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L Kornreich, A Shapira, G Horev, Y Danziger, S Tyano and M Mimouni

AJNR Am J Neuroradiol 1991, 12 (6) 1213-1216
http://www.ajnr.org/content/12/6/1213

CT and MR Evaluation of the Brain in Patients with Anorexia Nervosa

Liora Kornreich[1]
Abraham Shapira[2]
Gadi Horev[1]
Yardena Danziger[3]
Shmuel Tyano[2]
Marc Mimouni[3]

Thirteen adolescent girls with anorexia nervosa had MR imaging of the brain; 11 were also examined by CT. Fifteen children, ages 10–12 years, served as a control group. The CT and MR studies were evaluated qualitatively for cortical and central atrophic changes. CT detected sulcal and ventricular enlargement in 5/11 patients. On the MR images, enlarged sulci were seen in 10/13 and dilated ventricles in 5/13. In the anorectic patients, the range of the width of the third ventricle was 1–5 mm (mean, 3.2 mm) and the maximal distance between the anterior horns was 22.5–39.0 mm (mean, 30.0 mm). Anterior horns at their minimal width measured 11–30 mm (mean, 16.5 mm). The corresponding measurements in the control group were 1.5–3.5 mm (mean, 2.3 mm) for the third ventricle, 21–35 mm (mean, 28.5 mm) for the distance between the anterior horns, and 10–16 mm (mean, 12.8 mm) for their minimal width. Overall, the patient group had larger ventricles than the control group; however, the difference between the two groups was not significant. Measurement of the number of visible cortical sulci at one cut below the vertex yielded 2–11 sulci in the anorectic girls (mean, 6.6) versus 0–6 sulci (mean, 3.3) in the controls. These results are statistically significant ($p = .0009$), indicating peripheral volume loss in the anorectic patients. The MR examination did not reveal any additional structural or parenchymal changes when compared with the results of the CT studies. However, the pituitary glands of these patients did not have the expected normal pubertal hypertrophy on the MR examinations. On the contrary, they had a smaller mean height (4.6 mm as compared with 6.4 mm from the literature) and absence of the convex upper margin of the gland.

Apart from the smaller mean height of the hypophysis, MR studies of the brain in anorectic patients did not yield any additional information to that already known from CT studies.

***AJNR* 12:1213–1216, November/December 1991**

CT findings in patients with anorexia nervosa (AN), including atrophic changes in the brain parenchyma, have been described [1–7]. MR provides an additional imaging method for evaluating the parenchymal brain morphology and texture, and has a greater potential than CT to detect white or gray matter abnormalities and smaller mass lesions [8].

The purpose of this prospective study was to evaluate the contribution of MR imaging to the investigation of brain abnormalities in AN and to assess its ability to detect neoplastic or dystrophic changes not yet revealed by CT studies.

A variety of hypothalamic endocrine dysfunctions may occur in AN, but no demonstration of morphologic changes has yet been described [1–7, 9, 10]. We analyzed the size and shape of the pituitary gland in order to detect any imaging sign of pituitary-hypothalamic axis derangement.

Patients and Methods

Thirteen patients with AN seen in the adolescent clinic of the Beilinson Medical Center during the year 1989 were examined by MR imaging. Eleven of these patients had a CT

Received January 2, 1991; revision requested March 4, 1991; revision received May 24, 1991; accepted June 5, 1991.

[1] Department of Pediatric Radiology, Beilinson Medical Center, Petah Tiqva and Tel Aviv University Sackler School of Medicine, Petah Tiqva 49 100, Israel. Address reprint requests to L. Kornreich.

[2] Department of Adolescent Psychiatry, Beilinson Medical Center, Petah Tiqva and Tel Aviv University Sackler School of Medicine, Israel.

[3] Department of Pediatrics, Beilinson Medical Center, Petah Tiqva and Tel Aviv University Sackler School of Medicine, Israel.

0195-6108/91/1206-1213

study of the brain as well. The two imaging examinations were performed within 1 week of each other. The diagnosis of AN was based on the criteria listed in the *Diagnostic and Statistical Manual of Mental Disorders* [11].

All patients were females and presented with amenorrhea. The pertinent clinical data are summarized in Table 1.

The initial intent was to compare the MR studies of the anorectic girls with a control group of healthy adolescents. However, not enough "normal MR examinations" for statistical evaluation could be found in our records. Therefore, we were forced to refer to a CT-based control group. A group of 15 children (six males and nine females), 10–12 years old (mean, 12 years), who had had CT for sinusitis served as a control population. All the examinations were considered normal.

The CT studies were obtained on an Exel 1800 (Elscint, Haifa, Israel), and the majority were performed after IV administration of contrast medium when the referring physician wished to exclude a possible malignancy. Axial scans were obtained with a slice width of 5 mm and an increment of 8 mm.

Two experienced pediatric radiologists (blinded to the clinical status of the patients) evaluated the imaging studies. The CT scans were studied for cortical and central atrophic changes. To evaluate the changes, a rating system was used whereby the most severe degree of atrophy in this group was classified as grade 3, moderate atrophy as grade 2, and slight atrophy as grade 1.

A modification of the method designed by Huckman et al. [12] was used for the quantification of cerebral atrophy. Their method is based on the measurements of the following four parameters: the maximal distance between the frontal horns of the lateral ventricles, the width of the two lateral ventricles just anterior to the third ventricle, the width of the third ventricle, and the total width of the four largest cortical sulci seen in the highest three tomographic cuts. Owing to technical problems, we had to modify this last parameter. It is known that in adolescents widening of the cortical sulci should not be detected [4, 13]. In fact, the majority of visible sulci are narrower than 1 mm, making their measurement unreliable. Therefore, instead of measuring the sulcal width, we counted the number of visible sulci at one cut below the vertex at a constant gray-scale window. These measurements were compared with those of the control group (Table 2).

Informed consent was obtained prior to studying the anorectic patients. All MR examinations were performed on a 0.5-T MR imager (Elscint Gyrex 5000, Haifa, Israel). Sagittal scans with short TR/TE sequences (400/12/2) (TR/TE/excitations), as well as axial scans with short TR/TE (550,600/27) and long TR/TE (1800,2000/30,90) sequences were acquired. The slice width was 6 or 7 mm; the matrix was 220 or 256 × 256, with two signal averages. The MR findings were evaluated for the presence of hypothalamic structural changes and parenchymal dystrophic changes.

The height of the pituitary gland was measured in the midline sagittal short TR acquisition, and the configuration of its upper margin was classified according to the recent work of Elster et al. [14] (grade 1 = significantly concave, 2 = mildly concave, 3 = flat, 4 = mildly convex).

Owing to the unavailability of a normal control group, no measurements of the CSF compartments were made on the MR studies. However, the visual qualitative evaluation of the atrophy was compared with the CT grading.

TABLE 1: Clinical Information for 13 Patients with Anorexia Nervosa

Case No.	Age at Examination (years)	Duration of Illness (years)	Percent Underweight at Admission	Percent Underweight at Examination	Comments
1	18	1	30	13	
2	15	3⅓	25	+37	Bulimia following anorexia
3	16	1½	24	24	
4	16	2	28	7	
5	14¾	7⅔	20	10	
6	14	1¼	10	15	
7	16	1	10	9	
8	16⅓	3	38	41	
9	12½	1	30	6+	Recovery
10	14¼	2½	35	0	Recovery
11	13⅔	1	32	32	
12	14⅔	4	20	6	
13	15	1	18	15	
Mean	15	2½	24%	14.8	

TABLE 2: CT Measurements (mm) of the Cerebrospinal Compartments

	Patients (n = 11)	Controls (n = 15)	p
Third ventricle			
Range	1–5	1.5–3.5	
Mean	3.2	2.3	.6
SD	1.42	0.73	
Anterior horn width			
Range	22.5–39.0	21–35	
Mean	30.0	28.5	.8
SD	5.6	3.6	
Anterior horn at caudate			
Range	11–30	10–16	
Mean	16.5	12.8	.1
SD	7.1	1.7	
No. of visible sulci			
Range	2–11	0–6	
Mean	6.6	3.3	.0009
SD	2.6	1.6	

Note.—SD = standard deviation.

Results

In the control group (as evaluated by the CT studies) the range of the widths of the third ventricle was 1.5–3.5 mm; the maximal width of the anterior horns was 21–35 mm; and the width at the level of the caudate nucleus was 10–16 mm. These results are summarized in Table 2.

CT and MR evaluation of the anorectic patients revealed only three girls with moderate to severe signs of brain atrophy (cases 2, 8, and 13) (Table 3). There was no significant difference between patients and control subjects in the size of the lateral ventricles or the third ventricles. Two patients had ventricular dimensions of 2 SD greater than the control group. These were, in fact, graded as severe enlargement by the qualitative visual evaluation (cases 2 and 13). The number of identified sulci was significantly greater in the anorectic patients (p = .0009). The patients with the largest number of widened sulci were also considered abnormal in the qualitative screening (cases 2, 8, and 13).

The MR studies revealed enlarged sulci in 10 patients (five slight, three moderate, two severe) (Table 3). Widening of the lateral ventricles was noticed in five girls (one slight, one moderate, three severe).

A comparison of the MR and CT ratings of ventricular size

TABLE 3: Evaluation of Parenchymal Loss by CT and MR in 13 Anorectic Patients

Case No.	CT		MR	
	Sulci	Ventricles	Sulci	Ventricles
1	N	N	N	N
2	2	3	2	3
3	N–1	N	N–1	N
4	ND	ND	N	N
5	N	N	1	N
6	N	N	N–1	N
7	N	N	N	N
8	3	3	3	3
9	1	2	1–2	2
10	N	N	N–1	N
11	ND	ND	2	N
12	N	N–1	1	N–1
13	2–3	2–3	2–3	2–3

Note.—Degrees of enlargement: N = normal, 1 = slight, 2 = moderate, 3 = severe; ND = not done.

TABLE 4: Evaluation of the Pituitary Gland by MR in 13 Anorectic Patients

Case No.	Height (mm)	Shape*
1	4	2
2	6	3
3	8	3
4	3	2
5	4	3
6	6	3
7	4	3
8	3	1
9	3	1
10	7	3
11	3	3
12	3	2
13	6	3
Mean	4.6	2.5

* According to [14].

showed them to be in complete accordance; however, the MR findings suggested sulcal enlargement in four patients who were considered normal by CT, and estimated a higher degree of enlargement in an additional patient (Table 3).

High-resolution diagnostic MR images were obtained in all patients. No dysplastic anomaly was observed. The hypophysis and its stalk were visualized in the midline sagittal plane in all patients. The mean height of the gland was 4.6 mm (range, 3–8 mm); the mean grading of shape was 2.5, representing mild concavity of the upper margin or a flat appearance (Table 4). No correlation was found between the size or configuration of the pituitary gland and the severity or duration of the disease. No abnormality was detected in the hypothalamus. The signals obtained from the brain parenchyma were normal and no white matter lesions were noticed.

Discussion

Ethically, it is difficult to get CT scans on adolescent "normal volunteers"; therefore, the control group of the present study is small and not perfectly matched.

The control group was younger (mean age, 12 years) than the anorectic patients (mean age, 15 years); however, previous CT studies have shown no significant difference in the anatomic appearance of the brain in the age range of 12 to 15 years [13].

The present CT findings of CSF-space enlargement in patients with AN corroborate previous reports [1–7, 9]. The larger series demonstrate that sulcal widening is more common than ventricular dilatation [2, 4, 5]. Indeed, in the present group, the number of visible sulci was significantly higher in the anorectic patients while the ventricular dimensions were within the normal range. When comparing the visual evaluation of the CSF compartments by CT and MR, we found that even in this small anorectic group MR seems more sensitive than CT in detecting sulcal enlargement. This may be because MR has a better spatial resolution over the convexity, being free of beam-hardening and streak artifacts.

The differential diagnosis of atrophy in adolescents includes steroid or chemotherapy administration and dehydration [15]. However, none of our patients was undergoing drug treatment or demonstrated any clinical or biochemical changes of dehydration.

Previous investigators have reported a correlation between severity of weight loss [1, 4–6] and/or duration of disease [4] and degree of brain atrophy. Dolan et al. [3], in their study of 25 patients, did not observe any such linkage. In our group, no clear relationship was found between weight loss, duration of illness, and amount of brain atrophy. Only two patients (cases 2 and 13) had ventricular dimensions larger than 2 SD from the mean of the control group; neither of these two anorectic girls was markedly underweight or had protracted disease.

Different hypotheses have been proposed to explain the pathophysiology of brain changes in AN, including alterations in the cellular water distribution due to loss of intracellular proteins [1, 3] and changes in regional glucose metabolism [9]. Neuronal loss with subsequent gliosis in cortical areas was found in postmortem examinations of patients who died from AN [3]. These biochemical and pathologic changes are reflected clinically in impaired neuropsychological function [3, 4]. The possibility of an organic brain lesion as a cause of AN has been suggested [4, 5]. As shown in this study, neither anatomic dysplasia, signs of gliosis, nor gray or white matter abnormalities were detected by MR. Several authors [2, 4–6] pointed to the fact that the atrophic changes of AN show a trend of improvement following weight gain. Complete reversibility is rare [5]. Our patients had only a single examination, so that we are unable to appreciate any sign of amelioration in the subjects who attained normal weight.

A variety of hypothalamic endocrine dysfunctions were described in anorectic patients, with amenorrhea being an obligate symptom [13]. The possibility of a localized hypothalamic abnormality or of neoplasia or degenerative changes is plausible. No such lesions were shown in previous CT reports [1–7], nor in this group, even in the patients who had contrast-enhanced CT. MR did not detect any evidence of hypothalamic abnormality.

A recent report [14] described the occurrence of normal hypophyseal hypertrophy in pubertal girls, characterized by

an increase in the height of the gland and a preponderance of convex upper margins. When comparing the parameters of Elster et al. [14] with those of the anorectic patients in the present series, the latter demonstrated a smaller height and a smaller mean grade, suggesting a "flatter gland." These findings are probably related to the endocrine dysfunction resulting in amenorrhea.

Apart from the smaller mean height of the hypophysis, the screening of the brain with MR in the anorectic patients did not yield any additional information. Even with the availability of MR, the pathogenesis of AN remains an enigma.

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