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Studies on Capillary Circulation in Patients with Neurocirculatory Asthenia (I)

By

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(Received for Publication. Aug. 1, 1959)

INTRODUCTION

Neurocirculatory asthenia also called irritable heart¹⁾, effort syndrome or anxiety neurosis is a condition of instability and abnormal irritability of the nervous and circulatory system²⁾. In addition to the four cardinal symptoms of palpitation, precordial pain, dyspnea and fatigability and variable additional symptoms such as dizziness, nervousness, headache, syncope, etc., it has numbness, paresthesia and cold sensation in the extremities. Generally it is thought to be a mere functional disorder due to disharmony of the autonomic nervous system, and psychiatrists consider it an anxiety neurosis in which the heart becomes the object of "organ-selection". Maekawa³⁾⁻¹¹⁾ pointed out that almost all of these neuroses may be conditioned by subclinical adhesive cerebrospinal arachnoiditis, wherein "organ-selection" is determined by arachnoiditis of the spine and "neurosis-selection" takes place in the cerebrum.

In 1946 Cobb et al¹²⁾ pointed out that in the nail folds of patients with neurocirculatory asthenia there were significantly more capillaries of complex form than in normal controls. These findings are mentioned in White's "Heart Disease"²⁾.

The author attempted to clarify the mechanism of circulation of the skin in patients with neurocirculatory asthenia and allied diseases (Allied disease means atypical neurocirculatory asthenia which has only 2 or 3 out of 4 cardinal symptoms of neurocirculatory asthenia.) by means of capillaroscopy with special reference to

Maekawa's subclinical adhesive cerebrospinal arachnoiditis.

MATERIALS AND METHODS

The observations were made with Leitz' ordinary microscope, with ocular $\times 6$, objective $\times 10$, giving a magnification of 60 times. For the source of illumination a projector lamp (1 kw.) was used. The light was filtered through three filters for heat removal, and a light green filter for obtaining clear contrast. The light was focused with a lens. The place which proved most favorable for observation was the base of the nails of the second and fifth fingers, because the fingers can be easily fixed and at the base of the nail the capillary loops become more horizontal from the underlying vessel plexus to the epidermis.

The subjects were observed after lying supine on a bed for 30 minutes. The room temperature was adjusted to about 20°C and humidity was between 50% and 60%.

The fingers were placed in the holder beneath the objective lens and a drop of cedar oil was spread, usually with a cover glass.

When the capillaries in the edge of the nail fold were brought into focus, an area was found where the outermost series of loops could be seen clearly. A series of 20 capillary loops was then drawn on paper by the observer, the number of capillaries per square mm. in the outermost series was counted in about three fields and photographs were taken to measure the height and diameter of the capillaries.

From the drawing, the capillaries were at first divided into three morphologic types representing (1) hairpin-shaped form, (2) looped form and (3) complex

form according to Cobb et al¹²⁾. After the respective percentages were counted, they were averaged for four fingers and the average was recorded as the score for that patients.

Studies were carried out on 89 patients with neurocirculatory asthenia and allied diseases, and 36 patients with hypertension, admitted to Maekawa Clinic, Kyoto University Hospital, and on 6 healthy students of Kyoto University. The age of these subjects is shown in Fig. 1.

Fig. 1. Distribution of age.

RESULTS

A. Comparison between neurocirculatory asthenia and control groups with regard to capillary appearance.

(1) Shapes.

After twenty capillaries of the outermost

series were drawn, the percentages of each form were counted and the counts averaged for four fingers.

The average for the normal control group was $80.4 \pm 9.6\%$ hairpin-shaped forms and for the hypertensive group it was $39.4 \pm 14.8\%$ hairpin-shaped forms, whereas the average for the patients with neurocirculatory asthenia and allied diseases was $48.7 \pm 15.9\%$. These differences between the neurocirculatory asthenia group and normal group and between the neurocirculatory asthenia group and the hypertension group are significant statistically ($P < 0.05$), even when corrected the factor of small number. Fig. 2a shows the difference between the neurocirculatory asthenia group and the control groups in the hairpin-shaped forms. The peak of the curve for the patients with neurocirculatory asthenia and allied diseases is at 50%, whereas for the normal controls there is no peak and for the hypertensive controls it is at 30%.

The average number of complex forms for the normal controls was $3.3 \pm 3.28\%$ and for the hypertensives it was $25.6 \pm 12.9\%$, whereas the average for the patients with neurocirculatory asthenia and allied diseases was $21.2 \pm 14.0\%$. The difference between the neurocirculatory asthenia group and the normal control group is a significant one ($P < 0.05$). The curves of complex forms are shown in Fig. 2b.

Fig. 2a. Comparison between neurocirculatory asthenia group and control groups with regard to percentage incidence of hairpin-shaped capillaries.

●—● Patients with neurocirculatory asthenia
○—○ Normal controls
×····× Patients with hypertension

Fig. 2b. Comparison between neurocirculatory asthenia group and control groups with regard to percentage incidence of complex form.

●—● Patients with neurocirculatory asthenia
○—○ Normal controls
×.....× Patients with hypertension

(2) Number of loops.

The number of capillary loops per square mm. in the outermost series of the finger nail bed were counted for three visual fields by the aid of a micrometer, and the average for four fingers was compared.

The average for the normal controls was 8.0 ± 1.18 capillaries per square mm. and for the hypertensive controls it was 9.8 ± 1.51 capillaries per square mm., whereas the average for patients with neurocirculatory asthenia and allied diseases was 9.5 ± 1.9 capillaries per square mm.

The difference between neurocirculatory asthenics and normal controls is significant statistically ($P < 0.05$), but the difference between neurocirculatory asthenia and hypertension is insignificant.

Fig. 3 shows the contrast between neurocirculatory asthenia group and the control groups as to capillary number.

(3) Height of loops.

In the photograph the individual capillaries were magnified 100 times. With this magnification several distinctly focused loops were measured about a distance from the tip of the capillary loop to the base of the venous arm. And the average value for four fingers was determined.

The average height of the loops for normal

Fig. 3. Comparison between neurocirculatory asthenia group and control groups with regard to number of capillary loops per square mm.

●—● Patients with neurocirculatory asthenia
○—○ Normal controls
×.....× Patients with hypertension

controls was 0.195 ± 0.052 mm. and for the hypertensive controls it was 0.173 ± 0.035 mm., whereas the average height for patients with neurocirculatory asthenia and allied diseases was 0.188 ± 0.047 mm. as Fig. 4 shows. But there are no statistically significant differences between neurocirculatory asthenia and the controls.

Fig. 4. Comparison between neurocirculatory asthenia group and control groups with regard to height of capillary loops.

- Patients with neurocirculatory asthenia
- Normal controls
- ×.....× Patients with hypertension

(4) Diameter of the capillary arms.

The caliber of the arterial and venous arms of the capillaries was studied by means of photography with magnification of 320 times. Several distinctly focused arms were measured and the average value for four fingers was calculated.

Although changes in the caliber of the loops took place from moment to moment, these changes were relatively small. Figs. 5 and 6 show the diameter of the arterial and venous arms, respectively.

The average diameter of the arterial arms for the normal controls was $10.2 \pm 0.8 \mu$ and for the hypertensive controls was $6.5 \pm 1.37 \mu$, whereas the average for the patients with neurocirculatory asthenia and allied diseases was $7.6 \pm 1.65 \mu$. The distribution of the diameter of the arterial arms in the neurocirculatory asthenia and hypertension group is wider than in the normal group as Fig. 5 shows. The range of distribution is in patients with neurocirculatory asthenia and allied diseases from 5μ to 13μ , in hypertensives between 4μ and 11μ and in normal controls from 9μ to 11μ . One case of neurocirculatory asthenia whose arterial diameter is 13μ and venous diameter is 17μ has a complication of Raynaud's disease, and these values are wider than normal controls.

The average diameter of the venous arms for the normal controls was $13.4 \pm 1.17 \mu$, for the

Fig. 5. Comparison between neurocirculatory asthenia group and control groups with regard to diameter of arterial arms.

- Patients with neurocirculatory asthenia
- Normal controls
- ×.....× Patients with hypertension

Fig. 6. Comparison between neurocirculatory asthenia group and control groups with regard to diameter of venous arms.

- Patients with neurocirculatory asthenia
- Normal controls
- ×.....× Patients with hypertension

patients with neurocirculatory asthenia was $11.2 \pm 2.2 \mu$ and for the hypertensives was $9.8 \pm 2.05 \mu$. As Fig. 6 shows, the distribution curve is between 12μ and 15μ for the normal controls, between 8μ and 17μ for the neurocirculatory asthenics and between 6μ and 16μ for hypertensives.

These differences in the arterial and venous arms are all significant statistically.

In other words, the patients with neurocir-

culatory asthenia and allied diseases have more contracted arterial and venous arms than normal controls except for one case with the complication of Raynaud's disease. And this fact is more conspicuous in the cases of hypertension.

(5) Blood flow through capillaries.

Blood flow was observed by simple microscope inspection of the capillaries but no measurements of velocity of blood flow were made. The measurement of velocity of blood flow through capillaries was established by Basler in 1919¹³⁾. But this method is rather difficult.

The author observed the blood flow through capillaries, then divided it into three groups; fast, normal and slow flow and, moreover, whether the flow was granular or not.

The blood flow varied in the different capillaries in the same subject and also in the same capillary from moment to moment. But in the normal cases the blood flow through capillaries was comparatively smooth and granular flow was scarcely seen at 20°C. Moreover, when the room temperature raised above 20°C, there was no granular flow in most cases of neurocirculatory asthenia and allied diseases and hypertension.

As to the velocity of blood flow through capillaries, in 83.3% of normal controls it was normal and in 16.7% it was slow, in 66.6% of the patients with neurocirculatory asthenia and allied diseases it was slow and in 63.2% of hypertensives it was slow at 20°C as TABLE I shows.

TABLE I VELOCITY OF BLOOD FLOW THROUGH CAPILLARIES.

Flow	Normal controls	Neurocirculatory asthenics	Hypertensives
fast	0 %	4.8%	10.5%
normal	83.3	28.6	26.3
slow	16.7	66.6	63.2

In addition, at 20°C, 16.7% of normal controls had granular flow, 78.8% of hypertensives also had granular flow, whereas 70.3% of those with neurocirculatory asthenia and allied diseases had granular flow as TABLE II shows.

TABLE II GRANULAR FLOW.

Granular flow	Normal controls	Neurocirculatory asthenics	Hypertensives
(+)	16.7%	70.3%	78.8%
(-)	83.3	29.7	21.2

Figs. 7a, b and c show photographs of capillaries at the edge of the nail fold of normal controls, patients with neurocirculatory asthenia and hypertensive controls.

B. Relation of capillary appearance to subjective symptoms in patients with neurocirculatory asthenia.

In 83 out of 89 cases of neurocirculatory asthenia and allied diseases, comparisons between capillary picture of the finger nail folds and subjective symptoms were made. Headache, stiffness of shoulders, abnormal sensation in the upper extremities such as paresthesia, numbness or cold sensation, precordial pain or palpitation, dyspnea, abdominal pain or discomfort were selected and compared. These results are shown in TABLE III.

The average of hairpin-shaped forms in patients complaining of headache was $48.9 \pm 15.9\%$, and without headache it was $50.3 \pm 14.9\%$. It was $49.4 \pm 14.9\%$ in patients with stiff shoulders and $50.8 \pm 15.9\%$ those without stiff shoulders. The average of hairpin-shaped forms for patients complaining of abnormal sensation in the upper extremities was $45.3 \pm 15.4\%$ and for those complaining of no abnormal sensation in the upper extremities it was $56.4 \pm 12.6\%$. It was $46.8 \pm 15.1\%$ for the patients with precordial pain or palpitation and was $58.5 \pm 12.4\%$ in those without these complaints. It was $50.8 \pm 14.4\%$ in those complaining of dyspnea and $48.8 \pm 15.7\%$ in those patients without it, whereas the average of hairpin-shaped forms for patients complaining of abdominal pain or discomfort was $48.2 \pm 14.8\%$ and for those without abdominal complaints it was $51.4 \pm 17.1\%$. The differences between the patients with the complaint of abnormal sensation in the upper extremities and those without them and between the patients complaining of precordial pain or palpitation and without them are significant statistically ($P < 0.05$).

As to the average of the complex forms, statistically significant differences were found between the patients with complaints of abnormal sensation in the upper extremities and those without them.

As to the average number of loops and the height of the loops no statistically significant differences were found.

The average diameter of the arterial arms for the patients complaining of headache was 7.4

0.2 mm.

Fig. 7a. Capillaries in normal subjects.

- (1) J. M. 20-year-old man.
 - (2) R. M. 18-year-old man.
 - (3) J. S. 20-year-old man.
- b. Capillaries in patients with neurocirculatory asthenia.
- (1) T. N. 29-year-old man. With complication of W. P. W. syndrome.
 - (2) H. S. 21-year-old woman.
 - (3) Y. M. 37-year-old woman.
 - (4) F. M. 39-year-old woman. With complication of lone arrhythmia perpetua.
 - (5) K. N. 26-year-old man.
 - (6) H. K. 40-year-old woman. With complication of Raynaud's disease.
- c. Capillaries in patients with hypertension.
- (1) S. T. 49-year-old man.
 - (2) M. K. 66-year-old man.
 - (3) H. S. 49-year-old woman. With complication of hemiparesis. (paresed side)

TABLE III. SUBJECTIVE SYMPTOMS AND CAPILLARY APPEARANCE.

	Headache		Stiffness of shoulder		Abnormalities in upper extremities		Precordial pain or palpitation		Dyspnea		Abdominal discomfort	
	+	-	+	-	+	-	+	-	+	-	+	-
Number of cases	50	33	51	31	48	35	64	19	34	49	48	35
Hairpin forms (%)	48.8	50.3	49.4	50.8	45.3	56.4	46.8	58.5	50.8	48.8	48.2	51.4
Complex forms (%)	20.9	17.4	19.0	20.2	23.5	16.1	20.7	15.5	18.4	20.0	20.2	21.0
Number of loops per sq. mm.	9.7	8.9	9.5	9.7	9.0	9.7	9.4	9.6	9.0	9.8	9.2	9.7
Height of loops (mm.)	0.180	0.183	0.187	0.188	0.178	0.198	0.184	0.198	0.180	0.192	0.188	0.186
Diameter of arterial arms (μ)	7.4	8.0	7.5	7.9	7.9	7.5	7.5	8.1	7.4	7.9	7.9	7.2
Diameter of venous arms (μ)	11.3	11.4	11.2	11.5	11.3	12.4	11.2	12.0	10.8	11.8	11.8	10.7
Velocity of blood flow (%)	{ fast normal slow	4.6	6.5	5.0	5.9	8.7	0	0	7.1	10.0	0	12.5
		31.8	18.3	20.0	29.4	21.7	28.6	22.2	25.0	25.0	23.5	33.3
		63.6	75.0	75.0	64.7	69.6	71.4	77.8	67.9	65.0	76.5	66.7
Granular flow (%)	{ + -	65.8	80.0	74.3	69.6	74.4	75.0	84.6	68.2	65.4	78.1	69.4
		32.4	20.0	25.7	30.4	25.7	25.0	15.4	31.8	34.6	21.0	30.6

$\pm 1.1\mu$ and for those not complaining of them was $8.0 \pm 2.1\mu$, for the patients complaining of precordial pain or palpitation it was $7.5 \pm 1.61\mu$ and for those having no complaint of precordial pain or palpitation it was $8.1 \pm 1.8\mu$. However the average diameter of the arterial arms in patients complaining of abdominal discomfort was $7.9 \pm 1.74\mu$ and for those not complaining of abdominal discomfort it was $7.2 \pm 1.1\mu$. But these differences are all insignificant statistically.

With regard to the average diameter of the venous arms statistically significant difference was found only between the patients with and without complaints of abnormalities of the upper extremities.

As for the blood flow through capillaries statistically significant differences were observed between the patients with and without complaints of precordial pain or palpitation.

This indicates that the patients complaining of abnormal sensation such as paresthesia, numbness or cold sensation in the upper extremities and precordial pain or palpitation have more abnormally twisted and contracted capillaries than patients not complaining of these symptoms. The patients with complaints of abdominal discomfort or pain have more dilated capillaries than patients without them. In fact, patients with "abdominal neurosis"¹⁷⁾ showed twisted but rather dilated capillaries.

C. Relation of capillary appearance to myelograms.

According to Maekawa and Konishi¹⁰⁾¹⁴⁻¹⁸⁾, myelographically demonstrable arachnoid adhesions are statistically correlated with the complaints of patients with neurocirculatory asthenia and allied

diseases. So the author made a comparative study of the capillaroscopic findings of the finger nail folds and of the myelograms in 67 out of 89 patients with neurocirculatory asthenia and allied diseases. In 5 out of 67 patients the ventral myelograms were not obtained. The myelographies were carried out by Dr. Konishi.

(1) Shapes.

In 41 out of 62 cases having less than 59% of hairpin-shaped forms, there was a high incidence of arachnoid adhesions at the vertebral levels "Cv, VII, DIII-VI" ventrally as Figs. 8a and b show. These results were statistically significant. In the myelograms of the dorsal area, there was no significant difference between patients having more than 60% of hairpin-shaped forms and the patients having less than 59% hairpin-shaped forms.

(2) Number of capillary loops.

There were more arachnoid adhesions at vertebral levels "CvI, VII, DII, III" ventrally among 32 cases having 7-9 loops per square mm. than among 24 cases having more than 10 loops per square mm., as Figs. 9a and b show. In the myelograms of the dorsal area there was no significant difference between the two groups.

(3) Height of capillary loops.

Comparing 43 cases with loops shorter than 0.199 mm. with 22 cases having loops longer than 0.200 mm., there were more arachnoid adhesions at the vertebral levels Cv dorsally and DIII ventrally in the former as Fig. 10 shows.

(4) Diameter of capillary arms.

There were more arachnoid adhesions at vertebral levels "DI, II, IV, VI, VII" ventrally in cases having arterial arms 9-11 μ than in 41 cases having arterial arms narrower than 8 μ as Fig. 11

Fig. 8a. Hairpin-shaped form and myelograms (dorsal area).

- 22 cases having more than 60% hairpin-shaped forms
 ●—● 45 cases having less than 59% hairpin-shaped forms

Fig. 8b. Hairpin-shaped form and myelograms (ventral area).

- 21 cases having more than 60% hairpin-shaped forms
 ●—● 41 cases having less than 59% hairpin-shaped forms

Fig. 9a. Number of loops per square mm. and myelograms (dorsal area).

- 37 cases having 7-9 loops per square mm.
- 25 cases having more than 10 loops per square mm.

Fig. 9b. Number of loops per square mm. and myelograms (ventral area).

- 32 cases having 7-9 loops per square mm.
- 24 cases having more than 10 loops per square mm.

Fig. 10a. Height of loops and myelograms (dorsal area).

- 22 cases having loops longer than 0.200 mm.
 ●—● 43 cases having loops shorter than 0.199 mm.

Fig. 10b. Height of loops and myelograms (ventral area).

- 21 cases having loops longer than 0.200 mm.
 ●—● 39 cases having loops shorter than 0.199 mm.

Fig. 11a. Diameter of arterial arms and myelograms (dorsal area).

○—○ 11 cases with arterial arms 9-11 μ .
 ●—● 45 cases with arterial arms narrower than 8 μ .

Fig. 11b. Diameter of arterial arms and myelograms (ventral area).

○—○ 10 cases with arterial arms 9-11 μ .
 ●—● 41 cases with arterial arms narrower than 8 μ .

Fig. 12a. Diameter of venous arms and myelograms (dorsal area).

- 20 cases with venous arms 12-15 μ .
 ●—● 42 cases with venous arms narrower than 11 μ .

Fig. 12b. Diameter of venous arms and myelograms (ventral area).

- 18 cases with venous arms 12-15 μ .
 ●—● 39 cases with venous arms narrower than 11 μ .

Fig. 13. Granular flow and myelograms (ventral area).

- 10 cases without granular flow
●—● 32 cases with granular flow

Fig. 14. Hairpin-shaped form and pneumoencephalograms.

- adhesion or irregular sulci
● broadened or deepened sulci
× atrophic changes in the cerebrum

Fig. 15. Number of loops per square mm. and pneumoencephalograms.

- adhesion or irregular sulci
● broadened or deepened sulci
× atrophic changes in the cerebrum

Fig. 16. Height of loops and pneumoencephalograms.

- adhesion or irregular sulci
- broadened or deepened sulci
- × atrophic changes in the cerebrum

shows.

Among 18 cases having venous arms 12–15 μ and 39 cases having venous arms narrower than 11 μ , arachnoid adhesions occurred with higher frequency in the latter group at the vertebral levels “DII-V” ventrally as Fig. 12 shows. In the myelograms of the dorsal area there was no significant difference between those with and those without contracted capillaries.

(5) Blood flow through capillaries.

Among 8 cases with normal velocity of blood flow and 11 cases with slow or sluggish blood flow, arachnoid adhesions occurred with higher frequency in the latter at vertebral levels “CVII, DII, IV” ventrally.

Arachnoid adhesions were more frequent at the vertebral levels “Cv–DVI” ventrally in 32 cases having granular blood flow than in 10 cases having smooth blood flow as Fig. 13 shows.

D. Relation of capillary appearance to

Fig. 17. Diameter of arterial arms and pneumoencephalograms.

- adhesion or irregular sulci
- broadened or deepened sulci
- × atrophic changes in the cerebrum

pneumoencephalograms.

The author correlated the capillaroscopic findings of the finger nail folds with pneumoencephalograms¹⁰⁾¹⁹⁾ performed by Dr. Sawami.

The pneumoencephalographic findings were divided into three classes: adhesions or irregular sulci, broadened or deepened sulci and atrophic changes in the cerebrum.

(1) Adhesions or irregular sulci and capillaries of finger nail folds.

Adhesions or irregular sulci occurred with high frequency in the precentral area and the parietal lobe in cases with less than 59% hairpin-shaped capillaries. These findings were also frequent in the frontal lobe in cases having more than 10 capillaries per square mm. and in the precentral area in cases with slow blood flow through capillaries. There were no significant differences between cases with capillaries longer than 0.200 mm. and those with capillaries shorter than 0.199 mm.

Fig. 18. Diameter of venous arms and pneumoencephalograms.

- adhesion or irregular sulci
- broadened or deepened sulci
- × atrophic changes in the cerebrum

or between those less than 8μ and those $9-11\mu$ in the diameter of the arterial arms, or between those less than 11μ and those $12-15\mu$ in the diameter of the venous arms.

(2) Broadened or deepened sulci and capillaries.

Broadened or deepened sulci occurred with high frequency in the island in cases with more than 10 capillaries per square mm., and at the inner surface of the frontal lobe in cases with capillaries longer than 0.200 mm. There were no significant differences between the cases having more than 60% hairpin-shaped forms and those with less than 59%, between those less than 8μ and those $9-11\mu$ in the diameter of the arterial arms, and between those less than 11μ and those $12-15\mu$ in the diameter of the venous arms.

(3) Atrophic changes in the cerebrum and capillaries.

Atrophic changes in the pneumoencephalo-

Fig. 19. Granular flow and pneumoencephalograms.

- adhesion or irregular sulci
- broadened or deepened sulci
- × atrophic changes in the cerebrum

grams occurred with high frequency in the frontal lobe, the precentral area, the central area and the preoptic area of the hypothalamus in cases with hairpin-shaped forms less than 59% (Fig. 14); in the frontal lobe, the precentral area, the central area and the preoptic area of the hypothalamus in cases with more than 10 capillaries per square mm. (Fig. 15); and in the frontal lobe, under surface of the frontal lobe, the parietal lobe and the posteroinferior area of the hypothalamus in cases with capillaries shorter than 0.199 mm. (Fig. 16). Atrophic changes in the cerebrum were often seen in the pneumoencephalograms in the frontal lobe, the island and the cerebellar hemispheres in cases with arterial arms contracted less than 8μ and in the posterior part of the interpeduncular cyst in cases with arterial arms $9-11\mu$ in diameter (Fig. 17). They occurred with high frequency in the parietal lobe, the island and the posterior area of

the hypothalamus in cases with venous arms contracted less than 11μ (Fig. 18); in the frontal lobe and the parietal lobe in cases with granular flow, and in the posterior part of the interpeduncular cyst in cases without granular flow (Fig. 19). In relation to velocity of blood flow through capillaries, atrophic changes in the cerebrum occurred in the frontal lobe, the preoptic area of the hypothalamus and the central area in cases with slow blood flow, and in the posterior part of the interpeduncular cyst in cases with normal blood flow (Fig. 20).

Fig. 20. Velocity of blood flow through capillaries and pneumoencephalograms.

- adhesion or irregular sulci
- broadened or deepened sulci
- × atrophic changes in the cerebrum

These data confirmed that there was scarcely any relation between adhesions or irregular sulci and broadened or deepened sulci as seen in pneumoencephalograms and capillaries of the finger nail folds. Atrophic changes in the cerebrum, as seen in pneumoencephalograms in the frontal lobe, the precentral area, the central area, the parietal lobe and the preoptic area and the posterior area of the hypothalamus mainly, co-

incided with the abnormal capillary findings. But atrophic changes also occurred with high frequency in the posterior part of the interpeduncular cyst in cases with normal blood flow.

E. Changes in capillaries with improvement of conditions in patients with neurocirculatory asthenia.

23 out of 89 patients with neurocirculatory asthenia and allied diseases were re-examined. The condition of the patients was improved in 17 out of 23 cases, but in 6 out of 23 cases there was no improvement even after treatment.

(1) Shapes.

As Figs. 21a and b indicate, there was no significant difference in percentages of hairpin-shaped and complex forms before and after treatment.

Fig. 21a. Hairpin-shaped form before and after treatment.

- improved cases
- unimproved cases

Fig. 21b. Complex form before and after treatment.

- improved cases
- unimproved cases

Fig. 22. Number of capillary loops per square mm. before and after treatment.

○ improved cases
● unimproved cases

Fig. 23. Height of loops before and after treatment.

○ improved cases
● unimproved cases

Fig. 24a. Diameter of arterial arms before and after treatment.

○ improved cases ● unimproved cases

Fig. 24b. Diameter of venous arms before and after treatment.

○ improved cases ● unimproved cases

Vasodilatation can also be produced by antidromic stimulation of sensory nerves²⁷⁾²⁸⁾. Nerve pathways concerned with vasoconstriction and dilatation are depicted in Fig. 26²³⁾.

Fig. 26. Diagram of sympathetic vasomotor pathways to limbs.

Another way in which the caliber of blood vessels may be affected is by substances circulating in the blood capable of producing vasoconstriction and vasodilatation²⁹⁾. Of the physiologic substances capable of such action, epinephrine³⁰⁾ and norepinephrine³¹⁾ are well known. Ordinarily there is no epinephrine or norepinephrine circulating in the blood in assayable amounts sufficient to affect vascular caliber³²⁾. During stress, however, such humoral vasoconstriction may be considerable. Moreover there are vasoconstrictive substances derived from the kidney or from the blood and the brain³³⁾.

In addition to humoral and nervous control, there is some evidence that local factors may exercise basic control over vascular caliber³⁴⁾. The local factors may be influenced by various local and general metabolic changes. Local injury, for example, releases H-substance which provokes the triple response of Lewis³⁵⁾. However, the effect of local factors is often obscured

by nervous and humoral effects.

The author found that in patients with neurocirculatory asthenia and allied diseases there were more capillaries of complex form, slightly increased loops, contracted arterial and venous arms and sluggish granular blood flow than in normal controls.

The capillary forms change in chronic diseases such as the peripheral vascular disorders, nephritis, diabetes mellitus, arteriosclerosis, etc. Müller³⁶⁾ and his school³⁷⁾³⁸⁾ studied the capillaries in the various clinical conditions and concluded that the vasoneurotic diathesis was manifested as "Vasomotorismus" in youth and as arteriosclerosis in the aged. Weiss and Holland³⁹⁾ found that in patients with vasoneurosis there occurred abnormal capillary forms in the finger nail folds. Parrisius⁴⁰⁾ found that there were very abnormal capillaries adjacent to normal capillaries in vasoneurotic patients. Hagen⁴¹⁾ and Zeitz-Kuckenburg⁴²⁾ found the twisted capillaries and distinctly visible subcapillary venous plexus in "Vasomotoriker". In 1946 Cobb et al¹²⁾ studied capillaries of the finger nail folds in patients with neurocirculatory asthenia. They concluded that in 48 patients with neurocirculatory asthenia there were more capillaries of complex form than in 44 normal controls and the percentages of complex form in each class of subject studied were as follows: normal controls, 21; convalescent controls, 35; patients with acute neurocirculatory asthenia, 53; patients with chronic neurocirculatory asthenia, 56. The author's data as for capillary shape almost coincide with these Cobb's data. The irregular arrangement and winding loops of capillaries were observed by Büchsel⁴³⁾ in 55 patients with "vegetative Dystonie". These disturbances in the capillaries were similar to the variation in anxiety neurosis, hysteria, epilepsy and mental defect⁴⁴⁾⁻⁴⁵⁾. In patients with neurocirculatory asthenia and allied diseases, it is conceived that there may be chronic stimulation such as changes in nervous, humoral or metabolic controls or local asphyxia, and so changes in capillary shape occur.

Contracted arterial arms of capillaries were observed by Tomita⁵⁰⁾ in patients with vasoneurosis and Sugiura⁵¹⁾ in 21 cases of circumscribed arachnoiditis in our country. Parrisius⁴⁰⁾ observed the capillaries of vasoneurotic patients and said that there were so-called spastic atonic symptoms

such as contracted arterial arms and dilated venous arms and a tendency to anastomoses and bleeding. The author found contracted arterial arms and venous arms. Since the discovery by Rouget⁽⁵²⁾⁻⁽⁵⁴⁾ of cells in walls of capillaries which he believed to be a contractile nature, many investigators⁽³⁶⁾⁽⁵⁵⁾⁽⁵⁶⁾ gave strong support to the view that there is independent contractility in capillaries. Although the capillaries are probably not innervated directly, capillary flow is influenced by the blood flow of arteries and veins. Recently Folkow⁽⁵⁷⁾ stated that the true capillaries are not contractile in mammals but the vasoconstrictor fibers may markedly influence the capillary function. Therefore, there are two possible explanations of the narrow arterial and venous arms: the arterioles or metarterioles contract reducing the blood flow into the capillaries, or active contraction of capillaries occurs. Prolonged and severe arteriolar spasm caused reactive hyperemia⁽³⁶⁾. Accordingly, in cases with neurocirculatory asthenia and allied diseases it may be concluded that local arteriolar spasm or active contraction of capillaries of the skin occurs, but this is not very severe.

In 1918 Briscoe⁽⁵⁸⁾ for the first time studied capillary pressures in patients with irritable heart by means of the indirect Hooker's method and concluded that capillary pressures were elevated and the chief vascular spasm occurred distal to the capillaries. Parrisius⁽⁴⁰⁾ observed that the flow through capillaries alternated between fast and sluggish. Tomita⁽⁵⁹⁾ and Sugiura⁽⁵¹⁾ reported abnormal capillary flow in patients with vaso-neurosis. Büchsel⁽⁴³⁾ also observed slow blood flow through capillaries and disturbed "Tagesrhythmus" in patients with "vegetative Dystonie". Although the author conducted these examinations at 20°C and by the aid of strong light for illumination, blood flow was slow and granular in patients with neurocirculatory asthenia and allied diseases. Slow or granular blood flow may occur in normal healthy persons, but in normal cases it is rarely seen at given conditions. Slow and granular blood flow occurs in cases with arteriolar constiction, or interference with venous return, but only rarely with the latter⁽³⁶⁾.

In patients with neurocirculatory asthenia and allied diseases increased capillary loops were observed by the author, but the significance of this fact is not clear.

After treatment, when the patients' condition

has improved, blood flow through capillaries and the diameter of the arterial and venous arms tend to return to the normal range.

Moreover, it is interesting that there is a consistent progression from the most normal to the most abnormal capillaries, beginning with the normal controls and proceeding through patients with neurocirculatory asthenia and allied diseases to hypertensive patients. And the patients complaining of abnormal sensations in the upper extremities such as numbness, paresthesia and cold sensation, and precordial pain or palpitation have more abnormal capillaries than the patients not complaining of them.

As above mentioned, Maekawa⁽³⁾⁻⁽¹¹⁾ considered that the cause of neurocirculatory asthenia was subclinical adhesive cerebrospinal arachnoiditis. He examined these patients by myelography and pneumoencephalography and pointed out that there was a statistical correlation between frequency of occurrence of arachnoid adhesion at a given level of the spinal cord and the occurrence of complaints referred to the organ innervated by the involved segment. Moreover Maekawa and Morimoto⁽⁶⁰⁾⁽⁶¹⁾ reported that degenerative changes were found histologically in nerve cells especially of the lateral horn in the portion involved in arachnoid adhesion.

The author made a statistical comparative study on the capillaroscopic findings of finger nail folds and the myelographic findings in patients with neurocirculatory asthenia and allied diseases, and found that in patients having abnormal capillary pictures the myelograms had a high incidence of arachnoid adhesions at vertebral levels C_{vi}-D_v (at cord levels C₇-T₈) ventrally. These levels almost coincide with the preganglionic outflow to the blood vessels of the fingers (C₈-T₉) through anterior root⁽²⁸⁾⁽⁶²⁾⁻⁽⁶⁷⁾. Vasodilatation occurs upon stimulation of the posterior root⁽⁶³⁾, and it is limited to the dermatomal segment supplied by the posterior root being studied⁽⁶⁶⁾. But in the dorsal area no significant differences were discovered in the myelograms.

The author made a comparative study also on the capillaroscopic findings of finger nail folds and the pneumoencephalographic findings, and found that in patients having more abnormal capillaries pneumoencephalograms displayed atrophic changes in the cerebrum mainly in the premotor and motor cortex, the parietal lobe and the hypo-

thalamus. These areas coincide with that the center of sympathetic nerves to the peripheral blood vessels³⁹⁾⁻⁷⁹⁾ (premotor cortex and the hypothalamus). Moreover, in patients with neurocirculatory asthenia there may occur changes in metabolism⁸⁰⁾⁸¹⁾ or increase of circulating epinephrine like under the stress and those may cause the disturbances of capillary circulation. But, in this paper, the humoral and local control of peripheral blood vessels has not been discussed, because our knowledge of these controls is fragmentary.

SUMMARY

Capillary pictures of finger nail folds were studied in 89 patients with neurocirculatory asthenia and allied diseases, while 6 healthy persons and 36 patients with hypertension served as controls.

(1) In patients with neurocirculatory asthenia and allied diseases there were significantly less capillaries of normal hairpin-shaped form, more capillary loops per square mm., narrower arterial and venous arms and slower and granular blood flow through capillaries than in normal controls. But these abnormal findings are slighter than in patients with hypertension.

(2) The cases with subjective symptoms such as numbness, paresthesia or cold sensation of upper extremities and precordial pain or palpitation showed abnormal capillaries than the cases without these symptoms.

(3) In comparative statistical studies, myelograms revealed a high incidence of arachnoid adhesions at cord levels mainly between C₇ and T₈ (at vertebral levels C_{VI}-D_V) ventrally in patients with neurocirculatory asthenia and allied diseases showing abnormal capillaroscopic findings.

(4) In patients with neurocirculatory asthenia and allied diseases showing abnormal capillaroscopic findings, the pneumoencephalograms revealed a high incidence of atrophic changes mainly in the premotor and motor cortex, the parietal lobe and the hypothalamus.

(5) After the conditions were improved by treatment, the diameter of the arterial and venous arms and blood flow through capillaries tended to return to normal.

(6) It may be concluded that in patients with neurocirculatory asthenia there is peripheral vasoconstriction of the skin, but not very severe.

This constriction is probably due to sympathetic stimulation by subclinical cerebrospinal adhesive arachnoiditis.

The author wishes to express her thanks to Professor Dr. M. Maekawa for his constant interest and valuable suggestions in carrying out this work. The author also indebted to Dr. H. Sawami and Dr. N. Konishi of our clinic for their kind aid.

A part of this paper was reported at the 5th Kinki Regional Meeting of the Japanese Circulation Society.

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