THE EFFECT OF COLD FRESH AIR ON THE BLOOD-PRESSURE IN PNEUMONIA OF CHILDREN *

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It is the general impression of those who have treated children with pneumonia out of doors, or in cold rooms with good ventilation, that, in addition to the increased quiet of the patients and their greater tendency to sleep, the circulatory system is not so profoundly affected and stimulation is less frequently required. Any positive evidence in regard to these impressions has been, however, so far as we are aware, lacking.

In a study of the effects of various circulatory stimulants it was found that a child of 5 years with a febrile pneumonia who received a subcutaneous injection of 1 grain of camphor immediately after being brought in from a balcony in winter, suffered no rise in blood-pressure such as would be expected from the camphor, but on the contrary a decided fall and this fall continued for an hour. As a result of this experience it was decided to test the effect of cold fresh air on the blood-pressure of children with pneumonia and of those convalescing from the disease.

The determination of the blood-pressure of children under 2 years of age by any method involving palpation of the radial artery is so unsatisfactory that the results are usually almost worthless. The children are likely to be so much disturbed as to make the value of any reading uncertain, the arteries are difficult to palpate especially if the pressure is low and the usual cuff is altogether too large. Our results were obtained with a Faught sphygmomanometer which gives very accurate but, we believe, somewhat higher readings than other instruments of the same general type. It allows the point of obliteration of the radial pulse to be determined with great accuracy. This was found to be more reliable than the point of return of the pulse. The reading was always repeated. A special cuff narrower than those usually employed was used. This was rendered necessary by the size of many of the children. The personal element always enters somewhat into the use of instruments of the Riva-Rocci type but with the method which we have employed the variations due to different observers were very slight; in all cases, however, the pressures of each child were read by the same person. No determinations were made unless the child was absolutely quiet and unaffected by the manipulation. The influence of excitement and muscular exertion

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may, therefore, be eliminated. The readings reported are those of the systolic pressure.

There is even more uncertainty as to the average blood-pressure of normal children at the various ages than as to the average pressure of normal adults, and for very obvious reasons. Taking the observations of Wolfensohn-Kriss,¹ Kaupe,² Beretta³ and Oppenheimer and Bauchwitz,⁴ we may consider that the averages are fairly well represented by the following figures:

Age, Years	Blood-Pressure, mm.	Age, Years	Blood-Pressure, mm.
1/12-1	75- 80	5-8	90- 95
1-3	80- 85	8-10	95-100
3-5	85- 90	10-12	100-105

PNEUMONIA

Chart 1.—F. K., aged 8 years. Severe lobar pneumonia and beginning empyema. Operation two weeks later. Recovery. Each square represents five minutes.

Chart 2.—A. M., aged 25 months. Mild bronchopneumonia. Temperature never above 102.5 F. (39.2 C.). Recovery. Each square represents five minutes.

As already stated, we believe that the Faught instrument in the hands of those accustomed to its use gives readings as a rule from 5 to 10 mm. higher than most instruments of the Riva-Rocci type and that averages with this instrument would probably be a little higher than the figures

1. Wolfensohn-Kriss: *Archiv. f. Kinderh.*, 1910, liii, 332.
2. Kaupe: *Monatschr. f. Kinderh.*, 1910, 257.
3. Beretta: Quoted by Oppenheimer.
4. Oppenheimer and Bauchwitz: *Arch. f. Kinderh.*, 1905, xlii, 415.

given. There are, however, marked exceptions to these averages, chiefly on the high side, and it is not unusual to find the blood-pressure of a child 10 or 15 mm. of mercury higher than that of other children of the same age and development. These factors, however, do not influence the value of the variations which are brought about by the influence of cold fresh air, as it is the relative and not the absolute pressure that is of interest.

Studies of the blood-pressure in pneumonia have not allowed the formulation of any definite rules in regard to its behavior. The great

Chart 3.—F. F., aged 5 years. Prolonged extensive bronchopneumonia. Died March 25. Each square represents five minutes.

majority of observations have been made on adults, and irregularly, only one or two in the course of a day, with a great variety of instruments, and very seldom have control readings been made when convalescence has been completed. It is believed by Cook and Briggs,⁵ Trumpp⁶ and

5. Cook and Briggs: Johns Hopkins Hospital Reports: 1903, xi, 451.

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

Chart 4.—M. B., aged 2 years. Prolonged severe bronchopneumonia. In hospital from Nov. 10, 1910, to Jan. 10, 1911. Taken home against advice. Each square represents two hours.

Chart 5.—R. F., aged 6 years. Moderately severe lobar pneumonia, defervescing by lysis on March 18. Each square represents one-half hour.

Chart 6.—T. P., aged 2 1/4 years. Sharp attack of bronchopneumonia. Temperature normal on April 12. Each square represents six hours.

Chart 7.—C. M., aged 4 years. Bronchopneumonia with very irregular temperature. Defervescence by lysis on April 10. Each square represents two hours.

Muggia⁷ that there is an increase in the blood-pressure, especially of children, unless the patients are in collapse. Kaufmann and de Bary,⁸ Rongier,⁹ Carter,¹⁰ Durand-Viel,¹¹ Ambard and Beaujour,¹² Ekgren,¹³ Külbs¹⁴ and Gilbert and Castaigne¹⁵ believe that the pressure is in general lowered and that it may diminish markedly and suddenly at the time of crisis. Our observations were not made with the object of testing this point, but it is apparent that children seriously ill as were Patients 1, 3, 5, 8 and 10, may have, at ordinary room temperatures, a blood-pressure somewhat below what might be expected at that age. This point can only be determined by a great number of readings carried out throughout the course of the disease.

Chart 8.—S. B., aged 8 years. Frank lobar pneumonia. Defervescence by crisis on April 6. Each square represents three hours.

Chart 9.—M. L., aged 2 years. Bronchopneumonia. Defervescence by crisis March 16. Each square represents five minutes.

Our patients were treated in the wards of Bellevue Hospital, which are thoroughly ventilated and usually kept at a temperature of about 65 F. (18 C.), or on the balconies outside of the wards. In the wards

7. Muggia: Quoted by Beretta.

8. Kaufmann and de Bary: *Berliner klin. Wehnschr.*, 1888, xxv, 557.

9. Rongier: *Thèse de Paris*, 1900.

10. Carter: *Am. Jour. Med. Sc.*, 1901, cxxii, ii, 854.

11. Durand-Viel: *Thèse de Paris*, 1903.

12. Ambard and Beaujour: *Arch. gén. de méd.*, 1904, i, 520.

13. Ekgren: *Zeitschr. f. klin. Med.*, 1905, lvii, 411.

14. Külbs: *Deutsch. Arch. f. klin. Med.*, 1907, lxxxix, 457.

15. Gilbert and Castaigne: *Rév. gén. de clin. et de pract.*, 1899, xiii, 769.

they were covered lightly with blankets; outside they were clothed in woolen wrappers and covered with many blankets, according to the temperature. Hot water bottles were at their feet and they wore hoods. Only the faces were exposed. None was receiving circulatory stimulation at the time that the readings were made. The accompanying charts show some of the results on the blood-pressure in children divided into two classes—the heading “pneumonia” indicating that they were still suffering from the disease and were in the febrile stage, and “convalescent” that they had defervesced, although not necessarily free from pulmonary signs.

Chart 10.—H. G., aged 3 years. Lobar pneumonia running a severe course. Temperature normal on January 7. Each square represents one hour.

It will be seen from an examination of the charts that the effect of cold fresh air in patients with active pneumonia was always to produce a rise in blood-pressure and that removal to a warm but well-ventilated ward was to produce a fall in blood-pressure. We have never found this to fail, although in one or two instances the variation in pressure has not been as noticeable as in most of the charts shown. The rise is not apparent until half an hour or more, sometimes not until an hour, after

being put out of doors, and it does not reach its maximum for about two hours. Thereafter the effect, so far as we have observed, is continuous for even as long as thirty hours and we have not observed any tendency for the pressure to fall as if from exhaustion of the effect. We have not made observations on any fatal cases that were treated continuously out of doors and are therefore unable to say what would be the behavior of the blood-pressure in cases growing constantly worse and progressing to a fatal termination.

CONVALESCENT

Chart 11.—M. B., aged 18 months. Two weeks after pneumonia. Each square represents one-half hour.

Chart 12.—C. H., aged 10 years. Moderately severe lobar pneumonia. Temperature normal for ten days. Each square represents three hours.

On the other hand, after removal from the cold fresh air the blood-pressure falls rapidly; the fall is apparent in fifteen or twenty minutes and usually reaches its lowest point in an hour, to remain at this minimum unless influenced by the course of the disease, by stimulation, or by the child's again being placed out of doors, when it again rises.

In convalescents, on the contrary, the results are usually much less striking and may even be absent. Instead of a rise of 10 or 15 mm. of mercury, the difference is only a few millimeters or none at all.

Chart 15 is an exception and shows as great an effect as is found during the acute febrile period. The pressure in the ward was 80 mm., or about 10 mm. less than would be expected in health. Whether this low pressure, which is occasionally found in convalescence, as is mentioned by Weigert¹⁶ and other authors, can be thus influenced, in contradistinction to the pressure which is at or near normal, must remain undecided until a far greater number of observations can be made. We believe that it is very likely that this is the case.

The number of our observations have not been sufficiently numerous to allow us to say whether those children with a very low blood-pressure respond better than those whose pressure is nearly normal.

Chart 13.—D. W., aged 18 months. Had defervesced on March 15 after a mild attack of bronchopneumonia.

Chart 14.—B. A., aged 9 years. Mild lobar pneumonia. Defervescence by lysis. Temperature normal February 7. Each square represents six hours.

We have been unable to produce results by putting children out of doors in warm weather; as the temperature increases in the spring and the out-of-doors temperature approaches that of the ward, the effects are less and less marked until none whatever is produced. It would seem, therefore, that the all important factor is the cold.

The influence on the blood-pressure is undoubtedly brought about by reflex stimulation of the vasomotor center by the action of cold air on the skin of the face and on the nasal mucous membrane. No other part of the child is exposed and there is no additional factor that can be supposed to play a part. It is striking that this reflex should produce such a constant and continuous effect. As has been shown, the pressure remains at a higher level for hours, shows no tendency to fall and even

16. Weigert: Samml. klin. Vortr., 1907, Innere medicin, 138.

after a return to the ward does not fall to a point below that previously obtaining at the ward temperature.

As to the beneficial effect of cold air on the circulation, there can be no doubt that when the pressure is abnormally low an increase in this, which is accomplished without disturbance or irritation, which is constant and continuous and which causes no exhaustion or bad effects, is of the greatest value. We are quite aware that the determination of the blood-pressure alone does not give all the data in regard to the circulation, such as the mass movement of blood, etc., but taken with the ordinary methods of physical examination it is the best indication of the condition of the circulation that we possess. Chart 3 raises the question whether the cold by increasing the pressure to 98 mm. lessened the demands on the heart,

Chart 15.—A. S., aged 5 years. Lobar pneumonia, moderately severe. Temperature normal April 9. Each square represents three hours.

as indicated by a pulse-rate of 104, and whether the withdrawal of cold with the consequent fall of pressure to 72 demanded an increase of cardiac exertion, as indicated by a rise of the pulse to from 120 to 132. This leaves entirely out of account the other beneficial effects of cold fresh air.

The symptoms of the death of children from pneumonia are those of vasomotor failure. It is rare to see intense cyanosis, edema of the lungs and evidences of right heart incompetency. Whether under such circumstances cold air would have an influence in assisting the circulation we are unable to say.

Whether it is advantageous from the standpoint of the circulation to raise a blood-pressure which is at an average point or slightly above this is a question which we cannot at this time answer. It may be that the pressure is only maintained at this point by an unnecessary cardiac exertion accompanied by a very rapid pulse and that a high pressure, reflexly produced through the vasomotor system, may allow of greater rest to the heart. We are confident that we have observed no bad effects on the circulation nor have any been reported, notwithstanding the prevalence of the cold air treatment of pneumonia and the lack of selection of patients to be treated by this method. It is possible that from the beginning of the disease when the blood-pressure is not low, cold air may have a beneficial tonic action on the vasomotor center so as to render it less likely to be profoundly influenced by the organisms or their products, and it seems to us very likely that the other beneficial effects of cold air may so modify the disease as to render less likely the development of partial or complete circulatory failure.