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Reorganization After Stroke;A Short Report

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Abstract

The Disability caused by stroke mostly affects individuals between 20-75 years of age. Function of upper extremity is most commonly affected which reduce ability to perform ADLs. After stroke some degree of improvement occurs within 6 months. There are two mechanisms through which recovery occurs: I- Blood flow surrounding the injured areas of cerebral cortex resolute which speed up the metabolic process resulting in increased neuronal activity in remaining neurons. II- Surviving neurons make new connections with surrounding areas of cerebral cortex to restore neuronal function or to compensate for it. Both ways are interlinked to each other.

Keywords: Neuronal; Neurons; Parietal cortex; Ipsilateral

Introduction

Cognitive strategies are used to improve neuronal reorganization resulting in recovery or compensation of function. Different rehabilitation techniques are used in combination for neuroplasticity. Behavioral techniques alone are of little benefit.

Reorganization of Motor Areas after Stroke

Christian Grefkes determined that brain has intrinsic ability to regenerate in response to ischemia which it does so by reorganization of surviving neurons. This study also determined that reorganization of motor areas not only occur due to changes in corticospinal tracts but also brainstem pathways and Interhemispheric connections.

Stephen J. Page et al determined that mental practice (cognitive practice of functional movements) combined with task specific practice was more effective to improve upper extremity function as compared to task specific practice alone and the mechanism behind it was neuroplasticity in the motor areas of cerebral cortex. Post intervention fMRI revealed that there was activation of ipsilateral and contra lateral pre motor and primary motor areas of cerebral cortex and ipsilateral area of parietal cortex.

Michelle N.McDonnell et al determined that peripheral afferent stimulation combined with task specific training improved dexterity and functional task performance in sub acute stroke patients as compared to task specific training alone. This study concluded that afferent stimulation may facilitate reorganization of motor cortex in patients with hemiparesis.

Bruce T. Volpe et al determined that intensive sensory motor arm training either provided by therapist or robot improved the motor outcome in patients with chronic stroke thus facilitating neural reorganization but had no effect on disability. This study concluded that intensive sensory motor arm training improved the expression of cellular and molecular restorative physiology resulting in neural reorganization in motor areas.

Roberta B. Shepherd determined that task and content specific exercise, cognitive practice and skill training drive brain reorganization and improved neuromuscular and functional performance in stroke patients. This study concluded that performance oriented exercise and training improved functional outcomes and resulted in organizational changes in brain and spinal cord.

Regeneration after stroke

Ischemic stroke is caused by disruption of blood supply to brain which cause tissue damage8. The disruption of blood supply to cerebral cortex initiates a series of events; metabolic process stop causing accumulation of metabolites and oxidants in damaged area which cause neuro inflammation, it should be treated immediately otherwise irreversible tissue damage results. In response to degeneration counter mechanism occur to regenerate the lost neurons; changes occur from molecular to cellular levels. Axons sprout and make new synapses at postsynaptic and presynaptic junction. In adult brain, remaining projections give collateral branches to the surrounding area of damage to reinnervate axons. Regeneration is rapid in ischemic stroke as compared to traumatic brain injury.

Nick S. Ward et al determined that after stroke plastic changes occur in brain; firing of one neuron leads to firing of another neuron to which it is connected during learning. Axonal and dendritic sprouting occurs along with synaptogenesis in response to environmental demands. Rick M. Dijkhuizen determined that increased activation of contra lateral sensory motor cortex occurred in stroke in response to extent of injury in ipsilateral sensory motor cortex as showed by fMRI. Diffusion tensor imaging DTI showed structural changes during brain injury and reorganization.

Theresa A. Jones determined that new cortical connections get formed among the surviving neurons in response to environmental demands and behavior after stroke. The process of reorganization is initiated by cellular events in response to ischemia which leads to formation of new connections.

Susanna Freivogel et al determined that gait training with Lokohelp-system resulted in improvement in walking ability in non ambulatory stroke patients and also determined the mechanism behind it which is based on the principle of neuroplasticity.

Gajanan V Bhalerao et al determined the effect of motor relearning program versus bobath training in acute stroke rehabilitation and concluded that motor relearning program was more effective to improve functional outcome and reduce disability in stroke patients as compared to bobath training.

Reorganization of motor areas

Mostly stroke results in hemiplegia or paresis due to disruption of blood supply to motor areas. Middle meningeal artery is most commonly affected. Neuronal connections are lost. Surviving neurons make connections and innervate the surrounding areas of cerebral cortex and spinal cord. New neuronal connections restore or compensate for the lost function depending on their strength. There is possibility that when contras lateral connection dominate abnormal synergies develop. Surviving axons make new synapses which results in development of new neuronal pathways. Cerebral cortex has map of whole body which is responsible for controlling sensory and motor function. After injury cortical mapping is affected which get reorganized with development of new neuronal pathways? There is possibility that abnormal connections are formed during reorganization which are sensitive to behavior and leads to exaggerated reflex response (e.g. abnormal connections in the hippocampus cause seizures. Reorganization can cause restoration of motor or sensory function or compensate for it or leads to development of abnormal synergies with hyperreflexia.

Liang Wang et al determined that functional reorganization of motor network occurred after stroke. This study concluded that increased activation of motor network occurred in ipsilateral primary motor cortex and contra lateral cerebellum and decreased activation occurred in ipsilateral cerebellum after stroke as showed by fMRI.

Marian E. Michielsen et al determined that cortical reorganization occurred in chronic stroke patients in response to mirror therapy. Activation shifted towards affected hemisphere in hemi paretic stroke patients in which mirror therapy was applied as showed by fMRI.

Christian Grefkes et al determined that cortical and sub cortical areas of cerebral cortex are connected to each other via excitatory and inhibitory circuits. After stroke excitatory and inhibitory connections among cortical areas get affected.

Jianxin CAI Et Al determined that changes in gray matter occurred after stroke which contributes to cortical reorganization. Increase in gray matter volume in contralesional area of cerebral cortex after stroke predicted good motor recovery and atrophy of gray matter in ipsilateral cortical and sub cortical areas predicted poor motor recovery. This study concluded that reorganization of gray matter in contralesional areas of cortex contribute to motor recovery after sub cortical stroke.

Meret Branscheidt et al determined that there is evidence of clinical motor recovery but there is no evidence of cortical organization related to motor recovery as showed by resting fMRI in sub cortical stroke patients.

James R. Carey et al compared the effects of two telerehabilitation techniques for improvement of upper extremity hand function and cortical reorganization in chronic stroke patients and determined that both telerehabilitation techniques; repetitive tracking movement and repetitive simple movement had sufficient effect on hand function but had insufficient effect on cortical reorganization as duration of study was only 2 weeks.

Problem with Compensation

It's natural to use different strategies to compensate for the lost function. After Stroke, affected individuals learn to rely on non affected side for function. Recovery in lower extremity is fast than upper extremity33, that's why such activities should be practiced which require involvement of both limbs to prevent development of contracture on affected side. Constraint Induced Movement Therapy (CIMT) was a technique developed to use the affected upper extremity for task performance; many studies support its effectiveness for improvement of upper extremity function.

Judith D. Schaechter et al determined that motor recovery during the early stages of stroke resulted in contra lateral shift in the centre of activation in sensorimotor cortex and motor recovery during later stages of stroke resulted in posterior shift in the centre of activation in sensorimotor cortex as showed by fMRI. Motor activity log showed improvement in upper extremity hand function and Fugl Meyer stroke scale and wolf motor function test showed reduction in motor impairment.

Lin K-C, Chung H-Y et al determined the effect of constraint Induced Movement Therapy (CIMT) in patients with stroke and concluded that constraint Induced Movement Therapy increased activation of sensorimotor cortex in contra lateral hemisphere during the performance of activity by affected and unaffected hand as compared to conventional treatment which showed a decrease in activation of sensorimotor cortex in ipsilateral hemisphere during the performance of activity by affected hand.

Qiang Wang et al compared the effect of constraint Induced Movement Therapy with conventional therapy and intensive therapy and determined that constraint Induced Movement Therapy had apparent advantage over conventional therapy and intensive therapy for improving upper extremity function in stroke patients.

Rehabilitation after stroke

When skills are practiced with affected upper extremity neuronal connection gets strengthened. Cortical maps reorganize which result in improvement of function which varies with intensity and duration of activity.

Sung H. You et al determined that virtual reality resulted in ipsilateral and contra lateral sensory motor cortex activation leading to cortical reorganization and improvement in motor function after stroke as showed by fMRI.

Michael A. Dimyan et al determined that neuroplasticity occurs after stroke through motor rehabilitation strategies and medicine which leads to improved quality of life.

Limin Sun et al determined that motor imagery training is effective for cortical reorganization in sensorimotor areas (increased recruitment to sensorimotor cortex) in chronic stroke patients as showed by fMRI. Improvement in motor function also occurred as showed by Fugl Meyer upper extremity scale.

Robert Teasell et al determined that functional recovery after stroke depends on cortical reorganization. Reorganization of motor areas depends on site of lesion and time and intensity of rehabilitation technique (task or activity specific training effective for individuals with stroke).

Julie Vaughan Graham et al determined that bobath concept is widely used for neurorehabilitation in stroke patients and it's quite effective. The bobath concept focuses on selective performance of motor task with postural control and coordinated sequence of movement with sensory input to perform task properly.

Kelly P Westlake et al determined that lokomat robotic gait training was effective for improvement in locomotor function in chronic hemi paretic stroke patients as compared to body treadmill training and the mechanism behind it was neuroplasticity.

Epidural Stimulation of cortex

Greater improvement in function occurs when epidural cortical stimulation is combined with physical training and it also results in the development of functionally useful compensatory patterns of upper extremity.

Stephanie C. Jefferson et al determined that epidural stimulation of ipsilateral motor cortex along with rehabilitation training resulted in improvement in motor function and cortical reorganization.

Tran cranial Stimulation of cortex

Transcranial stimulation over motor areas causes improvement of motor task performance and basic hand function.

P.Manganotti et al determined that during early stroke cortical inhibition and facilitation involves both the hemispheres. Motor recovery during early and late stages of stroke is reflected by cortical disinhibition in unaffected hemisphere as showed by pulsed transcranial magnetic stimulation. This study concluded that the patients in which clinical motor function improved, reduction in cortical inhibition occurred and the patients in whom no improvement in motor function occurred, cortical inhibition remain unchanged during the early and late stages of stroke.

Christian Gerloff et al determined that in chronic stroke patient's cortico-cortical connection get reduced in affected hemisphere and increased in contra lateral hemisphere as showed by EEG analysis. Increased contralesional activity facilitates recovery of motor function, ipsilateral hemisphere is responsible for arousal of corticospinal tract command but there is no recruitment of uncrossed corticospinal tract fibres after application of transcranial stimulation over contra lateral primary motor cortex.

T. Platz determined that impairment oriented arm BASIS training resulted in medial shift in motor cortex of cerebral hemisphere and improved conduction times predicted motor recovery as indicated by transcranial magnetic stimulation (TMS).

Giovanni Di Pino et al determined that noninvasive brain stimulation technique (NIBS) can be used to evaluate neurorehabilitation after stroke. Two models were proposed; one was Interhemispheric competition model which proposed that by suppressing excitability of unaffected hemisphere, inhibition of affected hemisphere occur which leads to motor recovery. The other was bimodal balance recovery model which proposed that axonal and dendritic sprouting and synaptogenesis in unaffected areas of cerebral cortex leads to functional recovery.

Conclusion

Reorganization of surviving neuron occurs in motor areas of cortex after stroke, which results in cortical map reorganization. This reorganization can be normal or abnormal on the basis of new connections. Our behavior and environmental factors play an important role in it. For reorganization to be beneficial for functional improvement of affected limb correct neuronal input at right time is required. Early sensory stimulation and use of affected limb for task performance is not only beneficial for reorganization of cortex but also prevent use of compensatory strategy. Rehabilitation is also affected by severity, injured area, and time after stroke. Start of rehabilitation at early stages of stroke increase chances of improvement, this is an ongoing process.

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