
Neurogenic shock: The anesthesiologists' Nemesis
 Dr. med. Simon Sulser







Conflicts of Interest

- In the past 5 years I received honoraria / travel support for occasional consulting / lecturing:
 - CSL Behring
 - Sintetica SA


What does Nemesis mean?


- Goddess of Retribution
 - ...punishes people who overestimate their own capabilities...

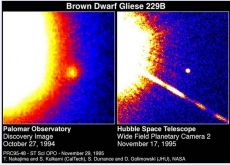




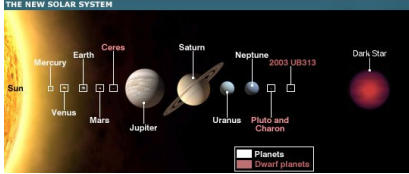
What does Nemesis mean?







Brown Dwarf Gliese 229B
Palomar Observatory
Discovery Image
October 27, 1994
Hubble Space Telescope
Wide Field/Strategy Camera 2
November 17, 1995
F. Marzari and S. Zuckerman, *Nature* 393, 1995



THE NEW SOLAR SYSTEM
Sun, Mercury, Earth, Venus, Mars, Jupiter, Saturn, Uranus, Neptune, Pluto and Charon, 2003 UB313, Dark Star
Planets, Dwarf planets

What does Nemesis mean?



How the surgeon sees me



How I see myself

What does Nemesis mean?

An always re-appearing opponent.

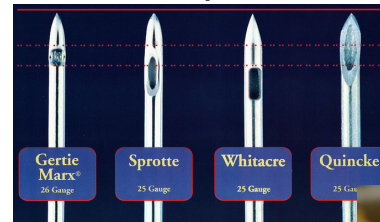


Hypotension

Intravenous & Inhalative Anesthetics



Spinal Anesthesia



Bleeding & Positioning



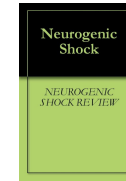
Image from <http://www.spinninghat.com>



Image by Kurt Schrage

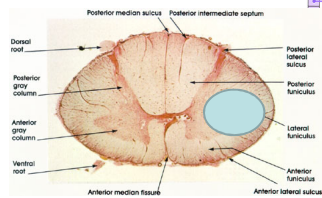
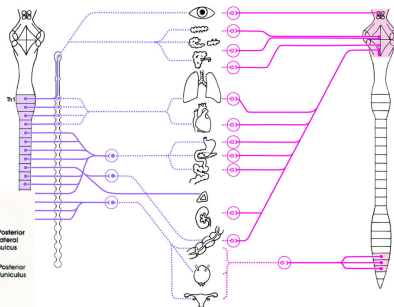
Neurogenic Shock

- cardiovascular shock
 - hypotension
 - bradycardia
- massive vasodilatation
- imbalance of sympathetic and parasympathicus



Ball PA. *Spine* (2001) 26: 27-30
 Furlan JC et al. *Neurosurg Focus* (2008) 25: E13

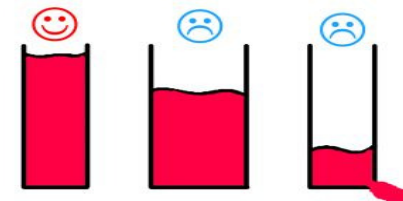
Imbalance of vegetative system



Graphics from: <http://www.thehumanbrain.info>

Neurogenic Shock

no shock distributive shock hypovolemic shock
 • neurogenic
 • allergic



Graphics from: <http://www.wikipedia.de>

Spinal Shock



<http://en.wikipedia.org>

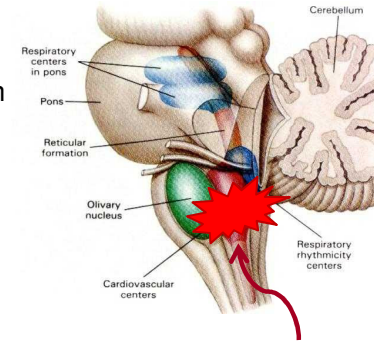
Atkinson PP, Atkinson JL. *Mayo Clin Proc* (1996) 71: 384–389.

spinal shock	neurogenic shock
<ul style="list-style-type: none"> special condition of spinal cord after trauma flaccid paresis areflexia loss of sensitivity 	<ul style="list-style-type: none"> cardiovascular shock

What causes this imbalance?

3 types of pathomechanisms:

- wrong processing of afferent information in the vasomotor center
- occulo-cardial, trigemino-vagal, spino-vagal, carotis-sinus reflexes

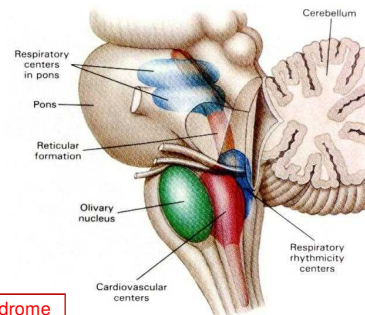


What causes this imbalance?

3 types of pathomechanisms:

- infratentorial pressure, edema, tumor in vasomotor center
- intoxication, basillaris thrombosis

usually high ICP leads to Cushing Syndrome with high Blood Pressure



What causes this imbalance?

3 types of pathomechanisms:

- transection of spinal efferent pathways
- trauma, tumor, infection



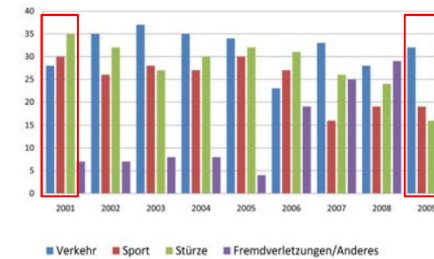
<http://en.wikipedia.org>

Pitfalls of Traumatic Spinal Injury

- neurogenic shock is a diagnosis of exclusion of other causes for hypotension
- patient in cardiovascular shock usually is tachycardic, not bradycardic

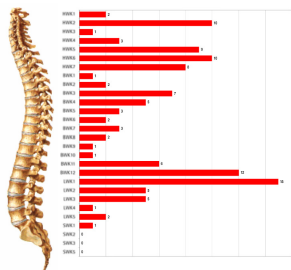
Statistics of Traumatic Spinal Injury

Entwicklung Unfall-Ursachen
2001–2009 in %

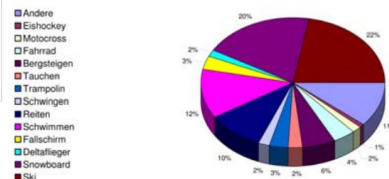


Statistics of Traumatic Spinal Injury

Niveau der unfallbedingten Wirbelfrakturen

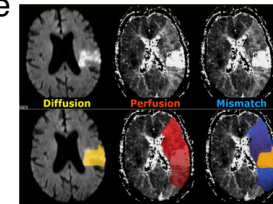


Querschnittslähmungen durch Verletzungen im Sport



problem with hemodynamic instability

- Insufficient spinal perfusion pressure may worsen long term outcome
 - primary vascular injury
 - vasospasms
 - compression and edema
 - endothelial injury
 - thrombosis



Anthes DL et al. *Neurosurgery* (1996) 39: 804-14
 Ducker TB et al. *Surg Neurol* (1978) 10: 64-70
 Bravo G et al. *Neurosci Lett* (1999) 270: 1-4
 Rowland JW et al. *Neurosurg Focus* (2008) 25: E2
 Tator CH et al. *J Neurosurgery* (1991) 75: 15-26

problem with hemodynamic instability

- can delay in operative intervention

Tuli S et al. *J Spinal Cord Med* (2007) 30: 482-90

Timing of Decompressive Surgery of Spinal Cord after Traumatic Spinal Cord Injury: An Evidence-Based Examination of Pre-Clinical and Clinical Studies

1. ...strong...evidence for...benefits of early surgical decompression in animal...models.
2. ...recommended...decompression...within 24h...optimal timing of surgical decompression...remains unclear.
3. There are clinical, neurological, and functional benefits of early decompression of the spinal cord

Furlan JC et al. *J Neurotrauma* (2011) 8: 1371-1399

the fight against Nemesis

- treatment of neurogenic shock with:
 - fluids
 - vasopressors
 - α-adrenergic (Noradrenalin, Neo-Synephrin)
 - β-adrenergic (Dobutamin, Adrenalin)
- duration of up to 2 weeks, afterwards neurogenic orthostase

Piepmeyer JM et al. *Cent Nerv Syst Trauma* (1985) 2: 153-60
 Lehmann KG et al. *J Am Coll Cardiol* (1987) 10: 46-52
 Levi L et al. *Neurosurgery* (1993) 33: 1007-17
 Vale FL et al. *J Neurosurgery* (1997) 87: 239-46

What Blood Pressure do we want?

- 45 patients with cervical SCI
- target syst. BP > 100 mmHg (MAP ~65)
- all patients needed fluid therapy
- 20% needed additional vasopressors
- good correlation between severity of injury and need for treatment

Piepmeyer JM et al. *Cent Nerv Syst Trauma* (1985) 2: 153-60

What Blood Pressure do we want?

- protocol for cardiovascular management with target MAP > 85mmHg
- vasopressor support

Cervical Injury ASIA A	90%
Cervical Injury ASIA B-D	52%
Thoracic Injury	31%

Vale FL et al. *J Neurosurgery* (1997) 87: 239-46

How do we know which MAP is good?

- Vale used MAP 85 mmHg in accordance to earlier studies of TBI and CPP

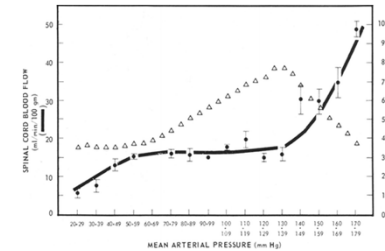
Vale FL et al. *J Neurosurgery* (1997) 87: 239-46

158 patients with TBI

29. Rosner MJ, Rosner SD, Johnson AH: Cerebral perfusion pressure: management protocol and clinical results. *J Neurosurg* 83:949-962, 1995

Cerebral perfusion pressure management can serve as the primary goal in the treatment of traumatic intracranial hypertension with substantially improved mortality and morbidity following TBI. The minimum level of CPP in this instance is greater than 70 mm Hg and frequently higher, defined by individual circumstances that may occasionally require a level of 100 mm Hg or more, but average 85 mm Hg. Systemic hypertension and iatrogenic maintenance of CPP do not potentiate or worsen intracranial hypertension.

Autoregulation of SCPP



Arthur I. Koberne. *J of Neurosurgery* (1974) 44: 12-15

Cardiovascular Incidents during first 12 Hours

- all severe cervical SCI had bradycardia (100%)
- less frequent with milder cervical SCI (35%)
- thoracic injury (13%)
- incidence of hypotension, use of vasopressors and cardiac arrest only observed in severe cervical SCI (68%, 35%, 18%)

Lehmann KG et al. *J Am Coll Cardiol* (1987) 10: 46-52

Hemodynamic Support

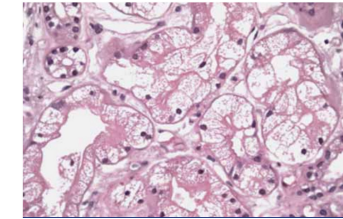
- MAP > 90 mmHg
- 60% of pts syst. BP < 90 at admission
- 82% exhibited volume resistant hypotension during first 7d

Levi L et al. *Neurosurgery* (1993) 33: 1007-17

conclusion for anesthetic management with vasopressors

- Degree of hemodynamic instability is proportional to the rostral position of the trauma.
- Complete injuries disrupt the sympathetic pathways and reduce pre- & postganglionic release of catecholamines.
 - T1-L2: systemic vasodilatation
 - T1-T6: pulmonary vasodilatation
 - T1-T4: bradycardia
 - T1-T9: adrenomedullary dysfunction

Which fluids to be used?



- pruritus
- renal insufficiency
- coagulation disorders

Graphics from <http://www.medicom.cc> (Intensiv-News)



The NEW ENGLAND JOURNAL of MEDICINE

Intensive Insulin Therapy and Pentastarch Resuscitation in Severe Sepsis

Frank M. Bruchmann, M.D., Christoph Engel, M.D., Frank Block, M.D., Ph.D., Andreas Heese-Hellmann, M.D., Hans Regaller, M.D., Norbert Weiler, M.D., Christen Moerer, M.D., Matthias Gruendling, M.D., Michael Oppert, M.D., Stefan Gross, M.D., Dirk Othoff, M.D., Ulrich Jaschinski, M.D., Stefan John, M.D., Rolf Rossaint, M.D., Tobias Viehe, M.D., Martin Schaefer, M.D., Peter Kern, M.D., Evelyn Kuhnle, M.Sc., Michael Kleinloger, M.D., Christiane Harzig, M.D., Christiane Heesbeen, M.D., Markus Leffler, M.D., Ph.D., and Konrad Reinhart, M.D. for the German Competence Network Sepsis (SepNet)
N Engl J Med 2009; 361:125-138 | January 19, 2009 | DOI: 10.1056/NEJoa070716

VISEP

Hydroxyethyl Starch 130/0.42 versus Ringer's Acetate in Severe Sepsis

Anders Fenner, M.D., Ph.D., Nicolai Haase, M.D., Anne B. Guttmann, M.D., Ph.D., Jyrki Teuhonen, M.D., Ph.D., Gudmundur Klemenzson, M.D., Anders Aneman, M.D., Ph.D., Kristian R. Madsen, M.D., Morten H. Møller, M.D., Ph.D., Jeanne M. Ekjær, M.D., Lars H. Poulsen, M.D., Asger Bendtsen, M.D., B.P.H., Robert Winding, M.D., Morten Steensen, M.D., Pavol Berezanec, M.D., Ph.D., Peter Sørensen, M.D., Morten Bendix, M.D., Ph.D., Kasper Strand, M.D., Ph.D., Jeppe Vibe, M.D., Jonathan G. Vitale, M.D., Klaus J. Thorsborg, M.D., Lars Quast, M.D., Jonas Nielsen, M.D., Ph.D., Lasse H. Andersen, M.D., Lars B. Holst, M.D., Kai-Inn Thomsen, M.D., James-Lorne Macleod, M.D., Hans L. Fabrice, M.D., Frederik Heerup, M.D., Frank C. Pogl, M.D., D.M.Sc., Thor P. Møller, M.D., Per Winkel, M.D., D.M.Sc., and Jens Wetterslev, M.D., Ph.D. for the 6S Trial Group and the Scandinavian Critical Care Trials Group
N Engl J Med 2012; 367:124-134 | July 12, 2012 | DOI: 10.1056/NEJoa1204242

6S

Hydroxyethyl Starch or Saline for Fluid Resuscitation in Intensive Care

John A. Myburgh, M.D., Ph.D., Simon Finfer, M.D., Rinaldo Bellomo, M.D., Laurent Billot, M.Sc., Alan Cass, M.D., Ph.D., David Gattas, M.D., Parisa Glass, Ph.D., Jeffrey Lipman, M.D., Bette Liu, Ph.D., Colin McArthur, M.D., Shay McGuinness, M.D., Dornilyn Rajbhandari, R.N., Colman B. Taylor, M.N.D., and Steven A.R. Webb, M.D., Ph.D., for the CHEST Investigators and the Australian and New Zealand Intensive Care Society Clinical Trials Group*

CHEST



14 June 2013
EMA/349341/2013

PRAC recommends suspending marketing authorisations for infusion solutions containing hydroxyethyl-starch

25 October 2013
EMA/640658/2013

Hydroxyethyl-starch solutions (HES) should no longer be used in patients with sepsis or burn injuries or in critically ill patients – CMDh endorses PRAC recommendations
HES will be available in restricted patient populations

colloids should be avoided in:

- sepsis
- burns
- renal disease

- OK for acute bleeding and hypovolemic shock

final conclusion

- neurogenic shock treatment with:
 - 1. fluids (cristalloids prefered)
 - 2. vasopressors (1. α -adrenergic 2. β -adrenergic)
- MAP 80-90 mmHg
 - may lead to significantly more blood loss

Thank You

