The Archives of Internal Medicine

Vol. XIII

FEBRUARY, 1914

No. 2

STUDIES ON THE CIRCULATION IN MAN

XI. THE BLOOD-FLOW IN THE HANDS AND FEET IN CERTAIN DISEASED CONDITIONS OF THE VESSELS OR OF THEIR VENOUS MECHANISM *

G. N. STEWART, M.D.
CLEVELAND

I. ARTERIOSCLEROSIS

It need scarcely be pointed out that several of the patients in the previous paper suffered from arteriosclerosis, in addition to valvular lesions of the heart or myocardial changes. In this section a few cases are brought together in which arteriosclerosis was pronounced and other lesions if present did not dominate the clinical picture. As a general result of the observations, it may be stated that in marked arteriosclerosis the flow in the hands is always smaller and the vasomotor reflexes weaker than in normal persons. Vasodilatation is easier to obtain by the application of warmth to the contralateral hand than vasoconstriction by the application of cold.

One of the purest cases of marked arteriosclerosis is that of Meyer G., a man aged 39, without detectable cardiac involvement. The flow was only 2.88 grams for the right hand and 3.46 grams for the left hand per 100 c.c. of hand per minute, with room temperature 22 C. An increase to 3.96 grams in the right was occasioned by immersion of the left hand in warm water, and the flow only fell to 3.52 grams when the left hand was subsequently put into cold water. It must not be forgotten, however, in connection with the small flow in this case that the man was a peddler accustomed to expose his hands in the open air in winter. Also he was a dispensary patient, and came from his work on a day in February.¹

Meyer G., Hebrew peddler, aged 39, height 5 feet 6½ inches, was admitted at the dispensary Sept. 3, 1910, with marked arteriosclerosis. There was great thickening of all accessible arteries. The heart examination was negative in result. He complains of having had pain in the stomach during the past year. A test-meal showed free hydrochloric acid. No masses are palpable in the abdomen. He attributes his condition to strain in pushing heavy loads on his hand-cart. The hand flow was measured Feb. 3, 1911. He still complains of pain

* From the H. K. Cushing Laboratory of Experimental Medicine, Western Reserve University.

1. See Paper IX of this Series, THE ARCHIVES INT. MED., 1913, xii, 678.

in the epigastrium. On emptying capillaries on the back of the hand by pressure the color returns very slowly. Pulse, 72. Mouth temperature, 36.7 C. Systolic pressure in the right brachial, 110. Hands put into bath at 2:49 p. m.; into calorimeters at 2:59½.² Volume of right hand in calorimeter, 525 c.c.; of left hand, 525 c.c. He is right-handed. His hands are large. (Table 1.)

Another outside worker (John O'R.), a street laborer aged 60, with a diagnosis of arteriosclerosis and myocarditis, had a flow of 5.49 grams per 100 c.c. per minute in the right hand and 5.44 grams in the left hand with room temperature 23 C. The contralateral vasoconstriction to cold

TABLE 1.—CALORIMETRIC MEASUREMENTS IN CASE OF MEYER G.

Time	Right	Left	Notes	Time	Right	Notes
2:58½	29.74	29.81		3:28	29.98	
3:01	29.69	29.75		3:29	30.00	
3:02	29.70	29.74	Room temp. 22.2 C.	3:30	30.02	
3:03	29.70	29.74		3:31	30.07	At 3:31 left hand put in water at 7.2 C.
3:04	29.70	29.74				
3:05	29.70	29.75		3:32	30.09	
3:06	29.70	29.75		3:33	30.11	
3:07	29.69	29.76		3:34	30.13	
3:08	29.69	29.75		3:35	30.16	
3:09	29.69	29.75		3:36	30.18	
3:10	29.69	29.78	Room temp. 22.3 C.	3:37	30.20	Room temp. 21.9 C.
3:11	29.71	29.80		3:38	30.21	
3:12	29.72	29.81		3:39	30.22	
3:13	29.73	29.82		3:40	30.23	
3:14	29.75	29.85		3:41	30.25	
3:15	29.77	29.89		3:42	30.27	At 3:42 left hand dried and wrapped in warm cloth.
3:16	29.78	29.90				
3:17½	29.80	29.93		3:43	30.29	
3:19	29.82	29.97		3:44	30.31	
3:20	29.83	30.00		3:45	30.33	
3:21	29.86	30.01	Room temp. 21.7 C.	3:46	30.36	Room temp. 22 C.
3:22	29.88	30.03		3:47	30.39	
3:23	.....	30.08	At 3:23 left hand put in water at 43 C.	3:48	30.42	
				3:49	30.45	Room temp. 22.2 C.
3:24	29.90	.....		3:50	30.48	At 3:50 hand out of calor.
3:25	29.92	.....		3:51	.....	Temp. of L. is now 29.75 C.
3:26	29.94	.....	Room temp. 21.6 C.	4:16	30.13	
3:27	29.96	.....		4:17	.....	Temp. of L. is now 29.48.

was slight, the flow in the right hand diminishing from 5.49 grams to 4.78 grams, but warmth gave a fair vasodilatation after the usual preliminary vasoconstriction. The protocol has already been published.³

Charles S., a man aged 69, with sclerosed vessels, high blood-pressure and enlarged cardiac dulness, but no murmurs, had a flow in the right hand of only 5.25 grams per 100 c.c. per minute and in the left a flow of 5.01 grams, with the high room temperature of 28.3 C. The response

2. In all the observations unless otherwise stated the quantity of water in each hand calorimeter was 3,015 c.c.

3. Cleveland Med. Jour., 1910, x, 385.

of the vessels to reflex impulses from the contralateral hand was very poor, cold producing a small diminution in the flow, warmth no response whatever beyond the initial flow.

Charles S., a hammer man, aged 69, was admitted to Lakeside Hospital, June 26, 1911. He had gonorrhea forty-five years ago; never any chancre. He has been a heavy coffee and tea-drinker except in the last four or five years. He seldom drank whisky or beer, and smokes little. Six years ago following an attack of pneumonia he ate a heavy meal and immediately felt short of breath, dizzy and faint. He has had dizzy spells ever since. The attacks of dyspnea are worse at night and come on suddenly. Lately there has been swelling of the feet and ankles. There is Cheyne-Stokes respiration with periods of complete apnea lasting forty seconds. The anteroposterior diameter of the thorax is increased. There is difficulty in expelling air from the lungs. The cardiac dulness extends from 7 cm. to the right of the midsternal line in the fourth interspace to 14.5

TABLE 2.—CALORIMETRIC MEASUREMENTS IN CASE OF CHARLES S.

Time	Right	Left	Time	Right	Notes
2:45	.....	30.65	3:00	30.95	Room temp. 28.3 C.
2:46	30.61	.....	3:01	30.99	
2:47	.....	30.68	3:02	31.005	
2:48	30.67	.....	3:03	31.02	3:04 L. hand put in water at 43 C. Room temp. 28.3 C.
2:49	.....	30.73	3:04	31.035	
2:50	30.73	.....	3:05	31.055	
2:51	.....	30.77	3:06	31.09	At 3:11 hand out of calorimeter. Temp. of L. is now 30.76 C. Room temp. 28.15 C.
2:52	30.76	.....	3:07	31.11	
2:53	.....	30.825	3:08	31.125	
2:54	30.825	.....	3:09	31.135	
2:55	.....	30.87	3:10	31.155	
2:56	30.88	.....	3:11	31.20	
2:57	30.905	.....	3:12½	.....	
2:58	30.92	.....	3:29	31.08	
2:59	30.94	.....			

Cooling of calorimeters, R., 0.12 degree in eighteen minutes, L., 0.11 C. degree in seventeen and one-half minutes. Volume of right hand in calorimeter 437 c.c., of left hand 410 c.c.

cm. to the left of the midsternal line in the fifth interspace. The first sound at the apex is very tympanitic in quality with a slightly roughened element in it. Second sound normal, no murmurs or adventitious sounds. The blood-vessels are sclerotic. Pulse regular in rate and rhythm. The ascent is slow, no diastolic. Blood-pressure: systolic, 180; diastolic, 120. Some edema of the skin of the genitalia and of the ankles is present. The skin is cool and dry. He has been on cardiac diet and treated with atropin and nitroglycerin. Hemoglobin, 95 per cent. Diagnosis, arteriosclerosis and myocarditis. He was discharged "improved," July 19, 1911.

The blood-flow in the hand was examined July 13, 1911. Mouth temperature, 36.3 C.; pulse (sitting), 80. Hands put into bath at 2:32 p. m.; into calorimeters at 2:44. At 2:55 p. m. left hand put into water at 8.5 C. Cooling of calorimeters, R., 0.12 degrees in eighteen minutes; L., 0.11 degree in seventeen and one-half minutes. Volume of right hand in calorimeters, 437 c.c.; of left hand, 410 c.c.

The last case to be referred to under this heading is that of Fred S., a man 58 years old, with pronounced arteriosclerosis of the vessels of the limbs, mitral insufficiency and pulmonary emphysema. The initial flow was 5.76 grams per 100 c.c. per minute for the right hand and 5.80 grams for the left hand, with an average room temperature of 23.8 C. Immersion of the left hand in warm water caused no change in the flow in the right for three minutes, an unusually sluggish reaction, but for

TABLE 3.—CALORIMETRIC MEASUREMENTS IN CASE OF FRED S.

Time	Right	Left	Room Temp. C.	Time	Right	Room Temp. C.	Notes
2:32½	31.09	31.07		3:00	31.78		At 3:03 left hand put in water at 8 C. He feels it very cold and withdraws hand intermittently.
2:35	31.06	31.05	23.4	3:01	31.81	....	
2:36	31.07	31.05	....	3:02	31.855	24.0	
2:37	31.08	31.06	23.6	3:03	31.895	....	
2:38	31.095	31.07		3:04	31.91		At 3:12 left hand put in water at 38.5 C.
2:39	31.11	31.08	....	3:05	31.92	23.9	
2:40	31.125	31.10	24.0	3:06	31.925	....	
2:42	31.17	31.15	....	3:07	31.95	....	
2:43	31.195	31.165	....	3:08	31.975	24.0	
2:44	31.22	31.185	....	3:09	31.995	....	
2:45	31.25	31.22	23.8	3:10	32.02	....	
2:46	31.29	31.26	....	3:11	32.04	24.0	
2:47	31.32	31.29	....	3:12	32.06	....	
2:48	31.36	31.34	23.9	3:13	32.085	....	
2:49	31.395	31.37	....	3:14	32.11	....	
2:50	31.425	31.40	....	3:15	32.13	24.2	
2:51	31.45		23.9	3:16	32.165		At 3:22 hand out of calor. 3:23 Temp. of L. is 31.00 C. 3:45 Temp. of L. is 30.79 C.
2:52	31.48	....	....	3:17	32.195	....	
2:53	31.505	....	....	3:18	32.22	24.2	
2:54	31.54	....	24.0	3:19	32.24	....	
2:55	31.59	....	....	3:20	32.27	....	
2:56	31.62	....	....	3:21	32.295	....	
2:57	31.66	....	23.9	3:22	32.32	....	
2:58	31.70	....	....	3:23	....	....	
2:59	31.74	....	24.0	3:45	32.02	....	

the next ten minutes of immersion of the left hand in warm water the flow in the right rose to 7.69 grams per 100 c.c. per minute. Immersion of the left hand in cold water caused a reduction of the flow in the right to 3.65 grams per 100 c.c. per minute for the first three minutes, the flow then rising to 5.54 grams per 100 c.c. per minute for the next six minutes of immersion. When the left hand was again put into the warm water, there was only a small increase in the flow in the right (to 6.46 grams per 100 c.c. per minute for ten minutes' immersion).

Fred S., a laborer, aged 58, was admitted to the City Hospital April 27, 1913, with marked arteriosclerosis, pulmonary emphysema and mitral insufficiency.

He complains of shortness of breath (asthma) which began in October last. He has not been able to work since. He says the condition seems stationary, neither improving nor growing worse. When he gets chilled an attack is brought on. The point of maximal cardiac impulse is 5 cm. outside the left nipple line. The greatest breadth of cardiac dullness extends at the sixth rib to the anterior axillary line; right border, right sternal margin. Roughened first sound at apex followed by systolic murmur, which is lost as the base is approached. Pulse fairly regular rhythm and rate, fair volume. Liver enlarged. Urine contains no albumin. A few hyaline and finely granular casts. Hot baths seemed to have a good effect on him.

The blood-flow in the hands was examined May 8, 1913. Hands in bath at 2:22½ p. m., in calorimeters at 2:33½. At 2:50 p. m. left hand put into water at 43 C. (Table 3.)

Cooling of calorimeters, R., 0.30 degree in twenty-three minutes, L., 0.61 degree in fifty-five minutes. Pulse (sitting) 116. Volume of right hand 497 c.c., of left hand 484 c.c. Rectal temperature 37.4 C. Water equivalent of calorimeters with contents, R., 3,492, L., 3,482. Blood-pressure left arm, systolic 126, 63 (sound gone). Another observation. Systolic 122, 101 (sudden diminution of sound), 63 (sound gone).

II. AORTIC ANEURYSM

If we leave out of account John M., a dispensary case who came in with cold hands on a winter day and could not wait for sufficient time to warm up and whose measured flow (3.96 grams per 100 c.c. per minute for the right hand) is therefore certainly too low,⁴ a point of some consequence comes out in Table 19 in which the results are summarized; that is, that for the age of the patient and the temperature of the room the hand flow in these cases of thoracic aneurysm are either of the normal order of magnitude or at least not so conspicuously deficient as in those cases dealt with in Paper X, in which the stress of the pathological change falls on the myocardium rather than on the blood-vessels.

John M., an iron-molder, aged 32 years, weight 140 pounds, height 5 feet, 3½ inches, was admitted at the dispensary suffering from aortic aneurysm as shown by the Roentgen ray. He complains of pain over the sternum. Systolic blood-pressure, right arm 155, left arm 150. Blood-flow in the hands examined Feb. 13, 1911. Pulse (sitting) 72. Mouth temperature 37.0 C. Room temperature 22.2 C. His hands were cold when he came in. Right hand in bath at 2:56 p. m., in calorimeter at 3:07 and out of calorimeters at 3:36. At 3:25 left hand put into water at 8.5 C.

It is not, of course, suggested that in some of the cases of aneurysm deterioration and disordered function of the myocardium or crippling of the valves may not be of graver import than the aneurysm itself. But so far as the aneurysm, or rather the underlying condition which has occasioned the aneurysm has not led to deterioration of the heart, there is no reason in the mechanics of the circulation why the blood-flow through

4. The fact that immersion of the left hand in cold water caused only a very slight diminution in the flow in the right while immersion of the left hand in warm water increased the flow decidedly (to 5.5 grams) indicates that the vasoconstriction produced by the exposure of the hand to the cold was initially considerable.

the hand should suffer. This is true even where the form of the pulse-wave may be greatly distorted by its passage through the aneurysmal sac. Of course, a sufficient degree of pressure of the sac on a subclavian artery or vein may diminish the flow in the corresponding hand. The great difference in the flow in the two hands in Paul K. may be accounted for by the pressure of the aneurysm on the left subclavian artery. The flow in his hands (for the last fifteen minutes in the calorimeters) was 7.64 grams for the right per 100 c.c. per minute and 5.9 grams for the left, with room temperature 22.6 C. (a ratio of 1.3:1). For the right hand this flow is not markedly subnormal for his age. The diagnosis was auricular fibrillation with mitral insufficiency (and stenosis), well compensated at the time of the blood-flow examination and aortic aneurysm. There

TABLE 4.—CALORIMETRIC MEASUREMENTS IN CASE OF JOHN M.

Time	Right	Time	Right	Time	Right
3:06	29.15	3:19	29.28	3:29	29.47
3:10*	29.13	3:20	29.30	3:30†	29.48
3:11	29.14	3:21	29.32	3:31	29.50
3:12	29.14	3:22	29.33	3:32	29.51
3:13	29.16	3:23	29.36	3:33	29.54
3:14	29.19	3:24	29.38	3:34‡	29.58
3:15	29.21	3:25	29.40	3:35	29.62
3:16	29.23	3:26	29.42	3:36	29.67
3:17	29.24	3:27	29.425	3:53	29.49
3:18	29.27	3:28	29.44	3:55	29.47

* Room 22.0 C. † At 3:30 left hand dried and wrapped up. ‡ Room 22.4 C. Volume of right hand 380 c.c.

is no evidence that the aneurysm, unless by its mechanical pressure, caused any change in the flow.

Paul K., a baker, 57 years old, was admitted to the City Hospital Feb. 21, 1912. There is a history of lues and of frequent acute attacks of articular rheumatism. A history of skin rash was obtained. He had gonorrhea ten or twelve times. His present illness began three weeks before admission. He had an attack of rheumatism at the time and began to be short of breath. His eyes have been swollen for three days. There is bulging over the heart. The thorax is barrel-shaped, and many dry râles can be heard. A loud systolic murmur can be heard over the apex, the heart is very irregular. Not all the heart-beats are felt at the wrist. Blood-pressure is 110 to 120. The Roentgen ray shows a marked prominence of the aortic arch on the left side and heart enlarged. He was put on digitalis. The pulse-rate, which was 132 on the morning after admission, fell rapidly. During March and April it varied between 75 and 90, his clinical condition improved and he was allowed to leave his bed and walk about the ward.

The blood-flow in the hands was examined April 24, 1912. Hands in bath at 1:32 p. m., in calorimeters at 1:42¾, and out of calorimeters at 2:06. (Table 5.)

Cooling of calorimeters in ten minutes, R., 0.13 degree; L., 0.12 degree. Volume of right hand 454 c.c., of left hand 451 c.c. He works mainly with his left hand although he is right-handed. Rectal temperature 38 C. Water equivalent of calorimeters with contents, R., 3,458; L., 3,456. After the examination it was noticed that the heart-rate was much increased (to 140 counted with a stethoscope) and that it was more irregular than before.

In Joseph C., a dispensary patient aged 50, with marked arteriosclerosis, a high systolic pressure (160 mm.) and distinctly dilated aortic arch, the flow was 6.69 grams for the right hand and 6.66 grams for the left, with room temperature 21.5 C. Considering the amount of arteriosclerosis and that in arteriosclerosis, as already stated, the hand flow has a tendency to be diminished, there is no evidence in this case that the presence of the aneurysm as such has reduced the flow.

Joseph C., an iron molder, aged 50, height 5 feet, 9½ inches, was admitted to the dispensary Jan. 30, 1911. He has been ill for six or seven years, during which time he has done no work. Six years ago he lost consciousness and after that his left arm was paralyzed. The grip of the left hand is weak, too weak, he says, to grasp objects; but on testing this the difference between the hands is not great. He gets very dizzy at times. There is much arteriosclerosis. He

TABLE 5.—CALORIMETRIC MEASUREMENTS IN CASE OF PAUL K.

Time	Right	Left	Room Temp. C.	Time	Right	Left	Room Temp. C.
1:42	31.13	31.29	....	1:56	31.40	31.465	....
1:44	31.07	31.21	....	1:57	31.45	31.50	....
1:45	31.08	31.21	22.8	1:58	31.49	31.525	22.6
1:46	31.095	31.225	....	1:59	31.51	31.53	....
1:47	31.11	31.23	....	2:00	31.56	31.58	....
1:48	31.13	31.25	22.8	2:01	31.605	31.61	....
1:49	31.165	31.29	....	2:02	31.65	31.635	....
1:50	31.19	31.31	....	2:03	31.70	31.67	....
1:51	31.21	31.32	....	2:04	31.75	31.71	22.6
1:52	31.25	31.35	....	2:05	31.795	31.75	....
1:53	31.29	31.38	22.9	2:06	31.83	31.76	....
1:54	31.32	31.41	....	2:16	31.70	31.64	....
1:55	31.37	31.43	....	....	....	....	....

suffers from pain in the head, also in the breast and in the left hand. The Roentgen ray shows a definite dilatation of the arch of the aorta. Wassermann reaction negative on Feb. 6, 1911.

The hand flow was examined on Jan. 31, 1911. Hands in bath at 2:52 p. m., in calorimeters at 3:05, and out of calorimeters at 3:20; 3,056 c.c. of water in each calorimeter. Pulse (sitting) 88. Mouth temperature 37.2 C. (Table 6.)

Cooling of calorimeters, R., 0.19 degree, and L. 0.16 degree in fourteen minutes. Volume of right hand 505 c.c., of left 480 c.c. Blood-pressure, systolic in right brachial 160, in left brachial 164.

In William B., a man aged 53, suffering from thoracic aneurysm, the flow in the right hand was 8.38 grams per 100 c.c. per minute and in the left 7.33 grams with room temperature 20.8 C. (for fourteen minutes

in calorimeters). The systolic pressure was very high (205 mm.). He was still taking nitroglycerin at the time of the blood-flow examination.

A second examination made at the dispensary nearly four weeks later showed a flow of 10.23 grams per 100 c.c. per minute for the right and 9.47 grams for the left hand, with room temperature 22.2 C. These flows are certainly not small for a man of his age and with sclerosed arteries. The inequality in the flow in the two hands is no greater than may be seen in normal persons, and it will be observed that the ratio between the flows in the two hands is the same at the two examinations (1:1.08).

TABLE 6.—CALORIMETRIC MEASUREMENTS IN CASE OF JOSEPH C.

Time	Right	Left	Room Temp. C.	Time	Right	Left	Room Temp. C.
3:04	29.13	29.12	20.3	3:16	29.55	29.51	....
3:06	29.11	29.10	....	3:17	29.61	29.53	21.5
3:07	29.14	29.11	....	3:18	29.67	29.62	....
3:08	29.18	29.12	21.5	3:19	29.72	29.67	....
3:09	29.20	29.14	....	3:20	29.78	29.71	....
3:10	29.25	29.19	....	3:32	29.61	29.58	....
3:11	29.29	29.22	....	3:34	29.59	29.55	....
3:12	29.34	29.31	....	....	....	....	....
3:13	29.39	29.33	21.4	....	....	....	....
3:14	29.45	29.39	....	....	....	....	....
3:15	29.51	29.43	....	....	....	....	....

TABLE 7.—CALORIMETRIC MEASUREMENTS IN CASE OF WILLIAM B. FIRST EXAMINATION

Time	Right	Left	Time	Right	Left
2:37	28.38	28.54	2:48	28.70	28.82
2:40	28.34	28.53	2:51	28.90	29.00
2:42	28.39	28.58	2:53	29.04	29.11
2:43	28.43	28.61	2:55	29.20	29.22
2:45	28.56	28.70	2:56	29.27	29.28
2:46	28.61	28.75	3:12	29.09	29.10

William B., a man aged 53, height 5 feet, 2 inches, weight 152 pounds, had an aneurysm of the thoracic aorta involving the innominate also to some extent. After being under observation at the dispensary for a considerable time he was admitted to Lakeside Hospital where he was under treatment for a month (digitalis and nitroglycerin). His hand flow was examined at the time of his discharge from the hospital. He felt much better than when he entered, on Dec. 22, 1910. He has no cough but there is a history of cyanosis, although there is no cyanosis now. He says his hands always feel rather cool, especially when his heart is bad.

Hands in bath at 2:26½ p. m., in calorimeters at 2:38½, and out of calorimeters at 2:56; 3,050 c.c. of water in each calorimeter. Room temperature 20.4 C.

Room temperature at end of observations 21.2 C. Volume of right hand in calorimeter 410 c.c., of left hand 390 c.c. Cooling of calorimeters in sixteen minutes 0.18 C. degree. Pulse (sitting) 84. Mouth temperature 37.1 C. Water equivalent of calorimeters with contents, R., 3,458; L., 3,442. (Table 7.)

The second examination was on Jan. 17, 1911. He says he feels about the same as at the first examination, only the shortness of breath on exertion is greater. Systolic blood-pressure 210. Hands put into bath at 3:09 p. m., in calorimeters at 3:21, and out of calorimeters at 3:37; 3,050 c.c. of water in each calorimeter. Room temperature 22.2 C.

TABLE 8.—CALORIMETRIC MEASUREMENTS IN CASE OF WILLIAM B. SECOND EXAMINATION

Time	Right	Left	Time	Right	Left
3:19	30.70	30.49	3:31	31.13	30.86
3:23	30.69	30.48	3:32	31.19	30.91
3:25	30.79	30.57	3:33	31.23	30.94
3:26	30.86	30.62	3:34	31.29	31.00
3:27	30.92	30.67	3:35	31.34	31.07
3:28	30.97	30.71	3:36	31.39	31.11
3:29	31.02	30.77	3:37	31.44	31.16
3:30	31.07	30.81	4:00	31.12	30.85

Cooling of calorimeters in twenty-three minutes, R., 0.32 C. degree; L., 0.31 C. degree. Volume of right hand in calorimeter 435 c.c., of left 410 c.c. Mouth temperature 36.9 C. Water equivalent of calorimeters with contents, R., 3,478; L., 3,458. Pulse (sitting) 88.

In Richard B, a man aged 38, with a large aortic aneurysm extending, as shown by the Roentgen-ray, to a considerable distance to the right of the sternum, there was a decided deficiency in the flow of the left hand as compared with the right (10.91 grams per 100 c.c. per minute for the right, 8.15 grams for the left, a ratio of 1.33:1). For the room temperature of 28 C., 10.9 grams is not a large flow, but neither is it decidedly small. The vasomotor reflexes from the right to the left hand were normal in direction, and not strikingly deficient in intensity, showing that the chief afferent path in the vasomotor reaction to warmth or cold (the nerves of warmth and cold sensation) have not appreciably suffered by stagnation of the circulation due to the pressure of the aneurysm on the right subclavian vein. Now, when pressure is maintained on the arm at a level somewhat below the systolic arterial pressure by means of the cuff of a sphygmomanometer the warmth sensation suffers early, so that it is impossible to appreciate the contact of a warm tube, while the sensation of pain is at this stage less affected. As has been pointed out in Paper X, a certain amount of venous distention, provided that the arterial pressure is correspondingly increased, may even be associated with an

increased flow, because of the increased cross-section of the smaller vessels. So far as the arterial path to the right arm in Richard B. is concerned, the conditions would favor a greater flow in the right hand, for as shown at the necropsy the aneurysm provided a much wider entrance than normal for the blood going to the right subclavian and possibly a reservoir which helped to maintain the flow during diastole.

Richard B., a colored gardener, aged 38, height 5 feet, 7½ inches, was admitted to Lakeside Hospital May 22, 1911, with an aneurysm diagnosed as aortic. He complains of hoarseness during the past two weeks and vomiting during the past week, also cough. He admits lues. There is a tender pulsating mass in the suprasternal notch with fulness in the right supraclavicular region. Heart 3 cm. to left of nipple. A distant systolic murmur at the supraclavicular notch. The aortic second is slightly accentuated. There is distinct diastolic shock, unilateral (right) distention of veins, and clubbing of fingers. The Roentgen ray shows an enormous shadow upward and to the right. The patient continued in the hospital until his death, Aug. 22, 1911. There was no right radial pulse for the last week of life. Blood examination on May 23, 1911, showed hemoglobin 95 per cent., leukocytes 5,000. June 1 the Wassermann test was strongly positive. The necropsy showed a saccular, spherical aneurysm of the innominate artery 3 to 4 inches in diameter. The arch of the aorta was not involved except for the somewhat enlarged ring at the beginning of the innominate opening into the sac.

Hand flow examined May 23, 1911. Pulse (sitting) 100. Mouth temperature 37.1 C. Hands put into bath at 2:44 p. m., into calorimeters at 2:54½. At 3:08 p. m. right hand put into water at 8.1 C.

TABLE 9.—CALORIMETRIC MEASUREMENTS IN CASE OF RICHARD B.

Time	Right	Left	Room Temp. C.	Time	Left	Room Temp. C.	Notes
2:54	30.43	30.38		3:13	31.225		At 3:16 put right hand in water at 43 C.
2:55	30.475	30.42	27.7	3:14	31.28	....	
2:56	30.53	30.43	....	3:15	31.325	28.0	
2:57	30.595	30.46	....	3:16	31.36	....	
2:58	30.695	30.525		3:17	31.38		Hand out of calorimeter. Temp. of R. is now 31.27 C.
2:59	30.78	30.60	....	3:18	31.415	....	
3:00	30.86	30.63	....	3:19	31.46	....	
3:01	30.935	30.69	27.9	3:20	31.525	28.3	
3:02	31.02	30.74	....	3:21	31.58	....	
3:03	31.12	30.825	....	3:22	31.625	28.2	
3:04	31.20	....	....	3:23	31.67	....	
3:05	31.295	30.93	....	3:24	31.725	....	
3:06	31.34	30.98	....	3:25	31.80	....	
3:07	31.395	31.02	....	3:26	31.85	28.2	
3:08	31.46	31.035	....	3:41	31.75	28.0	
3:09	....	31.07	28.0				
3:10	....	31.10	....				
3:11	....	31.125	....				
3:12	....	31.155	....				

Cooling of calorimeters, R., 0.19 degree in thirty-three minutes; L., 0.10 C. degree in fifteen minutes. Volume of right hand 495 c.c., of left 437 c.c. There is an obvious difference in the size of the two hands. He is right-handed.

The next case, that of Samuel S., a man 31 years old, illustrates the fact that even very marked differences in the form of the radial pulse on the two sides, differences perfectly evident both to the finger and on the sphygmogram, may be associated with a comparatively small difference in the flow in the two hands. The right radial showed a typical pulse of aortic insufficiency with abrupt ascent to a sharp apex and abrupt fall, while the left radial gave a sphygmogram with a rounded apex. The blood-pressure in the two brachials was also quite different, the systolic pressure being 157 in the right and 118 in the left. The physical signs of aortic insufficiency were present.

The blood-flow measurement showed a difference no greater than may be seen in normal persons between the two hands (11.11 grams per 100 c.c. per minute for the right and 10.32 grams for the left, with room temperature 22.2 C.), a perfectly normal flow for a man of this age. The conclusion was drawn that the aneurysm in distorting the form of the pulse-wave did not interfere materially with the free passage of blood through the left subclavian artery. The man died the same night about five hours after the examination by a rupture of the aneurysm into the left bronchus. It is worthy of remark that five hours before his death the blood-flow in his hands, which no doubt in this case was an index of the output of his heart, was quite normal. He was to die, not because his heart was failing, but because the wall of the aneurysmal sac had been thinned to the bursting point. A very different tale would have been told by the hand flow in a case of impending heart-failure as in Stephen F., or Albert H. (Paper X), or Anthony P.

Samuel S., a colored music teacher, aged 31, was admitted to the City Hospital Dec. 7, 1912, with thoracic aneurysm. He is a well-developed man 5 feet, 10½ inches tall, weight 160 pounds. He has had spells of intense dyspnea for the past six weeks. He has been continually getting worse to the present time, is much cyanosed, and suffers much from cough which he has had from the age of 16. He has smoked cigarettes to excess, and also has used a good deal of alcohol. He denies lues although he admits the possibility of it.

The left pupil is smaller than the right and does not react to light or accommodation. There is diffuse pulsation of the lower third of the neck. Tracheal tug is present. The left side of the thorax moves less than the right. The percussion note is dull over the entire left side [compression of the left lung by the aneurism(?)]. Over the left lung the breath-sounds are very faint, distant and bronchial in character. The cardiac dulness at the level of the second rib extends three fingers' breadth to the right of the right sternal border and the same distance to the left of the left sternal border. In the fourth interspace it extends from two fingers' breadth to the right of the right sternal border to the left midaxillary line. The apex beat is visible and palpable in the sixth interspace, two fingers' breadth outside the nipple line. Systolic and presystolic thrills are palpable over the apex. Loud booming systolic and diastolic murmurs are heard at apex. Loud presystolic murmur followed by systolic murmur is heard over aortic and pulmonic areas. The sternum rises fully a half-inch with each systole. The radial pulse is regular, rhythmical, asymmetrical, the sphygmogram of the left radial having a rounded apex, and that of the right a sharp (aortic insufficiency) apex. The pulse is synchronous in the two radials and

of good volume and tension. The difference in the form of the pulse-wave is very evident to the finger.

The blood-flow in the hand was measured Dec. 10, 1912. Hands in bath at 1:50 p. m., in calorimeters at 1:59½, and out of calorimeters at 2:13 p. m.

TABLE 10.—CALORIMETRIC MEASUREMENTS IN CASE OF SAMUEL S.

Time	Right	Left	Room Temp. C.	Time	Right	Left	Room Temp. C.
1:59	31.40	31.43	....	2:07	32.11	32.13	22.25
2:00	31.435	31.49	22.4	2:08	32.195	32.20	....
2:01	31.55	31.58	22.4	2:09	32.27	32.265	22.2
2:02	31.64	31.68	....	2:10	32.35	32.36	22.1
2:03	31.74	31.78	22.3	2:11	32.395	32.42	....
2:04	31.85	31.88	....	2:12	32.47	32.465	22.3
2:05	31.94	31.95	....	2:13	32.53	32.53	....
2:06	32.01	32.055	22.3	2:41	32.17	32.17	....

Cooling of calorimeters in twenty-eight minutes, 0.36 degree. Volume of right hand 580 c.c., of left hand 603 c.c. Water equivalent of calorimeters with contents, R., 3,559; L., 3,577. Rectal temperature 38.4 C. Blood-pressure left arm, systolic 118, 58 (sound suddenly diminished); right arm, systolic 157, 61 (sound abruptly diminished). Another observation on the right arm gave identical results. Three days previously, according to another observer, the pressures were 160 (systolic), 45 (change of sound) in the right, and 130, 55 in the left brachial.

A necropsy was performed by Dr. A. A. Johnson, Pathologist at the City Hospital, to whom I am indebted for the following details. Heart, left ventricle dilated moderately, average thickness 16 to 18 mm. Other cavities normal. The segments of all the valves except the aortic are normal and the orifices are not dilated. The aortic ring in the formaldehyd-preserved specimen measured 8 cm. The aortic valve segments are slightly thickened and curled along their free edges. The openings of the coronary arteries are free and of the usual size. The aorta immediately above the aortic ring is smooth and free from thickening. Opening from the anterior aspect of the transverse arch is a large sacular aneurysm adherent to the sternum. The sac is oval, 10 by 8 cm. in diameter. The walls are thin (2 to 4 mm.) and are quite free from fibrin. The opening from the aorta into the sac measures 5 by 3.5 cm. The innominate opens by a somewhat dilated mouth posterior and external to the opening into the aneurysm and situated opposite the middle of the latter opening. The left common carotid and subclavian arteries come off from the aorta about 1 cm. beyond the upper border of the opening between the aorta and the aneurysm. Rupture in the sac on the inferior surface has irregular edges and measures 3 by 1 mm., leading into the left bronchus 1 cm. from the bifurcation.

It will be seen that there was no stenosis of the orifice of the left subclavian, but its origin was situated distal to the orifice of the aneurysmal sac, while the origin of the innominate was directly opposite the center of that orifice. The direction of the opening of the innominate was such that the blood coming from the heart would pass straight into it, all the more as the opening of the innominate was somewhat dilated. This would account for the abrupt rise in the sphygmographic curve and

the high maximum pressure in the right arm. The sudden fall in the sphygmogram is partly due to actual regurgitation through the aortic orifice, was probably due still more to the effect of rapid expansion of the thin aneurysmal sac, which after closure of the aortic valve would still go on yielding and so exert a suction action, especially on the orifice of the innominate placed directly opposite it. On the other hand, the action of the large aneurysmal sac lying proximal to the left subclavian would be to damp the pulse-wave in that artery and delay the arrival of the crest. This would not necessarily affect the total flow, the pulsatory element in which is measured not by the absolute height of the crest, but by the area enclosed between the sphygmogram and the line of diastolic pressure.⁵

The last case included in the group of aneurysms (that of John McL.) is the only one which shows a notably small hand flow. It is placed in this group merely to emphasize the point that in drawing any general deductions from such measurements the proper classification of the cases is of great importance.

John McL., a plasterer, aged 50, height 5 feet, 11½ inches, was admitted to the City Hospital July 6, 1912, with general edema (in face, hands, arms, legs and feet), also cyanosis in the lips and fingers. He complains of "kidney trouble." He looks anemic. The heart shows an impure first sound at the apex. The aortic second is greatly accentuated, the blood-pressure is high (systolic 200). The abdomen is distended with free fluid. Albumin and casts were present in the urine all along. On July 11 about 7 liters of fluid was removed from the abdomen. There was no detectable fluid in the thoracic cavity. A diagnosis of hepatic cirrhosis was made. Aug. 19, 7,080 c.c. of fluid was removed from the abdomen.

On Aug. 27, 1912, the hand and foot flows were estimated and found exceedingly small (0.41 gram per 100 c.c. per minute for the right hand and 0.57 gram for the left hand, with room temperature 22.2 C.; 0.17 gram per 100 c.c. per minute for the right foot and 0.14 gram for the left foot, with room temperature 21.2 C.).

Aug. 28, 1912, 1,965 c.c. of liquid was taken from the abdominal cavity at 1:30 p. m., and the hand and foot flows were again measured. They were larger than on the previous day, but still quite small (1.11 grams per 100 c.c. per minute for a period of seventeen minutes for the right hand and 1.18 grams for the left hand, with room temperature 21.1 C.; 0.66 gram per 100 c.c. per minute for the right foot for the last ten minutes of a period beginning twenty minutes after insertion of the feet into the calorimeters, and 0.65 gram for the left foot). The ratio between the flows in the feet and hands (1:1.75) is near enough the normal to permit the conclusion that the small flow in both has a common cause. The presence of an aneurysm of the aorta was not

5. Paper V of this series, *THE ARCHIVES INT. MED.*, 1912, ix, 706.

diagnosed during life. The small blood-flow in the hands has certainly nothing to do with the existence of the aneurysm. It is without doubt dependent on the cardiorenal, or cardiorenalhepatic affection, that is to say, on such factors as the vasoconstriction of which the high blood-pressure is one expression, on the coincident anemia, and on the crippling of the heart muscle. The small flow in the feet may also depend in part on the mechanical hindrance imposed by the fluid in the peritoneal cavity or in the connective tissue of the legs. But if this were an important factor the ratio of hand to foot flow would be disturbed.

The patient died Dec. 27, 1912. The necropsy showed general peritonitis, aneurysm of the descending thoracic aorta, cloudy swelling and parenchymatous change in the kidneys. The pericardium was adherent to the left pleura, but not to the epicardium. The heart was pale (weight 300 grams), with some dilatation and hypertrophy of the left ventricle. The mitral orifice was dilated and the edges of the mitral valve were thickened and puckered. The edges of the aortic valve were thickened and slightly curled. The sinuses of Valsalva were dilated. Many sclerotic plaques were about the coronary openings. The right coronary vessels were not patent. The left coronary vessels were free but sclerosed. The aortic ring was much dilated, 10.5 cm. in circumference. The whole intima of the aorta was very much thickened. Here and there were areas of sclerosis. The openings of the large vessels were dilated. Eight centimeters beyond this there was an opening on the left posterior wall of the aorta 2 cm. in diameter, opening into a sac 4 cm. in diameter. The body of the fifth thoracic vertebra had been slightly eroded. Beyond this the thoracic aorta was much thickened in irregular areas. About 1,000 c.c. of straw-colored fluid was in the left pleural cavity. The abdomen contained about 10 liters of cloudy fluid with many shreds of fibrin. The visceral and the parietal peritoneum was dark in color and covered with exudate. The intestines were adherent. The liver showed no scarring; weight 1,660 grams. In the kidneys the cortex was not sharply differentiated from the medulla. The whole kidney was dark in appearance, with cloudy swelling to parenchymatous change. For these details I am obliged to Dr. A. A. Johnson.

III. MISCELLANEOUS VASCULAR CONDITIONS INCLUDING VASCULAR NEUROSES

Among these are three cases of Raynaud's disease.

Margaret H., aged 15, suffering from Raynaud's disease in the fingers, had a flow in the right hand of 5.33 grams per 100 c.c. of hand per minute and 6.67 grams in the left, with room temperature 23.6 C. The protocol has already been published.⁶ The considerable inequality in the flow in the two hands is probably due to a functional vasomotor difference. When there are no anatomical reasons for such a difference in flow it either disappears at subsequent examinations or is reversed as regards the two hands. In cases in which a marked difference is obtained in the two hands in several examinations, the deficiency being always in the same hand and the ratio of the flows in the two hands not changing greatly, there is reason to believe, in the absence of obvious anatomical differences, that the difference in flow may depend on pathological

6. *Heart*, 1911, iii, 79.

changes in the thorax or in the arm or hand itself which have not yet definitely disclosed themselves by other symptoms.

The flow in Margaret H. is distinctly subnormal, which corresponds with the fact that her hands were cold to the touch, although she did not have an attack during the examination. The relatively small flow may be related to the tendency to dyspnea which she states has existed for some years. The most striking result of the examination was the intense reflex vasoconstriction produced in the left hand when the right was put into cold water, the flow being reduced from 6.67 grams to 2.97 grams per 100 c.c. per minute. Although intense, the vasoconstriction was transient, lasting only for two minutes and then giving place to distinct vasodilatation, the flow increasing to 8.28 grams in the left hand, while the right continued in the cold water. Immersion of the right hand in warm water produced no further increase, but rather a decrease. The vasomotor mechanism of the hand seems, therefore, to respond with abnormal readiness to vasoconstrictor influences and with less than normal readiness to vasodilator influences. The short duration of the intense crossed reflex vasoconstriction relates the case to those of early peripheral neuritis,⁷ and it is of interest, in this connection, that neuritic changes may be associated with the Raynaud's syndrome.

The second case of Raynaud's disease was that of Mrs. W. G., aged 28, who was seen April 24, 1911. About one and one-half years previously, after a sleigh ride, she noticed that the fingers of both hands became cold, "white like those of a dead person" and numb. Sometimes the fingers became purple. All the phalanges were involved. She feels sure they were not frost-bitten. Since that time she has had many attacks, each lasting usually five to ten minutes, but occasionally almost an hour. The attack generally begins in the thumb. Putting the hands into cold water does not necessarily bring on an attack. A cold full bath is more likely to do so. The thumbs are apt to become numb if she holds anything in her hands for any length of time. Long before this condition came on her arms and hands used to go to sleep a great deal even when she was not lying on them. Also for as long as she can remember small injuries to the skin of the hands or arms healed badly. She pointed out the scar of a small burn on the left hand which was still raised above the surface although otherwise healed. It was a most trifling burn she said. Even a little scratch leaves a scar. She showed various marks of old injuries on the arm. She has been fighting the condition by going out to walk without gloves, continuing to walk with her hands exposed even when they became numb, and thought that some time she improved it in this way, her hands afterwards becoming warm. Her general method has been to immerse them in warm water on coming in. The attacks are apt to be induced by a damp day, even if not cold. The hands to-day feel markedly cold to the touch, not only the fingers, but the hands midway to the wrists. The day was not cold and she was wearing kid gloves. Her arms are mottled with purple spots. She has no trouble in the feet, nose, or elsewhere. Her general health is satisfactory, but there is some shortness of breath on exertion. She is fat and well nourished, and the arms and hands are quite plump. She suffers much from nervousness.

7. Paper XII of this series.

The blood-flow in the hands was examined April 24, 1911. Pulse 108 (sitting). Mouth temperature 37.55 C. Hands put into bath at 10:10 a. m. At 10:15 it was seen that the left arm was getting purple; the right arm remained unchanged. She said the left hand felt colder than the right, and that the left arm and hand felt as if swollen. Hands put into calorimeters at 10:20 a. m.

TABLE 11.—CALORIMETRIC MEASUREMENTS IN CASE OF MRS. W. G.

Time	Right	Left	Notes	Time	Right	Notes
10:19	30.125	30.13	Room temp. 25.3 C.	10:43	30.57	Room temp. 24.9 C. At 10:47 left hand put in water at 12 C.
10:24	30.11	30.13		10:44	30.60	
10:25	30.12	30.15		10:45	30.62	
10:27	30.17	30.19		10:46	30.67	
10:28	30.20	30.22		10:47	30.70	
10:29	30.22	30.24		10:48	30.71	
10:30	30.25	30.26		10:49	30.72	At 10:54 dried and wrapped left hand. It is red and is not specially cold to touch. Room temp. 27.4 C.
10:31	30.26	30.26		10:50	30.73	
10:32	30.27	30.27		10:51	30.75	
10:33	30.29	30.31		10:52	30.77	
10:34	30.31	30.32	At 10:34 put left hand in water at 43 C.	10:53	30.79	
10:35	30.33	.....	Room temp. 27 C. Face and ears red. She says the left hand feels swollen greatly.	10:54	30.81	
10:36	30.36	.....		10:55	30.83	
10:37	30.38	.....		10:56	30.86	
10:38	30.40	.....	Room Temp. 25.3 C.	10:57	30.89	
10:39	30.42			10:58	30.92	Hand out of calorimeter at 10:58.
10:40	30.47			10:59		10:59 temp. of L. is 30.30 C.
10:41	30.50			11:24	30.74	11:24 temp. of L. is 30.06 C.
10:42	30.54					Room temp. 25.8 C.

Cooling of calorimeters, R., 0.18 C. degree in twenty-six minutes; L., 0.14 degree in twenty-five minutes. Volume of right hand 391 c.c., of left hand 375 c.c. Water equivalent of calorimeters with contents, R., 3,408; L., 3,395. The left hand may be swollen a little, as her ring, which had been removed, now goes on with difficulty, yet the subjective feeling of extreme swelling which she had is obviously no index of the actual swelling.

The small initial flow in this patient (3.62 grams per 100 c.c. per minute for the right hand and 3.44 grams for the left, with the relatively high room temperature of 25.3 C.) is considerably more striking than in the case of Margaret H. This agrees well with the longer duration and greater development of the condition in Mrs. W. G. Immersion of the left hand in warm water caused a fair and persistent increase in the flow in the right (to 5.16 grams), although the absolute flow was still small. Subsequent immersion of the left hand in cold water caused a strong vasoconstriction in the right hand, diminution of the flow to 2.46 grams per 100 c.c. per minute for the first three minutes and 3.93 grams for the last four minutes. Although the temperature of the cold water was

purposely made higher than usual (12 C. instead of 8 C.), she complained greatly of the cold and withdrew her hand intermittently. This was seen also in the other cases, and the hypersensitiveness of the afferent receptors to cold as gauged by the sensation elicited has its parallel in their hypersensitiveness to cold as components of the reflex vasomotor arc.

The third case of Raynaud's disease (Mrs. C. B.) illustrates the condition when it has existed for a long time and has gone on to gangrene. The age of the patient was 29. Not only was the local condition more severe than in the last case, but the general physical condition was worse. The hand flow for a period of sixteen minutes before the vasomotor reaction was tested was 3.23 grams per 100 c.c. per minute for the right hand and 4.29 grams for the left. For the last six minutes of this period the flows worked out at 3.65 grams and 3.80 grams for the right and left hands, respectively. The reflex reaction to warmth was fair (the flow in the right hand increasing for the first two minutes of immersion of the left in warm water to 6.55 grams per 100 c.c. per minute), but it was transient, and for the last ten minutes of the period the flow was only 4.30 grams per 100 c.c. per minute. The reflex reaction to cold was also anomalous, possibly because of the existence at this stage of the disease of considerable anatomical changes in the vessel.

Mrs. C. B., aged 24, was admitted to the Lakeside Dispensary June 1, 1908, suffering from Raynaud's disease. She was treated with nitroglycerin without benefit. April 23, 1913, on account of coughs, sweats, and general weakness she was referred to the Medical Department of the Dispensary when the following data were elicited. Both hands are affected. The condition was first noted one day in winter seven years ago, the fingers becoming cold and pale and then getting purple. The attacks have been growing steadily worse, especially in the last five years. Sometimes small gangrenous areas form quickly at the ends of the fingers and quickly recover, but always with some loss of substance, so that the terminal phalanges of several of the fingers have lost a considerable proportion of their length and most of them have lost their nails. On all the fingers the nails are atrophic. She has considerable pain in the fingers when they "break out." She has had pain and marked stiffness in the right wrist and right forearm for about two years, and she uses the right hand but little on account of the stiffness of the wrist. The skin of the right forearm is somewhat stretched and distinctly glossy in comparison with that of the left. She cannot bear to put her hands into cold water. She has no such symptoms in her feet, nose or elsewhere. Some years ago she had a sore on her ankle, due, as she thinks, to a habit of kicking the ankle with the other foot. The sore refused to heal and she was put in hospital for several weeks, during which time her general health and strength improved greatly, and the sore also improved, although it took a long time before it was healed. She is pale and thin. There is some pigmentation of the skin and some dulness at the apex of the left lung. The radial pulse is small.

Examination of the blood-flow in the hands was made May 9, 1913. The marked pallor with some lividity and the "stone cold" feeling of the hands, especially of the fingers, was striking, although she was wearing gloves. The day was rather chilly. The terminal phalanx of one finger of the right hand had a small sore on the point of it which she said caused her some pain. Pulse (sitting) 112, weak. Hands in bath at 3:15 p. m., in calorimeters at 3:27. Mouth temperature, 37.35 C.

TABLE 12.—CALORIMETRIC MEASUREMENTS IN CASE OF MRS. C. B.

Time	Right	Left	Room Temp. C.	Time	Right	Notes
3:26	31.18	31.17	.....	3:53	31.135	3:52 left hand put in water at 43 C.
3:28	31.09	31.13	.....	3:54	31.155	Room 22.8.
3:29	31.09	31.13	21.3	3:55	31.16	
3:30	31.08	31.12	.....	3:56	31.17	Room temp. 22.9 C.
3:31	31.08	31.12	21.5	3:57	31.175	
3:32	31.08	31.11	.....	3:58	31.18	
3:33	31.085	31.11	.....	3:59	31.195	Room temp. 22.95 C.
3:34	31.08	31.11	21.8	4:00	31.20	
3:35	31.08	31.11	.....	4:01	31.20	
3:36	31.08	31.115	.....	4:02	31.205	
3:37	31.085	31.12	22.0	4:03	31.21	
3:38	31.085	31.12	.....	4:04	31.225	At 4:04 left hand put in water at 12 C.
3:39	31.085	31.125	.....	4:05	31.24	She feels it very cold. Left hand taken out of water intermittently.
3:40	31.09	31.14	.....	4:06	31.25	
3:41	31.085	31.15	22.1	4:07	31.255	Room temp. 22.7 C.
3:42	31.09	31.16	.....	4:08	31.26	The cold water is now at 13.5 C. The left hand is red. She says if it had not first been in warm water it would have been purple in the cold water. To the touch the left wrist is warm (vasodilatation), much warmer than the right.
3:43	31.09	31.17	.....	4:09	31.27	
3:44	31.09	31.18	.....	4:10	31.28	
3:45	31.09	31.195	.....	4:11	31.295	
3:46	31.095	31.20	22.0	4:12	31.305	
3:47	31.10	31.205	.....	4:13	31.34	4:13 hand out calorimeter.
3:48	31.10	31.21	.....	4:43	30.96	4:43 temp. L. 30.58 C.
3:49	31.105	31.215	.....			
3:50	31.115	31.22	22.6			
3:51	31.12	31.225	.....			
3:52	31.12	31.23	.....			

Cooling of calorimeters, R., 0.38 C. in 30 minutes; L., 0.65 C. in 51 minutes. Volume of right hand 273 c.c., of left 282 c.c. She is right handed. Water equivalent of calorimeters with contents, R., 3.313; L., 3.320.

It may be noted that in these three cases of Raynaud's disease there was evidence that a coexisting or preexisting general feebleness of the circulation conspired with the local condition in producing the symptoms. The blood-flow measurements suggested that if the general circulatory conditions had been normal the local tendency to vasoconstriction might not have sufficed to reduce the flow to the level at which the symptoms became obtrusive. This was the suggestion merely derived

from the three cases studied and it is not claimed that it has a general application. At any rate since hand flows habitually as small or smaller are often encountered in cases which never develop Raynaud's disease, the primary factor must be a tendency, whatever its essential cause, to the local diminution in the flow.

In a case of "dead fingers" in an elderly man affecting only the right hand, the flows were among the smallest observed in the whole investigation, and this not only in the hand obviously affected, but also in the other. The patient had been sitting in a well-warmed room for an hour before the examination, yet the calculated flow for the right hand was only 0.09 gram per 100 c.c. per minute and for the left 0.25 gram, with room temperature 20.5 C. A fair reflex vasodilatation was obtained in the right hand on the immersion of the left in warm water, the flow increasing to 0.5 gram, still of course a very small flow, but relatively a great increase. The dead condition of the right hand is therefore probably not due to anatomical change in the vessels, but to a vasoconstriction.

The next case in this group is that of Maurice T., a man 41 years old, who had lost a leg through obliterative arteritis.

Maurice T., a tailor's cutter, height 5 feet 7 inches, weight about 175 pounds, a well-built man, apparently in perfect health. He was seen April 17, 1911. About eight years ago in winter he began to feel the toes of the left foot cold. The little toe was first affected; gradually the same condition came on in the other toes. After awhile the toes became painful also. The whole foot became involved by degrees. Then cramp-like pains began to trouble him in the calf of the left leg. The trouble was worse in winter. Small nodules on the foot and toes became gangrenous. Eventually, four years ago, the left leg had to be amputated above the knee. The arteries were found extensively affected. He never had any pain above the knee. About six months ago he noticed that the little toe of his right foot was cold. Later on it began to pain him. Now the whole right foot is cold to the touch and the pulse in the *dorsalis pedis* poor. The little toe has a raw surface where it is contact with the next toe and the nail is apparently going to come off. He knows of no injury to it. The pain in the foot is so great that while he is in bed he cannot sleep. When he stands the pain disappears, but he has pain also when he walks. The arch of the right foot is broken down and he has to wear a support in his shoe. There is hyperidrosis of the foot in spite of the fact that it is cold. The flow in the hands was examined April 17, 1911. Mouth temperature 36.5 C. Hands put into bath at 10:05 a. m. and into calorimeters at 10:18. Pulse (sitting), 92.

At this time the foot calorimeters had not been constructed so that only an examination of the flow in the hands was made. This was done with the idea that some information of possible value for a prognosis in regard to the leg condition might be obtained, (1) from the absolute amount of the hand flow as an index of the flow in the periphery in general, (2) from the nature of the reflex vasomotor response as an index of the existence of a tendency to vasomotor spasm, a functional condition which there is good reason to believe may underlie or at least precede in certain cases the development of obliterative arteritis. The flow in the

right hand was 4.87 grams per 100 c.c. per minute and in the left 6.67 grams, with room temperature 25.7 C., a distinctly subnormal flow. Immersion of the right hand in cold water caused one of the most intense reflex vasoconstrictions in the contra-lateral hand which has been witnessed in the whole course of these observations, the flow declining to 2.59 grams per 100 c.c. per minute for the first five minutes and only reaching 5.59 grams after a further immersion in the cold water of four

TABLE 13.—CALORIMETRIC MEASUREMENTS IN CASE OF MAURICE T.

Time.	Right	Left	Notes.	Time.	Left	Notes.
10:17½	29.57	29.58	Room temperature 25.7 C.	10:38	30.24	Room temperature 25.5 C.
10:20	29.58	29.60		10:39	30.29	At 10:39 put right hand in water at 43°.
10:21	29.60	29.62				
10:22	29.62	29.65		10:40	30.31	Room temperature 25.0 C.
10:23	29.66	29.70	10:41	30.34		
10:24	29.70	29.76	10:42	30.38	Room temperature 25.1 C.	
10:25	29.74	29.82	Room temperature 25.6 C.	10:43	30.45	Room temperature 25.2 C.
10:26	29.78	29.86		10:44	30.52		Ears still red.
10:27	29.81	29.92	Room temperature, 26 C. Ears red.	10:45	30.60	Room temperature 25.2 C.
10:28	29.85	29.97		10:46	30.65		At 10:48 dried and wrapped right hand.
10:29	29.89	30.02	Right hand put in water at 9 C.	10:47	30.72	Room temperature 25.2 C.
10:29½				10:48	30.80		Room temperature 25.2 C.
10:30	....	30.08	The cold water is now 10.6 C. He feels the cold water extremely.	10:49	30.82	Room temperature 25.2 C.
10:31		30.09		10:50	30.88		Room temperature 25.3 C.
10:32	....	30.11		10:51	30.94	Room temperature 25.3 C.
10:33		30.12		10:52	31.00		Hand out of cal.
10:34	....	30.14	Room temperature 26.6 C.	10:53	31.07	Temp. of room 29.65 C.
10:35	....	30.15		10:54	31.13	
10:36	....	30.19	Hand out of cal. Temp. of room 29.65 C.	11:09	....	Temp. of room 29.65 C.
10:37	....	30.22		11:09½	31.01	

Volume of right hand, 470 c.c.; of left hand, 466 c.c. He is right-handed.

minutes. The reflex to warmth is also well marked, the flow in the left hand eventually rising to 10.96 grams. The general indication of the observations as regards the question propounded was that a vasomotor instability with a tendency to excessive vasoconstriction in the extremities might be the basis for the symptoms in the foot. The inequality in the flows in the two hands corroborates the idea of some degree of vasomotor abnormality. Anatomical changes in the nerves were of course not excluded. Unfortunately, the man soon after removed to a distant part

of the country, and up to the present it has not proved possible to learn the further history of the case.

In the case of Anthony P., a man 36 years old, with gangrene of the fingers and toes, the question arose whether the condition depended on a vasomotor neurosis.

Anthony P., a Polish laborer, aged 36 years, height 5 feet 8 inches, weight 150 pounds, was admitted to City Hospital, Oct. 9, 1912, complaining of sore fingers and toes. He froze his feet last winter. There is no history of frost-bite of the fingers. He had numbness of the fingers a year ago. Owing to the condition of his fingers he was forced to quit work about three weeks before admission. On admission the right hand showed beginning gangrene at the tip of the thumb, loss of the distal half of the nail of the middle finger, the remainder being undermined and loss of the entire nail of the ring-finger. The left hand showed purplish discoloration of the thumb, the nail being absent, loss of the entire nail of the index finger except the root, and gangrene about the base of the nail of the ring-finger.

A blood-flow examination of the hands was made on Oct. 11, 1912, with a very warm day (room temperature 27.8 C.). The flow came out only 1.22 grams for the right hand, and 1.12 grams for the left per 100 c.c. per minute, or allowing for the swelling of the left hand, 1.27 grams. The pulse-rate was 120 (sitting). The conclusion drawn was that if the small flow depended solely on the local conditions it was unlikely that the constriction of the vessels was purely functional, since the high room temperature would have caused vasodilatation. He was in such poor condition that a sufficient examination of the vasomotor reflexes was postponed. In the meantime cyanosis of the face and dilatation of the neck veins became prominent and physical examination revealed the signs of serious involvement of the heart (mitral stenosis, aortic insufficiency and signs of impairment of the myocardium). It was no longer possible to draw deductions from the small hand flow, and the slight response to the high external temperature as to the condition of the local circulation, since the state of the heart itself was sufficient to account for the small flow even provided that the cutaneous vasodilatation was the maximum possible with so small a driving power. Also fever (his rectal temperature was 39.65 C.) is associated with cutaneous vasoconstriction and a small hand and foot flow.⁸ Had the feet been normal, a comparison of the hand and foot flow might still have yielded information, since the cardiac insufficiency might be expected to diminish the flow in both without affecting the normal ratio between the hand and foot flow, whereas a vascular constriction (vasomotor or anatomical) confined to the hands would be revealed by a disturbance of this ratio in favor of the feet. The local conditions, however, soon became a matter of indifference in view of the serious involvement of the heart. The patient died October 12.

8. Stewart, G. N.: Paper VIII, Jour. Exper. Med., 1913, xviii, 372.

The necropsy showed the following: Left lung: infarct in the lower lobe 5 cm. in diameter. Right lung: infarct in upper lobe $2\frac{1}{2}$ cm. in diameter, and in lower lobe 5 cm. in diameter. Heart engorged on the right side and left side dilated; heart-muscle dark and flabby. The pericardium contains 100 c.c. of fluid. Aortic valve, left cusp hardened and shortened. Mitral admits tip of index-finger. Vegetations about the valves. Tricuspid, edges of valves thickened, recent vegetations. Liver, 1,800 grams, with chronic passive congestion. Spleen, weight 140 grams, chronic passive congestion. The kidneys show much arterial thickening. Blood-vessels: radial, practically no arterial thickening. The fingers show stasis of blood in the vessels. A cross-section of the index-finger shows much perivascular infiltration, but no thickening of the vessel walls. Pathological diagnosis, septic endocarditis.—(From Dr. Johnson's report.)

In a case of diabetic gangrene of the feet in a man 63 years old, the flow with a room temperature of 25.6 C. was 1.39 grams for the right foot and 1.83 grams for the left, or allowing for the swelling of the latter 1.95 grams. An interesting point is that the flow in the foot in which the gangrene had made most progress was greater than in the other foot. There is scarcely any question that this is due to inflammatory reaction. The diminished flow in the toes actually involved, if the flow is diminished there, would not show in a measurement of the flow through the whole foot. The sum of the flows in the feet, although subnormal, is not strikingly deficient, and the ratio of foot to hand flow (1:1.85) falls within the normal range. The hand flow was measured on the day preceding the observations on the foot and came out 2.65 grams for the right hand and 3.32 grams for the left per 100 c.c. per minute, with room temperature 22.0 C. In hospital cases presenting no rapid clinical changes, our experience has shown that such observations can safely be compared. The fact that the flow both in the hands and feet is decidedly below the normal agrees with the well-known feebleness of the cutaneous circulation in diabetes, and is probably in part due to cardiac changes. The vasomotor reflex, when warm water is applied to the contralateral hand, is very poor. Whether this indicates the beginning of pathological changes in the hand arteries also cannot of course be definitely stated. It is in any case interesting to correlate the enfeeblement of this vasomotor reflex with the enfeeblement or disappearance of skeletal reflexes such as the knee-jerk, which is known to occur in long-standing cases.

James P., a teamster 63 years old, was admitted to the City Hospital, Aug. 16, 1911, with a small ulcer on the inner surface of the left great toe and a scar in the same position on the right great toe. He came for treatment for his foot. It was found that the urine contained 4 per cent. of sugar with a trace of albumin. He was put on a diabetic diet. The blood-count showed erythrocytes 4,890,000, leukocytes 7,800, hemoglobin 90 per cent. April 28, 1912, the percentage of sugar in the urine was reduced to 0.8. April 11, 1912, when the blood-flow in the feet was examined there were small necrotic areas on the great and second toes of the right foot. The distal half of the left foot was bluish-red and the foot considerably swollen. The toes of the right foot were also bluish-red. He says that sometimes the left foot is hot, but when the flow in the feet was examined this was not the case.

Feet in bath at 1:21 p. m.; in calorimeters at 1:33, and out of calorimeters at 2:00; 3,740 c.c. of water in each calorimeter.⁹

Mouth temperature 37.45 C. Pulse (sitting), 68.

TABLE 14.—CALORIMETRIC MEASUREMENTS IN CASE OF JAMES P.

Time.	Right	Left	Room Temp. C.	Time.	Right	Left	Room Temp. C.
1:37	30.82	30.76	....	1:51	30.995	30.97	....
1:38	30.82	30.80	25.9	1:52	30.98	31.00	....
1:39	30.86	30.82	....	1:53	31.01	31.01	25.4
1:40	30.875	30.83	....	1:54	31.02	31.025	....
1:41	30.885	30.84	....	1:55	31.03	31.04	....
1:42	30.885	30.855	25.8	1:56	31.035	31.05	....
1:43	30.905	30.87	....	1:57	31.05	31.06	....
1:44	30.92	30.88	....	1:58	31.05	31.08	....
1:45	30.935	30.915	....	1:59	31.06	31.10	....
1:46	30.94	30.92	....	2:00	31.02	31.09	25.4
1:47	30.95	30.935	....	2:28	30.76	....	....
1:48	30.96	30.95	25.2	2:29	.....	30.75	....
1:49	30.975	30.96	....	2:32	30.71*	....	....
1:50	30.98	30.96	....	2:33	.....	30.72*	....

* After better stirring.

Cooling of calorimeters, R., 0.31 degree in thirty-two minutes, L., 0.37 degree in thirty-three minutes. Volume of right foot in calorimeter 1,090 c.c. of left foot 1,175 c.c. Rectal temperature (taken by himself and doubtless too low as compared with mouth temperature), 37.5 C. Water equivalent of calorimeters with contents, R., 4,760, L., 4,820.

The next case is remarkable for the fact that the flow in the hands per 100 c.c. per minute was very much less than in the feet, a quite unusual circumstance.

K., a laborer aged 50, was admitted April 15, 1912, to the City Hospital. He was much cyanosed on admission, and when the flow in the hands was first examined next day the cyanosis was still well marked in the face, nose, ears and hands, although less pronounced than on admission. There is gangrene of the toes on left foot. The pulse can be felt in the dorsalis pedis. Blood-pressure 140 systolic, 100 diastolic. He had some cough and rales of every description were heard all over the lungs. The fingers were markedly clubbed. The heart-sounds were weak. A soft systolic murmur and reduplicated second sound were heard over the left sternal border, more marked at the base. The heart was enlarged. The pulse at the wrist is not strong, but by no means so weak as to suggest that the blood-flow in the hands would be found so small as is actually the case.

April 16 the flow in the right hand came out only 0.27 gram per 100 c.c. per minute and in the left hand 0.28 gram, for a period of eighteen minutes in the calorimeters, with room temperature 23.8 C. Immersion of the left hand in warm water caused no increase whatever in the flow in the right. The very small flow in the hands agreed with the diagnosis

9. For the details of measurements of foot-flow see Paper VII of this series, Jour. Exper. Med., 1913, xviii, 354.

of myocarditis. It is possible also that a factor in the small flow was nervousness, as this was the first examination, and the patient was a foreigner, speaking no English. Still the effect of nervousness on the flow usually passes away more quickly.

April 18 he was again examined. The cyanosis was now much diminished and the radial pulse was stronger. The flow in the right hand was 1.05 grams and in the left 1.43 grams per 100 c.c. per minute, with room temperature 22.5 C., still quite a small flow, although much greater than at the last examination. In the right foot the flow was 2.15 grams per 100 c.c. per minute, and in the left foot 3.42 grams. Immersion of the right foot in cold water was accompanied by a reduction in the flow in the left foot to 2.68 grams, which was only slightly increased (to 2.87 grams) when the right foot was put into warm water.

Feet in bath at 2:07 p. m., in calorimeters 2:19 p. m. Patient sitting. 3.740 c.c. water in each calorimeter. At 2:45 p. m. the right foot was put into water at 10.5 C.

TABLE 15.—CALORIMETRIC MEASUREMENTS IN CASE OF K.

Time	Right	Left	Room Temp. C.	Time	Left	Notes
2:22	29.99	29.93	.....	2:46	30.605	Room temp. 20.7 C.
2:23	30.00	29.95	20.5	2:47	30.625	
2:24	30.02	29.99	.....	2:48	30.635	
2:25	30.03	30.05	.....	2:49	30.655	
2:26	30.045	30.08	.....	2:50	30.665	
2:27	30.07	30.125	.....	2:51	30.70	
2:28	30.08	30.14	20.4	2:52	30.715	
2:29	30.09	30.175	.....	2:53	30.725	At 2:54 right foot put in water at 42.8 C.
2:30	30.10	30.22	.....	2:54	30.745	
2:31	30.11	30.245	.....			
2:32	30.125	30.275	.....	2:55	30.76	Room temp., 21.0 C.
2:33	30.135	30.30	.....	2:56	30.775	Right big toe painful.
2:34	30.145	30.33	.....	2:57	30.80	
2:35	30.17	30.35	20.1	2:58	30.825	
2:36	30.19	30.38	.....	2:59	30.835	
2:38	30.21	30.42	.....	3:00	30.85	
2:39	30.22	30.46	.....	3:01	30.87	
2:40	30.23	30.47	.....	3:02	30.90	Room temp. 21.3 C.
2:41	30.23	30.50	.....	3:03	30.925	
2:42	30.235	30.52	.....	3:04	30.935	
2:43	30.24	30.535	.....	3:05	30.94	Foot out of calorimeter.
2:44	30.26	30.56	.....	3:17	30.75	Room temp. 20.9 C.
2:45	30.275	30.595	.....	3:18	.....	Temp. of R. is now 29.79 C.

Cooling of calorimeters, R., 0.485 C. in thirty-three minutes; L., 0.19 C. in twelve minutes. Rectal temperature 37.6 C. Volume of right foot in calorimeter 950 c.c., of left 985 c.c. Water equivalent of calorimeters with contents, R., 4,652; L., 4,679.

The question whether the gangrene was going to spread was what chiefly interested the physician in charge of the case. The fact that the

flow in the feet was so good was interpreted as favorable for the prognosis, although of course it was impossible to say to what extent the flow in the toes themselves had been interfered with. The left foot was somewhat swollen, as shown by the volume measurement. Yet it was only a little over 3 per cent. larger than the right. The greater flow in the left was probably related to a certain degree of inflammatory reaction. The foot soon began to heal up. But on April 25 the temperature, which had hitherto never surpassed 100 F., began to rise, reaching 104.2 F. on April 27. Then it fell and remained below 100 F. till his death on May 3.

The existence of a relatively good flow in the feet associated with a poor flow in the hands demands some further remark. It is probable that the immediate cause of the lesion in the left foot was exposure to cold. If so, it is likely that the already existing feebleness of the circulation and the poor response of the vasomotor regulatory mechanism were contributing causes. Very likely both feet suffered injury, although it only went on to gangrene in the left. The flow in both feet may, therefore, have been increased by the reaction to the injury caused by the freezing, and this in spite of the feeble driving-power of the heart. Thus the flow in the feet may have been brought up by the accident of the inflammation approximately to the normal flow, while that in the hands fell far below the normal.

Miss W., aged 25, weight 128 pounds, has lost fourteen pounds since her illness began. She first noticed pain in the ankles with some swelling in March, 1908. The pain increases as the day goes on, and at about 7 p. m. it is worse but on lying down she gets relief. In the morning her eyes are swollen. The wrists also swell when she works much with her arms. There is some shortness of breath. She must lie down some part of the day if she desires to sit up at night, even to 9 o'clock. An eruption consisting of raised red spots comes out periodically on the legs, also, though much less copiously, on the arms. There is burning pain and itching in the spots. In a day they get brownish, and in two days have disappeared to a great extent, except that a brown stain persists for weeks. Several spots 2 cm. in diameter which had come out the previous day on her legs were examined. The reddish color did not diminish on pressure. From her description the spots resemble urticaria at first and then hemorrhage takes place into the wheals. On the trunk also are spots which she describes as wheals, which itch and are painful, but the most purpuric-looking spots are on the legs. On the front of each tibia is a spot with a blackish crust from which she says some matter came out, but generally no liquid escapes from them. Her feet and toes are cold and so are her hands, especially the terminal phalanges of the fingers. Her nails grow irregularly, probably more quickly than before, and are ridged. There is distinct defect of sensation in the toes and the adjacent parts of the foot. A pin-prick is scarcely felt, and then only as contact. She does not feel any tickling sensation when the sole is stroked and there is no plantar reflex. Good knee-jerks can be obtained. There is a long reddish scar on the back of one finger of the left hand. She says she had "blood-poisoning" some time ago in a small wound caused by a tack and healing did not occur for eighteen weeks. The heart-sounds are clear and unaccompanied by murmurs. The urine contains no albumin, casts or sugar. Her eye-sight is not affected.

The blood-flow in the hands was examined May 9, 1911. Pulse 88. Mouth temperature 37.6 C. Hands put into bath at 10:14½ p. m., and into calorimeters at 10:24.

TABLE 16.—CALORIMETRIC MEASUREMENTS IN CASE OF MISS W.

Time.	Right	Left	Notes.	Time.	Right	Notes.
10:23	30.13	30.08	Room tempera- 24.0 C.	10:43	30.195	Room tempera- ture 24.3 C.
10:25	30.11	30.06		10:44	30.20	
10:26	30.10	30.05		10:45	30.215	At 10:45 left hand put in water at 9.1 C.
10:27	30.11	30.05				She feels left hand very un- comfortable.
10:28	30.09	30.04	Room tempera- 24.1 C.	10:46	30.215	
10:29	30.10	30.04		10:47	30.22	
10:30	30.10	30.04		10:48	30.225	Room tempera- 24.3 C.
10:31	30.10	30.03		10:49	30.225	
10:32	30.12	30.04		10:50	30.23	
10:33	30.12	30.035		10:51	30.23	
10:34	30.125	30.04		10:52	30.235	Room tempera- ture 24.4 C.
10:35	30.13	30.045				At 10:52 dried and wrapped left hand. It is pretty red.
10:36	30.145	30.06		10:53	30.235	
10:37	30.16	30.06	At 10:37 left hand put in water at 43 C.	10:54	30.24	
10:38	30.165	.....	Room tempera- ture 24.3 C.	10:55	30.245	Room tempera- ature 24.5 C.
10:39	30.17	.....	Left hand is fairly red and the veins of fair size.	10:56	30.245	Hand out of calorimeter. Feels pins needles in it.
10:40	30.17	.....		10:56½	.....	Temperature of L., 29.91 (at 10:56½).
10:41	30.18	.....		11:26	30.03	
10:42	30.185	.....				

Cooling of calorimeters, R., 0.215 C. in thirty minutes, L., 0.15 C. in nineteen and one-half minutes. Volume of right hand in calorimeter 292 c.c. of left 298 c.c. She is right-handed.

May 25, 1911, the physician in charge of the case reported that since the time of the blood-flow examination she had had rather severe intestinal symptoms and that her temperature rose to 103 F. He gave her calcium chlorid and alkalis. She is now much better than for a while and the spots have disappeared.

The flow in the right hand was 2.16 grams per 100 c.c. per minute, in the left 1.64 grams, with room temperature 24.1 C., a very poor flow for her age. Reflex vasodilatation is absent, or quite feeble, the flow in the right hand only rising to 2.38 grams when the left was immersed in warm water. Scraping the skin with a blunt point caused no local vasodilatation. Although the initial flow was so small a further reflex vasoconstriction, reducing the flow in the right hand to 1.72 grams, was obtained when the left hand was put into cold water. No doubt the

coexisting anemia is a factor in reducing the flow through the hands. The toxemia (rheumatic perhaps) on which the purpura depends may also depress the flow more directly, either by enfeebling the heart or by vasoconstriction. The conclusion deduced from the blood-flow measurements was that the feeble cutaneous flow might be a factor in the condition, and that so far as this went, the indication was that such measures should be adopted as would increase the flow in the skin, including the treatment of such anemia as was present.¹⁰

The last case to be described in this paper is that of Charles H.

Charles H., a clerk 42 years old, height 5 feet 10½ inches, weight 140 pounds, was admitted to the City Hospital Nov. 23, 1912, with edema of the right foot and leg. The swelling began a month ago, commencing at the toes with inflammation, he says, resembling erysipelas. A little over a year ago he accidentally injured the right lower leg by a blow with a hammer about midway between knee and ankle over the tibia. It healed at the time. Afterward a sore opened from which matter was discharged. He entered a hospital, where the leg soon healed. He has pain

TABLE 17.—CALORIMETRIC MEASUREMENTS IN CASE OF CHARLES H. FIRST EXAMINATION

Time	Right	Left	Room Temp. C.	Time	Right	Left	Room Temp. C.
3:26	31.43	31.43	....	3:51	31.15	31.165	....
3:29	31.36	31.31	22.7	3:53	31.135	31.18	23.0
3:31	31.33	31.26	....	3:55	31.125	31.185	23.1
3:33	31.305	31.24	22.8	3:57	31.12	31.19	23.15
3:35	31.28	31.23	23.1	3:59	31.105	31.21	23.1
3:37	31.26	31.195	23.15	4:01	31.09	31.225	....
3:39	31.235	31.18	....	4:03	31.08	31.24	23.0
3:41	31.22	31.17	23.1	4:05	31.07	31.24	....
3:43	31.20	31.16	....	4:07	31.06	31.245	23.0
3:45	31.18	31.155	23.1	4:10	31.01	31.18	....
3:47	31.17	31.155	23.0	4:21	30.865	31.04	....
3:49	31.16	31.15	....	....	.....	.....	....

as soon as he commences to walk. When he stands up for a few minutes the foot becomes very blue and the small blood-vessels distend. The swelling comes on with great rapidity (in ten or fifteen minutes) when he goes about on his feet, and disappears completely when he lies down for a little while. There are no varicose veins. He does not appreciate warmth or cold, or contact (blunt-point) on the dorsum of the right foot or on the lower third of the right leg. A pin-prick is felt as dull contact. There is no anesthesia above the level of the scar due to the injury, except for a small tongue just above and continuous with the scar. The right sole is very sensitive. It began to be hypersensitive just after the foot commenced to swell. When he awakes in the morning he has a burning sensation about the toe-nails of the right foot. This disappears when he walks about a little. When he stood up it was seen that his right leg became very red in the anesthetic region. On pressure the red color disappeared. He says that when he first came into the hospital the white spot produced on pressure remained for some time, but now it quickly becomes red again. When he first came into the hospital

10. Paper VI of this series, Jour. Exper. Med., 1913, xviii, 13.

the red color which came on when standing soon became pale blue, whereas after a fortnight in the hospital it remains red. The legs, however, continue to be cold to the touch. He would not know his leg and foot were becoming red if he did not see it. He says he cannot keep the right foot warm. When the left foot is sweating under the bedclothes and he puts his hand down to feel the right foot it is always cold. He looks anemic and feels pretty weak, though his appetite is good. He has lost nearly 30 pounds in weight since he had malaria in Texas three years ago. The knee-jerks and ankle-jerks are somewhat exaggerated, but there is no patellar or ankle clonus. Examination of the heart and lungs is negative in result and the heart sounds are clear though very weak and distant. The pulse is regular.

The flow in the feet was examined Dec. 5, 1912, the patient sitting. Feet in bath at 3:15 p. m., in calorimeters at 3:28, and out of calorimeters at 4:07; 2,775 c.c. of water in each calorimeter. (Table 17.)

Cooling of calorimeters in eleven minutes, R., 0.145 degree; L., 0.14 degree. Volume of right foot 961 c.c., of left 924 c.c. He has small feet (No. 7 shoes). Rectal temperature 37.6 C. Pulse (sitting) 100. Water equivalent of calorimeters with contents, R., 3,696, L., 3,668.

Second examination Dec. 10, 1912. Pulse (sitting) 96. Hands in bath at 3:14 p. m., in calorimeters at 3:27. At 3:40 right hand put into water at 42.8 C.

When taken out of the cold water the right hand was distinctly redder than the left. Cooling of calorimeters, R., 0.505 C. in forty-one minutes; L., 0.19 C. degree in sixteen minutes. Volume of right hand in calorimeter 367 c.c., of left hand 355 c.c. He is right-handed. Rectal temperature 37.35 C. Blood-pressure in right arm, systolic 108, 88 (sudden change in sound), 81 (sound gone). The left arm, systolic 108. (Table 18.)

TABLE 18.—CALORIMETRIC MEASUREMENTS IN CASE OF CHARLES H. SECOND EXAMINATION

Time	Right	Left	Room Temp. C.	Time	Left	Room Temp. C.	Notes
3:26	31.89	31.85	21.9	3:47	31.90	22.5	At 3:55 right hand put in water at 8.6 C.
3:28	31.85	31.81	22.0	3:48	31.91	22.4	
3:29	31.85	31.81	22.15	3:49	31.92	....	
3:30	31.85	31.81	22.15	3:50	31.925	22.8	
3:31	31.855	31.82	....	3:51	31.93	....	
3:32	31.86	31.825	22.4	3:52	31.935	22.9	The right hand is red. He feels the water very cold.
3:33	31.865	31.83	22.6	3:53	31.94	....	
3:34	31.87	31.84	22.8	3:54	31.945	22.7	
3:35	31.875	31.84	....	3:55	31.955	....	
3:36	31.88	31.85	22.6	3:56	31.955	....	
3:37	31.88	31.855	22.5	3:57	31.955		The right hand does not now feel cold at all. Still red.
3:38	31.895	31.86	....	3:58	31.955	....	
3:39	31.895	31.86	....	3:59	31.95	23.7	
3:40	31.895	31.865	....	4:00	31.945	....	
3:41	.....	31.875	23.0	4:01	31.94	23.5	
3:42		31.875		4:02	31.94		Hand out of calor. at 4:05. 4:21 temp. of R. is 31.39 C.
3:43	.....	31.875	22.8	4:03	31.94	....	
3:44	.....	31.88	....	4:04	31.935	23.7	
3:45	.....	31.885	22.7	4:05	31.93	....	
3:46	.....	31.89	....	4:21	31.74	....	

The distribution of the anesthesia and the history of the case seem to indicate that a nerve injury was the starting point of the vascular condition. The flow in the right foot was 0.51 gram per 100 c.c. per minute and in the left 1.35 grams, with room temperature 23.0 C. The flow in the right hand was 3.43 grams, and in the left hand 3.71 grams per 100 c.c. per minute, with room temperature 22.6 C. While, then, the flow in the hands is much below the normal, which corresponds well with the rather feeble action of the heart and with the patient's anemic condition, the flow in the left foot preserves a ratio to that in the hands not far from normal. The flow in the right foot, however, is distinctly poor, even in proportion to the poor hand flow. The cause accordingly of the small flow in the right foot is not a central one, but is local. This agrees well with the patient's observation that he cannot keep the right foot warm, and that the red color which it first exhibits when he stands becomes pale blue. The blood-flow measurement corroborates the conclusion that in the right foot the blood is stagnating in the capillaries of the engorged area.

SUMMARY

1. In cases with marked arteriosclerosis the blood-flow in the hands is smaller and the contralateral vasomotor reflexes less pronounced than normal.

2. In cases of thoracic aneurysm the flow in the hands may be normal. Where it is subnormal there is no evidence, apart from a unilateral deficiency in some cases due to the pressure of the aneurysm, that the existence of the aneurysm as such has any influence in diminishing the flow, the diminished flow being associated with coexisting pathological conditions (myocardial changes, valvular lesions).

3. A great difference in the form of the pulse-wave in the two radials associated with thoracic aneurysm does not necessarily indicate a difference in the flow through the hands. The hand flows may be identical when the sphygmograms from the radials on the two sides are very different.

4. In three cases of Raynaud's disease the hand flows were subnormal even in the absence of an actual attack, in the more advanced cases very much below the normal.

5. An abnormally great contralateral reflex vasoconstriction to cold seems to characterize the earlier stages of Raynaud's malady. When it has existed for a long time and gangrene has occurred, the vasomotor reactions indicate the existence of anatomical changes in the vessels, which do not permit vasomotor reflexes as intense as at first.

TABLE 19.—SUMMARY OF CALORIMETRIC

Case	Age	Date	Pulse Rate	Blood Pressure	Temperature (C.) of				Volume of Part in c.c	
					Room	Art Blood	Calorimeters		Right	Left
							Right	Left		
Chas. S....	69	7/ 8/13	80	180, (120)	28.3	36.3	30.70	30.75	437	410
					28.3	....	30.96	.....	.....	.....
					28.3	....	31.12	.....	.....	.....
Fred S....	58	5/ 8/13	116	122, (101)* 63	23.8	36.9	31.28	31.25	497	484
					23.9	....	31.47	.....	.....	.....
					23.9	....	31.70	.....	.....	.....
					23.9	....	31.91	.....	.....	.....
					24.0	....	31.99	.....	.....	.....
					24.2	....	32.19	.....	.....	.....
Paul K...	57	4/24/12	100	115	22.8	37.5	31.14	31.27	454	451
					22.6	....	31.52	31.54	.....	.....
Joseph C..	50	1/31/11	88	160	21.5	37.2	29.49	29.43	505	480
Wm. B....	53	12/22/10	84	205	20.8	37.1	28.81	23.97	410	390
		1/17/11	88	210	22.2	36.9	31.07	30.82	435	410
Richard B.	38	5/23/11	100	.....	27.9	37.1	31.03	30.75	495	437
					28.0	....	....	31.09	.....	.....
					28.0	....	....	31.26	.....	.....
					28.1	....	....	31.41	.....	.....
					28.2	....	....	31.66	.....	.....
Sam S....	31	12/10/12	124	L.,118,(58) R.,157,(61)	22.2	37.9	31.98	32.01	580	603
John McL.	50	8/27/12	....	156, 83	22.2	36.15	30.73	30.72	498	475
					21.2	....	30.53	30.44	1,697	1,712
		8/28/12	97	.....	21.1	36.7	30.63	30.59	507	454
					20.4	....	30.87	30.76	1,780	1,749
Mrs. W. G.	28	4/24/11	108	.....	25.3	37.55	30.22	30.24	391	375
					25.1	....	30.51	.....	.....	.....
					25.0	....	30.73	.....	.....	.....
					....	....	30.77	.....	.....	.....
					2.06	....	30.87	.....	.....	.....
Mrs. C. B..	29	5/ 9/13	112	.....	21.7	37.35	31.09	31.10	273	282
					22.3	....	31.10	31.27	.....	.....
					22.3	....	31.11	31.21	.....	.....
					22.8	....	31.14	.....	.....	.....
					22.9	....	31.19	.....	.....	.....
					22.8	....	31.24	.....	.....	.....
					22.7	....	31.25	.....	.....	.....
					22.7	....	31.30	.....	.....	.....
Maurice T.	41	4/17/11	92	.....	25.7	36.5	29.84	29.76	470	466
					26.3	....	....	30.11	.....	.....
					26.6	....	....	30.22	.....	.....
					25.0	....	....	30.34	.....	.....
					25.2	....	....	30.59	.....	.....
Anthony P.	36	10/11/12	120	.....	27.8	39.15	31.90	31.92	406	460
James P...	63	4/10/12	....	.....	22.0	37.05	30.51	30.59	438	414
					22.0	....	....	30.78	.....	.....
		4/11/12	68	.....	25.6	37.35	30.92	30.93	1,090	1,175
K.	50	4/16/12	116	140, 100	23.8	36.7	30.55	30.65	352	310
					24.0	....	30.44	.....	.....	.....
		4/18/12	....	.....	22.5	37.1	29.55	29.72	313	304
					20.3	37.0	30.13	30.26	950	985
					20.7	....	....	30.67	.....	.....
					21.1	....	....	30.84	.....	.....
Miss W...	25	5/ 9/11	88	.....	24.1	37.6	30.13	30.05	292	298
					24.3	....	30.19	.....	.....	.....
					24.3	....	30.23	.....	.....	.....
					24.4	....	30.24	.....	.....	.....
Chas. H....	42	12/ 5/12	100	.....	23.0	37.0	31.11	31.20	961	924
		12/10/12	96	108, (88) 81	22.6	36.8	31.87	31.84	367	355
					22.9	....	....	31.87	.....	.....
					22.7	....	....	31.92	.....	.....
					23.6	....	....	31.93	.....	.....

* As in the other papers, the numbers in brackets in this column give the pressure at which the sound had disappeared.

The condensed results of three of the cases referred to in this paper (Meyer, G., J. O'R. and this series (Heart, 1911, iii, 33).

Heat Given Off in Gram-Calories			Blood-Flow in Gm. Per Min.		Flow Per 100 c.c. of Part Per Min.		Notes
Right	Left	In Mins.	Right	Left	Right	Left	
930	822	8	23.07	20.57	5.25	5.01	Arteriosclerosis.
723	.....	8	18.81	.....	4.30	.....	Left hand in water at 8.5 C.
724	.....	7	22.18	.....	5.08	.....	Left hand in water at 43 C.
1,449	1,428	10	28.64	28.08	5.76	5.80	Arteriosclerosis.
410	.....	3	27.96	.....	5.62	.....	Left hand in water at 43 C.
1,790	.....	10	38.24	.....	7.69	.....	Left hand still in water at 43 C.
244	.....	3	18.18	.....	3.65	.....	Left hand in water at 8c.
731	.....	6	27.57	.....	5.54	.....	Left hand still in water at 8 c.
1,362	.....	10	32.13	.....	6.46	.....	Left hand in water at 38.5 C.
795	656	7	19.84	16.71	4.37	3.70	Aneurysm first seven minutes.
2,801	2,143	15	34.69	26.63	7.64	5.90	Last fifteen minutes in calorimeters.
2,580	2,460	11	33.81	31.09	6.69	6.66	Aortic aneurysm.
3,581	2,927	14	34.36	28.59	8.38	7.33	Thoracic aneurysm.
3,269	2,974	14	44.50	38.82	10.23	9.47	
3,247	2,239	11	54.03	35.62	10.91	8.15	Innominate aneurysm.
....	517	4	.....	23.89	.....	5.47	Right hand in water at 8.1 C.
....	792	4	.....	37.63	.....	8.61	Right hand still in water at 8.1 C.
....	413	3	.....	26.91	.....	6.16	Right hand in water at 4.3 C.
....	1,516	7	.....	44.23	.....	10.12	
4,466	4,292	13	64.47	62.28	11.11	10.32	Aortic aneurysm.
157	208	14	2.07	2.73	0.41	0.57	Cardio-renal disease with aneurysm.
114	100	8	2.81	2.43	0.17	0.14	Feet.
525	501	17	5.65	5.36	1.11	1.18	
616	608	10	11.74	11.37	0.66	0.65	Feet.
842	754	9	14.18	12.93	3.62	3.44	Raynaud's disease.
1,534	.....	12	20.18	.....	5.16	.....	Left hand in water at 43 C.
170	.....	3	9.23	.....	2.46	.....	Left hand in water at 12 C.
375	.....	4	15.36	.....	3.93	.....	Left hand still in water at 12 C.
477	.....	4	19.83	.....	5.07	.....	Left hand dried and wrapped.
298	299	8	6.61	6.64	2.42	2.35	Raynaud's disease first eight minutes.
795	1,079	16	8.83	12.12	3.23	4.29	Next sixteen minutes in calorimeters.
392	415	7	9.97	10.73	3.65	3.80	Last seven minutes of the sixteen.
200	.....	2	17.89	.....	6.55	.....	Left hand in water at 43 C.
651	.....	10	11.74	.....	4.30	.....	Left hand still in water at 43 C.
167	.....	2	15.18	.....	5.56	.....	Left hand in water at 12 C.
118	.....	2	10.74	.....	3.93	.....	Left hand still in water at 12 C.
477	.....	5	1,752	.....	6.41	.....	Left hand still in water at 12 C.
1,491	1,111	8	31.09	22.89	6.67	4.87	Arteritis in leg.
....	347	5	.....	12.07	.....	2.59	Right hand in water at 9 C.
....	589	4	.....	26.06	.....	5.59	Right hand still in water at 9 C.
....	382	3	.....	22.97	.....	4.93	Right hand in water at 43 C.
....	1,630	6	.....	51.09	.....	10.96	Right hand still in water at 43 C.
324	336	10	4.96	5.16	1.22	1.12	Gangrene of fingers; septic endocarditis.
1,033	1,199	15	11.59	13.75	2.65	3.32	Diabetes.
....	1,027	11	.....	16.54	.....	3.99	Right hand in water at 43 C.
2,023	2,858	23	15.19	21.50	1.39	1.83	Feet (left gangrenous).
95	87	18	0.95	0.88	0.27	0.28	Myocarditis; cyanosis. (Congenital heart?)
44	.....	10	0.78	.....	0.22	.....	Left hand in water at 41.8 C.
335	434	15	3.29	4.35	1.05	1.43	Cyanosis much less.
2,912	4,712	23	20.47	33.77	2.15	3.42	Feet (left toes gangrenous).
....	1,357	9	.....	26.46	.....	2.68	Right foot in water at 10.5 C.
....	1,726	11	.....	28.30	.....	2.87	Right foot in water at 42 C.
467	300	R 11	6.32	4.90	2.16	1.64	Purpura.
		L 9					
372	.....	8	6.97	.....	2.38	.....	Left hand in water at 43 C.
234	.....	7	5.04	.....	1.72	.....	Left hand in water at 9.1 C.
133	.....	4	5.04	.....	1.72	.....	Left hand dried and wrapped.
474	1,192	18	4.96	12.67	0.51	1.37	Feet (edema of right).
559	588	10	12.59	13.17	3.43	3.71	Hands.
....	210	4	.....	11.83	.....	3.33	Right hand in water at 42.8 C.
....	700	11	.....	14.49	.....	4.08	Right hand still in water at 42.8 C.
....	321	10	.....	7.32	.....	2.06	Right hand in water at 8.6 C.

the abrupt change in the sound occurred; the smaller number following is the pressure at which

Margaret H.) are omitted from the table, having already been given in Table II, Paper I, of