

# A STUDY OF THE BLOOD-PRESSURE IN ANEMIA IN INFANCY\*

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This study was undertaken because of the unexpected results obtained in an examination of the blood-pressure in a marked case of anemia in an infant. The history of this case will be given in detail further on. It was found on looking up the literature that there were very few data as to the blood-pressure in infancy, whether in health or in disease, and practically nothing as to the blood-pressure in anemia in infancy.

Shaw,<sup>1</sup> using Gärtner's tonometer, made 400 measurements on forty-five children ranging in age from 3 months to 12 years. He found that the systolic pressure under normal conditions varied between 90 and 110 mm. He also found that the age of the child appeared to have very little influence on the height of the blood-pressure.

Cook and Briggs<sup>2</sup> found that the systolic pressure during the first two years varied between 75 and 90 mm. They used a modification of the Riva-Rocci instrument and determined the pressure by palpation. They do not state the width of the band used, and give no data as to the number of babies examined.

Beretta<sup>3</sup> found that the systolic pressure in babies during the first year varied between 54 and 87 mm., the average being 76 mm. He used the Riva-Rocci instrument.

Stone<sup>4</sup> found that the ordinary reading in infants under 6 months was between 60 and 70 mm., and between 2 and 3 years, 80 to 90 mm. He used the Riva-Rocci apparatus, but gives no data as to

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1. Shaw: Albany Med. Ann., 1900, xxi, 88.

2. Cook and Briggs: Johns Hopkins Hosp. Rep., 1903, xi, 451.

3. Beretta: Abstr. in Monatschr. f. Kinderheilk., 1903-4, ii, 725.

4. Stone: Boston Med. and Surg. Jour., 1904, cl, 262.

the width of the cuff used, where the pressure was taken or how many babies were examined.

Oppenheimer and Bauchwitz<sup>5</sup> examined sixty-eight children ranging from the new-born to 14 years of age. They do not give the number of children tested at the different ages. They used a modification of the Riva-Rocci instrument, with a cuff 5 cm. in width. They state that the blood-pressure between birth and 6 months is 80 mm., from 7 months to 1 year, 90 mm., and from 2 years to 3 years, 90 mm.

Trumpp<sup>6</sup> made 1,062 observations on fifty-six infants, using Gärtner's tonometer. He found that the systolic pressure in healthy, quiet infants varied between 60 and 90 mm., the average being 80 mm. Readings between 60 and 70 mm. were ordinarily found only during sleep or in premature or feeble infants. The pressure was the same in the new-born as in older infants. Nervous excitement and muscular activity increased the pressure from 10 to 60 mm. The taking of food increased it from 8 to 10 mm. He studied nine cases of acute and eight of chronic disturbances of nutrition and found that the blood-pressure sank with the increase in the debility. Anything under 50 mm. was a bad sign. When there were marked changes in weight, the blood-pressure rose and fell with the weight. The blood-pressure rose with water retention.

Gordon<sup>7</sup> studied 170 normal children, but does not state the number of children at the various ages. He used Martin's modification of the Riva-Rocci instrument, with a cuff 12 cm. in width. He found that the systolic pressure under 1 year was 71 mm., at 1 year, 73 mm., and at 2 years 79.5 mm. He states that the figures are higher if a narrower armlet is used.

Hill<sup>8</sup> made nineteen examinations on sixteen babies under 2 years of age, ill with gastro-enteritis. The average systolic pressure in these cases was 102 mm., the average diastolic, 81 mm., and the average pulse-pressure, 21 mm. The highest systolic pressure was 130, the lowest, 85; the highest diastolic, 118, and the lowest, 60; the highest pulse-pressure 36 and the lowest 8. He emphasizes the importance of the pulse-pressure, and says that it is far more important than the systolic pressure alone. The pulse-pressure was somewhat lower in the infants that died, but there were many exceptions. He concludes that the blood-pressure is not of the same importance in infants as in adults. He used the Nicholson sphygmomanometer, a modification of the Riva-Rocci type. The instrument was applied on the

5. Oppenheimer and Bauchwitz: *Arch. f. Kinderheilk.*, 1905, xlii, 415.

6. Trumpp: *Jahrb. f. Kinderh.*, 1906, lxiii, 43.

7. Gordon: *Arch. Pediat.*, 1911, xxviii, 343.

8. Hill: *Arch. Pediat.*, 1913, xxx, 588.

TABLE 1.—NORMAL INFANTS

No.	Age in Months	Sex*	Systolic Pressure	Diastolic Pressure	Pulse Pressure	Hemo-globin %
1	2	♀	80-76	50-57	30-19	70
2	2½	♀	72	58	14	
3	3	♂	84	62	22	
4	3	♂	78	65	23	
5	3	♀	100-97	70-74	30-23	
6	3	♂	78	64	14	75
7	3	♂	78	61	17	
8	4	♂	82	69	13	
9	4	♂	88-90	52-57	36-33	
10	4½	♂	80-92	44-60	36-32	80
11	5	♂	82	64	18	
12	6	♂	92-96	75-74	17-22	
13	6	♂	98	82	16	
14	6	♂	88	72	16	
15	6	♀	94-95	40-60	54-35	80
16	6	♀	86	67	19	
17	6	♂	84-87	44-56	40-31	
18	6½	♂	98	78	20	
19	7	♀	90-92	50-57	40-35	
20	7	♀	90	76	14	70
21	8	♀	86	63	23	
22	8	♂	83	74	9	
23	8	♀	95	64	31	
24	8	♂	80-94	40-52	40-42	
25	8	♀	110	80	30	80
26	8	♂	88	59	29	
27	8½	♂	80-92	45-56	35-36	
28	8½	♀	95	70	25	
29	9	♀	87	68	19	
30	9	♂	110	80	30	70
31	10	♂	102-100	76-80	26-20	
32	10	♂	87	72	15	
33	11	♂	85	60	25	
34	11	♀	82	69	13	
35	11	♀	82	59	23	80
36	11	♂	89	66	23	
37	11	♀	92	78	14	
38	11	♀	100	76	24	
39	12	♂	94-92	70-73	24-19	
40	12	♂	100	74	26	80
41	12	♀	95	65	30	
42	12	♂	90	75	15	
43	12	♀	92	60	32	
44	13	♂	98	76	22	
45	13	♀	92	60	32	20
46	14	♂	100	80	20	
47	14	♂	97	83	14	
48	15	♂	100	79	21	
49	17	♂	100	70	30	
50	22	♂	104	84	20	
Average .....			90	66	25	

\* In this and the following tables ♂ stands for male and ♀ for female.

thigh and the readings made by auscultation over the popliteal artery. The systolic pressure was measured from the first sound heard, and the point at which the sound entirely disappeared was taken as the diastolic pressure.

It seemed advisable, therefore, to examine first a series of normal infants, in order to get a more definite normal standard. A series of poorly nourished babies, not suffering from anemia, was then examined to determine what effect, if any, the condition of the nutrition had on the blood-pressure. A small series of babies suffering from moderate anemia was then examined, and finally, a more detailed examination of the baby suffering from severe anemia was made.

The "Tycos" sphygmomanometer was used in this study. The width of the band was 5 cm. The tests were made on the arm, when possible, otherwise on the thigh. As a matter of fact, about one-half of them were made on the arm and one-half on the thigh. The determinations of the blood-pressure were all made with the stethoscope, the bell being applied over the vessels at the elbow when the cuff was applied on the upper arm, and in the popliteal space, when it was applied on the thigh. The systolic pressure was read when the sound was first heard; the diastolic pressure was read when the sound changed from sharp to dull.

Sixty-two observations were made on fifty normal babies. These results are given in detail in Table 1. The average systolic pressure in normal babies under 2 years of age was, therefore, 90 mm., the average diastolic, 66 mm., and the average pulse-pressure 25 mm.

TABLE 2.—COMPARISON BETWEEN VARIOUS PRESSURES IN THE FIRST AND SECOND YEARS

	First Year	Second Year
Number of Cases.....	38	12
Average Systolic Pressure .....	89	95
Average Diastolic Pressure .....	64	73
Average Pulse-Pressure .....	25	24
Highest Systolic Pressure.....	110	104
Lowest Systolic Pressure.....	72	90
Highest Diastolic Pressure.....	82	84
Lowest Diastolic Pressure.....	40	60
Highest Pulse-Pressure .....	54	32
Lowest Pulse-Pressure .....	9	14

Thirty-two of these babies were males and eighteen females. The average systolic pressure in the males was 91 mm. and in the females 86 mm. The average diastolic pressure in the males was 68 mm. and in the females, 64 mm. The average pulse-pressure in the males was

TABLE 3.—POORLY NOURISHED INFANTS

No.	Age in Months	Sex	Systolic Pressure	Diastolic Pressure	Pulse-Pressure	Hemo- globin Red Corpuscles	Diagnosis	General Condition	Spleen
1	1½	♂	74	36	38	80%	Indigestion, malnutrition	Poor	
2	2	♂	74	45	29		Pyloric spasm	Poor	
3	2	♂	69	40	29		Pyloric spasm	Poor	
4	2	♀	72	43	29		Feeding	Poor	
5	2½	♀	64	40	24	70%	Malnutrition	Fair	
6	3	♀	72	46	26		Malnutrition	Poor	
7	3	♂	60	47	13		Pyloric spasm	Poor	
8	3	♀	75	40	35		Indigestion	Poor	
9	4	♀	80	50	30		Feeding	Good	
10	4	♀	84	57	27		Pyloric spasm	Poor	
11	5	♂	80	40	40		Feeding	Fair	
12	5	♀	93	54	39		Indigestion	Fair	
13	5	♀	60	40	20		Malnutrition	Poor	
14	5	♂	83	52	31		Malnutrition	Poor	
15	7	♂	70	30	40	80%	Malnutrition	Fair	Spleen +
			75	30	45	4,000,000	Rachitis		
16	7	♂	92	35	57	70%	Malnutrition	Good	Spleen +
			90	40	50	4,550,000			
17	7	♀	94	63	31		Feeding	Poor	
18	10	♂	92	51	41		Syphilis	Poor	
19	10	♀	90	45	45		Scorbutus	Fair	
20	11	♀	87	60	27		Pyloric spasm	Poor	
21	11	♂	100	65	35		Malnutrition	Fair	
22	12	♂	90	72	18		Malnutrition	Fair	
23	13	♂	106	68	38		Malnutrition	Poor	
24	15	♂	102	73	29	80%	Otitis media	Poor	
						60%			
25	19	♂	87	60	27	6,480,000	Rachitis	Fair	
Average	.....	.....	89	53	36				

25 mm. and in the females, 27 mm. These differences are so slight that they are presumably unimportant. They do show, however, a slightly higher pressure, in both systole and diastole, in the males than in the females.

The highest systolic pressure was 110, and the lowest 72 mm., while the highest diastolic was 84, and the lowest diastolic 40 mm. The pulse pressure varied between 54 mm. and 9 mm.

TABLE 4.—ANEMIC INFANTS

Number	Red Cor- puscles	Hb., %	Spleen	Age in Months	Sex	Systolic Pressure	Diastolic Pressure	Pulse-Pressure	Murmur in Neck	Murmur in Heart	Murmur in Groin	Pistol Shot
1	2,000,000	40	Palpable at navel	4	♂	114	42	72	Systolic	Systolic at base	0	0
2	2,400,000		0	12	♂	120	40	80	Systolic	Systolic over whole precordia	Systolic	0
	2,600,000	30	.....	....	♂	95	60	35	Systolic	Systolic over whole precordia	Systolic	0
	2,640,000	31	.....	...	♂	120	55	65	Systolic	Systolic over whole precordia	Systolic	0
3	3,000,000	60	2 cm.	4	♂	100	20	80	Systolic	Systolic	0	0
4	3,200,000	70	Enlarged	8	♀	100	45	55	Systolic	Systolic	0	0
						105	45	60				
5	3,496,000	65	Just Palp- able	2	♂	60	25	35	0	0	0	0
						65	29	36				
6	3,500,000	70	0	3½	♂	90	40	50	Systolic	0	0	0
7	3,744,000	65	0	10	♂	96	40	56	0	0	Systolic	0
8	3,800,000	80	0	4	♂	84	48	36	0	0	0	0
9	3,800,000	75	0	8	♂	105	53	52	Systolic	0	0	0
10	4,000,000	50	0	8	♂	100	35	65	0	0	Systolic	0
						110	35	75				
	Average		.....			97	41	57				

Table 2 gives a comparison between the various pressures in the first year and in the second year. These figures seem to show that both the systolic and the diastolic pressure are somewhat higher during the second than during the first year, while the pulse-pressure is the same. The number of cases is too small, however, to warrant very definite conclusions on these points.

Twenty-seven observations were made on twenty-five poorly nourished, but not anemic, babies. These results are given in detail in Table 3.

The average systolic pressure in these babies was, therefore, 89 mm., the average diastolic, 53 mm., and the average pulse-pressure, 36 mm. The highest systolic pressure was 106 mm., and the lowest 60 mm., while the highest diastolic pressure was 73 mm. and the lowest diastolic pressure 30 mm. The highest pulse-pressure was 57 mm. and the lowest 13 mm. Comparison of the blood-pressures in the normal and poorly nourished babies shows that, while the average systolic pressure was practically the same in both cases, the diastolic pressure was lower and the pulse-pressure, therefore, higher in the poorly nourished babies.

Fifteen observations were made on ten babies suffering from anemia. These cases have been arranged in Table 4 according to the number of red corpuscles and not according to the age. This table shows that the systolic pressure was somewhat higher in these babies than in either the normal or the poorly nourished babies, while

TABLE 5.—

Age in Months	Hb., Per cent.	Red Corpuscles	White Corpuscles	Spleen, cm.	Liver, cm.	Systolic Pressure
12	25	1,800,000	28,000	5	2	124
14	55	2,720,000	47,000	6	4	100
18	70	3,776,000	?	4	4	110
24	?	?	?	13	5	120
25	40	2,480,000	19,500	13	5	124

the diastolic pressure was considerably lower and the pulse pressure, therefore, much higher. There was no definite relation, however, between the amount of the pulse-pressure and the degree of the anemia.

The most interesting observations were those in the baby suffering with severe anemia, to which reference has already been made. This baby was 12 months old when first seen. He was markedly pale, but not badly nourished. The left border of the heart was 6 cm. to the left, and the right border 2.25 cm. to the right of the median line, while the upper border was at the upper border of the third rib. The first sound over the whole precordia was followed by a blowing murmur, loudest in the third left interspace. It was transmitted better to the left axilla than to the right. The second pulmonic was considerably louder than the second aortic sound. There was no thrill. There was a pistol-shot in the groin. There was also a systolic murmur, but no diastolic murmur, in the groin. There was

a Corrigan as well as a capillary pulse. The extremities were not clubbed. The lower border of the liver was 2 cm. below the costal border in the nipple line, while the lower border of the spleen was 5 cm. below the costal border. The hemoglobin, estimated with the Sahli apparatus, was 25 per cent. There were 1,800,000 red corpuscles and 28,000 white corpuscles. The red corpuscles showed marked variation in size and shape, with marked polychromatophilia. There were many stippled cells. Thirteen normoblasts were seen in counting 100 white cells. A differential count showed: mononuclears, 44 per cent.; transitional forms, 12 per cent.; polynuclear neutrophils, 39 per cent.; eosinophils, 5 per cent.

The systolic blood-pressure was 124, and the diastolic pressure 0, giving a pulse-pressure of 124 mm. That is to say, the conditions in the peripheral circulation corresponded exactly to those found in aortic regurgitation in adults. It was thought for a time that there

—SEVERE ANEMIA

Diastolic Pressure	Pulse-Pressure	Murmur in Heart	Bruit in Neck	Murmur in Groin	Pistol Shot
0	124	Systolic over whole precordia	Systolic	Systolic	+
15	85	Murmur less marked.	Systolic	Systolic	0
30	80	Very slight systolic at base	Systolic	0	0
0	120	Systolic at base	Systolic	Systolic	+
30	94	Systolic at base	Systolic	0	0

must be an aortic regurgitation. Then the query arose as to whether these conditions might not be due to some change in the peripheral circulation as the result of the severe anemia. Further observations on the baby, which are detailed in Table 5, show that the latter was the true explanation.

When he was last seen, when 25 months old, he was fairly developed and nourished, but still markedly pale. He showed many of the changes in the bones characteristic of rickets. His heart was of normal size. There was a systolic murmur at the base of the heart, loudest in the pulmonic area. It was also audible along the sternum to the fourth left space. There was a bruit in the neck. There was a systolic murmur in the groin, but no pistol-shot. The liver was palpable 5 cm. below the costal border in the nipple line. The spleen filled the whole left half of the abdomen, extending 3 cm. beyond the median line.



The examination of the blood gave the following results:

Hemoglobin .....	40 per cent. (Sahli)
Red corpuscles .....	2,480,000
White corpuscles .....	19,500
Small mononuclears .....	28 per cent.
Large mononuclears and transition forms.....	76 per cent.
Polynuclear neutrophils .....	6 per cent.
Eosinophils .....	0 per cent.

The red corpuscles showed marked achromia and there was considerable variation in their size and shape, as well as polychromatophilia and basic stippling. Eight normoblasts and one megaloblast were seen while counting 200 white cells.

Comparison of the observations in this instance with those in the other anemic babies, the poorly nourished babies and the normal babies, show that with disturbances of nutrition there is a progressive lowering of the diastolic pressure and a corresponding increase in the pulse pressure. The systolic pressure, on the other hand, rises with the increase of the anemia. These observations merely bring out certain facts but, unfortunately, do not warrant any definite conclusions as to their cause.

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