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REVIEW/MISE AU POINT

Motor strategies of postural control after hemispheric stroke



Stratégies motrices du contrôle postural après AVC hémisphérique

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Summary After stroke, the causes of balance disorders include motor disorders, sensory loss, perceptual deficits and altered spatial cognition. This review focuses on motor strategies for postural control after stroke. Weight-bearing asymmetry, smaller surface of stability, increased sway, body tilting and sometimes pushing syndrome are observed. Weakness and sensory impairments account only for some of these disturbances; altered postural reactions and anticipated postural adjustments as well as abnormal synergistic muscular activation play an important part. These disorders are often linked to cognitive impairments (visuospatial analysis, perception of verticality, use of sensory information, attention, etc.), which explain the preeminent disorders of postural control seen with right rather than left-hemisphere lesions. Most of the motor changes are due to an impaired central nervous system but some could be considered adaptive behaviors. These changes have consequences for rehabilitation and need further studies for building customized programs based on the motor compartment of a given patient.

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Résumé Les troubles de la posture et de l'équilibre résultent de déficiences sensorimotrices, de troubles perceptifs sensoriels et/ou d'altération de la cognition spatiale. Cette revue de la littérature se focalise sur les stratégies motrices du contrôle postural après accident vasculaire cérébral (AVC). La diminution de la surface de la stabilité, l'asymétrie d'appui entre les deux membres inférieurs, les oscillations posturales et l'inclinaison posturale voire le « Pusher syndrome » peuvent être observés chez ces patients. Le déficit hémicorporel sensitivomoteur n'explique qu'en partie les troubles de la posture assise et debout. L'altération des stratégies posturales, des ajustements posturaux anticipés et les coactivations musculaires synergiques y participent aussi. De plus il existe des interactions entre ces stratégies motrices et les troubles de la cognition spatiale (négligence visuospatiale, bais de perception de la verticalité, préférences sensorielles, troubles attentionnels...). Les mécanismes des troubles posturaux prédominent chez les sujets avec lésion hémisphérique droite du fait d'une prédominance de celui-ci dans le contrôle spatial. La majorité des stratégies motrices posturales observées après un AVC sont secondaires à l'atteinte des réseaux neuronaux du système nerveux central mais certaines peuvent aussi être considérées comme des comportements adaptatifs. Comprendre les stratégies motrices d'un sujet donné est primordial pour construire des programmes de rééducation posturale personnalisés.

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Introduction

Postural control is the ability to control posture in order to maintain an upright stance during functional activities and to compensate for external and internal body perturbations to avoid falls. Impaired balance was found to be a predictor of falls in community-dwelling older women after stroke [37]. Balance and postural disorders are among the most prevalent consequences, affecting 50% of post-stroke patients in France [12]. They are responsible for medical and surgical complications due to falls, social isolation and impaired quality of life [10,63]. Rapid and optimal improvement of postural control in stroke patients is essential to ensure their independence, social participation and overall health.

The mechanisms of post-stroke balance disorders are diverse [25,56]. This postural disturbance may involve motor weakness, asymmetrical muscular tone, sensory loss, perceptual deficits and altered spatial cognition with reference to the postural body scheme. However, compensation strategies to stabilize posture could be developed. After stroke, the postural control would be more sensory-driven rather than anticipatory [29] because the anticipatory mechanism involves many cerebral structures: cortical (supplementary motor area and premotor area), subcortical (central gray nuclei and thalamus) and subtentorial (vestibular nuclei and cerebellum) [45]. Different postural strategies could be controlled by the central nervous system (CNS) to coordinate muscle activity against destabilizing forces applied to the body (extrinsic destabilization) or with self-induced movements (intrinsic destabilization).

This review focuses on studies of post-stroke motor strategies involved in the recovery of postural control during both quiet standing balance control and dynamic conditions.

Sitting posture

Impaired sitting posture is by itself a major cause of dependency because trunk control is required for the control of

more complex activities such as voluntary movements of the upper limb or standing posture or gait [22]. After stroke, the automatic axial muscle tonus and voluntary strength of the trunk are bilaterally impaired, most prominently on the paretic side [3]. Besides the paresis, other components in trunk control may be impaired, depending on the side of the lesion: "postural instability" would be significantly more frequent among patients with right-hemisphere lesions, and "apraxic responses" would be predominant among those with left-hemisphere lesions [3,65]. Indeed, the voluntary trunk control involves cognitive functions such as visuospatial exploration and mental representation ability for postural adaptation and the construction of the postural body schema [57,13]. Hemineglect and bias of the subjective vertical are important causes of postural asymmetry and instability [57,58,52,34,54,4]. Contraversive pushing, called "Pusher syndrome," is the most serious postural impairment [55]. It is a perceptual disorder observed with acute stroke, whereby patients lean towards the affected side and actively resist any attempt to correct this posture [33]. Pushing has been linked to biased verticality and hemispacial neglect, more common among patients with right – rather than left-hemisphere lesions [55].

Quiet standing balance control

Quiet standing postural control requires maintaining the center of gravity (CoG) within limits of stability. Center of pressure (CoP) measures are commonly used to assess this control by measuring the body position and the amount of body sway. After stroke, stabilometry is used to assess a surface of stability, which is smaller than for healthy subjects, beyond which the CoG cannot move without exposing the hemiparetic patient to loss of balance [51].

Weight-bearing asymmetry (WBA)

The quiet standing posture of hemiplegic patients after stroke is characterized by WBA, a shift in the mean position of the CoP toward the unaffected side and increased

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