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CONFIGURATION OF CHILDREN'S SKULL IN OBSTRUCTIVE HYDROCEPHALUS

ABSTRACT: The skull of an eight year-old boy who died of brain atrophy due to obstructive hydrocephalus with closure of the cerebrospinal fluid conduits at the interventricular foramen, was cranioscopically and craniometrically examined. The anthropological — medical consideration was aimed at the observation of principal external dimensions of the neurocranium and splanchnocranium and selected dimensions of the cranial base with the evaluation of growth changes. The craniometrical data were compared with the dimensions of the normal children's skull of similar age.

KEY WORDS: Hydrocephalus — Children's skull — Pathologically deformed skull.

INTRODUCTION

A macrocephalic skull of an eight year-old child who died of brain atrophy due to obstructive hydrocephalus with closure of the cerebrospinal fluid conduits at the interventricular foramen, belongs to the osteological collection in the Anatomical Museum of the Charles University Medical Faculty in Hradec Králové. The diagnosis of hydrocephalus was determined in the first month of the child's life due to the abnormal growth of the head. The cirmcumference of the head was of 660 mm at the age of seven and half years. The hydrocephalic skull was completely examined craniometrically and cranioscopically. The external dimensions of the skull investigated were compared with the dimensions of the control group of children's skulls in the osteological collection of the Department of Anatomy, Charles University Medical Faculty in Hradec Králové. The craniometrical data found in the normal children's skulls, individuals of the same age studied by Doskočil (1960, 1961a, 1961b), were used for the confrontation of the dimensions of the base of the studied hydrocephalic skull.

The aim of the present study was to follow up the abnormal growth of the hydrocephalic skull with the evaluation of the dimensions of the neurocranium in relation to the cranial base and splanchnocranium.

Literature describing pathologically deformed skulls with abnormalities in shape and size is quite extensive. Most of the authors deal with observation and comparison, especially of the external measurements in abnormally formed skulls of adults (Dokládal 1958, 1969, 1970, Doskočil 1960, 1962, Horáčková 1989). The anthropo-medical consideration of children's hydrocephalic skulls, with the aim of proportional evaluation, is less frequent (Doskočil 1960, Richards et al. 1991).

CRANIOSCOPIC EXAMINATION

Striking changes in the hydrocephalic skull of the eight year-old child appear mainly in its cranial vault. The comparison of the neurocranial and splanchnocranial parts shows that the former is much larger and the whole skull is significantly pathologically deformed.

An irregular oblong aperture of 40 × 20 mm, consequence of intravital trepanation, is found in the right parietal bone. The fonticulus anterior and frontal suture are persisting. Synostosis is observed in the sagittal suture nearly in its full extension, except for the pars postica and pars bregmatica. The other sutures persist. Characteristic saw-like edges typical for the serrated suture are recognizable only in the lamboid suture in the full extension and in the sagittal suture only in the pars postica. The other sutures show very fine saw-like edges to nearly smooth ones on both the external and internal sides.

Thickness of the bones of the cranial vault varies within 2 to 5 mm. The external side of a major part of the left parietal bone is pathologically changed. The surface is coarse with spongy structure coming out against this region. Thickness of the bone in the described parts reaches 11 mm. Significant disproportion is observed in the shape and size between the left and right parts of frontal squama and between both parietal bones.

On the sphenoidal bone in the temporal fossa there is evident disproportion in the size of the great wings on the two sides. On the left side the great wings reach 50 mm, on the right 20 mm only. The tympanic bone has a defect of 10 × 4 mm on both sides.

In the vertical view (*Fig. 1/1*) the shape of the braincase is considerably asymmetrical, the skull has a shape of an irregular ovoid with a significant dorsal vault in the region of the left parietal bone. On the contrary the occiput is heavily flattened. The described changes are characteristic for the plagiocephalic shape of the skull.

In the lateral view (*Fig. 1/2*) there is a strong enlargement and vaulting of the frontal squama which reaches its maximum in the region of the anterior fontanelle. From this site the line of the parietal profile slowly decreases down to the most dorsal vaulted part of the left parietal bone. At this point the line bends and decreases again along the left parietal bone to the mastoid process of the left temporal bone.

TABLE 1. *Dimensions (in mm) of the hydrocephalic skull neurocranium and splanchnocranium.*

Martin-Saller No.	Dimensions	Hydro-cephalic skull	Normal skulls (n = 7) Mean	s
1	Maximum length of the vault (g-op)	160	160.2	4.2
8	Maximum breadth of the vault (eu-eu)	170+	139.1	6.9
9	Minimum frontal diameter (ft-ft)	100+	91.2	3.9
17	Basibregmatic height of the skull (ba-b)	180+	122.2	4.1
23	Horizontal circumference of the vault	590+	483.0	13.9
24	Vertical circumference of the vault (po-b-po)	470+	318.4	17.1
25	Median-sagittal arch of the vault (n-o)	420+	346.4	3.5
26	Median-sagittal frontal arch (n-b)	150+	121.0	2.2
27	Median-sagittal parietal arch (b-l)	155+	114.6	6.5
28	Median-sagittal occipital arch (l-o)	110	110.8	8.2
45	Jugular breadth (zy-zy)	120+	109.5	3.9
48	Upper facial height of the face (n-pr)	60+	53.4	5.0
51	Mean orbital breadth (mf-ek)	left 40+	36.5	3.4
52	Mean orbital height left	36+	30.7	1.4
54	Nasal breadth (apertura piriformis)	21	21.1	1.6
55	Nasal height (n-ns)	45+	41.0	2.5
60	Maxillar length (pr-alv)	34+	39.5	2.2
61	Maxillar breadth (ekm-ekm)	49+	57.1	2.2
62	Palatinal length (ol-sta)	31	34.0	3.7
63	Palatinal breadth (enm-enm)	40+	35.5	2.7
64	Palatinal height	8+	6.1	1.7
38	Cranial capacity (in ccm)	2 625+	1 365.0	111.2

+ Statistically significant on 0.05 probability level

TABLE 2. *Cranial Indices.*

Martin-Saller No.	Index	Hydro-cephalic skull	Normal skulls (n = 7) Mean	s
I 1	Breadth – length Index	106.2+	86.8	3.8
I 2	Height – length Index	112.5+	76.3	2.9
I 3	Height – breadth Index (basion)	105.8+	88.0	3.8
I 13	Transversal frontoparietal Index	58.8+	66.7	3.2
I 39	Upper facial Index	50.0	48.8	4.3
I 42	Orbital Index	90.0	84.5	9.5
I 48	Nasal Index	46.6+	51.4	2.3
I 54	Palatal – Alveolar Index	144.1	144.4	4.8
I 58	Palatal Index	129.0+	105.1	8.3

+ Statistically significant on 0.05 probability level

TABLE 3. *Dimensions (in mm) of the hydrocephalic skull– external and internal cranial base.*

Dimensions	Hydro-cephalic skull	Normal skulls (n = 5) Mean	s
Endocranial breadth	169+	88.6	5.1
Breadth of lamina cribrosa	22+	11.0	1.7
Distance between foramina optica	25+	23.0	1.6
Breadth of fossa hypophysialis	14+	12.0	1.2
Distance between foramina rotundae	39+	29.6	2.1
Distance between foramina ovalia	49+	40.4	3.3
Length of crista pyramidis	52	54.4	4.1
Distance between pori acustici interni	51	49.4	5.5
Distance of porus acust. int. from the pyramid apex	25+	16.2	0.9
Distance between canales carotici	47	44.8	4.5
Distance between processus styloidei	66	69.8	6.6
Distance between foramina stylomastoidea	70	72.8	6.3
Breadth of foramen occipitale magnum	23	26.4	3.0
Endocranial length	134	136.0	4.7
Length of lamina cribrosa	21	22.4	2.9
Prehypophyseal length	48+	44.6	2.2
Length of hypophyseal fossa	15+	9.2	1.1
Posthypophyseal length	31+	34.4	2.5
Length of cranial base	85+	79.2	3.1
Length of foramen occipitale magnum	28+	32.4	3.2

+ Statistically significant on 0.05 probability level

In the frontal view (*Fig. 1/3*) the disproportion between the size of the neurocranium and splanchnocranium can be clearly seen. The pathological enlargement and striking vault of the bones of the neurocranium are most significant on the frontal squama, the temporal squama and to a small extent on both sides of the parietal bone. Lateral parts of the neurocranium passing into the cranial vault are significantly extended from the section of the temporal squama. The top of the calva in the bregmatic region shows a slight tower-like elongation. Metopic suture is deflecting to the right side, between the metopic suture and the coronal suture comes an irregular end of the persisting anterior fontanelle. The lower edges of the orbital aperture do not lie in horizontal line, the left is higher than the right one. Both permanent incisors and the first permanent molar are in the processus alveolaris of the right maxilla, on the left side there is the second permanent incisor and the second milk molar and partially first permanent molar are found. The crowns in both of the permanent canines are situated high in the processus alveolaris.

In norma occipitalis (*Fig. 1/4*) the vault, especially in the left half of the braincase, stands out. The occipital squama is deformed, the left part is slightly vaulted and the right part is quite flattened. In the lambdoid suture on the right side there appear sutural bones. The sagittal suture is nearly completely closed. The above described pathological changes are visible on the external side of the left parietal bone.

In norma basilaris (*Fig. 1/5*) the deformation and asymmetry of the whole base and the adjacent bones are apparent. The

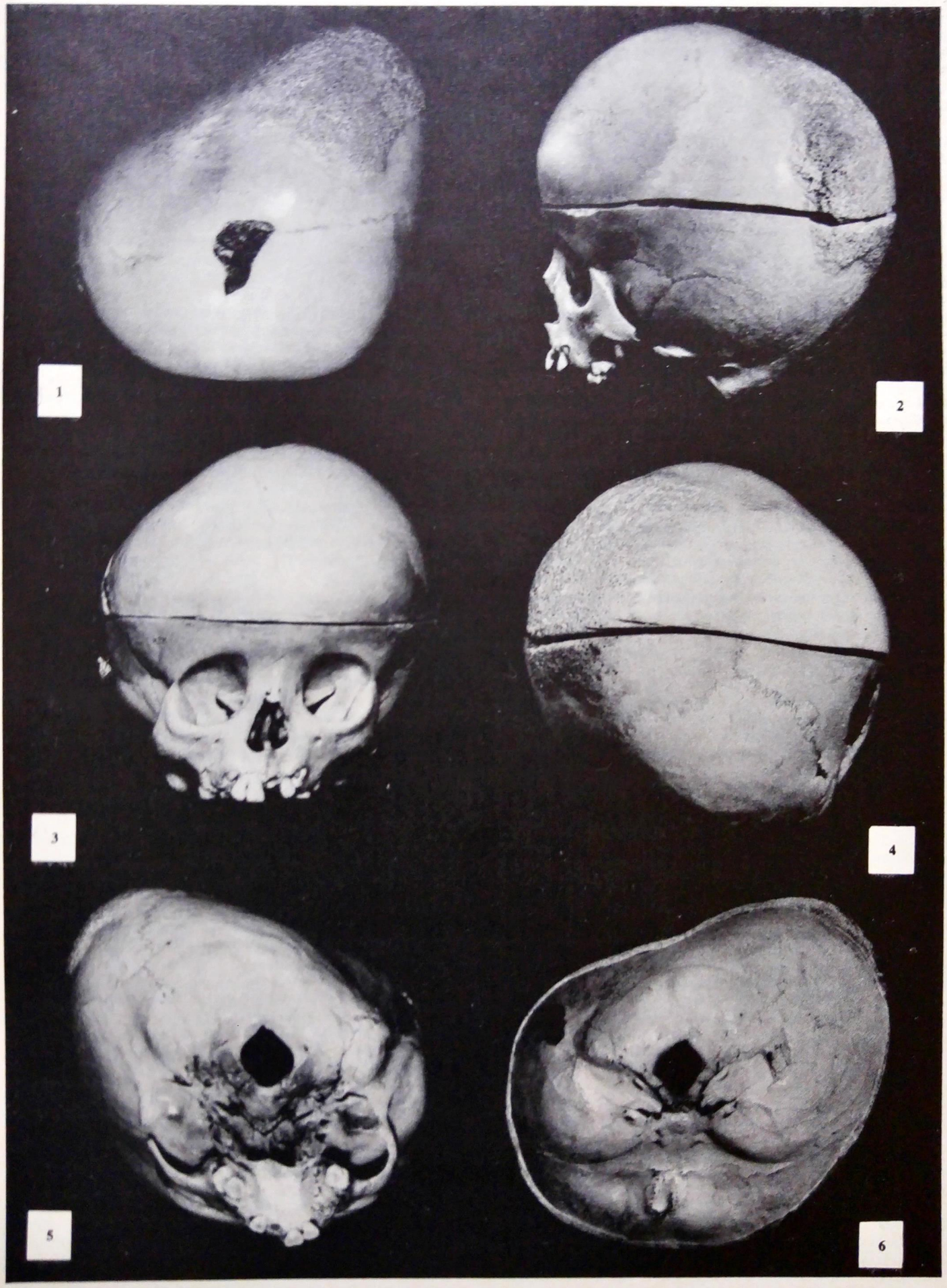

FIGURE 1. *Hydrocephalic skull of eight year-old child. 1. Norma verticalis, 2. Norma lateralis, 3. Norma frontalis, 4. Norma occipitalis, 5. Norma basilaris, 6. Basis cranii interna.*

axis connecting the dorsal and frontal margins of the foramen occipitale magnum and the axis leading in the elongation of the sutura palatina mediana do not form a straight line, both axes meet in a blunt angle. The above described prominent vault of the left half of the cranium is present mostly in the temporal and parietal section. We observe the internal cranial base (*Fig. 1/6*) with the signs of increased intracranial pressure, mostly evident in the region of the sella turcica. The borders limiting the hypophyseal fossa are indistinct, the fossa is widened and elongated.

DISCUSSION

On the basis of the metric examination, it could be stated that nearly all of the external dimensions differ from the mean dimensions of the control group (*Table 1*). Of the 16 evaluated dimensions, 11 are higher, with statistically significant differences (the maximum breadth of the neurocranium and basion-bregmatic height are significantly enlarged). Two dimensions are smaller (maxillar lenght and breadth) and only 2 dimensions correspond to those of the control group (the maximum length of the neurocranium and the nasal breadth). From six evaluated neurocranial arches, 5 are significantly larger, only the occipital vault (arch) is the same as in the control group (*Table 1*).

Twenty dimensions were followed and evaluated on the cranial base of the hydrocephalic skull. From 7 longitudinal dimensions, 3 larger and 2 smaller ones were of statistical significance. After the evaluation of longitudinal dimensions it could be summarized that the greatest elongation occurred in the anterior and middle cranial fossae. Significant changes were found in the breadth dimensions of the cranial base. Of the 13 dimensions, 9 were larger and from this number 7 dimensions had different statistical significances (the endocranial breadth is strikingly enlarged). A prominent widening of the cranial base appeared in the anterior and medial fossae.

SUMMARY

The facial part of the studied hydrocephalic skull does not show any significant enlargement. The whole neurocranium is on the contrary striking with its significant size. Evidence of it are the dimensions found. Greatest are the breadth of the neurocranium 170 mm, basion-bregmatic height 180 mm and the horizontal circumference (590 mm). The measured capacity of the skull, 2 625 ccm, is nearly two times that of the capacity found in the control group of children's skulls. The cranial base is mostly enlarged in the region of the anterior and medial fossae. Ventrodorsal elongation of the base is less evident and affects mostly the frontal parts. Prominent deformation and asymmetry of the cranial vault is caused not only by an anomalous growth of the brain but also by the premature synostosis of the larger part of the sagittal suture.

The described changes in the proportions of the neurocranium and splanchnocranium in the studied hydrocephalic skull are in accordance with the conclusions and observations done by other authors (Doskočil 1960, Richards et al. 1991).

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