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MRI in chronic toluene abuse: low signal in the cerebral cortex on T2-weighted images

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Abstract MRI may be helpful in showing brain toxicity associated with chronic toluene inhalation. We report clinical and MRI findings over 3 years in a man with gradual neurologic decline secondary to toluene abuse. Cerebral atrophy most prominently involved the corpus callosum and cerebellar vermis. On T2-weighted images, loss of gray-white matter contrast, diffuse supratentorial white matter high-signal lesions, and low signal in the basal ganglia and midbrain were seen. In addition, MRI showed abnormal labor cortical low signal on T2-weighted images, most prominent in the primary motor and visual cortex. This cortical T2 shortening, not previously described in this condition, may reflect iron deposition.

Key words Toluene · Organic solvents · Magnetic resonance imaging · Iron · brain

Introduction

Toluene is a neurotoxic organic solvent present in paints, inks, glues, and thinners. Toluene is commonly abused because it is intoxicating, inexpensive, readily available, and does not cause withdrawal symptoms [1]. Chronic inhalation of toluene may result in a variety of neurologic complication [1–8]. Brain MRI findings in chronic toluene abuse include generalized volume loss, loss of gray-white matter contrast, white matter high signal on T2-weighted images (T2 WI), and low signal in central gray matter on T2 WI [1, 3–6, 8]. We report cranial MRI findings in a case of chronic toluene abuse. The abnormal cortical low signal on T2 WI we found is previously unreported.

Case report

A 36-year-old man presented with a 6-year history of tremor, gait ataxia and visual blurring. His family noted that he was becoming dull and apathetic. He had been inhaling toluene for the past 15 years. His speech was severely dysarthric. Visual acuity was 20/200 on the left and 20/400 on the right; bilateral optic disc pallor and opsoclonus were noted. Severe ataxia was evident in both arms, with postural and intention tremor. His gait was broad-based, with marked ataxia. Reflexes were hyperactive with bilateral extensor plantar responses. Formal neuropsychological examination revealed significant impairment of calculation, short-term memory, and tasks of attention and vigilance. Insight and judgment were inappropriate. His verbal intelligence quotient (IQ) was 75. Normal laboratory studies included serum vitamin B_{12}, folate, thyroid-stimulating hormone, electrolytes and lumbar cerebrospinal fluid analysis. Cranial MRI findings are presented in Fig. 1. CT failed to reveal any abnormal calcification.

Abstinence from toluene and gabapentin therapy led to an improvement of visual symptoms 4 months later. The patient then resumed intermittent toluene abuse. Neurological examination and MRI 3 years after presentation were unchanged.

Discussion

Toxic toluene inhalation is most commonly the result of occupational exposure or recreational abuse. Because of its lipophilicity, toluene rapidly penetrates into the central nervous system (CNS) after inhalation. While the pathophysiology of its CNS effects remains specu-

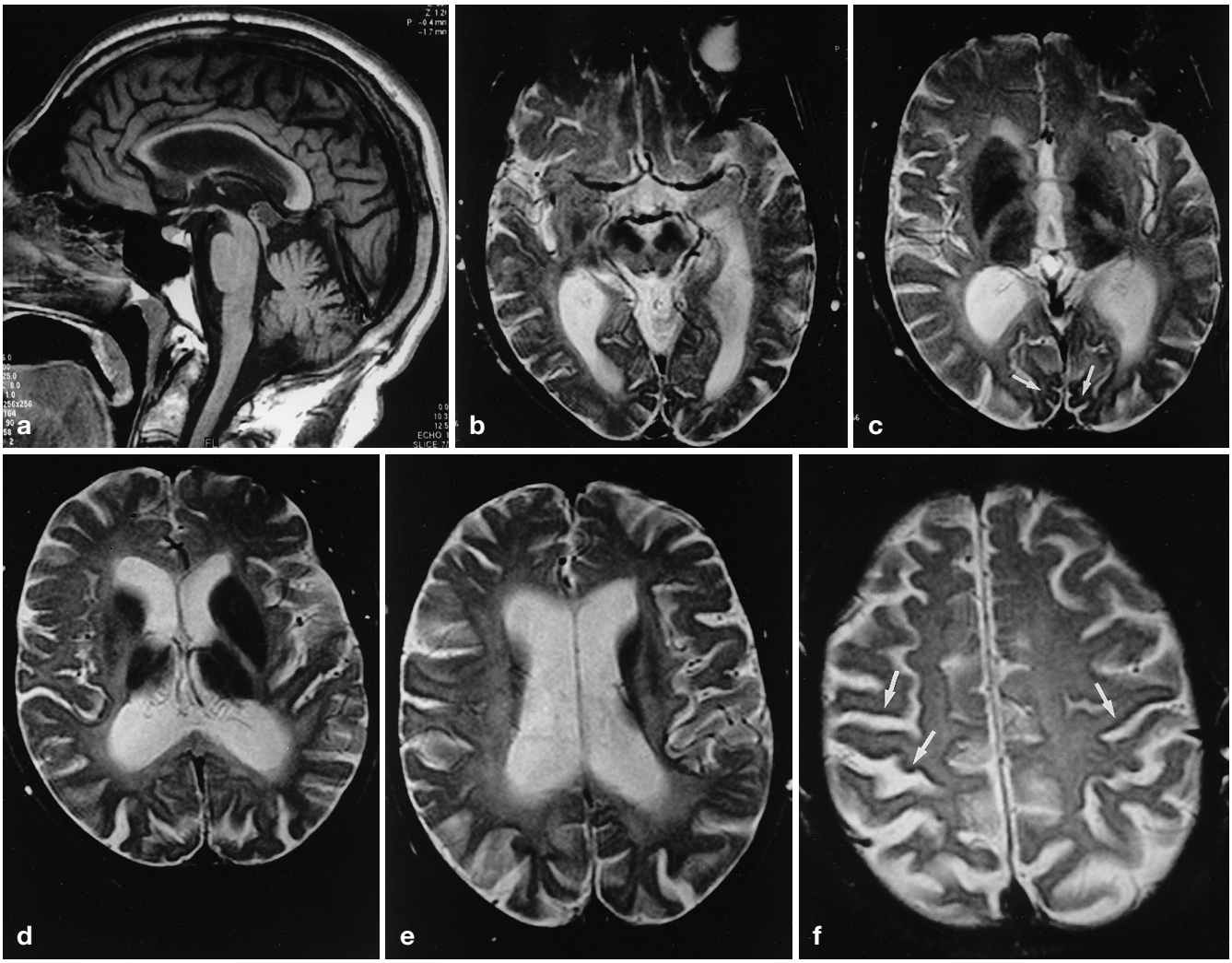

Fig. 1 Conventional spin-echo images. **a** Sagittal noncontrast T1-weighted (500/16). Cerebral atrophy is seen, most prominent in the corpus callosum and cerebellar vermis. **b–e** Axial T2-weighted (2000/100). There is generalized atrophy (enlarged ventricles and sulci), loss of gray-white matter distinction, and diffuse paraventricular white matter high signal. Bilateral low signal foci are present in the caudate, putamen, globus pallidus, red nucleus, substantia nigra, and thalamus. In addition, low signal is seen in lobar gray matter, most prominently the medial occipital *(c, arrows),* posterior frontal *(f, arrows)* and peri-Rolandic parietal cortex. Mild low signal was also seen in the basis pontis bilaterally. There was not abnormal contrast enhancement

lative, chronic toluene exposure may result in numerous neurologic complications [1–8]. Multifocal, progressive neurologic deficits with cerebellar dysfunction, optic atrophy, pyramidal tract signs, cranial nerve abnormalities such as visual loss, hearing loss and anosmia, personality changes, emotional instability and general cognitive decline have been attributed to its abuse.

MRI findings associated with chronic toluene abuse [1 3–6, 8] include generalised cerebral and cerebellar atrophy, poor gray-white matter differentiation, and thinning of the corpus callosum. High signal lesions have been noted on T2 WI in the paraventricular and subcortical white matter, internal capsule and brain stem. In addition, low-signal foci on T2 WI, consistent with T2 shortening, have been reported in the basal ganglia and thalamus. Deep central gray matter low signal is non-specific. For example, T2 shortening in the basal ganglia, most likely reflecting iron deposition, may also be seen in parkinsonian states [9, 10], multiple sclerosis [11], Hallervorden-Spatz disease [12], Huntington's disease [13], and most commonly in normal aging [14, 15]. However, other than possibly multiple sclerosis, none of these conditions typically result in concurrent T2 shortening within the thalamus.

The pathogenesis of the MRI lesions in toluene toxicity is poorly understood. Neuropathologic findings have been infrequently described [7, 16]. Paraventricu-

lar demyelination and gliosis, degeneration of ascending and descending white matter tracts, and neuronal loss have been noted. The etiology of the deep central gray matter T2WI low signal may relate to iron deposition [8] or the direct effects of toluene [4].

MRI findings in our patient are partially in agreement with those previously described in toluene abuse. However, we also observed T2 shortening (low signal) in the precentral and postcentral gyri and calcarine cortex. T2 shortening in the cortex, probably representing iron deposition, has been reported in many degenerative conditions such as Alzheimer's disease [10], amyotrophic lateral sclerosis [17], multiple sclerosis [11], and as part of normal aging [14, 15]. The mechanism of this focal iron deposition is unclear, although a number of hypotheses have been offered [8, 11 18]. In addition to its role in normal aging, iron plays a critical role in neuronal metabolism. Iron is normally cleared by axonal transport, so that any process causing a functional decrease in axonal transport could induce iron deposition in the brain [11, 14]. We hypothesize that subcortical myelin dysfunction in toluene toxicity may lead to a disruption of axonal transport and secondary iron accumulation in the cerebral cortex. In addition, because our patient was actively abusing toluene at the time of both MRI studies, direct effects of toluene, such as partitioning into cerebral tissue lipid membranes, may have contributed to the cortical T2 shortening [4]. Because pathological correlation was not available in this case, we cannot fully exclude less likely causes, such as calcification or chronic hemorrhage.

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