Past and Present

Dr Peter Smielewski/ M.Czosnyka
Dept of Clinical Neurosciences
University of Cambridge
Dr. Przemek Laniewski-Wollk
Children’s Health Centre, Warsaw, Poland

Dr. Laniewski was first who conceived an idea to write ‘user programmable’ software for signals analysis in intensive care and first proposed a name: Intensive Care Monitor
ICP ANALYZER FOR INTENSIVE CARE v2.1
(ICP, CPP, TEMP, PaCO2 & CSF DRAINAGE)

Warsaw University of Technology & Child's Health Centre

MAIN MENU: (press a number key)
1. Calibration
2. Patient's description
3. Monitoring
4. On-line analysis
5. End of on-line analysis
6. Off-line analysis
7. Drainage & system profile
8. Quit

IV. FINAL REMARKS

The program was written at Warsaw University of Technology (supported by the Polish Research Project 11.9) in close cooperation with Child's Health Centre where it was clinically tested in the Intensive Care Unit (starting from the September 1987).

The method of the ICP analysis, used in the program was introduced into clinical practice in 1984. Over 140 patients were monitored. Results were discussed in publications and presented at many conferences.

The authors would like to express their gratitude to Simonson & Weel - for the technical and financial support. They also hope you will enjoy this software. They will be greatly obliged for your critical comments and remarks.

Please send them to:

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Prof. Przemyslaw Wollk-Laniewski,
Department of Anaesthesiology and Intensive Care,
Child's Health Centre, Al. Dzieci Polskich 60,
Warsaw, POLAND.
David Price and Co-workers: Leeds and Wakefield : 1985

Thanks to Dr. David Price
First observations of Aamplitude-Pressure plot in TBI and introduction of RAP index
Intensive Care Monitor - ICM – probably in 1988

Thanks to Dr. Peter Smielewski
Computer supported multimodal bed-side monitoring for neuro intensive care

M. Czosnyka, H. Whitehouse, P. Smielewski, P. Kirkpatrick, E.P. Guazzo & J.D. Pickard
MRC Cambridge Centre for Brain Repair & Academic Neurosurgical Unit, Addenbrooke’s Hospital, Cambridge, UK
Baseline pressure well below shunt’s operating pressure. Shunt seems to be patent. In sitting position pressure gradually decreased to -10 mm Hg.
High precision display: paper, scissors, glue...
We started to use TCD clinically in 1993.
First transient hyperaemic response tests ion patients after SAH; thanks to Dr. P. Smielewski
First plateau waves captured with TCD

First observations of B waves
Autoregulation with TCD: Mx, Sx and Dx (1996):
Introduction of Pressure Reactivity Index:

ILLUSTRATION FROM 1995: PRx as RIA
Traffic lights

Warsaw 1987: RAP

Cambridge 1996: PRx

... and now
Continuous monitoring of cerebrovascular pressure reactivity allows determination of optimal cerebral perfusion pressure in patients with traumatic brain injury

Luzius A. Steiner, MD; Marek Czosnyka, PhD, DSc; Stefan K. Piechnik, PhD; Piotr Smielewski, PhD; Doris Chatfield, BSc; David K. Menon, PhD, FRCP, FRCA, FMedSci; John D. Pickard, MChir, FRCS, FMedSci
Most important problem: ICM was busy with calculation, parallel recording of digital data was impossible. Solution: two computers at the bedside, one running ICM, one WREC (software prepared by Dr. Wojtek Zabolotny, Warsaw University of Technology, Poland - 1992)
BioSan (Dr. Peter Smielewski, 1996) had very limited calculation engine but supported trending and digital recording !!!!
ICM+ Timeline

ICM+ begins

1980 1990 2000 2010

Warsaw University of Technology University of Cambridge

2002
ICP12 – Hong-Kong 2004 - official launch of ICM+
Cambridge Enterprise (subsidiary of Cambridge University) takes over IP rights to ICM+ and starts offering its licenses to other clinical research centres.
First Digital Interface: Phillips monitors

Department of Neurology,
Medical Centre Haaglanden,
The Hague, Netherland

Joseph T Tans
ICM+ Timeline

1980 1990 2000 2010

Warsaw University of Technology
University of Cambridge

ICM+ Portal

ICM+, Neurosurgery Unit, University of Cambridge
Forum on ICM+ brain monitoring

Forum: General discussions

- ICM+ General Forum
  - Forum on ICM+ brain monitoring software related issues
  - Relevant documentation
  - ICM+ Bugs Reports
  - ICM+ Wishes & Requests
  - ICM+ Related Research Areas/Projects
  - ICM+ User’s Meeting Turbingen 2010

Restricted area

Who is online:
In total there is 1 user online: 1 registered, 0 hidden and 9 guests (based on users active over the past 5 minutes)
Most users ever online was 4 on Fri Sep 19, 2008, 11:12 am

Registered users: smithjones
Legend: Administrators, Global moderators

Statistics:
- Total posts 8
- Total topics 7
- Total members 66
- Our newest member smithjones
The plug-in interface

The first plugin – Non-invasive ICP
by B Schmidt and R Plontke, Chemnitz, Germany
First ICM+ users’ group meeting

14th International Conference on Intracranial Pressure and Brain Monitoring
12. - 16. 9. 2010
Tübingen/Germany

ICM+ users’ club meeting
Department of Clinical Neuroscience,
Academic Neurosurgical Unit,
Addenbrooke’s Hospital, Cambridge University, United Kingdom

Sunday, September 12th; 11:00-14:00
ICM+ user group meeting, MIT June 2016
ICM+ Principles

Data collection interfaces

Analogue

Coax cable

Digital (Serial or Network Interface)

Ascii continuous export

Client/server model
Proprietary language
ICM+ Principles

Analysis pipeline

ICM+

Monitors

Data acquisition

Trends display

Collected signals

Real-time analysis pipeline

Virtual Signals

Primary Analysis

Final Analysis

Statistical summary function

Σ

Σ

Σ
Today mainly proprietary digital interfaces
Current off-line analysis tools

Artefacts editor

Signals calculator

Advanced Stats tool

ScriptLab

Special charts like HRV or MSE

Text format import
ICM+ functionality can be extended using 3rd party plugins.

- DLL library Implementing DSP interface
- DLL library Implementing Stats interface
- DLL library Implementing Chart interface
- DLL library Implementing Tools interface

ICM+ includes:
- DSP (Signal Calculator)
- Stats functions (Real-time analysis)
- Charts
- Tools (Intervention tests)

nICP plugin for ICM+
Patient management support
Secondary measures

Complexity of Homeostatic Regulation
- Mx
- MSE
- Entropy

Cerebral Autoregulation
- ORx
- COx
- PRx
- ARI

Optimal Arterial And Cerebral Perfusion pressure
- CPPopt

Arterial walls properties
- CrCP

Heart Rate Variability
- HRV

Baroreceptor Sensitivity
- BRS

Brain Compliance
- Ci

Cerebrovascular Compliance
- Ca

Entropy

Baroreceptor Sensitivity

Cerebral Autoregulation

Heart Rate Variability

Complexity of Homeostatic Regulation
Intervention tests analysis

**Transient Hyperaemic Response Test**

**CO2 reactivity test**

**Leg cuff autoregulation test**

**CSF infusion test**
Configuring ICM+, calculation of PRx and Optimal CPP
Positive end-expiratory pressure oscillation facilitates brain vascular reactivity monitoring

Ken M. Brady,1,2 R. Blaine Easley,1,2 Kathleen Kibler,1 David W. Kaczka,5 Dean Andropoulos,1,2 Charles D. Fraser III,6 Peter Smielewski,7 Marek Czosnyka,7 Gerald J. Adams,3 Christopher J. Rhee,4 and Craig G. Rusin3

1Anesthesiology, Texas Children’s Hospital, Baylor College of Medicine, Houston, Texas; 2Pediatrics, Texas Children’s Hospital, Baylor College of Medicine, Houston, Texas; 3Cardiology, Texas Children’s Hospital, Baylor College of Medicine, Houston, Texas; 4Neonatology, Texas Children’s Hospital, Baylor College of Medicine, Houston, Texas; 5Anesthesia, Harvard Medical School, Boston, Massachusetts; 6University of Texas at Houston Medical School, Houston, Texas; and 7Neurosurgical Unit, University of Cambridge, Addenbrooke’s Hospital, Cambridge, United Kingdom
Example of recording: raw data
Configuring ICM+: virtual signals accepted from raw data file (*.dat)
Primary analysis: 10 second averages of ABP, ICP and CPP
Final analysis: calculation of PRx
PRx calculated

No PEEP

PEEP
LOOK at two Periods 1: PRX ~-1 and 2: PRx~+1
4 minutes period: ‘proper’ PRx = -0.748
4 minutes period, below LLA: $PRx=+0.86$
Drawing U-shape ‘optimalCPP’ curve
U shape ‘optimal CPP’ curve
Calculation of ‘optimalCPP’ as a time-varying target
The 'OptimalValue' function is used to track optimal CPP, dividing X variables values into bins and calculating a statistic for Y variable at each bin. It then tries to fit a parabolic function to the resulting XY plot. The point of the minimum or maximum of the function is returned as the optimal X value and optimal Y value.

The function can also return:
- relative size of data included in the curve fit,
- span of the fitted curve, and
- the fit type:

0 - no fit possible,
1 - optimum point within the curve span,
2 - overestimation: actual optimum is below the curve span,
3 - underestimation: actual optimum is above the curve span,
Parameters of the function

Function options

Function: OptimalValue

- Missing Data Limit [%]: 100.00
- Number of bins: 15
- Minimum bin value: 0.00
- Maximum bin value: 90
- Minimum bin data count [%]: 1.00
- Minimum included data [%]: 50.00
- Minimum Y span: 0.00
- Concave: unchecked
- Need not include 'best': unchecked
- Use error weighting: unchecked
- Enforce Y range: unchecked
- Enforce Y region - Min: 0.00
- Enforce Y region - Max: 0.00
- Output value type: Optimal X
optimalCPP as continuous variable
2007-ICM+  Multi-centre collaboration

- Software installed
- Pending installations
- Negotiation phase
2014 ICM+ software: A multicentre collaborations platform

Steadily growing community of friends and collaborators