Reason for Hope: Predicting Outcome after Catastrophic Injury—Spinal Cord Injury

Christopher Formal MD
Magee Rehabilitation
October 14, 2016
Reason for Hope: Predicting Outcome after Spinal Cord Injury

• I. Introduction
• II. Neurological recovery
• III. Breathing & walking
• V. Residence
• VI. Future research
Introduction

I. How to structure outcome, and hope
II. Upper motor neuron/lower motor neuron basics
III. Classification of SCI
How to Structure Outcome, and Hope

Dr. Staas:  | WHO:  | Patient:
---|---|---
Medical  | Impairment  | I can’t move
Functional | Disability  | I can’t breathe ...
Psychosocial | Handicap  | I am far from home
Introduction

I. How to structure outcome, and hope
II. Upper motor neuron/lower motor neuron basics
III. Classification of SCI
UMN/LMN Basics

• Voluntary motion originates in the brain
• Pathways cross to the other side of the body
• This crossing occurs up high
• The pathway has two neurons
• First neuron (UMN) is up in the brain—its axon crosses, and goes to the spinal cord where ...
• It synapses with the second neuron (LMN)
UMN vs LMN Injury

• They both involve weakness—
• UMN injury yields spasticity
• LMN injury yields flaccidity
• With UMN Injury, electrical stimulation (of nerve or muscle) will cause muscle contraction
Introduction

I. Structure for outcomes and hope
II. Upper motor neuron/lower motor neuron basics
III. Classification of SCI
Description of spinal neurological deficit

• It is “simple” (no cranial nerves, etc.)
• Does not depend on imaging studies
• Two main steps—get the raw data, and then
• Put the data together to describe the injury
What is the raw data?

• Sensation
• Motor function
• To a lesser extent--reflexes
ASIA Classification

• Many different systems to classify SCI
• ASIA -- interdisciplinary
• 10th and Locust
• Level—everything is normal down to (and including)—the level, thus generally the lower in the cord the better
• Severity (“AISG”) is the reverse of school; E is normal, while A is no sparing of function
ASIA Impairment Scale Grade

• A: No motor or sensory function below (technically no sacral sparing)
• B: Some feeling present, but no motor function
• C: Some spared motor function, but weak
• D: Some spared motor function, not normal, but fairly strong (3/5 and better)
• E: Normal
• Reviews anatomy and pathophysiology
• Goes over the exam
• Provides a video course on performing the exam
• Instructional tests
Reason for Hope: Predicting Outcome after Spinal Cord Injury

• I. Introduction
• II. Neurological recovery
• III. Breathing & walking
• V. Residence
• VI. Future research
What about neurological improvement after SCI? What is in the literature?

• First—people are NOT expected to decline; decline would need investigation

• What is expectation for improving from ASIA Impairment Grade A? B? C?

• (Marino, Arch Phys Med Rehabil, 2011)
<table>
<thead>
<tr>
<th></th>
<th>1 year A</th>
<th>1 year B</th>
<th>1 year C</th>
<th>1 year D</th>
<th>1 year E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Admit as A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Admit as B</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Admit as C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Admit as D</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 year A %</td>
<td>1 year B %</td>
<td>1 year C %</td>
<td>1 year D %</td>
<td>1 year E %</td>
</tr>
<tr>
<td>----------------</td>
<td>------------</td>
<td>------------</td>
<td>------------</td>
<td>------------</td>
<td>------------</td>
</tr>
<tr>
<td>Admit as A</td>
<td>78</td>
<td>12</td>
<td>6</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Admit as B</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Admit as C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Admit as D</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Prognosis for ASIA A

• Most stay “complete”
• However—22% do become incomplete within the first year, and of these a minority improve to ASIA D
<table>
<thead>
<tr>
<th>Admit as</th>
<th>1 year A %</th>
<th>1 year B %</th>
<th>1 year C %</th>
<th>1 year D %</th>
<th>1 year E %</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>78</td>
<td>12</td>
<td>6</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>B</td>
<td>3</td>
<td>46</td>
<td>27</td>
<td>24</td>
<td>0</td>
</tr>
<tr>
<td>C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Prognosis for ASIA B

• (people should not decline)
• Over half will become motor incomplete
• A quarter will progress to ASIA D—thus functional strength in the lower limbs
<table>
<thead>
<tr>
<th></th>
<th>1 year A %</th>
<th>1 year B %</th>
<th>1 year C %</th>
<th>1 year D %</th>
<th>1 year E %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Admit as A</td>
<td>78</td>
<td>12</td>
<td>6</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Admit as B</td>
<td>3</td>
<td>46</td>
<td>27</td>
<td>24</td>
<td>0</td>
</tr>
<tr>
<td>Admit as C</td>
<td>0</td>
<td>1</td>
<td>22</td>
<td>77</td>
<td>0</td>
</tr>
<tr>
<td>Admit as D</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Prognosis for AIS C

• (should not decline)
• Over half will improve to ASIA D, thus functional strength in the lower extremities
<table>
<thead>
<tr>
<th>Admit as</th>
<th>1 year A %</th>
<th>1 year B %</th>
<th>1 year C %</th>
<th>1 year D %</th>
<th>1 year E %</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>78</td>
<td>12</td>
<td>6</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>B</td>
<td>3</td>
<td>46</td>
<td>27</td>
<td>24</td>
<td>0</td>
</tr>
<tr>
<td>C</td>
<td>0</td>
<td>1</td>
<td>22</td>
<td>77</td>
<td>0</td>
</tr>
<tr>
<td>D</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>84</td>
<td>14</td>
</tr>
</tbody>
</table>
Effect of time from injury ...

• Clearly a person with ASIA B injury of one day’s duration has a greater likelihood of improving to C or D than a person with ASIA B injury of one year’s duration

• BUT we don’t know much about this quantitatively; we don’t have a chart to use
Reason for Hope: Predicting Outcome after Spinal Cord Injury

• I. Introduction
• II. Neurological recovery
• III. Breathing & walking
• V. Residence
• VI. Future research
Breathing

• Usually the lungs are healthy
• If presented with air, the lungs will function properly—taking in oxygen and getting rid of carbon dioxide
• Problem is getting the air there—ventilation; a motor problem
Ventilation

• Moving the air in—inhalaion—diaphragm
• Moving air out—exhalation-especially coughing—lower muscles
• One can get along well with just ability to inhale—thus, if phrenic nerve is working
UMN vs LMN Injury

- They both involve weakness—
- UMN injury yields spasticity
- LMN injury yields flaccidity

- With UMN Injury, electrical stimulation (of nerve or muscle) will cause muscle contraction
Phrenic nerve pacing
Implanted system; nothing through the skin
Challenging surgery
Diaphragm must be conditioned
Diaphragm Pacing System
“DPS”

• Relatively easy to place ...
• Diaphragm must be conditioned
• A bridge, or a destination
• Parameters are managed externally
• “Percutaneous”
Reason for Hope: Predicting Outcome after Spinal Cord Injury

• I. Introduction
• II. Neurological recovery
• III. Breathing & walking
• V. Residence
• VI. Future research
Early prognosticators:

Crozier Arch Phys Med Rehabil 91
• Sparing of pin sensation predicts better prognosis for gait than touch sparing only.
• Why ...

Crozier Arch Phys Med Rehabil 91
• Better than 3/5 quad at three months predicts gait
• Why ...
Early prognosticators

Penrod, Arch Phys Med Rehabil 90
• Age below 50 is a good prognosticator for persons with a similar SCI syndrome
• Why ...

Middendorp, Lancet 2011
• Confirmed age, quads
• Also, plantar flexors—why?
• Also touch sense L3 and S1
Problems ...

• Varying definition of ambulation (note WISCI scale)
• What “we” need is information about prognosis for people based on findings sometime after injury
Data for persons at 1 month ...

• For 13 persons with SCI, ASIA B tetraplegia at 1 month—

• None were community ambulators at 1 year

• Some did regain some LE motors—these were people with preservation of pin sensation

(Waters, Arch Phys Med Rehabil, 1994)
BUT ...

• People with ASIA C injuries often did well
• Most of those with a “summed LE motor score” of 10 or better, as 30 days, were able to walk in the community at 1 year
• Perspective: 10 lower limb muscles; having trace function in all of them would give a LE score of 10

• Waters et al, Arch Phys Med Rehabil 1994
A Memorable Case ...

• 15yo boy was hurt wrestling—with tetraplegia.
• Presented for rehabilitation at day 16, with C6 level, sensory incomplete tetraplegia, no motor function in lower limbs. (“ASIA B”)
• Began to regain lower limb strength at day 51.
• Five months after injury, walking/running without assistance or device.
Body weight supported training

• Stegosauruses and babies
• Cats
• Hess’s Law
• Body weight supported training
  upright
  sensory input
  upper limbs free
Traditional Body Weight Support

Arms free/input through feet/upright

Therapist input to help facilitate response

Labor intensive in numbers of personnel and in exertion

Physically vigorous
Robotic Suspended Training

Arms free/input through feet/upright

Less labor intensive

“Smooth”
Overland Suspended Gait Training

Arms free/input through feet/upright
Allows overland training with obstacles
Allows some lateral motion
Three modalities ...

• Unusual to have all of them in one setting
• No paradigms for how to utilize with different persons
• Benefits extend well beyond ambulation
• Appropriate for training with persons with other impairments
External Powered Skeletal Support

Can substitute for A to B mobility; can replace, for certain situations, a wheelchair

Not truly suspended, arms are **not** free

More than a substitute; has been broadened to use as a training device
Upper Limb Systems
Reason for Hope: Predicting Outcome after Spinal Cord Injury

I. Introduction
II. Neurological recovery
III. Breathing & walking
V. Residence
VI. Future research
Residence and Life Satisfaction

87% of persons with acute SCI are discharged to a private residence in the community (Model Systems Data, University of Alabama/Birmingham)

Why is that important?
Which most affects Life Satisfaction?

Possibilities here--

- Impairment—paraplegia, say vs tetraplegia
- Disability—ambulatory, vs using a wheelchair
- Handicap/level of societal role—in an accessible vs inaccessible environment

Answer: Societal role

- Greater life satisfaction of a person with tetraplegia, using a wheelchair, in an accessible environment, than for a less impaired person in an inaccessible environment
- Cross cultural/cross generational (Dijkers, Spinal Cord, 1997)
Importance of societal role/handicap

• “If they develop a cure for my spinal cord injury, I will take advantage of it, when I can fit it into my schedule.”

• A good outcome (per the patient) can occur without neurological recovery.
Reason for Hope: Predicting Outcome after Spinal Cord Injury

• I. Introduction
• II. Neurological recovery
• III. Breathing & walking
• V. Residence
• VI. Future research
Future research—stem cells

• I. Framework for thinking of stem cells
• II. Why would such a cell help?
• III. Asterias
• IV. Jefferson & Magee
Basics

• A stem cell can branch out to make different, more specialized cells neurons
• Where does one get a neural stem cell?
• A goal: “Induced, pluripotent stem cell”

(no embryonic concerns, no immunosuppression)
Why would a stem cell help?

Three patients
• Chronic central cord syndrome with loss C8/T1 hand muscles
• A person with chronic incomplete paraplegia
• A person spinal cord injured two weeks ago, with “swelling”

Three cell types
• Neurons
• Myelin-producing cells
• Support cells
“Asterias”

• “OPC”
• Help for early on
• Collaborative with TJUH; Dr. Fried here as Principal Investigator; Mary Schmidt now in Atlanta meeting.
• A long-term view—15 years of follow-up
15 year follow up ....