THE UNIVERSITY OF MINNESOTA

GRADUATE SCHOOL

Report

of

Committee on Thesis

The undersigned, acting as a Committee of the Graduate School, have read the accompanying thesis submitted by **Gustave Joseph Noback** for the degree of **Master of Arts.** They approve it as a thesis meeting the requirements of the Graduate School of the University of Minnesota, and recommend that it be accepted in partial fulfillment of the requirements for the degree of **Master of Arts.**

P.E. Scammon
Chairman

C.M. Jackson

E.T. Bell.

A.T. Rasmussen

E.C. Rosenow
(by P.E. Scammon)

F.C. Mann

Dec 13 1920

THE UNIVERSITY OF MINNESOTA

GRADUATE SCHOOL

Report

of

Committee on Examination

This is to certify that we the undersigned, as a committee of the Graduate School, have given **Gustave Joseph Noback** final oral examination for the degree of Master of **Arts** . We recommend that the degree of Master of **Arts** be conferred upon the candidate.

Minneapolis, Minnesota

Dec. 13 1920

P. E. Scammon

Chairman

E. T. Bell

C. M. Jackson

J. P. Pierson

A. T. Rasmussen

On the Developmental Topography of the Thymus in the Human Fetus and Newborn

A thesis presented to the Faculty of the Graduate School of the University of Minnesota in partial fulfillment of the requirements for the Degree of Master of Arts

By

Gustave Joseph Noback

December

1920

On the Developmental Topography of the Thymus in the Human Fetus and Newborn.

Gustave J. Noback.

Contents

Introduction.

During prenatal life and the period of the newborn the thymus gland undergoes a number of alterations in form and relations. It is the purpose of the present paper to outline these changes with particular reference to the form of this organ in later fetal life and the modifications which it undergoes with the establishment of respiration.

Material

The material used in this study consisted of a series of fetuses and newborn children ranging in length from 100 to 550 mm. in crown-heel or total length. Four of these cases were observed at autopsy, the others form a part of the collection of the Institute of Anatomy of the University of Minnesota. The specimens, 62 in number, consisted of 45 stillborn infants and 17 children in which respiration had been at least partially established. Forty-seven were preserved by intra-vascular injection of an aqueous solution of formalin and chromic acid, one was a serially sectioned specimen, and four were observed at autopsy. Two individual thymi and one anterior dissection were in the material used in the course in fetal anatomy.

Methods

Following the suggestion of Hammar (09) that only thymi obtained from healthy individuals should be used in the study of this organ, no material was employed in which ~~showed~~ pathological conditions were macroscopically observable.

The dissection of the first 42 cases in the series was made in the following manner: The skin, subcutaneous tissues, muscles, etc., were reflected from the anterior thoracic wall and the cervical region as far superiorly as the inferior border of the mandible. Next, the sterno-cleido-mastoid and infra-hyoid muscles were removed and that part of the thymus extending above the sternal notch was measured with dividers. The ribs and clavicle were then cut at the anterior axillary lines, elevated, and separated from their connections with the underlying structures. In this manner the larynx, thyroid gland, thymus, pericardium, lungs, and larger vessels, etc., of the mediastinal and cervical regions were exposed.

All measurements of these various structures as shown on the drawings were made with fine pointed dividers and were plotted on ruled paper in the form of an outline drawing. These drawings are shown in figures 28 to 63 inclusive. At this point finished drawings, figures 1 to 8 inclusive, were made; the remaining drawings of anterior dissections were made by the writer. Figures 9 to 14 inclusive were drawn by the writer from his plottings of the anterior dissections which were made by the use of the graphic reconstruction apparatus designed by Professor Scammon.

Cases 43 to 58 inclusive, excepting number 56, were cross-sections. These were made by sectioning the specimens free-hand with a heavy sharp knife. Figures 15 to 21 inclusive, excepting

number 19, were selected from these sections and finished drawings were made of them. Number 56 of the series was H 456 of the collection of this Department and figure 19 was made from it with the projection microscope.

Cases number 59 to 62 inclusive, being autopsies, did not afford ideal conditions for this work. However, measurements were made with the dividers while the organs were in situ and the thymi carefully removed and placed on cotton wads in hardening fluid. The form was thus preserved, and the thymi then drawn to standard size. These drawings are shown as figures 95 to 100 inclusive.

As soon as the individual drawings were made the following further observations and measurements were made:

(a) The TYPE of thymus, i.e. location, - whether completely in the thorax or partly in the thorax and extending into the cervical region.(1)

(b) The LOBULATION of the thymus, i.e. number of lobes observable macroscopically.(1)

(c) The OVERLAPPING of the thymus on the RIGHT VENTRICLE, i.e. to what extent, if any, the right or left portions of the thymus extended over the right ventricle.

(d) The OVERLAPPING of the thymus by the LUNGS, i.e. to what extent, if any, either or both lungs overlapped the anterior aspect of the thymus.

(e) The FORM of the THYMUS, i.e. whether the configuration of the thymus was broad or elongated.

A 'broad' thymus was defined as one whose transverse diameter was equal to or greater than ~~their~~ its cranio-caudal diameter, and an 'elongate' thymus as one whose cranio-caudal diameter was greater than its transverse diameter.

(1) The first two classifications were determined by the criteria suggested by Coplin ('15).

A few thymi, because of their great lateral extension inferiorly, were classified as 'broad' even though their cranio-caudal diameters were a little greater than their transverse (due to the presence of slender cervical processes of some length).

(f) CONDITION OF THE LUNGS in relation to respiration.

The decision of whether or not an individual had breathed was based on the floating test (doximacia pulmonis) as well as a careful examination of the lobules and the appearance of the anterior border of the lungs with the hand lens. Lungs in which breathing has occurred show distinct characteristics when compared with those of the fetus or stillborn. The anterior borders and antero-inferior angles of the former have lost their sharp outlines and become rounded. The lobules on the surface are larger, more distinct and of higher color. On section, the lungs in which respiration has begun appear spongy, and upon pressure they emit a frothy fluid containing numerous fine air bubbles. The latter phenomenon is noted in material which has been preserved for months as well as in fresh specimens. The extent and order of expansion parts of the lungs followed the observations of Champneys ('81) excepting that he found that the anterior-inferior borders are often unexpanded.

After all the observations had been made in the individual cases, the data was brought together in tabular form as shown in table 1. Since the series is arranged according to crown-heel length of the cases, one may quickly discern the changes occurring in any type of observation in relation to the increase in body length and consequent age. Furthermore, the relation of the establishment of respiration to the various characters observed may

quickly be noted by following the column allotted to the record of whether or not the individual had breathed.

Analysis of material.

Table 1 is a tabulation of the data obtained from the writer's material and the following summary of the several observations is made from it.

THE TYPE OF THYMUS, - The predominating type is the Cervico-thoracic, i.e. 51 cases of 82.2 per cent. The Thoracic type is represented by 11 cases or 17.8 per cent.

THE LOBULATION OF THE THYMUS, - The Bilobed Type predominates with a total of 39 cases or 62.9 per cent. The Conglomerate, Trilobed, and Unilobed are respectively next in frequency with the following numbers and percentages: Conglomerate, 10 cases or 16.1 per cent; Trilobed, 7 cases or 11.1 per cent; Unilobed, 6 cases or 9.9 per cent.

THE THYMUS OVERLAPPED BY RIGHT LUNG, - This is present in 20 cases or 32.2 per cent.

THE THYMUS OVERLAPPED BY LEFT LUNG, - This occurs in 18 cases or 29.0 per cent.

THE RIGHT PORTION OF THYMUS ON RIGHT VENTRICLE, - This is present in 10 cases or 16.1 per cent.

THE LEFT PORTION OF THYMUS ON RIGHT VENTRICLE, - This occurs in 17 cases or 27.3 per cent.

THE BROAD THYMUS is present in 41 cases or 66.2 per cent.

THE ELONGATED THYMUS is present in 21 cases or 33.8 per cent.

The above figures are for the entire series, ~~i.e.~~ including the individuals that have not breathed as well as those which have breathed, and are recorded without regard to body size.

If the individuals that have not breathed are considered as a separate group (see table II), we find that the following numbers and percentages prevail in each of the series of observations made.

The TYPE OF THYMUS, The predominant type, here ~~is~~ the same as in the entire series, ~~i.e.~~ is Cervico-thoracic, with a total of 36 cases or 80 per cent. There are but 9 thoracic thymi or 20 per cent. These figures are very similar to those obtained in the group of those individuals which have breathed.

The LOBULATION. The Bilobed type also prevails in this group. There are 26 of these, or 57.8 per cent. The Conglomerate type rank next, with 9 cases or 20.0 per cent; the Unilobar number 6 cases or 13.4 per cent, and the Trilobed ~~are~~ is least numerous, having but 4 cases or 8.8 per cent.

The THYMUS OVERLAPPED BY RIGHT LUNG occurs in this group in but 3 cases or 6.6 per cent.

The THYMUS OVERLAPPING LEFT LUNG occurs in only 2 cases or 4.4 per cent.

These figures indicate that in the non-breathing individuals there is practically no overlapping of the thymus by the lungs.

The RIGHT PORTION OF THYMUS EXTENDING ON RIGHT VENTRICLE, There is not even one case of this kind in the non-breathing individuals.

The LEFT PORTION OF THYMUS EXTENDING ON RIGHT VENTRICLE, occurs in but 2 cases or 4.4 per cent.

In non-breathers the thymus practically does not extend at all on the right ventricle.

THE FORM OF THE THYMUS, the broad type of thymus predominates in this group with a total of 37 or 82.3 per cent. The elongated type occurs only in 8 cases or 17.7 per cent. From these figures it is deduced that the broad type of thymus is typical of individuals that have not breathed.

Table 3 is a summary of the several observations on the non-breathing individuals arranged in two groups on the basis of total body-length. The first group includes all cases having a total length between 10 and 30 cm. There are 21 cases in this series having an average length of 213.3 mm. The second group includes all cases of 30 cm. and over. There are 24 cases in this group with an average length of 39.2 cm. In each of these groups the same general conclusion regarding the lobulation of the thymus is reached, i.e. the bilobed type predominates as it does in the entire series of non-breathing individuals. The thoracic thymus is slightly more frequent in the second group and this may probably be interpreted as representing a stage in the migration of the thymus from its embryonic location in the cervical region to its final position in the thorax in postnatal life.(1)

There is no overlapping of the thymus by the lungs in the first group but in the second group we find a few instances of slight overlapping. This is probably due to the fact that in this group are included two cases which were suspected of having breathed very slightly. The thymus does not extend on the right ventricle on either side in any case in the first group. There are a few cases of this in the second group but the same comment as is made in the overlapping by the lungs applies also to this group. However, there are two cases of actual extension of the thymus on the left side.

There is quite a difference in the form of the thymus in the two groups. Less than two-thirds of the cases in the first group are of the broad type whereas every case in the second group is broad. The probable explanation of this predominance of the broad

(1) Canelli (20) in a study of 116 cases of young children found the thoracic type in 86 cases or 74.7%.

type in later fetal life lies in the constant increase in the relative weight of this organ during fetal life, especially after the seventh fetal month. This fact is clearly brought out by the collected data on the weight of the fetal thymus recorded in this laboratory.

Upon taking out of the series the 17 individuals which have breathed, and classifying them in a separate group, several striking differences are noted, when these are compared with the entire series.

Table 2 contains a summation of the observations in this group. It shows the following:

THE TYPE OF THYMUS, The predominating type here is the same as in the entire series, i.e., Cervico-thoracic with a total of 14 or 82.3 per cent. The Thoracic type is present in but three cases or 17.7 per cent. These figures indicate that the Cervico-thoracic type is the predominating one regardless of whether or not breathing has occurred, i.e., that this type predominates in the fetus as well as in the newborn.

THE LOBULATION, The Bilobed type predominates with a total of 13 cases or 76.3 per cent. The Trilobed type is next in order with three cases or 17.7 per cent; the Unilobed type is represented by but one case or 6 per cent, and there are no Unilobar thymi in this group.

In this latter group, then, we find the same type of lobulation predominant as is found in the entire series. However, there are more of the Trilobar than the Conglomerate which is the reverse of what occurs in the entire series; there are no cases of Unilobar type in this group although there were several in the entire series. There seems to be no reason to believe that the lobulation of the thymus

is influenced by the establishment of respiration even though the frequency of the more unusual types of lobulation differs somewhat in the two groups.

These results in regard to lobulation agree in the main with the findings of most other observers in that the Bilobed type is generally described as being the most prevalent.

THE THYMUS OVERLAPPED BY RIGHT LUNG, This occurs in all members of this group, i.e. in 100 per cent of the cases. This shows a very marked difference over the figures for the entire series and indicates that the right lung overlaps the thymus only in individuals that have breathed.

THE THYMUS OVERLAPPED BY LEFT LUNG, occurs in 16 cases or 94.1 per cent of this group. This shows that practically all of the overlapping by the left lung occurs in individuals that have breathed, in fact it occurs in the non-breathing individuals in but two cases.

THE RIGHT PORTION OF THYMUS EXTENDING ON RIGHT VENTRICLE, occurs in 10 cases or 58.8 per cent of this group. The entire series shows but 17.4 per cent, therefore this extension over the ventricle on the right side is much more frequent in the individuals which have breathed.

THE LEFT PORTION OF THYMUS EXTENDING ON RIGHT VENTRICLE, occurs in 15 cases of this group or 88.3 per cent. The entire series shows but 27.3 per cent; therefore this extension over the ventricle on the right side ~~indicates that it~~ is markedly more prevalent in the individuals in which respiration is established.

THE FORM OF THYMUS, the Broad type in this group occurs in 4 cases or 23.6 per cent, whereas the Elongated type occurs in 13 cases or 76.4 per cent. These figures indicate clearly that the

Elongated type is distinctly characteristic of individuals that have breathed.

Several thymi which were removed from individuals that had breathed were drawn to standard size; these are shown as figures 22 to 27 inclusive. All in this group are from the individuals of which anterior dissections were drawn excepting Figs. 24 and 26 which were obtained from the material used in the course in 'Anatomy of the Newborn' given in this Department.

This series of drawings shows various degrees of moulding of the thymus which correspond with the extent of expansion and compression by the lungs. The change in form from the broad fetal or stillborn type to the markedly moulded elongated type found in the individuals that have breathed is readily seen in this group. Most of them show a grooving at the level of the sternal notch thus indicating that the pressure at this point must have been very marked.

The thymi obtained at autopsies are illustrated by artist's drawings, figures 95 to 100 inclusive. Fig. 95 of No. 60, a full-term stillborn infant shows very clearly the very broad type. The lungs did not extend on the anterior surface of the gland nor did it show evidence of moulding. The writer believes that this thymus is typical of the full-term fetus and that it is not the type found in individuals which have breathed. Hammar's cross-section of 'Newborn infants' are of individuals with thymi of this type.

Fig. 97 is a drawing of No. 59 (body found in river). This was a premature child which had breathed. The lungs on both sides overlapped the thymus and it shows definite moulding on both sides.

By comparing this thymus with the series of anterior dissections and with the series of individual thymi, it is seen that it is very much like the thymus in Fig. 4 and Fig. 23. The latter two figures are of individual No.31 which had breathed.

Fig. 98 is a drawing of No. 61, a premature whose abortion was induced by overactivity on the part of the mother, and which had lived for a little more than twelve hours. The lungs overlapped the thymus on both sides, distinctly moulding the organ so that it presents lateral depressions. On the left side the thymus extended slightly on the ventricle. It resembles closely No. 31 of the writer's series as may be seen by comparing it with figures 4 and 23.

Fig. 99, a drawing of No. 62 of the writer's series (diabetic mother; Caesarian section) which was made of the thymus of an infant that had lived 26 hours. This thymus was overlapped on both sides by the lungs and it extended on the ventricle on the right side. Its lateral surfaces show marked moulding by the lungs. This thymus is very similar to that of No. 29, as may be seen by comparison with figures 5 and 25.

Figure 100 is of the thymus of a 14 month old girl (Acute Enteritis). This thymus was of the distinctly elongated type, with sides convexly moulded where the lungs had overlapped it. This thymus corresponded to those usually described for young children--in fact, it is very similar to the Spaltehols picture of a 12 year old boy as shown in figure 91.

The thymi observed at autopsy taken as a group seem to indicate that the moulding and change in relations of thymi as shown in the writer's series of cadaver cases takes place very early in life,- in fact, probably during the neo-natal period.

The relation of the thymus to the anterior skeletal wall in the late fetal stage and in the newborn may be seen in figures 9 to 14 inclusive. These are graphic reconstructions of numbers 39, 40, 31, 34, and 41 of the writer's series. These individuals are also shown in drawings, figures 2, 3, 4, 6, 7 and 8.

From a study of these cases, as well as others not figured, the writer is led to the conclusion that the degree of expansion of the lungs influences the extent of the thymus lateral to the borders of the sternum and also the extent of the thymus inferiorly. In the late fetus and stillborn the thymus extends as far laterally as the anterior axillary line. In cases of slight breathing it was noted that it was the right lung which had made the greater advance toward the median line and that the thymus on this side was less extensive than on the ~~right~~ left. The inferior limits of the thymus in stillborn individuals was in most cases at the upper border of the fourth costal cartilage with but a few as low as the upper border of the fifth costal cartilage. In the individuals which had breathed, the lateral extent was very slight, and occasionally not at all on one side. The inferior limit of the thymus in these cases was as a rule somewhat lower; a few were at the level of the upper border of the fourth costal cartilage, but those whose lungs were well expanded were as far down as the upper border of the sixth costal cartilage.

The posterior relations of the thymus are in a measure determined by its extent. A cervico-thoracic thymus may extend far into the neck and meet the inferior border of the thyroid gland as in the case of numbers 34 and 40, in which the thymus after coming into contact with the inferior border of the thyroid glands turned anteriorly and laterally. On the other hand, it may extend

inferiorly to such an extent that it will lie on the right ventricle. All of the thymi in the latter part of fetal life and in the newborn are related posteriorly with the pericardium over the base of the heart and the great vessels. On the right side they may extend to the right vagus nerve, as was true in one of the writer's cases. The left innominate vein in several cases was almost completely embedded in the posterior aspect of the thymus, - this also being true, in a few cases, of the superior vena cava. In the late fetus and in the newborn, the innominate artery is closely applied to, and crosses the anterior surface of the trachea; the left innominate vein is anterior to this crossing and practically just behind the upper border of the manubrium sterni. In several of the writer's cases the thymus projected posteriorly, or sent processes posteriorly, so that the above named structures were markedly compressed. In these cases, the innominate artery was so compressed against the trachea that it left a definite furrow marking its course across this tube and greatly constricted it. In another, the oesophagus was in turn compressed by the trachea so that its right border was reduced to a knife edge while its left free border was rounded. In another similar case the oesophagus had a marked dilation on the right side just superior to the constriction.

In still another case the thymus posteriorly partially enveloped the arch of the aorta so that the transverse diameter of this vessel was only half of its anterior-posterior diameter.

Figures 92-93 were drawn from No. 27. This individual, according to the criteria used, had not breathed. The figures show the very distinct compression that occurred in this specimen.

There is a deep groove in the thymus in which the left innominate vein had fitted. The superior portion of the thymus extended posteriorly between the innominate artery and the left common carotid until it pressed against and constricted the trachea. A little lower, the thymus must have compressed the left innominate vein so that the artery in turn was flattened against the trachea at this level thus constricting it. The oesophagus in this region in cross-section would be somewhat triangular in outline with the sharp apex under cover of the trachea. Figure 93 shows the deep groove on the anterior wall of the trachea; it also indicates the relation of the tracheal bifurcation to the sternal notch in later fetal life and in the newborn, i.e. that it is almost at the level of the sternal notch.

The drawings of the cross-sections also are instructive from the point of view of posterior relations of the thymus.

Figure 15 shows a section through the lower cervical region above the sternal notch. The thymus is bilobed and on the left extends posteriorly as far as the anterior wall of the oesophagus. It is also slightly in contact with the left surface of the trachea.

Figure 16 is ~~through~~ at a lower level, i.e. through the manubrium sterni and above the aortic arch. It shows a broad thymus through which passed the left innominate vein as it joined its fellow forming the superior vena cava. The greater posterior extent of the thymus is on the left side and a tongue-like process extends as far backward as the posterior wall of the oesophagus. It is also in contact with the right side of the trachea and has evidently slightly compressed the innominate artery and the trachea.

Figure 17 (stillborn) shows a broad thymus with a marked

antero-posterior diameter. This section is at a level just above the tracheal bifurcation. The thymus on the left is seen to extend even posterior to the trachea though it is not in direct contact with it. On the right side, the anterior surface of the superior vena cava is in direct contact with the thymus and partially enveloped by it.

Figure 18 (stillborn) is at a still lower level, ~~i.e.~~ through the arch of the aorta. We have here the decidedly broad type of thymus which in this case extends posteriorly to a very great degree. It is seen between the arch of the aorta and the superior vena cava and to continue posteriorly. It bears a medial indentation in which the right third of the tracheal bifurcation is enveloped. The thymus continues posteriorly close to the mediastinal wall until level with the anterior surface of the oesophagus.

Figure 20 (stillborn) is also a section through the tracheal bifurcation but slightly lower than the preceding one. This is also from an individual that had not breathed and shows the distinctly broad thymus with the lungs not extending on its anterior surface. This thymus is noteworthy due to the posterior projection which is here shown as an isolated mass. This mass was continuous with the main part of the thymus at a higher level. At this level it is situated between the superior vena cava and the tracheal bifurcation.

Figure 21 is through the heart, and shows the overlapping of the right ventricle by the thymus on the left side and the overlapping of the right atrium on the right side. The left lung does not extend on the anterior surface of the thymus but the right lung does so slightly.

Figure 19 was made from the serial sectioned individual. It was a premature which, according to microscopic examination, had breathed. The expanded alveoli are most numerous and marked in anterior border of the right lung which in this region is expanded. The section is through arch of the aorta and beginning of the tracheal bifurcation. The thymus in this case evidently has already been slightly compressed since its lateral bulges have almost disappeared. The thymus was a cervico-thoracic one, It was bilobed and of the elongated type. It was partly overlapped by the right lung which in the figure may be seen to extend almost to the midline of the thorax. The thymus in this case extends posteriorly for quite a distance almost touching the anterior surface of the tracheal bifurcation and partially enveloping the superior vena cava.

The descriptions of the thymus of the infant in the text-books varies with the author. In general the outline of the thymus on the anterior chest wall is described as a triangular area with the base extending horizontally from one sterno-clavicular joint to the other. The sides extend inferio-medially from these joints to the level of the second, third or fourth rib, the latter limit varying with different authors. It is held that a thymus lying within the above limits is of normal size, and that, if the thymus extends lateral to the sides of the triangle, it is probably enlarged. This enlarged or hypertrophied thymus then is suspected of exerting pressure upon the structures posterior to it. The findings here presented indicate that in the neo-natal period, the degree of expansion of the lungs is a much more potent factor in determining the lateral extension of the thymus than is the actual size of the organ. In this connection the writer wishes to point out that at

least during the period of the newborn, a thymus lying within this normal area may exert pressure upon the structures posterior to it. In fact, this is ~~just what~~ was the condition in individual No. 41, of which figure 8 is a drawing. Figure 14 is a drawing of the graphic reconstruction of this case and figure 27 is the drawing of the thymus after removal. (See also figure 94 which shows the greater part of the thymus removed in another case). The writer believes as Warthin points out, that the antero-posterior extent is of necessity an important point in determining whether or not a thymus is enlarged.

Discussion.

An examination of the literature on the 'normal' form and relations of the thymus in the late fetal stages and in the new-born infant reveals an apparent lack of recognition of marked changes in form and relations of this organ at birth and in the neo-natal period.

The descriptions and figures presented in the various texts, atlases and clinical publications make no mention of these changes. This is true despite the fact that the literature contains figures of 'newborn thymi' which vary widely in size, form and relations.

Applying the same criteria to the thymi in the literature as was used for his own material, the writer is able to discern the same two general types, i.e. broad and elongated.

The illustrations and descriptions in the literature of thymi in individuals of one month and older are practically all of the elongated type. However, the writer has been able to find but one reference in the literature where any statement is made that might point to the markedly elongated form of thymus being connected with the establishment of respiration (Sappey '89).

Cooper ('32) in his discussion figures several stages of fetal thymi. His specimen of the ninth fetal month is distinctly broad.

Luschka ('63) describes the broad type as being typical of the newborn infant. He has an illustration of a cross-section of the chest of a newborn child which is here reproduced in outline in figure 64. This shows the very broad thymus and the child was no doubt stillborn.

Sappey ('89) is the only one that the writer has been able to find who states that the thymus in the infant which has not breathed is of a large size; thus suggesting the broad type; and

he ~~with~~ and Hammar are the only ~~ones~~ writers who mention a possible relation between the elongated thymus and respiration. Sappey says: "Chez l'enfant qui n'a pas respiré, elle est en général plus large. Lorsque le respiration s'est établie, les poumons remontant sur cet organe et la comprimant de dehors en dedans, son extrémité inférieure devient plus étroite et assez semblable à une petite pyramide triangulaire." Thus he believes that the lungs in the establishment of respiration compress the thymus.

Mettenheimer ('94) points out that in the full-term stillborn child the lungs do not extend on the thymus and heart and that therefore these organs come in contact with the sternum anteriorly. This description certainly is of a broad thymus.

Gegenbaur ('96) presents a drawing of an anterior dissection of the thorax of a newborn infant. This drawing is reproduced in tracing in figure 65. It shows the uncompressed broad type of thymus. The lungs are distant from the midline and their anterior borders are sharp. This individual evidently was stillborn.

Chievitz ('99) describes a full-term fetus in situ. He has a drawing of the visceral mass as seen from before, which is here reproduced in outline as figure 67. This clearly shows the decidedly broad type of thymus which the writer describes as the late fetal type. The lungs do not extend on the anterior surface of the gland and it shows no moulding by them.

Zuckerkandl ('04) also shows a thymus of the distinctly broad type and with lungs that do not overlap the gland (see figure 68).

Sobotta ('08), in Bardeleben, illustrates a newborn child's thymus which is of the broad type.

Cunningham ('13) has an illustration of a full-time fetus which is here reproduced as figure 75. This is of the decidedly broad type with no overlapping by the lungs.

Quain ('14) reproduced in outline here as figure 78, shows the very broad thymus with no overlapping by the lungs.

Rauber-Kopsch ('11) here figure 79. This thymus is also of the very broad type and since it is shown isolated it is believed that it was not overlapped.

Hammar ('15) in discussing the thymus in the newborn describes it as a distinctly wide organ whose lateral surfaces are markedly convex and which bulge into the pleural cavities. He states that in the course of postfetal life the form of the thymus changes into a less wide and more lengthy form. With this change into a less wide and longer form there occurs a disappearance of the lateral bulgings of the thymus.

The following rather free translation of two of Hammar's paragraphs sums up his conclusions on the thymus in the newborn:

"I have not up to the present time examined enough material to be able to say at which time the relations of the thymus in the newborn are replaced by those prevailing in the older individuals. This is also true regarding the forces which effect this change. The remodelling of this organ into an elongated form, which does not bulge into the pleural cavities, probably takes place in some definite relation to breathing."

"It is clear that the herewith described newborn thymus form makes a decided invasion into the adjacent portions of the pleural cavities which would otherwise be more distended by the uncompressed lungs. The cross-sections presented show clearly the resistance which the thymus must offer to the complete expansion of the lungs.

In cases of thymus hypertrophy this resistance is obviously important but it is present even in thymi of normal size."

Figures 80, 81 and 82 are tracings of Hammar's illustrations. They clearly show the decidedly broad type, with the anterior borders of lungs sharp and not extending on the anterior surface of the thymus. He does not state whether or not these individuals breathed. From a comparison of his figures with the material the writer has studied, it would seem that his drawings traced in figures 80 and 81 would fit into the writer's series between case numbers 39 and 40. However, since the margins of the lungs in Hammar's figures are so sharp, and since there is no moulding of the thymus by the lungs, the writer concludes that these individuals must have been stillborn. This conclusion is strengthened on examination of Hammar's cross-section figures of a newborn which immediately follow. In these the thymus is extremely broad, its lateral surfaces bulge into the medial surfaces of the lungs which do not overlap the anterior face of the thymus in the slightest degree. His picture of the thymus shows it to be of the distinctly broad type.

Apparently the material Hammar used was stillborn.

Gray-Lewis ('20) presents a picture of full-time fetus which shows distinctly the broad type of thymus with no overlapping of the thymus by the lungs.

All of the foregoing broad type of thymi have corresponding cases in the writer's series. Since they are of the broad type, are not at all overlapped or moulded by the lungs, and have counterparts that have not breathed, the writer concludes that they are from stillborn individuals.

Poirier and Charpey ('01), figure 74, present a cross-section of the thorax of a newborn infant which has the elongated type of thymus with the right lung compressing it, and the left lung overlapping it.

Bardeleben ('14) presents a drawing of an anterior dissection of a fresh body of a normal fetus which is reproduced in figure 76. This drawing shows the distinctly elongated thymus with the lungs on its anterior surface,- in fact, the right lung has crossed the midline.

Morris-Jackson ('14) presents a picture of the thymus gland at birth. It is reproduced here in outline as figure 77. This thymus is somewhat elongated though the lungs do not distinctly overlap the organ. However, in the text it is stated that the thymus at birth is twice as long as wide.

The foregoing illustrations and descriptions from the literature clearly show the use of both broad and elongated types in descriptions of the thymus in the 'Newborn'. In some cases terms such as 'Fetus at Term', 'Full-term Fetus', etc., are used. In these latter named, the thymi illustrated or described are evidently from liveborn individuals.

These terms, to the writer, are confusing and it seems that the terms 'Stillborn' and 'Liveborn' would be more appropriate in describing organs in the 'Newborn' since it is evidently the living individual to which this information will be applied.

All of the above examples taken from the literature may, the writer believes, be classified according to the form of the thymus and its relation to the lungs. He believes that the first group, i.e. the 'broad type' are either from late fetal stages or from stillborn infants, and that the 'elongated type', i.e. second group,

are from individuals which were born alive and had breathed at least a short time.

The descriptions and pictures in the literature of thymi in children later than the neo-natal period, especially in early childhood, are all of the elongated type and show marked moulding by the lungs. Sappey ('89) illustrates an anterior dissection of the thorax of an infant six months old. It is reproduced in tracing as figure 84. The thymus is distinctly elongated and moulded. Joessel ('99) presents a dissection of the thorax of two and a half year old child. His figure is traced in figure 85. This thymus also is moulded and elongated.

Sobotta ('08) in Bardeleben, has a picture of the thymus of a two year old child. It is traced in figure 86 and is shown alone. Even though it is not in situ it is seen to be elongated and moulded. He also presents an anterior dissection of a fourteen year old girl which is here figure 87. This thymus is markedly elongated and moulded.

Piersol ('08) illustrates a cross-section of a child about one year old. The thymus as shown in figure 88 is overlapped by the right lung and thus moulded. This also is an elongated thymus; the writer, however, has seen corresponding thymi in much younger individuals.

Olivier ('11) presents a drawing of a dissection of a one month old infant's thorax, our figure 89. He states that it shows the normal type of thymus. It is a bilobed organ whose lobes are widely separated and relatively very small. It is similar to thymi which the writer finds in much older children. Since Olivier states that only two of his dissections were of infants, it seems probable that he had, in this case, the thymus of an infant in which

a marked involution of the thymus had taken place. Poirier and Charpey ('11) illustrate a dissection of the thorax of an infant two months old (see figure 90). This case shows distinctly the elongated, moulded thymus with the lungs overlapping and the thymus extending on the right ventricle.

Spalteholz ('20) presents the thymus of a boy twleve years old. His illustration is traced in figure 91 in which the thymus is seen to be elongated and so moulded that its lateral aspects are markedly convex.

Conclusions.

1. The lobation of the thymus is determined early in fetal life and the establishment of respiration obviously has no effect on it.

2. The thymus in the late fetus and in the newborn is predominantly of the cervico-thoracic type, i.e. its position is intermediate between the cervical location in the embryo and the thoracic location of the older infant, child and adolescent.

3. The thymus in the late fetus and stillborn child has a typical form and quite constant relations. Its lateral surfaces are convex and bulge against the medial surfaces of the lungs. The lungs very rarely extend at all on its anterior surface, and the thymus very rarely extends at all on the anterior surfaces of the right ventricle of the heart.

4. The thymus in liveborn infants has typical form and relations which are similar to those found in young children. It is elongated and moulded so that its anterior, lateral and posterior surfaces bear the impress of all the organs with which it is in contact. Its lateral surfaces usually show marked convexities which are occupied by the lungs which pass over the anterior surface of this organ. Unlike the fetal thymus, it usually extends more inferiorly passing over the right ventricle.

5. The change from the broad or fetal type of thymus to the elongated and moulded type found in the liveborn and in the young infant bears a direct relation to the establishment of respiration. The change in form and the moulding of the thymus seems to be the result of the expansion of the lungs. The organ is compressed from side to side by the medial surfaces of the expanding lungs. It is

compressed antero-posteriorly by the anterior borders of the lungs which become much thickened early in the establishment of respiration as they gradually overlap the thymus.

6. In some cases the thymic substance may extend posteriorly at birth to such an extent that the structures situated there are compressed by it. This may be due either to an unusually large thymus or to a very narrow superior thoracic aperture which will not allow the thymus to protrude into the cervical region.

7. The descriptions and illustrations in the literature of the thymus in the newborn child show great confusion. They include both the fetal (broad) and infantile (narrow or elongate) types and the distinction between the two has evidently passed unrecognized. The type of thymus which is the more frequently described as characteristic of the newborn and infant is the one which the preceding data indicate is usual for the fetus and stillborn as contrasted with the living infant.

Explanation of Tables.

Table No. 1. Tabulation of the several observations made on the entire series. Nos. 1 to 42 inclusive were dissections; Nos. 45 to 58 inclusive were transverse sections, and Nos. 59 to 62 were autopsies.

Table No. 2. Tabulation of the total number and the percentage of occurrence of these observations. These results are arranged in three columns, -1st, for the total series; 2nd, for the cases which have not breathed; and the 3rd, for the cases in which breathing had occurred.

Table No. 3. In this table the individuals which have not breathed are grouped into two classes. The first class includes all individuals up to 300 mm., and the second class all individuals above 300 mm. vs total body length?

Table 1.

Series Number	Standing Height in mm.	Sex	Type of Thymus	Lobulation of Thymus	Lungs overlap Thymus R.	Lungs overlap Thymus L.	Thymus extend on Ventricle R.	Thymus extend on Ventricle L.	Form of Thymus	Breathed
				DISSECTIONS						
1	100	F	C-T.	Cong.	-	-	-	-	B	-
2	119	M	C-T.	Bi.Lob.	-	-	-	-	E	-
3	123	F	Th.	Uni.L.	-	-	-	-	E	-
4	133	F	C-T.	Bi.Lob.	-	-	-	-	E	-
5	143	M	Th.	Cong.	-	-	-	-	B	-
6	186	F	C-T.	Uni.L.	-	-	-	-	E	-
7	200	F	C-T.	Bi.L.	-	-	-	-	E	-
8	220	F	C-T.	Bi.L.	-	-	-	-	B	-
9	223	F	C-T.	Bi.L.	-	-	-	-	B	-
10	223	M	C-T.	Tri.L.	-	-	-	-	E	-
11	224	F	C-T.	Bi.L.	-	-	-	-	B	-
12	226	M	C-T.	Cong.	-	-	-	-	B	-
13	234	F	C-T.	Cong.	-	-	-	-	B	-
14	235	M	Th.	Tri.L.	-	-	-	-	B	-
15	243	F	C-T.	Bi.L.	-	-	-	-	B	-
16	245	M	C-T.	Bi.L.	-	-	-	-	B	-
17	253	F	C-T.	Bi.L.	-	-	-	-	B	-
18	283	M	C-T.	Bi.L.	-	-	-	-	E	-
19	283	F	C-T.	Bi.L.	-	-	-	-	E	-
20	295	F	C-T.	Tri.L.	-	-	+	-	B	-
21	300	F	C-T.	Uni.L.	-	-	-	-	B	-
22	308	F	C-T.	Cong.	-	-	-	-	B	-
23	313	F	C-T.	Cong.	-	-	-	-	B	-
24	325	M	C-T.	Bi.L.	-	-	-	-	B	-
25	331	F	C-T.	Bi.L.	-	-	+	-	B	-
26	332	M	C-T.	Bi.L.	-	-	+	-	B	-
27	337	F	C-T.	Bi.L.	-	-	+	-	B	-
28	364	F	C-T.	Cong.	+	+	+	-	B	-
29	374	F	C-T.	Tri.L.	+	+	+	-	E*	+
30	384	F	C-T.	Tri.L.	+	+	+	-	B	-

Table 1. (Continued.)

Series Number	Standing Height in mm.	Sex	Type of Thymus	Lobulation of Thymus	Lungs overlap Thymus R.	Lungs overlap Thymus L.	Thymus extend on Ventricle R.	Thymus extend on Ventricle L.	Form of Thymus	Breathed
				DISSECTIONS						
31	402	F	C-T.	Tri.L.	+	+	+	+	B†	+
32	412	F	C-T.	Bi.L.	+	+	+	+	E	+
33	421	M	C-T.	Cong.	+	+	+	+	E†	+
34	401	F	C-T.	Bi.L.	+	+	+	+	E*	+
35	433	F	C-T.	Cong.	-	-	-	-	B	-
36	448	F	Th.	Bi.L.	-	-	-	-	B	-
37	453	F	C-T.	Bi.L.	-	-	-	-	B	-
38	470	F	Th.	Bi.L.	+	+	-	-	B*	+
39	485	M	C-T.	Bi.L.	+	-	-	+	B*	-
40	501	F	C-T.	Tri.L.	+	+	+	+	B*	+
41	510	F	C-T.	Bi.L.	+	+	+	+	E*	+
42	515	F	C-T.	Cong.	+	-	-	-	B	-
43										
				CROSS-SECTIONS						
43	295	F	C-T.	Uni.L.	-	-	-	-	B	-
44	310	F	C-T.	Bi.L.	+	+	-	+	E	+
45	320	M	C-T.	Bi.L.	-	-	-	-	B	-
46	340	F	Th.	Bi.L.	-	-	-	-	B	-
47	360	F	C-T.	Bi.L.	-	-	-	+	B	-
48	370	M	C-T.	Bi.L.	-	-	-	-	B	-
49	373	M	Th.	Bi.L.	-	-	-	-	B	-
50	375	F	C-T.	Bi.L.	+	+	-	-	E	+
51	380	M	C-T.	Bi.L.	+	+	+	+	E	+
52	380	F	C-T.	Bi.L.	+	+	+	+	E	+
53	382	M	C-T.	Bi.L.	+	+	+	+	E	+
54	410	M	C-T.	Bi.L.	-	-	-	-	B	-
55	420	F	C-T.	Bi.L.	-	-	-	-	B	-
56	430	F	C-T.	Bi.L.	+	-	-	-	E	+
57	480	M	Th.	Uni.L.	-	-	-	-	B	-
58	510	F	Th.	Bi.L.	-	-	-	-	B	-

Table 1. (Continued.)

Series Number	Standing Height in Mm.	Sex	Type of Thymus	Lobulation of Thymus	Lungs overlap Thymus R.	Lungs overlap Thymus L.	Thymus extend on Ventricle R.	Thymus extend on Ventricle L.	Form of Thymus	Breathed
				AUTOPSIES						
59	370	F	C-T.	Bi.L.	+	+	-	-	B	+
60	515	F	C-T.	Bi.L.	-	-	-	-	B	-
61	305	F	C-T.	Bi.L.	+	+	-	+	E	+
62	450	M	Th.	Bi.L.	+	+	-	+	E	+

*= Constriction or flattening of structures posterior to thymus.

+ = Cervical part of thymus very large.

Table 2.

Entire Series (62 cases)	No.of cases	%	Individuals that have not breathed No.of cases	%	Individuals that have breathed. (17 cases) No.of cases	%
Type of Thymus:						
Cervico-thoracic	51	82.2	36	80.0	14	82.3
Thoracic	11	17.8	9	20.0	3	17.7
Lobulation of Thymus:						
Unilobed	6	9.9	6	13.4	0	00.0
Bilobed	39	62.9	26	57.8	13	76.3
Trilobed	77	11.1	4	8.8	3	17.7
Conglomerate	10	16.1	9	20.0	1	6.0
Overlapping by Lungs:						
Right Lung	20	32.2	3	06.6	17	100.0
Left Lung	18	29.0	2	04.4	16	94.1
Thymus on Ventricle:						
Right Side	10	16.1	0	00.0	10	58.8
Left Side	17	27.3	2	04.4	15	88.3
Form of Thymus:						
Elongated	21	33.8	8	17.7	13	76.4
Broad	41	66.2	37	82.3	4	23.6

Table 3.

	100-300 mm. 21 Cases Av. L. 213 mm.		301-515 mm. 24 Cases Av. L. 392 mm.	
Lobulation	Number	Per cent	Number	Per cent
Uni.	3	14.3	2	8.3
Bi.	11	52.4	16	66.7
Tri.	3	14.3	1	4.1
Cong.	4	19.0	5	20.9
Type				
CT.	18	85.7	19	79.1
Th.	3	14.3	5	20.9
Lungs overlap Thymus				
Right	0	00.0	2	8.4
Left	0	00.0	1	4.2
Thymus extends on Ventricle				
Right	0	00.0	1	4.2
Left	0	00.0	4	16.7
Form of Thymus				
Broad	13	61.9	24	100.0
Elongated	8	38.1	0	00.0

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Explanation of Figures.

Fig. 1. Drawing of anterior chest dissection showing a very large (hypertrophied ?) thymus in a stillborn child 515 mm. crown-heel length. This is an extreme example of a broad or fetal type of thymus.

Fig. 2. Anterior dissection of an infant which had breathed (No.39-485 mm.). The thymus is still of the fetal type though it evidently was already compressed, as is shown by the cervical portion being forced against the thyroid gland. This cervical portion was 7 mm. in thickness.

Fig. 3. Anterior dissection of a newborn which had breathed (No. 40, - 501 mm.). The cervical portion of the thymus extended to the thyroid gland against which it was pressed, and then projected anteriorly. The anterior border of the right lung and the anterior-inferior angles of both lungs show the characteristic thickening in these areas in the earliest stages in the establishment of respiration.

Fig. 4. Anterior dissection of individual No.31 (402 mm.) which had breathed. The thymus has a very wide cervical portion which extended to the inferior border of the thyroid gland against which it was compressed.

Fig. 5. Anterior dissection of No.29 (374 mm.) which had breathed. The thymus extended so far posteriorly that it compressed the innominate artery, trachea and oesophagus. The thymus is markedly compressed from side to side, and the lobules of the lungs, anteriorly, were very marked.

Fig. 6. Anterior dissection of No.34 (401 mm.) which had breathed. The cervical portion of the thymus was compressed against the thyroid gland and then forced anteriorly and laterally.

Fig. 7. Anterior dissection of No. 32 (412 mm.) which had breathed. The cervical portion is quite large, and extends to the thyroid gland. The inferior-medial angles of the lungs have extended almost to the mid-line,- the right lung practically reaching it.

Fig. 8. Anterior dissection of No. 41 (510 mm.) which had evidently breathed longer than any other in the series. The thymus is markedly compressed, the right lung has crossed the mid-line, and the left in its middle region has reached it. The thymus does not extend far into the cervical region, but it does extend very far down on the right ventricle. It is, like all the others, marked by a groove where it was in contact with the superior border of the manubrium sterni. Posteriorly it compressed the aortic arch, innominate artery and trachea.

Fig. 9. A graphic reconstruction of No. 39 (485 mm.) which is also shown in Figure 2. The overlapping of the thymus by the lung, extent of cervical portion of the thymus, and relation of thymus to sternum and ribs are shown in this and the following graphic reconstructions.

Fig. 10. Graphic reconstruction of No. 40 (501 mm.) which is also shown in Figure 3.

Fig. 11. Graphic reconstruction of No. 31 (402 mm.) which is also shown in Figure 4. The extention of the thymus over the ventricle on the ~~right~~ left side is clearly shown. The right lung has almost reached the mid-line, but the anterior margin of the left lung is still a great distance from it.

Fig. 12. Graphic reconstruction of No. 34 (401 mm.) which is also shown in Figure 6. The overlapping of the thymus by both lungs, and the extent of the thymus inferiorly on the right ventricle is well shown.

Fig. 13. Graphic reconstruction of No. 32 (412 mm.). The anterior dissection is shown in Figure 7.

Fig. 14. Graphic reconstruction of No. 41 (510 mm.) also shown in Figure 8. The extent of thymus overlapped by the lungs is indicated by the broken line. The cervical portion of the thymus, and the relation of the thymus to the ribs and sternum are clearly shown in this drawing. The longitudinal axis of the heart, in this case, is much more nearly vertical than in any of the other individuals in the series. It will also be noted that the anterior-inferior angles of both lungs extend slightly below the angle of the costal arch. The outline of the thoracic cage, on comparison with the cases which have breathed less, shows that it has become more narrow and ovoid in shape.

Fig. 15. Cross section of No. 51 (380 mm.) through the cervical region just above the sternal notch; the thymus is bilobed.

Fig. 16. Cross section of a full-term fetus 510 mm. long (stillborn) below the sternal notch and above the aortic arch, showing the broad type of thymus. It will be noted that the innominate vein passes through the thymic substance to join its fellow, and that the thymic substance extends posteriorly as far as the posterior wall of the oesophagus.

Fig. 17. Cross section of a newborn infant 410 mm. long. This section shows a broad thymus with a rather extensive anterior-posterior diameter.

Fig. 18. Cross-section of a stillborn full-term fetus (480 mm.). This shows the characteristic broad type of thymus found in the late fetus and stillborn. This section is at the level of the aortic arch and shows a very marked posterior prolongation of the thymus. The convex sides of the thymus, characteristic in the stillborn, is well illustrated here. An evident constriction of the trachea due to partial surrounding by thymic substance is clearly shown.

Fig. 19. Projectoscope drawing of a cross-section of an eight and one-half month old premature which had breathed. This is number 56 of the series and had a crown-heel measurement of 430 mm. The level is through the upper portion of the aortic arch, and shows the right lung reaching almost to the mid-line. The thymus also has a posteriorly projecting portion.

Fig. 20. Cross-section of an eight month stillborn fetus (series No.54, 410 mm.) through the level of the aortic arch. This figure shows an isolated portion of the thymus situated between the superior vena cava and the beginning of the tracheal bifurcation.

Fig. 21. Cross-section through the atria and the right ventricle of the heart. The thymus in this case passes over the right atrium and extends on the right ventricle. The flattened left lateral surface, the overlapping by the right lung, and the extent of the thymus on the right ventricle would indicate that this individual had breathed.

Figs. 22 to 27 inclusive are a group of thymi removed from the bodies and drawn to standard size.

Fig. 22. Thymus from case number 39, also shown in situ in Fig. 2. This specimen shows a slight moulding by the overlapping lungs. Crown-heel length of this specimen 485 mm.

Fig. 23. Thymus from case No.31 (402 mm.) shown in situ in Fig. 4. The compression by the lungs is here shown by the lateral moulding and the anterior depression underlying the sternal notch.

Fig. 24. Thymus from a full-term liveborn infant. Marked moulding due to compression by the lungs and a depression at the level of the upper border of the manubrium sterni is well shown.

Fig. 25. Thymus from case No.29 (374 mm.) shown in situ in Fig. 5. The flattened sides and depression by the upper border of the manubrium sterni are well shown.

Fig. 26. Thymus of a liveborn infant showing very marked lateral compression; this figure also shows the groove made by the upper border of the manubrium sterni.

Fig. 27. Thymus from case No. 41 (510 mm.) shown in situ in Fig. 8. The marked impression on the left and moulding on the right side are well shown. A conception of the great sagittal extent of the organ may be obtained from this picture.

The above group of thymi, drawn to the same absolute length, illustrate the changes in form of this organ during the establishment of breathing.

Figs. 28 to 63 inclusive. Outline drawings, plotted to scale, of a series of dissections in situ of the thymi of a series 34 fetuses in newborn children ranging in total (crown-heel) length from 100 to 470 mm. None of these specimens had breathed.

Fig. 28. Fetus 100 mm. in length (No. 1).

Fig. 29. Fetus 119 mm. in length (No. 2).

Fig. 30. Fetus 123 mm. in length (No. 3).

Fig. 31. Fetus 133 mm. in length (No. 4).

Fig. 32. Fetus 143 mm. in length (No. 5).

Fig. 33. Fetus 186 mm. in length (No. 6).

Fig. 34. Fetus 200 mm. in length (No. 7).

Fig. 35. Fetus 220 mm. in length (No. 8).

Fig. 36. Fetus 223 mm. in length (No. 9).

Fig. 37. Fetus 223 mm. in length (No. 10).

Fig. 38. Fetus 224 mm. in length (No. 11).

Fig. 39. Fetus 226 mm. in length (No. 12).

Fig. 40. Fetus 234 mm. in length (No. 13).

Fig. 41. Fetus 235 mm. in length (No. 14).

Fig. 42. Fetus 243 mm. in length (No. 15).

Fig. 43. Fetus 245 mm. in length (No. 16).

Fig. 44. Fetus 253 mm. in length (No. 17).

Fig. 45. Fetus 283 mm. in length (No. 18).

Fig. 46. Fetus 283 mm. in length (No. 19).

Fig. 47. Fetus 295 mm. in length (No. 20).

Fig. 48. Fetus 300 mm. in length (No. 21).

Fig. 49. Fetus 308 mm. in length (No. 22).

Fig. 50. Fetus 313 mm. in length (No. 23).

Fig. 51. Fetus 325 mm. in length (No. 24).

Fig. 52. Fetus 331 mm. in length (No. 25).

Fig. 53. Fetus 332 mm. in length (No. 26).

Fig. 54. Fetus 337 mm. in length (No. 27).

Fig. 55. Fetus 364 mm. in length (No. 28).

Fig. 56. Fetus 374 mm. in length (No. 29).

Fig. 57. Fetus 384 mm. in length (No. 30).

Fig. 58. Fetus 421 mm. in length (No. 33).

Fig. 59. Fetus 433 mm. in length (No. 35).

Fig. 60. Fetus 448 mm. in length (No. 36).

Fig. 61. Fetus 453 mm. in length (No. 37).

Fig. 62. Fetus 470 mm. in length (No. 38).

Fig. 63. Lateral views of thymi from cases 34 and 40.

Figs. 64 to 83 inclusive are outline tracings of drawings of the thymus of the 'newborn' as figured in the literature.

Fig. 64. Cross-section of the chest in the newborn (Luschka '63).

Fig. 65. Anterior dissection of thorax of newborn (Gegenbaur '96).

Fig. 66. Anterior dissection of fetus at term (Huntington '97).

Fig. 67. Anterior view of viscera. Full-term fetus in situ. (Chievitz)'89).

Fig. 68. Thymus of newborn (Zuckerkandl '04).

Fig. 69. Thymus of a newborn (Sobotta in Bardeleben Handbuch '08).

Fig. 70. Anterior dissection of a newborn child (Piersol '08).

Fig. 71. Anterior dissection of a newborn (Testut and Jacob '09).

Fig. 72. Transverse section of the thorax of a newborn (Testut and Jacob '09).

Fig. 73. Anterior dissection of a newborn. (Corning '11.)

Fig. 74. Transverse section of a newborn. (Poirier and Charpey '11.)

Fig. 75. Anterior dissection of a full-time fetus. (Cunningham '13.)

Fig. 76. Anterior dissection of the thorax of a newborn (Bardeleben '14).

Fig. 77. Thymus gland at birth. (Morris-Jackson '14.)

Fig. 78. Thymus in the newborn (Quain '14).

Fig. 79. Thymus of a newborn (Rauber-Kopsch '14).

Fig. 80. Anterior view of the thymus of a full-term newborn (Hammar '15).

Fig. 81. Anterior view of the thymus of a full-term newborn (Hammar '15).

Fig. 82. Transverse section of a newborn (Hammar '15).

Fig. 83. Thymus of a full-time fetus (Gray-Lewis '20).

Figs. 84 to 91 inclusive. Outline tracings of drawings of the thymus of infants and young children as figured in the literature.

Fig. 84. Thymus in an infant of six months (Sappey '89).

Fig. 85. Anterior dissection of thorax of a two and one-half year old child. (Joessel '99.)

Fig. 86. Thymus of a two year old child, anterior view. (Sobotta in Bardeleben Handbuch '08.)

Fig. 87. Anterior dissection of the thorax of an 14 year old girl (lungs pulled away). (Sobotta in Bardeleben Handbuch '08.)

Fig. 88. Transverse section of the thorax of a child about one year old (Piersol '08).

Fig. 89. Thymus of an infant of one month (Olivier '11).

Fig. 90. Thymus of an infant of two months (Poirier and Charpey '01).

Fig. 91. Thymus of a 12 year old boy (Spalteholz '20).

Fig. 92. Drawings of case No. 27 (337 mm.) showing compression of structures posterior to the thymus.

(a) The moulded thymus, compressed great vessels, trachea and oesophagus are shown in their relative positions. The thymus shows the groove for the left innominate vein and a posterior superior knob-like process which projected between the innominate artery and left common carotid and against the trachea which it compressed. The innominate artery is seen to be flattened by the

thymus, - the and artery in turn compressed the trachea.

(b) Posterior view of thymus, heart and arteries.

(c) Lateral view of the compressed trachea showing the markedly flattened right border of the oesophagus.

Fig. 93. Series No. 27 (337 mm.), anterior view of the compressed trachea showing the diagonal course of the innominate artery, as is indicated by the furrow the artery has made upon the trachea.

Fig. 94. Drawing of case No. 29 (374 mm.) q The greater part of the thymus has been removed and only enough left so as to show its extent posteriorly. The thymus encloses the aortic arch. The oblique course of the innominate artery as well as its impression on the anterior surface of the trachea is shown.

Figs. 95. to 100 inclusive. A series of thymi secured at autopsy and hardened by immersion in crome-formol. The form of the specimens were preserved by mounting them on wads of cotton.

Fig. 95. Series No. 50 (515 mm.) full-term stillborn.

Fig. 96. Series No. 64 full-term infant which had lived four hours.

Fig. 97. Series No. 59 (370 mm.) premature infant, body found in river.

Fig. 98. Series No. 61 (305 mm.) premature which lived 12 hours.

Fig. 99. Series No. 62 (450 mm.) newborn infant which had lived 26 hours.

Fig. 100. Thymus of a 14 months old girl. This thymus was markedly moulded and compressed so that its anterior-posterior was but 4 mm.

Since the completion of this paper there has come to hand a copy of the Anatomische Hefte 1920, Band 59, Heft I, in which appears a paper by Ludwig Gräper entitled, "Die Anatomischen Veränderungen Kurz Nach Der Geburt". This article deals with the pleura and the thymus shortly after birth. In his discussion of the thymus the author draws some conclusions which are similar, in part, to some of the results obtained from the present study.

He states that the form of the thymus is changed during the first few breaths. It is compressed laterally by the expanding lungs and as a result its sagittal diameter is increased. He finds that the surfaces of the lungs which were in contact with the thymus posteriorly, change from an anterior to a medial direction. After compression, the thymus becomes somewhat triangular in cross-section with the base posterior.

Gräper finds that during establishment of respiration the anterior chest wall is elevated, thus increasing the space between the thymus and the sternum. It is with this space that the thymus accommodates itself as its sagittal diameter increases.

His conclusions are based on a study of over 50 cases. The paper is illustrated by 17 figures and 1 plate.