A close cooperation in developing the model has been established with the group of Prof. Brawanski of the Department of Neurosurgery at the University Hospital Regensburg, especially with Rupert Faltermeier for the physical part of the model and providing the data and Ralf Rothiel, who is a physician at the neurosurgery department.

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Model & Nonlinear Elements

Using a 7 compartment model:

- $A$=arterial, $C$=capillary, $V$=venous, $S$=sinus,
- $B$=brain tissue, $F$=fluid, $I$=injection of fluid.

A hydrodynamical model of the processes in the brain (an analog electric circuit, which is often more intuitive for physicists, can be developed in the same way).

Basic equation: “conservation of mass”:

$$\sum q_i = \frac{dm}{dt} + V \left( \frac{dp}{dt} \right)_{p \rightarrow \text{const}} + \left( \frac{dV}{dt} \right)_{p \rightarrow \text{const}} \quad \text{since} \quad m(t) = \rho(t) \cdot V(t)$$

Modeling the nonlinear “Elements”:

- **Autoregulation** is a feedback mechanism to ensure constant bloodflow ($R_{AC}$, $C_{AB}$).
- CSF-Circulation needs dissolves ($R_{CF}$, $R_{CV}$), Veins have a particular capacity ($C_{AB}$) and the Brain tissue is compressible ($C_B$).

Differential Equations & Solutions

For the simplest model we obtain two differential equations plus one constraint:

$$\frac{p_B}{C_B + C_H} = \frac{p_C - p_B}{R_{CB}} \left( \frac{p_B - p_S}{R_{BS}} + q_I + C_{AB} \cdot \rho \right)$$

$$R_{AC} = \frac{(R_{AC})_0 (p_A - p_C) - R_{AC}}{R_{BC} - R_{CB}}$$

$$\frac{p_A - p_C}{R_{AC}} - \frac{p_C - p_B}{R_{CB}} - \frac{p_B - p_S}{R_{BS}} = 0$$

The dynamical behaviour of the system (numerical results) shows the following well known clinical phenomena: Autoregulation & ICP plateau waves (Measurement [Ursino and Lodri, 1997] and Simulation)

**Outlook**

- ‘Standard’ analysis of the nonlinear differential equations and their behaviour:
  - which numerical solutions do we obtain?
  - do the fix points change to limit cycles, when parameters change?
  - will the system reach chaos?

- ‘Stability’ analysis: Stability of the fixpoints and their parameter dependence — most important for clinical applications!
  - Can we determine the state of health of the patient?

Furthermore, is it possible to...

- couple the oxygen-level (Ivons and Licox) to the model?
- can we treat local behaviour with this model?