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An update on predicting motor recovery after stroke

Nouveautés sur la récupération motrice après AVC

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Abstract

Being able to predict an individual's potential for recovery of motor function after stroke may facilitate the use of more effective targeted rehabilitation strategies, and management of patient expectations and goals. This review summarises developments since 2010 of approaches based on clinical, neurophysiological and neuroimaging measures for predicting individual patients' potential for upper limb recovery. Clinical assessments alone have low prognostic accuracy. Transcranial magnetic stimulation can be used to assess the functional integrity of the corticomotor pathway, and has some predictive value but is not superior when used in isolation due to its low negative predictive value. Neuroimaging measures can be used to assess the structural integrity of descending white matter tracts. Recent studies indicate that the integrity of corticospinal and alternate motor tracts in both hemispheres may be useful predictors of motor recovery after stroke. The PREP algorithm is currently the only sequential algorithm that combines clinical, neurophysiological and neuroimaging measures at the sub-acute stage to predict the potential for subsequent recovery of upper limb function. Future research could determine if a similar algorithmic approach may be useful for predicting the recovery of gait after stroke.

Keywords: Stroke; Rehabilitation; Prognosis; Motor

Résumé

Prédire la capacité individuelle du patient à récupérer ses fonctions motrices après AVC peut faciliter une utilisation plus efficace de stratégies ciblées de rééducation fonctionnelle, et une meilleure prise en charge des attentes et objectifs des patients. Cette revue résume depuis 2010 les développements des approches prédictives du potentiel individuel de récupération motrice du membre supérieur de chaque patient basées sur des mesures cliniques, neurophysiologiques et d'imagerie. Les évaluations cliniques seules ont une valeur prédictive faible. La stimulation magnétique transcranienne peut être utilisée dans l'évaluation de l'intégrité fonctionnelle de la voie corticomotrice, et montre une certaine valeur prédictive mais n'est pas supérieure quand elle est utilisée seule à cause de sa faible valeur prédictive négative. Les mesures de neuroimagerie peuvent évaluer l'intégrité structurelle des faisceaux descendants de la substance blanche. De récentes études montrent que l'intégrité du faisceau corticospinal et des voies motrices indirectes au sein des deux hémisphères peuvent se révéler des marqueurs prédictifs utiles de la récupération motrice post-AVC. L'algorithme PREP est actuellement le seul algorithme séquentiel combinant des mesures cliniques, neurophysiologiques et de neuroimagerie durantla phase subaiguë de l'AVC, qui est capable de prédire le potentiel de récupération motrice du membre supérieur. De futures études pourraient déterminer si une approche algorithmique similaire pourrait se révéler utile pour prédire la récupération de la marche post-AVC.

Mots clés : AVC ; Rééducation ; Pronostic ; Moteur

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1. English version

1.1. Introduction

Stroke is the third most common cause of long-term adult disability in developed countries [1]. There are nearly 800,000 strokes a year in the United States alone, with a third of all stroke survivors experiencing varying levels of disability [2]. The ability of stroke survivors to independently undertake activities of daily living is dependent on the recovery of motor function, particularly of the upper limb [3].

Recovery of motor function is characterized by the individual's ability to perform movements using the same effectors and muscle activation patterns in the same manner as prior to stroke [4]. Recovery is highly variable within the initial days after stroke when rehabilitation begins, making it difficult to estimate with any great degree of accuracy the extent of motor recovery that will be obtained months after stroke at the end of rehabilitation. The ability to predict an individual's potential for motor recovery could add value because it would allow for individually-tailored rehabilitation, management of patient and therapist expectations, and may result in more effective utilization of health resources.

This review provides an update on developments since 2010, when we proposed an algorithm for predicting the potential for recovery of upper limb function for individual patients [5]. Here we identify new studies on the key predictors of motor recovery post-stroke that provide general support for the proposed algorithm, and extend the idea to the lower limb.

1.2. A multimodal approach

Currently, three main methods have been identified for evaluating capacity for motor recovery in the initial days after stroke: clinical assessment scales, neurophysiological assessments, and neuroimaging techniques. In 2010 we proposed an algorithm to sequentially combine these measures to make accurate prognoses of upper limb recovery for individual patients as they begin rehabilitation, at the sub-acute stage of stroke. The algorithm begins with a clinical assessment within 72 hours of symptom onset [5]. Shoulder abduction and finger extension strength are each graded out of 5 using the Medical Research Council (MRC) grades, and then summed to produce a SAFE score (Shoulder Abduction, Finger Extension), with a maximum score of 10. This simple bedside test can identify patients with excellent potential for motor recovery in the upper limb. Patients with a SAFE score of 8 or more have the potential to make a complete or near-complete recovery within 12 weeks.

Patients with a SAFE score below 8 then have a neurophysiological assessment within a week after symptom onset. Transcranial magnetic stimulation (TMS) is used to assess the functional integrity of the corticospinal tract. TMS is a safe, non-invasive tool that can be used to stimulate primary motor cortex (M1). Stimulation of M1activates the corticospinal tract and induces responses in the contralateral muscles, visualised as a muscle twitch and recorded as motor evoked potentials (MEPs) using surface electromyography. TMS provides an objective and quantitative functional assessment of the motor cortex and its descending tracts after stroke. In the algorithm, if MEPs are present in the wrist extensor muscle, the patient has the potential to make a notable recovery of upper limb function within 12 weeks. While the recovery may not be complete, the patient will be able to use their affected upper limb in some activities of daily living by 12 weeks, even if they initially had a dense paresis and flaccid limb.

If MEPs cannot be elicited in the wrist extensors, diffusion-weighted MRI is used to assess the structural integrity of the posterior limbs of the internal capsules (PLICs). The PLICs contain the major white matter pathways between the motor and sensory cortices and the spinal cord. Damage to these pathways can be detected with diffusion-weighted MRI, which produces a measure of fractional anisotropy (FA). FA asymmetry between the PLICs of the lesioned and non-lesioned hemispheres can distinguish between patients with limited potential versus no potential for upper limb recovery [5].

1.3. The PREP algorithm

There is initial evidence in support of this sequential algorithmic approach. The predicting recovery potential (PREP) algorithm can accurately predict an individual's potential for recovery of upper limb function [6]. The PREP algorithm was tested with 40 sub-acute ischaemic stroke patients, to see whether it could predict individual patients' subsequent upper limb function at 12 weeks after stroke. It had positive predictive power of 88%, negative predictive power of 83%, specificity of 88% and sensitivity of 73%. The PREP algorithm improves upon preceding algorithms proposed [5], by defining the FA asymmetry threshold between limited and no potential for recovery for patients at the sub-acute stage (Fig. 1).

The PREP algorithm is designed for efficiency and economy, by starting with a simple bedside clinical assessment, and only using more advanced techniques if required to resolve uncertainty. The algorithm may be useful for setting realistic upper limb rehabilitation goals, and managing patient and therapist expectations. For example, rehabilitation goals for patients with notable recovery potential (a SAFE score below 8 and MEPs in the wrist extensors) could focus on strength, coordination and dexterity, while minimising compensation with the other hand. Rehabilitation for patients with no potential for upper limb recovery (a SAFE score below 8, no MEPs, and a high FA asymmetry) could focus on prevention of secondary complications such as shoulder subluxation and spasticity, and training compensation with the other hand for activities of daily living [6]. The PREP algorithm could also be used to more accurately stratify patients in clinical trials. Further work is under way to test the PREP algorithm in patients with haemorraghic or previous stroke, and to explore the potential clinical and economic benefits of using the algorithm in clinical practice.

There have been further studies published since 2010 that explore the usefulness of clinical, neurophysiological and