SCI Model System and SCI-ACT Information

Diana Pernigotti
Sr. Project Coordinator for SCI Research
SCI-ACT Chapter Secretary

December 7, 2017
Model Systems

Model Systems programs sponsored by National Institute on Disability, Independent Living and Rehabilitation Research as part of the Department of Education

- **Spinal Cord Injury Model Systems** 1970: Established with 14 centers
- Traumatic Brain Injury Model Systems 1987: Established with 5 centers
  - 1998: Increased to 17 centers
- Burn Injury Model Systems 1994: Established with four centers
SCI Model Systems

Currently funded
Form II Follow ups
Previously funded

2016–2021 Grant Cycle
SCI Model System

- Original idea, “…to demonstrate the superiority of comprehensive versus fragmented SCI care.”
- Embodies a vision of a comprehensive, interdisciplinary service delivery system, in which the finest talent works with persons with SCI to achieve his or her maximal potential.
- Goal of improving long-term functional, vocational, cognitive, and quality-of-life outcomes for individuals with SCI.
To contribute patient records to a **national database**, maintained by a national statistical center, which tracks the long-term consequences of SCI and conducts research in the areas of medical rehabilitation, health and wellness, technology, service delivery, short- and long-term interventions, and systems research.
Project Design continued

- Ability to carry out research projects including site specific projects

- Each Model System is charged with disseminating information and research findings to patients, family members, health care providers, educators, policymakers, and the general public
How do we do that?

Very competitive grant process every 5 years

- New England Regional SCI Center started in Boston Medical Center in 1976
  - Gaylord joined in 2006
  - Hospital for Special Care joined 2011–2016
- Boston Univ. School of Public Health replace BMC in 2012 to finish the 5 year cycle

Current cycle, 2016–2021, newly merged center

Spaulding New England Regional Spinal Cord Injury Center
Continuing the assessment of long-term outcomes of individuals with SCI by enrolling at least 30 subjects per year into the SCIMS database

Enrolled while inpatient at Gaylord
- Follow up ~ 1 year after injury and every 5 years afterwards

Newly injured, over 16, able to understand and respond to study questions and patient consent

(often referred to as the SCI Outcomes Study)
Gaylord’s Role in SCIMS Database

- Enroll new inpatients with traumatic SCI
- Continue follow up with NERSCIC participants from the last 40 years
- Co–Clinical lead for the study is Dr. Rosenblum
  - Dr. Kevin O’Connor at Spaulding is the other lead
- Special Ops Team
- SCI–FI development and testing
Database Information

- Form I interview— injury details, physical functioning, demographics and a brief medical history from before and right after the injury.

- Form II interviews— update on demographics, including work and school, technology use, satisfaction with life, pain level, recent health issues, interactions with other people, mobility and SCI-FI/AT assessment.
Your Help Is Needed

- Support the project!

- Long term research experiences follow up loss due to not being able to stay in touch with people through the years
  - Recovery or deceased

- Encourage people to continue their participation
The Model Systems Knowledge Translation Center (MSKTC) summarizes research, identifies health information needs, and develops information resources to support the Model Systems programs in meeting the needs of individuals with spinal cord injury, traumatic brain injury, and burn injury.

http://www.msktc.org/
MSKTC Resources

- Factsheets
- Slideshows
- Hot Topic Module

Research

- Quick Reviews
- Research Database
- SCI Systematic Reviews
- Other research opportunities and how to participate in Factsheet reviews
Quick reference on demographics and the use of services by people with SCI including lifetime cost of care and life expectancy chart
  ◦ Available in Spanish

The database has demographic and condition status data through 2016 for 32,159 people with SCI

https://www.nscisc.uab.edu/Public/Facts%20and%20Figures%20-%202017.pdf
Publications and Presentations

Since 1978

- 839 Journal articles
  - 26 led by NERSCIC staff
- 287 Professional Presentations
- 17 Chapters
- 4 Books
Other Studies

- **SCI–FI**– enrolled inpatient, testing computer adaptive testing for a tool to replace the FIM
  - Currently using SCI–FI/AT in Outcomes Study

- **EQuATe**– quality and equity of assistive technology provision and outcomes for individuals with SCI by understanding utilization and impact of assistive technology, raising awareness of variation in wheelchair quality and identify factors associated with variations

- **My Care My Call**– Completed test if a peer-led empowerment training program delivered by phone over a six month period can improve access to quality primary care and preventative services for people with traumatic SCI
Develop a measure of SCI physical functioning that is conceptually grounded, time efficient, sensitive to change, accepted by the SCI community for clinical trials and research, and ultimately, is superior to currently available measures.
How the CAT Works

1. Item Database
2. Item Selection Process
3. Patient Response
4. Score Calculation
5. Stop Rules
6. Functional Outcome Score
Sample Question

How much difficulty do you have grasping a fork or spoon?

- Instruction for participant: Select the response that best describes your current ability to do each activity without help from another person, but using any and all equipment or devices you normally use.
  - Responses are:
    - No difficulty
    - A little difficulty
    - Some difficulty
    - A lot of difficulty
    - Can’t do
SCI–FI/AT Acute Forms

- Testing at Gaylord in this cycle
- Pairs clinicians to complete the interview at the same time with people in acute rehab
- Evaluate the forms and check for inter–rater reliability
- Replacement for FIM across all settings, not just LTACHs
The CAT estimation process begins with a large item database where items are ordered according to their difficulty level. The CAT first selects an item of medium difficulty.

If the person responds positively, then the next items will increase in difficulty.

The CAT selects the next items based on the person’s response.

The test continues until a person consistently responds to items at a particular difficulty level.

If the person responds negatively, then the next items will decrease in difficulty.

Once a stopping rule is met, the test is complete and the person receives his or her score.
**EQuATe Study**

- Equality and Quality in Assistive Technology

- Pen and paper interview

- Questions based on demographics, assistive technology use specifically their primary wheelchair and any discrimination they may have experienced in obtaining it
  - Major goal–creating a guide that rates wheelchair manufacturers and vendors
Papers in progress:

- **Nature of Wheelchair Repairs** (Lead author: Toro) A follow up paper to “Wheelchair breakdown based on manufacturer and model”.
- **The Current State of Wheelchair Testing, Repairs, Consequences, and Maintenance** (Worobey), Instructional session at the International Seating Symposium (extended abstract)
- An investigation of the role of community characteristics in race and socioeconomic disparities in wheelchair prescription. (Amanda B./Kessler) – begin looking at data.
- **Race/ethnicity, socioeconomic, cultural disparities in SCI quality of life and outcomes**. (Denise F./Kessler) – begin looking at data.

Abstracts submitted for the SCIMS Special Issue:

- Longitudinal prediction of mobility status and quality of life scores in individuals with traumatic spinal cord injury. Pitt
- Type and frequency of reported wheelchair repairs and adverse consequences among people with spinal cord injury. Pitt
- Relationships between upper-extremity pathology, transfer skills, and personal characteristics of a sample of wheelchair users with spinal cord injuries. Pitt
- Effect of Group Wheelchair Skills Training on Quality of Life Measures among Manual Wheelchair Users. Pitt
- Preliminary Results on Effectiveness of Group Wheelchair Skills Training among Individuals with SCI
- The Social Determinants of Wheelchair Quality: Does Neighborhood of Residence Play a Role? Kessler
- Race/ethnicity, socioeconomic, cultural disparities in SCI quality of life and outcomes. Kessler
Published Papers from EQuATe


Recently completed as a site specific study, with a Peer Health Coach working at Gaylord

Successful outcomes
- Decrease in barriers to community participation
- Increase in service awareness and use
- Intervention participants reported significantly greater PAM scores

Four published articles with Gaylord as lead site in one
Current Recruitment in Connecticut

- EQuATe study
  - Over 18 years of age
  - Injured for at least one year
  - Signed consent form

- Call Diana 203–679–3563
Other Projects

- Research and education opportunities
  - [http://www.bu.edu/nerscic/](http://www.bu.edu/nerscic/)

- Provider Survey
- NESCIT– New England SCI Toolkit
Knowledge in Motion Lecture

- Lecture and webcast program held in Boston
- Various topics related to SCI
  - Integrated primary care
  - Nutrition for people with SCI
  - Current clinical research updates
  - Emergency preparedness
  - Sexuality
  - Skin care
  - Affordable Care Act update
- Next lecture: JANUARY 25, 2018 Peripheral nerve and spinal neurosurgery to improve functioning in people with SCI presented by Justin Brown, MD
Provider Survey

- Goal: to create a directory of health care providers who give exceptional, accessible care to people with SCI in New England.
- List of “SCI friendly” providers will be available to consumers and providers

http://www.bu.edu/nerscic/2014/02/05/survey-of-your-sci-care-providers-2/
New England Spinal Cord Injury Toolkit

Helps to ensure the person receives the same coordinated standard of care wherever they receive rehabilitation

- Education opportunity across lifespan
- Online access to Toolkit
- Gaylord.org/SCIToolkit
Topics in Toolkit

- Patient/Family/Caregiver Education
- Autonomic Dysreflexia
- Skin Care
- Bladder Management
- Bowel Management
- Sexual Health and Fertility
- Spasticity
Toolkit Contents

- Minimum care standards
- Named disciplines involved
- Identified the process for care delivery
- Recommended resources and how to measure outcomes
The Toolkit will Go LIVE!!

- Still Standards
- Short video clips
  - Interactions between clinician and person with SCI
  - Discussion about real consequences and benefits of education
Spinal Cord Injury Association of Connecticut, a Chapter of United Spinal (SCIACT) is located at Gaylord

Started in 1979 by Dr. Arnold at Gaylord with support from:

- Healthcare workers around Connecticut
- Family and friends of people with SCI and/or SCD
- NEPVA and New England SCI Foundation
- Most importantly, people with SCI
United Spinal and NSCIA merge

- United Spinal acquired NSCIA
- Processes at local level will be the same
  - NSCIA CT may change name to SCIA CT
- NSCIA CT members will be asked if they want to become US members
  - Will remain as Connecticut members
  - Monthly copy of New Mobility magazine (in print and online version)
  - If applicable, will be contacted by mail to support policy changes in Connecticut or nationally
SCIACT Supported Programs

- Think First
- Powerful Tools for Caregivers
- FES bikes in Connecticut
- CT Adaptive Rowing Program
- Take a Vet Sailing Event
- QU Walk and Roll
- Spokebenders
- Ryan Martin Basketball Camp
- Center for Disability Rights
SCIACT Supported Programs

- ThinkFirst in collaboration with Gaylord
- Powerful Tools for Caregivers
- FES bikes in Connecticut
- CT Adaptive Rowing Program
- Take a Vet Sailing Event
- QU Walk and Roll
- Spokebenders
- Quad rugby
- Ryan Martin Basketball Camp
- Center for Disability Rights
- Sport Associations at each of CT rehab hospitals
- Paint–A–Long Events
<table>
<thead>
<tr>
<th>Local</th>
<th>National</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCIACT</td>
<td>United Spinal</td>
</tr>
<tr>
<td>- Local services provided by local members</td>
<td>- National organization</td>
</tr>
<tr>
<td>- Support provided by local funders</td>
<td>- Support provided by government and private donations</td>
</tr>
<tr>
<td>- Access to speak with someone familiar with CT resources</td>
<td>- Lobbyists directly meeting with lawmakers</td>
</tr>
</tbody>
</table>
United Spinal and NSCIA merge

- United Spinal acquired NSCIA recently
- Processes at local level will be the same
  - NSCIA CT changed name to SCIA CT
- NSCIA CT members will be asked if they want to become US members
  - Will remain as Connecticut members
  - Monthly copy of New Mobility magazine (in print and online version)
  - If applicable, will be contacted by mail to support policy changes in Connecticut or nationally
SCI ACT Major Resources

- Peer Visitor Support
- Support Groups
- Resource Book (online access)
- Newsletters
- Free, local accessible events
- Collaboration with national organization for advocacy on local to national level
- Website with local and national information
  www.SCIACT.org

All members receive New Mobility magazine each month and a Welcome Knapsack from United Spinal
Fundraising

- All money donated in CT, stays in CT
- Major fundraiser is the Annual Twilight Gala held each March
  - Major sponsors and individual ticket sales
- Receive private donations in honor of or in memorial of someone
- QU Walk and Roll and newly created Pub Crawls throughout the state
Thank You!
Questions, concerns, comments?

Diana Pernigotti
203–679–3563
Dpernigotti@gaylord.org
Spinal Cord Injury

- SCI results in multiorgan dysfunction
- Review will include:
  - Model Systems
  - Epidemiology
  - Clinical anatomy
  - SCI examination
  - Acute SCI treatment
  - Orthosis
SCI

- Medical complications
- Functional outcomes
- Model SCI System of Care
Model SCI Center at Gaylord

National Institute on Disability, Independent Living, and Rehabilitation Research
NIDILRR funded. Primary research arm for Administration of Community Living
2006-2011, 2011-2016, 2016-2021 grant cycle
14 Centers Competitive
Since 1970, 28 different Model Systems have contributed Data
Mission of Model SCI Center

• Embodies the vision of a comprehensive interdisciplinary service delivery system in which the finest talents work with the person with SCI to achieve his or her maximal potential
Model SCI Centers

• All centers contribute to a data registry
• Approximately 32000 participants over 40 years
• SCI facts and figures at a glance
• www.nscisc.uab.edu
• SCI text: causes of death, life expectancy, age, work, medical complications, etc
Model SCI Research 2016-2021

• A Prospective study of Autonomic Dynamic Dysfunction to predict Infections after SCI (Ohio)
• Therapeutic intermittent hypoxia and functional recovery in individuals with SCI (RIC/Shirley Ryan Ability Lab)
• Telerehabilitation activity based upper extremity exercise program (TJU)
• Mirabegron and Oxybutynin Safety and Efficacy Trial in SCI (Kessler)
• Methods for the reduction of “unavoidable” pressures injury in persons with acute SCI (Case Western)
• Promoting the Psychological Health of Women with SCI: Virtual Intervention (TIRR)
• Cardiometabolic Disease/Syndrome after Spinal Cord Injury (Miami)
Spaulding New England Regional SCI Center Projects

Utilization of Complementary Integrative Healthcare from Craig

Equity and Quality in Assistive Technology (EQuATe) from UPITT

Spinal Cord Injury-Functional Index/Assistive Technology (SCI-FI/AT)
Data collection: inpatient, phasing into OP
Research assistant with support from staff
Site Specific Projects
Spinal Cord Injury-Functional Index/Assistive Technology (SCI-FI/AT)

1. Linkage - create and validate charts linking historical FIM to CAT functional index
2. Inpatient Short Forms - create and validate inpatient short form that can be completed efficiently by clinicians
Publications and Posters


13 Professional poster presentations
SCI

- Multiorgan System Dysfunction
- Decreases survival
- Decreases QOL
- Dual Diagnosis: For example TBI
- Motor power
- Sensation
- Social and psychological impact
- Medical complications
Epidemiology

- Incidence is approximately 54 cases per million per year
- 17,000 per year
- Prevalence is approximately 282,000
- 4:1 Male to female
- 64% white, 22% African-American, 11% Hispanic-Latino, 2% Asian, 1% Other
- Median charge for medical care at 1 year=$676,000 ($1,066,000 for high cervical)
Epidemiology

- Age = average 42 yrs old
- Gender = 80% men
- Etiology = MVA
- Falls in elderly
- Most common levels: C5, C6, T12, C7, L1
- 33% complete injuries
- Life expectancy: almost normal for incomplete
- 30yo C4 = 70% of normal life span
Age at Injury

Males: 23,442 (80.7%)  
Females: 5,610 (19.3%)
Etiology of Traumatic SCI

• MVA most common
• Falls is second, except in elderly where it is number 1
• Violence is third leading cause
• Other causes: Football, Trampoline, Diving, Horseback riding, etc
• Nontraumatic SCI: see separate section
Etiology by Event
<table>
<thead>
<tr>
<th>Category</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Motor Vehicle Crashes</strong></td>
<td></td>
</tr>
<tr>
<td>Automobile</td>
<td>35.8</td>
</tr>
<tr>
<td>Motorcycle</td>
<td>6.1</td>
</tr>
<tr>
<td>Bicycle</td>
<td>0.9</td>
</tr>
<tr>
<td>Other Vehicular</td>
<td>0.7</td>
</tr>
<tr>
<td>Fixed-Wing Aircraft</td>
<td>0.4</td>
</tr>
<tr>
<td>All-Terrain Vehicles and Cycles</td>
<td>0.2</td>
</tr>
<tr>
<td>Rotating Wing Aircraft</td>
<td>0.2</td>
</tr>
<tr>
<td>Boat</td>
<td>0.1</td>
</tr>
<tr>
<td>Snowmobile</td>
<td>0.1</td>
</tr>
<tr>
<td><strong>Sports</strong></td>
<td></td>
</tr>
<tr>
<td>Diving</td>
<td>8.5</td>
</tr>
<tr>
<td>Football</td>
<td>0.7</td>
</tr>
<tr>
<td>Snowsking</td>
<td>0.5</td>
</tr>
<tr>
<td>Horseback Riding</td>
<td>0.4</td>
</tr>
<tr>
<td>Surfing, Body Surfing</td>
<td>0.4</td>
</tr>
<tr>
<td>Gymnastics</td>
<td>0.3</td>
</tr>
<tr>
<td>Trampoline</td>
<td>0.3</td>
</tr>
<tr>
<td>Wrestling</td>
<td>0.3</td>
</tr>
<tr>
<td>Other Winter Sports</td>
<td>0.3</td>
</tr>
<tr>
<td>Other Sports, Unclassified</td>
<td>0.3</td>
</tr>
<tr>
<td>Field Sports</td>
<td>0.2</td>
</tr>
<tr>
<td>Hang Gliding</td>
<td>0.2</td>
</tr>
<tr>
<td>Waterskiing</td>
<td>0.2</td>
</tr>
<tr>
<td>Baseball, Softball</td>
<td>0.1</td>
</tr>
<tr>
<td>Rodeo</td>
<td>&lt;0.1</td>
</tr>
<tr>
<td>Basketball, Volleyball</td>
<td>&lt;0.1</td>
</tr>
<tr>
<td>Air Sports</td>
<td>&lt;0.1</td>
</tr>
<tr>
<td>Track and Field</td>
<td>&lt;0.1</td>
</tr>
<tr>
<td>Skateboarding</td>
<td>&lt;0.1</td>
</tr>
<tr>
<td><strong>Falls</strong></td>
<td></td>
</tr>
<tr>
<td>Acts of Violence</td>
<td></td>
</tr>
<tr>
<td>Gunshot Wound</td>
<td>14.6</td>
</tr>
<tr>
<td>Other Penetrating Wound</td>
<td>1.0</td>
</tr>
<tr>
<td>Personal Contact</td>
<td>0.9</td>
</tr>
<tr>
<td>Explosion</td>
<td>0.1</td>
</tr>
<tr>
<td><strong>Other</strong></td>
<td></td>
</tr>
<tr>
<td>Hit by Falling Objects</td>
<td>3.7</td>
</tr>
<tr>
<td>Pedestrian</td>
<td>1.7</td>
</tr>
<tr>
<td>Medical/Surgical Complication</td>
<td>1.7</td>
</tr>
<tr>
<td>Other, Unclassified</td>
<td>1.0</td>
</tr>
</tbody>
</table>
PERCENT OF PEOPLE WITH EACH NEUROLOGIC LEVEL AT DISCHARGE
SCI Anatomy - covered separately

- Spinal cord transfers motor information from brain to body
- Transfers info from body to brain
- Protected by vertebrae
- Blood supply: anterior spinal artery for anterior 2/3 and 2 posterior spinal arteries for posterior 1/3
- Artery of Adamkewicz: large lumbar radicular artery, midthoracic T8-L1 disrupted with injury to thoracoabdominal aorta
SCI Anatomy

- From foramen magnum to distal L2 vertebra
- Below L2 it is the cauda equina
- Pairs of nerve roots: 8 cervical, 12 thoracic, 5 lumbar, 5 sacral and 1 coccygeal
Cervical nerves
- Head and Neck
- Diaphragm
- Deltoids, Biceps
- Wrist Extenders
- Triceps
- Hand

Thoracic nerves
- Chest Muscles
- Abdominal Muscles

Lumbar nerves
- Leg Muscles

Sacral nerves
- Bowel, Bladder
- Sexual Function

The spinal cord ends between L-1 and L-2. The nerves continue to descend in the spinal column, exiting between the vertebrae and through the sacrum.

Upper motor neurons lie within the spinal cord.

Lower motor neurons are spinal nerves that branch off the spinal cord.

Conus Medullaris

Cauda Equina
Dorsal (posterior) columns
(Sensations from same side of body)

Cuneate fasciculus
(Discriminative touch and
proprioception, upper limb)

Gracile fasciculus
(Discriminative touch,
lower limb)

Dorsal spinocerebellar
tract (Proprioception;
lower limb, same side)

Nucleus proprius of dorsal
horn (Origin of contralateral
spinothalamic tract)

Ventral spinocerebellar tract
(Proprioception, both lower limbs)

Spinothalamic tract
(Simple touch, pain and temperature,
opposite side of body)

Lateral corticospinal
(pyramidal) tract
(From contralateral cerebral
cortex; skilled and willed
movements, same side
of body)

Lateral horn (Origin of
preganglionic sympathetic
fibers; in segments T1 to L2)

Limb muscles
Trunk muscles
Motor neurons
in ventral horn

Vestibulospinal tract (Uncrossed;
stimulates extensors of trunk and lower
limb, and flexors of upper limb)

Nucleus thoracicus
(Origin of dorsal
spinocerebellar tract; in segments T1 to L3)

Reticulospinal fibers
(Crossed and uncrossed; unskilled and involuntary
movements)

Fig. 54. Cell columns and tracts of the human spinal cord
Classification: ASIA

- American Spinal Injury Association
- Standards of Neurologic Classification
- Based on key muscle groups (10) and key sensory groups (28 Left and Right)
- ASIA Definitions
- ASIA impairment Scale
- ASIA Level of Injury
- ASIA SCI syndromes
ASIA

- www.asia-spinalinjury.org
- 6th edition: FIM eliminated
- Clinically oriented
ASIA

- Tetraplegia and Paraplegia Definitions
- Definition of complete and incomplete (preserved sacral)
- Impairment Scale:
  - A = complete
  - B = sensory incomplete
  - C = motor power but >50% of muscles <3/5
  - D = >50% more than 3/5
  - E = normal
ASIA Exam

- Motor exam: Manual Muscle test of all 10 groups, graded 0-5
- Sensory: PP and LT to all 28 dermatomes at indicated location
- Motor level: most caudal level with at least a 3/5, provided higher muscle is normal
- Sensory level: most caudal level LT and PP is intact
# ASIA Motor Exam

- TEST KEY MUSCLES
- LEFT AND RIGHT
- 0-5 MUSCLE SCALE
- C5: ELBOW FLEXORS
- C6: WRIST EXTENSORS
- C7: ELBOW EXTENSORS
- C8: FDP DIGIT III
- T1: ADM DIGIT V
- L2: HIP FLEXORS
- L3: KNEE EXTENSORS
- L4: ANKLE DF
- L5: HALLUX EXT
- S1 ANKLE PF
Neurologic Level

- MOTOR AND SENSORY, LEFT/RIGHT
- LEVEL: DETERMINE WHERE THERE IS BOTH NORMAL SENSORY AND MOTOR FUNCTION
- SENSORY: INTACT PP AND LT
- MOTOR: LOWEST KEY MUSCLE 3/5
- ROSTRAL SEGMENT MUST BE 5/5
- USE DERMATOME IF NO MYOTOME IS AVAILABLE (C1-4, T2-L1, S2-5)
ASIA Sensory Exam

Figure 1
## ASIA Motor Exam

### MOTOR

<table>
<thead>
<tr>
<th>Key Muscles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elbow flexors</td>
</tr>
<tr>
<td>Wrist extensors</td>
</tr>
<tr>
<td>Elbow extensors</td>
</tr>
<tr>
<td>Finger flexors (distal phalanx of middle finger)</td>
</tr>
<tr>
<td>Finger abductors (little finger)</td>
</tr>
</tbody>
</table>

- **0** = Total paralysis
- **1** = Palpable or visible contraction
- **2** = Active movement, gravity eliminated
- **3** = Active movement, against gravity
- **4** = Active movement, against some resistance
- **5** = Active movement, against full resistance
- **NT** = Not testable

### Key Points
- Hip flexors
- Knee extensors
- Ankle dorsiflexors
- Long toe extensors
- Ankle plantar flexors

- [ ] Voluntary anal contraction (Yes/No)
ASIA SCI Syndromes

• Central Cord Syndrome: cervical, older, canal stenosis=risk factor; sacral sparing; UE weaker than LE; lesion central in cord

• Brown-Sequard: cord hemisection; ipsilateral motor and proprioceptive loss, with contralateral loss of pain and temperature

• Anterior Cord Syndrome: paralysis, preserved posterior columns

• Posterior Cord Syndrome: rare: loss of pos. columns
ASIA SCI Syndromes

• Cauda Equina Syndrome: disrupt lumbosacral roots; purely lower motor neuron

• Conus Medullaris Syndrome: damage to roots and sacral portion of cord
Figure 2-27: Brown-Séquard Syndrome (Unilateral hemi-cord lesion).

Figure 2-29: Central cord syndrome.
Figure C

Upper Motor Neurons lie within the spinal cord.

Lower Motor Neurons are spinal nerves that branch off the spinal cord.

Conus Medullaris

Cauda Equina

The spinal cord ends between L-1 and L-2. The nerves continue to descend in the spinal column, exiting between the vertebrae and through the sacrum.
Frequency of ASIA A-E
ASIA Impairment Scale (AIS)

A = Complete. No sensory or motor function is preserved in the sacral segments S4-5.

B = Sensory Incomplete. Sensory but not motor function is preserved below the neurological level and includes the sacral segments S4-5 (light touch or pin prick at S4-5 or deep anal pressure) AND no motor function is preserved more than three levels below the motor level on either side of the body.

C = Motor Incomplete. Motor function is preserved at the most caudal sacral segments for voluntary anal contraction (VAC) OR the patient meets the criteria for sensory incomplete status (sensory function preserved at the most caudal sacral segments S4-S5 by LT, PP or DAP), and has some sparing of motor function more than three levels below the ipsilateral motor level on either side of the body. (This includes key or non-key muscle functions to determine motor incomplete status.) For AIS C – less than half of key muscle functions below the single NLI I have a muscle grade ≥ 3.

D = Motor Incomplete. Motor incomplete status as defined above, with at least half (half or more) of key muscle functions below the single NLI having a muscle grade ≥ 3.

E = Normal. If sensation and motor function as tested with the ISNCSCI are graded as normal in all segments, and the patient had prior deficits, then the AIS grade is E. Someone without an initial SCI does not receive an AIS grade.

Using ND: To document the sensory, motor and NLI levels, the ASIA Impairment Scale grade, and/or the zone of partial preservation (ZPP) when they are unable to be determined based on the examination results.
Early treatment of traumatic SCI

• ABC’s, transport in collar
• High dose methylprednisolone
• Radiograph entire spine (high frequency of multiple fx’s)
• Neurological examination
• Positioning, splinting, ROM, bowel, bladder, skin care, nutrition, pain control, respiratory treatment, early immobilization
Early treatment

- 50% undergo spine surgery
- Surgical stabilization or spine orthosis allows mobilization
- MRI better for cord and ligaments
- CT better for bone
- GSW: surgery rarely needed
Levels of SCI

- Most common = cervical
- Thoracic 35% and lumbosacral 11%
- Most common level C5 followed by
  - C4
  - C6
  - T12
  - T7
Spine Orthosis- More in upcoming lectures!

- Cervical Orthosis
- Soft collar: cervical muscle strain relief
- Philadelphia collar: foam reinforced
- Aspen: greater stability in lateral bending and rotation
- Miami J: hard plastic with cloth pads and an trach cutout
- SOMI: rigid chest support and adjustable chin
Spinal Orthosis

- Miverva brace: cervical thoracic brace with chest plate and headband: for C1-T1
- Halo vest: pins, ring: Pin complications possible: loosening, pain, infection, breakdown
- TLSO
- Jewett Brace: hyperextension TLSO
Rehabilitation

- Systematic, intensive, coordinated team approach
- Assessments by team
- Physical, psychological, social
- Family
- Education
- Physiatric Assessment
SCI Recovery

• OVERALL: 30-80% gain 1 level
• Initial strength is a predictor of future recovery
• Faster recovery = Better prognosis
• Most recovery seen in first 6 months
SCI Functional Outcomes

- Complete tetraplegia: 0/5 at one month = 24% chance of 3/5 in future. Prognosis of A is worse than E

- Complete paraplegia: 73% no change. If 1/5, 70% to a 3/5 at 1 year. 3-7% of 0/5 will be 3/5 at one year

- Most of recovery is within 1st year
Recovery for AIS A

- 20% improve to B-E, 10% C or D
- 70% recover one level
- 30% recover 2 levels
- 2/5 MMT at 1 week = 80% 3/5. At 1 month, there is a 95% chance of 3/5
- Initial strength is a predictor of future recovery
- Most recovery seen in first 6 months
Recovery ASIA B and C

- 40% of AIS B convert to C
- 40% of AIS B convert to D
- 60% of AIS C improve to D
Ambulation in SCI

- BROWN-SEQUARD: 90% unless over 50 YO, then it is 40%
- CENTRAL CORD SYNDROME: 50%
- MOTOR INCOMPLETE TESTED AT 72 HOURS: 87%
- ASIA A TO D Conversion seen in 2-3%
- ASIA B WITH PP: 70-90% will be ambulatory
Functional Electrical Stimulation

- FES Bike
- Direct muscle stimulation
- Implantable Electrodes and Gait
- Phrenic and Diaphragmatic pacing
Medical Complications of SCI
Covered in different lectures

- Spasticity
- DVT
- PE
- Autonomic Dysreflexia
- Function
- Spine stabilization
- HO

- Musculoskeletal overuse
- Sexuality/PLISSIT model
- ADL’s
- Substance Abuse
- Return to Community
- Wounds
- Respiratory
Medical Complications

- Respiratory Dysfunction
- Pain
- Heterotopic Ossification
- Pressure sores
- Postraumatic Syrinx
- Functional Electrical Stimulation
- Functional Outcomes overview
Post Traumatic Syrinx

- Cystic myelopathy; tethering
- Long term complication
- Loss of strength, sensation and pain
- 1-5%
- 2 months to 30 years
- All levels
- Increase spasms, sweating, Horner, orthostasis, worse with valvsalva
- MRI
- Surgical Rx
SCI Pain - covered in different lecture

- Common: 94%
- Acute, Subacute, Chronic
- Central pain: diffuse
- Radicular
- Visceral
- Sensory transition zone
- Neuropathic
- Somatic
SCI Pain

• Evaluate: history, physical
• Document descriptors of pain
• Identify type and potential factors
• Equipment, positioning, modalities, orthotics/spints, etc
• Meds: TCA, anticonvulsants, anesthetics, NSAID’s, Opiates, etc
Pressure Sores

- Annual incidence 25%
- Identify those at risk
- Immobility, completeness, urinary incontinence, age, cognition, anemia and low protein are all risk factors
- Paraplegics > tetraplegics
- Sacrum number 1 acutely, ischium chronic
- Prevention: support surface, turn, nutrition, education
- Treatment: wound care program, products
Heterotopic Ossification

- True bone formation
- Neurogenic and traumatic factors at play
- 16-53%
- Hips then knees, shoulders, elbows
- Risk: complete, pressure sores, spasticity
- Impact: positioning, nerve entrapment, sores
- Most diagnosed at 2 months
HO

- Signs and symptoms: pain, swelling, loss of ROM
- Looks like DVT at times
- Triple phase bone scan detects before radiographs
- Elevation in alkaline phosphatase early
- Treatment: continue ROM. Didronel may limit extent. NSAID’s. Surgery if mature
Respiratory Complications

- Significant cause of morbidity and mortality
- Pneumonia: most common cause of death
- Inadequate inspiratory muscle strength
- 50% of C3 will be weaned
- Higher levels SCI=risk of pneumonia
- Impact of trach and phonation
- Vent weaning
- Increased risk of sleep apnea
Muscles of Inspiration

Principal
- Sternocleidomastoid (elevates sternum)
- Scalene anterior
- Scalene middle
- Scalene posterior (elevate and fix upper ribs)
- Parasternal intercartilaginous muscles (elevate ribs)
- Diaphragm (domes descend, increasing longitudinal dimension of chest and elevating lower ribs)

Accessory
- External intercostals (elevate ribs)

Muscles of Expiration

Quiet breathing
- Expiration results from passive recoil of lungs

Active breathing
- Internal intercostals, except parasternal intercartilaginous muscles (depress ribs)
- Abdominal muscles (depress lower ribs, compress abdominal contents)
- Rectus abdominis
- External oblique
- Internal oblique
- Transversus abdominis
Respiratory and SCI

- Below L1: no problem
- T12-T5: decreased abs and intercostals
- T5-T1: intercostals
- Cervical: diaphragm is C3-5. C3 has partial diaphragm function
- ABD binder: increases lung volumes when sitting.
- Best position = supine. When sit, ABD pushes forward, pulls down diaphragm
Respiratory

- **C2**: Apneic
- **C3**: Ventilatory assistance. VC 100-300 by accessory muscles
- **C4**: Loss of some diaphragm
- **C4-8**: Expiration via passive recoil of ribs
- **T5-1**: Weak intercostals, weak cough, position of diaphragm not ideal
- **T12-5**: Abdominals and intercostals weak causing a decreased cough
Respiratory complications

- Check NIF, VC, O2 sats
- Check ASIA scale; level of injury
- Assess for ineffective cough, decrease secretion management
- Pulmonary toilet - manually assisted cough/change bed position/early mobilization/chest percussion/incentive spirometry; O2 sat monitoring; nebulized medications; VEST; mechanical exsufflation; Ventilator use
Surgery

- Spine stabilization
- Decompress neural elements
- Anterior or Posterior
  - Anterior: Lower lumbar, upper thoracic and occipitocervical area not amendable
  - Posterior: biomechanical disadvantage: most procedures only secure the posterior elements-need longer constructs.
- Pedicle screws: stabilize all three columns via posterior approach
Surgery

- Stabilize spine
- Early traction and surgical stabilization is advantageous
- Timing of surgery is being studied
- Fusion: autologous bone
- BMP
- Surgical hardware to fix
- External orthosis
Occipital – Atlantoaxial Complex

- Jefferson: Atlas fx: halo. If unstable, Posterior fixation
- Odontoid: 3 types: I and III with orthosis: II sometimes surgically
- Hangman: C2 fx pedicle fx: stable, orthosis
Many have ligamentous injury

C5 most common, Burst fx: anterior approach often: corpectomy to decompress, strut graft, and screw plate may be used

Facets subluxed: anterior or posterior.
Thoracic Spine Injuries

- T12 fx most common
- Lower thoracic: anterior or posterior
- Anterior via thoracotomy or thoracoabdominal approach
- Anterior in upper thoracic is rarely performed
- Rods, screws
Lumbar

- L1 fx most common
- Corpectomy of L1 or L2 with stabilization
- Lower lumbar, posterior screws in pedicles and rods may be used
SCI Outcomes

- Incomplete tetraplegia: 90% gain one motor level in the UE: 1-2/5, see 3/5 in 2 years usually.
- Incomplete paraplegia: 85% of 1-2/5 at 30 days achieve 3/5 within 1 year
- Ambulation: Central Cord, Brown Sequard; levels of injury and ambulation (3/5 hi flexors and one knee extensor)
Mortality

• LEADING CAUSE OF MORTALITY IN SCI: Pneumonia (18.9% YEAR 1)
• 1 YR MORTALITY: 6.5%
• PREDICTORS OF MORTALITY: age, male, violent etiology, C7 level or higher, complete injury, on ventilator, and poor health
• WWW.SPINALCORD.UAB.EDU
Pulmonary Outcomes

- C3 and C4: 83% wean (Peterson)
- C3: 51% wean (Wicks and Menter)
- C4: 78% wean (same)
- C5 and below: secretions, atelectasis, infection
- C5: Loose 50% of VC
- C6-8: loose 1/3 of VC
- T1-7: VC decreased slightly
- Halos vests: Decrease VC by 8%
Nontraumatic SCI

• 8/100000
• Spinal stenosis
• Tumor
• Vascular
• Infection: epidural abscess for example
• Noninfectious: transverse myelitis, motor neuron dx, radiation myelopathy, Syrinx, B12, paraneoplastic, cancer, SLE, toxic...
Nontraumatic SCI

- Vascular: AVM, Dissection, embolism, ischemia
- SLE
- Paraneoplastic
- Radiation Myelopathy
- Hereditary spastic paraparesis
- HIV
- Cancer: 15-40% of cancer has mets to spine
- Primary spine tumor: #1=multiple myeloma
- Benign spine tumor: #1= hemangioma
Spine tumors

- Extramedullary: breast, lung, prostate mets
- Intradural: neurofibroma, meningioma
- Intramedullary: ependymoma, astrocytoma
- Primary tumors most common in cord
- Secondary tumors 25X more common than primary
Spine Tumors

- Back pain most common presenting Sx
- Local, referred, radiating
- Exacerbated by Valsalva- traction on cord when lumbar lordosis reduced
- DTR changes
- Neuro changes
- Weight loss, fatigue, fevers
Spine tumors

- Cord compression #1 complication of cancer
- Brain mets #2
- Etiology of findings: Direct mechanical pressure
- Impair vascular integrity
- Spinal instability
- Bleeding, edema
- Diagnosis: H and P, ESR, PSA, CXR, CT
- Other labs: SPEP, UPEP, Ca, etc
- MRI
Spine Tumors - Treatment

- Steroids
- RT-decompresses structures: lymphoma, small cell CA, multiple myeloma most sensitive. Adverse: plexopathy, recurrence
- Chemo: lymphoma, myeloma, breast, prostate
- Surgery - for instability, impingement, RT failure
- Hydration
Infections

- Vertebral osteomyelitis - staph aureus
- TB
- Epidural Abscess
- Arachnoiditis - fibrotic process
- Intramedullary SC abscess - rare
- Transverse myelitis: viral, bacterial
Nontraumatic SCI

- No Model System database
- Less data
- Outcomes more variable
- Etiology diverse
- Individual considerations
Vascular

- SC stroke: ischemia
- Artery of Adamkiecz from T9 to L2, mostly L T11
- ASA: Anterior 2/3 of cord
- PSA: Posterior 1/3
- Vertebral arteries and A Adamkiecz feed spinal arteries
Blood supply to the spinal cord: horizontal distribution

Posterior

Posterior spinal artery

Anterior spinal artery

Peripheral

Central

Anterior

The central area supplied only by the anterior spinal artery is predominantly a motor area.
Stoke Syndromes

• Transection: abrupt onset, pain
• ASA: flaccid, plegia, pain and temperature loss, with vibration and joint position OK
• Brown Sequard: early in course of ASA infarct
• PSA: rare: pain, paresthesias
SCI Strokes

- Border zone or watershed infarct - low BP
- Aortic surgery
- Embolism: fibrocartilaginous from discs
- Venous infarction: rare
- Vertebral artery dissection
- Vasculitis
AVM

- Dural: most common
- Intramedullary: nidus in SC
- Juvenile malformations: rare
- Intradural, extramedullary: uncommon
- Gradual course
- Sensory disturbance, pain and leg weakness most common Sx
- Nothing is pathognomonic
AVM

- Angiography
- Myelography
- MRI
- Treatment: Embolize, surgery
- Treatment may not reverse symptoms. Pain may be relieved
Conclusions

- SCI impacts multiple organs and systems
- Gaylord is part of a Model System of care
- Epidemiology
- Etiology
- Anatomy
  ASIA
- Treatment
Conclusions

- Medical complications to be covered
- Medical complications discussed
- FES
- Outcomes
- Role of Rehabilitation