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Creating Clinically Useful *In Silico* Models of Intracranial Pressure Dynamics

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Creating Clinically Useful *in silico* Models of Intracranial Pressure Dynamics

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Aim

To create clinically useful computer simulation models of intracranial pressure (ICP) dynamics by using prospective clinical data to estimate subject-specific physiologic parameters.

Methods

- A differential equation-based model was used to simulate ICP dynamics
- ICP data was collected from patients with severe traumatic brain injury
- During data collection, changes to Head of Bed (HOB) and Respiratory Rate (RR) were applied according to a physiological challenge protocol
- Patient-specific parameters were estimated by a curve-fitting algorithm to minimize error between the model's prediction and the recorded ICP
- Estimated parameters included: base cranial volume, normal bleed rate, CSF drainage rate, systemic venous pressure, effectiveness of autoregulation, and smoothing factors that affect the moving averages on pressure changes

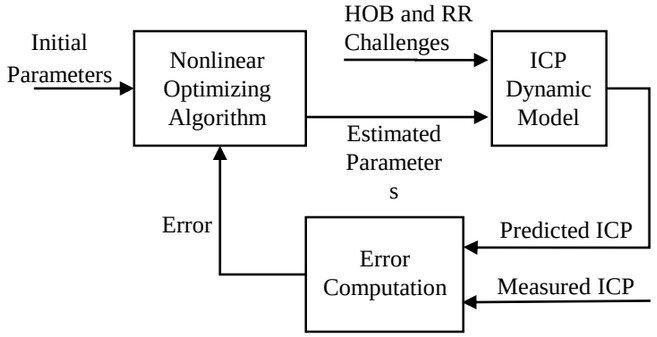

Figure 1: The Process for Estimating Patient-Specific Parameters

Results

Table 1: Summary of results

Patient and Session	Session Length (minutes)	Mean Absolute Error (mmHg)	Types of Challenges
P1, S1.5	12	0.9174	1 HOB
P1, S3	18	0.8935	1 HOB
P1, S4	45	3.7827	1 HOB, 3 RR
P1, S5b	35	3.2661	4 HOB
P2, S1	55	0.6864	4 HOB
P2, S4	65	0.8029	2 RR
P2, S7a	55	2.5520	5 HOB
P2, S7b	55	1.4257	4 RR
P2, S9b	55	0.5029	4 HOB
P3, S3b	70	3.0410	6 HOB
P201, S2	50	1.2125	3 HOB

Table 2: Means and Standard Deviations of Results

	All sessions	HOB challenges	RR challenges	1-3 challenges	4-6 challenges
μ	1.73	1.63	2.00	0.96	2.18
σ	1.19	1.13	1.57	0.18	1.31

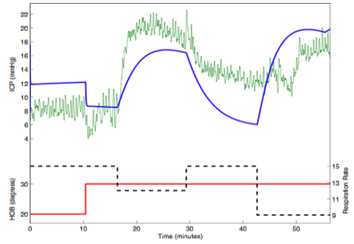

Figure 2: Patient 1, Session 4

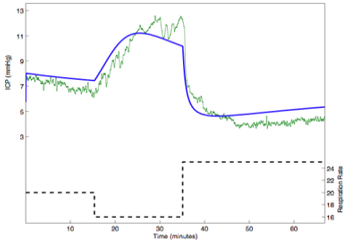

Figure 3: Patient 2, Session 4

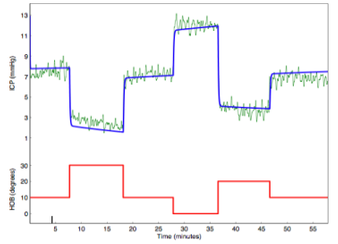

Figure 4: Patient 2, Session 9b

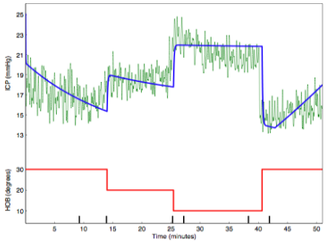

Figure 5: Patient 201, Session 2

Conclusions

While the model is not yet ready for clinical use, its performance continues to improve. We believe that these results support the pursuit of subject-specific models based on clinically annotated data.

References

[1] Wakeland, Wayne, Joe Fusion and Brahm Goldstein. 2005. Estimation of subject specific ICP dynamic models using prospective clinical data. *Biomedicine 2005* (07-09Sep2005).

[2] Ursino, M., Ter Minassian, A. Lodi, C A. Beydon, L. Cerebral hemodynamics during arterial and CO(2) pressure changes: in vivo prediction by a mathematical model. *Am J Physiol Heart Circ Physiol. 279*(5):H2439-55, 2000 Nov.

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