

THE BLOOD PRESSURE IN

DIPHTHERIA.

A thesis submitted for the Degree of  
Doctor of Medicine of the University  
of Glasgow.

by

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## INTRODUCTION.

During the latter part of 1931 Diphtheria began to assume epidemic proportions in the City of Hull. The number of cases notified was almost double that of the corresponding period in 1930, and the number of deaths was also markedly increased.

The following table compiled from the records of the Public Health Department of the City illustrates the increased incidence and severity of the disease.

TABLE 1.

---

Year.	Number of cases notified as diphtheria	Number of deaths.
1924	321	20
1925	498	26
1926	742	18
1927	747	33
1928	674	21
1929	852	37
1930	856	47
1931	1145	94
1932	1707	133
1933	1517	92
1934	1076	65

---

The figures relating to cases notified as diphtheria cannot be taken as representing the actual number of cases of diphtheria occurring in the City in the corresponding years. They include cases of tonsillitis, carriers, etc., which had been notified as diphtheria. The figures, none the less, show the increased prevalence of the disease.

In the record of deaths from diphtheria, the question of inaccuracy due to wrong diagnoses may be more or less disregarded, as, in 98% of fatal cases, the patients died in the City Fever Hospital where the diagnoses were well established.

In addition to the increased incidence of the disease there was an increase in the severity. The most striking feature was a profound toxæmia, usually accompanied by a well marked adenitis. In certain cases the toxæmia was out of all proportion to the extent of the faucial lesion. A case, admitted to hospital early on the second day of disease, with only moderate patching on each tonsil would yet show profound toxæmia. The following day, although the local lesion was not much worse, the patient died.

One very alarming factor was noted. In a certain number of cases toxæmia increased and death supervened in spite of what had formerly been considered adequate treatment with antitoxin. The dose of serum was doubled

and then quadrupled, but with no better result. Such fatal issues occurred even in cases admitted on the first or second day of disease.

These new conditions clearly called for investigation, and research was undertaken along various lines.

Leete, McLeod and Morrison (1) investigating the bacteriology of the disease reported as follows :

"We have demonstrated a heavy incidence of gravis infection in Hull diphtheria. Of a series of 310 cases of all grades of severity, 59% have shown this strain of diphtheria bacillus. This heavy incidence, we suggest, is the explanation of the high diphtheria morbidity and mortality recently experienced in Hull."

The disease was also investigated clinically. By reason of its importance, the cardiology of the condition was early and intensively studied. The symptomatology and physical findings were noted, and aid was sought from the electrocardiograph.

At irregular intervals during the course of the cardiac investigation, blood pressure readings were taken. A study of these seemed to indicate that in certain cases a fall in pressure occurred during the course of the disease, probably reaching its lowest point sometime during the second or third weeks.

The purpose of this thesis is to investigate this condition more fully, to see if a fall in blood pressure actually does occur in diphtheria, and if so, with what frequency. Further, if the occurrence of a fall is established, an attempt will be made to estimate its significance in prognosis.

## HISTORICAL OUTLINE.

Friedman (2), in 1893, was the first to show a fall of blood pressure in diphtheria. Using Von Baschs' sphygmomanometer, he took readings of 63 children, and found small oscillations in all cases. So long as they were within 5 to 10 mm. of mercury he did not consider that there were any grounds for anxiety. Of 15 cases in his series in which marked hypotension came on during the first week, only 2 recovered. He was of the opinion that if the blood pressure did not sink below 90 mm. in big children, and below 75 mm. in small children, the prognosis was not unfavourable. Readings of 65 mm. or under almost invariably denoted a fatal termination.

Using a pocket form of Hill and Barnard's apparatus, Biernacki (3) in 1899, published results of 26 cases, 6 of them fatal. He found that the fall in blood pressure bore a definite relationship to the degree of toxæmia present, and was most marked in those cases which died. Here the fall in pressure was slight to begin with, but suddenly became more marked, and persisted till death. In the 2 most severe cases this final drop only occupied 48 hours. In one case it was prolonged for 6 days.

A direct relationship between the fall in blood pressure and the severity of the attack was also noted in 1902 by Kolossova (4), who used Potain's sphygmomanometer. She further considered that an arterial pressure of 15 mm. or more below normal allowed of a prognosis of paresis, and that the presence of albuminuria was accompanied by a rise in blood pressure.

Durand Viel (5), in 1903, also using Potain's sphygmomanometer, investigated the blood pressure in 55 cases of diphtheria in children. He arranged his cases according to age, and within each group further subdivided them into mild, moderate, and severe. He concluded that whatever the type, mild, moderate, or severe, there is a fall of arterial pressure. The depth of the fall varied with the type, being least in mild cases and most marked in severe. It did not always appear in proportion to age, but was more appreciable over 9 years than in younger children. From a study of his findings he considered that when a child shows on several successive days a continuous fall of arterial blood pressure the outlook is bad, and a fatal issue may be feared.

In the same year Denis (6) noted a slight diminution in arterial tension in mild cases of diphtheria, and a more marked fall in severe cases. He observed that in complicated cases the return of the blood pressure to normal is slower than in simple cases, and the longer the return takes, the more reserved should be the prognosis. He states that various workers give figures below which they consider death must occur, but he does not believe that one figure is enough for a prognosis. Readings must be taken over several days.

The original Riva Rocci sphygmomanometer was used by Taddei (7) in 1904 in the investigation of 164 cases of diphtheria. He found that the blood pressure was not lowered in every case. In mild cases it was almost normal. Moderate cases showed a slight fall of short duration. Cases of toxic diphtheria showed a marked fall which might be preceded by a slight rise. This latter he considered might be due to the initial pyrexia. Albuminuria did not result in a rise in the blood pressure. On the contrary, the more persistent and massive the albuminuria, the longer and more marked was the hypotension.

Investigating the state of the blood pressure in the acute infectious diseases Weigert (8), in 1907, studied 46 cases of diphtheria, using Gartner's tonometer. The decrease in blood pressure was roughly parallel to the virulence of the infection. In mild and in uncomplicated cases the blood pressure was on the whole unaffected. Four of his cases were fatal, and gave very low readings. One case, aged 2 years, registered 40 mm. Certain of his cases developed severe myocarditis, yet the hypotension was no more marked than it was in the mild cases. Although recoveries did not show such low readings as fatal cases, he did not think that blood pressure readings were of any real value in prognosis.

Also using Gartner's tonometer Brückner (9) in 1909, took blood pressure readings in 200 cases of diphtheria. He found either a rise of blood pressure at the beginning, with a subsequent fall, or a subnormal blood pressure from the first. The depth of the fall depended on the severity of the case, and was only slight in mild cases. Those cases with only slight cardiac disturbance showed very little fall. Cases which terminated fatally showed a steady fall in blood pressure from the beginning. Like Weigert, Brückner considered that blood pressure readings were of less value in prognosis than a careful study of the general condition of the case.

In 1911 Rolleston (10) collected data from 179



cases. He used Martin's modification of Riva Rocci, and estimated the systolic pressure by disappearance of the radial pulse. No readings were taken of the diastolic pressure. In order to calculate the fall in blood pressure, he used two ranges of normal pressures, one given by Cook and Briggs, the other by Seiler. Of the 179 cases, 63 or 35% with Cook and Briggs' standard, and 45 or 25.1% with Seiler's standard, showed, for varying periods, a blood pressure below the normal. These low figures he explains as being due to the large number of mild cases in his series, in which the blood pressure was not lowered. The degree of hypotension bore a direct relationship to the severity of the attack, being pronounced and persistent in severe cases, and slight and transitory in mild cases.

In the great majority of cases the highest readings were obtained during the first week. This he attributes partly to the febrile disturbance of the acute stage and partly to excitement. The lowest readings were recorded during the second week, while return to normal, in most cases, had taken place by the end of the seventh week. He observes that any change in the blood pressure due to albuminuria is almost invariably a fall. With early paresis blood pressure tended to fall. In late paresis no effect was seen. With early serum rashes there was no change in the pressure, but in the large percentage of late rashes with fever there was a rise in blood pressure. He concludes by stating "Though blood pressure readings may be of some value in prognosis in conjunction with a study of the patient's general condition, they are by no means indispensable."

Norris, Bazett and McMillan (11), in 1927, stated practically similar conclusions to Rolleston. They found that diphtheria is accompanied by lowered arterial tension, the degree varying with the severity of the case. The highest readings were recorded in the first week, the lowest in the second, with a return to normal by the seventh week. Albuminuria was not always accompanied by a rise in blood pressure, and they discovered no fixed relationship between fever and blood pressure. Marked fall was usually found to be associated with cardiac involvement, and when progressive, was of bad prognostic import.

In 1930 Abt and Feingold (12) found a fall in blood pressure in all cases of diphtheria, the depth of the fall varying with the severity of the case. They noted that in early paralysis blood pressure tends to fall, while in late paralysis, no matter how extreme, blood pressure is usually not affected. Laryngeal cases showed readings disproportionately high for the age of the patient.

Tracheotomy was followed immediately by a marked fall in blood pressure.

The latest study is by Brockington (13) in 1931. After analysis of his series of cases he concluded that, in all cases of faucial diphtheria, after a latent period, there is a progressive fall in blood pressure followed by a rise. The depth of the fall is in direct relationship to the severity of the disease. Pressure did not begin to fall until the 7th, 8th or 9th day, irrespective of severity. In the first few days the blood pressure might even be increased, probably due to excitement. The lowest point was reached on the 8th to the 12th day, and in the event of recovery the pressure had returned to normal by the 12th to the 22nd day. He considers that 50% of the deaths occurring in the first three weeks of the disease are due to early cardiac failure, the remaining 50% are due to extreme hypopiesia, an exaggeration of the fall in blood pressure that occurs in all cases. Early cardiac failure may occur in cases of varying severity, death from hypopiesia is found only in the most severe type of diphtheria. There is a difference in the mode and time of onset in the two conditions. In early cardiac failure the symptoms develop suddenly and coincide with a sudden fall in blood pressure, while in extreme hypopiesia the blood pressure falls gradually and there is a gradual onset of symptoms. Also, cardiac failure is earlier in its onset than extreme hypopiesia, the average times given being the 6th and 11th days.

## METHOD OF THE INVESTIGATION.

As far as possible, all cases of diphtheria admitted to Hull City Fever Hospital are examined, and antitoxin administered, within one hour of admission. At the same time faucial cases are classified according to their severity. The factors taken into consideration are the following :

1. Extent of the faucial lesion.
2. Degree of adenitis.
3. Presence of a nasal lesion.
4. Foetor.
5. Degree of toxæmia.

The classification adopted is :

1. Mild.
2. Moderate.
3. Severe.

The severe cases are subdivided into :

- a. Severe +
- b. Severe + +

Mild cases are those showing slight lesions on one or both tonsils without adenitis or toxæmia.

Moderate cases show extensive lesions on one or both tonsils with perhaps slight adenitis, but no marked toxæmia.

In severe + cases the lesion involves both tonsils, spreads on to the faucial pillars, and sometimes involves the soft palate. There is usually an accompanying nasal lesion, and the adenitis and toxæmia are marked.

The severe + + cases show an extensive faucial lesion involving the tonsils, the faucial pillars, and spreading to the soft and hard palates. There is almost always a well marked nasal involvement, the adenitis is marked, and the toxæmia is profound.

The classification of a case is open to revision for a period of 36 hours after admission. Antitoxin controls

the spread of membrane, though there is a lag of about 24 hours even when it is given intravenously. Thus, if there is a marked spread of membrane at the end of this period the initial dose of antitoxin has been inadequate, and the case is now more severe than on admission.

All deaths from diphtheria occurring in the City Hospital are grouped into three classes.

1. Obstructive.
2. Toxic.
3. Cardiac.

The first type, obstructive, occurs only in laryngeal diphtheria, and the numbers are relatively small.

Deaths are recorded as toxic when the clinical findings are those of a profound toxæmia, without special cardiac symptoms or signs. They are recorded as cardiac when prominent cardiac symptoms and signs such as cardiac pain, bradycardia, numerous extrasystoles, or reduplication of the first mitral sound have been noted before death.

There is no doubt that in both toxic and cardiac deaths there is marked toxæmia, but in the former it seems to affect all the tissues of the body to a greater or less extent, while in the latter the myocardium is especially affected. The acute toxic death seems to occur earlier (3rd, 4th, or 5th day) than the toxic myocardial death (6th to the 14th day). The classification is clinically valid, and is convenient for statistical purposes.

The total number of cases investigated was 120, comprising 16 diphtheria carriers, 100 cases of faucial diphtheria, and 4 cases of laryngeal diphtheria. In every instance the clinical diagnosis was confirmed by bacteriological examination.

To have attempted a thorough investigation of 100 consecutive cases of faucial diphtheria would have been impossible. As the cases accumulated, the number of blood pressure readings required daily would have been so great as to interfere seriously with the routine work of the hospital.

To avoid any selection of cases the following method was adopted. Blood pressure readings were taken of 25 consecutive mild cases, then of 25 consecutive moderate cases, and finally of 50 consecutive severe cases.

The auscultatory method was employed in estimating the blood pressure, and both systolic and diastolic pressures were recorded. The type of instrument used was the *Beaumanometer*, a mercurial instrument being more satisfactory than an aneroid. A stethoscope with a flat chest piece, (Mitcham type) was found to be best as it minimises the risk of unconsciously compressing the brachial artery and producing sounds which might result in false readings.

All readings were taken with the patient lying down. The arm was bare, and care was taken to see that there was no tight roll of clothing at the shoulder which might cause an obstruction sufficient to produce sounds that might be heard to zero. The armlet was applied firmly but not too tightly, and the cuff inflated by small, rapid compressions of the bulb till the radial pulse could no longer be felt. The stethoscope was placed on the artery just below the compression cuff which was then deflated evenly. The return of the sounds was taken as the index of the systolic pressure. The pressure at which the sounds ceased to be sharp and clear cut, altering in tone and becoming softer, was taken as the diastolic pressure.

It was found unwise to delay long in making readings. In the first attempt only an approximate figure may be obtained. In that case it is best to deflate completely and allow an interval of one minute to elapse before making any further attempt. Otherwise a venous engorgement will result with a consequent change in the blood pressure. This point was emphasised by Livingston (14).

In many cases considerable difficulty was experienced in recording the diastolic pressure in children under 7 years of age. At younger ages it was frequently found impossible to obtain an accurate reading. In such cases the doubtful reading was omitted from the case record.

Durand Viel (5) stated that he found the estimation of the arterial pressure in children under 4 years of age almost impossible. Stocks (15) found it difficult to read the diastolic pressure in children under 7 years of age, and Abt. and Feingold (12) report a similar experience. Chadbrun and Petrovitch (16) state that the auscultatory method is not an easy one to use in children. The changes in the sounds are so gradual that the determination of the diastolic pressure is often very difficult, if not impossible.

So that the series of readings in each case might be taken, as far as was possible, under the same conditions,

the observations were made at the same time each day. This procedure is advised by Rolleston (10).

Daily readings were taken in all cases during the first three weeks in hospital. Thereafter they were taken on alternate days until the end of the sixth week in hospital. After this there was an interval of two days between each reading.

In each case investigated the blood pressure findings were charted. This made analysis of the cases easy, and facilitated the statistical summary.

## NORMAL BLOOD PRESSURE IN CHILDREN.

Of the 100 cases of faucial diphtheria investigated, 13 were over 12 years of age, and 7 over 15 years of age. None of the laryngeal cases were over 7 years of age.

Before it is possible to determine, in any particular case, the fall in blood pressure resulting from diphtheria, the normal blood pressure of the child affected must be known. At the beginning of the investigation it is therefore necessary to adopt a method of determining what is the normal blood pressure in each individual case. As a preliminary, we will review the literature dealing with normal blood pressure in children.

Friedman, in 1893, seems to have been the first to investigate the normal blood pressure in children. In the following year Von Basch made a study of the subject, but neither of these observers drew any definite conclusions.

In 1902 Potain (17), using his own modification of Riva Rocci, investigated the blood pressure in healthy children. He gave the following figures as representing normal pressure at the different ages.

<u>Age.</u>	<u>Arterial Pressure.</u>
5 - 7	86 mm.
8 - 12	94 mm.
13 - 17	137 mm.
18 - 20	151 mm.

He considered that age was the most important factor in influencing the blood pressure, and that there was a steady rise in pressure as the age of the child increased.

Kolossova (4) published her findings in the same year. She used Panchon's oscillometer, and agreed with Potain as to the effects of age, but also considered that the height and weight influenced the figure for any given age. In children of the same age, those which were well developed gave higher readings than those of poor physique.

Her findings were as follows :

<u>Age.</u>	<u>Arterial Pressure.</u>	<u>Age.</u>	<u>Arterial Pressure.</u>
1	80 - 85 mm.	8	95 - 100 mm.
2	80 - 85 mm.	9	---
3	85 mm.	10	95 - 100 mm.
4	85 mm.	11	100 - 110 mm.
5	90 - 95 mm.	12	---
6	---	13	100 - 110 mm.
7	90 - 95 mm.	14	---

In 1903 Durand Viel (5), using Potain's modification of Riva Rocci, made observations on healthy children. He considered that an isolated reading had but little value, and that normal pressure could only be determined in any case by taking a series of daily readings, and averaging the results. He agreed with Kolossova's findings as to the effect of physical development. The following table is given as representing normal pressure at the different ages.

<u>Age.</u>	<u>Arterial Pressure.</u>	<u>Age.</u>	<u>Arterial Pressure.</u>
4	88 mm.	10	126 mm.
5	96 mm.	11	126 mm.
6	104 mm.	12	131 mm.
7	107 mm.	13	139 mm.
8	117 mm.	14	141 mm.
9	118 mm.	15	141 mm.

Writing in the same year, Cook (18) stated "The normal varies through rather wide limits on account of many factors including height, weight, and size of the arm, and although we can say that such a pressure is good for a child of that age, or another is low, still in great part each case must be judged on its own merits." He gives a table as follows.

**Roughly Comfortable Limits of Pressure for Different Ages.**

First few months	Average	70 - 75 mm.
2nd six months	"	80 - 85 mm.
2nd year	"	80 - 90 mm.
3rd year	"	90 - 100 mm.

Continuing he stated "Between 3 - 10 years blood pressure seldom varies within wider limits than from 95 - 115 mm." He mentioned the various factors influencing blood pressure - height, weight, etc. - but did not attempt to find any relation between these variables.



During the investigation he used his own modification of Riva Rocci's sphygmomanometer.

The relation between height and weight and blood pressure was studied by Wolfensohn - Kriss (19) in 1910. She employed the auscultatory method, and the instrument used was the Riva Rocci. Her conclusions may be summarised as follows :-

1. Blood pressure increases with age.
2. Blood pressure increases with increase in height and weight.
3. Children of the same age but of different heights and weights have different blood pressures.
4. Sex is of no importance. Boys and girls show the same blood pressure if heights and weights are the same.

She gives the following table of normal readings at the different ages.

Age	Systolic Pressure.	Diastolic Pressure.	Age	Systolic Pressure.	Diastolic Pressure.
3	80 mm.	74 mm.	10	98 mm.	90 mm.
4	83 mm.	76 mm.	11	99 mm.	90 mm.
5	83 mm.	76 mm.	12	99 mm.	95 mm.
6	90 mm.	82 mm.	13	99 mm.	95 mm.
7	90 mm.	82 mm.	14	101 mm.	96 mm.
8	90 mm.	88 mm.	15	101 mm.	96 mm.
9	90 mm.	88 mm.			

Two other investigators Seiler (20) and Kaupe (21) published their results in the same year. Both used the Riva Rocci sphygmomanometer, and determined the systolic pressure by palpation. Neither worker gave a figure as representing the normal blood pressure at any age, but defined limits outside of which they considered that the pressure could be regarded as abnormal. Seiler's figures are as follows :-

Age	Maximum Blood Pressure.	Age	Maximum Blood Pressure.
2 - 3	75 - 80 mm.	10 - 11	93 - 96 mm.
4 - 5	79 - 90 mm.	12 - 13	94 - 106 mm.
6 - 7	85 - 95 mm.	14 - 15	93 - 104 mm.
8 - 9	90 - 95 mm.	15 - 16	103 - 120 mm.

Kaupe gives as under :-

<u>Age.</u>	<u>Arterial Pressure.</u>	<u>Age.</u>	<u>Arterial Pressure.</u>
3	81.8 - 90.0 mm.	9	81.5 - 90.0 mm.
4	78.3 - 86.4 mm.	10	82.6 - 97.7 mm.
5	74.0 - 82.2 mm.	11	87.2 - 96.0 mm.
6	82.1 - 97.5 mm.	12	83.1 - 92.0 mm.
7	78.0 - 91.0 mm.	13	88.0 - 96.6 mm.
8	80.2 - 90.5 mm.	14	96.0 - 101.0 mm.

These figures are interesting in that the blood pressure does not rise steadily with age.

In 1911 Michaels (22) investigated the normal blood pressure in children, using Cook's modification of Riva Rocci. She took into account not only the height and weight, but also the circumference of the arm, and estimated the pressure per square millimetre. In this way she considered that a more accurate standard of blood pressure was obtained. Systolic pressure was estimated by palpation of the radial, and the height and weight were measured. It was found that pressure apparently increased with increase in height and weight. When the circumference of the arm was measured, and the blood pressure per square millimetre calculated according to the formula

$$\text{Actual Blood Pressure} = \frac{\text{Height of column of mercury.}}{\text{Width of cuff X circumference of arm.}}$$

the result was found to vary not more than .0014 mm. in the series of 128 cases. In conclusion it is stated "The procedure is not so complicated as it seems at first glance."

Judson and Nicholson (23), using a modified Erlanger apparatus, investigated the blood pressure in 2,300 children in 1914. In the individual child variations in the systolic pressure were found to be considerable, but the diastolic pressure remained fairly constant. They found that the blood pressure increased with the age of the child, and with increase in height and weight in children of the same age. Sex had little or no influence.

They give the following figures, but make no claim that they represent an absolute standard. In compiling the table, age only was taken into account.

Age.	Systolic Pressure.	Diastolic Pressure.	Age.	Systolic Pressure.	Diastolic Pressure.
3	91.8 mm.	65.6 mm.	10	99.2 mm.	67.1 mm.
4	91.6 mm.	64.9 mm.	11	97.1 mm.	65.5 mm.
5	91.3 mm.	64.4 mm.	12	102.3 mm.	65.2 mm.
6	92.6 mm.	67.3 mm.	13	103.6 mm.	70.5 mm.
7	94.0 mm.	66.3 mm.	14	106.1 mm.	67.4 mm.
8	93.6 mm.	64.7 mm.	15	105.6 mm.	67.5 mm.
9	94.3 mm.	71.0 mm.			

An investigation on 1,633 school children by Stocks and Karn (15) in 1924 brought some important facts to light. They determined the systolic and diastolic blood pressures by auscultation, and used a Riva Rocci sphygmomanometer. They found that blood pressure rose more or less uniformly with age, and that pressure was correlated with bodily development apart from age. The systolic pressure was higher in the male than in the female, and social class had a considerable influence on the systolic pressure which is not fully explained by superiority in physical development. They thought that the difference was probably due to nutrition and type of diet.

No attempt was made to give an absolute range of standards, but a series of figures was given outside of which they considered that blood pressure readings are pathological. Their findings are given below.

Outside these limits Blood Pressure should be regarded as open to suspicion.

<u>Central Ages.</u>	<u>Systolic Pressure.</u>	<u>Diastolic Pressure.</u>
7	71 - 116 mm.	42 - 77 mm.
8	73 - 119 mm.	43 - 78 mm.
9	77 - 122 mm.	44 - 79 mm.
10	80 - 126 mm.	46 - 80 mm.
11	83 - 129 mm.	48 - 83 mm.
12	86 - 132 mm.	51 - 85 mm.
13	91 - 136 mm.	54 - 88 mm.
14	95 - 146 mm.	56 - 90 mm.
15	104 - 150 mm.	58 - 92 mm.

Outside these limits Blood Pressure almost certainly Pathological.

<u>Central Ages.</u>	<u>Systolic Pressure.</u>	<u>Diastolic Pressure.</u>
7	59 - 128 mm.	34 - 86 mm.
8	62 - 131 mm.	35 - 85 mm.
9	66 - 135 mm.	36 - 88 mm.
10	69 - 138 mm.	38 - 90 mm.
11	72 - 141 mm.	40 - 92 mm.
12	75 - 144 mm.	42 - 94 mm.
13	80 - 149 mm.	45 - 97 mm.
14	84 - 153 mm.	47 - 99 mm.
15	89 - 158 mm.	49 - 101 mm.

A study of 450 children between the ages of 4 and 15 years was made by Chadbrun and Petrovitch (16) in 1930. Two instruments were used in the investigation, the manometer of Vaquez - Laubry ( auscultatory), and the oscillometer of Panchon. The former instrument gave somewhat higher readings. They state "The auscultatory method is not an easy one to use in children. The changes in the sounds are so gradual that the determination of the diastolic pressure is often difficult if not impossible." They recommend that this method be rejected in favour of the oscillometer. The blood pressure was found to increase with age, but the increase was not always regular. No great variations in pressure were found for any given age whether the weight was greater or less than the normal. This was thought to be due to the fact that in poorly developed children there was less tissue between the artery and the armllet.

They give the average arterial pressures at different ages determined by Panchon's apparatus.

<u>Age.</u>	<u>Systolic Pressure.</u>	<u>Diastolic Pressure.</u>
4	87.0 mm.	47.0 mm.
5	93.3 mm.	52.0 mm.
6	95.4 mm.	52.0 mm.
7	101.4 mm.	53.9 mm.
8	104.0 mm.	50.4 mm.
9	100.0 mm.	55.0 mm.
10	103.0 mm.	53.0 mm.
11	105.0 mm.	55.0 mm.
12	115.0 mm.	55.0 mm.
13	115.0 mm.	59.0 mm.
14	120.0 mm.	65.0 mm.
15	114.0 mm.	62.0 mm.

The latest work was done in 1932, by Bonaba and Sarachaga (24) who investigated the blood pressure in 443 children, using Riva Rocci's sphygmomanometer. They found that the systolic pressure rose regularly with age, and that the regular rise was even more striking if the children were grouped according to their weights. There was also a progressive increase in the diastolic pressure, but this was less marked.

Their findings are as follows.

Age.	Systolic Pressure.	Diastolic Pressure.	Age.	Systolic Pressure.	Diastolic Pressure.
1	96 mm.	55 mm.	8	111 mm.	61 mm.
2	98 mm.	58 mm.	9	114 mm.	63 mm.
3	99 mm.	58 mm.	10	114 mm.	63 mm.
4	103 mm.	57 mm.	11	114 mm.	62 mm.
5	104 mm.	61 mm.	12	121 mm.	64 mm.
6	105 mm.	60 mm.	13	122 mm.	68 mm.
7	107 mm.	61 mm.	14	137 mm.	78 mm.

A study of the literature, as outlined above, reveals great differences in the results obtained by the various investigators.

All agree that blood pressure increases with age, until, at puberty, it approaches that of the adult, but there is no uniformity of opinion as to the extent of this increase. Kaupe (21) gives the systolic pressure at the age of 3 as 90 mm., and at the age of 14 as 101 mm. This represents an increase of 11 mm. over a period of 11 years. According to Durand Viel (5) the systolic pressure at 4 years of age is 88 mm. while at 15 it has risen to 141 mm. In this instance there is a rise of 53 mm. in 11 years. Other writers give intermediate figures for the increase over a corresponding period.

There is a similar disagreement in regard to the normal pressure for any given age. Thus at 5 years of age Wolfensohn - Kriss (19) gives the normal systolic pressure as 83 mm., and the normal diastolic as 76 mm. For the same age Bonaba and Sarachaga (24) give as normal readings, systolic pressure 104 mm. and diastolic pressure 61 mm. The normal as given by other observers lies between these extremes.

These widely different results are probably due to a lack of standardisation of instrument and method, and to a failure to realise the importance of various factors that influence the blood pressure. The most constant of these are the age, height and weight of the child, and probably also the circumference of the arm. Other less constant factors which cause variations in blood pressure are sex, the emotions, eating, sleep and exercise.

The importance of a standardised instrument and method is clearly shown in the work of Chadbrun and Petrovitch (16). Using two different types of instrument, they obtained two different standards of normal pressure. Here the margin of personal error would be the same in both cases.

We will now review the results of our investigation of the blood pressure in diphtheria carriers. Readings were taken in 16 consecutive cases, all of them perfectly healthy in every respect. They had been admitted as carriers only, and there was no history or indication of any clinical disease. The children were in hospital during the summer months when the weather was exceptionally fine. For all practical purposes they led an open air life, being only in the ward for meals, and to sleep.

The period spent in hospital ranged from 9 to 79 days, with an average period of 28 days.

As in the actual diphtheria cases, blood pressure readings were taken at the same time each day in an attempt to eliminate the variable factors which might influence the readings. In spite of this precaution, the pressure was hardly ever the same on two consecutive days. In no single case did the chart of the readings present a straight line, but showed a succession of irregular rises and falls.

This illustrates the inaccuracy of determining the normal pressure for any age by a single reading. Only by taking a series of readings and obtaining the average can a true value be obtained.

The following table gives the range of variation in the blood pressure of the carriers investigated.

TABLE 2.

	<u>Systolic Pressure.</u>	<u>Diastolic Pressure.</u>
Smallest range of variation.	10 mm.	6 mm.
Greatest range of variation.	20 mm.	28 mm.
Average range of variation.	14 mm.	14 mm.

The literature offers a bewildering choice of standards. Most writers give a series of readings as representing normal blood pressure at the different ages, but no author advances convincing proof for the acceptance of his findings.

Certain investigators - Kolossova (4), Cook (18), Seiler (20), Kaupe (21), Stocks and Karn (15) - do not give a normal pressure for the different ages, but define limits outside of which readings could be considered as abnormal.

While our findings, in the series of 16 carriers investigated, lead us to agree with these observers that this is the best method of determining whether or not an individual reading can be considered as normal, it is useless for the purposes of the present investigation. To calculate the fall in blood pressure in any case it is necessary to have a single figure as representing the normal blood pressure for the age of the patient. To meet this requirement we concluded that each case must be allowed to decide its own normal. This conclusion is in agreement with Cook's statement (18) "Although we can say that such a pressure is good for a child of that age, or another is low, still in great part each case must be judged on its own merits."

Before being discharged from hospital every diphtheria patient is in a late stage of convalescence, and there is no evidence of any impairment of the circulatory system. The normal blood pressure for each case is taken as the average of the readings recorded after the patient is allowed up in clothes.

This method is open to criticism on the ground that the patient may not have regained a normal state of health. If that were so the resulting error would be on the side of hypotension.

## FINDINGS OF THE INVESTIGATION.

As noted above, the present investigation covers 104 cases of diphtheria. Of these, 100 are cases of faucial diphtheria, the remaining 4 are laryngeal cases.

The faucial cases are divided into mild, moderate, and severe, and we will analyse the blood pressure readings for each class separately.

Whenever an average has been calculated the result is given to the nearest whole number. Thus 5.4 is recorded as 5, while 5.5 is recorded as 6.

In certain instances a series of 25 or 40 figures is averaged. The series is then divided into 4, 5 or more groups, which in turn are averaged. When these group averages are summed, and the average calculated, the figure obtained may differ from the average of the series of 25 or 40 cases. This is due to the unequal distribution of the variables in the series.



FAUCIAL DIPHTHERIA - MILD CASES.

Total Number 25.

The period spent in hospital ranged from 17 to 63 days, with an average period of 30 days. None of the cases developed any serious complication, so that a stay in hospital beyond the average period was due to the continuance of positive swabs at the time when the case should have been discharged.

Every case in the series showed a fall in blood pressure. The extremes were :-

Systolic Pressure ..... 8 mm to 24 mm.

Diastolic Pressure ..... 6 mm to 26 mm.

T A B L E 3.

Average fall in Blood Pressure - Mild Cases.

	Systolic Pressure.	Diastolic Pressure.
Average fall - series of 25 cases.	14 mm.	16 mm.
Cases admitted on the 2nd. day (6)	14 mm.	16 mm.
" " " " 3rd. " (8)	16 mm.	17 mm.
" " " " 4th. " (6)	13 mm.	15 mm.
" " " " 5th. " (3)	15 mm.	15 mm.
" " " " 6th. " (1)	12 mm.	12 mm.
" " " " 9th. " (1)	14 mm.	18 mm.

Throughout, the tendency seems to be for the diastolic pressure to show a greater fall than the systolic pressure.

When the cases are grouped according to the day of disease on admission an interesting fact emerges. Cases admitted on the 3rd day of disease show a greater fall in pressure than those admitted on the 2nd day. In cases admitted later than the 3rd day of disease the fall seems to be less marked.

T A B L E 4.

Average day of Lowest Reading - Mild Cases.

	Systolic Pressure.	Diastolic Pressure.
Average day of lowest reading - series of 25 cases.	11th.	11th.
Cases admitted on the 2nd. day (6)	11th.	12th.
" " " " 3rd. " (8)	9th.	11th.
" " " " 4th. " (6)	11th.	11th.
" " " " 5th. " (3)	8th.	9th.
" " " " 6th. " (1)	12th.	12th.
" " " " 9th. " (1)	13th.	13th.

In the majority of cases the lowest readings are on the same day for both systolic and diastolic pressures.

No conclusions can be drawn when the cases are arranged according to the day of disease on admission. The results are too erratic.

T A B L E 5.

Average day of Return to Normal - Mild Cases.

	Systolic Pressure.	Diastolic Pressure.
Average day of return to normal - series of 25 cases.	20th.	21st.
Cases admitted on the 2nd. day (6)	22nd.	23rd.
" " " " 3rd. " (8)	19th.	20th.
" " " " 4th. " (6)	20th.	21st.
" " " " 5th. " (3)	20th.	20th.
" " " " 6th. " (1)	20th.	20th.
" " " " 9th. " (1)	19th.	21st.

Most commonly the systolic pressure has returned to normal before the diastolic. It will be remembered that the fall was less than in the case of the diastolic.

It would seem that in cases admitted early in the disease the blood pressure takes longer to return to normal than in those admitted late in the disease.

The number of cases dealt with is small so that results must be accepted with caution. This is particularly the case where they are based on the grouping of cases according to the day of disease on admission. Here it may be possible to express an opinion after the complete series of 100 cases has been reviewed, but not before.

FAUCIAL DIPHTHERIA - MODERATE CASES.

Total Number 25.

In this series the period spent in hospital ranged from 25 to 94 days, with an average period of 55 days. Periods longer than the average are accounted for by the occurrence of complications, or the development of the carrier state.

Here also every case showed a fall in blood pressure. The range was :-

Systolic Pressure	.....	10 mm.to 28 mm.
Diastolic Pressure	.....	6 mm.to 30 mm.

T A B L E 6.

Average fall in Blood Pressure - Moderate Cases.

	Systolic Pressure.	Diastolic Pressure.
Average fall - series of 25 cases.	17 mm.	18 mm.
Cases admitted on the 1st. day (1)	12 mm.	18 mm.
" " " " 2nd. " (13)	18 mm.	19 mm.
" " " " 3rd. " (7)	18 mm.	18 mm.
" " " " 4th. " (1)	14 mm.	20 mm.
" " " " 5th. " (1)	20 mm.	18 mm.
" " " " 6th. " (2)	16 mm.	14 mm.

In the majority of cases the diastolic pressure falls lower than the systolic pressure. This also happened in the mild cases.

The fall in blood pressure in cases admitted after the 3rd day of disease tends to be less than in those cases admitted earlier in the disease.

T A B L E 7.

Average day of Lowest Reading - Moderate Cases.

					Systolic Pressure.	Diastolic Pressure.
Average day of lowest reading - series of 25 cases.					12th.	11th.
Cases admitted on the 1st. day (1)					10th.	6th.
"	"	"	"	2nd. " (13)	11th.	11th.
"	"	"	"	3rd. " (7)	12th.	12th.
"	"	"	"	4th. " (1)	11th.	8th.
"	"	"	"	5th. " (1)	11th.	11th.
"	"	"	"	6th. " (2)	14th.	14th.

In both systolic and diastolic pressures the lowest readings occur most commonly on the same day.

T A B L E 8.

Average day of Return to Normal - Moderate Cases.

Average day of return to normal - series of 25 cases.	Systolic Pressure.	Diastolic Pressure.
30th.	30th.	30th.
Cases admitted on the 1st. day (1)	35th.	35th.
" " " " 2nd. " (13)	31st.	31st.
" " " " 3rd. " (7)	28th.	27th.
" " " " 4th. " (1)	31st.	19th.
" " " " 5th. " (1)	35th.	35th.
" " " " 6th. " (2)	31st.	33rd.

In the majority of cases the systolic and diastolic pressures return to normal on the same day.

In cases admitted early in the disease the return of the blood pressure to normal is longer delayed than in cases admitted later in the disease.



FAUCIAL DIPHTHERIA - SEVERE CASES.

Total Number 50.

Of the total number of 50 cases 10 died. These will be excluded from the series and dealt with separately.

The 40 remaining cases spent a period in hospital extending from 39 to 126 days, with an average period of 71 days. Periods in hospital greater than the average were generally due to the occurrence of complications. The carrier state was less frequent than in the mild and moderate cases.

All cases showed a fall in blood pressure. This ranged from :-

Systolic Pressure ..... 14 mm. to 36 mm.

Diastolic Pressure ..... 12 mm. to 42 mm.

T A B L E 9.

Average fall in Blood Pressure - Severe Cases.

	Systolic Pressure.	Diastolic Pressure.
Average fall - series of 40 cases.	22 mm.	22 mm.
Cases admitted on the 1st. day (4)	22 mm.	23 mm.
" " " " 2nd. " (7)	23 mm.	22 mm.
" " " " 3rd. " (12)	23 mm.	24 mm.
" " " " 4th. " (10)	21 mm.	22 mm.
" " " " 5th. " (3)	22 mm.	19 mm.
" " " " 6th. " (2)	25 mm.	23 mm.
" " " " 7th. " (1)	26 mm.	24 mm.
" " " " 8th. " (1)	16 mm.	18 mm.

The general average gives an equal fall for both systolic and diastolic pressures, but in the majority of cases the diastolic falls slightly lower than the systolic. This also occurred in the mild and moderate cases.

Here again the maximum fall in blood pressure appears in those cases admitted on the 3rd day of disease. In cases admitted at a later stage in the disease the fall tends to be less. The figures in Table 9 for the 6th and 7th day cases would appear to contradict these findings, but we consider that they can be ignored in view of the small number of cases involved.

T A B L E 10.

Average day of Lowest Reading - Severe Cases.

					Systolic Pressure.	Diastolic Pressure.
Average day of lowest reading - Series of 40 cases.					12th.	13th.
Cases admitted on the 1st. day (4)					11th.	10th.
"	"	"	"	2nd. " (7)	12th.	13th.
"	"	"	"	3rd. " (12)	12th.	13th.
"	"	"	"	4th. " (10)	13th.	14th.
"	"	"	"	5th. " (3)	12th.	14th.
"	"	"	"	6th. " (2)	13th.	12th.
"	"	"	"	7th. " (1)	15th.	15th.
"	"	"	"	8th. " (1)	16th.	16th.

In the majority of mild and moderate cases the systolic and diastolic pressures reach their lowest level on the same day. Almost all the severe cases show the lowest point in the diastolic fall one day later than in the systolic fall.

T A B L E 11.

Average day of Return to Normal - Severe Cases.

	Systolic Pressure.	Diastolic Pressure.
Average day of return to normal - series of 40 cases.	32nd.	32nd.
Cases admitted on the 1st. day (4)	30th.	28th.
"      "      "      " 2nd. " (7)	34th.	34th.
"      "      "      " 3rd. " (12)	31st.	32nd.
"      "      "      " 4th. " (10)	31st.	30th.
"      "      "      " 5th. " (3)	30th.	33rd.
"      "      "      " 6th. " (2)	36th.	34th.
"      "      "      " 7th. " (1)	37th.	31st.
"      "      "      " 8th. " (1)	39th.	39th.

The results are variable, but on the average the systolic and diastolic pressures return to normal on the same day.

Omitting the 4 cases admitted on the 6th, 7th and 8th days of disease, the blood pressure takes longest to return to normal in those cases admitted early in the disease. The same finding was noted in both mild and moderate cases.

As was mentioned above, severe cases are further classified into severe+ and severe++. Of the total 50 severe cases, 30 were severe+, and 20 severe++. The 10 deaths occurred among the severe+ + cases.

Table 12 shows the differences between the 30 severe + cases, and the 10 severe+ + cases which recovered.

T A B L E 12.

	<u>Severe +</u>		<u>Severe ++</u>	
	<u>S.</u>	<u>D.</u>	<u>S.</u>	<u>D.</u>
Average fall in blood pressure.	22mm.	22mm.	23mm.	23mm.
Average day of lowest reading.	12th.	13th.	12th.	13th.
Average day of return to normal.	32nd.	32nd.	32nd.	32nd.

The two classes differ in only one particular. There is a greater fall in both systolic and diastolic pressures in the severe ++ cases. This is so slight that it would appear as if there was very little difference between the two groups. It must be remembered however that the 10 deaths occurred in the severe ++ cases. Those cases which survived must have had a considerable measure of natural immunity else they would have shared a like fate. Thus in spite of the severity of the faucial lesion the toxaemia was only a little more profound than in those cases classified as severe +.

Table 13 presents the various averages for the mild, moderate, and severe cases.

T A B L E 13.

	<u>Mild.</u>		<u>Moderate.</u>		<u>Severe.</u>	
	<u>S.</u>	<u>D.</u>	<u>S.</u>	<u>D.</u>	<u>S.</u>	<u>D.</u>
Average fall in blood pressure.	14mm.	16mm.	17mm.	18mm.	22mm.	22mm.
Average day of lowest reading.	11th.	11th.	12th.	11th.	12th.	13th.
Average day of return to normal.	20th.	21st.	30th.	30th.	32nd.	32nd.

## FAUCIAL DIPHThERIA - DEATHS.

Total Number 10.

These cases were admitted to hospital on the 2nd to the 10th days of disease. The average day of disease on admission was the 5th. The period spent in hospital before death took place varied from 2 to 14 days, with an average period of 6 days.

For a varying number of hours before death occurred it was impossible to make any reading of the blood pressure. No sounds could be heard. It was always possible to obtain a reading of the systolic pressure until the day before death, and in 5 cases readings were made on the actual day of death. In the case of the diastolic pressure, this was possible only on one occasion. Once it was impossible to make a diastolic reading for as long as 4 days before death.

One case in the series is of particular interest. A boy aged 4 years was admitted to hospital on the 3rd day of disease. There were extensive patches of membrane on both tonsils, moderate adenitis, and marked toxæmia. Albuminuria was noted on the following day. On the 6th day of disease the urine was scanty in amount and contained blood. The next day the patient developed uræmia with convulsions and died.

During the period spent in hospital the systolic pressure rose steadily from 88 mm. on admission to 106 mm. at the time of death. The diastolic pressure rose from 64 mm. to 76 mm.

There was no history of any previous kidney disease.

In all the other fatal cases there was a progressive fall in blood pressure until the time of death.

We can find no reference in the literature relating to blood pressure in diphtheria to any case similar to that detailed above.

A summary of the 9 cases in which there was a fall in blood pressure is given in table 14.

T A B L E 14.

	<u>Systolic</u> <u>Pressure.</u>	<u>Diastolic</u> <u>Pressure.</u>
Smallest fall in blood pressure.	20 mm.	8 mm.
Greatest " " " "	52 mm.	36 mm.
Average " " " "	38 mm.	26 mm.

The fall in the diastolic pressure appears to be much smaller than the fall in the systolic pressure. It must be remembered however, that the reading of the diastolic pressure was, on the average, impossible for 2 days before death. Thus the figures given represent the recorded fall. The actual fall was much greater.

LARYNGEAL DIPHTHERIA.

Total Number 4.

In each case the blood pressure on admission was markedly raised above the normal. After tracheotomy there was an immediate fall. Subsequent readings were in accordance with what would be expected having regard to the accompanying faucial lesion.

The fall in pressure in the 4 cases after tracheotomy was as under :-

Systolic pressure 42mm. 34mm. 20mm. 18mm.

Diastolic pressure 38mm. 32mm. 18mm. 14mm.

This gives an average of 29 mm. for the systolic pressure, and 26mm. for the diastolic pressure.



## DISCUSSION.

### Fall in Blood Pressure.

Every case in the series showed a fall in blood pressure, with the single exception of the case which developed uraemia. Here the blood pressure rose steadily till the time of death.

In the majority of cases the diastolic pressure showed a slightly greater fall than the systolic pressure.

Taddei (7) found that the blood pressure was not lowered in every case, while Weigert (8) states that in mild and uncomplicated cases the blood pressure was, on the whole, unaffected. In Rolleston's series of cases (10) only 35% with Cook and Brigg's standard, and 25% with Seiler's standard, showed a fall in blood pressure.

As the occurrence of uraemia accounts for the rise in blood pressure in our single exceptional case, we cannot agree with these observers. All other writers are in agreement with our findings.

As will be seen from Table 13, the fall in blood pressure bears a direct relationship to the severity of the attack, being least in mild cases, and most marked in severe cases. With this conclusion all other writers are in agreement.

### Time of Onset of Fall.

In every instance the fall in blood pressure was noted as soon as the case came under observation. There was no initial period during which the blood pressure was sustained at the normal level.

Taddei (7) noted a marked fall in pressure in toxic cases which might be preceded by a slight rise. In Brückner's series (9) certain of the cases showed a rise in blood pressure at the beginning with a subsequent fall. Brockington (13) states, "In all cases of faucial diphtheria after a short latent period during which the blood pressure remains normal there is a progressive fall in pressure. The fall most commonly begins on the 7th day, but may not begin till the 8th or 9th day."

Our findings are not in agreement with these observers.

Brückner (9) states that certain of his cases showed a fall in blood pressure from the first. All our cases showed this phenomenon. No other writer comments on this point.

#### Day of Lowest Reading.

Most commonly the lowest readings were recorded on the 11th, 12th and 13th days of disease. The extremes were the 6th and 18th days. In mild cases the lowest reading was recorded earlier than in severe cases.

In the majority of mild and moderate cases the systolic and diastolic pressures reached their lowest level on the same day, while in most of the severe cases the lowest reading for the diastolic pressure was recorded one day later than for the systolic pressure.

The general average gives the 12th day for both systolic and diastolic pressures in all types of cases.

Rolleston (10) and Norris, etc (11) found that the lowest readings occurred during the second week. In his series of cases Brockington (13) states that the lowest point was reached on the 8th to the 12th days. These findings are in accord with our own.

#### Day of Return to Normal.

The more severe the case, the longer did the blood pressure take to return to normal. In the mild cases the systolic pressure returned to normal before the diastolic, but in the moderate and severe cases both returned to normal on the same day. Table 13 shows the average day of return to normal for the different classes.

Denis (6) found that in complicated cases the blood pressure took longer to return to normal than it did in simple cases. This is in agreement with our own findings. Rolleston (10) and Norris, etc. (11) stated that normal blood pressure was re-established by the end of the seventh week. In our own series of cases the longest period to elapse was 47 days. Brockington (13) found that the blood pressure had returned to normal by the 12th to the 22nd day. In only one case in our series did the pressure return to normal on the 12th day. This was a mild case where the fall in pressure had only been 6 mm. We do not agree that the 22nd day represents the extreme limit by which time the blood pressure in all cases has returned to normal.

## The Blood Pressure Curve.

In every case investigated the chart of the blood pressure readings showed a curve. This was not regular, but was subject to a series of irregular rises and falls, the irregularity being most marked during the period when the blood pressure was returning to normal.

It was found that the more severe the case, the more regular tended to be the fall and rise. This is presumably due to the fact that in the presence of marked toxæmia, the patient does not readily respond to the various factors which influence the blood pressure, e.g. excitement. This view is supported by the fact that in all cases the fall in pressure, occurring during the period when the effect of the toxæmia is most pronounced, is more regular than the rise.

When the blood pressure has returned to normal the chart of the readings shows the same irregularity as was noted in the case of the carriers, but here it is less well marked.

We have noted above that the fall in blood pressure bears a direct relationship to the severity of the case, being least in mild cases and most marked in severe. Within each class, however, the fall varies widely in the different cases.

The extremes are shown in Table 15.

TABLE 15.

		<u>Systolic Pressure.</u>	<u>Diastolic Pressure.</u>
<u>Mild Cases.</u> (25).			
Smallest fall in blood pressure.	...	8 mm.	6 mm.
Greatest " " " "	...	24 mm.	26 mm.
Average " " " "	...	14 mm.	16 mm.
<u>Moderate Cases</u> (25).			
Smallest fall in blood pressure.	...	10 mm.	6 mm.
Greatest " " " "	...	28 mm.	30 mm.
Average " " " "	...	17 mm.	18 mm.
<u>Severe Cases</u> (40).			
Smallest fall in blood pressure.	...	14 mm.	12 mm.
Greatest " " " "	...	36 mm.	42 mm.
Average " " " "	...	22 mm.	22 mm.

It will be seen that in one instance a mild case showed a greater fall in pressure than a severe case. Some explanation must be found for these variations.

### Individual Immunity.

During the course of an epidemic the degree of natural immunity which an individual possesses determines his response to infection. The extremes are illustrated when two members of a family are infected by the same type of diphtheria organism, one becoming a carrier, the other developing severe diphtheria and dying. Between these conditions lie an infinite number of grades.

We have seen three cases of faucial diphtheria in nurses who had been immunised and rendered Schick negative. If they had been admitted to the wards in the usual way, without any knowledge of their Schick reaction, they would have been classified as severe cases. In each case recovery was uninterrupted. The lesion had been local with no accompanying toxæmia.

In any series of diphtheria cases a similar case might occur. There are almost certain to be a number of cases below the Schick negative line where the toxæmia is milder than the local lesion would lead one to expect. It is unavoidable that certain of these cases should be wrongly classified. By reason of their extensive local lesion they are called severe when in reality they are only moderate, or moderate when they are only mild.

We are of the opinion that such cases occur oftener than is realised. They must explain certain of those instances where the fall in blood pressure in any case is less than the average for the class.

The converse of the above condition also occurs. We noted above that cases were sometimes admitted to hospital with profound toxæmia and only a moderate faucial lesion. In spite of intensive serum therapy certain of these died.

Cases occur which exhibit this phenomenon to a lesser degree. They are classified according to the extent of the local lesion, and only when complications develop is the full extent of the toxæmia realised.

Such cases will show a fall in blood pressure greater than the average for the group with which they have been classified.

We can find no reference in the literature bearing on these matters.

Age of the Patient.

A further factor that influences the fall in blood pressure is the age of the patient.

Table 16 presents the findings for the mild, moderate and severe cases at various age groups.

TABLE 16.

Average Fall in Blood Pressure at different Age Groups.

	<u>Systolic Pressure.</u>	<u>Diastolic Pressure.</u>
<u>Mild Cases (25).</u>		
1 - 4 years (3)	11 mm.	13 mm.
5 - 9 " (14)	13 mm.	15 mm.
10- 14 " (5)	16 mm.	18 mm.
15- 22 " (3)	19 mm.	19 mm.
<u>Moderate Cases (25).</u>		
1 - 4 years (6)	14 mm.	13 mm.
5 - 9 " (14)	18 mm.	20 mm.
10 - 14 " (4)	19 mm.	20 mm.
15 - 34 " (1)	20 mm.	18 mm.
<u>Severe Cases (40).</u>		
1 - 4 years (5)	21 mm.	24 mm.
5 - 9 " (27)	22 mm.	22 mm.
10 - 14 " (5)	24 mm.	23 mm.
15 - 25 " (3)	23 mm.	18 mm.

In each class the fall in blood pressure increases with the age of the patient. This applies to both the systolic and diastolic pressures.

Certain of the age groups contain only very few cases so that the results must be accepted with caution, but we believe that they show the general trend.

Durand Viel (5) states "The fall in blood pressure is more noticeable in older children. In younger children

fall is inappreciable save in severe forms of the disease." While we are in agreement with the first part of the statement, our own findings did not support the latter part. In younger children the fall, though less than in older, was often considerable.

No other writer remarks on the influence that age may have on the fall.

#### Day of Disease on Admission.

Tables 3, 6 and 9 show that the fall in blood pressure is influenced by the day of disease on which antitoxin is administered. The maximum fall in any class occurs in those cases where antitoxin is not given until the third day of disease. This must be due to the fact that the earlier in the disease antitoxin is administered, the less severe will be the toxæmia, and the less marked the fall in pressure.

The number of cases admitted later than the third day of disease is small, and any conclusions drawn from them must be accepted with caution. It would seem, however, that they tend to show a fall in blood pressure less than the average. Probably the explanation is that such cases must have a considerable measure of natural immunity, otherwise the delayed administration would result in the case being more gravely ill than it was when admitted to hospital.

The only reference to the effects of delay in the giving of antitoxin is made by Norris etc. (11) who state that fall is most marked when there is delay in giving antitoxin. No qualifying statements are added.

#### Minor Factors influencing the Blood Pressure.

Various other factors exercise an influence on the blood pressure, but of a transient nature.

The emotions probably have the most marked effect. Excitement, in our own experience, may cause a rise of 20 to 30 mm., although usually it is considerably less. This factor was very commonly met with during the investigation, particularly when the child was first admitted to hospital. Janeway (25), Judson and Nicholson (23), Abt and Feingold (12) all express a similar view. Treadgold (26) considers the emotional factor one of great importance on first examination.

The taking of food influences the blood pressure. Janeway (25) found a rise of 5 mm. in the systolic pressure and a fall of 5 mm. in the diastolic, while Judson and Nicholson (23) found a rise of 15 - 20 mm. In our own experience food caused a rise of about 6 mm.

Sleep causes a fall in the blood pressure of 4 to 8 mm. Janeway (25), Judson and Nicholson (23) and Abt and Feingold (12) are in agreement with us on this point.

Exercise was found to cause a rise in blood pressure. In the present investigation this factor was only operative during convalescence. The majority of cases showed a rise of 4 to 6 mm. on first being allowed up in clothes. Janeway (25) and Norris etc. (11) both noted a rise of blood pressure following exercise. Their investigations, however, dealt with healthy children. Oddo (27) and Oddo and Archard (28) describe what they term the 'hypotension of effort'. They found that convalescents submitted to a slight effort frequently showed a fall in blood pressure, either at once or after a slight rise, the pressure remaining below normal for a variable period. This phenomenon was not noted in any of our cases.

The effect of these various factors is transient. They have no influence on the general trend of the blood pressure curve, although at points they may make it slightly irregular. By taking the readings in each case at the same time each day, it was attempted to neutralise the effect of these factors.

### Death.

The extreme example of fixation of diphtheria toxin is the death of the patient. Table 14 showed the average fall in blood pressure in those cases which died, the fall being much greater than in any other group.

As explained above, deaths were divided into cardiac and toxic. Three of the cases which died fell into the former group, the remaining 7 into the latter.

An examination of the blood pressure charts of the cardiac deaths shows, in the first stages, a steady and progressive fall in pressure, evidence of severe toxæmia. With the onset of grave cardiac involvement there

is a sudden and marked fall in blood pressure rapidly followed by death.

In the toxic deaths the blood pressure curve falls steadily throughout. There is no marked drop just before death, the downward slope being steep and more or less regular.

The total fall in blood pressure is much the same in both classes.

In his series of cases Brockington (13) considered that 50% of the deaths occurring during the first three weeks were the result of early cardiac failure, the remaining 50% being due to extreme hypopiesia. These seem to be identical with our own toxic and cardiac deaths respectively. It is difficult to believe that the sole cause of death is hypopiesia. At post mortem examination these cases show extensive pathological changes in every organ in the body. The fall in blood pressure is only one manifestation of the widespread damage.

Extensive pathological changes are also seen in cardiac deaths, but here the chief damage has fallen on the heart. As was mentioned, earlier, our classification was made on the outstanding clinical phenomenon at the time of death.

All writers are agreed that the greatest fall in blood pressure occurs in fatal cases.

### Paresis.

Fixation of diphtheria toxin is also demonstrated by the occurrence of paresis. In the presence of this complication there can be no doubt that the condition has been more than a local lesion. It will be interesting, therefore, to examine the mild, moderate and severe cases, to note if those which developed paresis show a greater fall in blood pressure than those which did not, and if there is a difference in the day when the lowest reading was recorded, and the day when the pressure returned to normal.

None of the mild cases developed paresis.

Table 17 shows the results for the moderate and severe cases.



TABLE 17.

Moderate cases (25).

Number of cases which developed paresis = 3.

	Cases which developed paresis.		Cases which did not develop paresis.	
	S.	D.	S.	D.
Average fall in blood pressure.	14 mm.	10 mm.	18 mm.	19 mm.
Average day of lowest reading.	11th.	11th.	12th.	11th.
Average day of return to normal.	32nd.	32nd.	30th.	30th.

Severe Cases (40).

Number of cases which developed paresis = 18.

	Cases which developed paresis.		Cases which did not develop paresis.	
	S.	D.	S.	D.
Average fall in blood pressure.	24 mm.	23 mm.	21 mm.	22 mm.
Average day of lowest reading.	12th.	13th.	12th.	13th.
Average day of return to normal.	31st.	31st.	33rd.	33rd.

In the moderate cases, those which did not develop paresis show a greater fall in blood pressure than those which did. This appears to be disappointing, but two factors must be borne in mind. Firstly, the latter group is a very small one, including only three cases, so that no valid conclusion can be drawn. Secondly, the ages of the three cases must be considered. They were respectively 2 years and 2 months, 2 years and 6 months, and 9 years and 7 months, and we consider that the ages of the first two cases precluded any great fall in blood pressure.

In the severe cases those which developed paresis show the greater fall in pressure.

It is interesting to note that in the moderate cases, the day of the lowest reading tended to occur earlier in those which developed paresis, and that the blood pressure took longer to return to normal. This is what might have been expected, since in those cases the toxaemia was more profound than in the none paralysed cases.

In the severe cases the average figures for the day of return to normal are the reverse of what was expected.

No writer quotes figures relating to these matters.

Of the 90 cases which recovered, 21 developed paresis. In no single instance did the onset of the paresis result in a fall in blood pressure.

Denis (6) considered that the onset of paresis produced no fall in the blood pressure. Rolleston (10) found that with early paresis blood pressure tends to fall, but in late paresis no effect is seen. He does not state what he means by early paresis. In our own series four cases developed paresis before the 12th day of disease when the blood pressure was still falling, but the onset was not accompanied by any sudden additional fall.

Abt and Feingold (12) state a similar finding to Rolleston.

Albuminuria.

In the City Fever Hospital albuminuria occurring in diphtheria, if not due to an intercurrent infection, is considered to be toxic in origin, whether it occurs in mild cases or in severe cases, whether its onset is early in the disease or late. Table 18 shows the averages for the different classes, of those cases which developed albuminuria, and those which did not.

TABLE 18.

Mild Cases (25).

Number of cases which developed albuminuria = 5.

	Cases which developed albuminuria.		Cases which did not develop albuminuria.	
	S.	D.	S.	D.
Average fall in blood pressure.	17 mm.	19 mm.	14 mm.	15 mm.
Average day of lowest reading.	11th.	15th.	10th.	10th.
Average day of return to normal.	25th.	26th.	19th.	20th.

Moderate Cases (25).

Number of cases which developed albuminuria = 16.

	Cases which developed albuminuria.		Cases which did not develop albuminuria.	
	S.	D.	S.	D.
Average fall in blood pressure.	18 mm.	19 mm.	17 mm.	17 mm.
Average day of lowest reading.	12th.	11th.	11th.	11th.
Average day of return to normal.	30th.	30th.	31st.	29th.

Severe Cases (40).

Number of cases which developed albuminuria = 33.

	Cases which developed albuminuria.		Cases which did not develop albuminuria.	
	S.	D.	S.	D.
Average fall in blood pressure.	23 mm.	23 mm.	19 mm.	19 mm.
Average day of lowest reading.	12th.	13th.	12th.	12th.
Average day of return to normal.	32nd.	33rd.	30th.	30th.

In each class, mild, moderate and severe, those cases which developed albuminuria showed the greatest fall in blood pressure, and the pressure took longer to return to normal. There seems to be a tendency for the blood pressure to reach its lowest level later in the complicated cases than in the uncomplicated.

Fifty four of the ninety cases which recovered developed albuminuria. In only one case was there an accompanying rise in the blood pressure, and here the albuminuria was the result of a streptococcal tonsillitis. Thus we state that albuminuria in diphtheria is not accompanied by a rise in blood pressure. This supports the view that the albuminuria is due to toxæmia and not to nephritis.

Kolossova (4) found that albuminuria was accompanied by hypertension. In his series of cases Taddei (7) found no rise in pressure resulting from albuminuria. He states "The more persistent and massive the albuminuria, the longer and more marked was the hypotension." If, as we think, albuminuria is the result of toxæmia, this is to be expected. Rolleston (10) observes that any change in the blood pressure due to albuminuria is almost invariably a fall. We agree that it does not result in a rise, but our experience does not confirm the occurrence of a fall. In none of our cases was there any disturbance of the blood pressure curve. Norris etc. (11) state that albuminuria is not always accompanied by a rise in blood pressure. In our series of cases it was never accompanied by a rise.

### Cardiac Complications.

The effect on the blood pressure of cardiac complications is variable. No definite results can be stated as following any given lesion. Of the 90 cases which recovered, 33 showed cardiac involvement of varying degrees of severity. A study of these cases seems to indicate that it is only in the presence of a severe cardiac complication that there is a fall in blood pressure.

Myocardial weakness as indicated by loss of tone, softness of the first mitral sound, development of a mitral systolic bruit, seems to produce no fall in pressure unless the condition is very marked.

Extrasystoles, if few, produce no effect. If numerous, and occurring along with myocarditis, there is a fall. A reduplication of one or other of the mitral sounds is usually accompanied by a marked fall. With this condition, there is usually evidence of myocardial weakness, or extrasystoles, or both.

Certain of Weigert's cases (8) developed more or less severe myocarditis, yet on the average, pressure did not sink lower than in mild cases. Brückner (9) found that slight cardiac disturbance produced no fall in blood pressure. Norris etc. (11) state "When there is a marked fall in pressure there is usually cardiac involvement."

Blood Pressure on Admission and the Effects of Temperature on Blood Pressure.

On admission the majority of cases showed a blood pressure above the normal. The majority also had a temperature above normal. Table 19 gives the findings in the 90 cases which recovered.

T A B L E 19.

	<u>Systolic Pressure.</u>	<u>Diastolic Pressure.</u>
Number of cases with hypertension on admission.	59.	44.
Number of these cases with pyrexia.	45.	33.
Number of these cases with no pyrexia.	14.	11.
Number of cases with normal blood pressure on admission.	9.	17.
Number of these cases with pyrexia.	6.	12.
Number of these cases with no pyrexia.	3.	5.
Number of cases with hypotension on admission.	22.	29.
Number of these cases with pyrexia.	14.	20.
Number of these cases with no pyrexia.	8.	9.

It will be seen that on admission the systolic pressure is more often raised above normal than the diastolic, while the diastolic pressure is more often normal or below normal than the systolic.

In each group - hypertension on admission, normal blood pressure on admission, or hypotension on admission - the majority of the cases show pyrexia, the percentage, however, being highest in those cases where the blood pressure on admission is above the normal.

During the course of the disease five cases ran an intercurrent temperature for varying periods due to streptococcal infection. In one case the temperature developed within the first twelve days when the blood pressure was still falling. No disturbance of the normal curve was noted. The remaining four cases developed a temperature either when the blood pressure was rising, or when it had returned to normal. In one case the onset of temperature coincided with a rise in pressure of 4 mm. which was sustained during the period of pyrexia. In the other three cases the temperature produced no change in the blood pressure.

It is difficult to assess accurately the effect of pyrexia on the blood pressure. In each of the three groups given in Table 19 the majority of cases showed pyrexia. In those cases where the blood pressure on admission was raised above normal, the percentage of cases with pyrexia is higher than in the other two groups. This would seem to indicate that temperature tends to raise blood pressure. The emotional factor however, complicates matters. We have noted above that excitement was of great importance on the first examination, its effect being more marked on the systolic pressure, and this reading was found to be more often raised above normal than the diastolic pressure. It is difficult, if not impossible, to determine the effect of these two factors in raising the blood pressure on admission. The five cases which developed an intercurrent temperature form too small a series from which to draw any conclusions.

On the evidence available we consider that it is impossible to form a definite opinion of the effect of pyrexia on the blood pressure.

Brückner (9) noted that in certain of his cases there was a rise of blood pressure at the beginning, with a subsequent fall. In his series Rolleston (10) found that in the overwhelming majority of cases, highest readings were obtained in the first week. This finding was also stated by Norris, etc. (11). None of these writers mentions whether the high pressures recorded were above normal.

Durand Viel (5) thought that fever tended to raise blood pressure, while Denis (6) considered that the elevation of temperature in diphtheria was too small, and of too short duration, to prove or disprove this fact. In severe cases Taddei (7) found a slight initial rise in the blood pressure which he considered to be due to the accompanying temperature.

Weigert (8) stated a similar finding in regard to his mild cases. The initial rise in his cases Rolleston (10) attributed to excitement and pyrexia. Norris etc. (11) do not consider that there is any fixed relation between temperature and blood pressure.

### Serum Rash.

Twelve cases in the series developed a serum rash. In the mild and moderate cases a rash occurred on 6 occasions, appearing between the 6th and 11th days of disease when the blood pressure was still falling. In one case the fall of pressure seemed to be arrested for 2 days, but in the others no effect was noted. Six of the severe cases developed a rash, the times of appearance ranging from the 9th to the 18th days of disease. In one case, where the rash appeared on the 9th day, there was an accompanying rise of temperature and the blood pressure rose by 18 mm. In a second case, rash appearing on the 13th day, there was a rise of 14 mm. In all the other cases the blood pressure was unaffected.

It would seem that the effect of a serum rash on the blood pressure is variable.

Rolleston (10) found that in the great majority of early serum rashes there was no change in the blood pressure, while in the majority of late serum rashes pressure is raised. By late rashes he meant those occurring after the second week. As in our few cases his results were variable. Norris, etc. (11) reported a similar finding.

### Laryngeal Diphtheria.

When dealing with laryngeal diphtheria we noted the marked fall in blood pressure following tracheotomy.

Janeway (25) pointed out that there was a marked increase in blood pressure in asphyxia, and that this fact was of importance in laryngeal diphtheria. Taddei (7), Rolleston (10), Norris, etc. (11), and Abt and Feingold (12) all comment on the marked rise in pressure in laryngeal cases. All agree as to the sudden and marked fall following tracheotomy. Our experience, therefore, coincided with that of these observers.



SIGNIFICANCE OF THE BLOOD PRESSURE IN PROGNOSIS.

We will now endeavour to estimate the prognostic significance of the blood pressure curve. When the diastolic pressure falls to a low level it is difficult to read accurately, particularly in young children. Therefore we will confine our attention to the systolic pressure where it is nearly always possible to obtain accurate readings, even at very low levels.

In the series of 100 cases of faucial diphtheria, 10 deaths occurred. With one exception, the blood pressure in the fatal cases fell steadily until the time of death, so that the last reading to be recorded was also the lowest. In the exceptional case uraemia developed and the blood pressure rose steadily till the time of death. Omitting the exceptional case, the lowest systolic pressures obtained in the fatal cases ranged from 38 to 66 mm. Table 20 gives the number of cases in the series of 100 in which a systolic pressure was recorded of the value shown.

TABLE 20.

Systolic Pressure.	Number of Cases in which recorded.	Number of these cases which died.	Number of these cases which recovered.
66 mm.	21	9	12
64 mm.	13	8	5
62 mm.	12	8	4
60 mm.	9	8	1
56 mm.	7	7	-
54 mm.	4	4	-
42 mm.	2	2	-
38 mm.	1	1	-

From the above table it will be seen that when the systolic pressure falls below 70 mm. the prognosis is grave. In one case a systolic pressure of 60 mm. was recorded, and yet there was recovery. This low pressure occurred on the 10th day of disease in a child of 5 years, and was due to a cardiac collapse. By the following day the heart action had improved and the pressure had begun to rise. This case illustrates the importance of determining the cause of the low blood pressure.

A low reading may occur in a case which is profoundly toxic. Here the blood pressure curve will show a steady fall from the time the patient first came under observation, or the low reading may be due to a cardiac collapse, in which case there will be a gradual fall in pressure, succeeded by a sudden drop at the time of onset of the cardiac symptoms. Thus it is misleading to rely on a single reading when attempting a prognosis.

Two facts emerge. A prognosis should never be given without considering the clinical condition of the case, and it is necessary to have more than one blood pressure reading.

While it is impossible to make a definite pronouncement on the matter in view of the small number of deaths in our series, we feel that in any case where there is a profound toxaemia, and where there has been a steady fall in the systolic blood pressure to 60 mm., death will ensue.

While we believe that a careful study of the general clinical condition of the patient still remains the best guide to prognosis, we consider that blood pressure readings are useful aids in helping to form a decision. They should never be used alone.

Friedman (2) considered that if the systolic blood pressure did not sink below 90 mm. in big children, and 75 mm. in small children, the prognosis was not unfavourable. Cases where it fell to 65 mm. or 60 mm. were almost invariably fatal. With these findings we are in agreement. Where recovery took place after a reading of 65 mm. or 60 mm. had been recorded, the fall in blood pressure was presumably due to a cardiac collapse. He further states that the diagnosis of cardiac involvement can be made much earlier by the sphygmomanometer than by ordinary clinical methods. In our own series of cases it was only in the presence of severe cardiac involvement that the blood pressure was affected, so that we cannot agree with this statement.

Durand Viel (5) distinguished between low blood pressure readings due to toxaemia, and those due to cardiac complications. He states "When a child shows on several successive days a fall in arterial blood pressure the outlook is bad, and a fatal issue may be feared. On the other hand, even when the outlook is favourable, the pressure may be lowered by a cardiac complication and yet the end result be cure."

A progressive and marked fall in pressure was considered by Denis (6) to be a very grave sign. Although the recoveries in his series did not show such low blood pressure readings as the fatal cases, Weigert (8) did not think that much prognostic value could be attached to blood pressure in diphtheria. This view was also stated by Brückner (9), and both agreed that the best guide was the clinical condition of the patient. Rolleston (10) considered that blood pressure readings, though of some value in conjunction with other prognostic signs, were by no means indispensable in forming a prognosis. More importance was attributed to blood pressure readings by Norris etc. (11) who considered that a progressive fall was of bad prognostic import, but added that a high pressure does not necessarily mean recovery. Our own experience inclines us to agree with their view. A progressive and marked fall is of bad import.

The fall in blood pressure, in any particular case, is of less practical importance as a guide to prognosis than the level to which the systolic pressure has fallen. This is due to the fact that to calculate the fall in any particular case requires the adoption of a normal blood pressure for the patient. In a previous section we have shown the wide range of standards offered, and, the extreme difficulty of arriving at a figure which will represent the normal blood pressure of the patient concerned. Thus it is difficult to ensure accuracy when calculating the fall in pressure in any particular case.

The nine cases in which the blood pressure fell steadily till the time of death showed a depth of fall in the systolic pressure ranging from 20 to 52 mm. The fall was calculated from the blood pressure at the time of admission.

Table 21 gives the number of cases in the series of 100 in which there was a fall in the systolic blood pressure of the extent shown.

TABLE 21.

Fall in Blood Pressure.	Number of Cases in which occurred.	Number of these Cases which Died.	Number of these Cases which recovered.
20 mm.	46	9	37
24 mm.	29	8	21
30 mm.	12	7	5
36 mm.	8	6	2
38 mm.	5	5	-
44 mm.	4	4	-
50 mm.	3	3	-
52 mm.	1	1	-

It will be seen that when there is a fall in the systolic pressure of 30 mm. the prognosis is grave. When there is a fall of 40 mm. probably no case recovers. We consider, however, that due to the difficulty of determining the normal blood pressure for the case concerned, the depth of the fall of blood pressure is of less value as an aid to prognosis than a record of the systolic pressures.

No writer comments on this matter.

Of the 90 cases which recovered 21 developed paresis. The minimum fall in blood pressure in these cases was 10 mm., the maximum 32 mm. Table 22 shows the number of cases developing paresis among those in which there was a fall in the systolic blood pressure of the extent indicated.

TABLE 22.

Fall in Blood Pressure.	Number of Cases in which occurred.	Number of these Cases which developed paresis.	Number of these Cases which did not.
10 mm.	89	21	68
12 mm.	81	20	61
14 mm.	75	19	56
16 mm.	65	19	46
18 mm.	52	18	34
20 mm.	37	15	22
22 mm.	28	13	15
24 mm.	21	9	12
26 mm.	15	8	7
28 mm.	9	4	5
30 mm.	5	2	3
32 mm.	3	1	2
34 mm.	2	-	2
36 mm.	2	-	2

It would seem that where there is a fall in the systolic pressure of more than 20 mm. some 50% of the cases develop paresis, but due to the small numbers dealt with this figure must be accepted with caution. This finding is too vague to be of any value in prognosis.

Kolossova (4) considered that an arterial pressure of 15 mm. or more below normal allowed of a prognosis of paresis. We cannot agree with this finding.

## CONCLUSIONS.

There is a fall of blood pressure in every case of diphtheria, the fall taking place from the beginning of the illness.

The more severe the case, the greater is the fall, and the longer does the pressure take to return to normal.

The extent of the fall is influenced by the age of the patient, and the day of disease on which antitoxin is administered.

When the blood pressure readings in any case are charted they show a curve, the lowest point in which occurs most commonly on the 11th, 12th or 13th day of disease.

The blood pressure curve is not influenced by the occurrence of albuminuria or paresis.

In conjunction with a careful study of the patient's general condition, blood pressure readings are of value in forming a prognosis. They should never be used alone.

APPENDIX.

Typical blood pressure charts of the various types of cases investigated.

KEY TO BLOOD PRESSURE CHARTS.

Systolic Pressure:



Diastolic Pressure:



Albuminuria:



Cardiac Involvement:



Paresis :-

Palatal:

P

Strabismus:

S

Ptosis:

Pt

Temperature:



Serum Rash:

S R

Up in Blankets:

B

Up in Clothes:

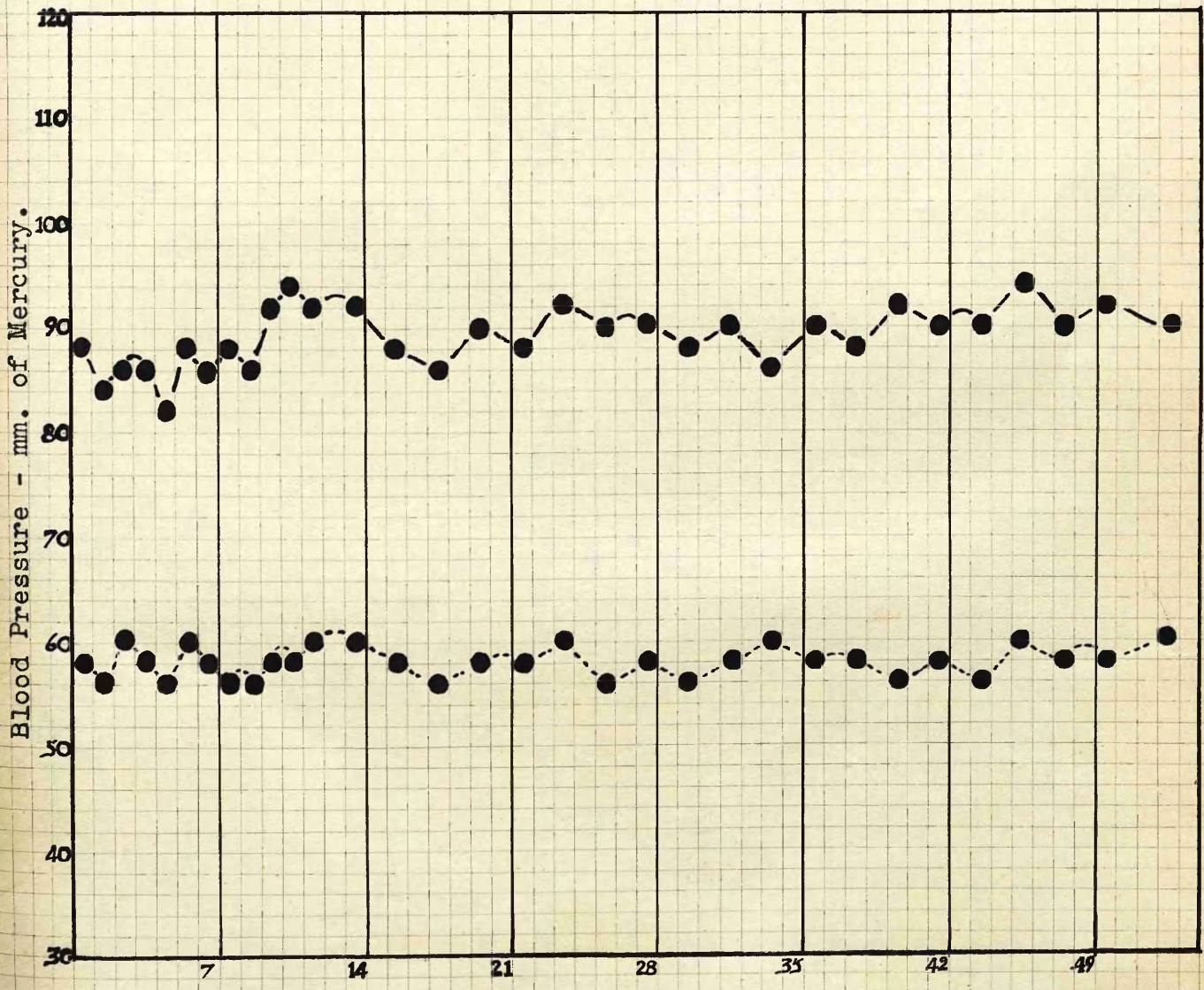
C



C.D. Aet. 6 years.

Diphtheria Carrier - Nasal.

Days in Hospital :- 52



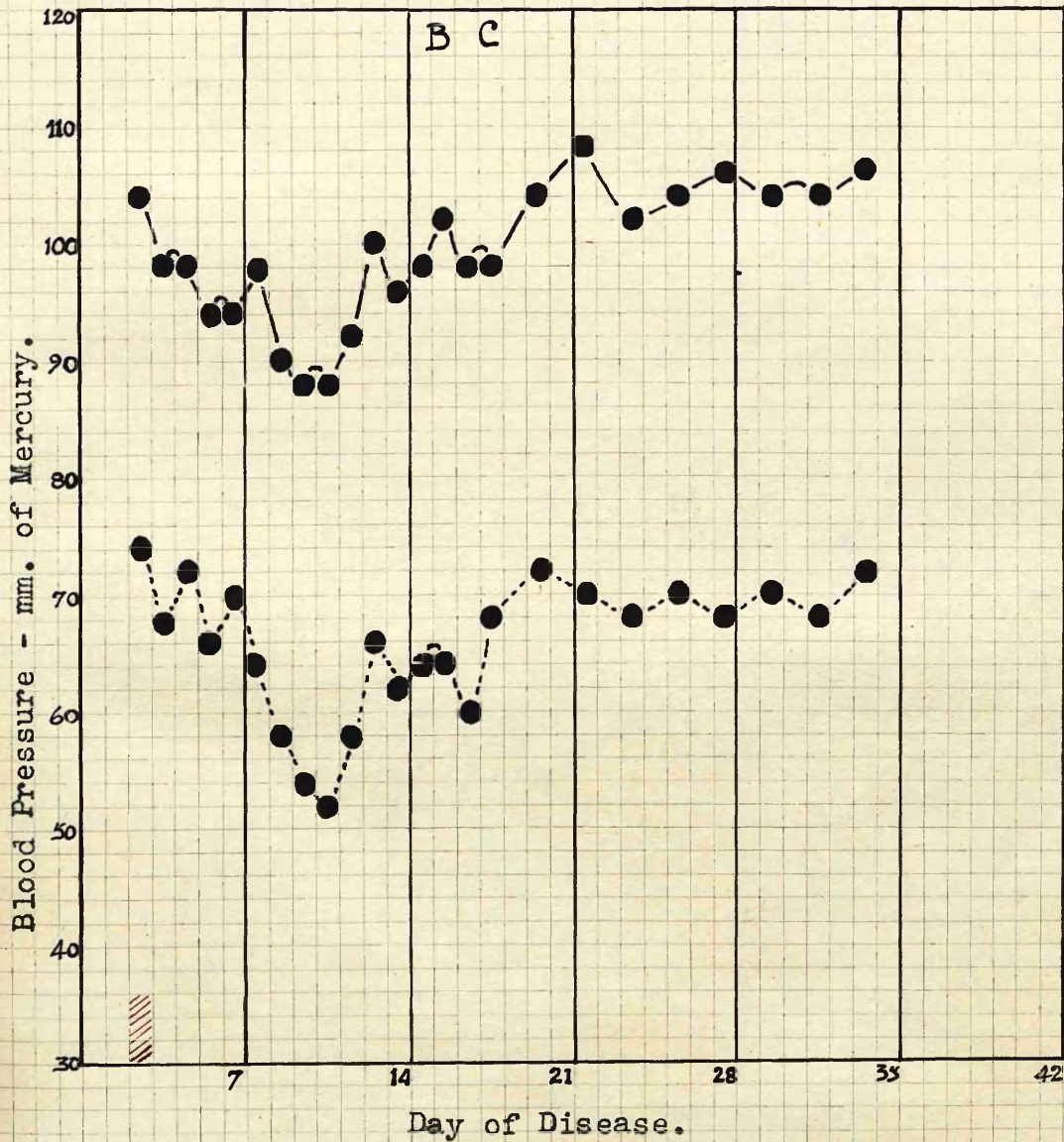
Days in Hospital.

E.M. Aet. 11 years 11 months.

Faucial Diphtheria - Mild.

Admitted on the 3rd. day of disease.

Days in Hospital :- 32 Recovery.

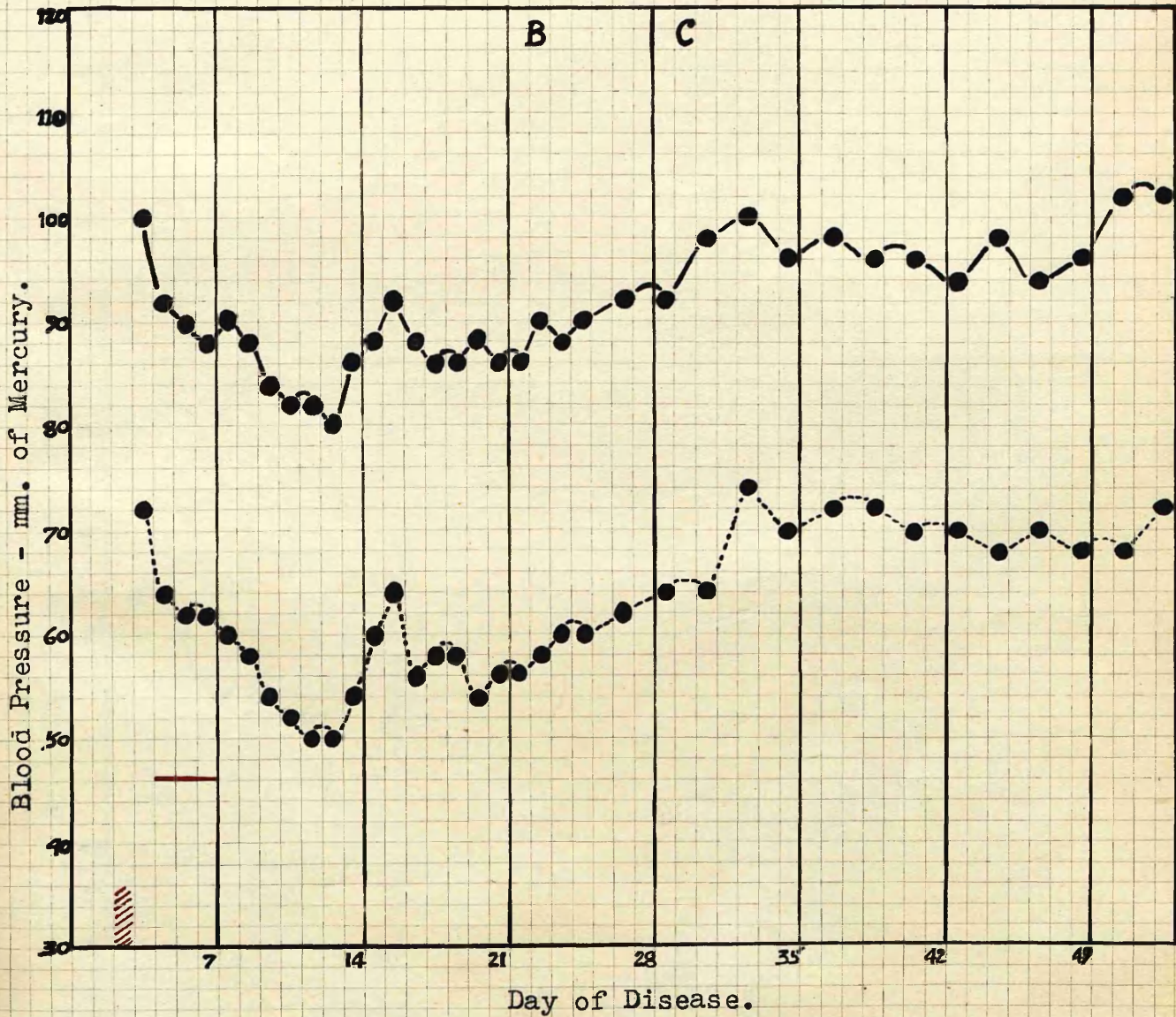


D.F. Aet. 11 years 1 month.

Faucial Diphtheria - Moderate.

Admitted on the 3rd. day of disease.

Days in Hospital :- 51                      Recovery.

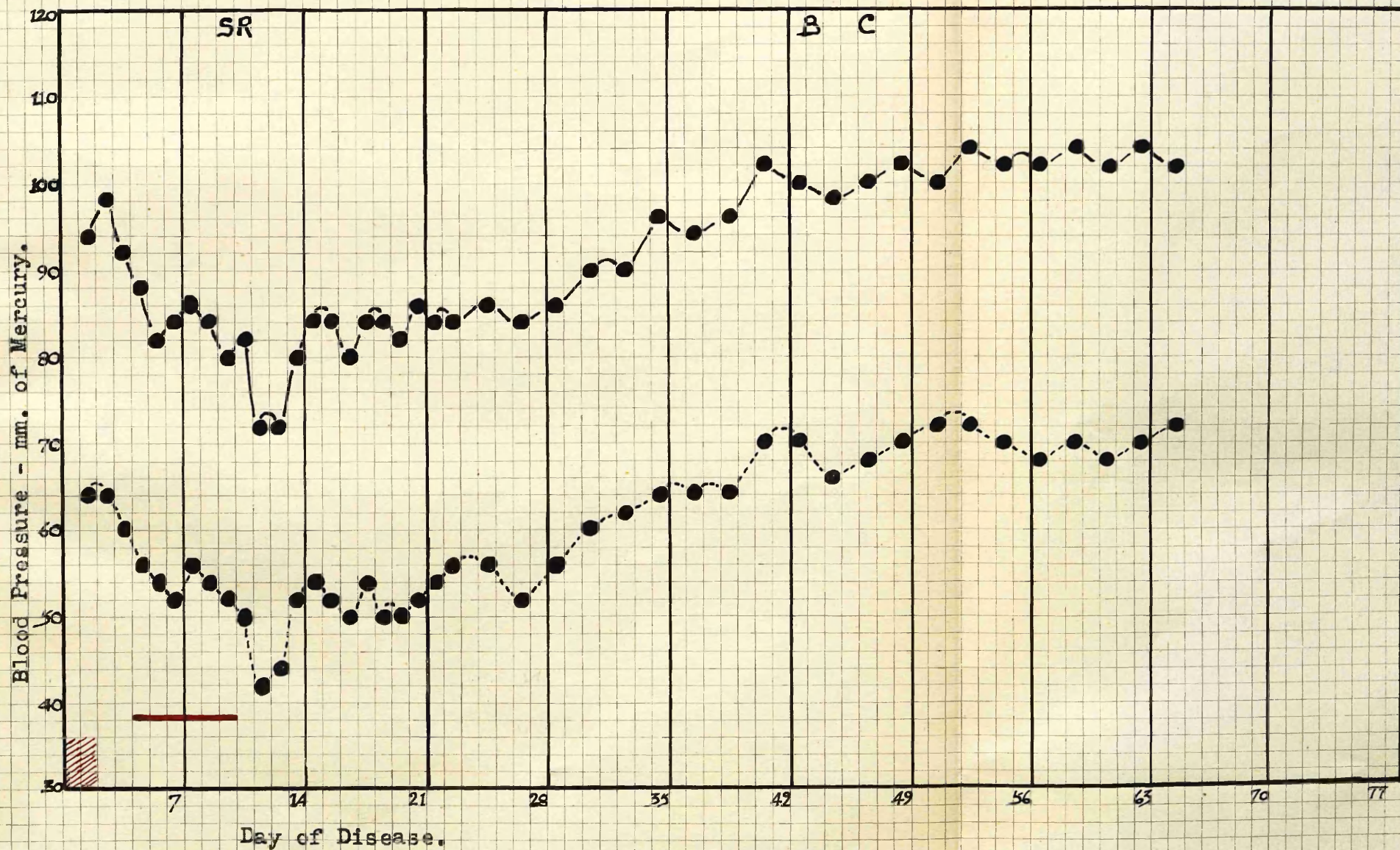


J.F. Aet. 5 years.

Faucial Diphtheria - Severe+

Admitted on the 1st. day of disease.

Days in Hospital :- 65 Recovery.

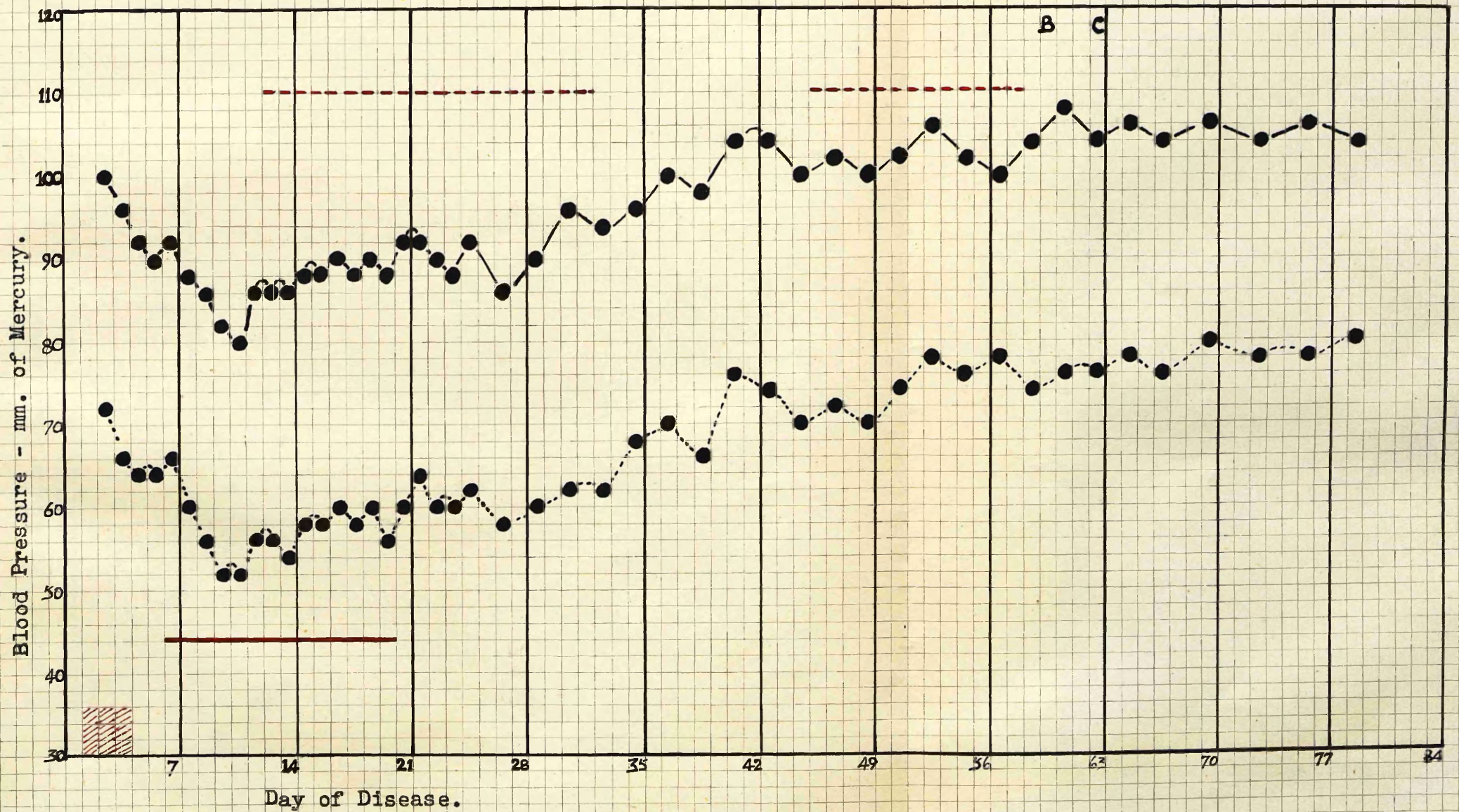


N.S. Aet. 7 years 3 months.

Faucial Diphtheria - Severe+

Admitted on the 2nd. day of disease.

Days in Hospital :- 79 Recovery.

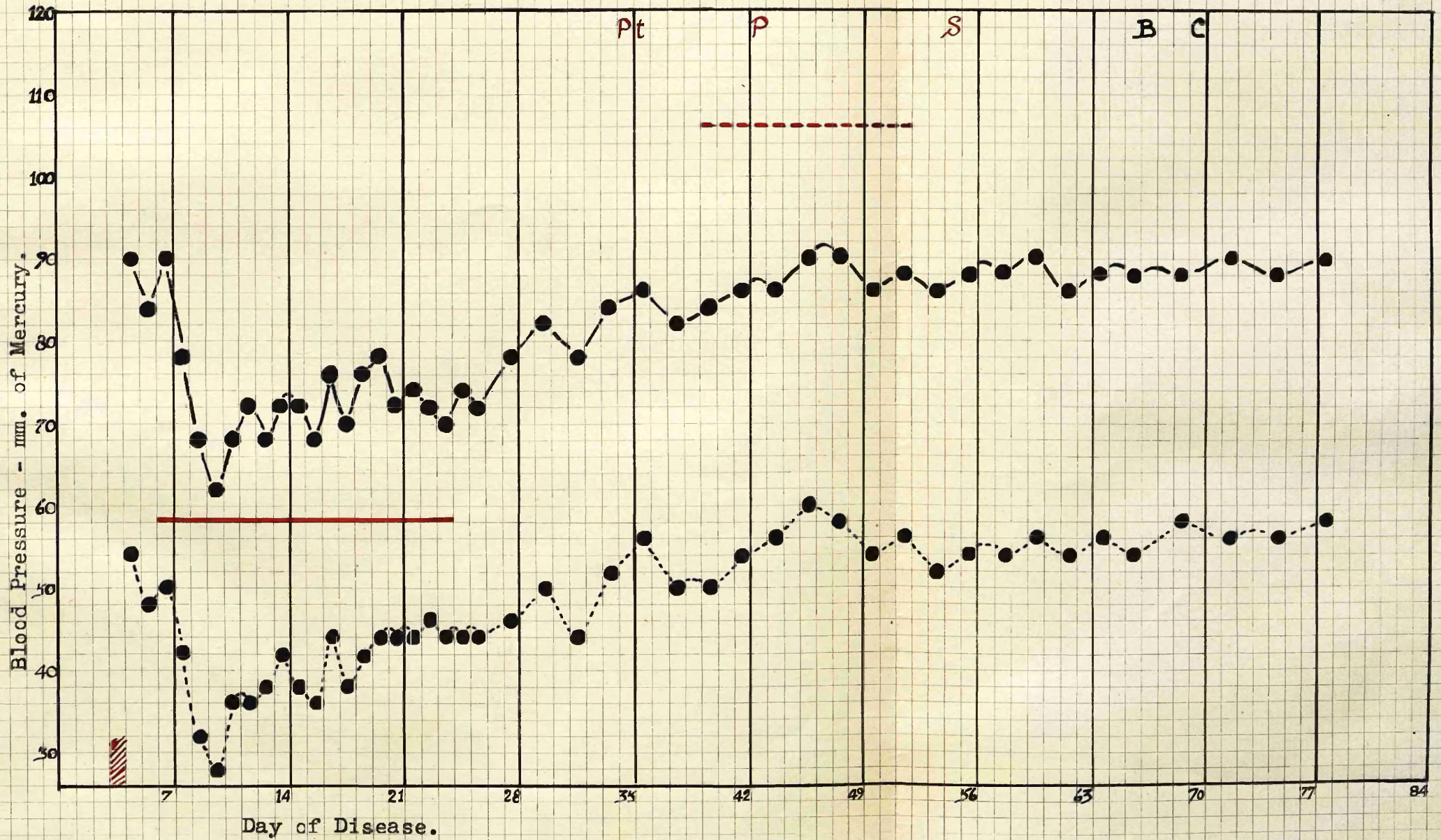


L.E. Aet. 5 years 9 months.

Faucial Diphtheria - Severe ++

Admitted on the 4th. day of disease.

Days in Hospital :- 79 Recovery.



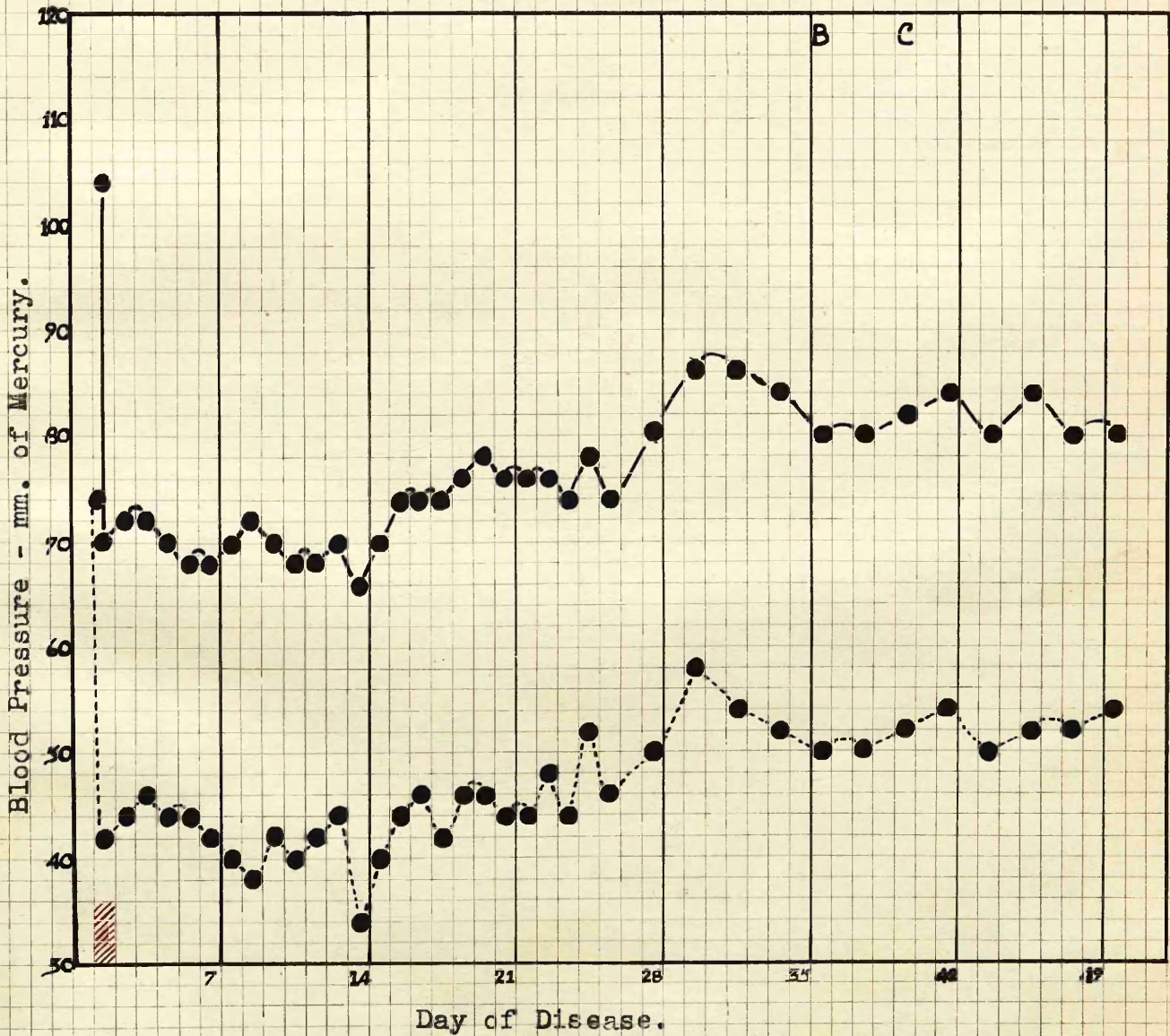
D.S. Aet. 4 years.

Laryngeal Diphtheria - Tracheotomy on admission.

Admitted on the 2nd. day of disease.

Days in Hospital :- 50

Recovery.

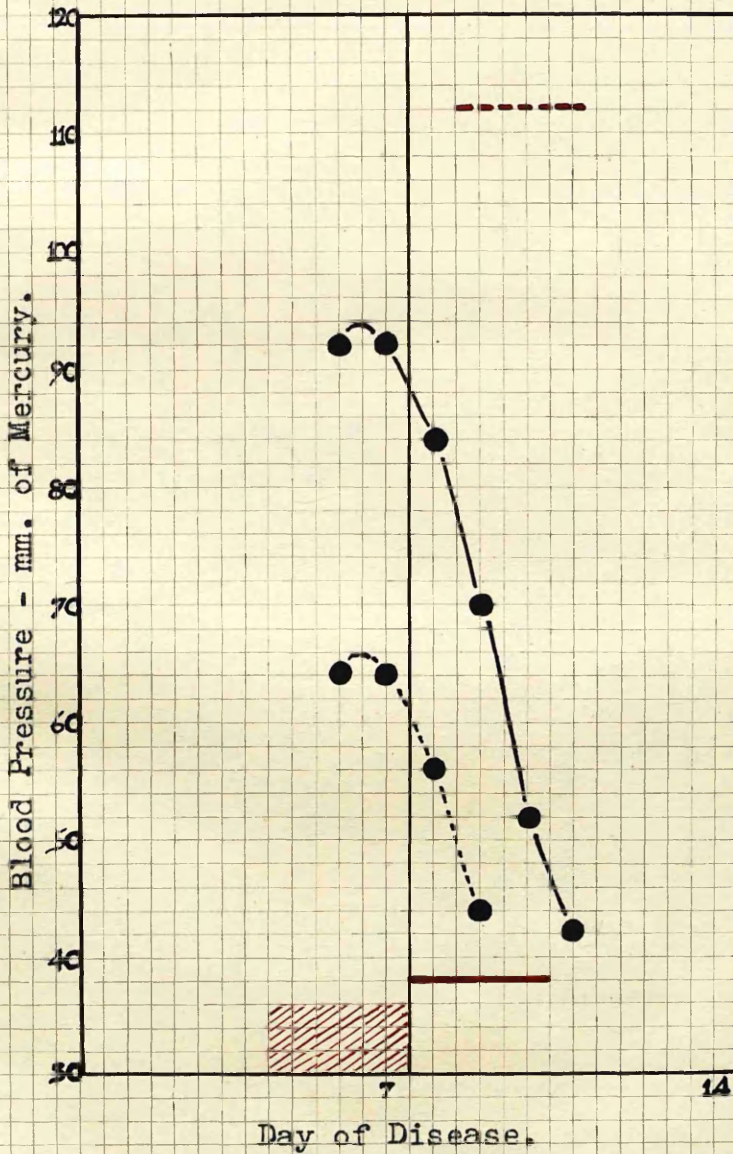


B.C. Aet. 9 years 11 months.

Faucial Diphtheria - Severe++

Admitted on the 5th. day of disease.

Days in Hospital :- 6 Toxic Death.



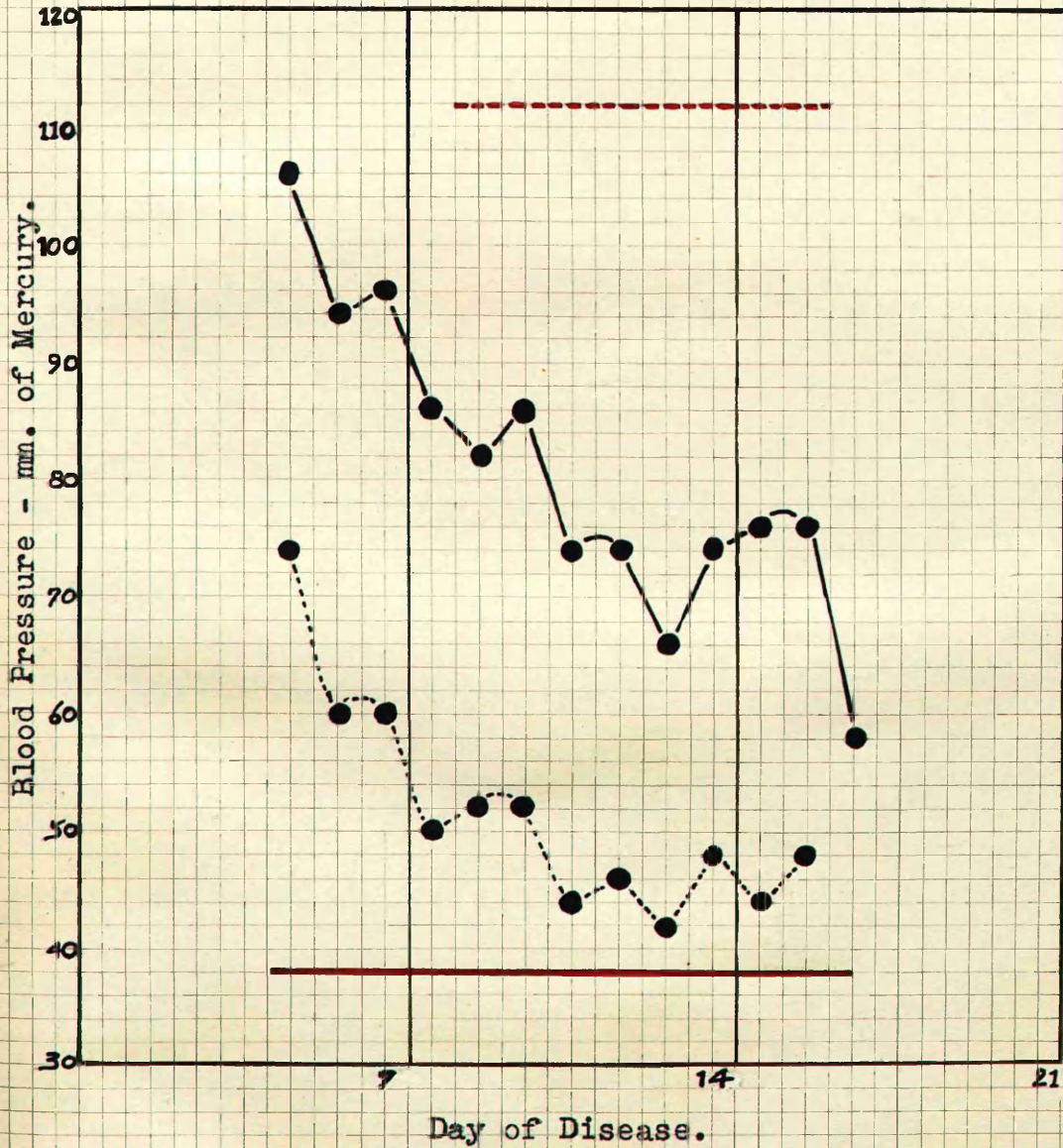


V.W. Aet. 10 years 6 months.

Faucial Diphtheria - Severe ++

Admitted on the 4th. day of disease.

Days in Hospital :- 14.      Cardiac Death.



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