PNEUMONIAS in GLASGOW, with SPECIAL REFERENCE to their PNEUMOCOCCAL TYPES and ASSOCIATED ORGANISMS.

THESIS for DEGREE of DOCTOR of MEDICINE (M.D.)

by

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The following hundred cases of pneumonias occurring in Glasgow between the months of March and June 1923 were examined and recorded with a view to determining whether one type of pneumococcus predominated in the city as a whole, or in the various districts, and whether the four types gave rise to different clinical forms of pneumonia.

Each patient, on admission, was examined clinically for signs of pneumonia, and if present, a specimen of their sputum, as free as possible of saliva, was collected in a sterile bottle for microscopical examination. In the case of children, a throat swab was inserted well down the pharynx during a fit of coughing and the sputum evacuated thus obtained. The sputum in both cases was examined within half an hour.

MOCROSCOPIC EXAMINATION

Two films were made of each sputum, the one stained by Ziehl Neelsen's method to help to exclude the possibility of tuberculosis, and the other with Lugol's modification of Gram's stain to confirm the presence of

the pneumococcus. A note was made at the same time of the other organisms present, seldom more than three or four in number unless the sputum contained much saliva. These associated organisms will be taken up in detail later on.

MOUSE INOCULATION -

A small bit of the sputum, washed in several changes of sterile normal saline and emulsified with saline was injected into the peritoneal cavity of a white mouse. When the mouse appeared to be in an acutely ill condition a preliminary exploration was made of the peritoneal cavity and a small amount of fluid withdrawn by a specially prepared smooth, fine pointed pipette to prevent the accidental puncturing of the abdominal organs. A smear, stained by Lugol's modification of Gram's stain, was examined for the presence of the pneumococcus and if found in much greater numbers than the other organisms the mouse was either killed at once, or preferably, left to die.

MOUSE AUTOPSY -

The animal was then firmly secured so that the abdomen was exposed. The surface was well soaked with tincture of iodine and a small incision being made in

the skin, the pipette was thrust through the abdominal wall. As much as possible of the peritoneal fluid, which as a rule was of a glairy character, was then drawn off and pipetted into a sterile centrifuge tube; the peritoneal cavity was subsequently washed out several times with sterile normal saline, the fluid from each series of washings being added to the original undiluted fluid. This entire amount was then used for the agglutination tests.

In order to procure a further means of verifying the organism the practice was made of now obtaining a culture from the heart's blood. The heart was exposed, the pericardium opened and the front of the right ventricle seared with a red hot platinum spud. A very fine capillary tube was thrust into the right ventricle, and the blood withdrawn immediately inoculated into bouillon and on to sloped tubes of agar, both tubes being incubated for about eighteen hours. Smears were made of the blood at the same time, stained with Gram's stain and examined for the pneumococcus. A greater number was always present and a more vigorous growth obtained on culturing when the mouse was allowed to die than when it was killed on first showing symptoms.

DETERMINATION of TYPES -

For this the peritoneal fluid was always used in the first instance. The fluid collected in the centrifuge tube was centrifuged at a low speed to throw down the cells and fibrin in the exudate. The supernatant fluid, containing the organisms, was then pipetted off into another sterile tube and centrifuged at high speed for about fifteen minutes to throw down all the organisms. The supernatant fluid now obtained was pipetted off and discarded, and the sediment thoroughly well emulsified with about 3 ccs. of sterile normal saline. If this emulsion proved to be not entirely homogeneous in character the fluid was centrifuged again at low speed, and the larger particles being thrown out, an even emulsion was obtained.

This method resulted in having about 3 ccs. of a bacterial suspension of a turbidity resembling that of a twenty four hours bouillon growth of pneumococcus. Occasionally, owing to the small amount of fluid originally obtained, it was impossible to get this depth of turbidity but this standard was always aimed for.

ACTUAL TEST -

Throughout the whole series, the agglutinating serum employed was that supplied by the Mulford Laboratories, Philadelphia, and in the various dilutions recommended

by them. A set of five small test tubes (7·5 cms x 1 cm) thoroughly cleaned and sterilised was set up. In tube I there was put ·475 ccs. sterile saline + ·025 ccs. Type I serum giving a 1 in 20 dilution of the serum. To this was added ·5 ccs. of the bacterial emulsion, giving a final dilution of serum of 1 in 40. These quantities were exactly repeated in tube 2, the only difference being that Type II serum was substituted for Type I. In tube 3, used for identifying the atypical Type II pneumococcus, there was placed ·5 ccs. Type II undiluted serum and ·5 ccs. bacterial emulsion. To tube 4 was added ·4 ccs. sterile normal saline, ·1 cc. Type III serum and ·5 ccs. bacterial emulsion thus giving a serum dilution of 1 in 10. Tube 5 was used for the determination of the bile solubility of the organism (thus eliminating the possibility of it being a streptococcus); in it was placed ·1 cc. sterile ox bile and ·4 ccs. of the bacterial suspension.

TABLE I

Tube	Sterile saline	Serum	Bacterial Suspension
1	·475 ccs.	·025 ccs. Type I	·5 ccs.
2.	·475 ccs.	·025 ccs. Type II	·5 ccs.
3	-	·5 ccs. Type II	·5 ccs.
4	·4 ccs.	·1 cc. Type III	·5 ccs.
5	·1 cc. sterile ox bile	-	·4 ccs.

The five tubes were then placed either in the incubator at 37°C, or in a water bath at the same temperature. Agglutination took place within half an hour in the latter case, but at least one hour, sometimes several hours, had to elapse before definite agglutination was visible by the former method. In some cases there was no agglutination, but when the organism was definitely bile soluble it was then classified as Type IV pneumococcus.

In any case in which doubt existed as to the specificity of the agglutination, corroboration was effected by using the growths obtained from the cultures of the heart's blood. In some the bouillon growth was used, in others an emulsion was made of the dew-like growths on one or two agar tubes, and the agglutination test was then carried out with the same technique as above.

MEDIA -

The media, bouillon and agar, used throughout, were prepared from an infusion of fresh meat, as recommended by Avery, Chickering & Cole, who emphasise that particular attention should be paid to the following points:-

1. The media must be prepared directly from infusion of fresh meat and not from beef extract.
2. The re-action of the media should be from ·3 to ·5 acid to phenolphthalein..

3. Sterilisation must be effected by exposing to steam at 100°C for 20 minutes on three successive days.

These points were carefully observed and no difficulty was experienced in getting fairly luxuriant growths.

TYPE PERCENTAGE -

Of the total number of cases examined the percentages were as follows:-

Type I - 25%
" II - 42%
" IIA - 8%
" III - 17%
" IV - 8%

From these figures it is apparent that Type II predominated in the city between the months specified. The districts from which the cases were removed were noted on admission to see if any one type was more prevalent in one district than another, but it was found that all types occurred alike in the various districts, as shown in the following table:-

Table II

Districts	Types I	II	IIA	III	IV	Totals
Bridgeton) Parkhead)	2	4	-	1	1	8
Tollcross	1	1	-	-	-	2
Garngad) Townhead)	2	9	-	2	1	14
Cowcaddens	3	4	-	1	-	8
North Westerm) Maryhill)	4	6	3	3	1	17
Springburn	2	6	1	4	1	14
Partick) Whiteinch)	6	8	2	2	2	20
Sandyford) Overnewton)	1	2	1	1	-	5
Anderston	4	2	1	3	2	12
Totals	25	42	8	17	8	

The same diversity was found on analysing the cases as regards sex, age and occupation. Both male and female were affected alike, the male in greater proportion, 61% to the female 39%; and the occupations varied greatly, the majority of the men being labourers and of the women, housewives.

AGE GROUPS -

As regards the ages of the patients it was found that the highest incidence was below the age of ten, the next in frequency being the decade between 20 and 30. In the latter group, as will be seen by the following table (III), the order of the percentage of the various types remained the same as when taken over the whole series. In the group below 10, on the other hand, the order of frequency is Type II, followed by Type III then Type I and Type IV, which would seem to point to the fact that children are more susceptible than adults to the Type III organism.

TABLE III

AGE	SEX	TYPE I	II	IIA	III	IV	%
1-10	M	4	2	2	5	2	15
	F	1	8	-	2	-	11
11-20	M	4	4	1	2	-	11
	F	1	2	1	1	1	6
21-30	M	8	4	1	1	-	14
	F	2	3	3	1	-	9
31-40	M	-	3	-	1	1	5
	F	-	2	-	1	1	4
41-50	M	-	8	-	2	-	10
	F	1	1	-	-	2	4
51-60	M	1	2	-	-	-	3
	F	1	1	-	-	-	2
61-70	M	1	1	-	-	-	2
	F	1	-	-	1	-	2
71-80	M	-	1	-	-	-	1
	F	-	-	-	-	-	-
81-90	M	-	-	-	-	-	-
	F	-	-	-	-	1	1

MORTALITY -

The statistics given in the following table (IV) show the outcome of the disease among the individuals infected with the various types. As will be seen Type II gives rise to the greatest number of deaths but if calculated as percentage mortality of those affected in each type, both Type I and II are equal at 16% while Type III is only 11·8%. The death which occurred in Type IV can hardly be relied on as giving a fair representation of the severity of the illness produced, as the patient was an old lady of 87 with marked arterio sclerosis and myocarditis. It is evident therefore that on the whole the severity of the illness is influenced to some slight extent by the pneumococcus present but taken individually no prognosis could be justifiably given.

TABLE IV

Type	Sex	Percentage incidence	Percentage mortality	Ages of fatal cases
I	M	18	2) 4·16%	17 & 22
	F	7	2)	27 & 42
II	M	25	-) 8·16%	-
	F	17	5)	Between 3 & 74
IIA	M	4	2)	6 & 29
	F	4	1)	30
III	M	11	2	35 & 43
	F	6	- 11·8%	-
IV	M	3	-	-
	F	5	1 12·5%	87

TYPE of ILLNESS -

It is convenient for comparison of the results to divide the pneumonias into five groups, viz:-

1/

(1) Typical lobar pneumonia with continuous fever and a crisis occurring on from the fifth to the tenth day.

(2) Bronchopneumonia with remittent and occasionally intermittent fever extending over two weeks and ending by lysis.

(3) An intermediate form in which the fever was continuous for about nine to twelve days, followed by defervescence by lysis.

(4) Where there was a distinct typical lobar pneumonia at the commencement of the illness but where, after the crisis, there was a secondary rise of temperature lasting for several days, or even two to three weeks, accompanied by lung symptoms with no evidence of purulent effusion.

(5) Cases in which purulent effusion developed.

GROUP 1 -

The great majority, 47% of the cases, came under this group and the accompanying table (V) shows that each type of organism was present. Both sexes were alike affected and the ages varied greatly, the two extremes being $2\frac{1}{2}$ years and 69 years respectively. The sputum was without exception of the typical rusty and tenacious character at some stage of the illness.

TABLE/

TABLE V

Type	Sex	Number affected	Ages	Deaths
I	M	12	8½-65	2 (17 years, 22 years)
	F	5	17-60	2 (27 years, 62 years)
II	M	10	19-69	1, 46 years
	F	8	2½-53	-
IIA	M	1	17	
	F	1	26	
III	M	7	3-43	1, 43 years
	F	2	5 & 12	-
IV	M	1	35	-
	F	0	0	-

The mode of onset among the adults was in every case typical of lobar pneumonia, being ushered in by rigors, headache, pain in the side, cough and occasional vomiting, while with the children there was usually a history of vomiting, or convulsions, followed by a troublesome cough with obviously quickened respirations.

The histories of the following three cases may be taken as illustrative of this group.

I R.O. Male, 21 years, Labourer.

Admitted 12.25 p.m. 18th April 1923
on his fourth day of illness.
Pulse - 116. Temp. - 102°. Respir. - 30

HISTORY of ONSET - Patient has been ill since 14th April, complaining of cold and shivering with pain

in back and left side. Severe cough present with expectoration.

PHYSICAL EXAMINATION

19. 4. 23. Patient well nourished. Appears very acutely ill. Colour-cyanosed.

Pulse - rapid but quality good.

Respirations increased and laboured.

Tongue - coated, brown and dry. Herpes round left angle of mouth.

Heart - borders normal. Sounds rapid but pure.

Lungs - Anteriorly - right lung clear to percussion and auscultation. Dullness in left axilla with much diminished R.M. Posteriorly - right lung clear to percussion and auscultation; left lung - lower lobe dull to percussion and V.F. increased. R.M. tubular over that area and V.R. increased. A few fine moist râles can be heard at upper limit to dullness.

Cough - severe and harsh.

Sputum - scanty, rusty and very difficult to expectorate.

Patient was very restless and talkative during the night and attempted to get out of bed.

Pulse - 124. Temp. - 103°. Respir. - 32

20. 4. 23. Patient still very acutely ill and was delirious through the night.

Colour extremely cyanosed and breathing difficult.

Pulse - bounding

Lungs - a few coarse moist crepitations are present to-day over the dull area.

Pulse - 128. Temp. - 102°. Respir. - 34.

Sputum - rusty and tenacious.

Microscopic examination -

1. No T.B. found
2. Very numerous pneumococci.
3. Gram - ve rods.
4. Large Gram + ve staphylococci.
5. Occasional Gram - ve bean shaped diplococci.

The pneumococci on being typed were proved to belong to Type I.

21. 4. 23. Slept better last night but condition still acute.

Pulse - fairly good but bounding.

Cough - rather looser and breathing easier.

Pulse - 112. Temp. - 102°. Respir. - 34

22. 4. 23. Crisis occurred during the night. Patient slept well and condition is much improved.

Cough - much easier.

Sputum - more frothy in character.

5. 5. 23. No abnormality can be made out on examination of chest.

No cough and no spit present.

Patient dismissed to-day - well.

II. J.C. Male. 35 years. Labourer

Admitted 11.45 p.m. on 20th May 1923 on his fourth day of illness.

Pulse - 100. Temp. - 101°. Respir. - 30

HISTORY of ONSET - Patient complained of shivering and pain in the chest on 16th May. He then developed a troublesome cough with spit which was dark in colour.

PHYSICAL EXAMINATION

21. 5. 23. Patient well built and well nourished.

Appears fairly comfortable this morning.

Temperature came down to 98·4 during the night.

Colour and pulse - good.

Respirations - normal.

Tongue - lightly coated and moist.

Heart - borders and sounds normal.

Lungs - Anteriorly - clear to percussion and auscultation. Posteriorly - left base dull to percussion and full of coarse moist rales heard over both inspiration and expiration.

Cough - slight with small amount of mucoid spit.

Microscopical examination of spit -

1. No T.B. found.
2. Scant pneumococci.
3. A few Gram - ve rods.

The pneumococcus proved to be Type IV.

Pulse - 72. Temp. - 98°. Respir. - 28.

1.6.23. No abnormality of chest on physical examination.

No cough and no spit present.

Patient dismissed to-day - well.

III. A.Y. Male. 3 years.

Admitted 7 p.m. on 31st March 1923 on fourth day of illness.

Pulse - 144. Temp. - 101·2°. Respir. - 64.

HISTORY of ONSET - Child was sick and vomiting on 27th March. He has been fretful since and has been coughing a lot.

PHYSICAL EXAMINATION

1.4.23 Child fairly well nourished.

Appears sharply ill.

Colour - pale.

Tongue - heavily coated and mouth dirty.

Pulse - rapid but quality good.

Respirations, increased but easy.

Stools - green and offensive.

Heart - nothing of note.

Lungs - Anteriorly - clear to percussion and auscultation. Posteriorly - left base impaired to percussion and full of very fine moist crepitant râles. Rest of lungs clear.

Cough - fairly severe and frequent.

Sputum - (obtained by throat swab) very tenacious and mucoid.

Microscopic examination of spit -

1. No T.B. found.
2. Numerous pneumococci.
3. Gram +ve staphylococci.
4. Occasional round Gram - ve organisms in groups of four.

The pneumococcus belonged to Type III.

Pulse - 128. Temp. - 102·4°. Respir - 50.

2. 4. 23. Child sharply ill. Is very fretful and restless.

Colour at times very flushed and

Pulse quality varies.

Pulse - 140. Temp - 102.6°. Respir. - 44.

4. 4. 23. Crisis occurred during the night. Child appears exhausted but rests quietly.

Pulse quality improved.

Lungs - not examined.

Pulse - 112. Temp. - 98·4°. Respir. - 26.

14. 4. 23. No abnormality of chest on physical examination.

No cough left.

Child dismissed to-day - well.

The course of the illness appeared to be more severe in those arising from Type I, cyanosis being more marked, and insomnia and delirium being frequent. On the other hand, the case arising from Type IV pneumococcus was exceedingly mild, the patient having his crisis immediately after admission, though he had only been off work for three days. There was however, a very definite consolidation at the base of the left lung which cleared up rapidly. As regards the situation of the pneumonia with relation to the type, it was found that any lobe or lobes might be affected independently of the type present.

The mortality was 12% - a pretty fair average for acute lobar pneumonias, and as already stated, the majority of the deaths occurred with the Type I pneumococcus. The death of the female patient of 27 years was due to the complication of pneumococcal peritonitis, the pus on being inoculated into a white mouse giving rise to a septicaemia also due to the Type I organism. The other female patient of 42 years was in a profoundly toxic, semi-conscious condition on admission and died on the ninth day of illness. In her case both the upper and lower lobes of the right lung were affected. Of the other four deaths, three died at the stage of hepatization

practically on the day when the crisis was expected to take place, while the fourth, the boy of 17 years with the Type I infection, succumbed to a pneumonia affecting first the right lower lobe, then spreading finally to both the upper and middle lobes.

GROUP 2.

In this group of thirteen cases the mode of onset was much more gradual but the average general course of the illness was more severe. The most usual history obtained was that the patient had not been well for some days and had been troubled with a cough which was gradually becoming more severe. Occasionally this was the only symptom present but in others there was in addition a history of sickness and vomiting, wheezy and laboured breathing, with a tight feeling across the chest. The physical examination of the chest showed in all cases the typical signs of bronchopneumonia, while in the three children cyanosis was extreme. The sputum was of a much more purulent character than in the previous group of cases, not one having the rusty appearance, though several were streaked with bright blood.

The two following cases are typical examples of this clinical group.

I. Mrs M. Female. 35 years. Housewife.

Admitted 8.30 p.m. 18th March 1923 on her eighth day of illness.

Pulse - 128. Temp. - 102°. Respir. - 30.

HISTORY of ONSET - Patient has felt out of sorts for the past week. She thought she had got cold and had a bad cough with blood streaked spit. Her cough has been getting worse, and she feels breathless.

PHYSICAL EXAMINATION.

19. 3. 23. Patient well nourished.

Appears sharply ill.

Colour - cyanotic.

Pulse - rapid and soft.

Respirations - increased and wheezy with some dyspnoea. Appears "choked up."

Tongue - brown and dry.

Heart - borders normal. Sounds pure but soft.

Lungs - Anteriorly: left lung clear. Right lung clear to percussion but axilla full of small moist râles.
Posteriorly: left lung clear - right lung, no definite impairment to percussion over lower lobe but breathing slightly tubular in patches and over other areas there are small moist râles.

Cough - prolonged and soft with copious purulent spit. Has not been blood stained since admission.

Pulse - 124. Temp. - 101°. Respir. - 28

Microscopic examination of spit -

1. No T.B. found.
2. Numerous pneumococci.
3. Numerous staphylococci.
4. Occasional Gram - ^{ve} rods which are sometimes in clumps beside the pneumococci.

The pneumococcus was Type II.

20. 3. 23. Patient very restless and breathless during the night but feels rather better to-day.

Pulse quality still soft.

Pulse - 116. Temp. - 99·4°. Respir. - 24.

22. 3. 23. Condition much the same.

Colour - still a little cyanosed.

Breathing easier and cough less troublesome.

Lungs on short examination - all clear but right base which is full of moist rales.

Pulse - 120. Temp. - 100°. Respir. - 30.

26. 3. 23. Temperature still elevated.

Condition rather easier. Sleeps better at night and

Cough not so troublesome.

Pulse - 100. Temp. - 99°. Respir. - 28

30. 3. 23. Temperature has come down by lysis since above note and patient is very comfortable.

Colour - good.

Pulse - quality much improved.

Lungs - all clear except for occasional rales in right base.

Pulse - 92. Temp. - 98·4°. Respir. - 24.

15.4.23 No abnormality on physical examination of chest.

No cough and no spit.

Dismissed to-day - well.

II. T.W. Male. 3 years.

Admitted 10 p.m. 10th April 1923 on second (?) day of illness.

Pulse - 144. Temp. - 102°. Respir - 36

HISTORY of ONSET - Child has had a slight cough for some weeks. He was sick and vomiting yesterday and had a convulsion lasting about ten minutes.

PHYSICAL EXAMINATION .

11.4.23. Child rather poorly nourished and

appears sharply ill.

Colour - pale

Pulse - rapid and quality poor.

Respirations - increased and embarrassed

Tongue - coated and mouth dirty.

There is occasional twitching of the child's limbs.

Stools - green and offensive.

Heart - nothing of note.

Lungs - Anteriorly: left lung clear to percussion and auscultation; right lung - no definite impairment to percussion.
Breathing slightly tubular over right apex and there are occasional râles in right axilla. V.R. increased over right apex relative to left.
Posteriorly: left lung clear; right lung - no definite impairment to percussion but full of coarse moist râles.
Small patch at lower angle of scapula with tubular breathing.

Cough - very troublesome.

Sputum - (obtained by throat swab) muco-purulent.

Pulse - 146. Temp. - 99·8°. Respir. - 44.

Microscopic examination of spit -

1. No T.B. found.

2. Occasional short streptococci.

3. Fairly numerous pneumococci which were proved to belong to Type II.

14.4.23 Child looking slightly better to-day but temperature still swinging between 99·8° and 102·8°.

Lungs - as on admission.

18.4.23 Child not looking well to-day.

Colour - very pale.

Has been very restless and fretful.

Pulse - at times almost imperceptible and

Breathing - difficult.

Lungs - as above and in addition left lower lobe is full of coarse moist râles.

Stools - normal.

Pulse - 140. Temp. - 102°. Respir. - 48

23.4.23 Child still very seriously ill.

Colour - cyanosed and

Breathing very rapid and difficult.

Pulse soft and irregular.

Right ear discharging to-day.

Pulse - 132. Temp. - 102·6°. Respir. - 48

29.4.23 Child much weaker. Has been sick and vomiting several times.

Colour - cyanosed.

Pulse - imperceptible

Respirations - rapid though easier.

Lungs - both anteriorly and posteriorly full of coarse moist râles. Several patches with tubular breathing posteriorly.

Stools - green

Pulse - 130. Temp. - 101·6. Respir. - 28

2.5.23 Child gradually became much weaker and cyanosis more marked.

Was sick and vomiting again to-day.

Died at 1.10 p.m.

The mortality, as will be seen by Table VI, was high reaching 31%, even eliminating the case with the

Type IV pneumococcus where death, as already stated, was not directly due to the pneumonia.

TABLE VI

Type	Sex	Number affected	Ages	Deaths
I	M	-	-	-
	F	1	65	-
II	M	3	3 - 20	1, 3 yrs.
	F	1	35	-
IIA	M	3	6 - 29	1, 6 yrs. 2 (29 yrs.
	F	1	30	1, 30 yrs.
III	M	-	-	-
	F	1	24	-
IV	M	-	-	-
	F	3	19 - 87	1, 87 yrs.

The ages of the four patients in whom the illness terminated fatally were 3, 6, 29 and 87 years respectively, the mortality thus appearing at first sight to be as high among the adults as among the children. It is clear however, that this is not a valid conclusion when it is noted that death was not directly due to the pneumonia in either of the adults. The patient of 87 years has already been dealt with, and in the case of the male patient of 29 years, the illness was complicated by chronic valvular disease of the heart accompanied by nephritis, broncho-pneumonia being a terminal feature of a failing compensation

When it is also noted that only three of the patients were below ten years, and that of these, two died, it will be obvious, even considering the small number of cases present, that this type of pneumonia was much more severe in children. As in the previous group, all types of organism are present, Type IV again giving rise to a mild form of infection.

Unfortunately a post mortem examination was only obtained in the one case of the patient of 87 years, where it was found that the lung condition had almost entirely cleared up, death being due to the advanced myocarditis.

GROUP 3

This group, containing 28 cases, was intermediate in frequency between the two previous ones and had a mortality of 14% - roughly the same as Group 1.

TABLE VII

Type	Sex	Number affected	Ages	Deaths
I	M	2	5 and 51	-
	F	-	-	-
II	M	10	8 - 74	3 (49 yrs (53 " (74 "
	F	6	4½ - 50	-
IIA	M	-	-	-
	F	2	18 and 27	-
III	M	3	4 - 35	1, 35 yrs
	F	2	4 and 39	-
IV	M	1	7	-
	F	2	34 and 49	-

The onset and physical signs, together with the sputum, were typical of lobar pneumonia, the only differentiation being the termination by lysis instead of by crisis. It is obvious that this difference in defervescence cannot be explained by the type of organism present, as, alike with the other two groups, every type was found. Nor can it be explained on the ground of the age or sex of the patient, the former varying widely (Table VII).

The following case may be taken as typical of this group.

I. W.W. Male. 47 years. Blacksmith

Admitted 4.5 p.m. 9th April 1923 on his fifth day of illness.

Pulse - 116; Temp - 102·4°; Respir. - 32

HISTORY of ONSET - Patient took ill on the 5th April with shivering and general pains. Was sick and vomiting the same day and had a cough and spit the following day. At times he was delirious.

PHYSICAL EXAMINATION

10.4.23 Patient well nourished.

Appears sharply ill.

Colour - flushed.

Pulse - rapid and rather soft.

Respirations - rapid and laboured.

Tongue - heavily coated and herpes present round mouth.

Heart - borders normal. Sounds rapid but pure. Second pulmonic sound accentuated.

Lungs - Anteriorly - clear to percussion and auscultation. Posteriorly - definite impairment to percussion over left lower lobe. V.F. and V.R. both increased and R.M. is markedly tubular. There is friction rub outwards towards the axilla.

Cough - short and hard with rusty tenacious spit.

Pulse - 108. Temp. - 101°. Respir. - 28

Microscopic examination of spit -

1. No T.B. found.
2. Numerous pneumococci.
3. Fairly numerous Gram - ve rods in pairs.
4. Large round Gram - ve cocci.

The pneumococcus belonged to Type II.

12.4.23 Patient still sharply ill.

Pulse quality improved and

Respirations easier

Pulse - 108. Temp. - 99°. Respir - 28

14.4.23 Condition much improved

Temperature has come down by lysis.

Colour and pulse both good.

Respirations normal in rate and easy.

Slight cough still present with scanty mucoid spit.

Lungs - left lower lobe full of very fine crepitant râles, otherwise clear.

Pulse - 88. Temp. - 97·6°. Respir. - 22

28.4.23 No abnormality made out on physical examination.

No cough and no spit present.

Dismissed to-day - well.

The three patients with the Type IV organisms were again only very mildly ill. Of the four deaths, (Table VII), all were directly due to the lung condition. Both the middle and lower lobes of the right lung were affected in the male patient of 49 years, as verified at the post mortem examination. In the patient of 74 years both the upper and lower lobes of the right lung were affected, this also being corroborated at the post mortem examination. An examination was not granted in the other two patients; they both died on the tenth day of illness after the temperature had gradually come down, and the physical signs at the time were those of massive consolidation of the lower lobe of the right and left lung respectively.

GROUP 4

Only five cases occurred in this group, and of

these none was fatal. As will be seen by the following table (VIII) the ages varied from 2½ years to 70 years, and again there appears to be no relation to the type of pneumococcus present.

TABLE VIII

Type	Sex	Number Affected	Ages	Deaths
I	M F	- -	- -	- -
II	M F	2 -	24 and 58 -	- -
IIA	M F	- -	- -	- -
III	M F	1 1	48 70	- -
IV	M F	1 -	2½ -	- -

The secondary rise was in all cases accompanied by a degree of delayed resolution in the lobe of the lung originally affected. The male patient aged 48, with the Type III pneumococcus, was examined and X-rayed at intervals of three or four weeks, and it was found that the consolidation gradually cleared away. He had a slight cough with purulent spit for a month after his temperature finally settled but no evidence of tuberculosis could be obtained. When last seen - in the second week of July, four months after the commencement of his illness - no abnormality

could be made out either by physical examination or by X-rays.

The following is a short account of his entire illness, one which is typical of this group as a whole.

J.W. Male. 48 years. Labourer

Admitted 4.5p.m. 3rd March 1923 on his third day of illness.

Pulse - 128. Temp. - 103°. Respir. - 36.

HISTORY of ONSET - Patient complained of shivering and pain in the left side on 1st March. Since then he has had a troublesome cough with a dark spit.

PHYSICAL EXAMINATION

4.3.23 Patient fairly well nourished but is

Sharply ill.

Colour - pale

Pulse - rapid but quality fairly good.

Respirations - increased but easy.

Tongue - heavily coated: moist.

Heart - left border at nipple line; others normal. Sounds very soft but pure.

Lungs - Anterior: clear to percussion but emphysematous.
Posterior: back rounded. Emphysematous. Also dullness present over right base with increased V.R. and V.F. R.M. markedly tubular. There are a few fine crepitations in left base but no dullness to percussion.

Cough - short and dry with small amount of rusty, tenacious sputum.

Pulse - 128. Temp. - 102·2°. Respir. - 36

Microscopic examination of spit -

1. No T.B. found.
2. Very numerous pneumococci.
3. A few Gram -ve rods.
4. Occasional short streptococci.

10.3.23. Condition much improved.

Had crisis during the night.

Colour and pulse both good and

Respirations easy.

Pulse - 92. Temp. - 97·6°. Respir. - 28

16.3.23. Temperature elevated last night and is still 102°.

Patient complains of pain in right side.

Respirations increased to 30.

Heart - as above.

Lungs - left base still has very fine crepitations and right lobe is still relatively dull to percussion.

Spleen - very slightly enlarged.

Spit - re-examined but no T.B. found.

21.3.23 Temperature settled to-day for first time since above note.

Respirations - still slightly increased, 28.

Colour - pale.

Pulse - 92 and quality good.

27.3.23 Right lower lobe still dull to percussion and R.M. slightly tubular.

Left base normal.

Spleen - normal.

Short cough with purulent spit which again shows no T.B.

Pulse - 84. Temp. - 98·2°. Respir. - 24

29.3.23 X-ray report:-

"Right lung - there is a marked opacity at the base, due possibly to fluid.

Left lung - no abnormality."

Right lung explored in three places but no fluid found.

Temperature - still subnormal.

5.4.23 Condition unchanged.

Still short cough, with purulent spit.

19.4.23 Condition improving slowly.

X-ray report:-

"Right lung - there is an interlobar pleuritic thickening and increased detail from the fourth costal cartilage downwards. This looks like a post-pneumonic condition and will probably clear away.

Left lung - no abnormality."

Sputum - negative for T.B.

23.4.23 Dismissed to-day - improved.

To return for re-examination.

29.5.23 No abnormality on physical examination.

Slight cough but no spit.

X-ray report:-

"Right lung - there is a slight interlobar pleuritic thickening. Otherwise the lung is normal.

Left lung - no abnormality."

2.6.23 No abnormality either on physical or X-ray examination.

No cough or spit.

14.7.23 Patient in good health and lungs appear normal.

The female patient of 70 years had an illness of almost the same type, the temperature swinging for two or three weeks after the original crisis; a very definite delay of lung resolution being present. The sputum in this case also remained purulent for about a month but finally cleared up with the physical signs, no evidence of tuberculosis being obtained. On dismissal in her sixth week no abnormality could be found, and the patient appeared to be in her usual health. Practically the same history was present in the case of the two male patients with the Type II organism. The man of 58 years

was examined regularly during the two months following his illness, and finally all signs and symptoms of a lung condition disappeared. It was found impossible to follow up the other patient of 24 years after his dismissal on the fourth week of illness, but at that time there was only the merest trace left of the original damage to the lung. The child of $2\frac{1}{2}$ years was very mildly ill, the secondary rise of temperature being only accompanied by a slight cough and occasional râle present over the original consolidation.

From the foregoing it may again be said that this special group of pneumonias associated with delayed resolution does not arise from infection with a special type of organism nor does it depend on the age or sex of the individual.

GROUP 5

In this group of seven patients there was only one adult but the illness ran the same course as with the children. In every case the onset was acute resembling that of lobar pneumonia. The temperature in four instances came down to normal somewhere between the seventh and ninth days, and for a few days the patient appeared comfortable. The lung symptoms subsided as regards dyspnoea, cough and spit, though a slight degree of dullness persisted over the affected area. This was

then followed by an increase of the dullness both in area and in quality and also by a swinging temperature. In the other three cases the temperature did not show an initial drop, but changed to a swinging character with the development of increased dullness and the typical signs of the presence of an effusion.

As typical of this group the following case may be quoted:-

D.J. Male. 3 years.

Admitted 3.30 p.m. 7th May 1923 on the fourth day of illness.

Pulse - 130. Temp. - 101°. Respir. - 40

HISTORY of ONSET. Child was sick and vomiting on 3rd May and developed a troublesome cough. His left side seemed to be sore.

Physical Examination of Patient

8.5.23. Child rather poorly nourished and

Appears sharply ill.

Colour - flushed.

Tongue - lightly coated.

Throat - clean.

Pulse - rapid but quality good.

Respirations - increased but easy. Slight blush over chest probably resulting from a poultice applied before admission.

Stools - normal

Heart - nil.

Lungs - Anteriorly - left upper lobe dull to percussion and R.M. markedly tubular. Rest of lungs clear.
Posteriorly - left upper lobe dull to percussion and R.M. tubular. V.F. and V.R. both increased over that area. No adventitious sounds.

Slight cough present but no spit obtainable.

Pulse - 140. Temp. - 100·4°. Respir. - 40.

10.5.23 Temperature came down by crisis last night and child appears comfortable.

Pulse improved.

Pulse - 110. Temp. - 98·4°. Respir. - 28

13.5.23 Temperature elevated last night.

Right ear painful and discharging.

14.5.23 Temperature swinging between 98° and 100°.

Lungs - left base very dull to percussion and dull area increased. R.M. absent. Explored and 2-oz creamy. pus withdrawn. Pus on microscopic examination showed numerous pneumococci which were found to belong to Type I.

15.5.23 6-oz very thick pus withdrawn by aspiration. Needle blocked several times.

Temperature swinging and

Pulse quality only fair.

17.5.23 Incision made into left pleural cavity under chloroform and copious thick pus evacuated with numerous clots of pus of liver-like consistence.

Drainage tube inserted.

21.5.23 Wound discharging freely.

Tube taken out to-day.

Temperature settled.

Pulse quality good and

Respiration normal.

16.6.23 Very slight discharge from wound.

Surrounding lung resonant.

Child's general condition improving steadily.

3.7.23 Child up and running about.

Wound healed well and

Lung below appears to be normal.

To confirm the diagnosis of an empyema in every case, an initial exploration of the chest was always made, and the pus so obtained examined microscopically. The pneumococcus was found without exception and a small quantity of the pus was then inoculated into a white mouse, typing of the organism being carried out on the peritoneal exudate, as already described. It was found in six of the cases that the same type of pneumococcus

was present as had been found in the sputum; the seventh patient, the child of 3 years, had only a severe cough on the day of admission and no sputum was obtainable. After several aspirations it was found necessary in each of the seven cases to open and drain the pleural cavity, convalescence then proceeding uninterruptedly.

TABLE IX

Type	Sex	Numbers affected	Ages	Deaths
I	M F	4 1	3 - 19 6	- -
II	M F	0 2	- $2\frac{1}{2}$ and 11	- -
IIA	M	-	-	-
III & IV	F	-	-	-

In the case of the female child of $2\frac{1}{2}$ years with the Type II pneumococcus, a deep seated abscess occurred in the left thigh in her fifth week of illness when the wound in the chest had almost ceased discharging. The pus from the chest, as in the other six cases, had given a pure growth of pneumococci, but the pus from the abscess proved to contain both pneumococci and streptococci, the former in much greater numbers. These on being typed were also found to belong to Type II. The

abscess was incised but the wound continued to discharge for fourteen days with no sign of abatement, and an X-ray plate taken at this stage showed that there was definite disease in the lower third of the femur. The pus examined again now contained non-bile-soluble streptococci in very large numbers; no pneumococci seemed to be present. A further operation was performed and drainage tubes inserted after which healing gradually took place.

Five of these seven cases, as will be seen from Table IX, arose from Type I pneumococcus, the other two from Type II, Types III and IV not appearing at all. Even though the number contained in this group is comparatively small it would seem a reasonable conclusion to draw, (including the case of peritonitis already mentioned) that Type I pneumococcus is much more liable to produce pus than any of the others.

Reviewing and grouping all the above clinical types as a whole as in the following table (X), it will be obvious that while lobar pneumonia was the most common form present in the series under discussion, broncho-pneumonia had by far the greatest group-percentage mortality. It also shows at a glance that any of the various forms may arise indiscriminately from any type of organism, Type IV being the least virulent.

TABLE X

Type of Organism

Clinical Group	I	Fatal Cases	II	Fatal Cases	IIA	Fatal Cases	III	Fatal Cases	IV	Fatal Cases	Totals	% Deaths
1	17	4	18	1	2	-	9	1	1	-	47	12%
2	1	-	4	1	4	3	1	-	3	-	13	31%
3	2	-	16	3	2	-	5	1	3	-	28	14%
4	-	-	-	-	-	-	2	-	1	-	5	-
5	5	-	-	-	-	-	-	-	-	-	7	-

ASSOCIATED ORGANISMS

It was thought that it might be of interest to identify as far as possible the chief organisms present in the sputum as well as the pneumococcus. For this purpose a small piece of sputum was selected, washed several times in sterile normal saline and the centre teased out. Of this some was smeared over agar plates, both aerobic and anaerobic McLeod's capsules being used for the latter, and a small amount was also injected intraperitoneally into a mouse. The mouse, as usual, was killed on showing severe symptoms, and aerobic and anaerobic agar plates were inoculated with the material both from the

peritoneum and from the heart's blood. All five sputa were examined in this manner and the following organisms were obtained.

DIRECT INOCULATION of the SPUTUM

A. Aerobically

(1) Fairly large circular colonies of yellowish colour and smooth surface. When smears, Gram stained, were examined they were found to consist of Gram +ve cocci irregularly arranged. A gelatin tube inoculated with a loopful of the organism showed marked liquefaction. It was evident that this was the staphylococcus pyogenes aureus.

(2) Small, round almost clear, discrete colonies, which on microscopic examination proved to be Gram + ve streptococci. Of these, two types were identified. Both showed a clear zone of haemolysis on a blood-smeared agar plate. The first, and rather smaller, colonies did not ferment lactose but fermented mannite and salicin and so were proved to be streptococcus haemolyticus II. The other and larger clear colonies, fermented lactose and salicin but not mannite and so were evidently the streptococcus pyogenes. The sugar media used throughout the series consisted of 1% of the sugar in peptone water, and the test was carried out with Durham's fermentation tubes.

(3) Large moist creamy, somewhat sticky colonies consisting of Gram - ve non-motile rods. Litmus milk inoculated with a loopful showed lilac colouration. It produced gas in glucose medium but not in lactose medium. No capsule could be made out but in all probability this organism was Friedlander's bacillus, and the same as a capsulated one mentioned later among the organisms recovered from the heart's blood of the inoculated mouse.

B. Anaerobically

The colonies cultivated anaerobically were found to be identical with the foregoing though the streptococcal

colonies were very scant.

INOCULATIONS from PERITONEAL FLUID

A. Aerobically

(1) The greatest number of colonies were of dew-like appearance, small and discrete, consisting of Gram + ve lanceolate organisms either diplococcal or in short chains. When inoculated into sterile ox bile they were found to be bile soluble, and so proved to be the pneumococcus.

(2) Other colonies which proved to be identical with those grown from the sputum direct were the staphylococcus pyogenes aureus, streptococcus pyogenes, streptococcus haemolyticus II and the bacillus of pneumonia.

(3) In addition, in one case only out of the five, there appeared greyish colonies with a rather irregular outline consisting of Gram - ve flattened diplococci, which on subculture grew at room temperature though not so luxuriantly as in the incubator at 37°C. As it did not produce acid in glucose, maltose or saccharose it was identified as the micrococcus catarrhalis.

(4) In one other case, in which a slide prepared from the sputum showed Gram + ve micrococci growing in fours, a few moist, whitish colonies were obtained. These on examination were found to consist of Gram + ve encapsulated cocci growing in fours, which did not liquefy gelatin and were therefore most probably the micrococcus tetragenus. This organism was also found associated with the pneumococcus in the heart's blood in this one case. The patient from whom the sputum was obtained, died from double lobar pneumonia.

B. Anaerobically - only the staphylococci, streptococci and pneumobacilli were found.

INOCULATIONS FROM THE HEART'S BLOOD

A. Aerobically

In all five cases the pneumococcus was grown and

identified but in two of the five an additional organism was present.

The first of these proved to be the micrococcus tetragenus already mentioned as occurring in the one case, and the other showed very small discrete, whitish, round colonies, occurring in fair numbers though not nearly so luxuriant as the pneumococci. When smeared and stained with Gram they were seen to consist of very tiny Gram - ve cocci somewhat resembling the influenzal group of organisms but decidedly coccal in form.

B Anaerobically

The only organism found was this last mentioned Gram - ve coccus, and that only in the one case. It was not noticed in the direct smear of the sputum probably on account of the smallness of its size, which would make it extremely difficult to identify unless present in fair numbers. Nor was it got in the cultures from the peritoneal fluid, as possibly the other organisms present in the material smeared on the agar may have outgrown it. However, throughout the whole series of a hundred cases this organism was found on several occasions growing along with the pneumococcus on the agar tubes inoculated with the heart's blood. The sputum in each instance was obtained from a patient with a very acute illness, and it would seem as though this organism had some connection with the severity of the pneumonia. Further work, however, would have to be done in order to identify it.

CONCLUSIONS -

It must always be remembered in drawing any conclusions that we are dealing only with the patients admitted to hospital, and not with the total number of persons affected in a district. Their removal or non-removal, may have depended on many things but still, considering the class of patient, it is probable that the series examined is a very fair sample of what was

occurring all over the town. Therefore, from consideration of all the foregoing evidence it seems reasonable that the following conclusions may be drawn.

I. Type II pneumococcus predominated in the city during the months specified (see Table II) but all the types occurred alike in the various districts irrespective of the age and sex of the individual with the possible exception that children seem to be more liable to infection with Type III than adults (see Table III).

II. In this particular series the greater incidence of Type III infection among children is not due to the greater frequency of bronchopneumonia, only one case of bronchopneumonia arising from Type III, and that in an adult (see Table VI).

III. Types I and II were of equal virulence with a percentage mortality of sixteen, while Type IV was the most benign. (see Table IV and page 10).

IV. Even knowing the type of pneumococcus present, no prognosis can be made as regards the course and termination of the illness individually, with the possible exception of Type IV, which consistently gave rise to a very mild type of pneumonia (see Tables V - IX).

V. Pus formation mainly resulted from infection with the Type I organism.

VI. Typical lobar pneumonia had the greatest incidence but broncho-pneumonia was by far the most fatal form. There was, however, a dearth of baby

pneumonias in this series, otherwise the incidence of bronchopneumonia would have been greatly increased and the percentage mortality would probably have remained as high.

VII. Complications of pneumonia, such as empyema, peritonitis and abscess formation arose from the same type of pneumococcus as caused the original disease.

VIII. The most frequently associated organisms were the staphylococcus pyogenes aureus, streptococcus pyogenes and haemolyticus II, the pneumobacillus, the micrococcus catarrhalis and tetragenus.

IX. A very small Gram - ^{ve} coccus present in several sputa seemed to have some definite relation to the severity of the illness.

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