Can we unveil the black box of symptoms following stroke?

Introduction

I am an applied movement control scientist and work with stroke patients to restore lost control using patient's own self-organized stroke brain as the best tool to re-reorganize it in the presence of gravity by channalizing the dialogue between brain and paretic body. I receive Emails of chronic stroke subjects from around the world pleading me to help them to alleviate spasticity and put them on the road to true recovery and not allow compensatory recovery.

Few days before I received one mail that shook my inner soul and aggravated intense pain in my heart that I am feeling since the time I was studying in Valens at a centre for stroke rehabilitation in Switzerland 25 years ago learning Bobath technique and watching the helplessness in the eyes of stroke subjects and their family, feeling helpless myself that I am not able to change the many decades old, symptom based treatment approach in Neuro-physiotherapy where focus is on the muscle; "the victim" of brain lesion and not on the root cause of the chain of symptoms that develop with passage of time.

I am reaching out to you today in order to help the world of stroke sufferers and to change the world of physical medicine and rehabilitation to help the future stroke patients in the hope that future patient will not have to struggle like the stroke victims suffering today despite spending huge money on treatment to treat muscle weakness, muscle spasticity, muscle contracture. Muscle simply is the victim and not the root cause.

Tubular vision of different experts in multidisciplinary approach

Multidisciplinary approach in stroke rehabilitation focuses on different parts of the body according to their specialization. Multidiscipline has its advantages as well as some disadvantage in terms of tubular vision that divides the "one whole" into separate parts. We all know that human body works as one whole entirely integrated unit and not as separate parts like in manmade machine wherein, if one part is not functioning it does not have its influence on another and one can repair individual part for machine to restart. For human machine, one needs to account for the influence of various body parts of a unified whole on one another. Gestalt described "one whole is bigger than the sum total of its individual parts".

This is not all

Besides shocking number of stroke victims and mind boggling financial figures, there is much more to understand about human suffering from stroke and direct and indirect economic burden on patient, family, and on state funds. Many stroke survivors receive limited therapy and are then discharged to the community, where they often remain chronically disabled, socially isolated, and at risk for common post-stroke rehabilitation complications such as falls, disuse atrophy, and cardiovascular de-conditioning etc. Those who want therapy in chronic state at his / her own costs has one single goal to recover completely but may not receive full value to their money and value for time spent on therapy when goal of service provider is to teach compensation, treat contracture and advice anti spastic drug and anti depressive drug. On top of all service provider's expectations *[silent & undeclared]* for restoration of lost control and restoration of productive life for the patient is as good as negligible.

Differences in goal

There is fundamental difference in the goal [1] of the patient, and goal of the service providers in physical medicine and rehabilitation. Goal of the stroke subject following stroke is to get back to normal self, patient wants his leg and arm and hand to move like it did before stroke happened to him without any compromise. Whereas, primary goal of the neuro-physiotherapist in stroke rehabilitation is to make the stroke subject independent in function like sitting, standing, walking and in activities of daily living (ADL) as soon as possible. Secondary goal in therapy is to treat the paretic weak / spastic muscle, which is the victim of lesion in the brain and is not the root cause of all symptoms.

Muscle, the victim becomes flail, weak and paretic from lesion. These paretic muscles with passage of time turn spastic, develop synergic grouping at the cost of selective control, remain weak and get contracted despite intense rehabilitation efforts. Many physiotherapist I am sure ask themselves in their own minds about uselessness of symptom based approach when symptoms reappear despite their constant efforts. I know many physiotherapists also feel let down and frustrated when many different techniques that they learn and diligently apply to their patients but do not get the satisfactory results. Many therapists wonder in their mind on how long it will take for the future stroke patient not to suffer like their fellow patients of yester years who struggled against muscle weakness, muscle contracture and spasticity despite huge efforts! Certainly it is not easy to challenge many decades old existing system especially when it is multidisciplinary with hidden hierarchy where everyone concerned is responsible for their area of expertise but no one is singly wholly responsible.

What remains constant always is “the change”; Change is the way of life.

“Out of the box” ideas of one single individual in a profession of multidisciplinary rehabilitation field are difficult to be noticed. Being taken seriously is a far cry especially when evidence based practice is in vogue. Existing treatment methods that focus on muscle weakness and muscle spasticity are either without any evidence and few with evidence are based on mono-disciplinary studies of the symptoms. The root cause of the multiple complex symptoms that develop with passage of time and complete picture of its evolution is yet in a black box and is waiting to be unveiled in this 21st century. We will need not only a strong desire to bring the change to unveil the black box but we will need to shed our inertia to ask why same symptoms resurface again and again despite treatment.

Much needed Change will come only when we ask why one should continue to treat paretic muscle when after century long therapeutic efforts patient asks same question …when will my hand function and when will I walk normal? We also need to ask, is it necessary to give high importance to corticospinal tract and voluntary control just because we encounter loss of voluntary control in all out patients. Can we restore voluntary control without facilitating lesioned cortex with TMS and without robotic help? Shall we ask is voluntary control a goal for lesioned brain?

Next question and series of questions

We need to ask new questions for the same and mostly unresolved symptoms of the stroke subject well described by our predecessors, who wrote books and developed techniques with their the then vision about muscle. We need to think independently without bias and without the interpretation of symptoms by our predecessors. We need to read all our patients as new books, still unread and unexplored.

We need to ask is it the small lesion in the brain alone that is responsible for complex sensory motor symptoms that develop with passage of time. Or is it *"something else" [Rajul Vasa unpublished observation]* that is waiting to be unveiled.

To understand stroke as a condition and to answer many questions that comes to our minds while treating stroke patients day in and day out and to perceive factors responsible besides lesion behind evolution of the chain of complex sensory motor problems one needs a new way of thinking. The fundamental change in our way of thinking must be a shift of emphasis from the parts to the whole. Tubular vision in multidisciplinary rehabilitation needs to grow beyond lesion in CNS and beyond muscles.

Physiotherapists have to grow beyond being a technician offering techniques to strengthen the paretic muscle and inhibit spastic muscles and ask……..

1. When supreme nature, always works on optimality principle then, why the victim; "the weak flail muscle" turns spastic, develops synergic grouping at the cost of selective control and get contracted instead of becoming normal? Is optimality principle [2] [3] of biological system the precise reason, why flail muscle turns spastic, develops synergic grouping and gets contracted for some functional reasons like "Binding and Towing" *[Rajul Vasa unpublished observation]* of paretic body by self-organizing stroke CNS?

2. Why do we not ask if, one can exploit amplification property of the brain in our benefit to restore lost control when it is capable to make many muscles on one entire side of the body to become paretic and flail from a small lesion in one of the hemisphere and complicate the simple into complex problem with time?

3. We need to ask can one amplify restoration of lost sensory motor control, speech and cognitive control and make way for selective control instead of allowing development of abnormal synergic grouping in chain of paretic muscles?

4. Why do we approach speech, sensory-motor control in Upper limb in lower limb, and cognitive recovery separately with different special experts targeting only one specific problem when speech, gesture, posture, movement and cognition all are highly interdependent?

5. Why do we feel satisfied with task specific functional training with compensation and activities of daily living [ADL] for function and promote altered compromised motor behavior?

6. Why do we not ask if, the spared regions of the brain could also become a problem with self-organizing ability of the brain to prioritize safety of COM without waiting for any medical external interference!

7. Why do we not ask if, plasticity of the stroke CNS could possibly be negative and detrimental with compensatory motor control and not necessarily positive and beneficial in restoring lost control?

8. Why do we not ask if, Structural changes reported in scientific studies following stroke in non lesioned hemisphere with experience dependent plasticity [4, 5] with constant use of non paretic good side for postural and supra postural activities could be one of the important cause why stroke subject is unable not to, "not use" good side and also unable to use the paretic side despite forcing the use of paretic hand, despite constraining good hand and despite healing of lesion.

9. Why do we not ask why to force the use of paretic upper limb for activities which are normally unilateral? Why do we not see that movements of paretic upper limb when forced upon by constraining good limb are esthetically not so pleasing and invariably spatio-temporally inefficient and energetically uneconomic, then why one should indulge into practicing them just because

"learned non use" was experimented on monkeys who normally ambulate on all fours? Why do we not ask why constraining good lower limb of stroke subject did not become part of CI therapy?

10. Why do we not ask what is the reason of post stroke depression? Is it simply the lesion or is it from effects of self-image crisis when the stroke subject relearns to be independent but in a completely compromised behavior which hurts his ego and self image especially when movements that he took for granted before stroke now needs constant attention and becomes energy consuming and extremely fatiguing.

11. Why do we not ask what does antidepressant drug do? Does it help in restoring the lost control for the stroke subject?

12. Why initial few symptoms like lesion in the brain and paresis in muscles multiply and weave into cobweb of complex problems like spasticity, contracture, weakness, clonus, associated reaction, abnormal synergic grouping, paraesthesia, neglect, pain, abnormal sensation, depression, memory loss, speech, cognition and perceptual problems etc. with snow ball effect despite huge efforts on the part of the therapist to treat the victim; "the muscle".

13. Why does therapist and drug both fail to give long term benefit in inhibiting spastic muscle and in restoring lost sensory motor control despite huge efforts?

14. What about stroke CNS post lesion? How does it cope with different internal as well as external invariant and variant constraints?

15. How do paretic MSS with increased degree of freedom [6] of multiple linked segments from initial paresis cope against the force of gravity? Does increased degree of freedom [6] of multiple linked segments pose serious threat to the safety of global COM?

16. What does the self organizing dynamic brain do to prioritize safety of COM in stroke subjects during postural and supra postural tasks?

17. What makes the increased degrees of freedom [6] that predominated in the initial acute state to turn into reduced and restricted degrees of freedom?
18. What makes negative symptom of paretic muscle to turn into positive symptoms like spasticity?

19. What is the muscle wisdom behind losing sarcomere, losing viscosity and elasticity and turning stiff and contracted?

20. What are the major challenges in rehabilitation therapeutics? Is it the negative symptom the weakness [7], positive symptom; the spasticity, [8] Abnormal synergic grouping, [9] associated reactions, [10] passive tissue contracture [11] learned non-use [12] that develop with time post stroke OR ***something else?*** **(**Rajul Vasa unpublished observation)

Prioritizing safety of COM

Self-organizing brain without waiting for any external help begins to take steps to meet one single goal to defend itself against the force of gravity and to prioritize safety of COM following stroke. It exploits number of structures from within without any external assistance to prioritize safety of COM when one side of the muscle motors cannot generate enough power to combat the force of gravity.

"Binding and towing" & "leading and following": new motor behavior.

My experiences on stroke subjects has led me to clinically conclude that the whole exercise of self-organizing brain to exploit different structures from within to reinstate stability to mechanically imbalanced

paretic musculo-skeletal system [MSS] and all its attempt to give it safety from falling is the root cause behind development of chain of complex sensory motor symptoms and varied motor behavior.

Self organizing stroke CNS exploits…..

1. Basic fabric the fascia and connective tissue to generate forces from contracture to bind paretic MSS to the good MSS at the central axis for easy and economic towing of paretic MSS. Towing puts a full stop to exchange of dominance between two sides of the MSS allowing the good side to lead the entire body exclusively making the paretic side to be a constant follower of the good side to prioritize safety of COM. Paretic MSS depends on the leading good MSS for geocentric reference when gets towed by good MSS thereby providing safety to COM.
2. It also exploits anticipatory postural motor activity with slightest movement of COM to induce continuous spastic contraction in chain of paretic muscles for synergic grouping in many linked segments that also helps reduce and restrict the increased degrees of freedom from paresis.
3. Synergic grouping with anticipatory spastic continuous activity in chain of muscles also gives special direction to the limbs. Upper limb goes in flexed posture and hip adduction for LL helps limbs to move towards the central axis. Flexed upper limb also reduces the moment arm and does not allow the arm to reach out in open thereby restrict segmental COM from moving out of the BOS which can pose threat to the safety of COM. Adduction at the hip also helps the LL mass to remain within BOS thereby reducing threat to the safety of COM. Synergic grouping also prevents selective control at individual segments sacrificing the volitional control to ensure safety a priority. Constant one direction of the paretic limbs towards central axis strengthens the egocentric reference of paretic body. Binding of paretic body to central axis with connective tissue contracture and contracture in fascia enable it to depend on good MSS for geocentric reference when being towed.
4. Self-organizing CNS also exploits inertial mass of the paretic segments to induce stretch on paretic muscle for reflex contraction to sustain the weight of the segment against the force of gravity.
5. Unopposed mechanical pull of good trunk muscles rotate the torso away from paretic hip thereby shift the weight of the head, arm, trunk [HAT] on the good hip to unload the paretic hip from burden of sustaining HAT mass. Asymmetry in loading of two LL (lower limb) gives safety to COM.

Cobweb of sensory-motor symptoms and its vicious cycle

Inter limb knowledge, inter limb sensation, spino spinal activity, cerebello-cerebellar activity, interactive forces, and inter segmental forces, inertial forces etc generated during different ADL activities of daily living post stroke with uninterrupted use of good limbs to control COM and to restore COM during all postural and supra postural activities gives birth to unending reverberating vicious circle of different complex sensory motor problems with development of abnormal synergic grouping, associated reactions, reflex activity and anticipatory continuous spastic activity, Paraesthesia and increased abnormal sensation, neglect, pusher effect, perceptual and cognitive difficulties, depression, memory loss, difficulty in reloading the lower limb and difficulty in reaching out with upper limb.

Re-reorganize, self-organized brain

- Solution is to help self-organized CNS to re-reorganize therapeutically and channalize natural recovery by exploiting bilateral innervation of the trunk to expand boundaries of COM movement.

- Exploit passive inertial mass of the trunk in simple basic postures before it becomes a constant trouble maker in terms of causing imbalance and causing disequilibrium of COM.

- Act in tandem with the brain to prioritize safety of COM at all costs with one difference and that is promote paretic MSS to restore and control COM rather than defend it and do not allow self-organized brain to promote and endorse non paretic good side limbs to control, restore and propel COM during all postural and supra postural activities.

- Do not allow self-organizing brain to promote Binding and Towing of paretic MSS with spastic continuous anticipatory contraction, contracture and synergic grouping on optimality principle for economy of energy while moving in 3 dimensional space.

- Balance out the imbalance in proprioceptive sensory input to mirror image structures like spine and cerebellum before it adapts to reduced ongoing sensory input due to paresis and lack of movement and before it endorses the asymmetry in loading between two legs for safety reasons.

- Shift the treatment attention from stimulating descending motor corticospinal pyramidal tract with TMS, fMRI, Robot, etc. to ascending proprioceptive sensory input to spine and cerebellum and cortex which is highly capable of modulating, channelizing, regulating descending motor output to periphery as desirable in therapeutics.

- Let selective volitional control, speech, gesture, sensation and cognitive recovery emerge as a byproduct automatically by focusing on one single control parameter the COM safety brought in exclusively with paretic side MSS.

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