THE DEVELOPMENTAL STUDY ON THE THALAMIC NUCLEI IN JAPANESE FETUS

YAMADORI, Takashi

(Citation)
The Kobe journal of the medical sciences,7(4):1-25

(Issue Date)
1961

(Resource Type)
departmental bulletin paper

(Version)
Version of Record

(URL)
https://hdl.handle.net/20.500.14094/0100489248

THE DEVELOPMENTAL STUDY ON THE THALAMIC NUCLEI IN JAPANESE FETUS

Takashi YAMADORI M. D.

The anatomical study of the thalamus has been performed from the 19th century by such authors as Nissl[1] (1889), Russell [3] (1891), Monakow[4] (1895), Kuhlenbeck[15] (1930), Miura[19] (1933), Niimi[39] (1949) and others. As for the anatomical study of the thalamus during the fetal period, there are valuable works by Fortuyn[6] (1912), Ingvar[9] (1923), Kuhlenbeck[15] (1930), Gilbert[24] (1934), Cooper[41] (1950), Nakamura[49] (1954) and others. Among them, Cooper[41] and Nakamura[49] observed the evolution and differentiation of the thalamic nuclei through the whole fetal period in human fetus and reported it precisely. Nakamura[49] reported that the thalamic nuclei are completely divided in the 170mm length human fetus.

The measuremental study of the thalamus were reported by Grünthal[22] (1934), Lawrence[55] (1959), Morooka[56] (1960), and Suzuki[60] (1961). Grünthal[22] studied it by using primates, Lawrence[55] by using dolphin, Morooka[56] by using primates and Suzuki[60] by using carnivores. Grünthal[22] compared the volumes of thalamic nuclei in human, rhesus monkey and chimpanzee by classifying the thalamus into lateral group, internal nucleus, anterior nucleus and centrum medianum.

However, there is no papers up to now that reported the development of the thalamic nuclei in human fetus by measuring volumes of thalamic nuclei with growth and by observing the general form making reconstruction models. Therefore it was planned to follow the development of the thalamic nuclei by measuring volume of each nuclear group, comparing these results with other animals and also tracing the division of the each nuclues; and here some interesting results were obtained.

MATERIALS

The crown-rump length, body weight and brain weight of the used fetus were measured and fetus of earlier stage were stained with Mayer's Hematoxylin and fetus of later stage were stained by Nissl's method. These are shown on the table IA and IB.

山鳥　崇
Department of Anatomy, Division I, Kobe Medical College (Director: Prof. Hajimu Takeda)

Table IA Preparations Stained with Mayer's Hematoxylin

Crown-Rump Length	Weeks	Body Weight	Fixation
6.3mm	3	0.05 g	Formalin
8.4	6	0.09	〃
8.8	7	0.08	〃
11.6	11	0.21	〃
25.0	12	1.92	〃
54.0	12	12.8	〃
68.0	13	19.1	〃
80.0	15	37.9	〃
101.0	16	73.3	〃
111.0	17	101.0	〃
127.0	19	182.4	〃
143.0	20	211.8	〃
169.0	21	309.2	〃
190.0	24	514.6	〃
205.0	27	756.5	〃

Table IB Preparations Stained by Nissl's Staining Method

Crown-Rump Length	Weeks	Body Weight	Brain Weight	Fixation
108mm	15	77.0 g	12.0 g	Alcohol
113	20	250.0	39.0	〃
182	23	400.0	66.0	〃
215	25	540.0	95.0	〃
216	27	970.0	137.0	〃
265	29	1160.0	153.0	〃
270	30	1460.0	203.0	〃
310	32	1660.0	206.0	〃
300	35	1720.0	254.0	〃

METHODS

1. Extirpatiron of the brain

The brains were extirpated from the spinal cord by cutting at the Decussatio pyramidum and their weights were measured. Among them, the brains which were stained with hematoxylin were fixed with 10% Formalin solution and the brains which were stained by Nissl's method were fixed with absolute alcohol.

The fetus which were too small to extirpate brains were fixed without extirpating the brains and were used to the study.

The photographic pictures were taken before the embedding to record the original form of the brains of fetus.

2. Determination of the standard lines

As standard lines, FO line and FO vertical line were used. FO line is an direct line which combines frontal end and occipital end of the brain, and FO vertical line is a vertical line to the FO line on the mid-sagittal plane.

As standard planes, FO sagittal plane and FO horizontal plane were used.

The cerebrum was separated from the brain stem by being cut at the lower end of the superior colliculus and then was cut again at the mid-sagittal plane.

The left halfs were only used for this study. The FO line was projected on the lateral surface and the dorsal surface respectively. These left halfs of cerebra were embedded into the celloidin and cubic celloidin blocks were made.

The above mentioned lines were also projected on these blocks and these lines were slightly incised with a knife. These incisions were used afterwards as standard to make reconstruction models.

3. Sectioning and staining

The celloidin blocks were frontally sectioned in 40 micron thickness continuously and stained with Mayer's Hematoxylin or by Nissl's method.

4. Reconstruction models

The sections of the cerebrum and the thalmic nuclei were enlarged to 6.25^2 times with photographic enlarger and the forms of them were drawn on section papers. Then those pictures were drawn again on 1mm thick straw boards. These strawboards were cut with scissors into the drawn form and were sticked together to make reconstruction models.

As these pictures were drawn every four sections and the thickness of the every section is 40 micron, the enlargement on the straw board in one dimension is 6.25 times.

$$1\text{mm}/40\text{ micron} \times 4 = 6.25$$

5. Measurement

i) Length, Height and Breadth

FO length of the thalamus or the cerebrum were obtained by multiplying 40micron to the number of sections in which the thalamus or the cerebrum is observed.

The height and the breadth were obtained by measuring the enlarged picture of the thalamus and the cerebrum. The numbers of these dimensions were divided by 6.25 respectively, as these dimensions had so enlarged.

ii) Volume

The volume was obtained by summing up the planimetried areas of each thalamic nucleus and the cerebrum. The number of each dimension was divided by 6.25 to compute the real volume.

DESCRIPTION

1. 6.3mm embryo

The diocele occupies the major part of the brain in this fetus and optic stalk is stretching lateralward from the lower end of the diocele. The lens invagination is recognized with thin layer of retinal pigment cells. At the lateral wall of the diocele the ependymal layer and the mantle layer are not yet clearly distinguished. Therefore the region which will grow as the thalamus is not certain at this stage.

2. 8.4mm embryo

At this stage, the two layers, the mantle layer and the ependymal layer can be recognized on the lateral wall of the Ventriculus tertius. However, these layers are not so prominent and primodia of the Septum pellucidum, Fornix and Corpus callosum are not recognizable.

3. 8.8mm embryo

Sections of this specimen is somewhat oblique to the frontalplane. The section is almost same with that of 8.4mm embryo. Namely the ependymal and the mantle layers are well recognized on the wall of the Ventriculus tertius through the broad Foramen interventriculare. The region which will grow as the thalamus is not yet so clearly demarcated from the neighbouring tissues.

4. 11.6mm fetus

This specimen is also sectioned somewhat oblique to the frontal plane. The differentiation of the Ventriculus tertius and the Ventriculus lateralis is clearer than above embryo and primodia of the Corpus callosum, Septum pellucisum and Fornix are recognizable. At the section in which the Foramen interventriculare is seen, the Corpus striatum, which is locating above the Sulcus opticus is recognizable. The region lying under the Corpus striatum is so called preoptic region and this is the place where the thalamus will be completed in future. However, there are no fissures on the wall of the Ventriculus tertius which divide the thalamus from the diencephalon at this stage. In the posterior sections from the Foramen interventriculare, the ependymal and the mantle layers are very clear.

5. 25mm fetus

In this fetus, the Ventriculus tertius and the Ventriculus lateralis become narrower and the cerebral surface becomes more complicated one. Also on the

wall of the Ventriculus tertius the Sulcus diencephalicus dorsalis, the Sulcus diencephalicus medius and the Sulcus hypothalamicus become clear and therefore the four parts of the thalamus, namely Epithalamus, dorsal thalamus, ventral thalamus, and Hypothalamus can be divided. Among them, the development of the dorsal thalamus is most prominent and three layers are divisible. These are the inner germinal layer which has fine congregated cells, outer germinal layer which has somewhat sparse cell distribution and outermost thick mantle layer.

Describing precisely the sections in which the thalamus is seen frontal to occipital, the Foramen interventriculare disappears at the section of 3.7 mm from the frontal end and at the same time the Sulcus limitans namely Sulcus hypothalamicus appears. By this groove, the thalamus is divided into the Hypothalamus and the ventral thalamus. At the section of 4.2mm, Sulcus diencephalicus medius appears dorsally to the Sulcus hypothalamicus. At the same time a layer which is called the Zona limitans intrathalamica by Kuhlenbeck[15] appears in the Sulcus diencephalicus medius and by this layer congregated cell group of the dorsal thalamus and sparse cell group of the ventral thalamus are differentiated. However, this layer disappears at the section of 5.24mm by the confluenence of the Sulcus diencephalicus medius and the Sulcus hypothalamicus.

At the section of 4.4mm, the Sulcus diencephalicus dorsalis appears and divides the Epithalamus from the thalamus dorsalis but this groove become indistinct at the section of 6.28mm. At the section of 5.08mm, the thalamus looks very large, but the ventral thalamus is going to disappear and the Zona limitans intrathalamica is very indistinct. However, in the more occipital sections, the Sulcus hypothalamicus becomes very prominent and the development of the dorsal thalamus is remarkable, but there is no differentiation of nuclei also in these sections and the dorsal thalamus disappears at the section of 6.2mm from the frontal end.

6. From 54mm fetus to 101mm fetus

In 54mm fetus, the Nucleus reticularis which develops from the ventral thalamus is very prominent and also the dorsal thalamus and the Zona limitans intrathalamica appear very clearly. However, the nuclei in the dorsal thalamus are not clear at this stage except very vague cell group along the wall of the Ventriculus tertius.

The sections in 68mm fetus is about same with that of 54 mm fetus. The Nucleus reticularis covers only the anterior half of the lateral nuclear group of the thalamus.

In 80mm fetus, there is much progress in the differentiation of the dorsal thalamus. The Nuclus anterior ventralis and the Nucleus lateralis dorsalis in the dorsal nuclear group, the Nucleus medialis dorsalis and the Nucleus laminalis in the dorsal group of the medial nuclear group (the medio-dorsal nuclear group), the Nucleus medialis ventralis in the ventral group of the medial nuclear group (the medio-ventral nuclear group) and cells of the lateral nuclear group and the

posterior nuclear group are recognizable. The median group of the medial nuclear group (the medio-median nuclear group) is not certain but is recognizable as the vague cell group along the wall of the Ventriculus tertius. The Nucleus reticularis is also prominent at this stage but not covering the whole lateral nuclear group.

In 101mm fetus, sections are about same as those of 80 mm fetus.

7. From 108mm fetus to 300mm fetus

As for the fetus more than 108mm length, the description is done mainly on the preparations which were stained by Nissl's staining method to describe the cells.

In 108mm fetus, Nissl granules can not be recognized and there is no progress in the differentiation of the nuclei comparing with 101mm fetus except medio-median nuclear group. Particularly the Nucleus paratenialis can be recognized as a small cell group medio-dorsally to the Nucleus medialis dorsalis.

There is no progress in the differentiation of the nuclei also in 113mm fetus but the Fasciculus mamillothalamicus is very clearly recognized ventrally to the lateral nuclear group.

In preparations of 182mm fetus and 215mm fetus, Nissl granules and cells become clear and also all nuclei which consist of the thalamus can be recognized; namely seven groups 17 nuclei, the dorsal nuclear group (Nucleus anterior dorsalis, Nucleus anterior medialis, Nucleus anterior ventralis and Nucleus lateralis dorsalis), the medio-median nuclear group (Nucleus paratenialis, Nucleus reuniens arcuatus, Nucleus rhomboides and Nucleus paramedianus), the medio-dorsal nuclear group (Nucleus medialis dorsalis and Nucleus laminaris), the medio-ventral nuclear group (Nucleus medialis ventralis and Nucleus parafascicularis), the lateral nuclear group (Nucleus lateralis ventralis and Nucleus ventralis), the posterior nuclear group(Nucleus pulvinaris and Nucleus limitans) and Nucleus reticularis.

The Nucleus anterior dorsalis develops dorsally to the Nucleus anterior ventralis as lean congregated cell group and these nuclei disappear about same time.

The Nucleus anterior ventralis is much larger than the former and has oval shape between the Nucleus medialis dorsalis and the Nucleus anterior dorsalis, and disappear at about the middle of the thalamus. The cells of this nucleus are relatively deeply stained and aggregated. The Nucleus anterior medialis is a sparse, vague, round cell group which locates medially to the Nucleus anterior ventralis. This nucleus is sometimes difficult to identify.

The Nucleus lateralis dorsalis is a cell group which appear dorsally to the Nucleus anterior ventralis when this nucleus is going to disappear at the middle of the thalamus and later this is replaced by the posterior nuclear group. This nucleus has congregated cells at the anterior portion but the concentration become lower at the occipital portion.

Among the nuclei which belong to the medio-median nuclear group, the

Nucleus paratenialis locates dorsally to the Nucleus anterior medialis but this nucleus is very difficult to identify. The nucleus reuniens arcuatus locates ventro-medially to the Nucleus paratenialis. The Nucleus rhomboides is seen in the Adhaesio interthalamica in the sections of 215mm fetus but this nucleus is not seen in 182mm fetus. The Nucleus paramedianus is recognized along the wall of the Ventriculus tertius. The cells of these nucli are small but congregated.

As for the medio-dorsal nuclear group, the Nucleus medialis-dorsalis occupies just about the center of the thalamus. This nucleus connects with the Nucleus dorsalis ventralis dorsally, medio-median nuclear group medially, lateral nuclear group laterally and the Nucleus lateralis ventralis ventrally. The sectional area of this nucleus is relatively large but the cells are small and round in form. The Nucleus laminaris is a thin cell group in the Lamina medullaris interna and encircles the Nucleus medialis dorsalis.

The medio-ventral nuclear group is consisted of the Nucleus medialis ventralis and the Nucleus parafascicularis. The former is also called as the Nucleus centrum medianum and locates in the posterior half of the thalamus. The cell dispersion is thinner than that of the Nucleus medialis dorsalis. The latter develops medially to the Nucleus medialis ventralis.

The lateral nuclear group is consisted of the Nucleus lateralis ventralis and the Nucleus ventralis. I included the Nucleus lateralis dorsalis into the dorsal nuclear group and did not count it into the lateral nuclear group.

The Nucleus lateralis ventralis is a massive nucleus which extends in the whole length of the thalamus except the pulvinar part. This nucleus locates at the dorso-lateral part of the thalamus and is consisted of aggregated cells. The Nucleus ventralis is also a gigantic nucleus which occupies the ventral part of the lateral nuclear group. The borderline between the Nuclus lateralis ventralis is not so clear but the dispersion of cells in the ventral nucleus is relatively thinner and these cells are lined radially. In the ventral nucleus, it is possible to differentiate anterior, intermediate and posterior portion, and particularly in the posterior portion the postero-medial part and the postero-lateral part are recognizable. The postero-medial part is divided precisely again into the medial part and the lateral part.

The Nucleus reticularis is the nucleus which develops most laterally. The cells in it have spindle form and are arranged like stream in the nucleus. The dispersion of cells are very thin particularly at the ventral part, therefore the borderline is very vague in this portion.

The Nucleus pulvinaris and the Nucleus limitans form the posterior nuclear group. The former occupies the most occipital part of the thalamus and forms so called "pulvinar". Nakamura[49] divided this nucleus into Pars lateralis, Pars intermedia, Pars media, Pars ventralis and Pars supragenicuiata, Dekaban[45] into Nucleus pulvinaris oralis, Nucleus pulvinaris lateralis, Nucleus pulvinaris medialis and Nucleus pulvinaris inferior. However, these parts are very difficult to id-

entify. Although there is no description about the nucleus in Dekaban[45] or Toncray's[35] reports, the Nucleus limitans is between the Nucleus pulvinaris and the mid-brain at the ventro-medial border line.

All thalamic nuclei are more clearly differentiated in 215mm fetus and Nissl granules become very clear. These tendency become prominent with the development of the fetus.

When we observe the cells in each nucleus through the every stage of the development, oval cells are very common in the Nucleus anterior dorsalis and oval, round and spindle cells are recognized in the Nucleus anterior ventralis. The cells in the Nucleus lateralis dorsalis are about same with those of the Nucleus anterior ventralis but dispersion is very thick. Triangular or oval cells are recognized in the Nucleus paratenialis, and in the Nucleus medianus there are various types of cells such as round, oval, spindle or triangular. In the Nucleus medialis dorsalis, round, oval or spindle cells are aggregated but in the other hand oval or spindle cells are very sparsely recognized in the Nucleus medialis ventralis. In the Nucleus parafascicularis, cells are somewhat larger than that of the Nucleus medialis ventralis. The cells in the lateral nuclear group are round, oval, or spindle but in the reticular nucleus only spindle. The arrangement and form of cells are same with the former in the Nucleus laminaris but round or spindle cells are predominant in the posterior nuclear group.

RECONSTRUCTION MODELS

Reconstruction models of the thalamus were made about the fetus of after 54mm length and their forms were observed.

1) *Dorsal View*

In general, the form of the thalamus is oval and there is no prominent difference of view between reconstruction models in different developmental stages ; namely the dorsal nuclear group can be seen most prominently at the anterior half of the thalamus. Medially to this nucleus, the medio-median nuclear group is seen after 108mm fetus and laterally to the dorsal nuclear group there are the lateral nuclear group and the Nucleus reticularis. In the posterior half, the lateral nuclear group and the posterior nuclear group are the most prominent. The latter occupies about posterior ¼ of the thalamus. In the thalamus of 80 and 101mm length fetus, the medio-dorsal nuclear group locates most medially instead of the medio-median nuclear group.

2) *Lateral View*

Generally the form of the thalamus is deformed oval. The reticular nucleus occupies the major part of the thalamus. In 54 and 68mm fetus, the reticular nucleus covers only the lower anterior part of the thalamus but it increases and

covers about whole anterior half of the thalamus in 80 and 101mm fetus, and in the fetus of more than 101mm length it increases gradually and covers about 2/3 of the thalamus. At the posterior part of this nucleus we can see the slant band of the lateral nuclear group and then the pulvinar at the posterior 1/4.

3) *Frontal View*

In earlier developmental stages, namely in the fetus of less than 113mm length (excepting 111mm fetus), it is possible to observe the medio-dorsal nuclear group from the front. In these fetus, the medio-dorsal nuclear group occupies about the center of the thalamus and is surrounded by the medio-median nuclear group, dorsal nuclear group and lateral nuclear group. However, in the fetus after 127mm length (including 111mm fetus), we can not see the medio-dorsal nuclear group but the medio-median nuclear group, dorsal nuclear group, lateral nuclear group and reticular nucleus are the nuclear groups which can be observed from the front.

4) *Ventral View*

The ventral view is about same in all fetus. The medio-ventral nuclear group is seen only by this view in front of the posterior nuclear group but the almost all part is occupied by the reticular nucleus. The slender medio-median nuclear group is seen at the most medial portion in the fetus of after 108mm length. The lateral nucleus is seen in arch form between the medio-madian nuclear group and the reticular nucleus in front of the posterior nuclear group.

5) *Medial View*

All these seven nuclear groups can be seen in the fetus after 108mm length. Namely, the medial nuclear group (Mm, Md and Mv) occupies the major portion of the thalamus, the posterior nuclear group is seen at the portion of posterior 1/4, the dorsal nuclear group and the reticular nucleus are seen at the upper and the lower margin of the medial nuclear group, and the lateral nuclear group is seen between the medio-median nuclear group and the reticular nucleus or between the posterior nuclear group and the medial nuclear group. However, in 80 and 101mm fetus, the medio-median nuclear group can not be observed at the centre ; and in the fetus less than 80mm length, there are no differentiation of these nuclear groups.

6) *Occipital View*

The thalamus shows deformed square shape but there is nothing particular to describe except that the posterior nuclear group occupies the major part of the thalamus. A part of the dorsal nuclear group, medio-median nuclear group, medio-ventral nuclear group, posterior nuclear group and reticular nucleus are seen around the posterior nuclear group.

RESULTS OF MEASUREMENT

1. Length, Height, Breadth and rates between these three dimensions.

The upper half of the table II shows the data of Hematoxylin stained preparations. The length percentage of the thalamus to the hemisphaerium is in the range of 21.5～31.0%, the height percentage is in the range of 23.3～41.0% and the breadth percentage is in the range of 35.2～48.7%. The lower half of the table shows the data of Nissl stained preparations. Although there were no deformation in the formalin fixed brains, there were deformations due to the contracton of the brain which were caused by alcohol fixation in Nissl stained preparations and numbers are rather variable. However, the length percentage is in the range of 17～28%, height percentage is in the range of 20～30% and breadth is in 34～46% and rather stable.

It is very clear from the table that length and breadth of the thalamus and hemisphaerium increase with the development. The number of length and height percentage in the Hematoxylin stained preparations are larger than these of Nissl stained preparations and this will due to that the embryos or fetus of the early developmental stage show relatively larger percentage in the Hematoxylin stained preparations. There is no remarkable change in the percentage of breadth.

The comparison of these percentage with those of primates and carnivores reveals that the breadth percentage is smaller in humen fetus than those in primates or carnivores but there is no prominent difference in the other percentages.

2. Length–Height Index (Height/Length × 100), Length–Breadth Index (Breath/Length × 100) and Breadth–Height Index (Height/Breadth × 100)

These indexes are as shown on the table III. In formalin fixed preparations, these indexes are stable than those of alcohol fixed preparations.

Among these three indexes, the breadth–height index is the largest and the length–breadth index is the smallest both in the thalamus and the hemispha erium. There is no increase or decrease of these indexes with the development of fetus.

When we compare these indexes with those of primates, the length–breadth index of both the brain and the thalamus are smaller and breadth–height index of the thalamus is larger in human fetus. Comparison of these indexes with those of carnivores shows that the length–breadth index is larger in carnivores than in human fetus and breadth height index is smaller than human fetus. However, the order of indexes between these three is exactly same with that of human fetus both in primates and carnivores.

3. The volume of the thalamus and the cerebrum, and percentages of the thalamus to the cerebral hemisphaerium

The volume of the thalamus and the cerebrum and percentages of the thalamus to the hemisphaerium are shown in the figure.

It is very clear that the volume of the thalamus and the hemisphaerium increase with the growth of fetus. However, the percentage of the thalamus to the hemisphaerium decreases with the growth and it becomes rather constant (about 2%) after 143mm fetus. This means the development of the hemisphaerium, particularly cortex is worse in the earlier stage as these are seen in sections.

These numbers concerning the volume show no difference between Nissl stained preparations and Hematoxylin stained preparations.

4. Thc volume of each nuclear group and its percentage to the whole volume of the thalamus

The volumes of all nuclear group are shown on the table IV, and percentage of each nuclear group to the whole volume of the thalamus is shown on the table V and in the figure. As it is described before, the thalamic nuclei was differentiated into seven groups from the study of reconstruction models.

These are dorsal nuclear group (D), medio-median nuclear group (Mm), medio-dorsal nuclear group (Md), medio-ventral nuclear group (Mv), lateral nuclear group (L), reticular nucleus (R) and posterior nuclear group (P).

It is quite natural that each nuclear group increases its volume with the growth of fetus, but further there are few interesting points when we observe the order of volume of each nuclear group with growth.

If we arrange all fetus in development stage mixing Nissl stained preparations and Hematoxylin stained preparations and compare the precentage of volume of each nuclear group, the result becomes as follows:

Crown-Rump Length	Volume order of nuclear groups	Staining
80mm fetus	L>Md> P > D >Mv> R	H
101 〃	L>Md> P > D >Mv> R	H
108 〃	L>Md> D > P >Mv> R >Mm	N
111 〃	L>Md> P > D >Mv> R >Mm	H
113 〃	L>Md> P > D >Mv> R >Mm	N
127 〃	L>Md> P >Mv> R > D >Mm	H
143 〃	L>Md> P >Mv> R > D >Mm	H
169 〃	L>Md> P > R >Mv> D >Mm	H
182 〃	L> P >Md>Mv> R > D >Mm	N
190 〃	L> P >Md> R >Mv> D >Mm	H
205 〃	L> P >Md> R >Mv> D >Mm	H
215 〃	L> P >Md> R >Mv> D >Mm	N
216 〃	L> P >Md> R >Mv> D >Mm	N
265 〃	L> P >Md>Mv> R > D >Mm	N
270 〃	L> P >Md> R >Mv>Mm>D	N
310 (32 weeks)	L> P >Md> R >Mv>Mm>D	N
300 (35 weeks)	L> P >Md> R >Mv>Mm>D	N

H: Hematoxylin
N: Nissl

The lateral nuclear group is the largest in whole developmental stages and occupies 32～46% of the thalamus, namely about 2/3 to half of the whole thalamus. The medio-dorsal nuclear group or the posterior nuclear group follow the former.

The dorsal nuclear group shows the most prominent change through the whole developmental stages. Namely this nuclear group occupies 10 to 16% in the earlier stage but this percentage decreases with the development and finally it becomes the smallest nuclear group in the thalamus. In the other hand, medio-ventral nuclear group occupies always 6～9% and also the reticular nucleus occupies about 5～12% but the latter nucleus has very scattered cell distribution.

DISCUSSIONS

The various classifications had been done cocerning the thalamic nuclei by various authors. These are Nissl[1], Turner[2], Kuhlenbeck[15] in old days and Sheps[34], Dekaban[45], and Nakamura[49] recently. The comparison of my classification with those of recent authors are shown on the table VI.

I classified these 17 nuclei into four main groups as Nakamura[49], Morooka[56] and Suzuki[60] did but I tried to divide it more precisely and classified them into seven groups from the observation of reconstruction models. These are dorsal nuclear group (D), medio-median nuclear group (Mm), medio-dorsal nuclear group (Md), medio-ventral nuclear group (Mv), lateral nuclear group (L), posterior nuclear group (P), and reticular nucleus (R). The dorsal nuclear group includes Nucleus anterior dorsalis, Nucleus anterior ventralis, Nucleus anterior medialis and Nucleus lateralis dorsalis. The medio-median nuclear group includes Nucleus paratenialis, Nucleus reuniens arcuatus, Nucleus rhomboides and Nucleus paramedianus. The medio-dorsal nuclear group is consisted of Nucleus medialis dorsalis and Nucleus laminaris, and the medio-ventral nuclear group is consisted of Nucleus medialis ventralis and Nucleus parafascicularis. The lateral nuclear group includes Nucleus lateralis ventralis and Nucleus ventralis, and the posterior nuclear group is consisted of Nucleus pulvinaris and Nucleus limitans. The reticular nucleus is the only nucleus which was calculated by itself.

The different points between Nakamura's classification[49] are those;
1) Nucleus lateralis dorsalis is included in the dorsal nuclear group as this nucleus is difficult to identify from the Nucleus anterior ventralis in the fetus of early developmental stage, and 2) Nucleus lateralis ventralis and Nucleus ventralis are included in one group as these two nuclei are very difficult to differentiate.

In this study, the author did not include the Epithalamus, the Hypothalamus and the ventral thalamus except Nucleus reticularis into the thalamus. The thalamus was limited only to Herrick's dorsal thalamus[8] and reticular nucleus.

The primodium of the thalamus is recognized from the 11.6mm fetus (11 weeks). At 25mm fetus, the thalamus is divided into the thalamus dorsalis, the thalamus ventralis and the Hypothalamus by the appearance of the Sulcus hypothalamicus and the Sulcus diencephalicus medius. The development of the thalamus dorsalis is particularly prominent, and in 80mm fetus seven groups which were described above can be recognized. The each nucleus in these group becomes clear with the development and in 182mm fetus we can differentiate the all nuclei which are recognized in the adult.

The anterior nuclear group can be differentiated from the 80mm fetus but chief nuclei in this group can be identifyed in 182mm fetus. The borderline between the Nuclus anterior ventralis and the Nucleus lateralis dorsalis become clear from this fetus. Namely the latter appears dorsally to the former nucleus just like to cover it and grows, but it merges to the Nucleus lateralis ventralis at the posterior part of the thalamus. In 215mm fetus, the borderline between the Nucleus anterior ventralis and the Nucleus lateralis dorsalis is not so clear but it become clear again in fetus after 216mm length. Although I counted the Nucleus lateralis dorsalis into the dorsal nuclear group because of the vague borderline in the early developmental stage, as Morooka and Suzuki did in primates and carnivores using myelin sheath stained preparations, it seems more natural to classify it into the lateral nuclear group as this nucleus seems a part of the lateral nuclear group.

The nuclei in the medio-median nuclear group are very difficult to identify except the Nucleus paratenialis. Particularly the nuclei in the Adhaesio interthalamica were difficult to identify as I studied only the left half of the thalamus except few cases of earlier stage. The Nucleus paramedianus locates at the posterior part of the median line but its borderline is vague due to the thin distribution of cells. Sheps[34], Walker[31] and Toncray[35] described this nucleus as the Nucleus paraventricularis but there is no description concerning this nucleus in Lawrence's report[55] about the thalamus of the dolphin. Although Walker[31] in monkey and Toncray[35] in human identifyed the Nucleus medialis ventralis (different nucleus from my classification) in the medio-dorsal nuclear group, this nucleus is not so clear as to be recognized as an independent nucleus. The Nucleus laminaris is called as the Nucleus paracentralis and the Nucleus centralis lateralis by Walker[31], Sheps[34], Toncray[35], Dekaban[45] and Lawrence[55] but this nucleus was calculated with the Nucleus medialis dorsalis as the Nucleus laminaris is surrounding the Nucleus medialis dorsalis like a part of it. The medio-ventral nuclear group is consisted mainly of so called Nucleus centrum medianum but I called it as Nucleus medialis ventralis like Nakamura[49] and Morooka[56] did as it is locating vantrally to the Nucleus medialis dorsalis.

There is the Nucleus parafascicularis in this nuclear group but this nucleus looks as a part of the Nucleus medialis ventralis.

Also the Nucleus lateralis ventralis and the Nucleus ventralis were measured together as the lateral nuclear group. In these nuclei, cells are congregated and are stained lightly in the former but they are stained deeply and arranged sparsely and radially to the lateral side in the latter. However, these two nuclei are very difficult to differentiate. Nakamura,[49] Walker[35] and others divided these nuclei into the lateral nucleus and the ventral nucleus. Although the Nucleus lateralis ventralis is simple but the Nucleus ventralis is divided into the Nucleus ventralis anterior, Nucleus ventralis intermedius and Nucleus ventralis posterior by Nakamura[49] and Morooka[56]. Nakamura divided these part from the obserevation of sections but Morooka[56] described two grooves which are running medio-laterally at the ventral side of the reconstruction models, namely Sulcus N and Sulcus O and divided above three parts following to these grooves. However, I could not recognize the Nucleus ventralis intermedius distinctively. Particularly it was impossible to differentiate the Nucleus ventralis anterior and the Nucleus ventralis intermedius. The Nucleus ventralis posterior can be identified easily as it has well developed postero-medial part and postero-lateral part. The classifications of the ventral nucleus by Sheps[34] and Dekaban[45] is somewhat different. They differentiated this nucleus as Nuclus ventralis anterior, Nucleus ventralis lateralis and Nucleus ventralis posterior. However, following to the observation of continuous series of sections, the author think Nakamura's classification[49] is more suitable.

In this report, the Nucleus reticularis is included into the lateral nuclear group in broad meaning.

The Nucleus pulvinaris consists of the pulvinar as its name indicates and Nakamura[49] divided this nucleus into five parts, namely Pars lateralis, Pars intermedia, Pars medialis, Pars ventralis and Pars supragenicuiata. Dekaban[45] divided it into Nucleus pulvinaris oralis, Nucleus pulvinaris lateralis, Nucleus pulvinaris medialis and Nucleus pulvinaris inferior but Sheps[34] did not divid it so fine. These parts are difficult to identify, particularly in the earlier developmental stage; but in 300mm fetus (35 weeks) it is possible to divide Pars lateralis, Pars medialis, Pars intermedia and Pars ventralis (or Pars supragenicuiata).

The Nucleus limitans is measured with the Nucleus pulvinaris. This nucleus is difficult to identify in 205mm fetus, 265mm fetus and 310mm fetus (32 weeks).

The volume ratio of the thalamus to the cerebral hemisphaerium is about 2% after 143mm fetus and stable. This number 2% is lower than 3.5% by Grünthal[22] in human, 2.06～3.88% in carnivores by Suzuki and 2.08～2.84% in primates by Morooka except rhesus monkey (1.81) and crab-eating monkey (2.02) which show same percentage with human fetus.

As for the length, breadth and height of the thalamus, the ratios of these

dimentions on the thalamus to the cerebrum are 17～31%, 20～41% and 34～49% respectively as described above. There is no prominent change in these ratios with the development. Therefore there is no valuable change in Length-Height index, Length-Breadth index and Breadth-Height index with the growth of fetus.

Comparing those data with those of primates and carnivores, the length ratio of the thalamus to the cerebrum has no difference with them but the ratio of breadth and height are lower than those animals. It can be thought that this result means the development of the cortex to the parietal or temporal direction is prominent in human fetus than those animals. The comparison of these data between primates and carnivores reveals no prominent differences.

As to the indexes of these dimensions, length-height index in human fetus is about same with those of primates and carnivores but length-breadth index is smaller than those animals and breadth-height index is larger than those animals. In general the development of the thalamic nuclei is proportional after the diffdrentiation of these nuclei had been completed. However, the lateral nuclear group, and the Nucleus medialis dorsalis occupies the major part of the thalamus in human fetus and have important function as association nuclei. In the other hand, the dorsal nuclear group, particularly the Nucleus anterior ventralis decreases its percentage with the development. This may possible to think that the Nucleus anterior ventralis which belongs to the Paleothalamus shows relatively worse development comparing with other nuclei.

CONCLUSIONS

By using 24 brains of human fetus in different developmental stages, the development of the left thalamus were studied from the standpoint of ontogenesis utilizing continuous series of sections and measuremental way. For this purpose, 40 micron thick continuous celloidin sections of the left cerebra were prepared concerning the every fetus and these sections were stained with Mayer's Hematoxylin or by Nissl's staining method. These sections were microscopied and the form of each nucleus were enlarged and drawn on the section papers and their volumes were measured. Also the reconstructon models were made to observe the thalamic nuclei as a whole and to study the progress of form with the development. The follwings are the results thus obtained.

1. The primodium of the thalamus appears on the wall of the Ventriculus tertius at first already in 11.6mm fetus. This part is divided into the Epithalamus, the Thalamus dorsalis, the Thalamus ventralis and the Hypothalamus with the appearance of the Sulcus diencephalicus dorsalis, medius and ventralis. These differentiation are completed in 25mm fetus.

2. With the growth of fetus, the differentiation of nuclei in the Thalamus dorsalis becomes clear, and in 108mm fetus seven nuclear groups can be recogn-

ized clearly. These groups are the medio-median nuclear group, medio-dorsal nuclear group, medio-ventral nuclear group, dorsal nuclear group, lateral nuclear group and posterior nuclear group, and reticular nucleus from the Thalamus ventralis The 17 nuclei become distinctive in 182mm fetus.

3. The rate of the volume of the left thalamus to the cerebral hemisphaerium were obtained in each fetus of different developmental stage. This rate decreases gradually with the development and it shows about 2 percent after 14 3mm fetus (20 weeks). This may indicates that the development of the hemisphaerium is not so good before 20 weeks (113mm fetus) but the development of the hemisphaerium and the thalamus becomes proportional after 20 weeks (113 mm fetns).

4. About the volume between seven nuclear groups, the dorsal nuclear group decreases its percentage prominently in parallel with the development, but the posterior nuclear group and the Nucleus reticularis increase their percents slightly, and there is no change in other nuclear groups. The lateral nuclear group occupies the largest portion through the whole developmental stage and the percentage of the medio-median nuclear group is the smallest in these groups until 270mm fetus.

5. Rates of the length, breadth and height of the whole thalamus to the cerebrum, are 17～31% in length, 20～41% in height and 34～49% in breadth. There is no big difference in these rates from 54mm to 300mm fetus.

6. The general form of reconstruction models is slightly deformed oval which has its long axis in fronto-occipital direction, and has the slight prominence of the anterior nucleli at the frontal end and swelling of the pulvinar in the occipital portion.

7. The rates of the whole volume of the thalamus to the cerebral hemisphaerium in carnivores coincides with the data of 108 mm to 265 mm fetus and these rates in primates coincide with the data of 113mm to 300mm fetus. As for the percentage of each nuclear group in the thalamus, there is no change in Mm+d, L and R but Mv of the human fetus is larger than primates and carnivores. The rate of the posterior nuclear group is larger in primates than in human fetus but this rate in carnivores is generally smaller than in human fetus and coincides with the data of about four to five months old fetus (80mm to 1 13mm fetus) except dog (20.7) and leopard(26.7).

ACKNOWLEDGMENTS

The author wishes to express his thanks to Professor Hajimu Takeda for his kind advice and encouragement.

REFERENCES

1) Nissl, F.: Die Kerne des Thalamus beim Kaninchen, Neur. Central bl. Bd. 8, 1889
2) Turner, D. H.: Morphology of the Avian Brain, J. Comp. Neur., Vol. 1, 1891
3) Russell. H., Pemberton, M. A.: Recent Investigations on the structure and relations of the optic thalami, J. Comp. Neur., Vol. 1, 1891
4) Monakow, C. V.: Experimentelle und pathologische anatomische Untersuchungen über die Haubenregion, den Sehhügel und die Region subthalamica, Arch. Psychiat, Bd, 27, 1895
5) Herrick, D. T.: The morphology of the forebrain in Amphibia and Reptilia, J. Comp. Neur., Vol. 20, 1910
6) Fortuyn, A. D.: Die Ontogenie der Kerne des Zwischenhirns beim Kaninchen, Arch. Anat. Entw. Ges., 1912
7) Friedemann, M.: Die Cytoarchitechtonik des Zwischenhirns der Cercopitheken mit besonderer Berücksichtigung des Thalamus opticus, J. Psych. Neur. Bd. 18, Ergänzungschaft 2, 1912
8) Herrick, D. T.: The internal structure of the midbrain and thalamus of Necturus. J. Comp. Neur. Vol. 28, 1917
9) Ingvar, S.: On thalamic evolution, Acta Med. Scand., Vol. 59, 1923
10) Huber, G. C. and Crosby, E. C.: On thalamic and tectal nuclei and fiber paths in the brain of the American alligator, J. Comp. Neur. Vol. 40, 1926
11) Gurdjian, E. S.: The diencephalon of the albino rat, J. Comp. Neur., Vol. 43, 1927
12) Huber, G. C. and Crosby, E. C.: The nuclei and fiber paths of the avian diencephalon, with consideration of telencephalic and certain mesencephalic, centers and connections, J. Comp. Neur., Vol. 48, 1929
13) Rioch, D. Mck.: Studies on the diencephalon of the Carnivora. I. The nuclear configulation of the thalamus, epithalamus and hypothalamus of the dog and cat, J. Comp. Neur., Vol. 49, 1929
14) Rioch, D. Mck.: Studies on the diencephalon of the Carnivora. II Certain nuclear configulations and fiber connections of subthalamus and midbrain of the dog and cat, J. Comp. Neur. Vol. 49, 1929
15) Kuhlenbeck, H.: Bemerkungen über den Zwischenhirn, Bauplan bei Säugetieren insbesondere beim Menschen, Anat. Anz. Bd. 70, 1930
16) Clark, W. E. Le Gros: The structure and connection of the thalamus, Brain, Vol. 55, 1932
17) Windle, A. F.: The neurofibrillar structure of the 7mm cat embryo, J. Comp. Neur., Vol. 55, 1932
18) Ingvar, W. R., Hannett, F. W.: The topography of the nuclei of die diencephalon of the cat J. Comp. Neur., Vol. 55, 1932
19) Miura, R.: Über die Differenzierung der Grundbestandteile im Zwischenhirn des Kaninchens, Anat. Anz. Bd. 77, 1933
20) Windle, W. F.: Neurofibrillar development in the central nervous system of cat embryos between 8 and 12mm long, J. Comp. Neur., Vol. 58, 1933
21) Herrick, C. T.: The amphibian forebrain, VI Necturus, J. Comp. Neur., Vol. 58, 1933
22) Grünthal, E.: Der Zellbau im Thalamus der Säuger und des Menschen, J. Psych. NernBd. 46, 1934
23) Crouch, R. L.: The nuclear configuration of the thalamus of Macacus rhesus, J. Comp. Neur., Vol. 59, 1934
24) Gilbert. M. S.: The early development of the human diencephalon, J. Comp. Neur. Vol. 62, 1935
25) Papez, T. W.: Thalamus of turtles and thalamic evolution, J. Comp. Neur., Vol. 61, 1935

26) Atlas, D. and Ingram, W. R.: Topography of the brain stem of the rhesus monkey with special reference to the diencephalon, J. Comp. Neur., Vol 66, 1937
27) Walker, A. E.: A note on the thalamic nuclei of Macaca mulatta, J. Comp. Neur., Vol. 66, 1937
28) Walker, A. E. and Fulton, T. E.: The thalamus of the Chimpanzee, III Metathalamus, normal structure and cortical connection, Brain, Vol. 61, 1938
29) Gurdjian, E. D.: The diencephalon of the albino rat, J. Comp. Neur., Vol. 43, 1938
30) Solnitzky, O.: The thalamic nuclei of Sus scrofa, J. Comp. Neur., Vol. 69, 1938
31) Walker, A. E.: The medial thalamic nucleus, J. Comp. Neur., Vol. 73, 1940
32) Rose, T. E.: The ontogenic development of the rabbit's diencephalon, J. Comp. Neur., Vol. 77, 1942
33) Krieg, Wendell, T. S.: The medial region of the thalamus of the albino rat, J. Comp. Neur., Vol. 80, 1944
34) Sheps, T. G.: The nuclear configuration and cortical connections of the human thalamus, J. Comp. Neur., Vol. 83, 1945
35) Toncray, T. E. and Krieg, W. T. S.: The nuclei of the human thalamus, A comparative approach, J. Comp. Neur., Vol. 85, 1946
36) Rose, T. E.: Structure and relations of limbic cortex and anterior thalamic nuclei in rabbit and cat, J. Comp. Neur., Vol. 89, 1948
37) Krieg, W. T. S.: A reconstruction of the diencephalic nuclei of Macacus rhesus, J. Comp. Neur., Vol. 88, 1948
38) Jiminez-Castellanos, T.: Thalamus of the cat in Horsley-Clarke co-ordinates, J. Comp. Neur., Vol. 91, 1949
39) Niimi, K.: Zur vergleichenden Cytoarchitektonik der vorderen, medianen und medialen Kerngruppe des Shehügels des Menschen, Acta Med. Univ. Kioto, Vol. 27, 1949
40) Niimi, K.: A comparative anatomical study on the thalamus of primates, Nokenkyu, Vol. 7, 1950
41) Cooper, E. R.: The development of the thalamus, Acta Anat. Vol. 9, 1950
42) Rose, T. E. and Mountcastle, V. B.: The thalamic tactile region in rabbit and cat, J. Comp. Neur., Vol. 97, 1952
43) Hunt, W. E. and O'Leary T. L.: Form of thalamic response evoked by peripheral nerve stimulation, J. Comp. Neur., Vol. 97, 1952
44) Mountcastle, V. B. and Henneman, E.: The representation of tactile sensibility in the thalamus of the monkey, J. Comp. Neur., Vol. 97, 1952
45) Dekaban, A.: Human thalamus, I. Division of the human adult thalamus into nuclei by use of the cytomyeloarchitechtonic method, J. Comp. Neur., Vol. 99, 1953
46) Niimi, K.: Zur vergleichenden Cytoarchitechtonik der lateralen, hinteren und ventralen Kerngruppe des Sehhügels des Menschen, Acta Med. Univ, Kioto, Vol. 30, 1953
47) Kurotsu, T.: Anatomy of the diencephalon (Hypothalamus), Saishin-Igaku, 8-10, 1953
48) Suzuki, Y.: Zur vergleichenden Anatomie des Thalamus der Reptilien, Arbeiten aus der zweiten Abteilung des anatomischen Institutes der Universität zu Tokushima, Heft I, 1954
49) Nakamura, T.: Über der Entwicklung der Thalamuskerne beim Menschen, Arbeiten aus der zweiten Abteilung des anatomischen Institutes der Universität zu Tokushima, Heft I, 1954
50) Niimi, K.: Anatomy of the thalamic nuclei, The recent progress in the field of basic science (Kisoigaku Saikin no Shinpo), Vol. 1, (anatomy and pathology), 1956
51) Niimi, K., Asahi, Y. and Anabuki, M.: Zur thalamocorticalen Verbindung des Hundes, Acta Anat. Nippon, Heft 32, 1957
52) Okamura, N.: On the development of the medial and lateral geniculate body in man, Arbeiten aus der zweiten Abteilung des anatomischen Institutes der Universität zu Tokushima, Heft II, 1957

53) Nagano, N.: A comparative anatomy of the dorsal thalamus of the common marmoset, Arbeiten aus der zweiten Abteilung des anatomischen Institutes der Universität zu Tokushima, Heft V, 1958
54) Takasu, J.: The myeloarchitecture of the thalamus of carnivores, Arbeiten aus der zweiten Abteilung des anatomischen Institutes der Universität zu Tokushima, Heft V, 1958
55) Lawrence, K.: The thalamus of the dolphin (Tursiops truncatus) and comparison with other mammals, J. Comp. Neur., Vol. 111, 1959
56) Morooka, Y.: The comparative anatomy of the thalamic nuclei of primates, Bull. Kobe Med. Coll., Vol. 20, 1960
57) Nakayama, K.: The comparative anatomy of the dorsal thalamus in carnivores, Arbeiten aus der zweiten Abteilungen des anatomischen Institutes der Universität zu Tokushima, Heft VIII, 1960
58) Nakano, T.: Experimental-anatomical studies on the cortical connections of the anterior thalamic nuclei in carnivores, Arbeiten aus der zweiten Abteilungen des anatomischen Institutes der Universität zu Tokushima, Heft VIII, 1960
59) Niimi, K.: Hagizaki, H. and Nakano, T.: A contribution to the knowledge of the cortical connections of anterior thalamic nuclei in the monkey, Arbeiten aus der zweiten Abteilungen des anatomischen Institutes der Universität zu Tokushima, Heft VIII, 1960
60) Suzuki, S.: Comparative anatomical study on the thalamus of the Carnivora, Bull. Kobe Med. Coll., Vol. 22, 1961

ABBREVIATIONS

D: Dorsal nclear group
L: Lateral nuclaear group
P: Posterior nuclear group
R: Reticular nucleus
Mm: Medio-median nuclear group
Md: Medio-dorsal nuclear group
Mv: Medio-ventral nuclear group
Dio: Diocele
Ops: Optic stalk
Inf: Infundibulum
Foi: Foraman interventriculare
Str: Striatum
Pro: Preoptic region
Ep: Ependymal Layer
Mp: Mantle Layer
Sd: Sulcus diencephalicus dorsalis
Sm: Sulcus diencephalicus medius
Dth: Dorsal thalamus
Vth: Ventral thalamus
Zl: Zona limitans intrathalamica
Av: Nucleus anterior ventralis
Ad: Nucleus anterior dorsalis
Am: Nucleus anterior medialis
Pt: Nucleus paratenialis
Rh: Nucleus rhomboides
Ld: Nucleus lateralis dorsalis
Lv: Nucleus lateralis ventralis
La: Nucleus laminalis
V: Nucleus ventralis
Md′: Nucleus medialis dorsalis
Mv′: Nucleus medialis ventralis
Pf: Nucleus parafascicularis
P′: Nucleus pulvinaris
Cgm: Corpus geniculatum mediale
Cgl: Corpus geniculatum laterale
VIII: Ventriculus tertius
Fo: Fornix
Pal: Globus pallidus
Put: Putamen
St: Stria terminalis
Pm: Nucleus paramedianus
Vpl: Nucleus ventralis, pars posterior lateralis
Vpmm: Nucleus ventralis, Pars posterior medialis, medial part
Vpml: Nucleus ventralis, Pars posterior medialis, lateral part

Fig. 1 Reconstruction Models

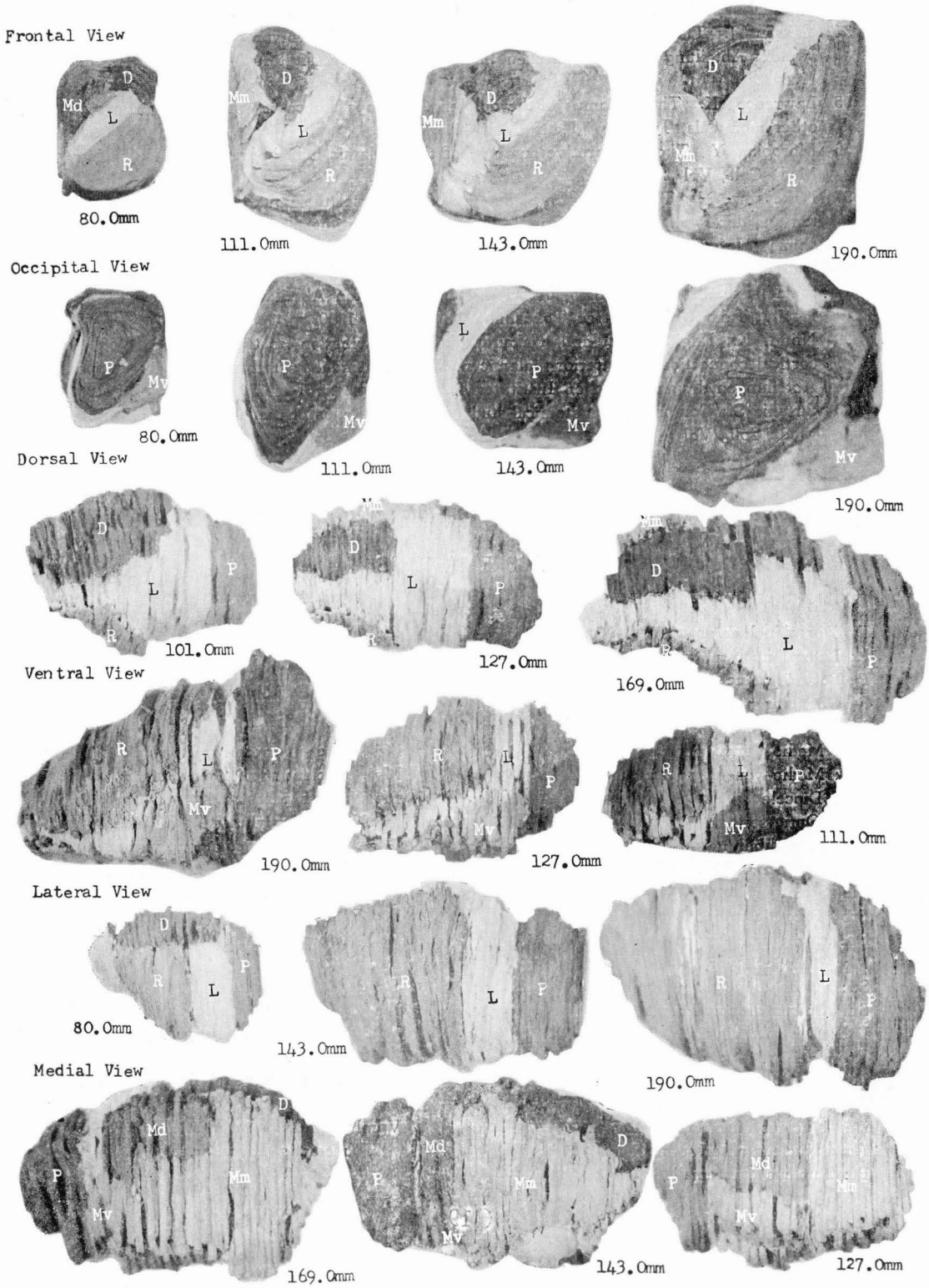

Fig. 2 Sections

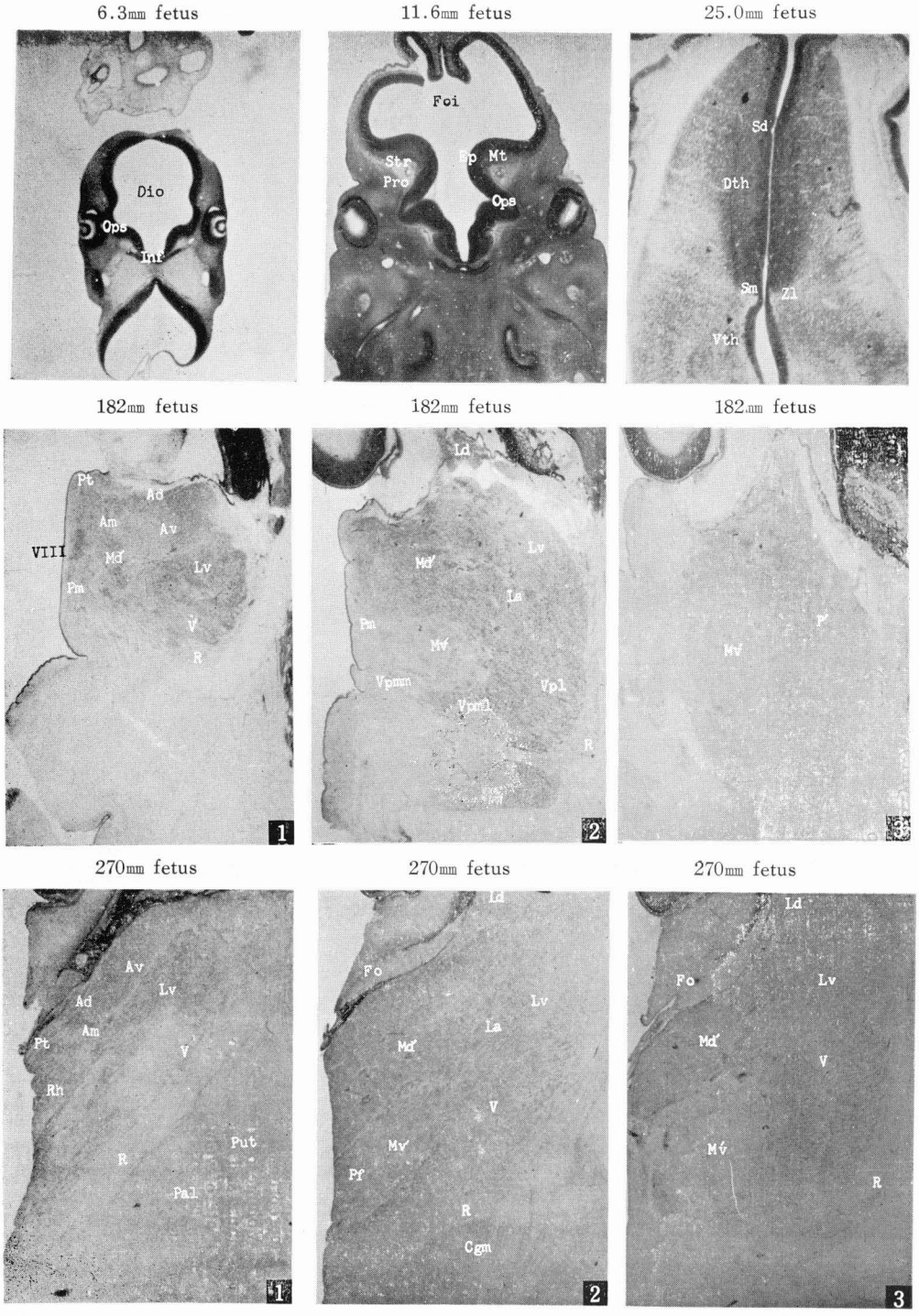

Fig. 3 Volume of the cerebrum and the thalamus, and percentage of volume of the thalamus to the cerebrum (left hemisphaerium)

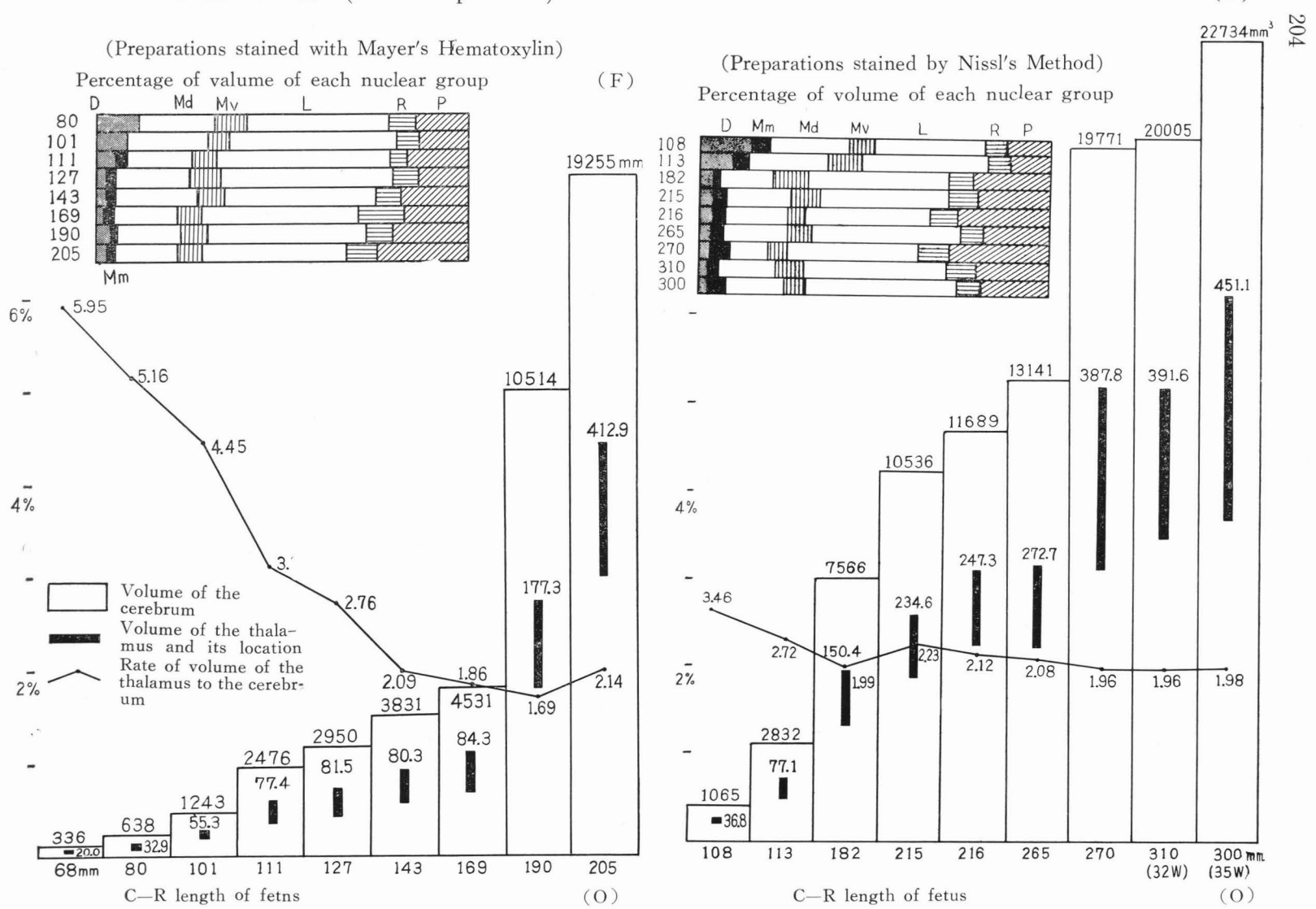

Table II Breadth, Height and Length

Fetus	Breadth			Height			Length		
C—R Length of Fetus	Thalamus	Cerebrum	%	Thalamus	Cerebrum	%	Thalamus	Cerebrum	%
54mm	2.6mm	6.1mm	42.1	4.0mm	9.8mm	41.0	3.8mm	12.5mm	30.8
68	2.6	7.3	35.2	4.6	11.2	39.5	4.5	16.0	28.0
80	3.5	8.8	40.0	5.1	13.0	39.5	5.4	18.6	29.3
101	4.0	9.1	43.9	5.6	19.1	29.3	5.5	25.5	21.6
111	4.3	11.4	38.0	6.2	20.5	30.5	7.0	30.0	23.7
127	5.8	11.8	48.7	5.0	21.3	23.3	7.3	29.0	25.1
143	5.3	11.6	45.5	5.8	24.3	23.7	7.6	33.3	22.8
169	5.1	12.0	42.7	6.2	24.2	25.7	8.1	35.0	23.1
190	6.4	15.5	41.2	8.0	30.1	26.6	10.6	49.3	21.4
205	8.2	21.3	38.4	10.9	36.5	29.8	12.8	54.3	23.6
108	2.8	6.6	42.4	2.6	9.1	28.6	4.9	24.4	20.0
113	4.2	9.8	42.9	3.5	15.5	22.6	5.5	26.6	20.8
182	3.1	7.8	39.7	4.4	18.1	24.3	10.8	50.3	21.5
215	8.0	18.2	44.0	4.4	16.8	26.2	6.9	39.4	17.7
216	3.4	10.0	34.0	7.7	28.1	27.4	7.3	38.9	18.7
265	4.6	11.0	41.3	6.3	21.9	28.8	6.8	37.8	18.0
270	5.2	13.5	38.5	6.1	20.7	29.5	14.0	52.4	26.7
310 (32w)	5.2	12.1	43.0	7.9	32.0	24.7	9.8	45.9	21.3
300 (35w)	7.8	16.8	46.4	6.0	29.5	20.3	12.8	45.9	27.9

upper half: Preparations stained with Mayer's Hematoxylin
lower half: Preparations stained by Nissl's method

Table III Indexes between Length, Height and Breadth

	Length-Height Index		Length-Breadth Index		Breadth-Height Index	
C—R Length of Fetus	Thalamus	Cerebrum	Thalamus	Cerebrum	Thalamus	Cerebrum
54mm	104.2	78.2	66.7	48.7	156.3	160.5
68	103.6	70.0	57.1	45.5	181.3	153.9
80	94.1	69.8	64.7	47.4	144.5	147.3
101	101.4	74.9	72.5	35.7	140.0	209.6
111	88.6	68.8	61.4	38.2	144.4	180.3
127	68.1	73.5	79.1	40.9	86.1	179.7
143	75.8	73.1	69.5	34.9	109.1	209.7
169	72.2	69.2	63.4	34.2	121.9	202.0
190	75.8	61.0	50.6	31.5	125.0	193.8
205	85.0	67.2	63.8	39.2	133.3	171.4
108	53.3	37.4	57.4	27.1	92.9	137.9
113	63.4	58.3	76.1	36.8	83.3	158.2
182	40.7	36.0	36.1	15.5	141.9	232.1
215	63.2	42.6	115.9	46.2	55.0	92.3
216	105.8	72.3	46.7	25.7	226.5	281.0
265	91.7	57.9	67.6	29.1	137.0	199.1
270	43.6	39.5	37.1	25.7	117.3	153.3
310 (32w)	80.9	69.7	53.3	26.4	151.9	264.5
300 (35w)	46.9	64.2	60.9	36.6	76.9	175.6

upper half: Preparations stained with Mayer's Hematoxylin
lower half: Preparations stained by Nissl's method

Table IV Volume of each nuclear group mm³

C—R Length of Fetus	D	Mm	Md	Mv	L	R	P	Total
54mm								16.6
68								20.0
80	3.8		6.9	2.6	12.5	2.4	4.5	32.9
101	5.0		12.0	3.1	25.0	3.3	7.2	55.3
111	5.1	2.2	13.1	5.0	36.1	3.6	12.3	77.4
127	2.4	2.3	17.0	6.5	37.4	5.8	10.1	81.5
143	2.2	2.0	18.3	5.2	33.3	5.1	14.2	80.3
169	2.2	2.1	14.5	5.6	35.6	10.1	14.2	84.3
190	8.1	3.7	30.0	12.1	76.7	12.3	34.4	177.3
205	12.7	7.9	71.7	27.2	161.8	34.9	96.7	412.9
108	6.0	1.7	8.4	2.2	11.7	2.1	4.7	36.8
113	8.0	2.6	17.3	7.4	28.1	5.0	8.7	77.1
182	5.2	2.6	25.4	14.2	60.1	9.1	33.8	150.4
215	9.8	8.2	44.5	17.4	87.8	16.1	50.8	234.6
216	10.1	7.0	46.0	10.5	91.8	15.7	66.2	247.3
265	11.2	6.5	52.4	17.1	115.7	16.8	53.0	272.7
270	14.1	18.7	41.4	22.9	147.6	33.0	110.1	387.8
310 (32w)	11.1	12.3	63.5	28.3	161.6	29.2	85.6	391.6
300 (35w)	13.3	21.8	79.1	25.8	193.6	26.9	90.6	451.1

upper half: Preparations stained with Mayer's Hematoxylin
lower half: Preparations stained by Nissl's method

Table V Percentage of volume in each nuclear group %

C—R Length of Fetus	D	Mm	Md	Mv	L	R	P
54mm							
68							
80	11.72		20.97	8.03	38.16	7.30	13.79
101	8.98		21.66	5.56	45.35	5.47	12.97
111	6.62	2.89	16.95	6.43	46.63	4.64	15.85
127	2.81	2.79	20.91	7.98	45.94	7.16	12.42
143	2.79	2.43	22.79	6.46	41.43	6.38	17.70
169	2.62	2.53	17.16	6.67	42.17	12.02	16.83
190	4.58	2.09	16.90	6.82	43.24	6.95	19.41
205	3.07	1.91	17.36	6.58	39.19	8.45	23.42
108	16.23	4.69	22.71	6.04	31.73	5.77	12.82
113	10.41	3.36	22.43	9.57	36.45	6.50	11.28
182	3.44	1.76	16.87	9.46	39.96	6.08	22.49
215	4.12	3.44	18.74	7.31	36.96	8.03	21.41
216	4.08	2.82	18.61	4.25	37.12	6.35	26.78
265	4.10	2.38	19.21	6.26	42.45	6.16	19.43
270	3.63	4.82	10.67	5.91	38.07	8.51	28.39
310(32W)	2.82	3.14	16.23	7.23	41.27	7.46	21.85
300(35W)	2.98	4.88	16.62	5.78	43.41	6.03	20.30

upper half: Preparatins stained with Mayer's Hematoxylin
lower half. Preparations stained by Nissl's method

Table VI COMPARISON OF CLASSIFICATIONS

	Yamadori 1960	Nakamura 1949	Dekaban 1953	Sheps 1945	Toncray 1946
D	anterior dorsalis	ant. n. g. anterior dorsalis	ant. n. g. ant. dorsalis	ant. n. g. anterodorsalis	ant. group ant. dorsalis
	anterior ventralis	ant. ventralis	ant. ventralis	anteroventralis	ant. ventralis
	anterior medialis	ant. medialis	ant. medialis	anteromedialis	ant. medialis
	lateralis dorsalis			interanterodorsalis	
Mm	paratenialis	median n. g. paratenialis	medial n. g. paratenialis	median. n. g. paratenialis	midline nuclei paratenialis
				centralis medialis	centralis medialis
	reuniens arcuatus	reuniens arcuatus	Nuclei of	reuniens	reuniens
	rhomboides	rhomboides	Massa intermedia	rhomboidalis	rhomboidalis
	paramedianus	paramedianlus	paraventricularis	paraventricularis	paraventricularis
			midline nuclei	Griseum paraventriculare	
Md	medialis dorsalis	medial n. g. medialis dorsalis	medialis dorsalis	medial. n. g. dorsomedialis	medial group medialis dorsalis (med. ventralis)
	laminaris	laminaris	paracentralis	paracentralis	paracentralis
			centralis lateralis	centralis lateralis	centralis lateralis
			centrum medianum	centrum medianum	centrum medianum
Mv	medialis ventralis	med. ventralis			
	parafascicularis	parafascicularis	parafascicularis	parafascicularis	parafascicularis
L	(lat. dorsalis)	lat.n.g. lateralis dorsalis	lat. dorsalis	lat. dorsalis	lat dorsalis
	lat. ventralis	lat. ventralis	lat. posterior	lat. posterior	lat. posterior
	ventralis	ventralis			
	anterior	ant. med.	vent. anterior	vent. anterior	vent. anterior
		ant. lat.	vent. lateralis	vent. lateralis	vent. lateralis
	intermed.	intermed.			
	post. med.	post. med.	vent. p. medialis	vent. p. medialis	vent. posteromedialis
	med. part	med. part	parvocellularis		
	lat. part	lat. part	vent. p. medialis	vent. p. intermed.	vent. intermedius
	lat.	lat.	mediocellularis		
		vent. n. g.	ventro-lateral n. g.	lateral. n. g.	lateral n. group
			vent. p. lateralis	vent. p. lateralis	vent. posterolat.
			vent. p. inferior		vent. posterinf.
					vent. ventralis
R	reticularis	reticularis	reticularis	reticularis	reticularis
P	pulvinaris	post.n.g. pulvinar	pulvinaris	post.n.g. pulvinar	pulvinaris
	limitans	limitans		limitans	