

# FOURTH VENTRICLE COMPUTED TOMOGRAPHY INDEXES

## Standardisation and characteristics in neurocysticercosis

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**ABSTRACT - Objectives:** to propose standardisation of fourth ventricle dimensions and to study its characteristics in neurocysticercosis. **Method:** a control group (CG) constituted by 114 individuals with normal CT, and 80 patients with neurocysticercosis composed the group with neurocysticercosis (GN). Measures of the inner cranial diameter (Cr), fronto-polar distance between both lateral ventricles (FP), antero-posterior (AP) and latero-lateral (LL) fourth ventricle width based the standardisation of six indexes. **Results:** AP/Cr, AP/LL and AP/FP were the more discriminative indexes, presenting in CG the mean values of 0.063, 0.267 and 0.582, respectively. The indexes in GN had values statistically higher than in CG. From GN, 51 patients had increased indexes values above 2 standard deviation of the CG mean. AP/LL was  $\geq 1$  in 95% of patients with ventricular shunting and in 88% with depression. It also occurred in 73% patients with satisfactory follow-up and in everybody who died. **Conclusion:** AP/Cr, AP/LL and AP/FP may represent fourth ventricle dimensions.

**KEY WORDS:** fourth ventricle, indexes, computed tomography, standardisation, neurocysticercosis.

### Índices do IV ventrículo em tomografia computadorizada de crânio: padronização e características na neurocisticercose

**RESUMO - Objetivos:** propor padrão de normalidade das dimensões do IV ventrículo e estudar suas características em neurocisticercose. **Método:** em um grupo controle (GC) constituído de 114 indivíduos com tomografias normais e em outro grupo composto de 80 doentes com neurocisticercose (GN), mediram-se a distância fronto-polar de ventrículos laterais (FP) e os diâmetros craniano interno (Cr), ântero-posterior (AP) e látero-lateral (LL) do IV<sup>o</sup> ventrículo para a padronização de seis índices. **Resultados:** AP/Cr, AP/LL e AP/FP foram os índices mais discriminatórios e apresentaram, em GC, valores médios de 0,063, 0,267 e 0,582, respectivamente. Em GN os valores foram estatisticamente superiores a GC. Selecionaram-se 51 doentes do GN com índices  $\geq 2$  desvios-padrão da média em GC. Neles, AP/LL foi  $\geq 1$  em 95% doentes com derivação líquórica e em 88% com depressão, ocorrendo em 73% com evolução satisfatória e todos que faleceram. **Conclusão:** AP/Cr, AP/LL e, principalmente, AP/FP são representativos das dimensões do IV ventrículo.

**PALAVRAS-CHAVE:** IV ventrículo, índices, tomografia computadorizada, padronização, neurocisticercose.

The isolated fourth ventricle (IV<sup>thv</sup>), also referred in the literature as occluded, trapped, sequestered, encysted, disproportionately large, double compartment hydrocephalus, or communicant IV<sup>thv</sup>, is a clinical-pathological entity firstly described by Foltz & Shurtleff<sup>1</sup>, in 1966. Although pathogenesis remain in the field of controversies, this picture could happen as before as after the installation of ventricular shunting<sup>1,2</sup>. Clinical manifestations are variable, happening from an acute posterior fossa syndrome, sometimes associated with abrupt alterations of the humour<sup>3</sup>, until a progressive dilation of IV<sup>thv</sup> as a

casual computerized tomography (CT) finding<sup>4</sup>. Usually, the diagnosis occurs in the presence of IV<sup>thv</sup> dilation being the other cameras moderately increased or normal<sup>5</sup>. Before the advent of CT, the diagnosis was possible through the gaseous and contrasted ventriculography<sup>6,7</sup>, always in the field of the subjectivity, and becoming very difficult in borderline situations. In the attempt to give more objectivity to the diagnosis, Evans<sup>8</sup> proposed an index to define the hydrocephalus degree. The searched literature<sup>9-11</sup> has few references on dimensions of the IV<sup>thv</sup>, all of them with different methodologies.

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Cysticercosis is the infection with the metacestode larval form of the parasite *Taenia solium*, characterised by an accentuated tropism for the central nervous system provoking local reactions and/or far from its installation site. The beginning or not of symptoms depends on host-parasite interaction, expressed through an immune response, mediated by immunoglobulins and cytokines, and as a result of multiple associated mechanisms, generating a clinical and laboratory polymorphism. The more frequent clinical manifestations are represented by epilepsy and intracranial hypertension (ICH), associated or not with psychic disturbances and meningoencephalitis. This last has a fundamental role on the formation of hydrocephalus the most important sequel due to the fibrosis in the basal cistern. The epilepsy is characterised by more than one type of crisis and a difficult control of the seizures<sup>12,13</sup>, and could be the first manifestation of hypertensive hydrocephalus, diffuse cerebral oedema, or the effect mass of giant cysts. ICH is a frequent and immediate consequence of the inflammatory reaction, as in the subarachnoid space<sup>14,15</sup>, as in the parenchyma<sup>16,17</sup>, or as a direct response to the physical presence of parasites. Psychic disturbances in neurocysticercosis, could float from mild symptoms like apathy, cognitive disturbances, alterations in the humour and memory, to more severe psychiatric pictures as dementia, depression and schizophrenia<sup>18-22</sup>. Neurological manifestations are generally associated<sup>12,19,21</sup>, and could be one of the signs as of ICH<sup>12,19,23</sup>, as of hypertensive or normal pressure hydrocephalus<sup>19,24,25</sup>.

The objective of this paper is to propose a standardisation for representative indexes of the fourth ventricle dimensions, using traditional CT exams, and to study its characteristics in neurocysticercosis.

## METHOD

This project of research evaluated by the Commission of Ethics in Research of the School of Medicine of Botucatu-UNESP received favourable concept (Of. 086/98 - CEP).

### *Standardisation of fourth ventricle CT indexes (Control Group = CG)*

*Inclusion criteria:* a hazard selection of individuals with normal CT of skull which didn't present in diagnosis nor follow-up evaluation exam any structural lesion (surgical or not) was done. The measures of the lateral ventricles maximum fronto-polar distance (FP), and the largest inner cranial diameter (Cr) in the same slice of the measured FP were in all exams performed (Fig 1B). The largest IV<sup>th</sup>v antero-posterior (AP) width, as well as the latero-lateral (LL) in the same slice of the measured AP (Fig 1C), in all selected exams were measured. When the IV<sup>th</sup>v presented characteristics similar as shown in Figure 1A, the considered value of AP resulted from the arithmetic average of the obtained measures of  $\alpha$  and  $\beta$ . If the patient had more than one CT, the final value of the indexes based on the arithmetic average of all values obtained in all CT of the same patient. Based on the statistical analyst suggestion, only one person using common plastic transparent rule and glass magnifying performed all the measures.

To put into practice the measures proposed above, for AP and LL selected were those slices where the IV<sup>th</sup>v appeared larger and showed (in the same level) the struc-

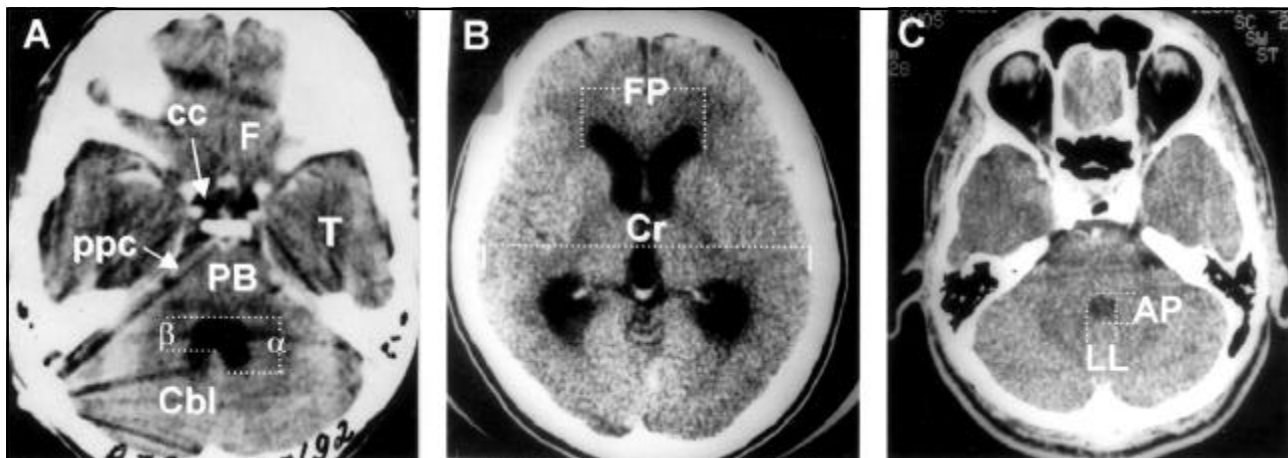


Fig 1. A. Structures which should be present to perform measures of AP and LL : frontal lobes (F), temporal lobes (T), pre-pons (ppc) and/or chiasma cisterns (cc), pons or close to transition pons-bulb (PB), and cerebellum close to middle cerebellar peduncle (Cbl). B. Structures which should be present to perform measures of FP and Cr, and the identification of the maximum distance between frontal horns (FP) and the maximum inner cranial diameter at the same level of the measured FP (Cr). C. Identification of the maximum antero-posterior IV<sup>th</sup>v width (AP) and at the same level of the measured AP the latero-lateral IV<sup>th</sup>v width (LL).

tures presented in Figure 1A. It means that frontal lobes, temporal lobes, pre-pons and/or chiasma cisterns, transition pons-bulb and cerebellum close to middle cerebellar peduncle should be seen in the same slice the IV<sup>th</sup>v was larger. For FP and Cr measures (Fig 1B) selected were those slices where the third ventricle appeared larger and showed (in the same level) the frontal horns of lateral ventricles more distant between itself.

In this way, 114 patients of both sexes (M= masculine and F= feminine), with age varying from 1 to 83 years ( $I_1$  = younger than 19 years,  $I_2$  = 20 to 39 years,  $I_3$  = older than 40 years) were selected. These control patients were gathered in six sex/age subgroups ( $MI_1$ ,  $MI_2$ ,  $MI_3$ ,  $FI_1$ ,  $FI_2$ ,  $FI_3$ ). The analysed CT exams are part of the Service of Computed Tomography of the Hospital of the Clinics of the School of Medicine - UNESP files. The exams had performed with CT 9800 Q model General Electric equipment.

**Exclusion criteria:** patients with absence of CT contrasted phase and presenting problems in the clearness for the identification of IV<sup>th</sup>v limits were excluded. CT scans showing asymmetrical head position and presence of any detectable lesion even if all the other CT of the same patient has been normal had also excluded from this study. The uncertainty in the diagnosis of normality expressed by just descriptive report without any conclusion, and divergence between the Radiology and Neurology opinion were also considered as exclusion criteria.

To evaluate the IV<sup>th</sup>v involvement FP/Cr, AP/Cr, LL/Cr, AP/FP, LL/FP, and AP/LL indexes constituted were compared.

**Statistical analysis:** based on analysis of variance to verify sex (M and F) and age group ( $I_1$ ,  $I_2$  and  $I_3$ ) effects. Descriptive statistics to obtain arithmetic average ( $\bar{x}$ ), standard deviation (sd), coefficient of variation (CV), median (Md), minimum and maximum values of each studied variable, and coefficients of lineal correlation for evaluation between couple of variables were utilised. Application of F statistic to compare groups for the group of variables was executed<sup>26</sup>.

#### *Group with neurocysticercosis (GN)*

**Inclusion criteria:** patients presenting the diagnosis of neurocysticercosis accomplished by at least one CT before and another after therapeutic schedule with albendazole (ABZ) and dextrochlorpheniramine (DCP). Thus, could be selected 80 patients that formed the GN, constituted by 8 patients in  $MI_1$ , 22 in  $MI_2$ , 16 in  $MI_3$ , 4 in  $FI_1$ , 20 in  $FI_2$  and 10 in  $FI_3$ . Except for normal CT, the above CG mentioned inclusion criteria were included. Diagnosis of neurocysticercosis<sup>27</sup> based mainly on evidence of lesions suggestive of neurocysticercosis on neuroimaging studies. In addition, positive cerebrospinal fluid (CSF) immunologic tests for the detection of anticysticercal antibodies (before, during or after specific therapy), symptoms improvement or remission as well as disappearance of

intracranial lesions after a trial with ABZ + DCP, were employed.

The presence of at least one of the three IV<sup>th</sup>v representative indexes with increased values defined the IV<sup>th</sup>v involvement. In that way, it was possible to select 51 patients from GN that constituted the group of neurocysticercosis with involvement of IV<sup>th</sup>v (GN-IV<sup>th</sup>v). Age, sex, clinical manifestations, depression and association with representative indexes of IV<sup>th</sup>v were the parameters studied in the three forms of clinical evolution: good (GEv), with sequel (SEv) and death (DEv).

**Exclusion criteria:** patients that filled the same exclusion criteria previously mentioned for CG, and had not the above mentioned diagnostic criteria for neurocysticercosis were excluded from this study. In other words, presenting nothing but associated subcutaneous cysticercosis, just intracranial calcifications on CT, impossibility to perform CSF exams or immunologic tests, did not participate in this study.

**Standardisation of terms:** *Index increase* = index with obtained value higher than two standard deviation of the statistical average found in the studied controls. *Depression* = presence almost daily, during more than two weeks, of four or more of the following manifestations: discouragement or depression, apathy, decrease or increase of appetite, voluntary isolation, floating and silent cry, increase or loss of sleep. *Parinaud's syndrome* = paralysis or paresis of the upper gaze with alteration in the ocular convergence but conservation of the eyes of doll phenomenon. *Good evolution* = patients that came back to the normality of their habitual and personal activities, without need of any type of help, using or not symptomatic medication. *Evolution with sequel* = patients that stayed with partial or total dependence for the execution of their habitual and personal activities, using or not symptomatic medication.

## **RESULTS**

Tables 1-3 and Figure 2 present the results.

In CG, the rate of classification error was 17.54%. The  $MI_2$  subgroup showed statistical significant correlation ( $p < 0.05$ ) with AP/Cr, LL/Cr, AP/FP and LL/FP indexes. In  $MI_3$ , this correlation occurred with FP/Cr ( $p < 0.05$ ), LL/FP ( $p < 0.01$ ) and, in  $FI_1$ , just with LL/FP ( $p < 0.01$ ). The indexes didn't showed significant correlation ( $p > 0.05$ ) with the  $MI_1$ ,  $FI_2$  and  $FI_3$  subgroups. Statistical analysis of the obtained data considered the indexes AP/Cr, AP/FP and AP/LL the most discriminatory.

The studied indexes did not present significant statistical difference between CG and GN, and in the subgroups ( $F = 0.74$ ;  $p > 0.10$ ). The before and after periods related to the ABZ + DCP therapy also

Table 1. Fourth ventricle indexes: significant statistical correlation in subgroups of the control group.

Subgroups Indexes	MI <sub>1</sub> (n= 25)	MI <sub>2</sub> (n= 20)	MI <sub>3</sub> (n= 17)	FI <sub>1</sub> (n= 16)	FI <sub>2</sub> (n= 19)	FI <sub>3</sub> (n= 17)
FP/Cr and AP/Cr	-	-	-	-	-	-
FP/Cr and LL/Cr	-	-	-	-	-	-
FP/Cr and AP/FP	- 0.57 **	- 0.46 *	- 0.82 **	-	-	-
FP/Cr and LL/FP	- 0.59 **	- 0.57 **	- 0.84 **	-	-	- 0.59 *
FP/Cr and AP/LL	-	-	-	-	-	-
AP/Cr and LL/Cr	0.77 **	0.83 **	-	-	0.62 **	0.84 **
AP/Cr and AP/FP	0.80 **	0.93 **	0.81 **	0.93 **	0.93 **	0.99 **
AP/Cr and LL/FP	0.60 **	0.74 **	-	0.61 **	0.62 **	0.76 **
AP/Cr and AP/LL	0.64 **	0.57 **	0.80 **	0.74 **	0.76 **	0.87 **
LL/Cr and AP/FP	0.53 **	0.87 **	-	-	0.52 *	0.87 **
LL/Cr and LL/FP	0.72 **	0.94 **	0.56 *	0.83 **	0.85 **	0.96 **
LL/Cr and AP/LL	-	-	-	-	-	-
AP/FP and LL/FP	0.82 **	0.89 **	-	0.74 **	0.70 **	0.84 **
AP/FP and AP/LL	0.63 **	0.42 *	- 0.67 **	0.69 **	0.74 **	0.82 **
LL/FP and AP/LL	-	-	-	-	-	-

n= number of patients. \* p < 0.05; \*\* p < 0.01.

Table 2. Fourth ventricle indexes: statistical analysis among the obtained values in the control group (CG) and the group with neurocysticercosis (GN).

Indexes	CG $\bar{x} \pm sd$	GN $\bar{x} \pm sd$	Statistic	Significance level	Comments
FP / Cr	0.244 ± 0.034	0.257 ± 0.041	5.98	p < 0.05	CG < GN
AP / Cr	0.063 ± 0.020	0.082 ± 0.037	19.17	p < 0.001	CG < GN
LL / Cr	0.109 ± 0.026	0.102 ± 0.034	2.37	p > 0.10	CG = GN
AP / FP	0.267 ± 0.100	0.323 ± 0.143	10.19	p < 0.010	CG < GN
LL / FP	0.458 ± 0.136	0.409 ± 0.139	5.95	p < 0.025	CG > GN
AP / LL	0.582 ± 0.139	0.797 ± 0.213	72.29	p < 0.001	CG < GN

Multivariable analysis for comparison of groups: F = 13.26; p < 0.001.

Table 3. Fourth ventricle indexes: comparison between control group (CG) and the group with neurocysticercosis (GN) subgroups, before (NB) and after (NA) albendazole plus dextrochlorpheniramine therapy.

Subgroups Indexes	MI <sub>1</sub>	MI <sub>2</sub>	MI <sub>3</sub>	FI <sub>1</sub>	FI <sub>2</sub>	FI <sub>3</sub>
FP / Cr	CG = NB CG = NA	CG < NB <sup>1</sup> CG ≤ NA <sup>3</sup>	CG = NB CG = NA	CG = NB CG = NA	CG = NB CG = NA	CG < NB <sup>1</sup> CG = NA
AP / Cr	CG < NB <sup>1</sup> CG = NA	CG = NB CG = NA	CG < NB <sup>2</sup> CG < NA <sup>1</sup>	CG = NB CG = NA	CG = NB <sup>2</sup> CG < NA <sup>2</sup>	CG < NB <sup>2</sup> CG ≤ NA <sup>3</sup>
LL / Cr	CG = NB CG = NA	CG > NB <sup>1</sup> CG = NA	CG = NB CG = NA	CG = NB CG = NA	CG = NB CG = NA	CG = NB CG = NA
AP / FP	CG < NB <sup>1</sup> CG = NA	CG = NB CG = NA	CG = NB CG = NA	CG = NB CG = NA	CG = NB <sup>1</sup> CG < NA <sup>1</sup>	CG ≤ NB <sup>3</sup> CG = NA
LL / FP	CG = NB CG = NA	CG > NB <sup>1</sup> CG = NA	CG = NB CG = NA	CG = NB CG = NA	CG = NB CG = NA	CG = NB CG = NA
AP / LL	CG < NB <sup>4</sup> CG < NA <sup>1</sup>	CG < NB <sup>4</sup> CG < NA <sup>1</sup>	CG < NB <sup>1</sup> CG < NA <sup>1</sup>	CG = NB CG = NA	CG < NB <sup>1</sup> CG < NA <sup>1</sup>	CG < NB <sup>4</sup> CG ≤ NA <sup>3</sup>

<sup>1</sup> p < 0.05; <sup>2</sup> p = 0.05; <sup>3</sup> 0.05 < p < 0.10; <sup>4</sup> p < 0.001

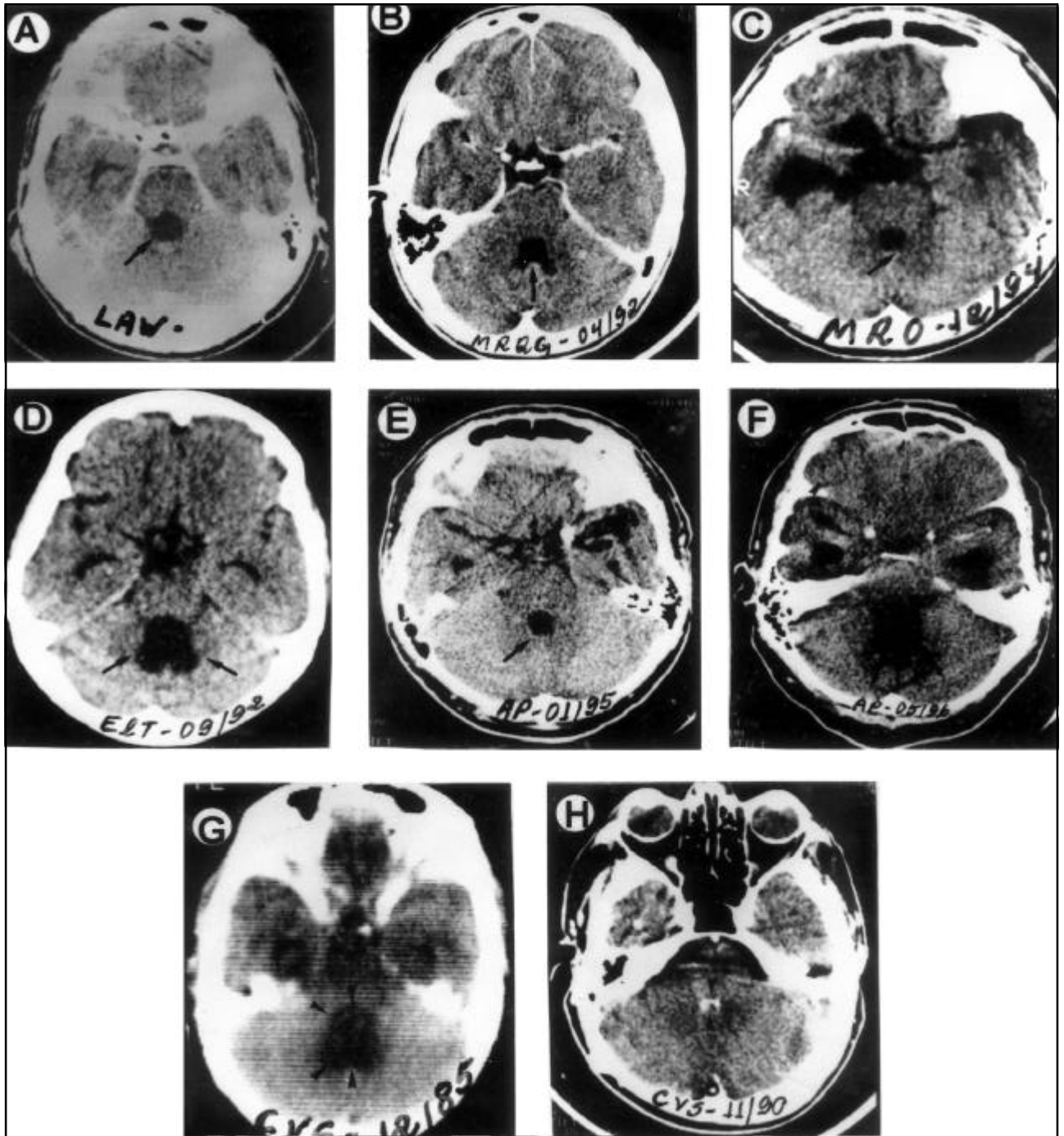


Fig 2. **A and B.** CT of patients with good evolution showing round aspect IV<sup>thv</sup> (A) or like "coconut hat" (B). These characteristics presented normalisation in 27 (80%) patients. Three patients had CT suggestive of IV<sup>thv</sup> cyst in two of them and, in the lateral ventricle, in one. **C and D.** CT of patients with sequel showing round aspect IV<sup>thv</sup> (C) or like "indigenous canvas" (D). Patients with the characteristic of C presented normalisation of the aspect associated to improvement of the sequels, in all the patients. Patients with the characteristics of D, stayed unaffected, being observed correlation clinic/CT in those with worsening or maintenance of sequels. Two patients had CT suggestive of IV<sup>thv</sup> cyst. **E, F, G and H.** Five patients with fatal evolution showed round IV<sup>thv</sup> on CT (E) with maintenance or progressive antero-posterior diameter increase (F) of this characteristic. In the other four patients, CT showed accentuated increase of IV<sup>thv</sup> before the cysticidal therapy (G), followed by regression (H) of its size after albendazole treatment plus ventricular shunting. Patients with the characteristics of H had another IV<sup>thv</sup> increase 2 months to 2 years after therapeutic schedule. All the nine patients presented constant changes in their IV<sup>thv</sup> dimensions.

did not present difference (FP/Cr:  $p > 0.50$ , AP/Cr:  $p > 0.50$ , LL/Cr:  $p > 0.40$ , AP/FP:  $p > 0.50$ , LL/FP:  $p > 0.50$ , AP/LL:  $p > 0.30$ ). Except for the indexes LL/Cr and LL/FP, the others (AP/Cr, AP/FP and AP/LL) showed more higher values in GN than in GC ( $F = 13.26$ ;  $p < 0.001$ ).

In the GN-IV<sup>thv</sup>, the patient age varied from 12 to 72 years, with prevalence of men (57%) and age group of 21-40 years (49%). ICH (55%), meningoencephalitis (49%), hydrocephalus (45%), epilepsy (41%), vascular disorders (12%), chronic cerebral oedema (8%), mental disorders (8%) and spinal cord involvement (8%), were the isolated (10%) or associated (90%) presentation of clinical manifestations. Had good evolution 34 (67%) patients, 8 (15%) developed or stayed with sequels, and 9 (18%) died one to 19 months after the end of the therapeutics with ABZ. Epilepsy (56%), ICH (38%) and meningoencephalitis (35%), in this order, were the more frequent clinical pictures presented by patients with GEv. ICH (75%), hydrocephalus (62%) and meningoencephalitis (50%) were more common in patients with SEv. ICH associated to hydrocephalus happened in everybody who died.

Depression was verified in 30 (59%) patients, 17 (57%) men and 13 (43%) women. It was associated to Parinaud's syndrome in 18 (60%), committing 13 (43%) patients with GEv and everyone with SEv or DEv. In 14 (27%) patients, all presenting GEv, depression and Parinaud's syndrome did not occur. The depressive picture presented own characteristics depending on the type of evolution. Patients with GEv showed floating manifestations, revolt feeling for the medication need, spontaneous and easy externalisation of the sentiments, besides a good response to the common anti-depressive drugs. Patients with SEv presented more sporadic although more lingering periods of depression characterised by negative reaction to the presence of sequel and being verified an association between improvement of the sequel and regression of the depression. Connotation of bitterness, sensation of irreversibility and a nostalgia feeling was characteristics of the depression of patients who died, besides any therapeutic response to anti-depressive drugs. This kind of depression appeared 2-8 weeks before death, when the manifestations become sudden and progressively more intense and was followed by the installation of severe infectious processes.

Patients with GEv showed a discreet and temporary Parinaud's syndrome, although in four of them it acquired characteristic of periodicity and consisted of paresis of the upper vertical gaze. The same hap-

pened in those with SEv. Parinaud's syndrome verified in those who died happened as paralysis of the upper vertical gaze, associated to ophthalmoplegia during the episodes of ICH exacerbation.

Twenty-one (41%) patients had ventricular shunting. Depression and/or Parinaud's syndrome were present in four (19%) patients with GEv even before this surgical procedure. However, in 17 (81%) cases, depression and/or Parinaud's syndrome appeared only after surgery, predominantly in those patients who died.

Two (6%) patients with GEv, one (12%) with SEv, and six (67%) with DEv had the typical CSF syndrome in neurocysticercosis. Normal CSF exam was verified in 10 (29%) patients with GEv, in one (12%) with SEv, and in none with DEv.

The exclusive increase of the AP/LL index was observed in 22 (65%) patients with GEv, in five (62%) with SEv and in seven (78%) with DEv. The increase of the FP/Cr index, suggestive of supratentorial hydrocephalus, was associated to the increase of the discriminatory indexes in one (3%) patient with GEv, in another (12%) with SEv and in seven (78%) with DEv.

Just one of the three indexes was increased in 40 (78%) patients, two in 20 (32%), and all the three in 16 (31%). This increase was exclusively due to AP/LL in 34 (67%) cases and associated with AP/Cr and/or AP/FP in 17 (33%). All the three discriminatory indexes were increased so much before as after cysticidal therapy in 23 (45%) patients: in 14 (41%) of them with GEv, in three (37%) with SEv and in six (67%) who died.

The index AP/LL > 1 was found in all the patients with clinical picture of benign intracranial hypertension or psychiatric alterations as the first and most important manifestation. It also occurred in 86% patients with ICH and cerebrovascular disturbances, in 74% with hydrocephalus, in 71% with epilepsy, in 64% with meningoencephalitis, and in 50% with migraine-like headache or spinal cord involvement. AP/LL > 1 was associated to the depression in 26 (87%) patients and it happened before ABZ + DCP treatment in 37 (72%), after this one in 36 (71%) and, so much before as after, in 13 (25%). From these last 13 cases, eight (23%) of them presented GEv and five (55%) died.

## DISCUSSION

Evaluation of extension of the ventricular involvement should base on an ideal combination of measures that include the different brain areas and not just based in the subjectivity of the personal experience. In this study, CT measures of the IV<sup>thv</sup> had as

normal, those individuals which presented some neurological complaint and whose CT had normal medical reports. It is not possible to accomplish radiology exams in people not having mental or neurological symptoms without hurting ethical precepts when submitting healthy individuals without any clinical manifestation to an unnecessary exhibition of radiation. Consequently, the concept of normality, adapted inside for the values of the interval of two standard deviation of the statistics average of the studied indexes, is a questionable term and it would be more appropriate to say "acceptable as not-altered".

Due to the variability in the size of the films and in the head angularity of the accomplished exams impeding the uniformity of direct measures for the study of IV<sup>thv</sup>, it was necessary to establish indexes. The FP/Cr index just has reference in the literature, with the denomination of index of Evans<sup>8, 11, 28-30</sup>, presenting similar values to the found in the studied individuals.

The CSF spaces global analysis doesn't suggest correlation among measures and age<sup>9, 31</sup>. On the other hand, the IV<sup>thv</sup> shows a continuous and progressive increase with passing of the years<sup>11</sup>. Although the analysed indexes had not shown correlation with sex and age, the individual statistical analysis suggests that the AP/Cr, LL/Cr, AP/FP and LL/FP indexes increase ( $p < 0.05$ ) during men lifetime. On the other hand, the LL/FP index decreases ( $p < 0.01$ ) in men above the 39 years and in women until 19 years. The only index that doesn't suffer influences of age and of sex it is AP/LL. Possibly volumetric differences in the neuroaxis explain these observations<sup>9, 11, 28, 29</sup>.

In other words, it is possible to say that the IV<sup>thv</sup> involvement but not its isolation manifest through the AP/FP, AP/Cr and AP/LL indexes - the discriminatory indexes. The presented data show that the AP/LL index doesn't depend on the presence of supratentorial hydrocephalus nor of the inner cranial diameter, and doesn't suffer influence of age or sex. Consequently, the AP/LL index can be considered "the fourth ventricle sentinel", besides being its more representative index.

The searched literature didn't show any reference on the methods to identify an isolation of fourth ventricle except for the subjective evaluation, nor the manner to characterise its involvement. Even so, several neurological pathologies are related to IV<sup>thv</sup> enlargement including neurocysticercosis<sup>5, 32, 33</sup>.

The ventricular inflammatory process seems to

be reflected in the elevated values of the indexes AP/Cr ( $p < 0.001$ ), AP/FP ( $p < 0.010$ ) and AP/LL ( $p < 0.001$ ) in patients with neurocysticercosis when compared to the control group. Even so, the LL/Cr and LL/FP indexes were, respectively, equal ( $p = 0.10$ ) and smaller ( $p < 0.025$ ).

Patients with neurocysticercosis presenting increased the three discriminatory indexes showed that the fourth ventricle became isolated definitively in those who died, lingering but passenger in those with sequels, and of smaller intensity and fleeting in those who had satisfactory evolution. Although it has no difference with between before and after ABZ + DCP therapy, the indexes values did not alter in patients with good evolution, decreased in those with sequels and increased in the cases who died. The AP/LL<sup>31</sup> showed an association with more severe clinical pictures and difficult therapeutic control, and it was present in most of the patients with depressive manifestations. Its value above the unit seems to suggest not only a suffering IV<sup>thv</sup> but also a premonitory sign of its temporary or definitive isolation. In neurocysticercosis it can be considered as an prognostic index when depression is present and AP/FP or AP/Cr have increased values.

The IV<sup>thv</sup> involvement in neurocysticercosis could take place so much for a possible neurotropism of cysticerci antigens as for local biochemical alterations related to the presence of these antigens. It seems that many factors take part of a context involving complex and multivariable mechanisms perhaps modulated by genetic factors. Depression and immunodeficiency have serotonin<sup>34</sup> as a common biochemical substratum, with serotonergic neurons located on brainstem. Perhaps it can exist, mainly in the serious forms of neurocysticercosis, some type of preferential lesion for the serotonergic system or for some modulating neurotransmitter system<sup>21</sup>. Depression and immunodeficiency occurred in the patients with neurocysticercosis who didn't have good evolution.

The presented data suggest be the depression associated with increased indexes a signal to worsen clinical evolution mainly if Parinaud's syndrome is also present. The reversibility of manifestations observed in the patients with good evolution and in some of those with sequels suggest a metabolic disturbance due to oedema directly against the ventricular system and not to a destructive lesion<sup>35</sup>.

When the symptoms referred by the patients with neurocysticercosis improved or disappeared, the in-

dexes return to normal values. However increased values of indexes, mainly the AP/LL, were more evident in patients who died possibly, due to the fact that severe patients have accomplished more CT, contributing to a more easy detection of increases.

The presented data allow to conclude that: 1) The AP/Cr, AP/FP and AP/LL indexes can be considered as discriminatory indexes of the fourth ventricle, being AP/LL the sentinel index. 2) Increased value of one of the discriminatory indexes can suggest a beginning or a resolution of a fourth ventricle involvement. The increased values of two of the discriminatory indexes suggest a current involvement or a possible incipient isolation. The increase of the three discriminatory indexes is compatible with isolated fourth ventricle and the certainty of its involvement. 3) AP/LL and FP/Cr when increased together suggest a partial isolation of fourth ventricle, or hydrocephalus of double compartment. 4) The isolated fourth ventricle can be characterised by the fourth ventricle involvement syndrome linked to perseverance of the AP/LL index<sup>3</sup> 1 in two or more exams, associated or not with the increase of AP/Cr and AP/FP indexes. 5) The fourth ventricle involvement syndrome may be defined as an association of hydrocephalus (with or without ventricular shunting), depression, clinical polymorphism, temporary or persistent Parinaud's syndrome, typical CSF syndrome and, at least, one of discriminatory indexes in evolutionary CT exams. 6) The incomplete fourth ventricle involvement syndrome, regression of one or more of its components, and lower number of discriminatory indexes, are factors that suggest a better clinic evolution. 7) The perseverance in the format and the rounded characteristic of fourth ventricle as CT evolutionary aspects suggest a better prognostic than its variability.

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