

原爆後10年を経過して行った前回の研究(1956-57年)において証明された放射線の後影響は、原爆後30年を経過して行われた今回の調査(1972-73年)でも依然として認められたが、前回の調査時ほど顕著ではなかった。被爆時に10歳以下で100 rad以上の放射線を受けた被爆者の爪床部のみに有意な影響が観察された。口唇粘膜および舌下粘膜では評価された対象例数が少ないために、統計的に有意の差は認められなかった。しかしながら、被爆時10歳以下で100 rad以上の線量を受けた者では、この両部位ともに異常の頻度は対照群におけるそれより高い傾向を示した。

評価値を加齢の指標として用いた場合、放射線が加齢に及ぼす影響に関して、被爆群と対照群の間には

effect on the aging process using the relationship of score values to age as an index of aging. This is in accord with results of studies of A-bomb survivors which suggested that radiation induces life shortening attributable primarily to cancers, but not a general acceleration of the aging phenomenon.

## INTRODUCTION

A previous study of capillary morphology to determine the nonspecific somatic effects of radiation was conducted in 1956-57 approximately 10 years after exposure to the atomic bomb.<sup>1,2</sup> At that time, 435 selected subjects were examined at ABCC in Hiroshima to seek morphological changes in four sites: fingernail fold, labial mucosa, lingual mucosa, and bulbar conjunctiva. In an attempt to quantify the changes numerical values were assigned to those items which were considered to represent anatomic abnormalities of the superficial minute vessels. That study revealed an increase in the morphological abnormalities of fingernail fold capillaries related to age in those exposed within 2000 m from the hypocenter. It is of interest that a higher frequency of abnormalities was observed also in the labial and lingual mucosae of those exposed to 100 rad or more who were under 10 years at the time of the bomb (ATB).

The findings of the initial study were reported at the Symposium of Late Effects of Irradiation on the Vascular System of the International Congress of Radiation held at Evian in July 1970,<sup>1</sup> when the participants expressed their hope that follow-up studies would be made in order to evaluate the subsequent changes in the aging phenomenon.

In the present study the changes in the capillary morphology of A-bomb survivors were reevaluated to determine whether the radiation effect observed in the earlier study could be still detected, and whether the radiation would accelerate nonspecific aging process in the vascular system.

## METHOD

Microscopic and photographic observations were made on selected subjects of the Adult Health Study (AHS) population seen in the ABCC clinic between 12 October 1972 and 31 August 1973.<sup>3,4</sup>

有意の差は認められなかった。原爆被爆者に関するこれまでの調査結果では、放射線は主として癌による寿命の短縮をもたらすが、全般的に加齢現象を促進させるものではないことが示唆されている。今回の調査結果はこれと一致するものである。

## 緒言

毛細血管の形態に関する前回の調査は、放射線の非特異的な身体影響を調べるために、原爆被爆から約10年後の1956-57年に実施された。<sup>1,2</sup> 当時、広島ABCCで抽出された435人の対象者について、指爪床部、口唇粘膜、舌下粘膜および眼球結膜における形態的变化を調べた。表在性細小血管の解剖学的異常であると考えられるこれらの項目における形態的变化を数値化する試みとして、数値が与えられた。その調査結果では2000m未満の近距離の被爆者に、指爪床部毛細血管の形態に年齢に関係して異常が増加することを認めた。100rad以上の線量を受けた被爆者で原爆時10歳未満であった者の口唇粘膜および舌下粘膜にも、異常の頻度が高いことが認められたことは興味ぶかい。

1970年7月に、Evianで開かれた国際放射線学会で、血管系に及ぼす電離放射線の後影響に関するシンポジウムにおいて、前回の調査の所見を報告したが、<sup>1</sup> その際、出席者から加齢現象におけるその後の変化を評価するため、追跡調査を実施するようにと要望された。

今回の調査では、原爆被爆者の毛細血管の形態的变化を再評価して、初期の調査で認められた放射線の影響が、依然として認められるかどうか、血管系における非特異性の加齢現象を促進させるかどうかを確認するために実施した。

## 方法

1972年10月12日から1973年8月31日までにABCC臨床部で受診した成人健康調査対象集団<sup>3,4</sup>から選ばれた対象者について、顕微鏡および写真撮影による観察を行った。

Morphological evaluation was attempted by assigning numerical values to important items in accordance with the criteria used previously.<sup>1,2</sup> These were graded 0, 1, 2, or 3 according to the degree and extent of such changes, and these values were added to obtain the total score for each individual.

The following nine items were selected to obtain the total score of the morphological changes in the superficial minute vessels of the fingernail fold: dilatation, waving, tortuosity, branching, clubbing, tangling, granularity, fine capillary, and number of front loops per unit area.

For the evaluation of the labial and lingual mucosae, the following six items using the same criteria as in the previous reports were selected: dilatation, branching, granularity, fine capillary, number of front loops per unit area, and loop parallelism.

As listed in Table 1, none of abnormalities taken individually are pathognomonic of aging or radiation damage, but increase in morphological abnormalities is generally accepted to be senile or degenerative changes, or irreversible changes.<sup>5-13</sup> When functional changes of long duration, such as decreased blood flow, are combined with morphological abnormalities or vice versa, acceleration in degenerative changes might well develop in this system. Therefore, high score values are considered to represent senile or degenerative changes. In view of the distribution of scores in the control group, a total score of 15 or more was judged to be abnormal for the fingernail fold and 9 or more for the labial mucosa and lingual mucosa, because no gross morphological abnormality was demonstrated among those with a score less than 15 and 9, respectively, in the previous study.

**Sampling Plan.** Study cases were selected from the AHS population by simple stratified random sampling on the basis of dose group.<sup>14</sup>

Three groups each containing the same number of cases as the selected index cases were randomly selected on the basis of sex and age from the AHS population scheduled for clinical examination at ABCC during the period October 1972-August 1973. Those engaged in occupations or those with local or general physical conditions considered to affect capillary morphology were excluded.<sup>1,2</sup>

前回用いた基準にしたがって、重要な項目に数値を与えて、形態的評価を試みた。<sup>1,2</sup> これらの評価は、異常変化の程度に応じて0, 1, 2または3の分類値に分け、これらの分類値を加算して各個人の合計評価値を得た。

指爪床部の表在性細小血管における形態的変化の合計評価値を求めるために、次の9項目、すなわち、拡張、波状化、迂曲、分岐、係蹄頂拡張、捻転、顆粒状血流、微細毛細管および単位面積当たりの前係蹄数を選んだ。

口唇粘膜および舌下粘膜の評価については、前回の報告書の場合と同じ基準を用いて、拡張、分岐、顆粒状血流、微細毛細管、単位面積当たりの前係蹄数および係蹄の平行性の6項目を選んだ。

表1に示したように、個々の形態的異常は加齢または放射線障害の特有的症候ではないが、この形態的異常の増加は、一般に老人性または退行性変化あるいは不可逆性変化であると考えられる。<sup>5-13</sup> 血流減少のような長期の機能性変化が形態的異常と結合したとき、あるいは結合しなかったときに、この血管系に退行性変化の促進が起こる可能性が十分ある。したがって、評価値が高いことは、老人性または退行性変化を示すものと考えられている。対照群における評価値の分布では、合計評価値が指爪床部では15以上、口唇粘膜および舌下粘膜で9以上の場合を異常とした。これは前回の調査で評価値がそれぞれ15および9未満の場合には明白な形態学的異常が認められなかったためである。

**対象者の抽出。** 調査対象例は成人健康調査対象集団から線量群<sup>14</sup>に基づいた単純層化任意抽出法によって選んだ。

1972年10月—1973年8月の期間にABCCで実施されている臨床検診に予定された成人健康調査対象集団から、研究群の対象者を選び、これと同数の三つの比較群を下記のように性別および年齢別に無作為に抽出した。毛細血管の形態に影響を及ぼすと考えられる職業従事者および局所的あるいは全身的病変の認められる者は除外した。<sup>1,2</sup>

TABLE 1 MORPHOLOGICAL CHANGES OF THE FRONT LOOPS OF SUPERFICIAL BLOOD VESSELS IN THE AGED

表1 加齢による表在性血管の前係蹄における形態的变化

Year	Author	Site	Morphological Changes in the Aged	References
1946	Roth <sup>5</sup>	nail fold	↑ Tortuosity ↑ Difference of caliber between arterial & venous limbs ↓ Number of front loops ↓ Blood flow	"Peripheral Vascular Disease" Ed. by E. V. Allen et al. Saunders Co. 148-178
1948	Braasch & Nickson <sup>6</sup>	nail fold	↑ Branching, ↑ Plexus distortion ↑ Distortion of papilla Mean number of morphological changes on a total basis:  Students: 15-30 1.22 Aged: 63-97 2.07 Radiologists: 21-30 1.33 41-50 1.89 61-77 2.94	Radiology 51, 719-27
1954	Mendelowitz <sup>7</sup>	nail fold	↓ Number of front loops ↑ Difference of caliber between arterial & venous limbs ↓ Blood flow	"The Digital Circulation" Grune & Stratton, New York
1956	Gibson et al <sup>8</sup>	nail fold	Normal patterns are classified into A, B, C, & D types	J. Neur. Ment. Dis 123, 219-31
1961	Wakano <sup>9</sup>	labial & lingual mucosae	↓ Number of front loops ↑ Morphological abnormality ↓ Pararellism of loops	J. Osaka University Dental School. 6, 263-302
		gingival mucosa	↓ Number of front loops ↑ Morphological abnormality ↓ Caliber of limbs	
1965	Fukushiro <sup>10</sup>	nail fold	High incidence in morphological abnormality	J. Jap. Dermatol. 75, 659-77
1970	Kato et al <sup>11</sup>	nail fold	↑ Tortuosity ↑ Crossing ↓ Number of front loops	J. Jap. Coll. Angiol. 10, 89-95
1971	Tsuya et al <sup>12</sup>	nail fold	Morphological abnormality (Score values on a total basis) Normal range < 15	J. Jap. Coll. Angiol. 11, 37-47
		labial & lingual mucosae	Normal range < 9	
1970	Laws et al <sup>13</sup>	digital artery	Intimal thickening (50+ years of age) tortuosity associated with destruction of elastica	Br. J. Radiol. 40, 740-47

Note: ↑ increase      ↓ decrease

Group 1: Exposed to 100+ rad (index cases)

Group 2: Exposed to 1-99 rad, matched by sex and age in 5-year intervals to Group 1

Group 3: Exposed to less than 1 rad, matched by sex and age in 5-year intervals to Group 1

Group 4: Not in city at time of bomb, matched by sex and age in 5-year intervals to Group 1

第1群: 100 rad 以上の線量を受けた被爆者(研究群の対象者)

第2群: 1-99 rad の線量を受けた被爆者で、第1群と性および5歳年齢範囲に対応した者

第3群: 1 rad 未満の線量を受けた被爆者で、第1群と性および5歳年齢範囲に対応した者

第4群: 原爆時市内にいなかった者で、第1群と性および5歳年齢範囲に対応した者

**Technique.** Photographs were taken of three sites, fingernail fold, labial mucosa, and lingual mucosa. These were examined using a technique similar to that of the previous study so that detailed comparative analysis might be made between the first (1957) and the second study (1973).<sup>1,2</sup> Microscopic observation was made at X39 magnification and photography at X3 magnification. Only the photographs were used for scoring and not the microscopic observations. The score value may be less sensitive in the current study as both photographic and microscopic observations were used in the previous study.

Of the 435 subjects examined in the previous study only 195 (30/102 males & 165/333 females) belonged to the AHS population. All of these cases available during the current study period were selected for examination. However, the desired follow-up study was found not to be feasible.

## RESULTS

Of the 1494 cases selected for study, 120 refused to participate in this study, and thus microscopic and photographic observations were made on 1374 cases. Table 2 shows the distribution of examinees by dose, sex, and age. The examinees are equally distributed in the various dose groups by age and sex. The refusals would not, in any way, bias the study. On the other hand, a large number of photographs were unreadable because they were taken by a technician inexperienced in capillary photography. In all, the number of photographs found satisfactory for analysis was 833 (61%) for the fingernail fold, 556 (40%) for the labial mucosa, and 474 (34%) for the lingual mucosa (Table 3). Fortunately, the unsatisfactory photographs were randomly distributed among the

技法. 指爪床部, 口唇粘膜, および舌下粘膜の3部位について写真撮影を行った. これらの写真撮影は, 前回の調査と類似した方法を用いて撮影することによって, 前回の調査(1957年)と今回の調査(1973年)との間の詳細な比較解析ができるようにした.<sup>1,2</sup> 顕微鏡観察は39倍の拡大率で実施し, 撮影した写真は3倍に引き伸ばした. なお, 今回の調査では, 顕微鏡所見を用いず, 写真のみをもとに評価した. 前回の調査では, 写真および顕微鏡所見の両者を用いて評価したので, 今回の調査では評価値の感度が幾分低下しているかも知れない.

前回の調査で検査を受けた435人の対象者のうち, 成人健康調査集団に属するのはわずか195人(男30/102人, 女165/333人)であった. 今回の調査期間中に定期検診を受けた者全員が検査の対象者として選ばれた. しかし, 望ましい追跡調査はできなかった.

## 結果

本調査のために選んだ1494例のうち, 120例は本調査への参加を拒否した者で, 1374例について顕微鏡による写真観察が行われた. 表2に被検者分布を線量群, 性および年齢別に示した. 被検者は各線量群とも年齢別および性別に等しく分布している. したがって, 検査拒否による調査の偏りは全く認められなかった. 反面, 毛細血管写真撮影に未経験の技術員によって撮影されたため判読できない多くの写真があった. 結局, 解析の対象として評価できうる満足な写真の数は, 指爪床部833枚(61%), 口唇粘膜556枚(40%), 舌下粘膜474枚(34%)であった(表3). さいわい, 評価できなかった不満足な写真は, 4調査群に無作為に分布しており偏っていなかった. こ

TABLE 2 DISTRIBUTION OF EXAMINEES BY DOSE, SEX, AND AGE

表2 線量、性および年齢別被検者分布

Age	Total	Dose Group in rad														
		Sex Combined <sup>a</sup>					Male					Female				
		NIC	<1	1-99	100+	Total	NIC	<1	1-99	100+	Total	NIC	<1	1-99	100+	Total
<40	141	32	32	39	38	62	12	17	14	19	79	20	15	25	19	79
40-49	457	110	113	128	106	192	48	49	51	44	265	62	64	77	62	265
50-59	285	77	69	69	70	112	36	24	26	26	173	41	45	43	44	173
60-69	316	83	85	79	69	122	28	32	32	30	194	55	53	47	39	194
70+	175	41	43	49	42	79	23	15	22	19	96	18	28	27	23	96
Total	1374	343	342	364	325	567	147	137	145	138	807	196	205	219	187	807

TABLE 3 DISTRIBUTION BY EXAMINATION SITE AND SEX OF ELIGIBLE CASES IN GRADING CAPILLARY FINDINGS

表3 毛細血管所見を評価した部位および性別対象者分布

Dose Group	Total			Male			Female			
	Total	Eligible*	%	Total	Eligible	%	Total	Eligible	%	
				Fingernail Fold						
NIC	343	212	61.8	147	85	57.8	196	127	64.8	
<1	342	204	59.6	137	75	54.7	205	129	62.9	
1-99	364	223	61.3	145	79	54.5	219	144	65.8	
100+	325	194	59.7	138	75	54.3	187	119	63.6	
Total	1374	833	60.6	567	314	55.4	807	519	64.3	
				Labial Mucosa						
NIC	343	145	42.3	147	63	42.9	196	82	41.8	
<1	342	136	39.8	137	50	36.5	205	86	42.0	
1-99	364	142	39.0	145	52	35.9	219	90	41.1	
100+	325	133	40.9	138	57	41.3	187	76	40.6	
Total	1374	556	40.5	567	222	39.2	807	334	41.4	
				Lingual Mucosa						
NIC	343	130	37.9	147	56	38.1	196	74	37.8	
<1	342	116	33.9	137	38	27.7	205	78	38.0	
1-99	364	118	32.4	145	43	29.7	219	75	34.2	
100+	325	110	33.8	138	45	32.6	187	65	34.8	
Total	1374	474	34.5	567	182	32.1	807	292	36.2	

\*Eligible cases mean those who were graded because of satisfactory photographs.

対象者とは、写真撮影が満足に評価されたものをいう。

four study groups. It is not likely to bias the results in any significant manner. Group 3 and Group 4 were combined and used as the control group, both groups being exposed to less than 1 rad.

The relationship between the two-score classification based on the same criteria as the previous

のことは有意性を結論づける結果に偏りはないと考えられる。第3群と第4群は1 rad未達の線量を受けた被爆者から構成されているので、対照群として合計した。

前回の調査と同じ基準に基づいた評価値2区分間の



study was analyzed for the fingernail fold (< 15 vs 15+), labial mucosa (< 9 vs 9+) and lingual mucosa (< 9 vs 9+).<sup>1,2</sup> In the previous study it was demonstrated that those with a score of 15+ in the fingernail fold and 9+ in labial and lingual mucosae presented gross morphological abnormalities.

**Fingernail Fold.** Of the morphological changes in the superficial minute vessels of the fingernail fold, 833 cases (314 males and 519 females) were graded for the degree and incidence of abnormalities of the evaluated items (Table 4). The relationship between the two-score classification (< 15 vs 15+) was found to be significantly higher in females (60.7%) than in males (49.4%) at the 2% level. However, no significant difference by sex was noted in the relationship between the score classification and dose group. Therefore, to examine the relationship of the two-score classification to dose, data were analysed with both sexes combined because the number of cases was not very large.

関係, すなわち, 指爪床部 (< 15対15+), 口唇粘膜 (< 9 対 9+) および舌下粘膜 (< 9 対 9+) による解析が行われた。<sup>1,2</sup> これは前回の報告で, 指爪床部の評価値15+, 口唇粘膜および舌下粘膜の評価値9+をもつ者に大きな形態的異常が認められたためである。

指爪床部. 指爪床部の表在性細小血管における形態的变化について, 833例(男314例, 女519例)が, 異常の程度および頻度を数量化した項目の評価値によって分類された(表4). 評価値2区分間の関係(< 15対15+)は, 2%の水準で女(60.7%)の方が男(49.4%)よりも有意に高いことが認められた。しかし, 性別の評価値区分および線量群との関係では有意差は認められなかった。例数もあまり多くないので, 評価値2区分と線量との関係を調べるために, 男女を合計して解析した。

TABLE 4 PROPORTION WITH SCORE 15+ FOR FINGERNAIL FOLD BY SEX AND DOSE  
表4 性および線量別指爪床部の評価値15+の割合

Sex	Total		Control		1-99 rad		100+ rad		Significant Level
	Number	%	Number	%	Number	%	Number	%	
Male	314	49.4	160	46.3	79	48.1	75	58.7	NS
Female	519	60.7	256	59.4	144	63.9	119	59.7	NS
Total	833	56.5	416	54.3	223	58.3	194	59.3	NS

The proportion with score 15+ by age and dose groups for the fingernail fold is shown in Table 5. The relation between radiation dose and score classification was found to be significant ( $P=0.3$ ) in only the young age group who were under the age of 40 at time of examination (ATE) or under the age of about 10 ATB. The proportion with score 15+ (67.3%) of the two groups combined exposed to 1 rad and over with a total mean dose of 165 rad (gamma of 122 rad and neutron of 43 rad) was significantly higher than that (40.0%) of the control group. Table 6 shows the mean values by the three age groups and the three dose groups, and the results of analysis of variance. Comparison of mean score values (Table 6A) with three age groups showed an evident increase in the control, starting from a low mean score of 13.4 at 27-39 years of age and thereafter increasing sharply to

表5に, 指爪床部の評価値15+の割合が年齢および線量群別に示されている。放射線量と評価値区分との関係は, 検査時40歳未満, すなわち原爆時10歳未満の若年齢群においてのみ有意差( $P=.03$ )が認められた。1 rad以上の線量を受けた2線量群の平均合計線量は165 rad (ガンマ線122 rad, 中性子線43 rad)で, 評価値15+の割合(67.3%)は, 対照群の割合(40.0%)よりも有意に高かった。年齢3群と線量3群別の平均値, および分散分析の結果は表6に示す。平均評価値と年齢3群との比較(表6A)では, 対照群において年齢27-39歳の平均評価値13.4という低値から急激に上昇して40歳後の15.4-16.2

TABLE 5 PROPORTION WITH SCORE 15+ FOR FINGERNAIL FOLD BY AGE AND DOSE

表5 年齢および線量別指爪床部の評価値15+の割合

Age ATE	Total		Control		1-99 rad		100+ rad		Significant Level
	Number	%	Number	%	Number	%	Number	%	
27 - 39	89	55.1	40	40.0	26	73.1	23	60.9	P .025
40 - 59	462	54.3	229	54.1	125	56.0	108	52.8	NS
60 +	282	60.6	147	58.5	72	56.9	63	69.8	NS
Total	833	56.5	416	54.3	223	58.3	194	59.3	NS

TABLE 6 SCORE FOR FINGERNAIL FOLD CAPILLARY &amp; TWO-WAY CLASSIFICATION DESIGN

表6 指爪床部の評価値および二元配置法

## A. Mean and standard deviation of score for fingernail fold capillary by dose and age

## A. 線量および年齢別指爪床部毛細血管の平均評価値および標準偏差 (SD)

Age ATE	Total			Control			1-99 rad			100+ rad			Significant Level
	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	
27 - 39	89	15.0	6.7	40	13.4	7.0	26	16.5	6.0	23	16.0	6.7	NS
40 - 59	462	16.0	7.1	229	15.4	7.0	125	16.1	6.8	108	16.9	7.6	NS
60 +	282	17.0	6.8	147	16.2	6.3	72	16.6	7.4	63	17.4	6.1	NS
Total	833	16.1	7.0	416	15.6	7.0	223	16.3	6.9	194	17.0	7.0	P .05

## B. Results of analysis of variance of two-way classification design

## B. 二元配置法による分散分析の結果

Item	Sum of Square	DF	Mean Square	F-ratios	
Age effect eliminating dose effect	199.66	2	99.83	2.05	NS
Dose effect ignoring age effect	299.01	2			
Dose effect eliminating age effect	317.78	2	158.89	3.27	P .04
Age effect ignoring dose effect	180.89	2			
Interaction	98.85	4	24.71	.51	NS
Between cells	597.52	8	74.69		
Within cells (error)	40065.48	824	48.62		
Total	40663.00	832			

reach the plateau values of 15.4 - 16.2 after 40 years of age. These curves for the control population were used as the control values for subsequent comparative study. As shown in Table 6B, the effect of radiation on score value, excluding the effect of age group, showed a significant difference at the 4% level for both sexes combined. However, the effect of age group on the score value, eliminating the effect of dose group, was found not to be significant because the number of cases in the young age group was small in comparison with the older age group.

のプラトー値に達する明らかな増加が認められた。対照群から得られた曲線を以後の比較調査で対照値として用いた。表6Bに示すように、年齢の影響を除いたとき放射線が評価値に及ぼす影響については、4%の水準で有意な差が男女合計した場合に認められた。一方、線量の影響を除いたとき、年齢が評価値に及ぼす影響については、若年群の例数が高齢群に比べて少ないため有意差は示唆されなかった。

TABLE 7 PROPORTION WITH SCORE 9+ FOR LABIAL MUCOSA BY SEX AND DOSE

表7 性および線量別口唇粘膜の評価値9+の割合

Sex	Total		Control		1-99 rad		100+ rad		Significant Level
	Number	%	Number	%	Number	%	Number	%	
Male	222	41.0	113	37.2	52	40.4	57	49.1	NS
Female	334	40.1	168	39.3	90	44.4	76	36.8	NS
Total	556	40.5	281	38.4	142	43.0	133	42.1	NS

TABLE 8 PROPORTION WITH SCORE 9+ FOR LABIAL MUCOSA BY AGE AND DOSE

表8 年齢および線量別口唇粘膜の評価値9+の割合

Age ATE	Total		Control		1-99 rad		100+ rad		Significant Level
	Number	%	Number	%	Number	%	Number	%	
27-39	61	37.7	26	34.6	19	26.3	16	56.3	NS
40-59	318	39.9	159	37.1	86	46.5	73	38.4	NS
60+	177	42.4	96	41.7	37	43.2	44	43.2	NS
Total	556	40.5	281	38.4	142	43.0	133	42.1	NS

TABLE 9 MEAN AND STANDARD DEVIATION OF SCORE FOR THE LABIAL MUCOSA BY DOSE AND AGE

表9 線量および年齢別口唇粘膜の平均評価値および標準偏差

Age ATE	Total			Control			1-99 rad			100+ rad			Significant Level
	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	
27-39	61	6.8	4.2	26	6.1	4.3	19	6.4	4.1	16	8.5	4.0	NS
40-59	318	7.2	4.9	159	6.9	5.0	86	7.4	4.7	73	7.6	5.0	NS
60+	177	7.5	5.1	96	7.4	4.8	37	7.5	5.3	44	7.7	5.4	NS
Total	556	7.3	4.9	281	7.0	4.9	142	7.3	4.8	133	7.8	5.0	NS

Labial Mucosa. For the labial mucosa, 556 cases (222 males and 334 females) were available for morphological evaluation (Table 7). The proportion with score 9+ appears to be slightly higher in the 100+ rad group in comparison with that of the control group for males. However, no significant difference was observed in the relationship between score and dose group. When the relationship of dose was compared by age group, the proportion of score 9+ in the 100+ rad group (56.3%) was higher than that in the control group (34.6%) for the young age group under 40 ATE or less than 10 ATB, but the difference was not significant (Table 8). Both comparisons of the proportion with score 9+ and of mean score values of three age groups showed no significant dose related difference (Tables 8 & 9).

口唇粘膜. 口唇粘膜では556例(男222例, 女334例)の形態的評価が行われた(表7). 男で100rad以上の線量群の評価値9+の割合は, 対照群に比べて若干高いようであった. しかし, 評価値と線量群との関係において, 有意な差は認められなかった. 線量関係を年齢群別に比較した場合, 100rad以上の線量を受けた群の評価値9+の割合(56.3%)は検査時40歳未満または原爆時10歳未満の若年齢群における対照群の割合(34.6%)よりも高かったが, この差は有意ではなかった(表8). 年齢3群についての評価値9+の割合(表8)と平均評価値の比較(表9)は, いずれも, 線量に関して有意な差を示さなかった.

TABLE 10 PROPORTION WITH 9+ FOR LINGUAL MUCOSA BY SEX AND DOSE

表10 性別および線量別舌下粘膜の評価値9+の割合

Sex	Total		Control		1-99 rad		100+ rad		Significant Level
	Number	%	Number	%	Number	%	Number	%	
Male	182	28.0	94	26.6	43	20.9	45	37.8	NS
Female	292	27.4	152	27.6	75	24.0	65	30.8	NS
Total	474	27.6	246	27.2	118	22.9	110	33.6	NS

TABLE 11 PROPORTION WITH 9+ FOR LINGUAL MUCOSA BY AGE AND DOSE

表11 年齢および線量別舌下粘膜の評価値9+の割合

Age ATE	Total		Control		1-99 rad		100+ rad		Significant Level
	Number	%	Number	%	Number	%	Number	%	
27 - 39	50	14.0	22	9.1	16	12.5	12	25.0	NS
40 - 59	274	30.3	139	30.2	72	23.6	63	38.1	NS
60 +	150	27.3	85	27.1	30	26.7	35	28.6	NS
Total	474	27.6	246	27.2	118	22.9	110	33.6	NS

TABLE 12 MEAN AND STANDARD DEVIATION OF SCORE FOR LINGUAL MUCOSA BY AGE AND DOSE

表12 年齢および線量別舌下粘膜の平均評価値および標準偏差

Age ATE	Total			Control			1-99 rad			100+ rad			Significant Level
	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	
27 - 39	50	4.3	3.0	22	3.6	2.7	16	4.3	2.7	12	5.3	3.7	NS
40 - 59	274	5.7	4.5	139	5.6	4.7	72	5.1	4.2	63	6.6	6.0	NS
60 +	150	5.8	4.3	85	5.8	4.4	30	5.4	4.0	35	6.0	4.5	NS
Total	474	5.6	4.3	246	5.5	4.4	118	5.1	3.9	110	6.3	4.5	NS

Lingual Mucosa. For the lingual mucosa, the proportion with score 9+ increased with dose in the young age group less than 40 ATE or less than 10 ATB. However, no statistically significant relation was noted in dose, sex, or age (Tables 10 and 11). The results of analysis of mean score were also insignificant (Table 12).

## DISCUSSION

As described in our previous report, we studied with a capillary microscope the superficial minute vessels of the fingernail fold, labial mucosa, and lingual mucosa in 435 young atomic bomb survivors approximately 10 years after exposure to the atomic bomb.<sup>1,2</sup> In that study the effects of radiation were evaluated by selecting important abnormalities considered to

舌下粘膜。舌下粘膜では、検査時40歳未満または原爆時10歳未満の若年齢群の評価値9+の割合は、線量と共に増加した。しかし、線量、性または年齢に関する統計学的な有意差は認められなかった(表10および11)。また平均評価値による解析結果も有意ではなかった(表12)。

## 考 察

前回の報告で指摘したように、毛細血管顕微鏡を用いて、原爆被爆から約10年後の若い原爆生存者435人の指爪床部、口唇粘膜、および舌下粘膜の表在性細小血管について調べた。<sup>1,2</sup> その調査研究では、老人性または退行性の形態的変化を示すと考えられる重

represent the senile or degenerative morphological changes.<sup>5-13</sup>

The present study was made approximately 30 years after exposure to the A-bomb for the purpose of following up the radiation effects observed in the previous study.

There have been many reports indicating that the morphological and functional abnormalities in the vascular system increase with age. This tendency was also observed in the current study with respect to the superficial blood vessels of fingernail fold, labial mucosa, and lingual mucosa. However, the differences that were observed are not statistically significant.

In the previous study (1956-57), significant effects of irradiation were demonstrated in the superficial minute vessels of the fingernail fold, labial mucosa, and lingual mucosa of those exposed to 100+ rad under the age of 10 ATB, but in the present study (1972-73) a significant effect was observed only for the fingernail fold. A similar tendency for increased abnormalities was observed in the labial mucosa and lingual mucosa although without significance.

The regression analysis was made for the various sites by studying first the relation of the scores to age and individual dose, and second, the relation of mean values to three age and dose groups. The slopes indicating the relation of scores to dose were compared between the control and exposed but no definite difference could be observed to demonstrate any effect of irradiation on aging.<sup>15,16</sup>

As the morphological abnormalities observed 10 years after the A-bomb can be considered irreversible late changes, the results of the current study conducted 30 years after the A-bomb suggest that radiation-induced late capillary changes still persist with minimal recovery. Physiologically, these changes may induce insufficient microcirculation and create a body burden. The significance of these results should be further pursued in relation to aging and pathological changes observed in the RERF Life Span Study sample.

The results of studies made heretofore on A-bomb survivors have suggested that radiation induces life shortening attributable primarily to

要な異常<sup>5-13</sup>を選んで、放射線の影響を評価した。

今回の調査は、前回の調査で認められた放射線の影響の追跡調査を行う目的で、原爆から約30年後に行った。

血管系における形態的および機能的異常が年齢と共に増加することを指摘した多くの報告がある。この傾向は、指爪床部、口唇粘膜、および舌下粘膜の表在性血管に関する現在の調査でも認められた。しかし、観察された差は統計的に有意性が認められるものではなかった。

前回の調査研究(1956-57年)では、原爆時10歳未満であった100 rad以上の線量を受けた被爆者の指爪床部、口唇粘膜、舌下粘膜の表在性細小血管には、放射線の有意な影響が認められたが、今回の調査研究(1972-73年)では、指爪床部にのみ有意な影響が認められた。口唇粘膜および舌下粘膜にも同じような傾向は認められたが、有意性は認められなかった。

各部位について、評価値と年齢および各人の線量との関係、さらに年齢3群および線量3群の平均値に対する関係を調べるために回帰分析が行われた。対照群と被爆群との間で線量の評価値に対する関係を示す勾配が比較されたが、加齢に及ぼす電離放射線の影響を示す明確な差は認められなかった。<sup>15,16</sup>

原爆10年後に観察された形態学的異常は不可逆性の後影響であると考えられたが、原爆30年経過して実施された今回の調査の結果は、放射線誘発の晩発性毛細管変化は最小の回復をもたらすが依然として認められることを示唆する。生理学的には、これらの変化は微小血管循環不全をもたらす、身体的な負荷の因となるかも知れない。これらの結果の意義は、放影研の寿命調査で観察される老人病的変化および病理学的変化との関係において追跡されるべきである。

原爆被爆者に関するこれまでの調査結果では、放射線は、主として癌による寿命の短縮をもたらすが、

cancers but not a general acceleration of the aging phenomenon. The findings of the present study are consistent with this tentative conclusion with respect to aging.

一般的に加齢現象を促進させるものではないことが示唆されている。本調査の結果は、加齢に関するこの暫定的な結論と一致するものである。

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