REHABILITATION OF NEUROLOGICAL DISABILITY: THE PATH AHEAD

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Objective

To assess our current progress in rehabilitation therapies for neurological illnesses, and to chart the path ahead using new development areas that show particular promise.
1. Role of learning and neural plasticity in neurological rehabilitation
2. Focus on stroke recovery as a model system – Cumberland report on Translational Research
3. Examples from robotics applications
4. Measurement issues
5. Recommendations going forward
“Rehabilitation, for patients, is fundamentally a process of relearning how to move to carry out their needs successfully.”

1. Recovery is linked to some type of **learning process**

2. This learning involves acquiring compensatory strategies to utilize residual neural systems, and more importantly, to promote restoration of function in damaged brain or spinal cord areas.

3. Learning involves plastic changes in neuronal structure and function, that are also manifested as changes in brain imaging.

   (although not all changes in brain images are a reflection of such structural change)
Neurorehabil Neural Repair. 2009 Feb; 23(2):97-107

The Future Of Restorative Neurosciences In Stroke: Driving The Translational Research Pipeline From Basic Science To Rehabilitation Of People After Stroke

Major advances during the past 50 years highlight the immense potential for restoration of function after neural injury, even in the damaged adult human brain. Yet, the translation of these advances into clinically useful treatments has been very slow.

**Objective**

We will consider why the traditional model of a “translational research pipeline” that transforms basic science into novel clinical practice has failed to improve rehabilitation practice for people after stroke.
Rehabilitation of neurological disability: the path ahead

From Cumberland report

1. Most treatments trialed in vitro and in animal models have not yet resulted in obviously useful functional gains in patients;

2. Most clinical trials of restorative treatments after stroke have been limited to small-scale studies;

3. Patient recruitment for larger clinical trials is difficult;

4. The determinants of patient outcomes and what patients want remains complex and ill defined, so that basic scientists have no clear view of the clinical importance of the problems that they are addressing;

5. Research in academic neuroscience centers is poorly integrated with practice in front-line hospitals and the community, where the majority of patients are treated;

6. Partnership with both industry stakeholders and patient pressure groups is poorly developed.”
1. We argue that interaction between patients, front-line clinicians, and clinical and basic scientists is essential so that they can explore their different priorities, skills, and concerns.

2. These interactions can be facilitated by funding research consortia that include basic and clinical scientists, clinicians, and patient/caregiver representatives with funds targeted at those impairments that are major determinants of patient and caregiver outcomes.

3. Consortia would be instrumental in developing a lexicon of common methods, standardized outcome measures, data sharing, and long-term goals.

4. Interactions of this sort would create a research-friendly, rather than only target-led, culture in front-line stroke rehabilitation services.
A brief diversion to illustrate our experience with one group of new technologies – Rehabilitation Robots
A collage of current robotic systems
Robotic therapy training gains are modest (e.g., Fugl-Meyer score)

From David Reinkensmeyer, UCI

T-WREX

There are now many new rehabilitation robots

1. Most have focused on restoration of gait, because this is the most demanding task physically for therapists (e.g., Lokomat®)

2. These lower extremity interventions have the most rigorous physiological rationale

3. There are many new devices emerging for upper extremity treatment, and several have reached the point of clinical trials – but rationale for their use is much less clear
Planar robots – MIT Manus

James Patton, PhD and Sandro Mussa-Ivaldi, PhD

The means by which these robots exert their therapeutic effects remains unclear.

1. Repetitive training with active concentration promotes skill acquisition and cortical reorganization – based on cortical plasticity

2. Error minimization – here voluntary movements are supported and corrected by the robot (eg. MIT Manus)

3. Error Augmentation – here force fields are applied that initially increase the error, but over a period of time, the movement errors subside, and when the training is completed, there is often more sustained improvement (Patton & Mussa-Ivaldi)

4. Task-specific training is necessary, but it works better when there are some variation in tasks

At the moment, we do not know which strategy is superior.
1. There is not strong evidence that this technology really works well in neurological injury.

2. Locomotion training in SCI or in stroke has had limited success, when novel treatments (robotics, or body weight supported manual training) are compared with high-quality physical therapy.

3. Robotics show promise, but do not show clearly better results than skilled therapists. Nonetheless, robots offer interventions that may not be practical to deliver by other means.
Sensitive issues – the role of technology in clinical practice

1. We have begun our own RIC robotics initiatives with the idea that PTs and OTs will guide robot development, as a tool to augment their clinical management and care delivery.

2. Can therapists really guide this development? Most do not have training (nor do physicians for that matter).

3. There is also a certain fear of the technology – “Robophobia”

4. Are we ready for robots in the clinic?
Virtual reality vision and touch

1. It is a valuable adjunct technology
2. It is valuable in 3-D environment for testing – avoids the use of real objects
3. It can be used to manipulate sensation as a treatment tool
4. It can provide immersion – real world preparation
Error augmentation (EA)
1. We are much better at diagnosis but not clearly better at therapy than we were 20 years ago

2. Use of quantitative methods to describe chronic neurological impairments has helped, although there is not yet widespread application in clinical practice

3. So we have trouble measuring severity of the impairment, and how well we are doing to reduce this impairment. This is a key deficit.
1. Use of the Functional Independence Measure (FIM) in clinical practice and a small number of other measures in outpatient practice and nursing homes, but there is no widespread assessment of function

2. We use some locomotion measures (6 minute walk, 10 meter walk, timed up and go) for lower extremity and locomotion function

3. For upper extremity we use grip strength, sometimes manual dexterity (9 hole peg test, box and block) for testing of impairment. But not widely used.

4. We are limited mainly because of time constraints and limited knowledge base
Issues to discuss – what do we need to make progress?

1. Basic science
   - Mechanisms of neural plasticity
   - Analysis of the injured brain – does it learn the same way?
   - Therapy dosage – need for animal models to test options (I do not believe we can test dosage options fully in humans)
   - Combined interventions – also hard to test in humans
   - Clinical/basic partnerships

2. Measurement issues – need for more technology/sensors to establish better tracking of compliance and outcomes

3. Novel therapies – relatively few new drugs are available in our fields (e.g., SCI recovery)

4. More effective trials and trial design – we do not use adaptive trial designs hardly at all

5. Computational models – can they help us to program rehabilitation?
Developing a skilled and suitably trained workforce

1. We need to educate and train a new generation of clinicians who can understand the use of new technologies for diagnosis and treatment of neurological disability

2. We need to forge better clinical/scientist/industry partnerships

3. We need to develop more sensitive and accurate measures of impairment, and of functional outcomes.