Adrenoleukodystrophy: Imaging with CT, MRI, and PET

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A patient with adrenoleukodystrophy (ALD) was tested with a series of CT scans, magnetic resonance imaging (MRI), and positron emission tomographic (PET) images. The computed tomographic (CT) scan revealed the classical pattern described in ALD but showed little relation to the clinical presentation and the evolution of the disease. The MRI showed a larger area of abnormality than the one detected with the CT scan and was more sensitive to progression of the disease process. The PET scan done for cerebral blood flow and glucose metabolism showed derangements on gray matter that were not detected with either of the previous tests.

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Adrenoleukodystrophy (ALD), a sex-linked recessive disorder of the nervous system is characterized by widespread demyelination of the cerebral white matter and by adrenal insufficiency. The clinical and pathologic features of the disease have been comprehensively reviewed (*1*).

The computed tomographic (CT) scan has been of prime importance in providing information for the diagnosis of ALD (*2*). Furthermore the typical lesions seen with CT scan, i.e., symmetrical areas of edema-like density surrounding the ventricular trigones with peripheral contrast enhancement have never been observed in any disease other than ALD (*3*). However, the correlation between the clinical symptomatology and the extent and location of the lesions seen on CT is poor. Nor is there a correlation between the extent of the lesions and the duration of clinical evolution (*3*).

Magnetic resonance imaging (MRI) has been shown to have greater sensitivity in detecting cerebral demyelination than the CT (*4*) and appears as a very promising imaging technique for the diagnosis and monitoring of the evaluation of ALD. Preliminary studies done with MRI in these patients show abnormalities which could not be detected with CT scan (*5–8*). Positron emission tomography (PET), being a technique designed for functional imaging (*9*) is well suited to delineate the effects of white matter degeneration on the function of the overlying cortex.

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CASE REPORT

ALD was diagnosed in a 24-yr-old male with a 10-year history of primary adrenal insufficiency who presented with progressive loss of visual acuity. Subsequently, ALD was diagnosed in a cousin. The neuropsychiatric evaluation was unremarkable except for left hemianopsia. A CT scan was done during this first hospitalization. Ten months later a second CT and MRI evaluation was performed. Neurological examination revealed further progression of visual defect and decreased proprioception. Readmission 8 mo later was precipitated by an acute psychosis with paranoid delusions and persecutory auditory hallucinations. At this point visual loss was almost complete. There was severe disruption of proprioception, hypertonicity, bilateral Babinski, and generalized ataxia. Patient was also developing progressive loss of memory and attention span. For this third evaluation a set of CT, MRI and PET studies were obtained.

The CT scans were performed using a whole-body imager GE/9000 and were done with and without contrast material. The CT findings on the first evaluation, 10/24/84 (Fig. 1A), revealed bilateral asymmetric areas of diminished attenuation about the trigones and occipital horns of the lateral ventricles, the splenium of the corpus callosum and the right temporal lobe along the temporal horn. Uniform contrast enhancement is noted at the interface between this active demyelinating process and uninvolved normal brain, a pattern typical of ALD. The second CT scan on 9/5/85 (Fig. 1B) revealed persistent white matter changes, however, the degree of enhancement had decreased. There was no evidence of rostral progression of the demyelinating process into the parietal or

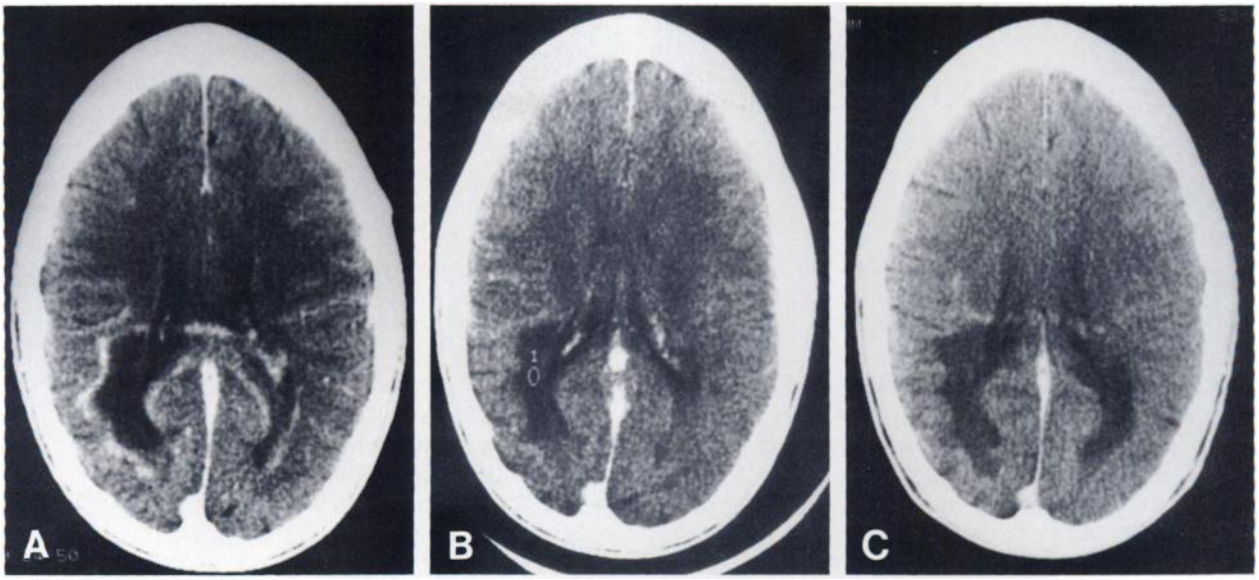

FIGURE 1
A, B, and C: CT scan images with contrast at the level of the centrum semiovale. A: Image taken in 1984 showing areas of decreased density in the white matter at the posterior poles surrounded by the characteristic areas of peripheral contrast enhancement. B: Image taken in 1985 showing similar areas of edema-like density as in 1984 but with a decrease in the peripheral zones of contrast enhancement. C: Image taken in 1986 showing similar areas of involvement to the previous ones.

frontal lobes, calcification in the demyelinated white matter areas or mass effect. The CT done on 4/2/86 (Fig. 1C) revealed little change from the previous one with a decrease in the contrast enhancement of the posterior low density areas.

The MRI in 1985 was performed using a 0.5 Tesla superconducting magnet.* The followup MR in 1986 was obtained using a 1.5 Tesla signa system.† Imaging sequences were obtained using standard screening sequences with the individual imaging system. T_2 weighted images, in 1985 with 0.5T were acquired with spin-echo (SE) sequence with TE and TR times of 120 and 2,000 msec. respectively (SE 120/2,000) while T_2 weighted images with 1.5T system were performed with SE 70/2,000.

The MRI done on 9/85 (Fig. 2A) showed normal ventricle size with a mild mass effect of the atria of both lateral ventricles. Marked increased signal intensity was noted in the white matter around the atria of the lateral ventricle. This change was seen predominantly on the right side and extended along the temporal horn bilaterally. Marked increase in signal intensity was noted in this area on T2 weighted images. The MRI done on 4/86 (Fig. 2B) showed further progression of white matter abnormalities. The increased signal intensity on T2 weighted images was also noted in the posterior aspect of the corpus callosum, the right parietal and occipital poles and the temporal pole white matter. No other deep white matter abnormalities were seen.

A PET scan was performed using the TOFPET (*10–11*) which has an in-plane and axial resolution of 11 mm full width at half maximum. This camera collects nine simultaneous image planes with a 10.8 mm separation. Images were

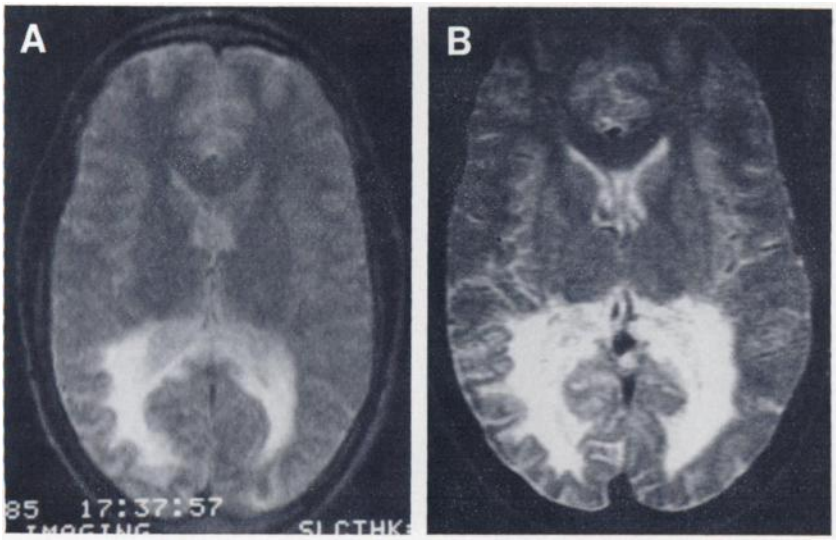

FIGURE 2
A and B show MRI images taken in 1985 and 1986 respectively. Images correspond to a level where thalamus and basal ganglia are easily seen. A: (TE = 2000 TR = 120). B: (TE = 2000 TR 70). The study of 1986 shows further extension of edema into white matter tracts.

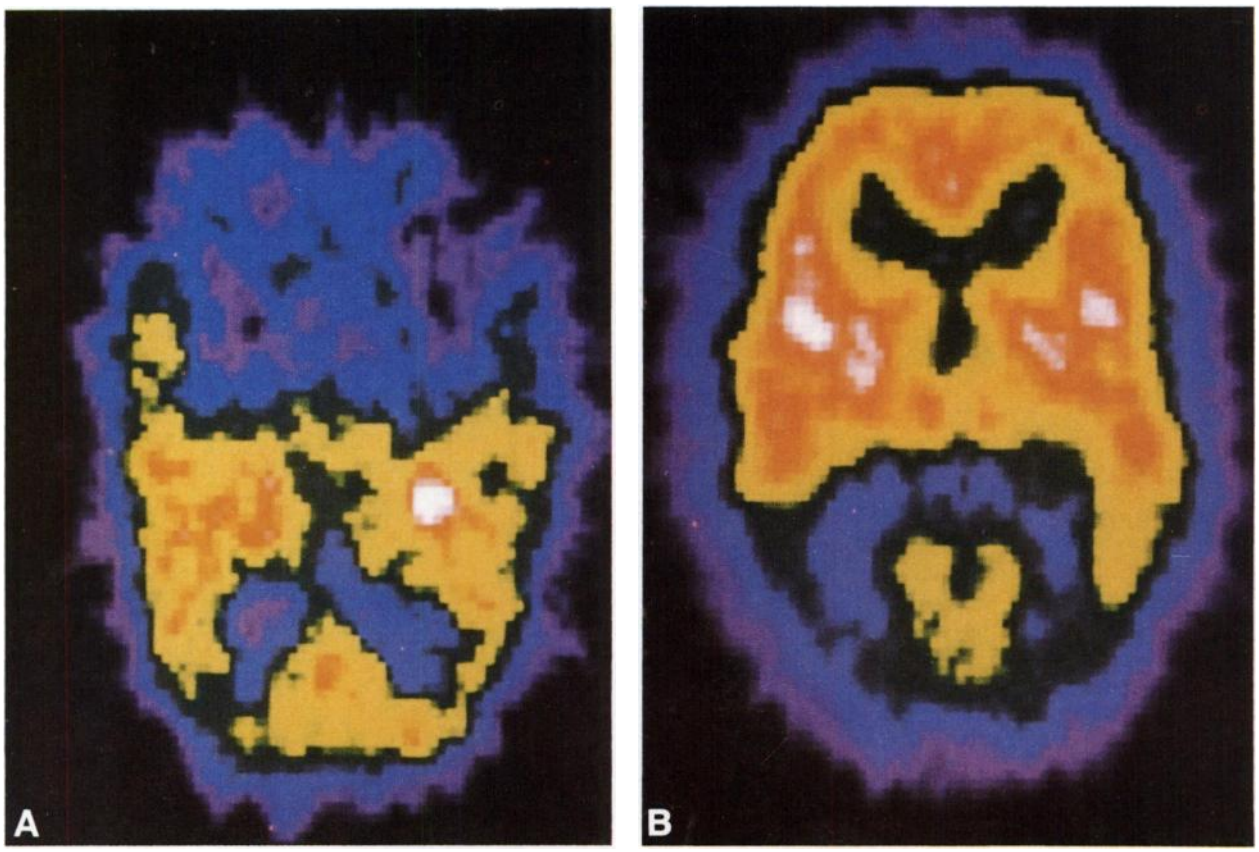

FIGURE 3
A and B show PET scan images for cerebral blood flow and for FDG uptake respectively at the level of basal ganglia. Both images show decreased flow and metabolism of occipital cortex. The color scale represents the temperature spectrum with the warmest areas representing the region with the highest concentration of radioactivity.

taken perpendicular to the body axis. Measurements for cerebral blood flow (CBF) were done using the i.v. bolus injection of $H_2{}^{15}O$ technique initially developed by Raichle et al. (*12*) and modified by Fox et al. (*13*) to omit arterial sampling. This technique provides relative measurements which have been shown to adequately reflect the changes in CBF (*14,15*). Images for glucose uptake were performed with an intravenous injection of 8 mCi of fluorine-18 deoxyglucose (FDG) (*16*). Images for FDG were not quantified and were expressed as relative concentration of the compound. Both the $H_2{}^{15}O$ (Fig. 3A) and the FDG (Fig. 3B) studies revealed similar regional abnormalities showing severe decreases in blood flow and FDG uptake in the gray matter of the occipital cortex, and the temporal cortex. The higher slices also revealed derangements in the posterior parietal cortex. The frontal cortex, anterior parietal cortex, cerebellum and subcortical structures appeared to be relatively intact.

DISCUSSION

Several papers have been published on the characteristic ALD abnormalities shown with CT scan (*2*). These studies consistently demonstrate location of the earliest changes in the posterior cerebral region. These lesions seen as irregular areas of decreased attenuation advance with successive involvement of the parietal, temporal and frontal lobes (*3*). The greater sensitivity of MRI over CT in detecting demyelination and the preliminary MRI reports done on patients with adrenoleukodystrophy suggest that MRI may be more sensitive in detecting the lesions than CT and may allow for an earlier diagnosis of this disease.

For this patient the sequential CT scans did not show progression of disease despite the clinical deterioration of the subject. The sequential MRI showed evolution of the disease process from 1985 to 1986. The different field strengths in the MRI devices used could have contributed to some of the differences in the images. However, the fact that the extension of the abnormalities observed in the follow-up MRI correlated well with the clinical deterioration of the patient suggest that the MRI changes in 1986 reflected progression of the disease.

The PET scan revealed regional defects localized to the posterior areas of the brain. However, different from CT and MRI, it showed severe disruption not only of white matter but also of the parietal, occipital and temporal cortex. Decreased functioning of these gray matter areas correlated well with the location of brain areas that would account for the psychiatric and neurological symptoms in this patient.

In summary, in this patient with ADL the MRI proved to be more sensitive than CT in showing progress of disease whereas PET was able to show gray matter abnormalities that were not recognized by CT or MRI.

NOTES

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