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AJNR Am J Neuroradiol 1994, 15 (7) 1377-1382
<http://www.ajnr.org/content/15/7/1377.citation>

This information is current as
of April 18, 2024.

Radiologic-Clinical Correlation

Hemiballismus

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Clinical History

A 65-year-old recently retired surgeon in good health developed disinhibited behavior over the course of a few months, followed by onset of unintentional, forceful flinging movements of his right arm and leg. Magnetic resonance imaging demonstrated a 1-cm rim-enhancing mass in the left subthalamic region, which was of high signal intensity on T2-weighted images (Figs 1A-E). Positive serum human immunodeficiency virus antigen and antibody titers were found, with mildly elevated cerebrospinal fluid toxoplasma titers. Anti-toxoplasmosis treatment with sulfadiazine and pyrimethamine was begun, with resolution of the hemiballistic movements within a few weeks and decrease in size of the lesion. A stereotactic biopsy was performed but was nondiagnostic.

Discussion

Clinical Features

The term *hemiballismus* refers to a rare movement disorder characterized by involuntary, large-amplitude movements of the limbs of one side of the body. The term is

derived from the Greek word meaning "to throw," because the typical involuntary movements of the affected limbs resemble the motions of throwing (1). Such movements usually involve one side of the body (hemiballismus) but may involve one extremity (monoballismus), both legs (paraballismus), or all the extremities (biballismus) (2, 3). The motions are centered around the shoulder and hip joints and have a forceful, flinging quality. Usually either the arm or the leg is predominantly involved. Although at least some volitional control over the affected limbs is still maintained, the involuntary movements typically can be checked by the patient for only a few moments (1). The movements are usually continuous but may be intermittent (4). Thus, the disorder can be disabling because of the disruptive effects on daily activities. The force of the motions is such that injury to the affected limbs may result unless efforts are made to prevent forceful contact with surrounding objects (eg, by padding of bed rails) (3). The motions are most notable during rest and are increased by stress (3). They usually can be suppressed to some degree by concentration or voluntary motions of the limbs and are typically absent during sleep (2). Early reports of hemiballismus stressed a poor outcome, with death usually resulting from infection related to disability or from the effects of overactivity (eg, cardiac failure and exhaustion) (5). Before the development of neuropharmacologic treatment of this disorder, persistent hemiballismus was occasionally treated with drastic

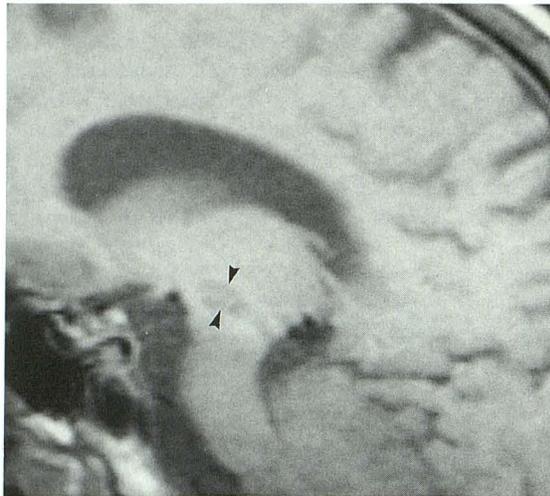
Received July 2, 1993; accepted after revision April 15, 1994.

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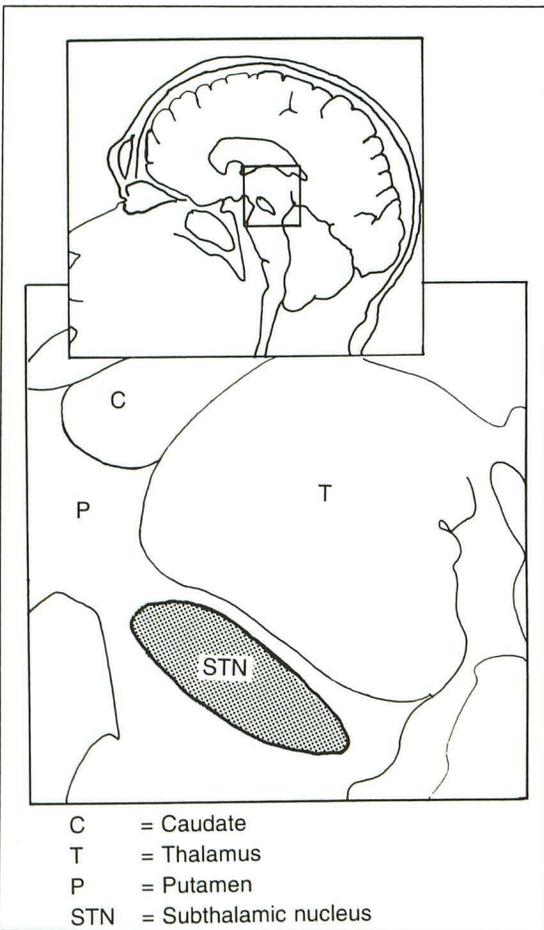
Index terms: Basal ganglia; Brain, abscess; Acquired immunodeficiency syndrome (AIDS); Radiologic-clinical correlations; Movement

AJNR 15:1377-1382, Aug 1994 0195-6108/94/1507-1377

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A



B

Fig 1. A and B, Noncontrast sagittal T1-weighted (500/11/2 [repetition time/echo time/excitations]) image performed 1 cm to the left of midline demonstrates the lesion (arrowheads) as a region of hypointense signal with a very thin rim of hyperintense signal. The spatial relationship of the lesion to the thalamus is optimally demonstrated in this imaging plane.

measures to prevent self-injury and avoid exhaustion. These measures included binding the extremity to the torso, inducing flaccid paralysis of the arm by brachial plexus stretch injury or alcohol injection, and even, rarely, amputating (2).

Hemiballismus is distinguished from hemichorea, another, closely related, involuntary dyskinetic movement disorder, by the fact that hemichoreic movements are slower, more randomly distributed, and less violent, have smaller excursions, and primarily involve distal musculature (2, 6, 7). Hemiballismus and hemichorea frequently coexist, however, and each type of movement disorder may evolve into the other (4). The two disorders are considered by some authors to be two points on a clinical spectrum, with hemiballismus being a severe form of hemichorea (4, 8). Furthermore, experimental evidence in primates suggests that in both disorders there is a decrease in synaptic activity within a common pathway involving fibers from the subthalamic nucleus to the globus pallidus (7). Both hemiballismus and hemichorea also may be associated with other types of abnormal movements, such as myoclonus, bradykinesia, dystonia, or athetosis (4).

Most patients with hemiballismus are affected in middle age or later life (2, 4, 5, 8). The rate of onset is variable and depends to a large extent on the cause. Hemiballismus secondary to infarction typically has a sudden onset. In the less common cases of hemiballismus from infectious, inflammatory, metabolic, or neoplastic causes, the clinical course is frequently slowly progressive during days, weeks, or months (4). Despite early reports indicating poor outcomes (5), presently the prognosis is usually good, with the majority of patients recovering spontaneously within 6 months or responding to neuropharmacologic therapy (9). A minority of patients have prolonged courses, lasting years (9, 10).

Etiology

There is a wide variety of causes of hemiballismus. In most elderly patients, a vascular origin (ie, a discrete infarction or hemorrhage) is found, often involving the contralat-

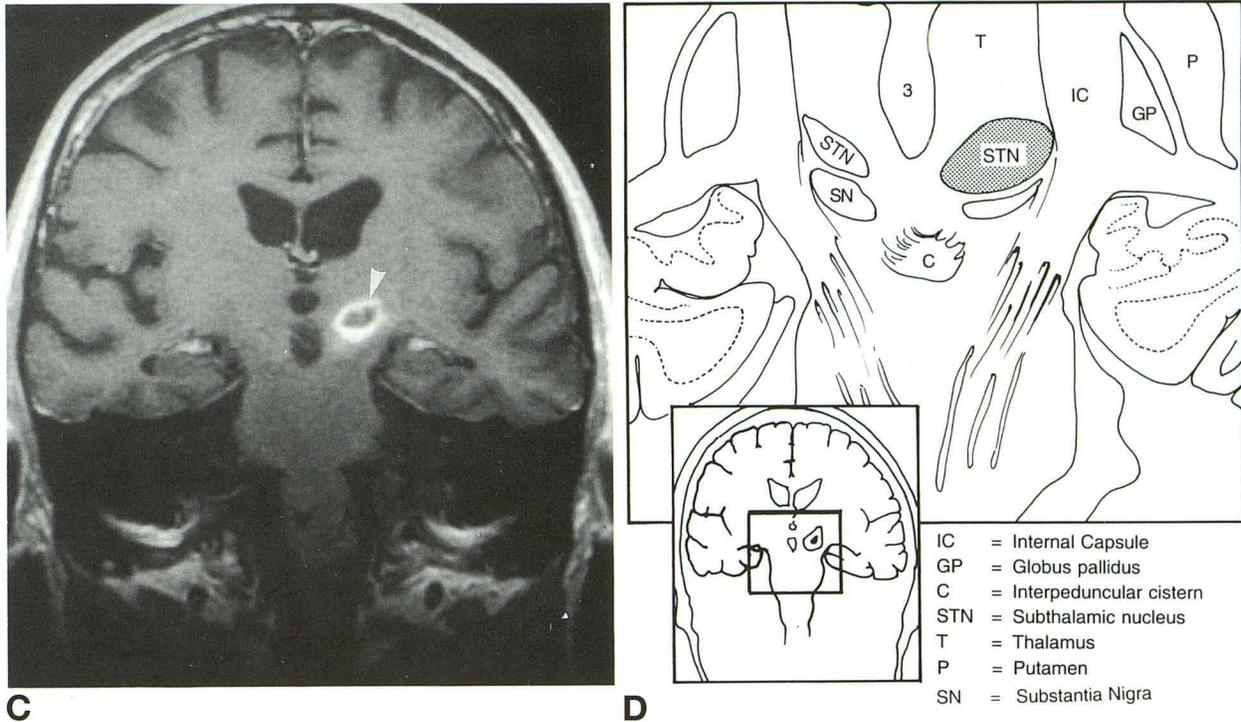


Fig 1. C and D, Contrast-enhanced coronal T1-weighted image (500/11/2) performed through the subthalamic region and the cerebral peduncles. A ring-enhancing lesion (arrowheads) is present within the left subthalamic region. The mass is located caudal to the left thalamus and medial to the left internal capsule.

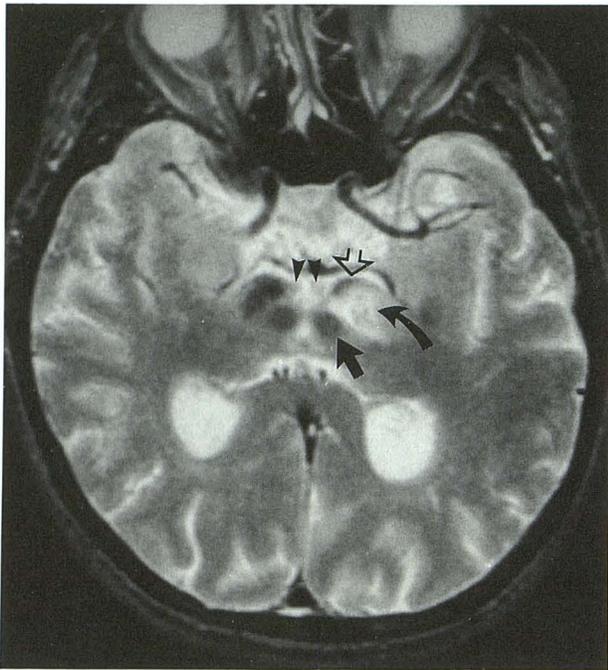
eral subthalamic nucleus (2, 5, 8). In most middle-aged patients, a nonvascular cause is usually found (4). Reported causes other than infarction include primary or secondary neoplasms (4, 11), arteriovenous malformations (12), multiple sclerosis (13), tuberculous meningitis (14), encephalitis (4), systemic lupus erythematosus (4), nonketotic hyperglycemia (15), and thalamotomy for parkinsonism (16). Rarely, hemiballismus is induced by drugs, including oral contraceptives and phenytoin, but usually only in patients with preexisting basal ganglia abnormalities (2). Hemiballismus in the patient presented here resulted from a toxoplasmosis abscess, an uncommon cause (4, 17).

Neuroanatomy and Pathophysiology

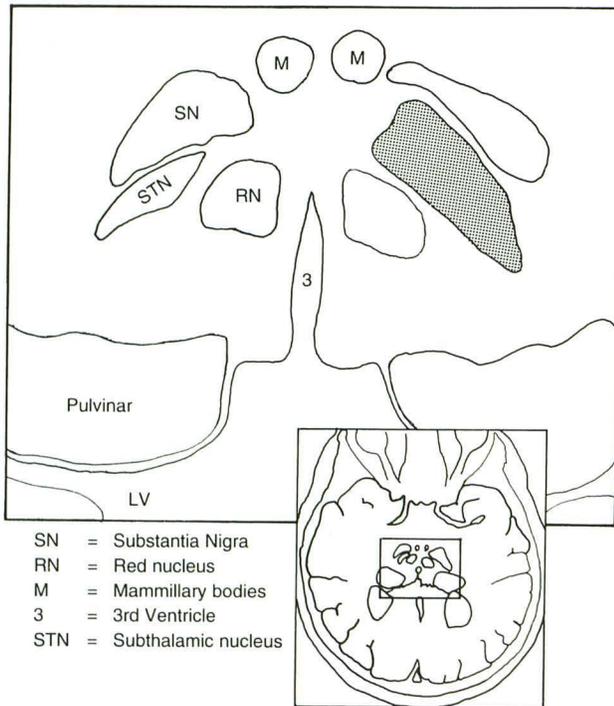
Hemiballismus typically results from a lesion in the contralateral subthalamic nucleus, its efferent or afferent pathways, or their projection areas (3, 8). The subthalamic nucleus is a lens-shaped structure located along the

medial and cephalad margin of the peduncular portion of the internal capsule (Fig 1D) (18). The internal capsule thus is interposed between the subthalamic nucleus and the globus pallidus, with which it has important neural connections. The caudal portion of the subthalamic nucleus overlies the rostral portion of the substantia nigra. The vascular supply of the subthalamic nucleus is derived from branches of the anterior choroidal, posterior cerebral, and posterior communicating arteries (2), and an infarction causing hemiballismus therefore can result from occlusion of branches of any of these arteries (19).

The neural pathways connecting the subthalamic nucleus to its projection areas are complex. Large afferent and efferent pathways connect the subthalamic nucleus and the medial and lateral segments of the globus pallidus. These pathways, thought important in the development of hemiballismus, extend both around and through the peduncular portion of the internal capsule (through the subthalamic fasciculus) (3). The subthalamic nucleus also has important efferent connec-



E



F

Fig 1. E and F, Axial T2-weighted image (2500/80/1) performed through the subthalamic region just at the level of the mammillary bodies (arrowheads) and the most cephalad extent of the mesencephalon. The lesion involves the subthalamic nucleus (curved arrow) but also extends to involve the left substantia nigra (open arrow), which is displaced ventrally by the mass. The red nucleus (arrow) is not involved by the mass.

tions to the substantia nigra, pars reticulata, and afferent connections from the motor and premotor cortex (3).

The importance of the subthalamic nucleus in the development of hemiballismus was initially established by ablation of the nucleus in primates (20). It should be noted that a lesion in the subthalamic nucleus does not always result in hemiballismus, for example, if the pyramidal tract and red nucleus are also destroyed (3). Thereafter, a number of pharmacologic means were developed to produce functional decrease in the activity of the subthalamic nucleus without destroying nearby fiber tracts (21). Injection of a γ -aminobutyric acid antagonist into, or very close to, the subthalamic nucleus is one means of inducing hemiballismus that has the same quality as that produced by a subthalamic nucleus lesion, but which differs in latency of onset and duration (21). The extent and severity of upper limb or lower limb involvement varies between the injection site chosen, suggesting that the subthalamic nucleus may have a somatotopic representation (21).

Lesions affecting the afferent or efferent pathways of the subthalamic nucleus (eg, the subthalamic fasciculus) (20) or the subthalamic nucleus projection areas also can produce hemiballismus (2, 8). The neostriatum (ie, putamen and caudate nucleus) is the most common site involved other than the subthalamic nucleus (10, 22). Hemiballismus also may result from lesions in the thalamus or, in rare instances, at sites distant from the basal ganglia with which the subthalamic nucleus has major connections (eg, the precentral or postcentral gyrus) (3). There is evidence that hemiballismus caused by lesions at sites other than the subthalamic nucleus may be more persistent than those solely involving the subthalamic nucleus (10).

The mechanism by which hemiballismus is produced is not completely understood. There is increasing evidence that the subthalamic nucleus has a tonic inhibitory influence on the thalamus by means of excitatory projections onto inhibitory neurons in the medial globus pallidus (23). These inhibitory fibers, in turn, project to the ventrolateral nucleus of the thalamus, from which excitatory thalamocortical pathways project. Therefore, a de-

structive lesion in the subthalamic nucleus could result in disinhibition of these excitatory pathways, resulting in production of hemiballistic movements. Although the mechanisms by which lesions in the caudate and putamen produce hemiballismus are poorly understood, they are also presumed to be caused by interruption of topographic connections from the caudate and putamen to the globus pallidus.

Radiology

Neuroradiologic examinations of patients with hemiballismus or hemichorea must focus on the contralateral subthalamic nucleus and its major pathways and projection sites. Infarctions causing hemiballismus are usually seen as small low-attenuation regions on computed tomography or a focus of hyperintense signal on T2-weighted images, within the subthalamic nucleus (Fig 1E) (24). Hemorrhage within the subthalamic nucleus is often on the basis of hypertension or rupture of a small vascular malformation. A ring-enhancing mass lesion in this region could be caused by either a neoplasm (most commonly a metastasis rather than a primary neoplasm) or an abscess. However, careful evaluation of the basal ganglia, thalamus, and selected other regions of the brain is also indicated, because lesions causing hemiballismus or hemichorea have been demonstrated by computed tomography or magnetic resonance in the caudate nucleus (25), thalamus (4), corpus striatum (26), putamen (15), lenticular nucleus (27), and corona radiata (28). Computed tomographic identification of lesions producing hemiballismus can prove difficult, because of their small size (24). The multiplanar capability of magnetic resonance offers a number of distinct advantages in demonstration of lesions involving the subthalamic nucleus or any of its projections. Nonetheless, computed tomography and magnetic resonance findings in a recent series of patients with hemiballismus demonstrated lesions in the subthalamic nuclei, basal ganglia, or thalami in only slightly more than 60% of cases (4).

Treatment

Many patients with hemiballismus secondary to cerebrovascular accidents have spontaneous, gradual improvement during the course of weeks or months, possibly secondary to resolution of edema surrounding the infarct and reperfusion of affected tissue (4). Before the development of present neuropharmacologic therapy, stereotactic ventrolateral thalamotomy was the procedure of choice (29) and is still used in selected cases. However, persistent hemiballismus is often treated by neuropharmacologic means, which are usually effective in reduction of the movements (4, 8). This therapy is based on the knowledge that dopaminergic activity results in inhibition of subthalamic nucleus neuronal firing, with the result that a decrease in dopamine activity should result in decrease of the dyskinetic movements (2, 8). Dopamine antagonists, especially haloperidol and phenothiazines (8), are most commonly used, with dopamine-depleting agents (eg, reserpine) less commonly used. The majority of patients either improve spontaneously or respond to these medications (4). In the patient presented here, the hemiballistic movements resolved after treatment of the specific cause of the hemiballismus (ie, antitoxoplasmosis therapy).

Acknowledgment

We are grateful to Ernest Picard, MD, for clinical information regarding the patient presented in this article and for a helpful review of the manuscript.

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