Neurological assessment & acute rehabilitation

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Neurological assessment: ISNCSCI

ISNCSCI
(International Standards for the Neurological Classification of Spinal Cord Injury)

" Accepted as the most accurate and reliable instrument for documenting neurologic status following SCI "

ISNCSCI

- **Major revisions** of the standards were completed in **1992**, **1996**, and **2000**
- **Minor revisions** of the standards were completed in **2002, 2006, 2009, 2011, and 2013**

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

ASIA — American Spinal Injury Association

ISCOS — International Spinal Cord Society

Patient Name _____ Date/Time of Exam _____

Examiner Name _____ Signature _____

RIGHT

MOTOR KEY MUSCLES		SENSORY KEY SENSORY POINTS Light Touch (LTR)	Pin Prick (PPR)
	C2		
	C3		
	C4		
Elbow flexors	C5		
Wrist extensors	C6		
Elbow extensors	C7		
Finger flexors	C8		
Finger abductors (little finger)	T1		
	T2		
	T3		
	T4		
	T5		
	T6		
	T7		
	T8		
	T9		
	T10		
	T11		
	T12		
	L1		
Hip flexors	L2		
Knee extensors	L3		
Ankle dorsiflexors	L4		
Long toe extensors	L5		
Ankle plantar flexors	S1		
	S2		
	S3		
	S4-5		
		(50)	(56) (56)

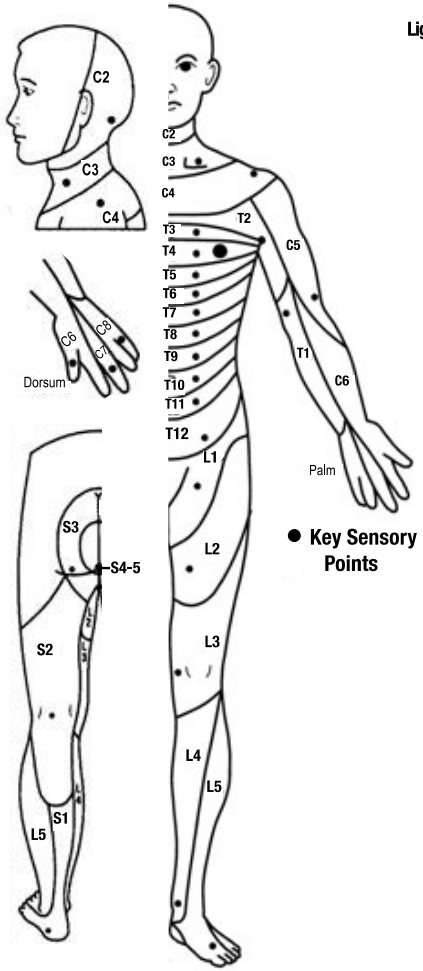
UER (Upper Extremity Right)

LER (Lower Extremity Right)

Comments (Non-key Muscle? Reason for NT? Pain?):

(VAC) Voluntary Anal Contraction (Yes/No) ☐

RIGHT TOTALS (MAXIMUM) (50) (56) (56)



● Key Sensory Points

LEFT

SENSORY KEY SENSORY POINTS Light Touch (LTL)	Pin Prick (PPL)	MOTOR KEY MUSCLES	
		C2	
		C3	
		C4	
		C5	Elbow flexors
		C6	Wrist extensors
		C7	Elbow extensors
		C8	Finger flexors
		T1	Finger abductors (little finger)
		T2	
		T3	
		T4	
		T5	
		T6	
		T7	
		T8	
		T9	
		T10	
		T11	
		T12	
		L1	
		L2	Hip flexors
		L3	Knee extensors
		L4	Ankle dorsiflexors
		L5	Long toe extensors
		S1	Ankle plantar flexors
		S2	
		S3	
		S4-5	
(56)	(56)	(50)	

UEL (Upper Extremity Left)

LEL (Lower Extremity Left)

MOTOR *(SCORING ON REVERSE SIDE)*

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
5 = normal corrected for pain/disuse*
NT = not testable

SENSORY *(SCORING ON REVERSE SIDE)*

0 = absent *2 = normal*
1= altered *NT = not testable*

☐ (DAP) Deep Anal Pressure (Yes/No)

LEFT TOTALS (MAXIMUM)

MOTOR SUBSCORES

UER ☐ + UEL ☐ = *UEMS TOTAL* ☐ (MAX (25) (25) (50))

LER ☐ + LEL ☐ = *LEMS TOTAL* ☐ (MAX (25) (25) (50))

SENSORY SUBSCORES

LTR ☐ + LTL ☐ = *LT TOTAL* ☐ (MAX (56) (56) (112))

PPR ☐ + PPL ☐ = *PP TOTAL* ☐ (MAX (56) (56) (112))

NEUROLOGICAL LEVELS
Steps 1-5 for classification as on reverse

	R	L
1. SENSORY	☐	☐
2. MOTOR	☐	☐

3. NEUROLOGICAL LEVEL OF INJURY (NLI) ☐

4. COMPLETE OR INCOMPLETE? ☐
Incomplete = Any sensory or motor function in S4-5

5. ASIA IMPAIRMENT SCALE (AIS) ☐

(In complete injuries only)
ZONE OF PARTIAL PRESERVATION
Most caudal level with any innervation

	R	L
SENSORY	☐	☐
MOTOR	☐	☐

Muscle Function Grading

0 = total paralysis

1 = palpable or visible contraction

2 = active movement, full range of motion (ROM) with gravity eliminated

3 = active movement, full ROM against gravity

4 = active movement, full ROM against gravity and moderate resistance in a muscle specific position

5 = (normal) active movement, full ROM against gravity and full resistance in a functional muscle position expected from an otherwise unimpaired person

5* = (normal) active movement, full ROM against gravity and sufficient resistance to be considered normal if identified inhibiting factors (i.e. pain, disuse) were not present

NT = not testable (i.e. due to immobilization, severe pain such that the patient cannot be graded, amputation of limb, or contracture of > 50% of the normal ROM)

Sensory Grading

0 = Absent

1 = Altered, either decreased/impaired sensation or hypersensitivity

2 = Normal

NT = Not testable

When to Test Non-Key Muscles:

In a patient with an apparent AIS B classification, non-key muscle functions more than 3 levels below the motor level on each side should be tested to most accurately classify the injury (differentiate between AIS B and C).

Movement	Root level
Shoulder: Flexion, extension, abduction, adduction, internal and external rotation **Elbow:** Supination	**C5**
Elbow: Pronation **Wrist:** Flexion	**C6**
Finger: Flexion at proximal joint, extension. **Thumb:** Flexion, extension and abduction in plane of thumb	**C7**
Finger: Flexion at MCP joint **Thumb:** Opposition, adduction and abduction perpendicular to palm	**C8**
Finger: Abduction of the index finger	**T1**
Hip: Adduction	**L2**
Hip: External rotation	**L3**
Hip: Extension, abduction, internal rotation **Knee:** Flexion **Ankle:** Inversion and eversion **Toe:** MP and IP extension	**L4**
Hallux and Toe: DIP and PIP flexion and abduction	**L5**
Hallux: Adduction	**S1**

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 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.

ASIA
AMERICAN SPINAL INJURY ASSOCIATION

INTERNATIONAL STANDARDS FOR NEUROLOGICAL CLASSIFICATION OF SPINAL CORD INJURY

ISCOS
INTERNATIONAL SPINAL CORD SOCIETY

Steps in Classification

The following order is recommended for determining the classification of individuals with SCI.

1. Determine sensory levels for right and left sides.
The sensory level is the most caudal, intact dermatome for both pin prick and light touch sensation.

2. Determine motor levels for right and left sides.
Defined by the lowest key muscle function that has a grade of at least 3 (on supine testing), providing the key muscle functions represented by segments above that level are judged to be intact (graded as a 5).
Note: in regions where there is no myotome to test, the motor level is presumed to be the same as the sensory level, if testable motor function above that level is also normal.

3. Determine the neurological level of injury (NLI)
This refers to the most caudal segment of the cord with intact sensation and antigravity (3 or more) muscle function strength, provided that there is normal (intact) sensory and motor function rostrally respectively.
The NLI is the most cephalad of the sensory and motor levels determined in steps 1 and 2.

4. Determine whether the injury is Complete or Incomplete.
(i.e. absence or presence of sacral sparing)
*If voluntary anal contraction = **No** AND all S4-5 sensory scores = **0** AND deep anal pressure = **No,** then injury is **Complete.** Otherwise, injury is **Incomplete.***

5. Determine ASIA Impairment Scale (AIS) Grade:

Is injury Complete? **If YES, AIS=A** and can record ZPP (lowest dermatome or myotome on each side with some preservation)

NO ↓

Is injury Motor Complete? **If YES, AIS=B**

NO ↓ (No=voluntary anal contraction OR motor function more than three levels below the motor level on a given side, if the patient has sensory incomplete classification)

Are at least half (half or more) of the key muscles below the neurological level of injury graded 3 or better?

NO ↓ **AIS=C**

YES ↓ **AIS=D**

If sensation and motor function is normal in all segments, AIS=E
Note: AIS E is used in follow-up testing when an individual with a documented SCI has recovered normal function. If at initial testing no deficits are found, the individual is neurologically intact; the ASIA Impairment Scale does not apply.

Proper testing position??

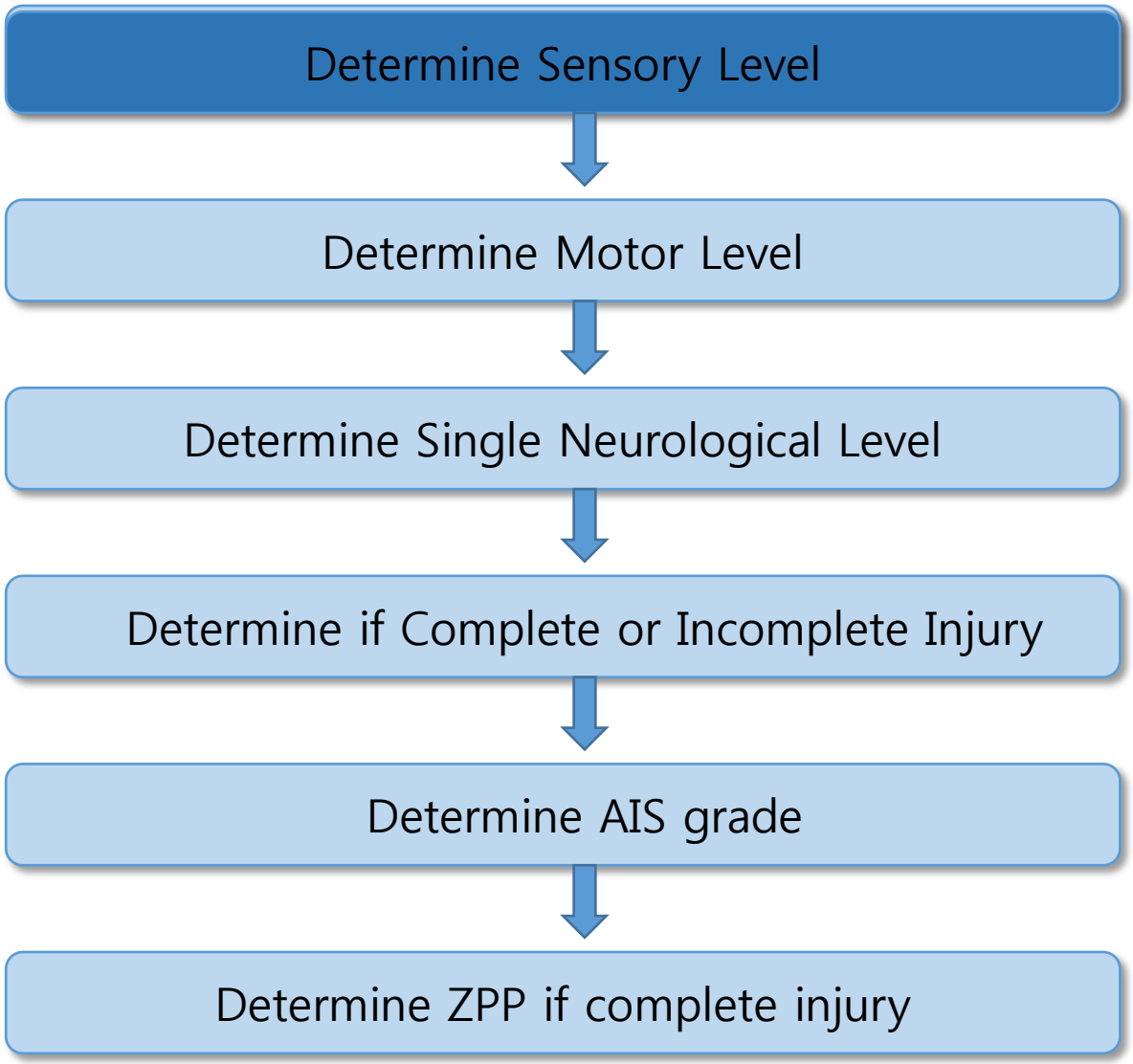
SUPINE!!! for valid comparison throughout the phases of care

except for the rectal examination (can be performed side-lying)

In pediatric patients

Child and caregiver must both ***understand exam***.

Sit next to the child while explaining.


Determine Sensory Level
Determine Motor Level
Determine Single Neurological Level
Determine if Complete or Incomplete Injury
Determine AIS grade
Determine ZPP if complete injury

Where??

- Key sensory points

Where is the reference area??

- Patient's cheek

Which modality??

- Light touch (***tickle***) and Pin prick (***pointy***)

HOW??

- Patient eyes are ***closed*** or ***covered***.
- Caregiver stands on contralateral side and hold's the child's attention.

- Starting with ***light touch*** then testing pin prick sensation
- First, conduct on yourself.
- Let the child use the pin on you or caregiver.

- ***caudal-to-rostral sequence***

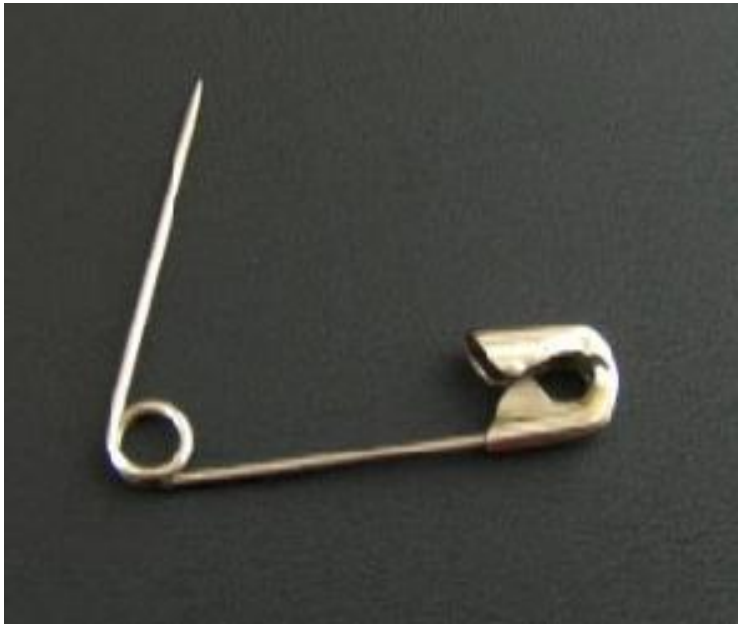
Light touch

- tapered wisp of cotton
- stroked once, not exceed 1cm

- 0 = absent
- 1 = altered (impaired or partial appreciation, including hyperesthesia)
- 2 = normal or intact (similar as on the cheek)

Pin prick

- disposable safety pin
- stretched apart to allow testing on both ends
- pointed end for sharp, rounded end for dull



- 0 = absent or **inability to distinguish** between dull and sharp sensation (as well as no feeling when being touched by the pin)
- 1 = can distinguish between the sharp and dull edge of the pin, but the pin is not felt as sharp as on the cheek
- 2 = Pin is felt as sharp in the tested dermatome as when tested on the cheek

- If in doubt, **8 out of 10 correct answers** are suggested as a standard for accuracy

Determine Sensory Level

- ***most caudal dermatome*** which light touch and pin prick sensations are **intact**

- if sensation is abnormal at C2 and intact on the face
  - sensory level - **C1**
- if sensation is intact on one side for light touch and pin prick at all dermatomes
  - sensory level - recorded as **"INT (intact)"**

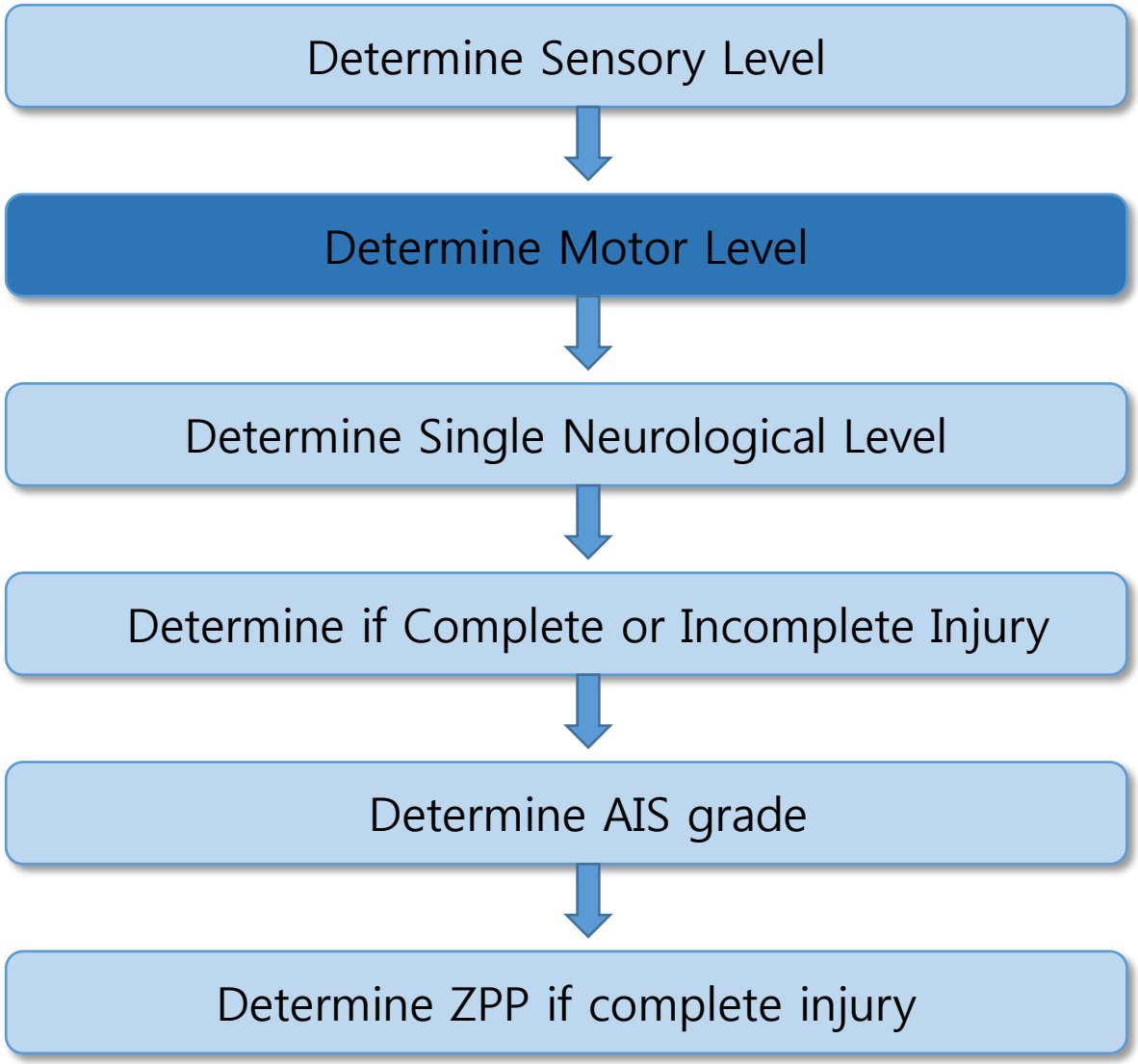
Sensory Level??

	Right		Left	
	Light touch	Pin Prick	Light touch	Pin Prick
C2	2	2	2	2
C3	2	2	1	1
C4	1	2	1	0
C5	1	0	0	0

C3/C2

Pitfalls of the sensory exam in pediatric patients

- Scoliosis
- Pelvic obliquity


Determine Sensory Level
Determine Motor Level
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Determine AIS grade
Determine ZPP if complete injury

Key muscles??

- C5: Elbow flexors (biceps, brachialis)
- C6: Wrist extensors (ECRL and ECRB)
- C7: Elbow extensors (triceps)
- C8: Finger flexors (FDP) to the middle finger
- T1: Small finger abductors (ADM)
  - ***not fully developed until age 4 or 5***
- L2: Hip flexors (iliopsoas)
- L3: Knee extensors (quadriceps)
- L4: Ankle dorsiflexors (TA)
- L5: Long toe extensors (EHL)
- S1: Ankle plantar flexors (GCM, soleus)

HOW??

- 0 = total paralysis
- 1 = palpable or visible contraction
- 2 = active movement, full range of motion (ROM) with gravity eliminated
- 3 = active movement, full ROM against gravity
- 4 = active movement, full ROM against moderate resistance in a muscle specific position
- 5 = (normal) active movement, full ROM against full resistance in a muscle specific position expected from an otherwise unimpaired person

HOW??

- **5*** = (normal) active movement, full ROM against gravity and sufficient resistance to be considered normal if identified inhibiting factors (i.e. pain, disuse) were not present
- NT = not testable (i.e. due to immobilization, severe pain such that the patient cannot be graded, amputation of limb, or *contracture of >50% of the ROM*)

- ***"Plus"*** **and** ***"Minus"*** **scores are NOT used**

HOW??

- Use an ***appropriate amount of resistance***.
- For each motion assessed, demonstrate the requested movement or passively move the patient's body.
- Test for **Grade 3 first**, then move "up" or "down" the scale accordingly
- Place stabilizing and resisting hands accurately

Determine Motor Level

- ***lowest key muscle*** function that has a **grade of at least 3**, and segments **above that level** are judged to be intact (**grades as 5**)

Motor Level??

	Right	Left
C5	5	5
C6	5	4
C7	3	4
C8	3	3

C7/C6

C1-C4, T2-L1, S2-S5?

- motor level is **presumed to be the same as the sensory level** if testable motor function above that level is normal as well

Anorectal exam

Deep Anal Pressure (DAP)

- gentle pressure to the anorectal wall

OR

- gently squeeze the anus against the inserted index finger
- Use the ***small finger*** for children ***under 3***, inserted shallow.

- Present/Absent
- In patients who have light touch or pin prick sensation at S4-5, examination of DAP is not required

Voluntary anal contraction (VAC)

- Present/Absent

- If, there is VAC present, the patient has a motor incomplete injury

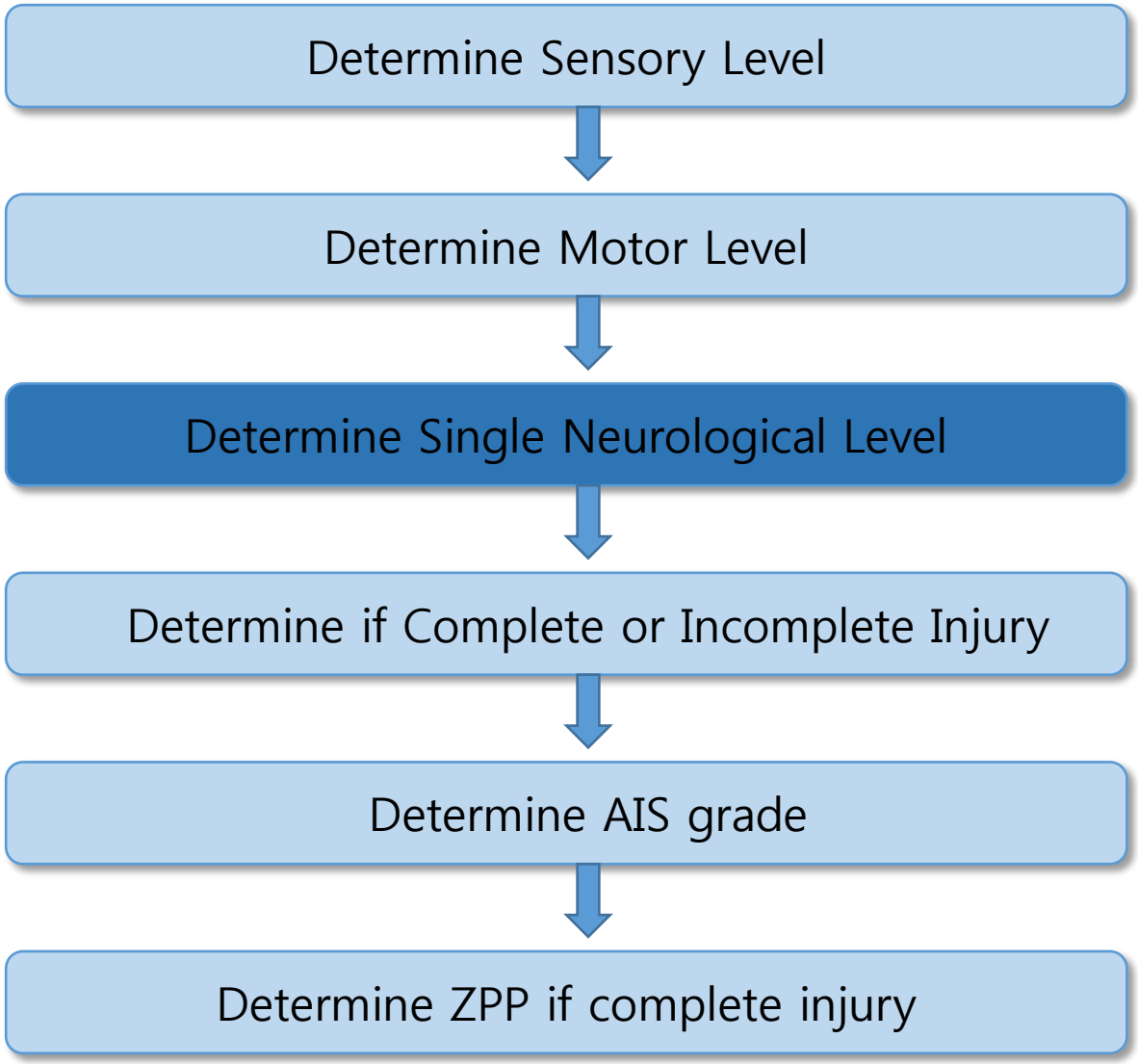
- Caution
  - reflex anal contraction
  - produced by Valsalva maneuver (light and not circular contracted feeling)
  - produced by gluteal contraction

- 10 and younger: parent or caregiver remains in the room.
- Older than 10: ask the patient.

- If a parent or caregiver is not present, have another professional staff member present during the exam.

- Adolescents should have a choice in gender of examiner, if possible.

- ***Conduct*** anorectal examination ***last***.
- Use ***family-appropriate terms***.
- Under 8yrs old: use a doll for explanation.


Determine Sensory Level
Determine Motor Level
Determine Single Neurological Level
Determine if Complete or Incomplete Injury
Determine AIS grade
Determine ZPP if complete injury

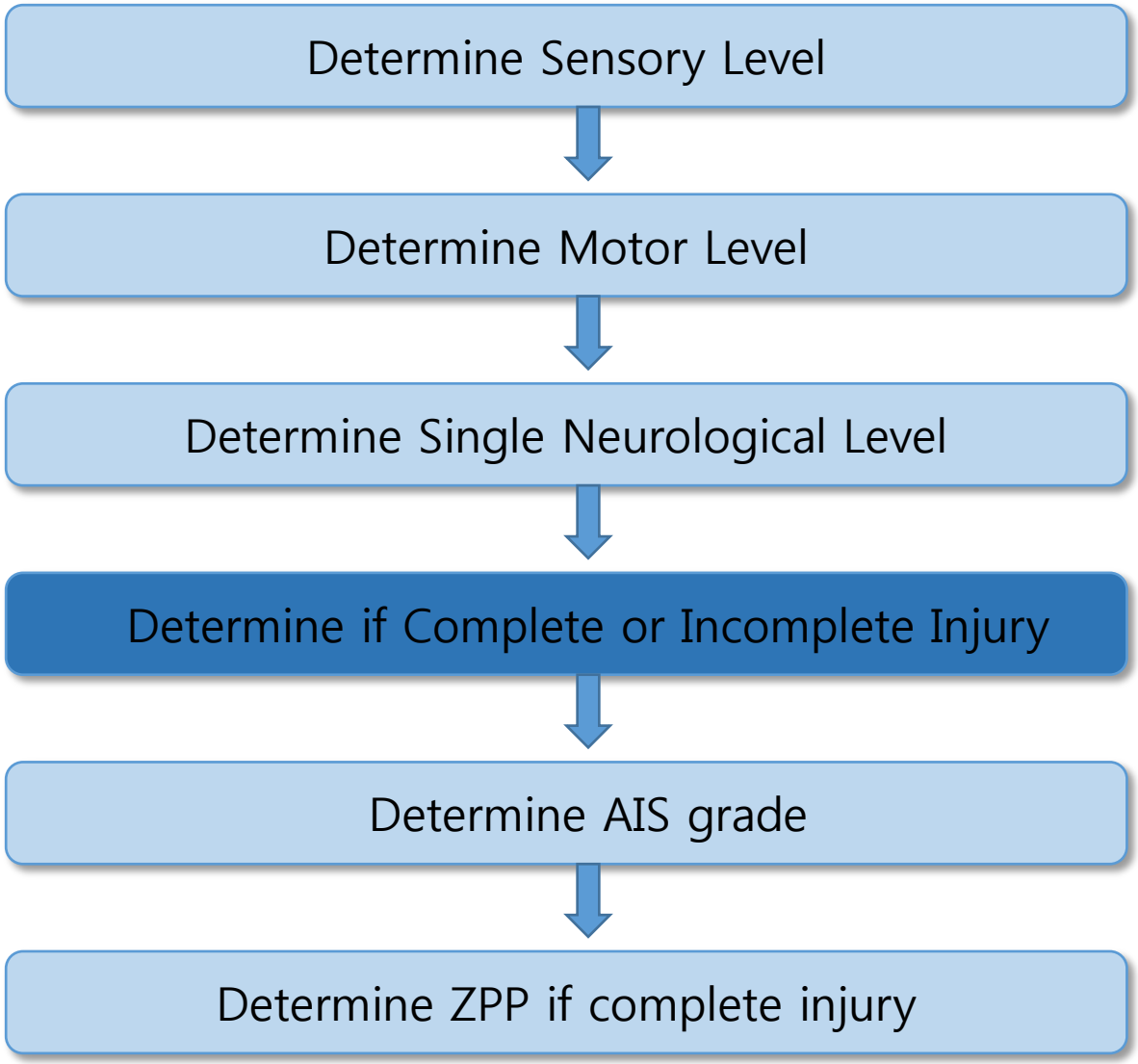
Neurological Level of Injury (NLI)

- most caudal segment with intact sensation and antigravity muscle function strength

- single NLI is the most rostral of 2 sensory levels and 2 motor levels

- sensory level: C6/C5
- motor level: C7/C6

→ single NLI: C5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Determine Motor Level
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Determine ZPP if complete injury

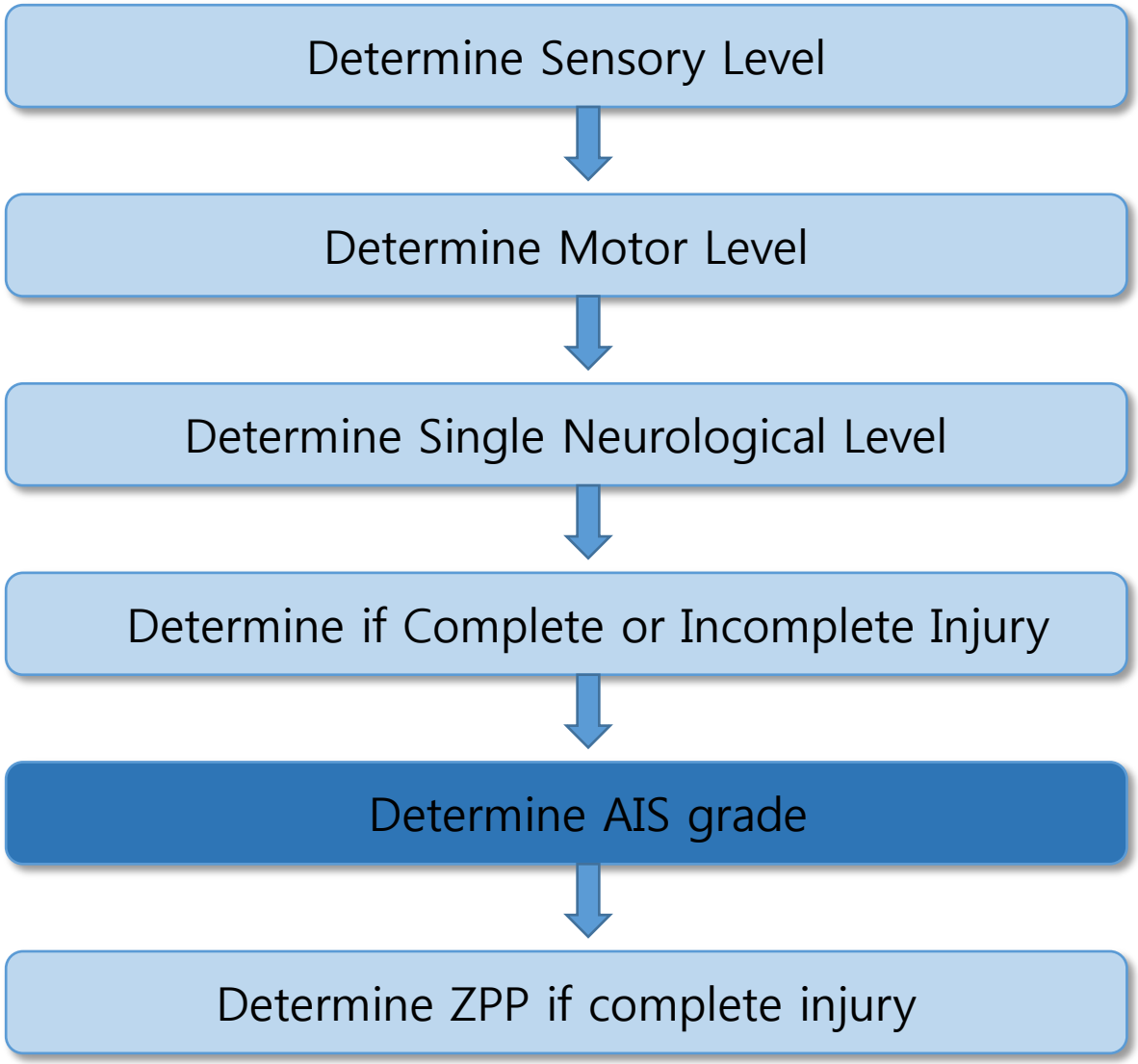
Determine if Complete or Incomplete Injury

Sacral Sparing

- presence of sensory or motor function in the most caudal sacral segments

- preservation of light touch or pin prick sensation at the S4-5 **OR**
- presence of deep anal pressure **OR**
- presence of voluntary anal contraction

- Absence of sacral sparing: Complete injury (AIS A)
- Presence of sacral sparing: Incomplete injury (AIS B,C,D)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ASIA Impairment Scale (AIS)

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- **B = Sensory Incomplete.** Sensory but not motor function is preserved below the neurological level and includes the sacral segments S4-5, 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 below the neurological level*, and ***more than half*** of key muscle functions below the single NLI have a muscle ***grade less than 3 (Grades 0-2)***.

- **D = Motor Incomplete.** Motor function is preserved below the neurological level*, and ***at least half*** (half or more) of key muscle functions below the single NLI have a muscle ***grade ≥ 3***.

* For an individual to receive a grade of C or D, they must have

① voluntary anal sphincter contraction or

② sacral sensory sparing (at S4-5 or DAP) with sparing of ***motor function more than 3 levels below the motor level*** for that side of the body

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.

AIS B or C??

- Sensory level: C5/C5, Motor level: C6/C5, NLI: C5
- S4/5 light touch (+)

	Right	Left
C5	5	4
C6	4	3
C7	2	2
C8	1	1
T1	0	0
L2~S1	0	0

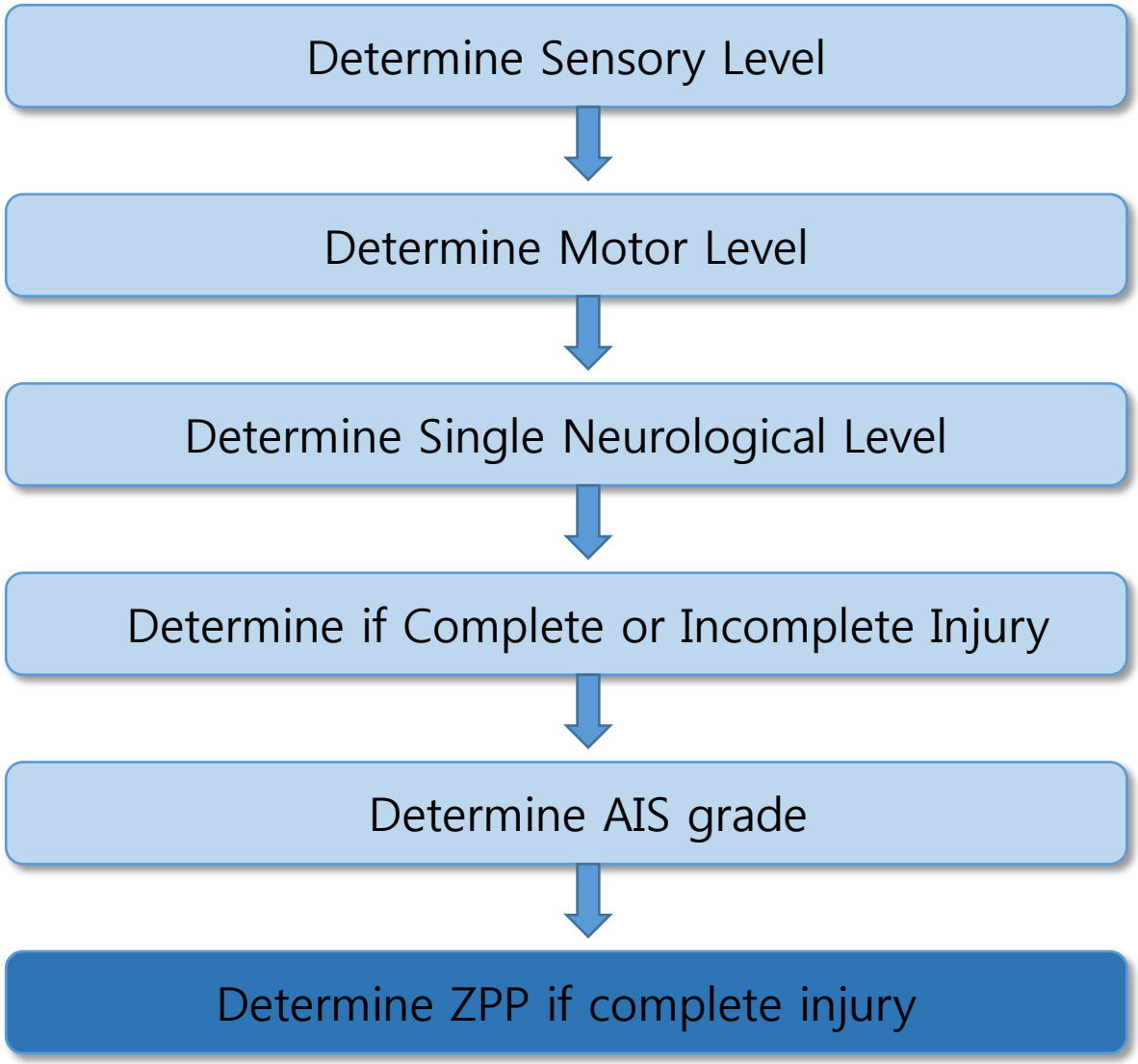
- sparing of ***motor function more than 3 levels below the motor level*** for that side of the body? **NO!!**
- **AIS-B**

AIS B or C/D??

- Sensory level: C5/C5, Motor level: C6/C5, NLI: C5
- S4/5 light touch (+)

	Right	Left
C5	5	4
C6	4	3
C7	2	2
C8	1	1
T1	0	1
L2~S1	0	0

- sparing of ***motor function more than 3 levels below the motor level*** for that side of the body? **YES!!**
- **AIS-C**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Determine ZPP if complete injury

Zone of Partial Preservation (ZPP)

- used only with complete injuries
- dermatomes/myotomes caudal to the sensory and motor levels that remain partially innervated

- “NA” in ZPP boxes for incomplete injuries

Guidelines for use of the ISNCSCI in children

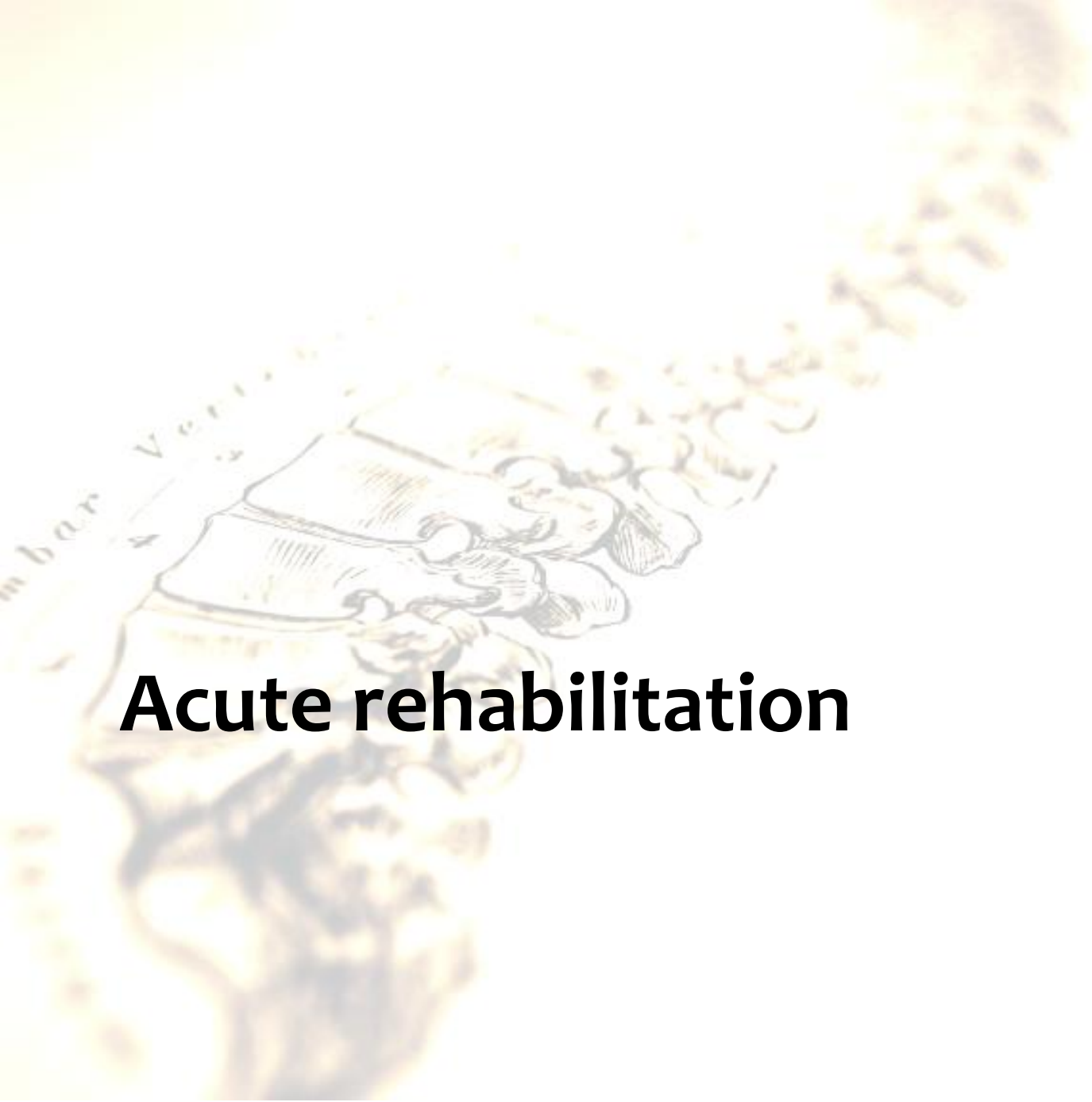
- for reliable and excellent inter-rater agreement
  - ***at least 6 years old***

- 4 years & younger
  - motor, sensory level should be estimated
  - use alternative methods to appreciate perianal sensation

- 5 years
  - attempt the exam but stop if indicated

- 6-8 years
  - typically able to complete the exams

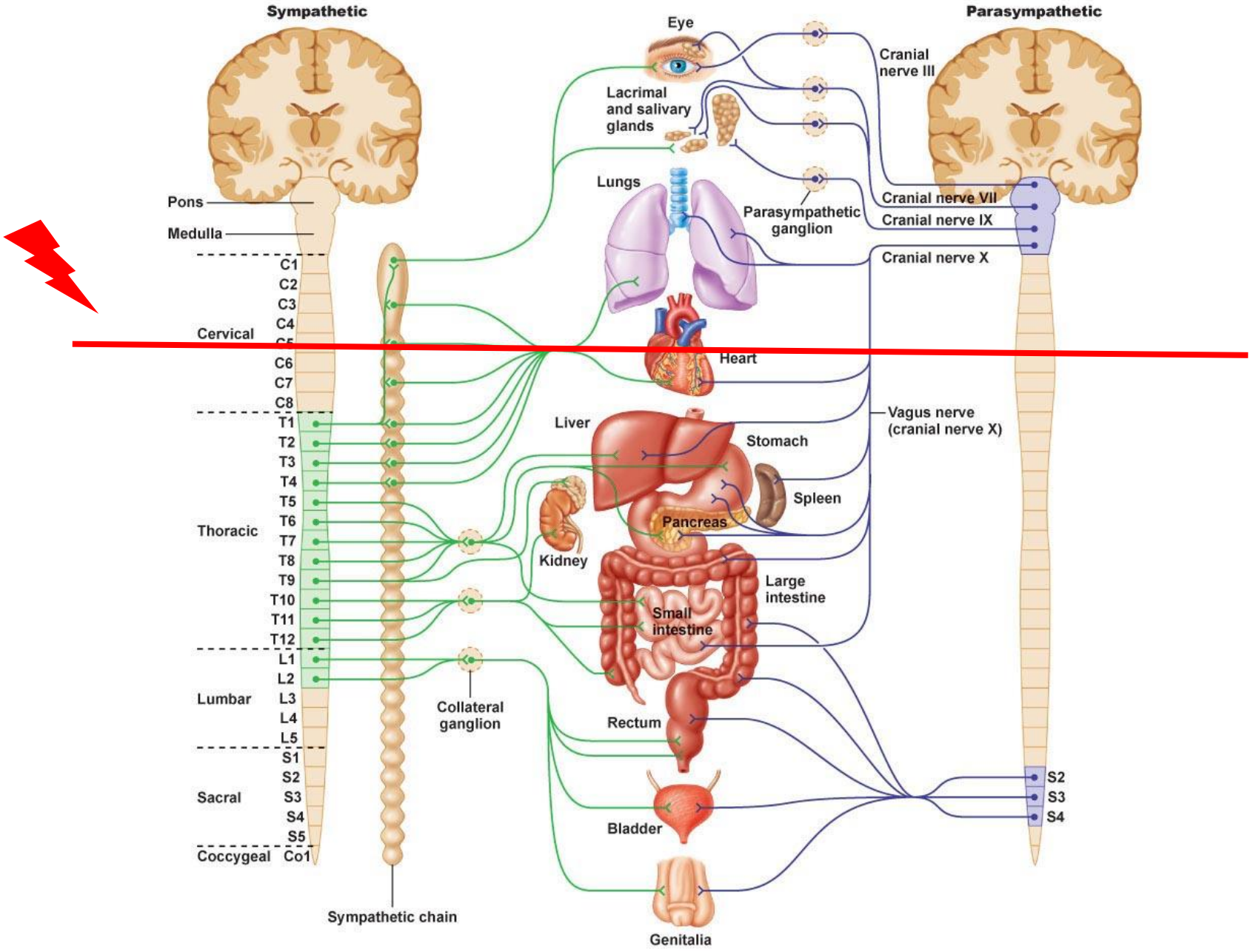
Clinicians ***should not label*** a child ***as complete or incomplete*** until the child is of an appropriate age to participate in the anorectal exam.



Acute rehabilitation

Orthostatic hypotension

Pulmonary dysfunction


Sympathetic
Parasympathetic
Eye
Cranial nerve III
Lacrimal and salivary glands
Lungs
Parasympathetic ganglion
Cranial nerve VII
Cranial nerve IX
Cranial nerve X
Pons
Medulla
C1
C2
C3
C4
Cervical
C5
C6
C7
C8
Heart
Vagus nerve (cranial nerve X)
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10
T11
T12
Thoracic
Liver
Stomach
Spleen
Pancreas
Kidney
Large intestine
Small intestine
L1
L2
L3
L4
L5
Lumbar
Collateral ganglion
Rectum
S1
S2
S3
S4
S5
Sacral
Bladder
Coccygeal
Co1
Sympathetic chain
Genitalia
S2
S3
S4

Orthostatic hypotension (OH)?

Classic orthostatic hypotension

(by the American Academy of Neurology and the American Autonomic Society in 1996)

기립 자세 또는 적어도 경사침대에서 60° 이상으로 기립 후
3분 이내에

수축기 혈압 **(SBP) ≥20mmHg**
이완기 혈압 **(DBP) ≥10mmHg** 감소되었을 때

Orthostatic hypotension (OH)?

Other variants of orthostatic hypotension

(in the 2011 update)

- initial OH
  - 기립 15초 내에
  - SBP ≥40mmHg
  - DBP ≥20mmHg 이상 감소될 때

- delayed OH
  - 기립 3분 후 증상을 동반한 기립성 저혈압이 나타날 때

- 사지마비
- 완전 손상
- 오랜 침상 안정기간
- 식사 후
- 알코올 섭취 후
- 아침 기상 후
- 뜨거운 환경에 노출된 경우

- 약한 두통
- 어지러움
- 이명
- 시야 혼탁
- 피로감
- 발한
- 오심
- 기절

Pathophysiology

sympathetic nervous system dysfunction

loss of skeletal muscle pumping activity

low catecholamine levels

impaired function of baroreceptor

hyponatremia, low plasma volume

Habituation to OH

renin-angiotensin-aldosterone system

peripheral α-adrenoreceptor hyperresponsiveness

increased sensitivity of baroreceptor

spasticity

Nonpharmacologic treatment

- 악화인자 최소화시키기
- 고염식이
- 압박스타킹 착용
- 복대 착용
- 기능적전기자극치료
- 점진적인 기립 연습시키기
- 자는 동안 상체를 세우기

✓ 기립 연습 전 식사는 소량만 섭취
✓ 주말에 앉기 연습 지속하기

Nonpharmacologic treatment

- 악화인자 최소화시키기
- 고염식이
- 압박스타킹 착용
- 복대 착용
- 기능적전기자극치료
- 점진적인 기립 연습시키기
- 자는 동안 상체를 세우기

Pharmacologic treatment

- α_1-adrenergic receptor agonist (midodrine)
- mineralocorticoid (fludrocortisone)
- vasoconstrictor (ephedrine)

Pharmacologic treatment

midodrine

- **α_1-adrenergic receptor agonist**
  - directly increases BP **by arteriolar and venous constriction**

- peak plasma concentration level: **1hr**
- half-life of active metabolite (desglymidocrine): 3-4hrs
- initial dose: 2.5mg tid

- side effect: **excessive supine hypertension at night**
  - **taking the last dose at least 4hrs before bedtime**

fludrocortisone

- **potent mineralocorticoid** with little glucocorticoid activity
- pressor action **by sodium retention**
  - occurs over several days
  - doses should be altered no faster than on a weekly or biweekly interval
- **↑sensitivity of arterioles to norepinephrine**

- half life: 2-3hrs
- initial dose: 0.05-0.1mg/day

- side effect
  - weight gain due to fluid retention
  - hypokalemia (in 50% within 2wks)
  - hypomagnesemia (in 5%)
  - headache
- potential drug interaction with warfarin
- should be avoided in patients with congestive heart failure

ephedrine

- first available orally active **sympathomimetic drug**
- **release of stored catecholamine**
- **nonselective α, β receptor agonist** with both central and peripheral action

- initial dose: 25-50mg every 4hrs

- side effect
  - supine hypertension
  - tremulousness
  - palpitations
  - cardiac arrhythmia
  - urinary retention

Orthostatic hypotension

Pulmonary dysfunction

Obstructive lung disease – COPD, asthma

- Oxygenation impairment
- Eucapnic or hypocapnic
- Hypercapnia – only acute respiratory failure or end-stage

Restrictive lung disease – SCI, myopathy, ALS

- Ventilation impairment
- Hypercapnia precede significant hypoxia

Inspiration

Primary muscles

- active during both quiet breathing and exercise

Diaphragm
Intercostal muscles

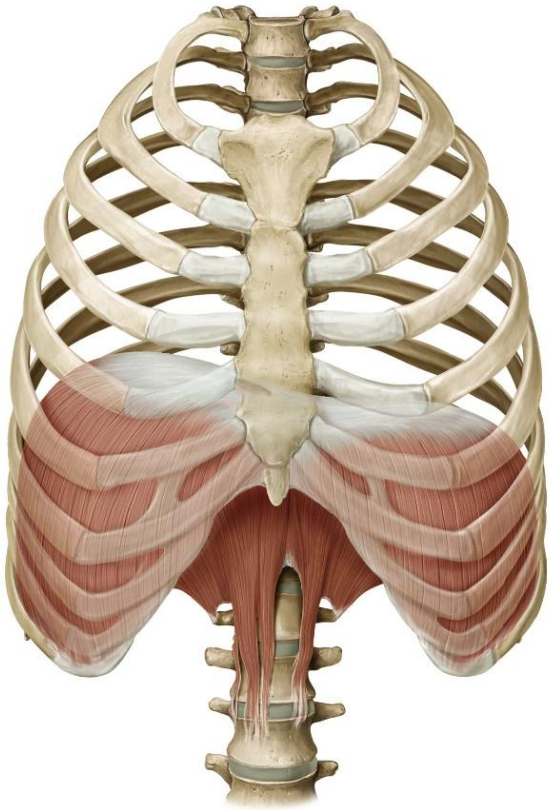
Accessory muscles

- assist primary muscles under conditions of increased ventilation demand

Scalene
Sternocleidomastoid (SCM)
Trapezius
Pectoralis major

Diaphragm

- Innervation by phrenic nerve (C3~C5)
- 65~75% of vital capacity is provided by diphragm
- Contraction draws the central tendon down
  - flattens the diaphragm
  - increasing the thoracic volume



Accessory muscles

- SCM, Trapezius – CN XI (spinal accessory nerve)
- Scalene – C3~C8
- Pectoralis major – C5~T1
- Less affected after spinal cord injury

- When patient uses his accessory muscles excessively, it is the **sign of impending respiratory failure.**

Expiration

- Not actively participate in by recoiling power (passive)

- During forced exhalation
  - **abdominal pressure increase** (rectus abdominis, transverse abdominis, internal and external oblique abdominal muscle)
  - push upward the diaphragm

Respiratory Failure

I. Abrupt Respiratory Failure

High cervical, complete injury (C1~C3)

Sudden ventilator failure

→ Intubation / tracheostomy

II. Acute / Recurrent Respiratory Failure

III. Late-onset Respiratory Failure

I. Abrupt Respiratory Failure

II. Acute / Recurrent Respiratory Failure

above C3 (incomplete) / C4~C6

mucous plugging / infection

→ Tracheostomy

Expectoration Failure !

III. Late-onset Respiratory Failure

I. Abrupt Respiratory Failure

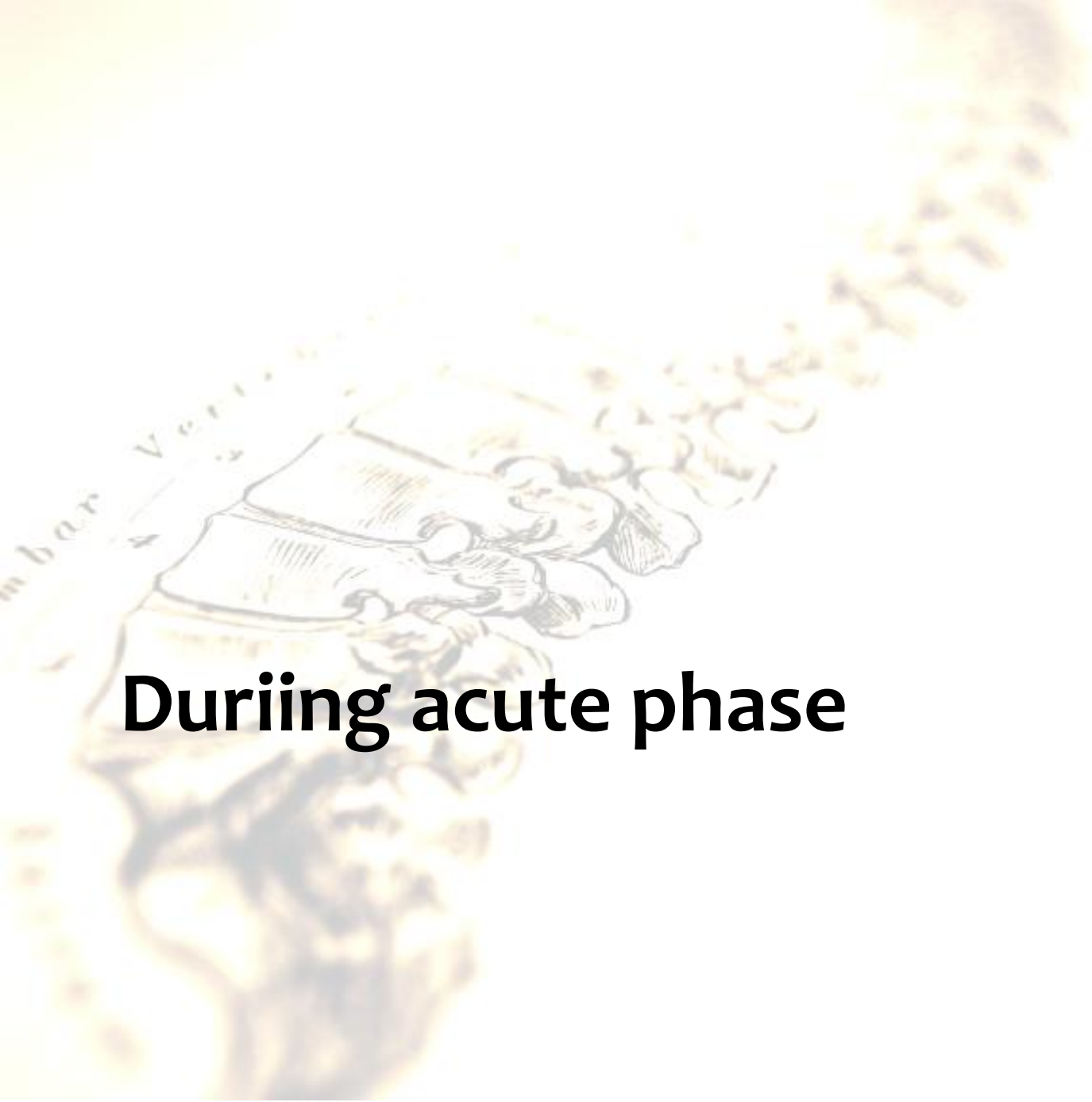
II. Acute / Recurrent Respiratory Failure

III. Late-onset Respiratory Failure

Chronic hypoventilation

→ Respiratory muscle fatigue !

→ Need ventilator support



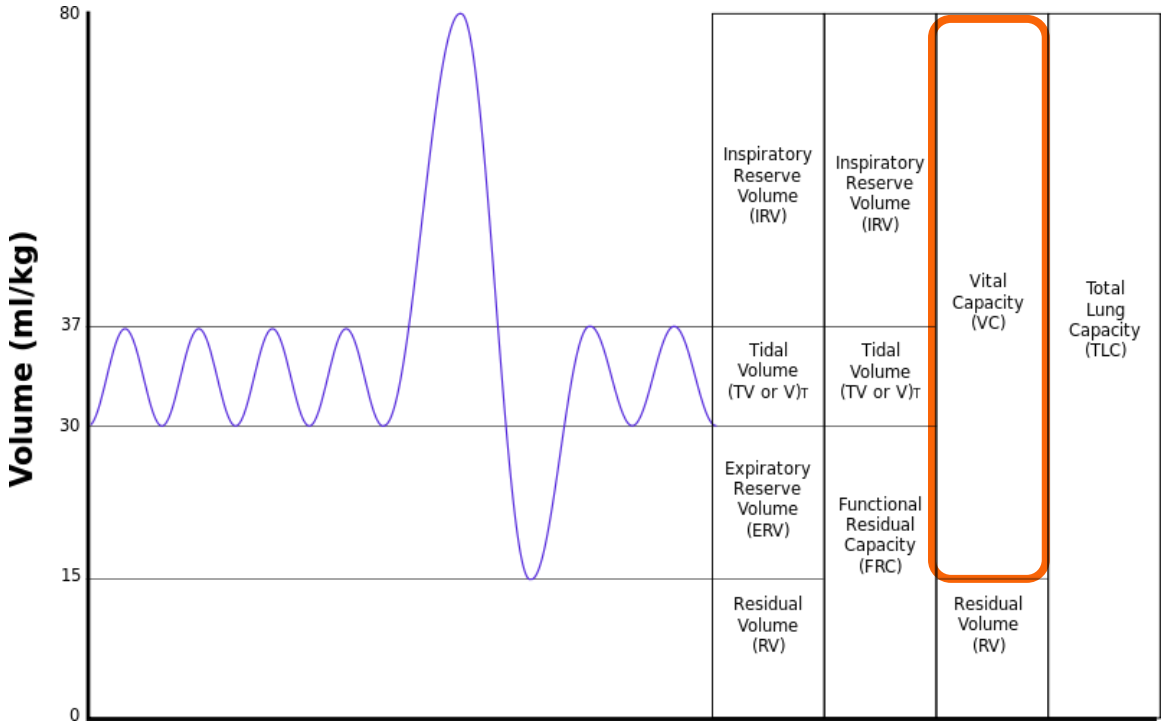
Duriing acute phase

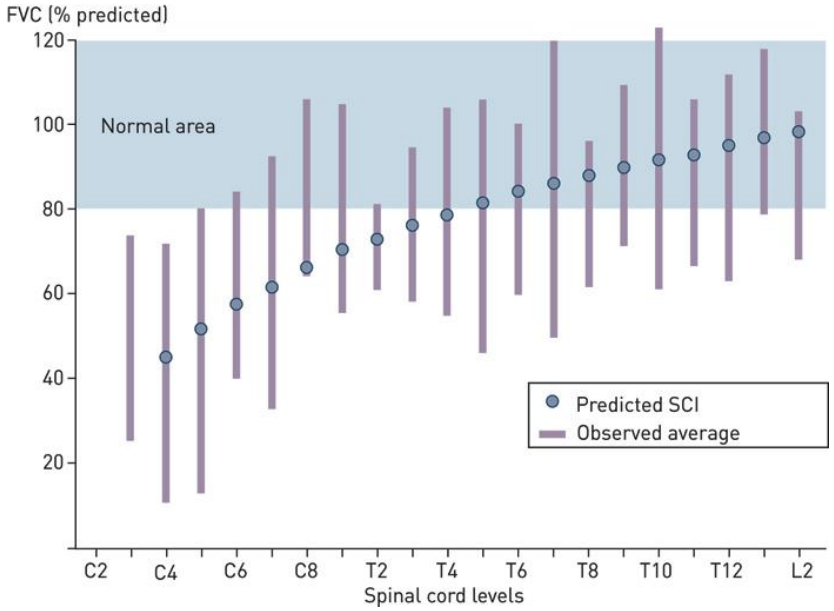
1. **Muscle weakness**

2. **Atelectasis**
   - d/t Impaired lung expansion, weak cough, retained bronchial secretion
3. **Retained secretions/Mucus plugging**
   - d/t increased parasympathetic tone, weak cough
4. **Bronchospasm**
   - d/t increased parasympathetic tone

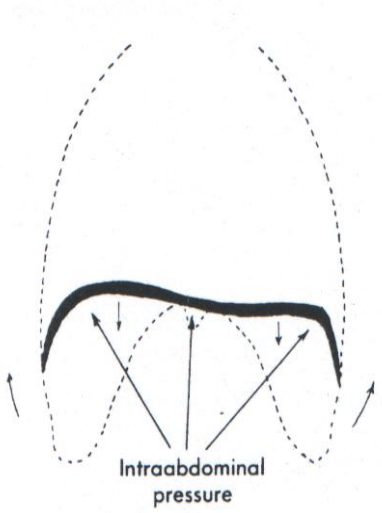
Patient evaluation

Vital capacity





	FVC	FEV1
1 week after SCI	30% of predicted value	27%
5 weeks	45%	42%
5 months	58%	59%



SCI patients

VCsitting **<** **VCsupine**

Normal subjects
Myopathy, ALS

VCsitting **>** VCsupine

MEP, MIP (maximal expiratory, inspiratory pressure)

Evaluation for respiratory muscle strength

PCF (peak cough flow)

Normal cough

- Precough inspiration to 85-90 % of TLC
- 360 - 720 L/min (6 – 12 L/sec)

Elimination particle from airway – at least ***160L/min***

Gas analysis – ABGA, oximetry, capnography

- Stable patient without intrinsic pulmonary disease
  – ABGA is unnecessary
- PaO_2
  - sensitive to atelectasis
  - SpO_2 – inaccurate if SaO_2<75%, hypothermia, low blood pressure
- **$PaCO_2$**
  - **ventilation abnormality**
  - end-tidal CO_2 – 3~5mmHg differ from $PaCO_2$

Nocturnal noninvasive blood gas monitoring

→ Any symptomatic Pt with decreased VC

Multiple nocturnal SpO_2 < 95%

→ ↑nocturnal $PaCO_2$ → Require Tx for nocturnal hypoventilation

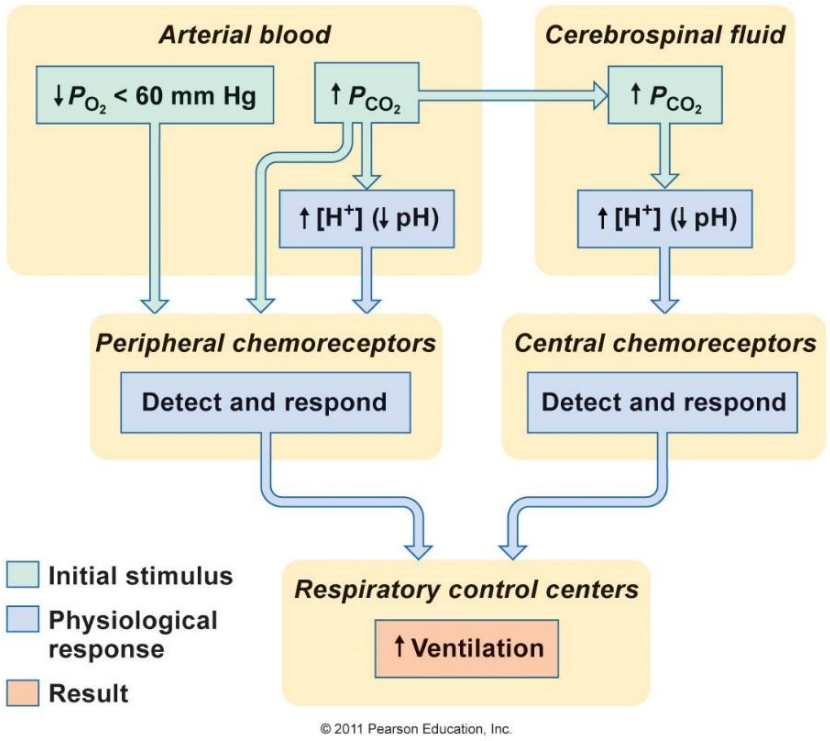
- Acute respiratory acidosis

(pH <7.36)

- Chronic respiratory acidosis

(pH 7.36~7.45)

  - renal compensation by renal excretion of carbonic acid (H_2CO_3) is increased and bicarbonate reabsorption



chronic hypercapnia

acute hypoxemia

O_2 supply → **Aggravation of hypercapnia**

Management

Aggressive management of secretion and atelectasis are the cornerstones of early treatment.

Clearing of secretions

suctioning, assisted coughing, postural drainage, percussion/vibration, mechanical insufflator-exsufflator, high-frequency chest wall oscillation

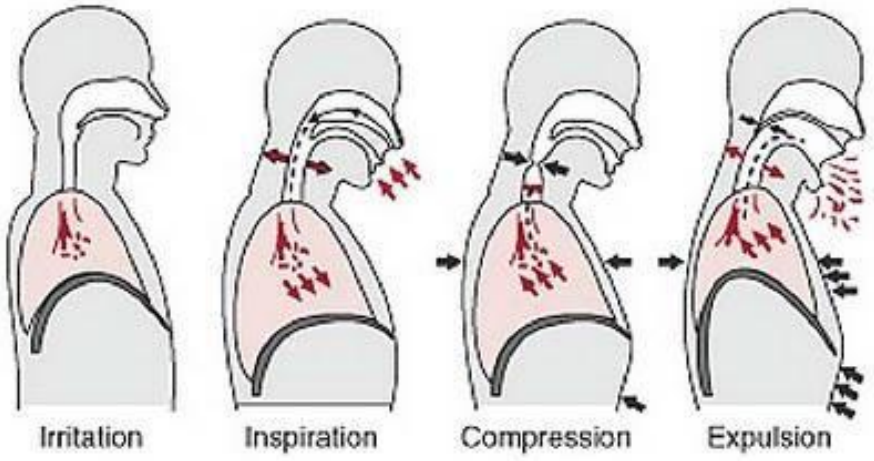
Expansion of the lungs

high TV setting, incentive spirometry, ambu bagging (air stacking), mechanical insufflator-exsufflator

Clearing of secretions

Cough

1. **Inspiratory phase**
   - Inspiratory volume > 2.3 L
2. Compression phase
   - glottis closure, high intrathoracic pressures (up to 300 cmH2O)
3. **Expulsive phase**

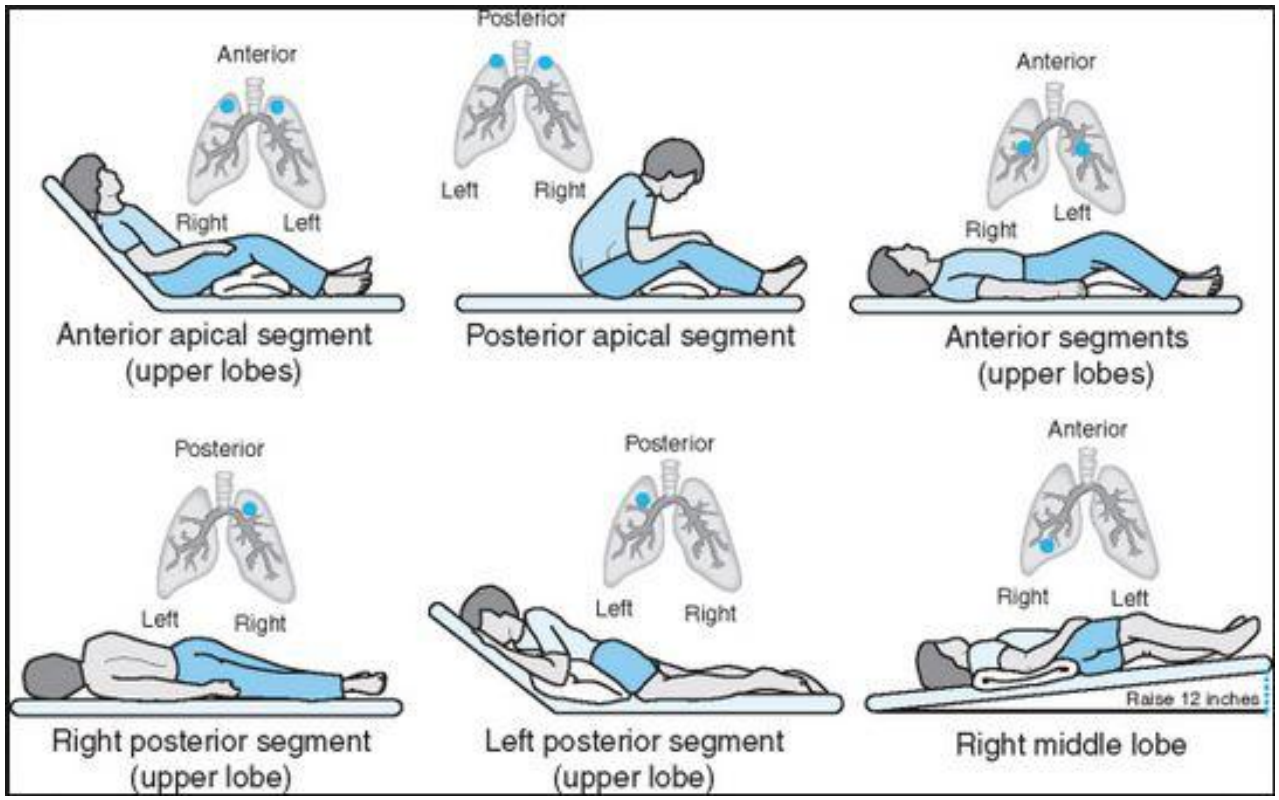


Assisted coughing

- **manual thrusts**
  - **PCF <160 L/min**

- **manual thrusts with maximal insu**
  - **VC <1.5L**
  - **Assisted PCF <160 L/min**

Postural drainage with Percussion/Vibration



Mechanical insufflator-exsufflator (MI-E)

20~50cmH_2O Insufflation/Exsufflation

4~5 cycles with short period of normal breathing or ventilator use to avoid hyperventilation

Contraindication

- bullous emphysema, pneumothorax, pneumomediastinum

Cough assist®

Cough & Suction®

High-frequency chest wall oscillation (Vest®)

Expansion of the lungs

Incentive spirometer

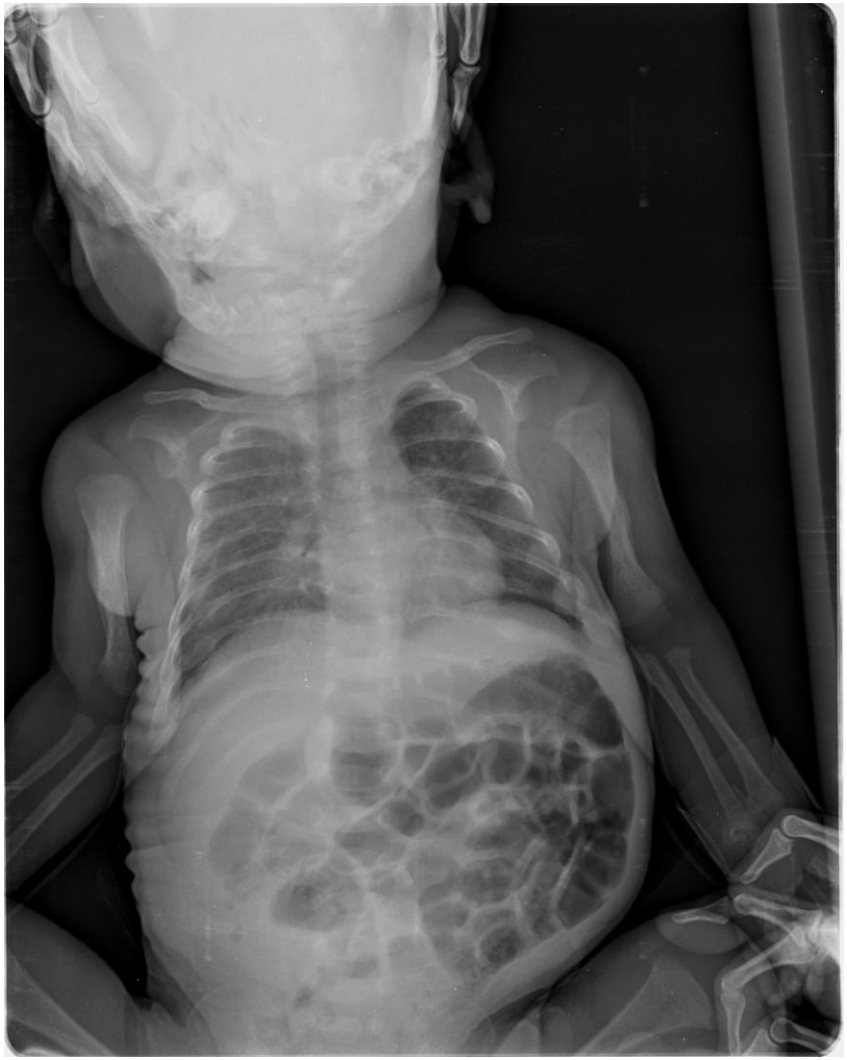
Air staking exercise

- decreased VC → decreased compliance, microatelectasis
- ROM exercise for lung is required

✓ High TV with ventilator

✓ Mechanical insufflator-exsufflator

✓ **Air stacking exercise by ambu bagging**




RPA

Glossopharyngeal breathing

- 6~9 gulps of 60~200 ml each

- Glossopharyngeal breathing

Ventilator

Home ventilator

Thank you for your attention!!

- ISNCSCI

  http://www.isncscialgorithm.com

- ASIA e-learning

  http://lms3.learnshare.com/home.aspx