

**RANCHO LOS AMIGOS**  
NATIONAL REHABILITATION CENTER



# Projected Functional Recovery

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# Objectives

- Discuss functional recovery potential for individuals living with spinal cord injury based on neurologic level
- Outline the impact of early patient/caregiver education following a diagnosis of spinal cord injury
- Identify two interventions which may provide early independence following spinal cord injury
- Synthesize how severity of spinal cord injury impacts long-term prognosis for dysphagia and decannulation



# Introduction

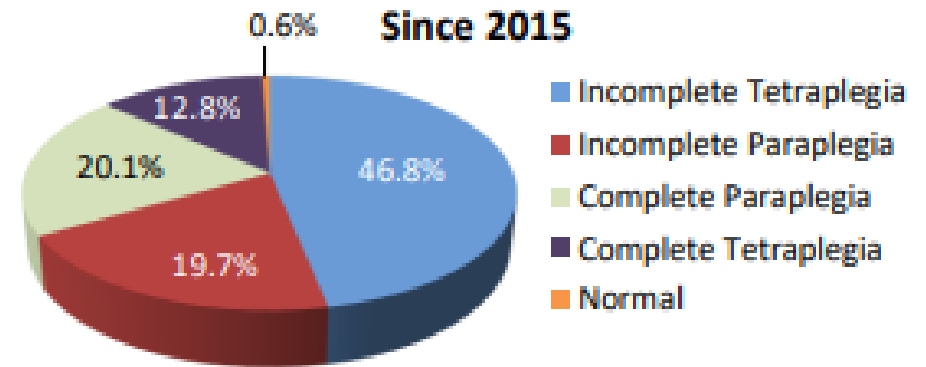
- The question of recovery is at the forefront of everyone's mind
- Interprofessional team members play an integral role in functional recovery and mental fortitude
- The interventions of each team member assist and build on each other to facilitate the acquisition of the skills necessary to achieve the highest possible function





# Demographics

- Estimated 299,000 people living with a SCI in the U.S.
- 18,000 new SCI cases each year in the U.S.
- Incomplete tetraplegia accounts for 46.8% of new SCI annually





# Hospitalization

- Acute care setting
  - Average LOS: 12 days
  - Higher acuity
  - Limited time/treatment visits
  - Limitation to treatment spaces
- IP Rehab setting
  - Average LOS: 32 days
  - Stable?
  - More time/treatment visits
  - Unlimited\* treatment spaces



*Data courtesy of Model Systems Knowledge Translation Center*



# Neurological Level of Injury

- The **International Standards for Neurological Classification of Spinal Cord Injury (ISNCSCI)** in conjunction with the **ASIA Impairment Scale (AIS)** is the gold standard for identifying level and severity of spinal cord injury
- Training to complete ISNCSCI exam available through <https://asia-spinalinjury.org/learning/>

**ASIA** INTERNATIONAL STANDARDS FOR NEUROLOGICAL CLASSIFICATION OF SPINAL CORD INJURY (ISNCSCI) **ISCOS**

Patient Name \_\_\_\_\_ Date/Time of Exam \_\_\_\_\_  
Examiner Name \_\_\_\_\_ Signature \_\_\_\_\_

**RIGHT** **MOTOR** **KEY MUSCLES** **SENSORY** **KEY SENSORY POINTS** **LEFT** **MOTOR** **KEY MUSCLES** **SENSORY** **KEY SENSORY POINTS**

**UER** (Upper Extremity Right) **UER** (Upper Extremity Left)

**LER** (Lower Extremity Right) **LER** (Lower Extremity Left)

**RIGHT TOTALS** (MAXIMUM) (50) (56) (56) **LEFT TOTALS** (MAXIMUM) (50) (56) (56)

**MOTOR SUBSCORES** **SENSORY SUBSCORES**

**NEUROLOGICAL LEVELS** **3. NEUROLOGICAL LEVEL OF INJURY (NL)** **4. COMPLETE OR INCOMPLETE?** **5. ASIA IMPAIRMENT SCALE (AIS)** **6. ZONE OF PARTIAL SENSORY PRESERVATION**





# Clinical Factors and Predictors

## Will I get stronger?

### COMPLETE PARAPLEGIA

1 month post injury

- 0/5 strength >>> 3/5 strength: 5%
- 1/5 strength >>> 3/5 strength: 64%

### INCOMPLETE PARAPLEGIA

1 month post injury

- 0/5 strength >>> 3/5 strength: 26%
- 1/5 strength >>> 3/5 strength: 85%

### COMPLETE TETRAPLEGIA

1 month post injury

- 0/5 strength >>> 3/5 strength: 24%
- 1/5 strength >>> 3/5 strength: 97%

### INCOMPLETE TETRAPLEGIA

1 month post injury

- 0/5 strength >>> 3/5 strength: 20%
- 1/5 strength >>> 3/5 strength: 95%

Waters et al 1998



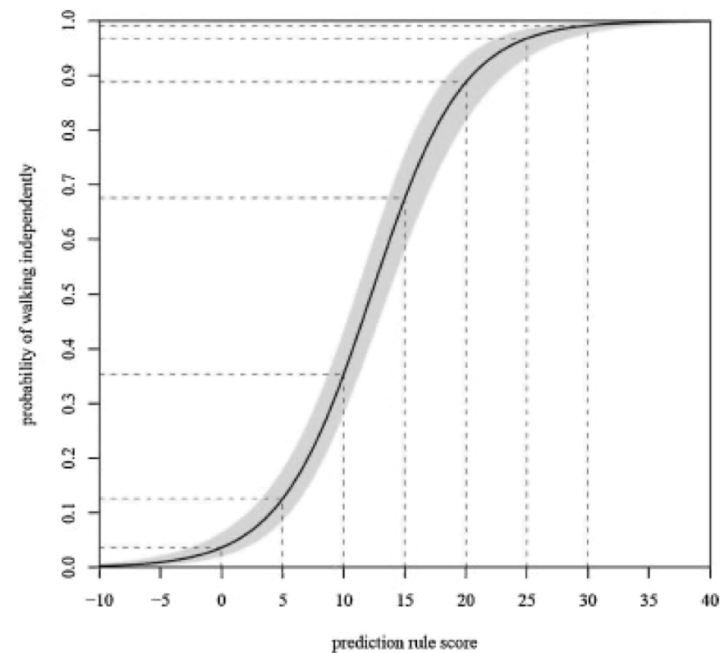


# Clinical Factors and Predictors

## Will I walk again?

### Clinical Prediction Rule 1 year post

- 5 Predictors:
  - Age
  - L3 motor score
  - S1 motor score
  - L3 light touch score
  - S1 light touch score
- Score Range: -10 to 40



van Middendorp et al 2011



# Clinical Factors and Predictors

Increased trends in conversion rates (1995-2015):

- Tetraplegia: increased from **17.6%** to **50%**
- High paraplegia (T1-T9): increased from **5.3%** to **17.6%**
- Low paraplegia (T10 and below): increased from **8.0%** to **23.1%**
- Significant factors include:
  - Year of injury
  - Level of injury
  - Method of injury
  - Age
  - Sex



# Clinical Factors and Predictors

## Sensation

- AIS B: more likely to convert to motor incomplete in 1 year
- NLI T6-T12: sensory sparing 3 segments increase likelihood of AIS conversion
- Sacral sensory sparing in all ISNCSCI exam components: higher likelihood to convert to motor incomplete

## Motor recovery in 1 year

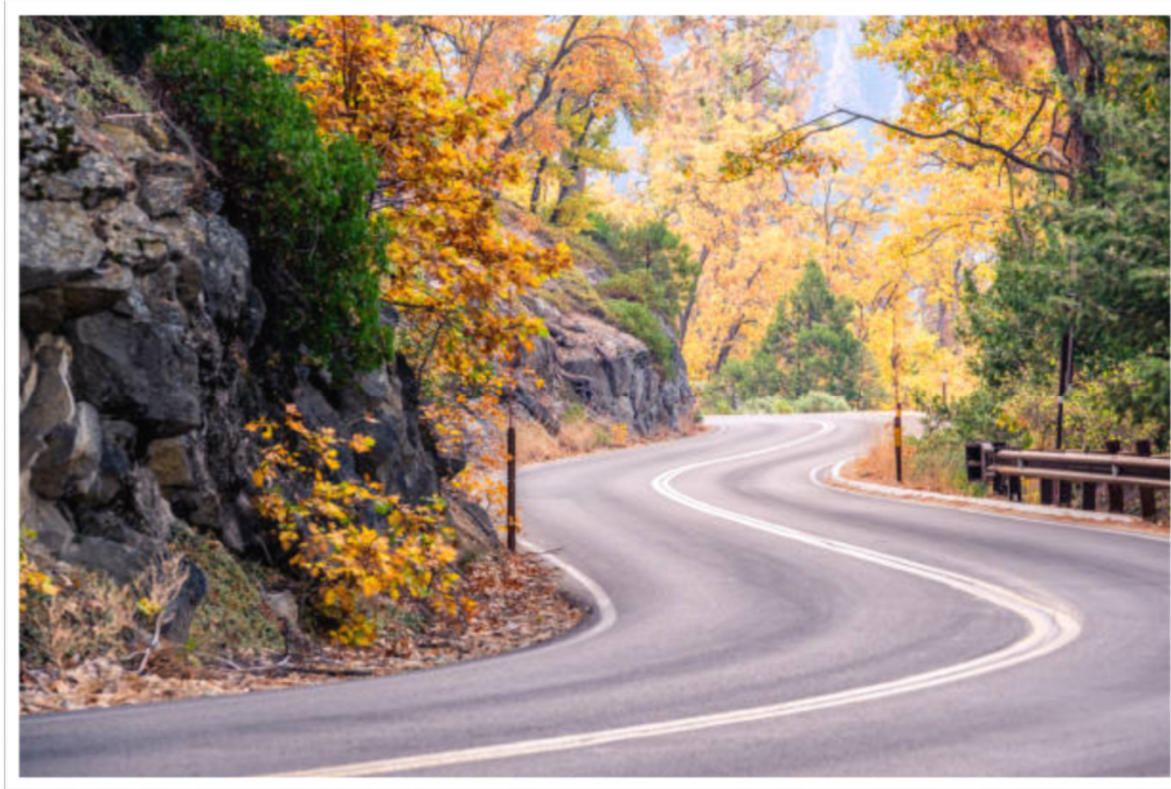
- Motor ZPP: strong indicator of recovery for complete tetraplegia
- Regain of at least 1 level of motor return: 65% of individuals living with complete tetraplegia
- Majority of recovery in 9 months (plateau at 18 months)
- VAC alone is not as strong of a predictor in conversion from AIS C to AIS D. Other sacral exam components must be present



# Complete vs Incomplete: Interventions

- Treat everyone with the goal of full recovery in mind
- Recovery is a gradual progression
- Recovery is multi-faceted and variable
- Recovery is not limited to function
  - Whole person – Whole Body approach











# Secondary Considerations

Orthostatic  
Hypotension

Contractures

Pneumonia

Atelectasis

Deep Venous  
Thrombus

Pain

Shoulder  
Injuries

**Dual diagnosis SCI +TBI**

Pressure  
Injuries

Autonomic Dysreflexia

Pulmonary Embolism

Fracture

Heterotopic Ossification





# Dual Diagnosis: SCI +TBI Assessment

- Confirmation of loss of consciousness
- Glasgow Coma Scale
- Duration of Post-Traumatic Amnesia + Orientation
- Rancho Los Amigos Levels of Cognitive Functioning Scale
- Initial Imaging

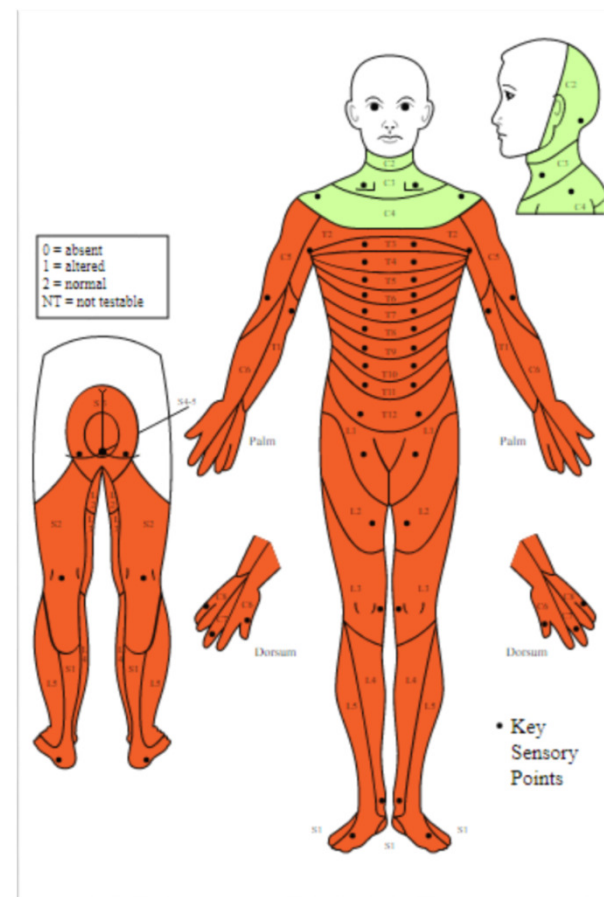




# C1-C4

## Key Muscles

- C1-C3: sternocleidomastoid, cervical paraspinal, neck accessories, platysma
- C4: Upper Trapezius and Diaphragm





## C1-4 Expected Functional Recovery

- Communication may range from verbal to needing augmentative alternate communication (AAC)
- Set-up drinking with adapted equipment
- Full dependence in self-care
- Full dependence for bed mobility and transfers
- Fully independent with operating power wheelchair for mobility\*
- Emerging movement of head and neck
- C4 – ability to shrug shoulders, potential to breathe without a ventilator

\*Head array, sip and puff, chin control



# Interprofessional Interventions

- Patient/caregiver education
  - Introduce SCI education
  - Device management (example: Halo release/off-loading, resting hand splints, offloading boots)
  - Distress signal/ "clicking"
  - Directing care/promoting self-management
  - Dysphagia
  - Speaking valve management
  - Communication
- Treatment
  - Initiate ROM
  - Positioning
  - Edema management
- Clinical Pearls/Tricks of the trade





## Understanding Spinal Cord Injury: Part 1— The Body Before and After Injury

May 2022 <https://msktc.org/sci/factsheets> SCI Factsheet

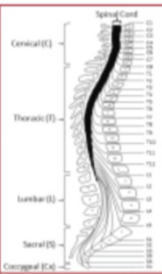
This factsheet is intended to be a starting point for understanding the normal functions of the spinal cord and how those functions might change after spinal cord injury (SCI). The impact of injury is different for everyone, so it is impossible to answer every question of interest. However, this factsheet will answer a few common questions.

### What is the spine?

The spine (also known as the "backbone") is the connected column of bones running from your head to your lower back. A single bone is called a "vertebra" (pronounced VER-eh-rah), and multiple bones are called "vertebrae" (pronounced VER-teh-bray). The figure shows the spine and vertebrae.

The figure also shows the five sections of the spine. Each section is made up of a group of vertebrae.

- At the top of the spine, at your neck, is the cervical (C) section. There are 7 vertebrae in this section. Each vertebra is numbered top to bottom from C1 to C7.
- Below the cervical section is the thoracic (T) section. There are 12 vertebrae here. Each is numbered from T1 to T12.
- The lumbar (L) section follows. There are 5 vertebrae here. Each is numbered from L1 to L5.
- The next section is the Sacral (S) section. This is also called the "sacrum." Here the 5 vertebrae are fused together as one bone.
- At the bottom of the spine, 3 to 5 vertebrae are fused together as one bone segment in the coccygeal (Co) section. This is also called the "tailbone."



"The end of the spinal cord is the conus medullaris. Below the conus medullaris, the spinal nerve roots look like a horse's tail, which is why these nerves are called the cauda equina, the Latin term for "horse's tail."

The Spinal Cord Injury Model System Program is sponsored by the National Institute on Disability, Independent Living, and Rehabilitation Research, Administration for Community Living, U.S. Department of Health and Human Services. (See <https://msktc.org/sci/model-system-centers> for more information).

### What is the spinal cord?

The spine surrounds and protects the spinal cord, which is a fragile, dense bundle of nerves running from the base of your brain down through the open space in the vertebrae (also known as the spinal canal). The spinal cord ends near the L1 vertebra, but spinal nerve "roots" continue to run from the end of the spinal cord to the lower spinal canal.

### What does the spinal cord do?

Your brain and spinal cord are part of your body's nervous system. The brain is the command center for your body. The spinal cord is the nerve pathway that allows your brain and body to communicate.



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## Understanding Spinal Cord Injury, Part 2—Recovery and Rehabilitation

January 2020 [www.msktc.org/sci/factsheets](http://www.msktc.org/sci/factsheets) SCI Factsheet

This fact sheet is the second in a two-part series in understanding spinal cord injury and answers some of the common questions people have during the early period after injury. Part one, The Body Before and After Injury, explains terms and information that are discussed in this fact sheet, including severity, level of injury, and changes in function.

The Spinal Cord Injury Model System Program is sponsored by the National Institute on Disability, Independent Living, and Rehabilitation Research, Administration for Community Living, U.S. Department of Health and Human Services. (See <https://www.msktc.org/sci/model-system-centers> for more information).

### Can paralysis caused by spinal cord injury be reversed?

Everyone wants to know if there is a "cure" for spinal cord injury (SCI). There continues to be significant progress made toward this goal, but, despite any claim that there is a cure, there is currently no cure or proven way to completely reverse paralysis caused by SCI.

### Will I gain any improvements?

There is almost always hope for at least some improvement after SCI. Here are the three areas for potential improvement after SCI.

1. The severity of your injury may improve. At the time of your injury, your injury is graded as either complete or incomplete. One example of improvement is that you may be first classified as AIS C and improve to AIS D.
2. The level of your injury may improve. At the time of your injury, you are diagnosed with a neurological level of injury. One example of improvement is that you may be first classified with a C4 level of injury and improve to a C5 level.
3. Your functional abilities may improve. These are the activities that you are capable of doing with the movement that you have. This also includes what you can do with the help of home modifications, medical equipment, adaptive devices, assistive devices, and assistive technologies. One example of improvement is that you may not first have the strength or movement needed to push a wheelchair but gain the needed strength and movement over time.

### How much improvement will I gain?

There is no guarantee and no way to know how much, or if any, improvements you will have. You have to wait to see what happens in the months after your injury. However, here are a few basic rules of thumb on improvement.

- Many people with complete injuries regain 1 to 2 levels of injury. The improved muscle movement can result in improved functional abilities.
- People with incomplete injuries are more likely than people with complete injuries to regain muscle movement.
- Your chances for regaining muscle movement are better as long as you are seeing gains in muscle movement or feeling.
- Your chances for regaining control of muscle movement get lower the longer you go without seeing any gains in muscle movement or feeling.



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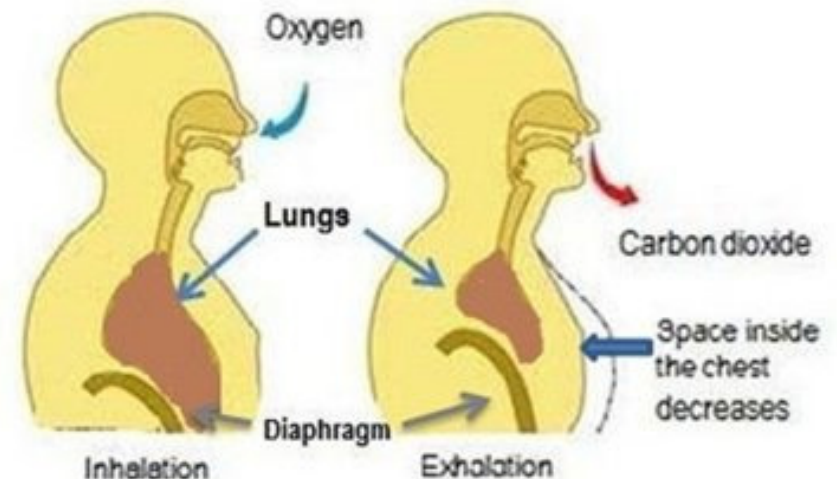
Level of Injury	Expected Muscle Control	Functional Goals	What is Needed
		<p><b>Breathing</b> C2-C3 Depends on ventilator. C4 May initially need a ventilator, but most adjust to breathing without a ventilator.</p> <p><b>Communication</b> C2-C3 Talking is sometimes difficult, very limited, or impossible. If the ability to talk is impaired, typing and communication can be accomplished independently with setup assistance of synthesized speech device, smartphones, tablets, and computers. C4 Talking is normal.</p>	<p>C2-C3 • Suction equipment to clear secretions. • Two ventilators with a generator and battery on hand as a backup in the event of power loss. C4 • Cough assist device</p> <p><b>Impaired Voice</b> C2-C3 • Synthesized speech device • Sip and puff switch activated attendant call chime. • Computer with camera and eye-gaze or motion-tracking technology. • Mouth stick for physical touch typing. A stylus on mouth stick can be used for smartphone, tablet, and computer touchscreen use.</p> <p><b>Non-Impaired Voice</b> • Microphone with voice recognition software • Mouth stick for physical touch typing. A stylus on mouth stick can be used for smartphone, tablet, and computer touchscreens.</p>

<https://msktc.org/sci/factsheets>



# The Respiratory System: Normal Breathing

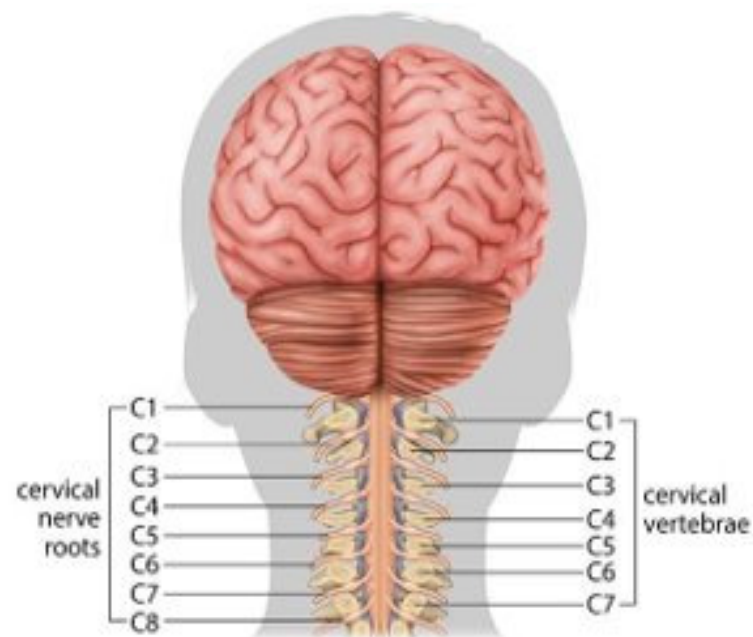
- Ventilation: Mechanical movement of air in and out of the lungs
- Respiration: Exchange of oxygen and carbon dioxide
- The diaphragm is the primary muscle for inhalation





# The Respiratory System After a High Tetraplegia

- Greater risk for respiratory complications the higher and more complete the injury
- Commonly require tracheostomy
- C1-C3: Ventilator dependent
- C4: May initially depend on ventilator but sometimes with potential to breath without
- Increased risk factors for patients with spinal cord injuries and tracheostomies





# Risk Factors for Tracheostomy and Decannulation

- AIS A and B
- Operative Treatments
- Major Fracture/Dislocation
- Intubation upon arrival
- Respiratory failure is most frequent complication of traumatic spinal cord injury
- Age significantly associated with tracheostomy
- Older patients associated with increased frequency of complications, higher mortality, poorer prognosis
- Mortality higher in non-decannulation groups with no patient recovering from paralysis within one year vs decannulation groups





# Causes of Dysphagia in Cervical Spinal Cord Injury

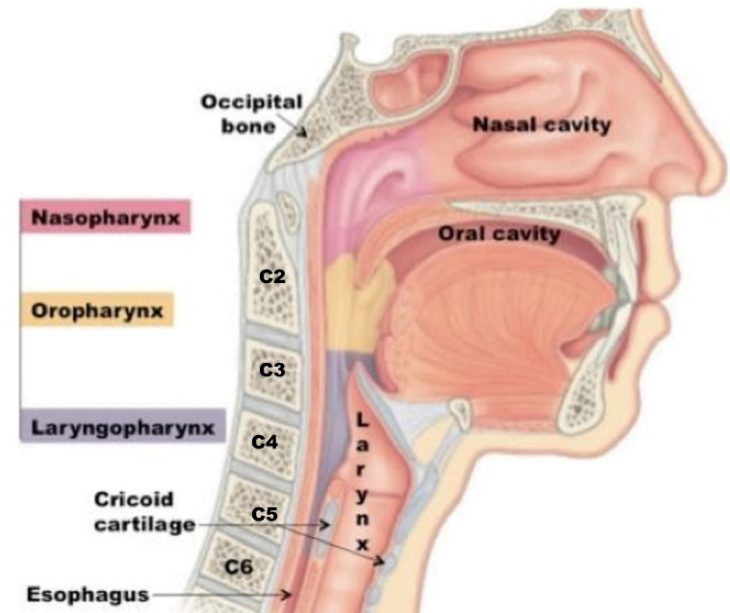
- Prevalence of dysphagia in patients with spinal cord injury ranges from 16-60%
- Upper Spinal Cord Anatomy/Neurology
- Spinal Surgery Consequences
- Respiratory Muscle Dysfunction
- Esophageal Impairment
- Medical Management





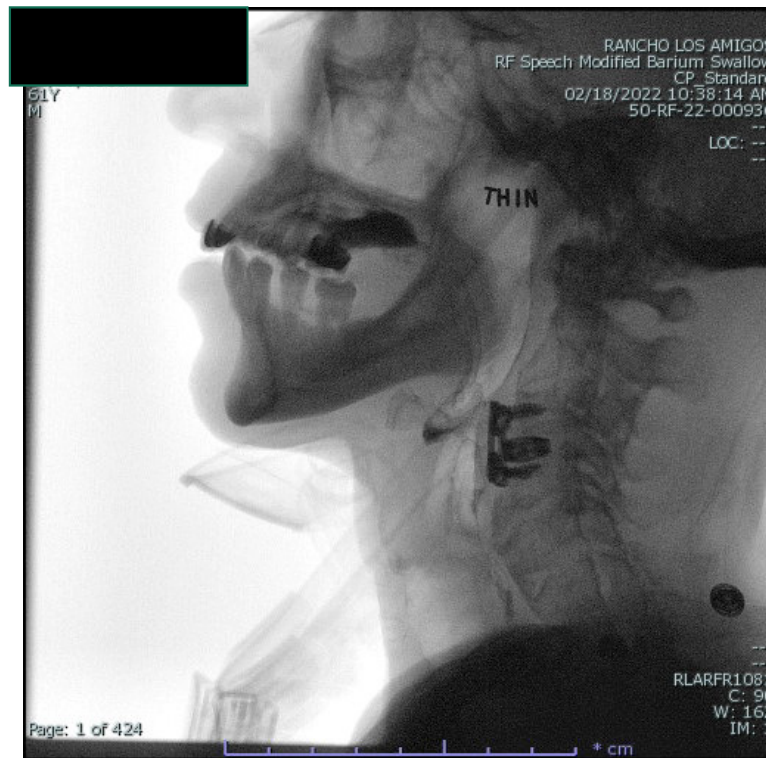
# Risk Factors for Dysphagia

- Age
- Injury severity
- Level of Injury
- Presence of Tracheostomy
- Coughing
- Voice Quality
- Bronchoscopy Need
- Pneumonia
- Mechanical Ventilation
- Nasogastric Tubes
- Comorbid Injury
- Cervical Injury





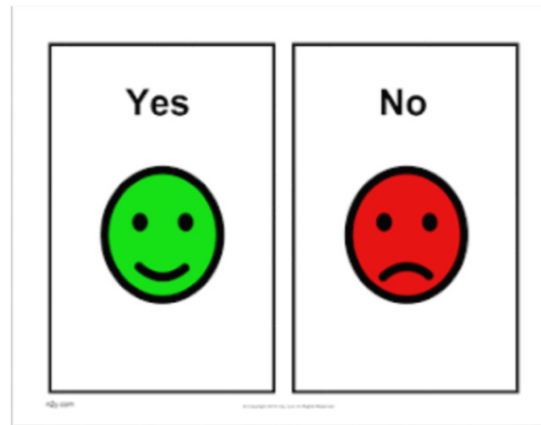
# Modified Barium Swallow Study





# Communication

- Blinking
- Picture board
- White board
- Black board
- Visual scanning board
- Eye gaze



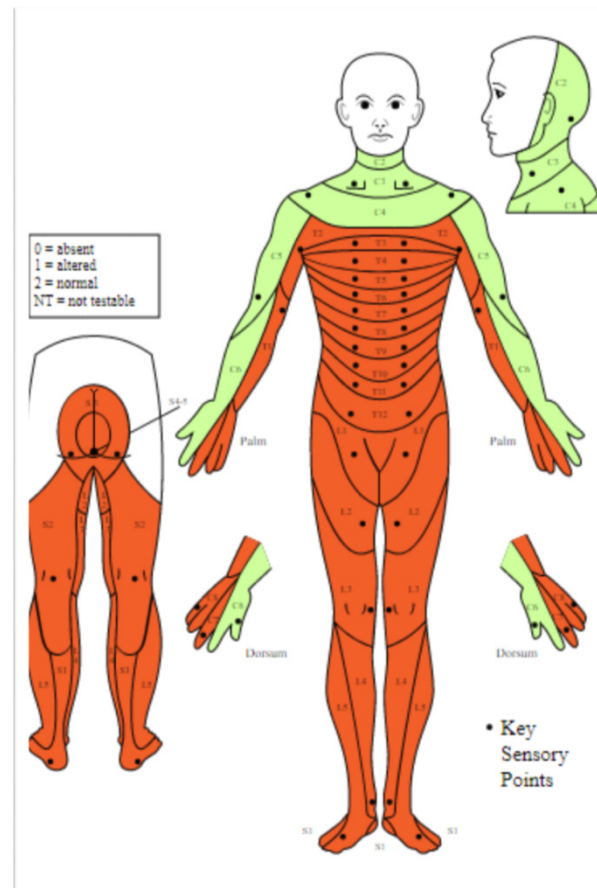


# C5-C6

## Key Muscles

C5: Biceps and Deltoid, Brachialis, Brachioradialis, Rhomboids, Serratus Anterior (partially innervated)

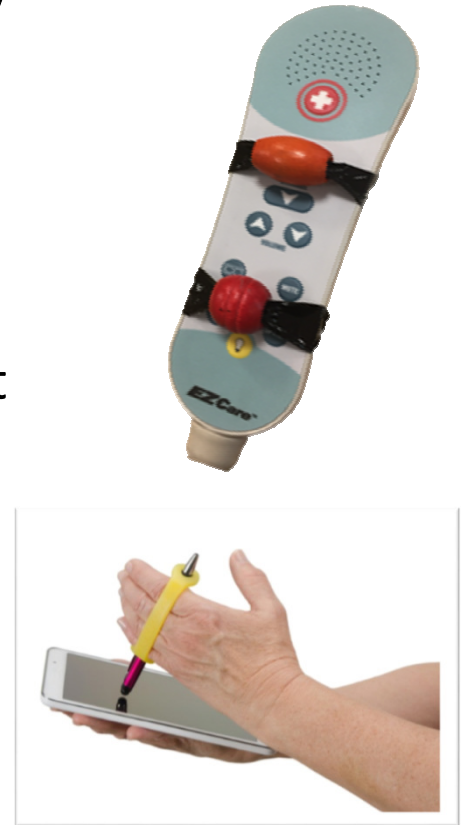
C6: Extensor Carpi Radialis Longus and Brevis, Clavicular Pectoralis, Serratus Anterior





## C5-C6 Expected Functional Recovery

- Ability to bend elbows, move wrists, turn forearm/palms
- Fully independent in breathing and communication (with assistive device)
- May require assistance for cough/secretion expulsion
- Set up for eating/drinking/brushing teeth with equipment
- Set up – some assistance for upper body dressing/bathing/grooming
- Total – some assistance for bladder and bowel management, skin check
- Set up – some assistance for bed mobility and transfers
- Fully independent with operating power wheelchair for mobility (potential for use of manual wheelchair)

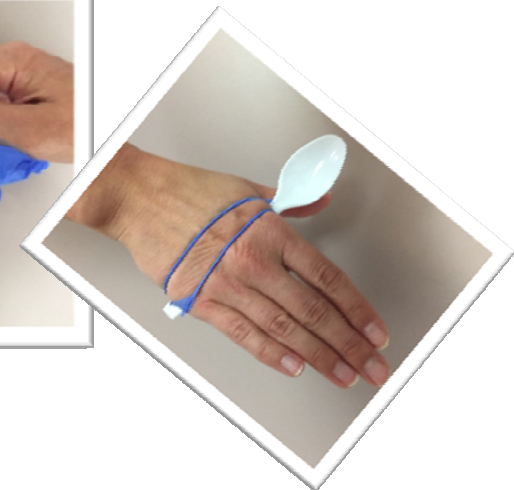


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Knowledge Translation Center*



# Interprofessional Interventions

- Patient/caregiver education
  - Management of orthostatic hypotension: abdominal binder, ted hose, ace wraps
  - Directing care/promoting self-management
- Treatment
  - Positioning
  - Initiate ROM
  - Upright tolerance
  - Breathing exercises
  - Introduce universal cuff or similar equipment for eating/brushing teeth
  - Introduce low tech adaptation for smartphone
- Clinical Pearls/Tricks of the trade





# Breathing Exercises

## Objective

- To increase strength and endurance

**Guidelines:** Optimal position starting in supine.

- First increase time/duration of exercise to a maximum exercise time of 10-15 minutes.

## Exercises

- Breather (Equipment)
- Triplicate Breathing
- Breath Holds
- 2 Quick Breaths
- Shoulder Shrugs



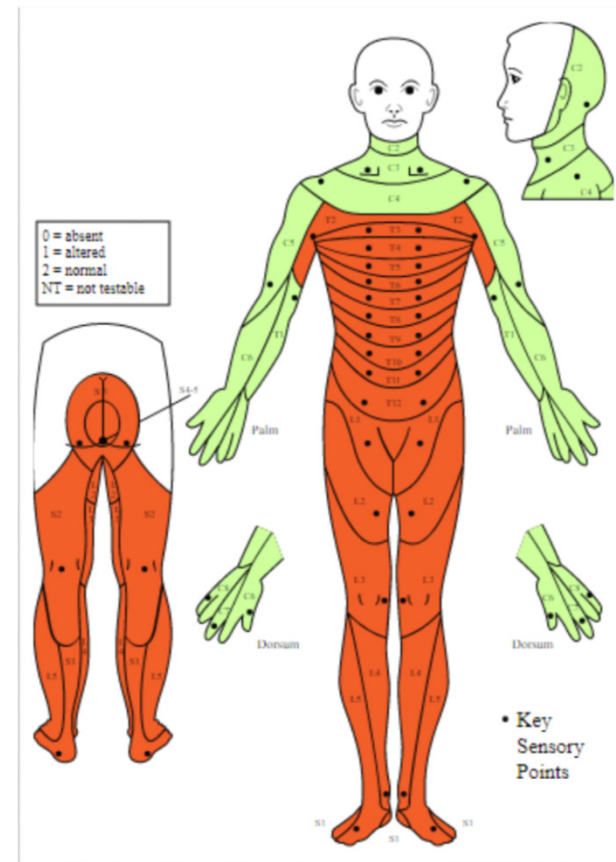




# C7-T1

## Key Muscles

- Triceps - elbow extension
- Latissimus Dorsi and Triceps
- Flexor carpi radialis (C7-C8)
- Flexor digitorum superficialis & profundus (C8-T1)
- Lumbricals & interossei (C8-T1)
- Abductor/Flexor/Opponens pollicis (C8-T1)





## C7-T1 Expected Functional Recovery

- Ability to extend elbows
- Development of hand and finger movement (fine motor skills)
- Fully independent in breathing and communication
- Fully independent with eating, grooming, upper body bathing & dressing
- Independent - some assistance for lower body bathing and dressing
- Independent – set up assistance for bladder and bowel management, skin check
- Fully independent with bed mobility and transfers
- Fully independent with manual wheelchair for mobility

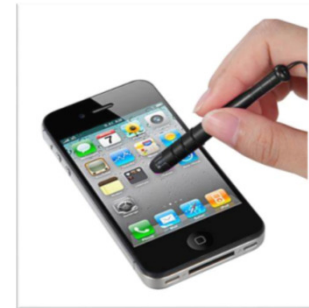


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# Interprofessional Interventions

- Patient/caregiver education
  - Directing care/promoting self-management
  - Management of orthostatic hypotension: abdominal binder, TED hose, ace wraps
  - Developing a plan collaboratively to continue program outside of therapy visits
- Treatment
  - Breathing exercises
  - Initiate ROM
  - Introduce low tech adaptation for smartphone
  - Upright tolerance/out of bed
- Clinical Pearls/Tricks of the trade



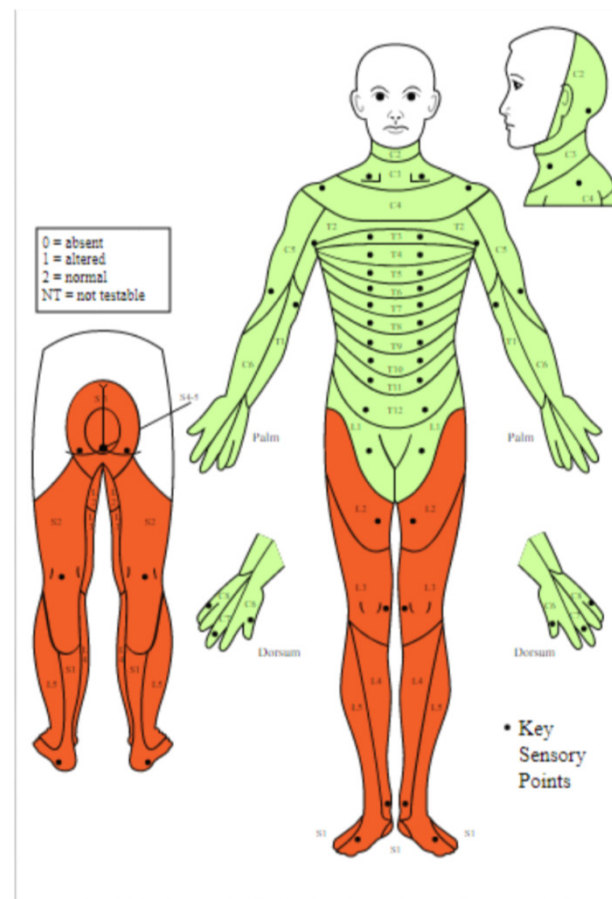




# T2- L1

## Key Muscles

- Intercostals
- Rectus abdominis
- Transverse abdominis
- External obliques
- Internal obliques
- Back extensors





## T2-L1 Expected Functional Recovery

- Development of trunk control as innervation of chest and abdominal muscles (T6-T12) emerges and improves
- Fully independent in breathing, eating/drinking, and communication
- Fully independent in self-care and ADLs
- Fully independent with bed mobility and transfers
- Fully independent with manual wheelchair for mobility





# Interprofessional Interventions

- Patient/Caregiver Education
  - Directing care/promoting self-management
  - Management of orthostatic hypotension: abdominal binder, ted hose, ace wraps
  - Developing a plan collaboratively to continue program outside of therapy visits
- Treatment
  - Upright tolerance
  - Breathing exercises
  - Initiate ROM
  - **Dual task/cognitive activities**
- Clinical Pearls/Tricks of the trade

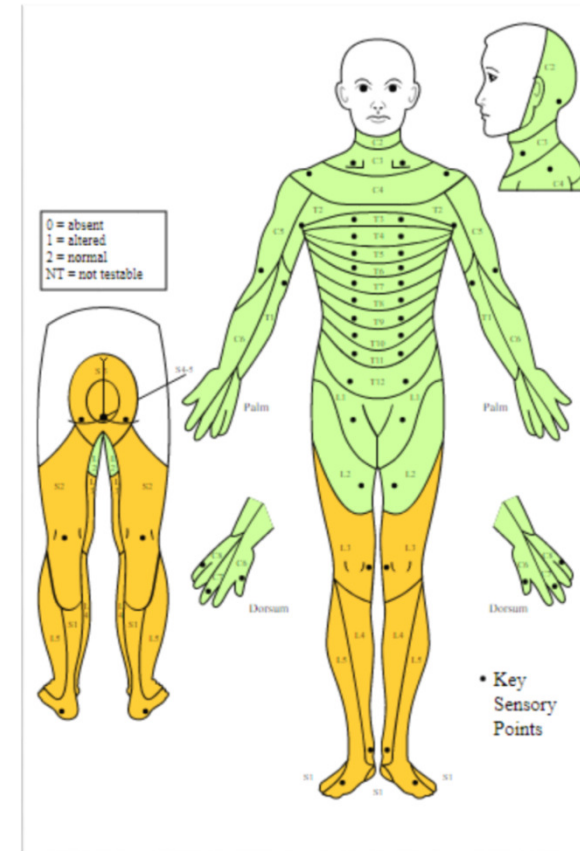




# L2-S1

## Key Muscles

- Hip flexors
- Hip extensors
- Hip abductors
- Knee extensors
- Knee flexors
- Ankle DFs
- Ankle PFs
- Toe Flexors
- Toe Extensors







## L2-S1 Expected Functional Recovery

- Additional movement in the hips, knees, ankles, and/or toes
- Fully independent in breathing, eating/drinking, and communication
- Fully independent in self-care and ADLs
- Fully independent with bed mobility and transfers
- Fully independent with manual wheelchair, walking\*, or a combination of both for mobility



*Data courtesy of Model Systems  
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# Interprofessional Interventions

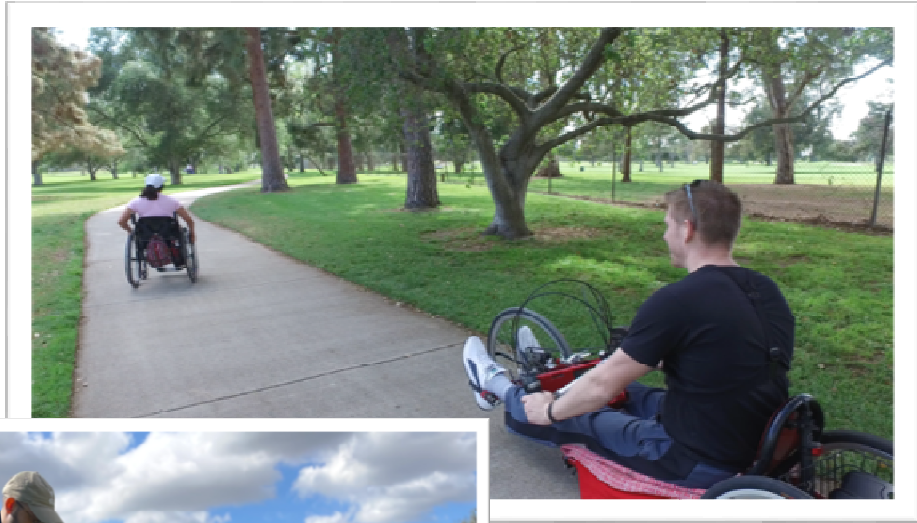
- Patient/Caregiver Education
  - Directing care/promoting self-management
  - Management of orthostatic hypotension: abdominal binder, TED hose, ace wraps
  - Developing a plan collaboratively to continue program outside of therapy visits
- Treatment
  - Upright tolerance
  - Breathing exercises
  - Initiate ROM
  - Dual task/cognitive activities
  - **Increase time out of bed**
- Clinical Pearls/Tricks of the trade





# Conclusion

- The ISNCSCI, AIS, and data collection help to guide healthcare professionals in prognosis discussions, clinical decision-making, management, and POC development
- Current trends demonstrate a change in conversion and recovery rates compared to historical trends
- Early interventions (and inclusion of family/friends) are essential in an individual's adjustment/adaptation, education, and empowerment
- Role of Interprofessional team members is to protect, preserve, and strengthen the individual's body for optimal health, well-being, and recovery beyond our point of care
- Interprofessional team members assist individuals with navigating a life change in a positive, supportive manner
- Instill hope





תודה  
Dankie Gracias  
Спасибо شكراً  
Merci Takk  
Köszönjük Terima kasih  
Grazie Dziękujemy Dékojame  
Ďakujeme Vielen Dank Paldies  
Kiitos Täname teid 谢谢  
**Thank You** Tak  
感謝您 Obrigado Teşekkür Ederiz  
감사합니다  
Σας ευχαριστούμε ขอบคุณ  
Bedankt Děkujeme vám  
ありがとうございます  
Tack



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## Resources

Model Systems Knowledge Center [www.msktc.org/sci](http://www.msktc.org/sci)





# APPENDIX: Breathing Exercises

## General Guidelines

- Diaphragm is the primary mover for breathing. Accessory muscles such as scalenes, sternocleidomastoid, pectorals, and intercostals assist with inspiration
- The optimal position for exercising the diaphragm is lying on your back.
- As the individual improves, progress toward upright position.
- In the upright position, an abdominal binder is often helpful for supporting the diaphragm and maintaining intra-abdominal pressure in the upright position.

## Objective

- To increase strength and endurance, first increase time/duration of exercise to a maximum exercise time of 10-15 minutes.
- When you have reached time goal, increase resistance of exercise or weights.



# APPENDIX: Breathing Exercises

## Exercises:

- Breather (Equipment): Goal is to strengthen diaphragm and respiratory muscles by breathing through resistance. Level 1 least resistance. Level 5/6 hardest resistance. For endurance: time
- Breather (Equipment): Goal is to strengthen diaphragm and respiratory muscles by breathing through resistance. Level 1 least resistance. Level 5/6 hardest resistance. For strengthening: sets and reps
- Triplicate Breathing: Goal is to increase lung expansion and strengthen inspiratory muscles. Lie on back, take three successive breaths trying to get more air into lungs with each breath. Exhale slowly.
- Measured in time/ duration or repetitions.
- 2 Quick Breaths: Goal is to increase lung expansion and strengthen inspiratory muscles. Lie on back, take two successive quick breaths, and then exhale slowly. Try to get more air into the lungs with each breath. Measure in time/duration or repetitions. 7 mins



# APPENDIX: Breathing Exercises

## **Exercises (continued):**

Breath Hold: Goal is to strengthen inspiratory muscles by taking a deep breath. Lie on back, take a deep breath, and hold as long as you can, slowly exhale. Measured in time/duration or repetitions.

Shoulder Shrugs: Goal is to strengthen neck muscles, your accessory breathing muscles. Lie on back or sit up, breathe in as you shrug your shoulders up into ears, hold 2-5 seconds, relax. To increase difficulty, shrug shoulders against manual resistance of another person. Measure in sets and repetitions.