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The morphology of the primate spleen.

by C. von Krogh.

Translated from: Anthropologischer Anzeiger, 13: 89-100 (1936).

The form of the primate spleen has been examined but little heretofore. Aside from a paper by Klaatsch (1892) and another study by Retterer and Neuville (1916), no additional publications are known to me. Sobotta wrote in 1914: "Apparently the spleen has been neglected in the section of anthropoids; at least, I am unable to find data on the spleen in the literature dealing with primates." The more recent literature pertaining to primates has not added to knowledge of the spleen. Apparently the realization of its variable size and the scant knowledge about its development and function (which only recently has seen some clarification) have contributed to the conclusion that such an investigation would prove futile.

I have been forced to limit myself to external dimensions in this work. A study of the internal structure will furnish a needed complement.

The material included 31 specimens: Two prosimians, 23 simians (including 7 anthropomorphs) and five human specimens. Unfortunately I was unable to obtain the spleen of a gorilla, leaving a considerable gap in the series. Four specimens were eliminated due to pathological organ alterations. Of the remaining spleens, those of the same species showed such close similarity that the morphological variability within a species must be considered slight (Fig. 1). The absolute dimensions of the organ naturally are subject to wide fluctuations, which caused me to negate their value, in contrast to earlier investigators. They will fluctuate according to age, nutrition, etc. The form and, with it, the proportions, will be extensively independent of these factors.

In order to fix the form, each spleen was placed in a 10% formol solution immediately after section, adjusted to the exact specific gravity of the spleen by addition of alcohol or saline. This measure caused the spleen to float without touching the surface or the bottom. Thus its natural shape remained unchanged during hardening. After a certain amount of time (½ - 2 days) it had solidified to such a degree that it could be handled without altering its shape. Longer exposure to the formol solution was avoided to prevent shrinkage and a corresponding morphological change. Now a cast was prepared of each specimen according to Poller's molding method. The casts of particularly small spleens (e.g. prosimians) are best fashioned of wood metal which reflects even the finest relief. A hominite mass meets the requirements of larger specimens. In the event sufficient hardness is not obtained by means of the formol solution --- which never happened in my work ---, it is possible to float the spleen in a gelatine solution and to remove the solidified solution on one side. After one half of the spleen has been embedded in negative material, the other part of the gelatinous mass is removed and the other side of the spleen is placed in negative material. In this manner, natural casts may . fashioned even of soft organs.

The preparation of casts permits the drawing of longitudinal and transverse sections, not possible with the original spleens, since they can never be hardened to the degree necessary for handling, without undergoing shrinkage.

In order to describe an object in such a manner that someone who is not acquainted with it can visualize its form clearly, it is not sufficient to use words of the generally descriptive type. A multitude of things may be covered by such terms as large, small, oblong, triangular. I have therefore placed illustrations and sketches next to the descriptive terms, which in my opinion will clarify the shape of the object more rapidly and efficiently than long descriptions.

I have reproduced the medial plane of the spleen in most cases, since it offers a better clue to the shape, especially when the organ is strongly curved. When several specimens of one species were available, the spleen with the most typical configuration has been depicted.

I have sketched the longitudinal section through the two extreme dorsal and ventral points, perpendicular to the greatest width. Since no external homologous points are recognizable on the spleen which would permit cross sections, I have assumed six points with the express realization that a more or less arbitrary schematization has been made. Fig. 2 shows how these points were arrived at. The distance from the extreme dorsal to the extreme ventral point, measured on the facies diaphragmatica, was divided into seven equal parts. Cross sections were placed on the resulting six points of the lateral side of the longitudinal cut, so that the sectional surface was perpendicular to the longitudinal cut on one hand, and perpendicular to the median line (*) on the other. The cuts were numbered, starting at the ventral end. The more the spleen is curved along its longitudinal axis, the more are the cut surfaces inclined toward each other, whereas they must be parallel in case of a completely straight form. The fact that they are close together in a small spleen and farther apart in a large one, is unimportant, since the interval of the cuts in relation to the total size

(*) The median line is defined as the line connecting the two extreme points of the longitudinal section, at which the perpendicular distance to the external margins is identical at every point.

of the organ is identical in all cases.

In the following chapters, each illustration is accompanied by the longitudinal section and six cross sections. A separate explanation is not given every time, Fig. 2 offers an unequivocal interpretation. I hope that the illustrations, in conjunction with the sketches, and supported by explanatory words concerning the position and special particularities, will present a clear picture of the splenic dimensions.

Description of the individual spleens.

The spleen of the prosimians generally is oblong, according to Klaatsch similarly constituted as that of carnivores. In Stenops gracilis, the posterior lobe is seen as a small, pointed protuberance (Table III, 3). The dorsal end is slightly bent inward. In Tarsius spectrum (Table III, 4), the bend has become a turn, giving the spleen a spiral appearance. The comparison to a narrow, thin ribbon with twists of variable degree (Klaatsch) seems to be sound.

The simians initially offer a surprising multiplicity of forms. Later we shall see that they, too, indicate a certain pattern.

Platyrrhinae.

Among the hapalides, the "Pinselaeffchen" (Fig. 3 and Table III, 6) has a form recalling the spleen of prosimians in certain respects. However, the bent dorsal end (caput lienis) is considerably thicker. The width decreases steadily toward the ventral end (cauda lienis). There seems to be a tendency to constriction here, which may be so severe that parts of the cauda are abstricted and form accessory spleens. The cross section is more rounded, in contrast to the prosimians. The spleen is superimposed with the caput on the upper margin of the left kidney and stretches along its entire length between the colon transversum and the stomach. Retterer found numerous variants among the hapalides and omits a more detailed specification of the form.

The spleen of cebides is also oblong and bent inward dorsally. Cebus capucinus (Fig. 4 and Table III, 1) shows a widening at the ventral end, leading to a bifurcation of the cauda. Whereas the facies gastrica and renalis in the species discussed so far had almost invariably been located on a plane, they nearly form a right angle here, distinctly apparent from the transverse sections. At first glance the form seemed so odd that it suggested an individual variation, but the examination of additional specimens invariably revealed the same shape. Daubenton (1764) and Retterer (1916) also described the prismatic, caudally split structure, apparently typical for this species. The spleen is situated far back with its dorsal part, stretches in a slight curve between the left kidney and the stomach and surrounds the cauda pancreatis like a pair of pliers with its two ventral ends.

The spleen of Mycetes (howling monkey) strongly recalls the hapalide form, except for its S-shaped course along the longitudinal axis (Fig. 5 and Table III, 2). Furthermor , its inward-bent caput is not the thickest part, the latter being situated more toward the middle. The cross sections again show a prismatic structure. The position is similar to that of the hapalides.

According to Retterer, the spleen of Ateles also has a prismatic cross section.

Catarrhinae.

The spleen of the macaque (Fig. 6 and Table III, 11) is oblong, the greatest width is found at the ventral end. The caput has a pointed terminus. It thus assumes a club-like shape. Retterer has seen a hammer-like form among Macacus rhesus, where the widening at the ventral end was so pronounced that it terminated in two ends without division. This hammer-like broadening is still recognizable in a spleen of my own material, although it is pathologically altered. The position of the macaque spleen is the usual one between the stomach and the left kidney; the cauda pancreatis borders on the ventral expansion.

While the cross sections in the case of the macaque are oval, with pointed ends owing to the sharp margo anterior, those of the mandrill (Cynocephalus maimon, Fig. 7 and Table III, 7) are triangular, similar to those of the cebides. Otherwise the spleen of the mandrill is so similar to that of the macaque that further description is unnecessary. Due to the ventral broadening, the macaque and mandrill spleens have the form of a pointed isosceles triangle.

In the baboon (Cynocephalus hamadryas, Fig. 8 and Table III, 10) the widening has become so pronounced that the form may be compared to an equilateral triangle, as mentioned already by Klaatsch. This is due primarily to the shift of the extension at the margo posterior toward the center. The ligamentum renolienale, only weakly evident in the macaque and mandrill, is strongly developed in the baboon and underlines the triangular appearance.

If the baboon spleen is visualized as being strongly bent inward medially at the dorsal and ventral end, we have the form found in the long-tailed monkeys. Cercopithecus cephus L. (Fig. 9 and Table III, 9; see also Fig. 1) reveals a caput that is even more pronouncedly rolled in than the ventral end. The latter shows a peculiar notch, giving the cauda a nose-like extension. This notch had already been observed by Retterer in connection with several species of long-tailed monkeys. While generally the longest distance is always found between the dorsal and the ventral ends, we have the appearance here as if the width (from the attachment of the ligam. renolienale to the margo anterior) exceeded the length. However, this only seems true in situ; the point of the caput is displaced inward due to the strong involution and no longer coincides with the extreme dorsal point.

The spleen of the mangabey (Cercocebus fuliginosus, Fig. 10 and Table III, 8) has no involution and is generally constituted like that of the baboon; the triangular shape is no longer as pronounced owing to the rounded corners. The cauda, especially, is strongly blunt and well-rounded. The transverse section tends toward the triangular shape, particularly in the dorsal part.

Unfortunately I was able to obtain only one newborn Semnopithecus (Fig. 11 and Table III, 5). The spleen seemed to occupy a median position between those of Cercopithecus and mangabey. This cannot be said with certainty, however.

The gibbon (Fig. 12 and Table IV, 13) shows an oblong-triangular spleen. Whereas in all other species the longitudinal plane in situ describes an acute angle with a sagittal plane, this angle is almost 90° in the gibbon. This position causes a fairly strong longitudinal curvation. The dorsal part of the facies renalis shows a sharp-edged elevation which gives it a prismatic cross section. This is probably the reason why Klaatsch wants to associate the gibbon form with that of the cebides. However, I do not feel there are special reasons for this.

The orangutan spleen (Fig. 13 and Table IV, 15) has a pear-shaped outline; it is slightly bent inward dorsally. Facies gastrica and renalis are on the same plane at the dorsal end, they describe an obtuse angle in the center which becomes progressively smaller toward the ventral end (see cross sections). The cauda pancreatis does not border on the ventral end, but in the middle. The area of congruence is distinctly recognizable on the illustration by its roughness. The margo posterior is bent inward in the dorsal portion. I cannot agree with Retterer, who claims to see a similarity to the gibbon spleen.

The spleen of the chimpanzee (Fig. 14 and Table IV, 12) shows the same contours as that of the orangutan, with the exception that the indentation of the margo posterior is missing in the dorsal part. It shows a flat area at this point, which extends over the tip of the caput. This flattening has led to a ridge-like, S-shaped elevation in the medial plane, giving the chimpanzee spleen a special character. The longitudinal section shows it to be thinner and somewhat more bent than that of the orangutan. Retterer has found an incision on the facies diaphragmatica, which he lists as typical for chimpanzees. Among my four specimens, only two revealed this incision (Table IV, 16) where the spleen had fused with the diaphragm. I dare not decide whether this is only a pathological manifestation. A larger number of examinations would offer certainty in this matter.

The human spleen (Fig. 15 and Table IV, 18) has a uniformly oval outline and frequently shows slight notches in the margo anterior. Only a bulge-like thickening is found at the point on the medial plane where the chimpanzee shows a ridge-like elevation, but the cross sections of both spleens are nevertheless highly similar. T. thickness of the human organ approximates that of the orangutan. The curvature of the longitudinal axis is weak and entirely uniform. According to Klaatsch, the spleen of a human embryo 5 cm in length distinctly shows the three original lobes. This stage would correspond to the condition of the lower monkeys. The spleen of newborn apparently has no distinct shape. While Fig. 16 (see also Table IV, 17) shows a form already resembling an adult human spleen, Fig. 17 (see also Table IV, 14) recalls rather the form of the lower monkeys. (For a detailed treatment of the human spleen, see: J. Sobotta, The anatomy of the spleen, Jena, 1914.)

Index of thickness.

The absolute measurements of length and width do not suffice for the quantitative comparison of the different forms. Measurements must be made that offer the possibility, when expressed as a relation to the organ's total size, of comparing small forms with large ones. Such irregular objects as spleens give no clue to their shape through an ordinary index — e.g. of length and width or thickness. For this reason the cross-sectional surface was related to the total volume at six points at which the cross cuts had been made. An expression is thus obtained of the thickness of each of these six points in relation to the entire organ. In addition, this index gives us the opportunity to compare the thickness of each of these six points with the homologue of another spleen. Calculation proceeds as follows:

$$\text{Index} = \frac{a \cdot 100}{\left(\sqrt[3]{v}\right)^2}$$

where a is the content of the sectional surface and v the volume. A reduction of the third power of the volume into the second was necessary in order to make a comparison to the surface possible. Thus, the cross-sectional surface is expressed in percent of the side surface of a cube formed of the volume.

The following table offers a perspective on the thickness index of the examined spleens, divided according to cross sections 1-6. Average values have been listed for several specimens.

Description	Cross section					
	1	2	3	4	5	6
Human, 3 specimens	24.5	54.4	62.9	65.8	58.1	42.0
Human, newborn #1	22.3	34.7	37.2	42.2	44.7	24.8
Human, newborn #2	10.9	16.3	24.4	38.0	24.4	16.3
Chimpanzee, 4 specimens	18.2	26.0	37.0	63.0	53.9	34.4
Orangutan, 2 specimens	20.6	42.9	59.8	53.3	48.1	31.6
Gibbon	23.7	52.7	51.6	47.4	28.4	9.5
Semnopithecus	13.3	20.0	80.1	66.7	40.5	26.7
Mangabey	34.7	72.3	60.7	49.1	43.7	20.2
Long-tailed monkey, 3 specimens	81.0	87.9	81.0	49.3	28.4	14.1
Baboon, 2 specimens	22.0	69.2	97.5	69.2	59.7	22.0
Mandrill	33.0	42.4	42.4	42.4	33.0	18.9
Macaque	51.9	51.9	38.8	25.9	19.4	12.9
Mycetes	20.5	35.8	33.2	41.9	43.5	28.1
Cebus Cap., 3 specimens	23.9	17.9	35.9	23.9	17.9	49.6
Hapale	11.6	29.0	17.4	34.8	40.6	58.1
Tarsius sp.	32.5	42.9	28.9	32.5	32.5	32.5
Dog, 2 specimens	38.8	30.8	26.8	21.4	21.4	20.1
Rabbit, 5 specimens	26.5	17.7	17.3	13.5	12.9	8.9

Fig. 18 reflects a graphic representation of the thickness index in anthropomorphs. The smaller the curve values, i.e. the less the given sectional surface represents the entire spleen, the thinner it is at the corresponding point. The well-rounded, uniformly thick splenic form of the adult human, the dorsally strongly thickened form of the chimpanzee and the narrow, thin, centrally somewhat wider form of the human newborn are visualized without difficulty from the curves.

Fig. 19 depicts the same for the remaining Catarrhines. The peculiarities of the different triangular forms are more distinctly expressed here than could be accomplished with words. The club-like form of the macaque spleen with a uniformly dorsad course terminating in a pointed end, and the uniformly thin shape of the mandrill organ lead to the Platyrrhinal and prosimian forms depicted in Fig. 20. The irregularities seen in the illustrations cannot be expressed more favorably than in these curves. The curves of the dog and rabbit are included for comparison.

Summary.

When the whole series from the prosimians to the human is viewed in its totality, the splenic forms which initially seemed multifarious, pattern themselves into a phylogenetic sequence:

The thin, ribbon-like form of the prosimians closely follows that of the lower mammals. That of the Platyrrhines is frankly irregular. While Hapale and Cebus still show an oblong shape -- Hapale with a round cross section and the major part at the dorsal end, Cebus, on the other hand, with a prismatic cross cut and ventral widening, Mycetes, with its sweeping form, recalls the prosimians (Tarsius) and Hapale with its pointed ventral end, without showing a relationship with these forms otherwise. The Catarrhine spleen has a triangular shape up to the anthropomorphs, in which connection the macaque and mandrill with their oblong, ventrally widened forms are nearest to Cebus. Cebus, on the other hand, already gives a more specialized impression than the species mentioned. The uniform shape of the baboon spleen, the involution of the long-tailed monkey and the dulled mangabey organ allow the recognition of their kinship in spite of these essential differences. It is noteworthy also that the spleens of all lower eastern monkeys have a pointed dorsal end (cf. Fig. 19). The gibbon represents the connection with the anthropomorphs. It still shows the triangular shape with the pointed dorsal end. The orangutan and chimpanzee, on the other hand, no longer give indications of it. The greatest width and thickness is again at the dorsal end; the outline, however, already reveals a nearly uniformly oval shape and thus leads to that of man, which makes a nearly symmetrical impression. But here, too, a slight predominance of the dorsal portion is evident (Fig. 18).

The extent to which a functional reason for this formal development might be found in the living habits of the individual species (jumpers, climbers, runners, hangers, walkers), must be subjected to detailed investigation.

Since Sobotta (1914) was induced to write, due to the dearth of knowledge concerning the primate spleen: "The primates generally have a spleen formed similarly to that of man, but the organ is slightly longer than that of man, even among the anthropoids," I believe to have succeeded in clearly showing the multifariousness of the forms on one hand, and the possibility of giving this multiplicity a phylogenetic coherence, on the other.

Illustrations.

Fig. 1. Three spleens of Cercopithecus cephus L. The congruous form is very distinct, despite differences in size. Natural size.

Fig. 2. Likeness and sketches of a canine spleen (terrier), 3/5 natural size (r = facies renalis, g = f. gastrica, d = facies diaphragmatica).

Fig. 3. Spleen of Hapale, nat. size.

Fig. 4. Cebus capucinus, nat. size.

Fig. 5. Mycetes, nat. size.

Fig. 6. Macaque, nat. size.

Fig. 7. Mandrill (Cynocephalus maimon), nat. size.

Fig. 8. Baboon (Cynocephalus hamadryas), nat. size.
Fig. 9. Cercopithecus cephus L., nat. size.
Fig. 10. Mangabey (Cercocebus fuliginosus E. Geoffr.), nat. size.
Fig. 11. Semnopithecus (newborn), nat. size.
Fig. 12. Gibbon, nat. size.
Fig. 13. Orangutan, 3/5 nat. size.
Fig. 14. Chimpanzee, 3/5 nat. size.
Fig. 15. Adult human spleen, 3/5 nat. size.
Fig. 16. Newborn human spleen (No. 1), nat. size.
Fig. 17. Newborn human spleen (No. 2), nat. size.
Fig. 18. Distribution of the thickness index among anthropomorphs: a-adult human, b-chimpanzee, c-orangutan, d-newborn human (No. 1), e-newborn human (No. 2), f-gibbon.
Fig. 19. Distribution of the thickness index among the lower eastern monkeys: a-Semnopithecus, b-baboon, c-mangabey, d-mandrill, e-Cercopithecus, f-macaque.
Fig. 20. Distribution of the thickness index among the western monkeys, prosimians and lower mammals: a-Hapale, b-Cebus, c-Tarsius, d-Mycetes, e-dog, f-rabbit.

Literature

Klaatsch, H., 1892, The morphology of the mesenteric structures at the intestinal canal of vertebrates. Part. II: Mammals. Morph. Jahrb. Vol. 18, p. 609-716.

Loth, E., 1931, The anthropology of the soft parts. Masson, Paris, 538 p.

Retterer, E. and Neuville, H., 1916, The form and connections of the spleen of Catarrhines. Compt. Rend Soc. Biol., Paris, Vol. 79, p. 490-495; The form and connections of the spleen of platyrrhines, p. 574-576.

Sobotta, J., 1914, The anatomy of the spleen. Handb. d. Anatomie, Vol. 3, Section 4, Appendix p. 281-328. Fischer, Jena.