



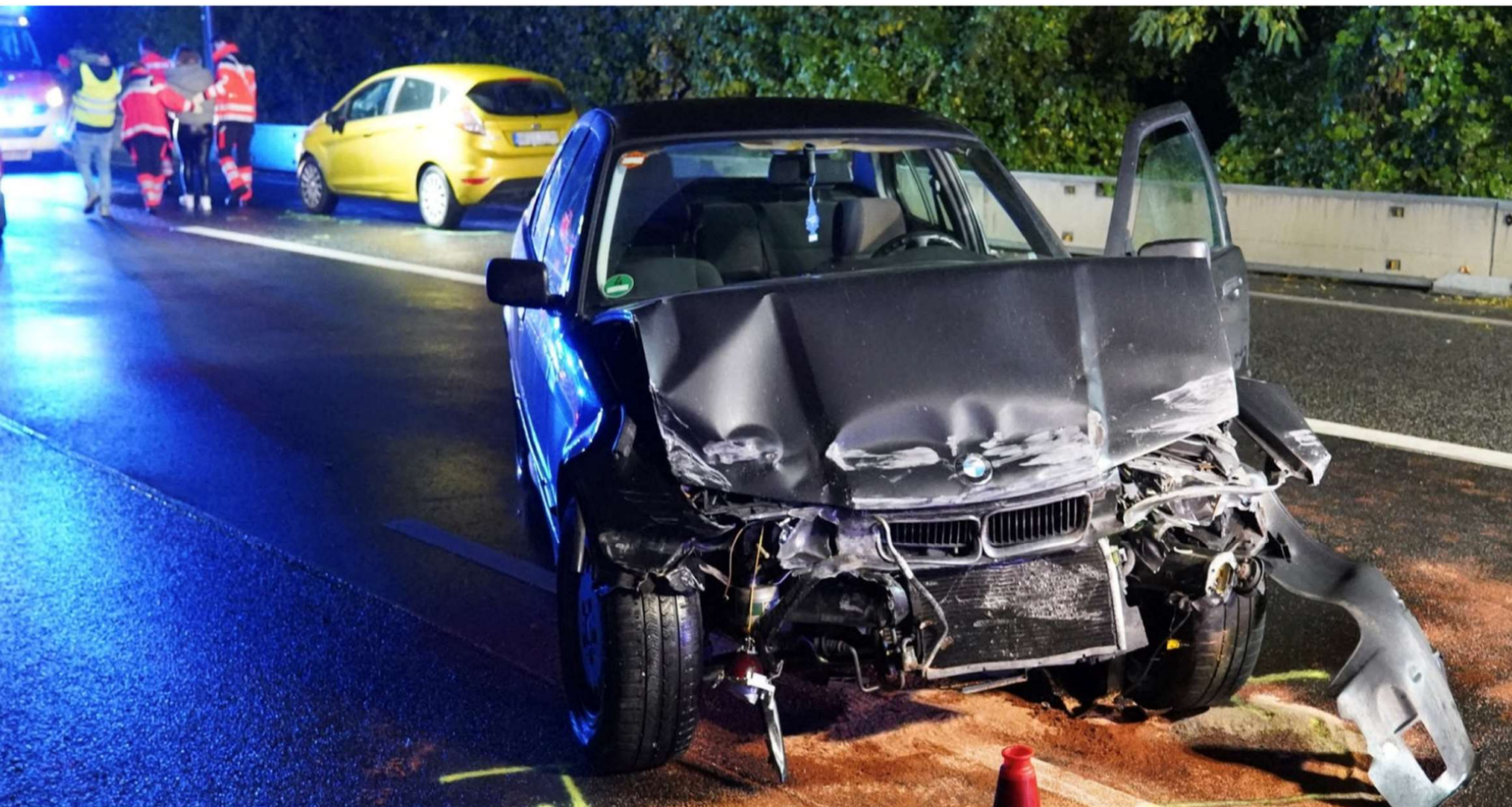
# Neurogener und spinaler Schock

...die Geschichte vom schockierten Rückenmark

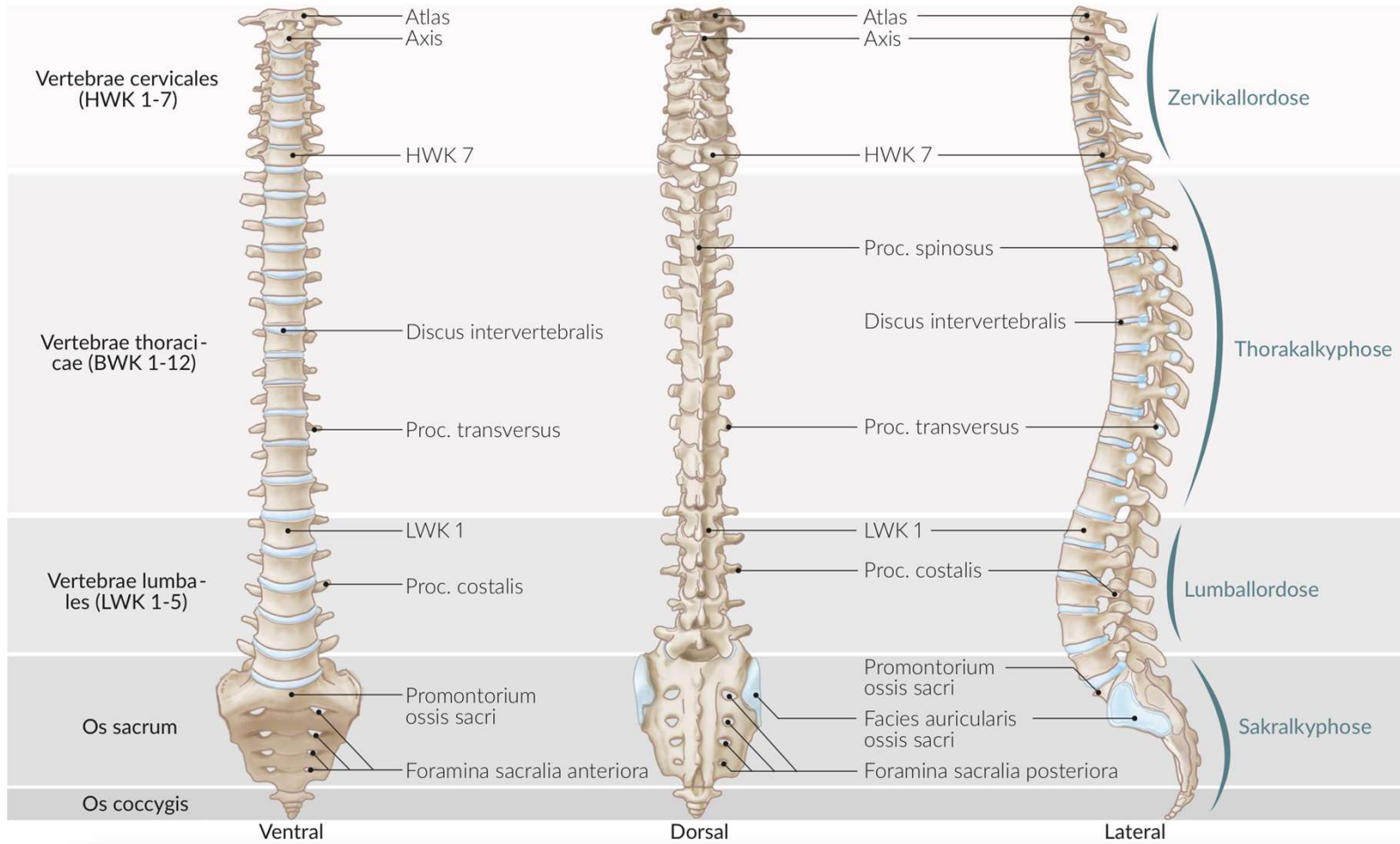
# Agenda



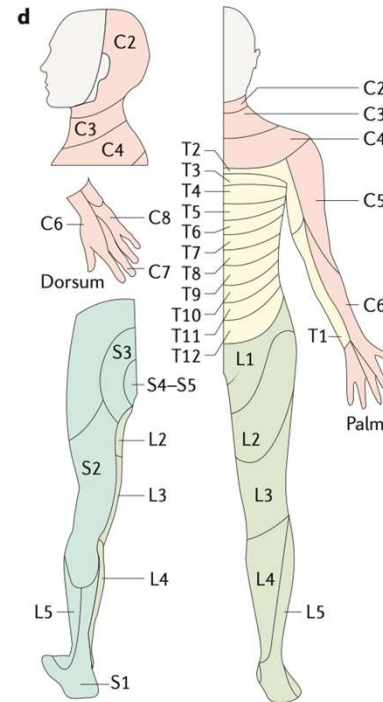
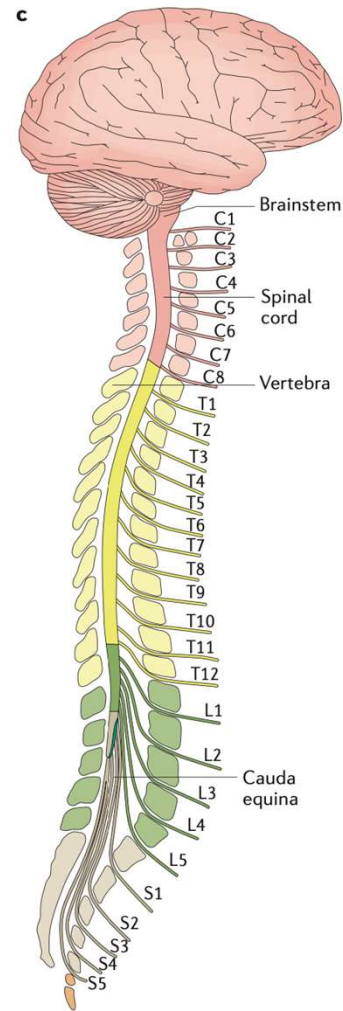
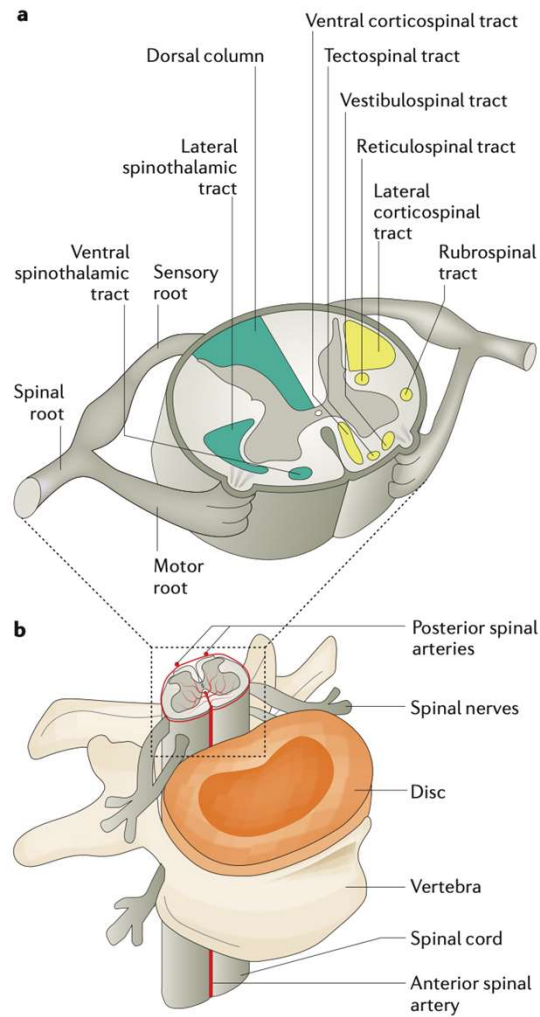
- Anatomie
- Definition Schock
  - Neurogener Schock
  - Spinaler Schock
- Diagnostik in der Notaufnahme & Vergleich der Schockformen
- Therapiekonsequenzen
- Zusammenfassung



# Anatomie



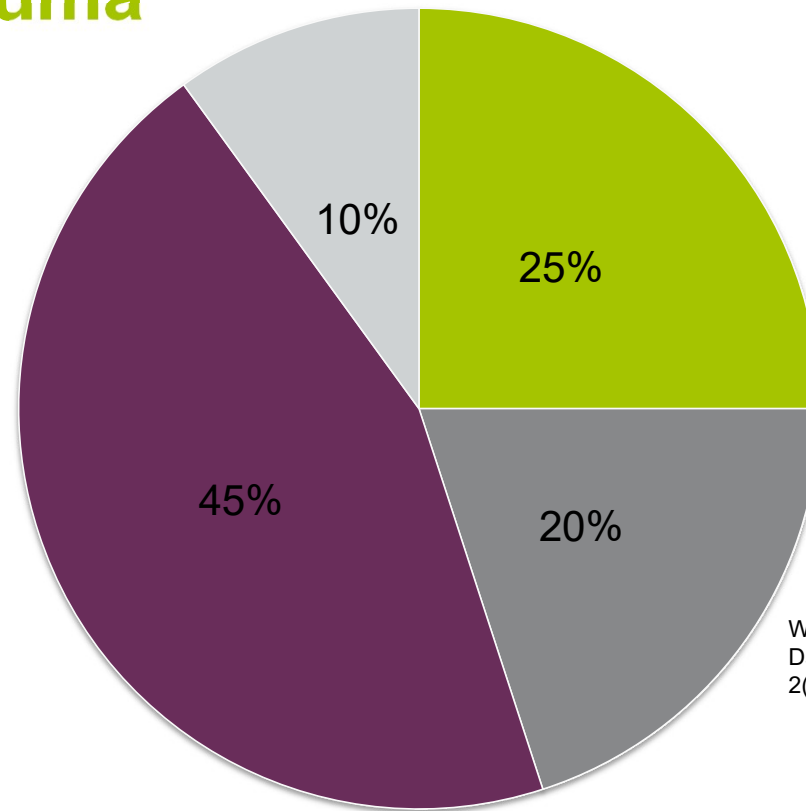
# Anatomie



Segment	Muscle Group
C5	Elbow flexors
C6	Wrist extensors
C7	Elbow extensors
C8	Finger flexors
T1	Finger abductors
L2	Hip flexors
L3	Knee extensors
L4	Ankle dorsiflexors
L5	Long toe extensors
S1	Ankle plantar flexors

Ahuja CS, Wilson JR, Nori S, Kotter MRN, Druschel C, Curt A, Fehlings MG. Traumatic spinal cord injury. Nat Rev Dis Primers. 2017 Apr 27;3:17018. doi: 10.1038/nrdp.2017.18. PMID: 28447605.

# Wirbelsäulentrauma



■ Lumbal      ■ Thorakal      ■ Cervical      ■ Sakral

Winkler, D., Blattert, T., & Meixensberger, J. (2007). Das Wirbelsäulentrauma. Notfallmedizin Up2date, 2(1), 73–92. doi:10.1055/s-2007-964870

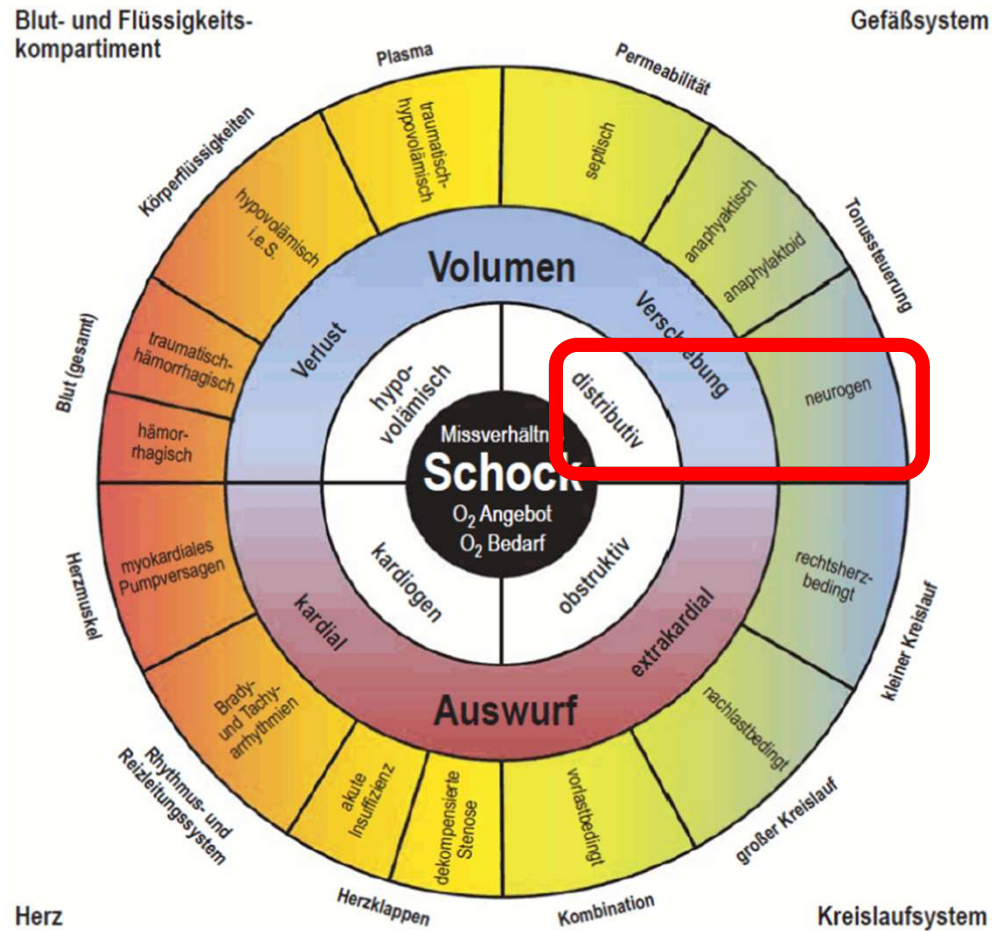


# Definition Schock

- Der Schock ist gekennzeichnet durch ein akutes bis subakutes, fortschreitendes, **generalisiertes Kreislaufversagen** mit konsekutivem Missverhältnis zwischen Sauerstoffangebot und Sauerstoffbedarf auf Zellebene und **lebensbedrohlicher Gefährdung der Vitalfunktionen**.

<https://viamedici.thieme.de/> Aufruf 29.01.2024 15:31

# Definition Schock

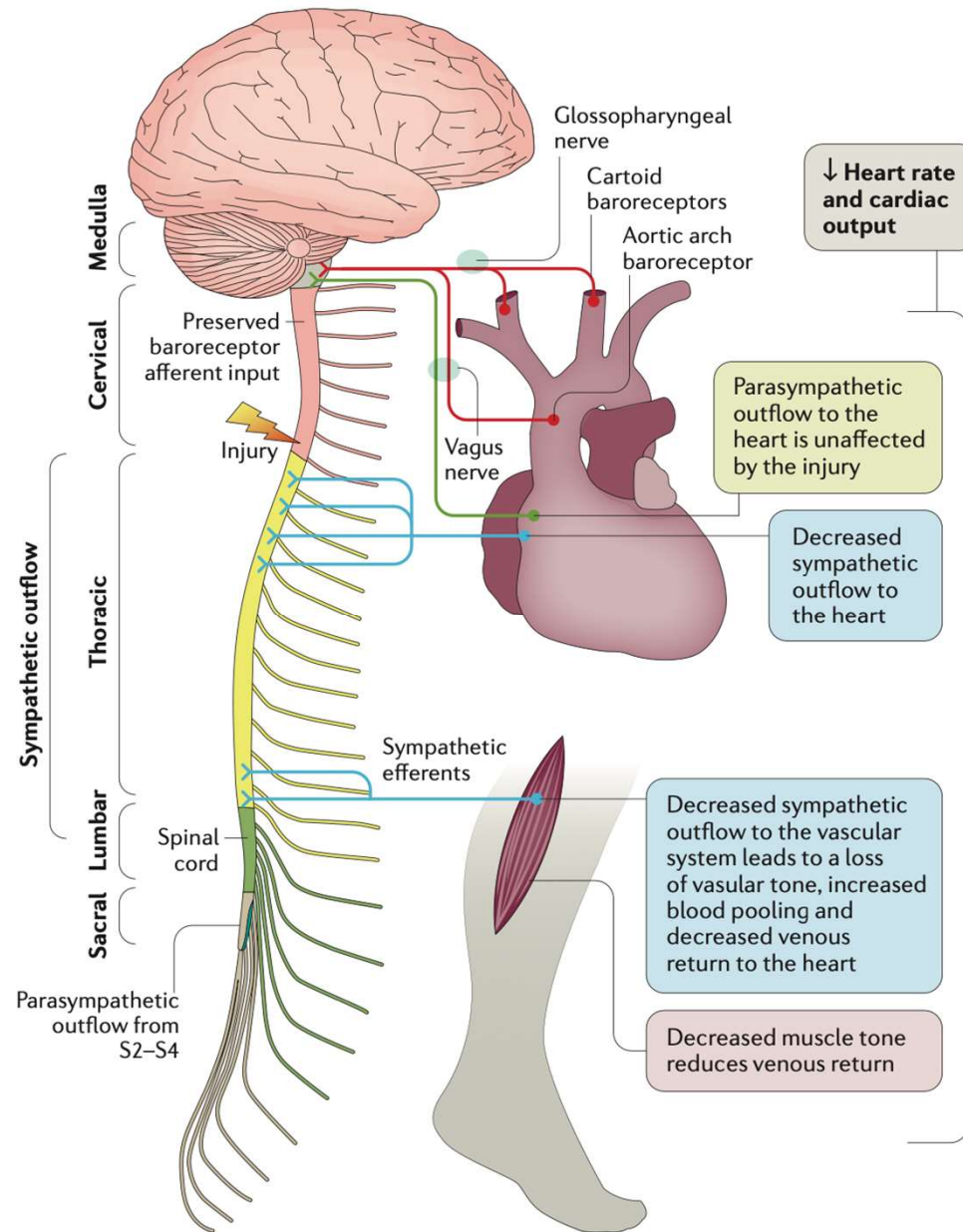


Standl, Thomas; Anneck, Thorsten; Cascorbi, Ingolf; Heller, Axel R.; Sabashnikov, Anton; Teske, Wolfram  
 Nomenklatur, Definition und Differenzierung der Schockformen  
 Dtsch Arztebl Int 2018; 115(45): 757-68; DOI: 10.3238/arztebl.2018.0757

# Neurogener Schock

- Form des distributiven Schocks
- akute neurogenen Dysregulation der Vasomotoren (meist über Th4)
  - generalisierter Vasodilatation (verminderter Sympathikotonus)
  - relative Hypovolämie (Blutvolumen normal, venöse Kapazität erhöht)
- Ätiologie: Meist traumatisch, sonst WS-Eingriffe, cerebrale Ischämien (Basilaris), SAB, Meningitiden, usw...
- Letalität: 20%

# Neurogener Schock



Ahuja CS, Wilson JR, Nori S, Kotter MRN, Druschel C, Curt A, Fehlings MG. Traumatic spinal cord injury. Nat Rev Dis Primers. 2017 Apr 27;3:17018. doi: 10.1038/nrdp.2017.18. PMID: 28447605.



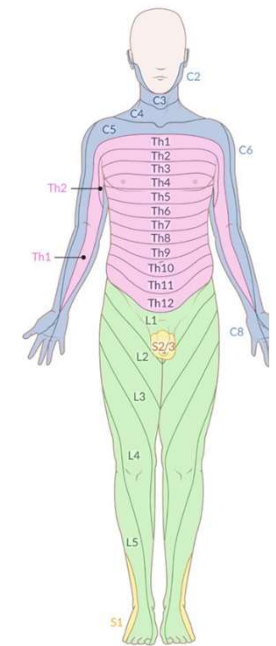
# Neurogener Schock - Symptome

- Blutdruckabfall <100mmHg systolisch
- Herzfrequenzabfall <60bpm
- Verlust der spinalen Reflexe
- Ausschlussdiagnose!

# Spinaler Schock



- Akute Phase eines kompletten Querschnittsyndroms mit Läsion der (meist) gesamten afferenten und efferenten Leitungsbahnen des Rückenmarks
- potenziell reversibel
- Kann neurogenen Schock beinhalten
- Symptome abhängig von Höhe der meist traumatischen Läsion





# Definition Schock

- Der Schock ist gekennzeichnet durch ein akutes bis subakutes, fortschreitendes, **generalisiertes Kreislaufversagen** mit konsekutivem Missverhältnis zwischen Sauerstoffangebot und Sauerstoffbedarf auf Zellebene und **lebensbedrohlicher Gefährdung der Vitalfunktionen**.

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# Spinaler Schock

- Initial Phase: (meist) mechanisches Trauma
- Primär Phase
  - Ödem, Hämorrhagie, Ischämie, Infiltration durch inflammatorische Zellen
- Sekundär Phase
  - Persistierendes Ödem, Gefäßthrombosen, Vasospasmen
- Chronische Phase
  - Degeneration der Neuronen, Vernarbung

# Höhenlokalisierung/Kennmuskeln

Höhe	Muskel	Reflex
<b>C3/4</b>	Diaphragma	
<b>C6</b>	M. Biceps brachii	Bicepssehnenreflex
<b>C7</b>	M. Triceps brachii	Trizepssehnenreflex
<b>C8/Th1</b>	Mm. Interossei dorsales	Fingerspreizung
<b>L2</b>	M. Iliopsoas (Hüftbeugung)	Cremasterreflex
<b>L4</b>	M. Quadriceps femoris	Patellarsehnenreflex
<b>S1</b>	M. Gastrocnemius	Achillessehnenreflex

# Risikoabwägung Spinale Verletzung

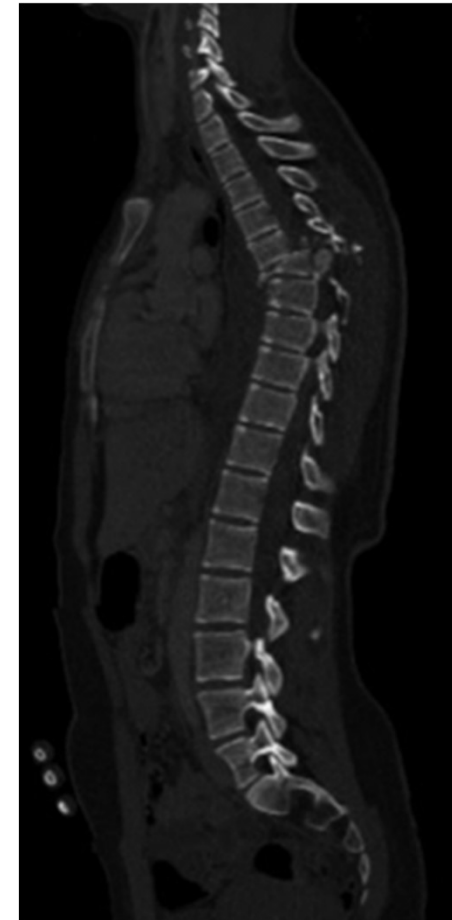


Low risk	High risk
Einfacher Auffahrunfall	Hochrasanz Unfall
Sitzend in der Notaufnahme	Parästhesien (v.A. der OExtr)
Toleriert Drehung der HWS	>65J
Keine Schmerzen über den Proc. Spinosi	Axiale Stauchung beim Unfall
Verzögerter Schmerzbeginn	Ejektion aus Fahrzeug

# Spinaler Schock - Symptome



- Unterhalb des Querschnitts beidseits
  - Sensibilitätsstörungen: Analgesie und Anästhesie
  - Schlaffe Paraplegie oder Tetraplegie
  - Areflexie: Ausfall von Eigen- und Fremdreflexen
- Atone Überlaufblase
- Fehlender Analreflex
- Übergang in Spastik nach 6-8 Wochen



# Querschnittsyndrome



Syndrom	Symptome	Bildgebung
<b>Hirnstamm-schädigung</b>	Hirnnervenausfälle Tetraparese Pathologische Atmung	cCT-A inkl. cervicale Gefässe
<b>A. Spinalis anterior Syndrom</b>	Plötzlicher Querschnitt, v.A. motorisch Meist kein Trauma Kein Schmerz + Temperaturempfinden, erhaltene (Tiefen-)Sensibilität	CT-A Aorta
<b>Leriche Syndrom</b>	Ischämie beider Beine	CT-A Aorta bis prox. Oberschenkel
<b>Conus-Cauda Syndrom</b>	Periphere Parese der Beine, typisch Reithosenanästhesie Harn- und Stuhlinkontinenz	MRT der WS

# Vergleich der "Schockformen"



Klinik	Neurogener Schock	Spinaler Schock
Akut	☐	☐
Kreislaufversagen	☐	(-)
Distale Eigenreflexe	-	-
Meist traumatisch	☐	☐
Lebensbedrohlich	☐	(-)

**Alles klar...Was nun?**



# Diagnostik im Schockraum

- Gemäss ATLS (cABCDE-Schema)
  - Primary Survey (z.B. relevanter Blutverlust?)
    - A: ?
    - B: ?
    - C: ?
    - D: ?
    - E: ?
  - eFAST (z.B. Spannungspneumothorax?)
- Zunächst CT, Goldstandard für WS Trauma ist MRT

# Schockraum-Therapie Neurogener Schock



Zwei relevante Probleme müssen adressiert werden

- Hypotonie:
  - Noradrenalin Mittel der ersten Wahl
  - Moderate Flüssigkeitszufuhr (cave: es besteht prinzipiell kein Volumendefizit)
- Bradykardie:
  - Atropin
  - Ggf. niedrig dosiert Adrenalin


# Schockraum-Therapie Spinaler Schock




- Adäquater Perfusionsdruck des Rückenmarks muss aufrecht erhalten werden (80-90mmHg MAP)
- Weitere Schäden durch Manipulation oder unsachgerechte Lagerung vermeiden, Headblock o.ä. , Logroll
- Ggf. Gabe von osmotisch wirksamen Substanzen (Einzelfallentscheidung, keine Evidenz)
- Gabe von Methylprednisolon (grosse Diskussion, Haus- und fachgesellschaftsabhängig – Evidenz nur für UAW)

# Dokumentation: ASIA Klassifikation





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



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

Examiner Name \_\_\_\_\_ Signature \_\_\_\_\_

**RIGHT MOTOR KEY MUSCLES**

**UER (Upper Extremity Right)**

Elbow flexors **C5**

Wrist extensors **C6**

Elbow extensors **C7**

Finger flexors **C8**

Finger abductors (little finger) **T1**

**LER (Lower Extremity Right)**

Hip flexors **L2**

Knee extensors **L3**

Ankle dorsiflexors **L4**

Long toe extensors **L5**

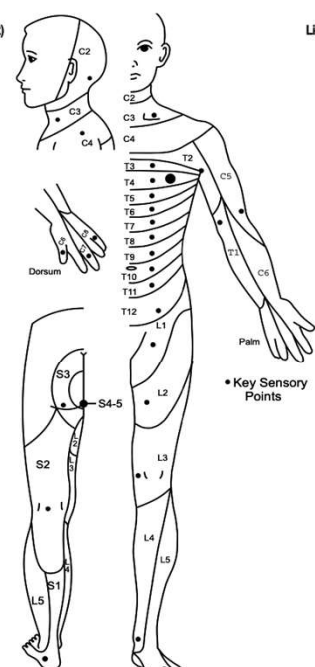
Ankle plantar flexors **S1**

(VAC) Voluntary Anal Contraction (Yes/No)

**RIGHT TOTALS (MAXIMUM)**

UERM  + UEL  = UEMS TOTAL  (MAX 25) (25)

LER  + LEL  = LEMS TOTAL  (MAX 25) (25)



**KEY SENSORY POINTS**

Light Touch (LTR) Pin Prick (PPR)

Light Touch (LTL) Pin Prick (PPL)

**MOTOR KEY MUSCLES LEFT**

**UEL (Upper Extremity Left)**

Elbow flexors **C5**

Wrist extensors **C6**

Elbow extensors **C7**

Finger flexors **C8**

Finger abductors (little finger) **T1**

**MOTOR (SCORING ON REVERSE SIDE)**

**LEL (Lower Extremity Left)**

Hip flexors **L2**

Knee extensors **L3**

Ankle dorsiflexors **L4**

Long toe extensors **L5**

Ankle plantar flexors **S1**

(DAP) Deep Anal Pressure (Yes/No)

**LEFT TOTALS (MAXIMUM)**

LTR  + LTL  = LT TOTAL  (MAX 56) (56)

PPR  + PPL  = PP TOTAL  (MAX 56) (56)

**NEUROLOGICAL LEVELS**

Steps 1-6 for classification as on reverse

1. SENSORY **R**  **L**

2. MOTOR **R**  **L**

3. NEUROLOGICAL LEVEL OF INJURY (NL)

4. COMPLETE OR INCOMPLETE?  (In injuries with absent motor OR sensory function in S4-5 only)

Incomplete = Any sensory or motor function in S4-5

5. ASIA IMPAIRMENT SCALE (AIS)

6. ZONE OF PARTIAL SENSORY PRESERVATION **R**  **L**

MOTOR **R**  **L**

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# Dokumentation: ASIA Klassifikation



## 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
- 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)
- 0\*, 1\*, 2\*, 3\*, 4\*, NT\* = Non-SCI condition present \*

## Sensory Grading

- 0 = Absent 1 = Altered, either decreased/impaired sensation or hypersensitivity
- 2 = Normal NT = Not testable
- 0\*, 1\*, NT\* = Non-SCI condition present \*

\* Note: Abnormal motor and sensory scores should be tagged with a "\*" to indicate an impairment due to a non-SCI condition. The non-SCI condition should be explained in the comments box together with information about how the score is rated for classification purposes (at least normal / not normal for classification).

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

## 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 S4-5 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  $\geq 3$ .

**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  $\geq 3$ .

**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.



## 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

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 and the ASIA Impairment Scale does not apply.

### 6. Determine the zone of partial preservation (ZPP).

The ZPP is used only in injuries with absent motor (no VAC) OR sensory function (no DAP, no LT and no PP sensation) in the lowest sacral segments S4-5, and refers to those dermatomes and myotomes caudal to the sensory and motor levels that remain partially innervated. With sacral sparing of sensory function, the sensory ZPP is not applicable and therefore "NA" is recorded in the block of the worksheet. Accordingly, if VAC is present, the motor ZPP is not applicable and is noted as "NA".

# Weiterführende Therapie Neurogener Schock/Spinaler Schock

- Abhängig von Ursache
  - Dekompression bei Kompression
  - Operative Stabilisierung bei Instabilität
  - Revaskularisierung bei z.B. Basilaris-Verschluss
  - Antibiotische Therapie bei Meningitis

<https://www.emrap.org/corependium/chapter/recZKLYS5ioaqTJb4/Spinal-Cord-Injuries#h.7zzyr17qoiua>

# Ausblick



Treatment	Stage	ClinicalTrials.gov identifier or refs
<b>Pharmacological</b>		
Minocycline*	Phase III	NCT01828203
Riluzole*	Phase IIb/III	NCT01597518
Granulocyte colony-stimulating factor*	Phase I/II	219,220
Cethrin†	Phase II/III	NCT02669849
Anti-Nogo-A antibody†	Phase II	NCT00406016
<b>Procedural</b>		
Systemic hypothermia	Phase II/III	221,222
Cerebrospinal fluid drainage	Phase II	NCT02495545
Blood pressure augmentation	Phase II	NCT02495545
<b>Neuromodulation</b>		
Spinal cord stimulation	Phase I	NCT02592668
Deep brain stimulation	Phase I	NCT02006433
<b>Cell-based strategies</b>		
Oligodendrocyte precursor cells	Phase I/II	NCT02302157
Schwann cells	Phase I	NCT01739023
Umbilical cord-derived stem cells	Phase III	NCT02481440
Bone marrow-derived mesenchymal stem cells	Phase II	NCT02570932
<b>Bioengineering</b>		
Robotic exoskeletons	Phase I	NCT02322125
Functional peripheral electrical stimulation	Phase I/II	NCT01479777
Implantable bioengineered scaffolds or matrices	Phase III	NCT02138110

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# Zusammenfassung

- Neurogener- und Spinaler Schock meist auf Grundlage von Trauma
- Neurogener Schock als Komplikation des Spinalen Schocks
- Neurogener Schock ist Ausschlussdiagnose
- Spinaler Schock = Akutphase der Myelonverletzung
- Vorgehen immer nach ATLS
- Diagnostik: Klinik und CT

# Fassen Sie sich bitte kürzer!



- Spinaler Schock  $\neq$  Schock ,enthält ggf. neurogenen Schock
- CT
- **N**eurogener Schock = **N**oradrenalin
- Do no further harm!



# Gibt es Fragen?





Kompetent  
Umfassend  
Nah

**Vielen Dank für eure  
Aufmerksamkeit**