Wavelet Based Algorithm for Autoregulation Monitoring with ICM+

Xiuyun Liu, PhD
Department of Anesthesiology and Critical Care Medicine
School of Medicine
Johns Hopkins University

Email: liuxiuyun1@gmail.com
CA Assessment

Static Way

Shows how much CVR reacts to changes in CPP measured with long-term changes in CPP (or ABP) Pharmacological increase or decrease in ABP

Dynamic Way

Characterizes what the time delay of changes in CVR relative to step change in CPP measured with short-term changes in CPP (or ABP)

- Thigh-cuff test
- Time correlation
- Transfer-function analysis
- Valsalva manoeuvre
- Transient hyperaemic response test

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Frequency Domain

[Image of a graph showing frequency domain analysis with axes labeled Frequency Domain, Input, and Output.]
For Linear and Stationary system: statistical moments remain constant over time.

For non-stationary, noisy signal analysis. It is able to perform local analysis and reveal signal features with desired temporal–frequency resolution.

**FFT vs Wavelet Transform**
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Key Wavelet Concepts: Scaling & Shifting

Scaling

$\psi(t)$

$\text{large scale factor} \quad \text{low frequency}$

$s > 1$

$\text{small scale factor} \quad \text{high frequency}$

$0 < s < 1$
Key Wavelet Concepts: Scaling & Shifting
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- Phase shift: produces a local measure of the delay between the two time series.
- Phase coherence: can be used to find correlated areas in time-frequency space of two signals.
Thrombin is the principal enzyme of hemostasis. It catalyzes the conversion of fibrinogen to fibrin and activates procoagulant factors V, VIII, XI, and XIII.
Wavelet for stroke model
Piglet Lower Limit of Autoregulation Model

Wavelet phase shift between ABP and ICP: 0.0067 – 0.05 Hz

wPRx: cosine of phase shift

Coherence: was used to reject the corresponding unreliable phase values through Monte Carlo Simulations

Below LLA: bad CA
Above LLA: good CA

Thanks to Dr. Ken Brady and Dr. Jennifer Lee
Plugin in ICM+

Matlab → Delphi → ICM+
Plugin in ICM+

Matlab ➔ Delphi ➔ ICM+
Plugin in ICM+

Matlab → Delphi → ICM+
wPRx (wavelet PRx in piglet)

Thanks to Dr. Ken Brady
Wavelet for stroke model
Cerebrovascular pressure reactivity monitoring using wavelet analysis in traumatic brain injury patients: A retrospective study

Xiuyun Liu1,2, Joseph Donnelly1, Marek Czosnyka4,5, Marcel J. H. Ariëns1,6, Ken Brady1, Davide Cardile1, Chiara Rubboli1,6, Manuel Cabezas1, Dong-Jae Kim7, Christina Haubrich7, Peter J. Hutchinson1, Peter Smielewski1

1 Division of Neurosurgery, Department of Clinical Neurosciences, Addenbrooke’s Hospital, University of Cambridge, Cambridge, United Kingdom, 2 Institute of Electronics Systems, Warsaw University of Technology, Poland, 3 Department of Intensive Care, University of Maastricht, Maastricht University Medical Center, Maastricht, The Netherlands, 4 Sunny College of Medicine, Houston, Texas, United States of America, 5 Department of Neurosciences, University of Genova, Genova, Italy, 6 Department of Brain & Cognitive Engineering, Korea University, Seoul, South Korea, 7 Faculty of Medicine, University of Aachen, Germany

* pd001@cam.ac.uk
wCOx, wHVx in piglets

68 pediatric piglets after cardiac arrest

Thanks to Dr. Jennifer Lee
wCOx, wHVx in piglets

68 pediatric piglets after cardiac arrest

Thanks to Dr. Jennifer Lee
wCOx in lung transplant patients

Graphs showing ABP, COx, wCOx, HVx, and wHVx over time.
wCOx in lung transplant patients

Mean COx

Without Stroke or Delirium

With Stroke or Delirium

P = 0.046

Mean wCOx

Without Stroke or Delirium

With Stroke or Delirium

P = 0.046

Mean HVx

Without AKI

With AKI

P = 0.07

Mean wHVx

Without AKI

With AKI

P = 0.039
Over the years, a dynamic patient-targeted CPP protocol based on the CA ability of cerebral vasculature has been proposed. In 2002, Steiner et al, introduced this concept of looking at CPPopt by plotting PRx against CPP to generate a U shape curve from the whole monitoring period.
The mortality increased steadily with the median CPP shifting below CPPopt.

An inverse ‘U’-shape curve with the highest favourable outcome rate appeared at the smallest difference between CPP and CPPopt.

In contrast, the unfavourable outcome showed a rate increasing below or above CPPopt.

The disability rate was increased while median CPP is above CPPopt.

wPRx for ABPopt
wPRx for ABPopt
Thank you for your listening.

liuxiuyun1@gmail.com