How I do infusion test.

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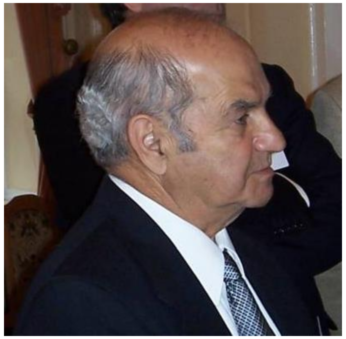
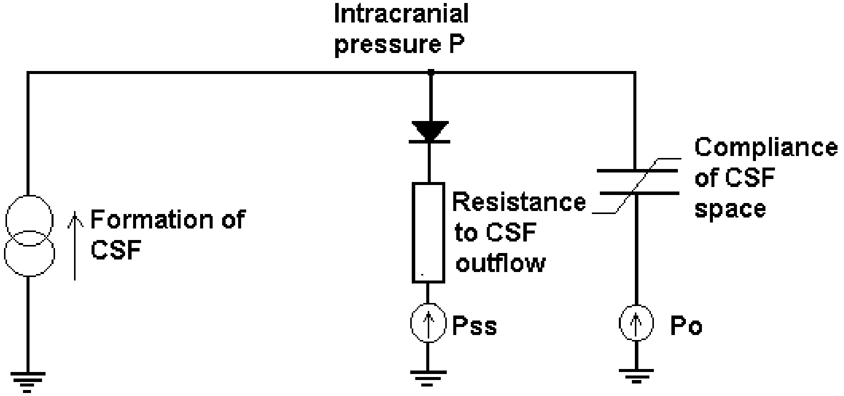
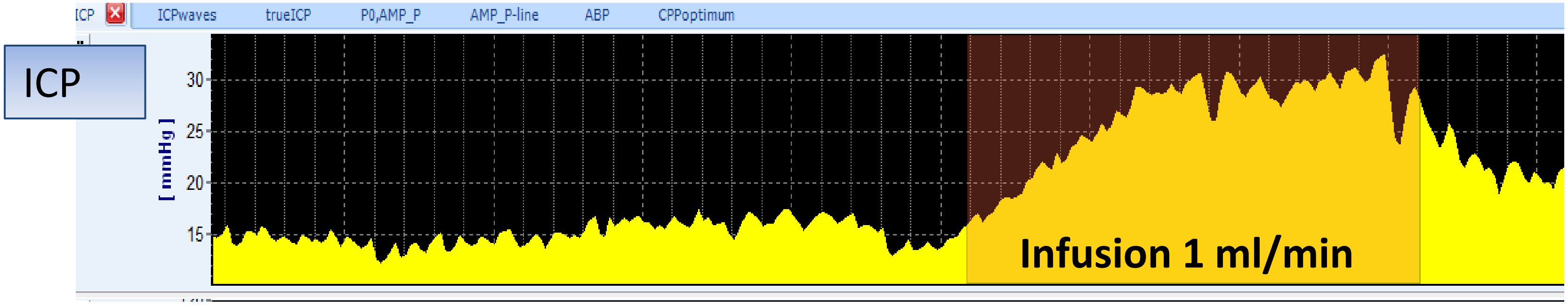
University of Cambridge, UK

Infusion test: procedure to identify model of CSF compensatory reserve introduced in 1973 by Anthony Marmarou. Essential parameters: Resistance to CSF outflow and compliance of CSF space



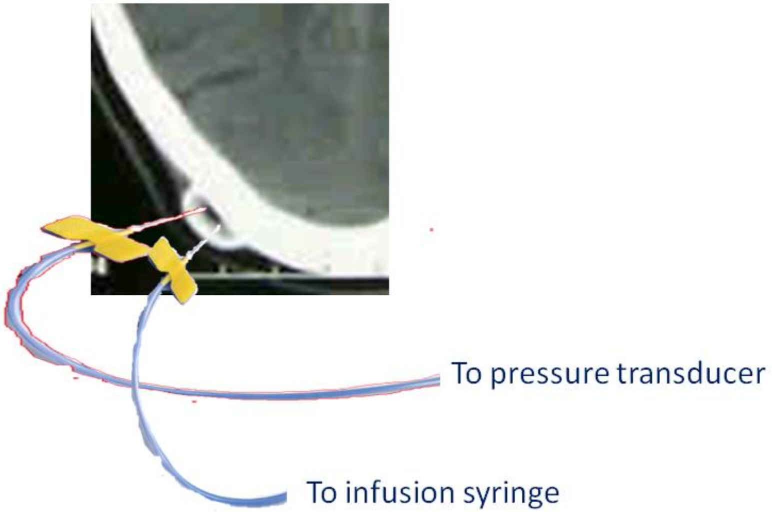




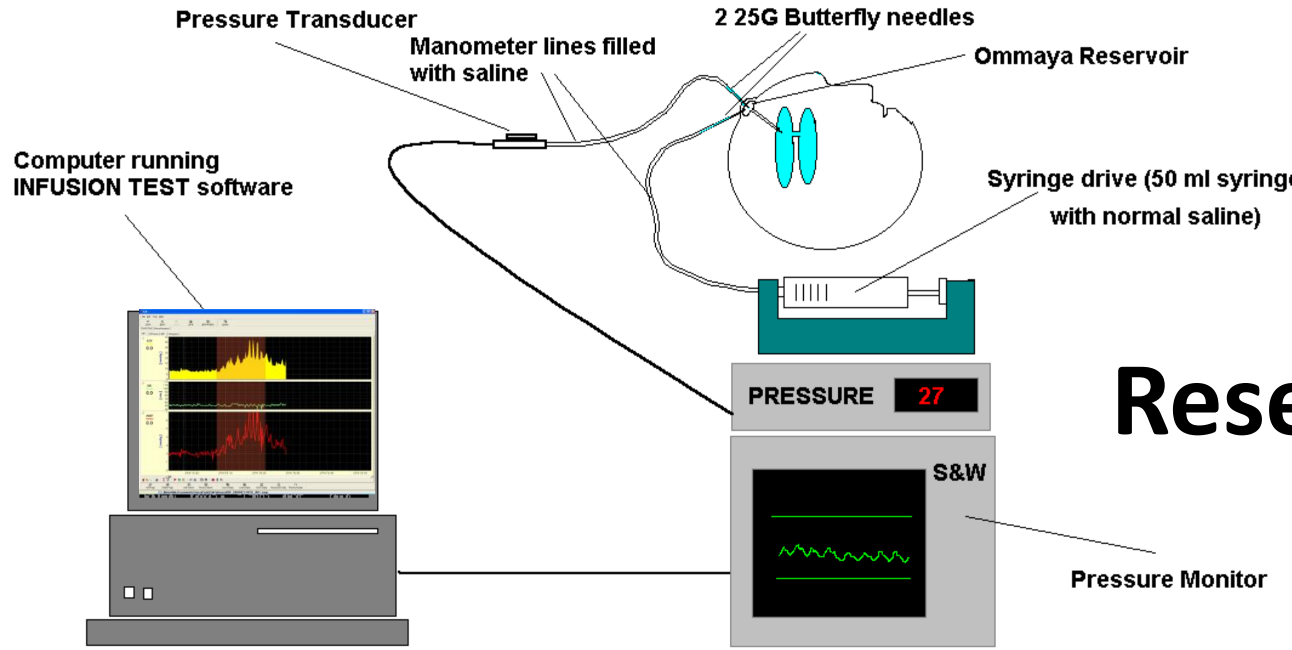
TIME ~30 minutes

What we need?
Hardware
Pressure transducer, tubing, needles

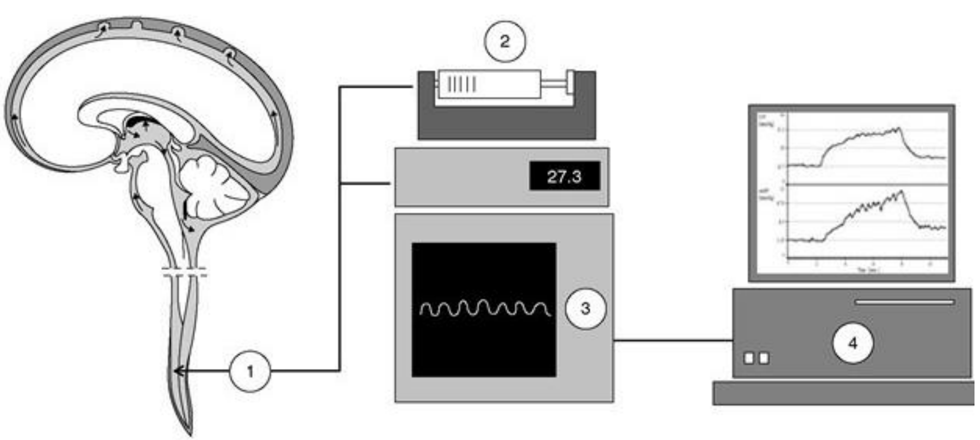
Essential: sterile preparation of transducer and tubing



Measurement set-up

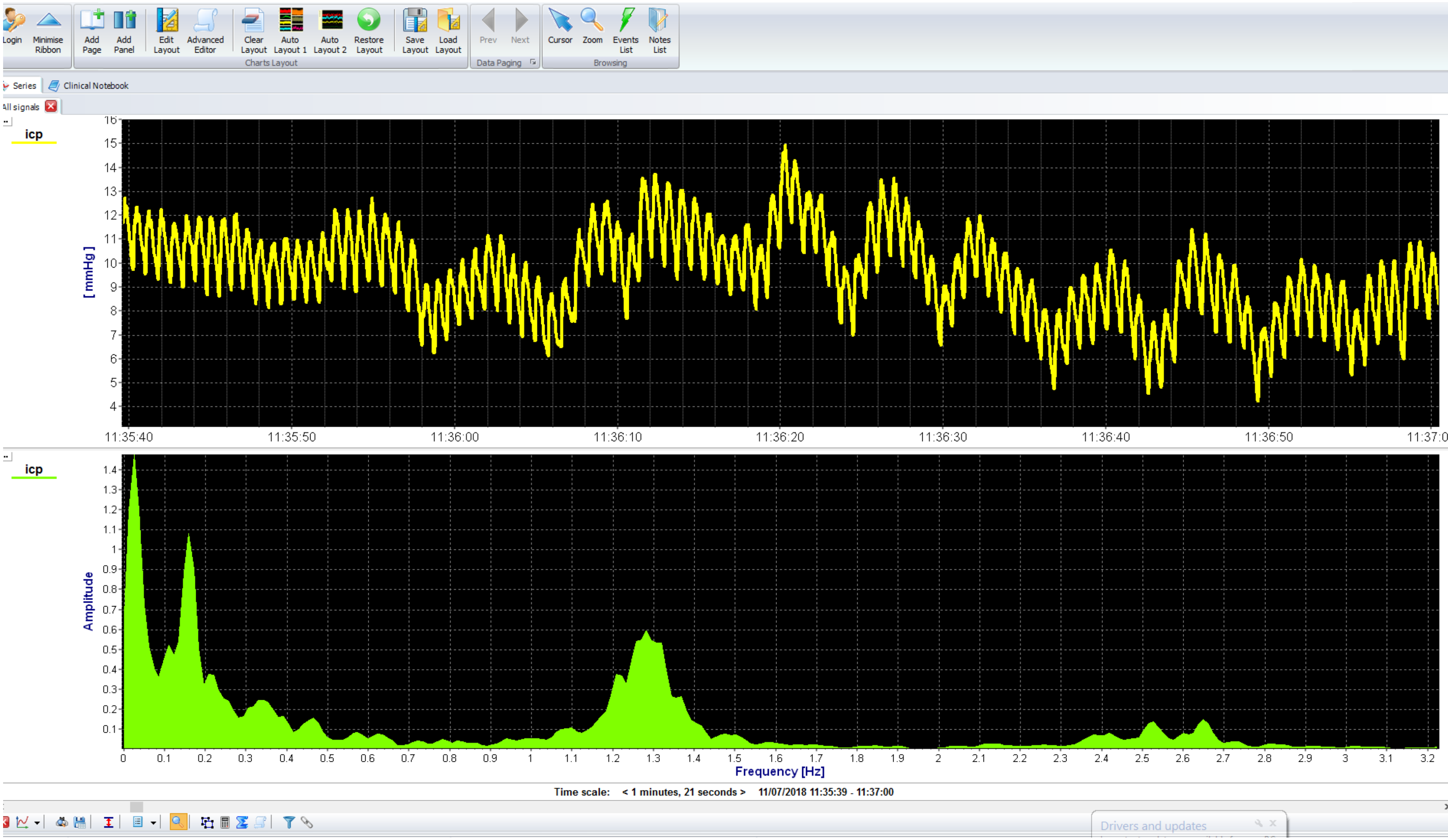


Reservoir



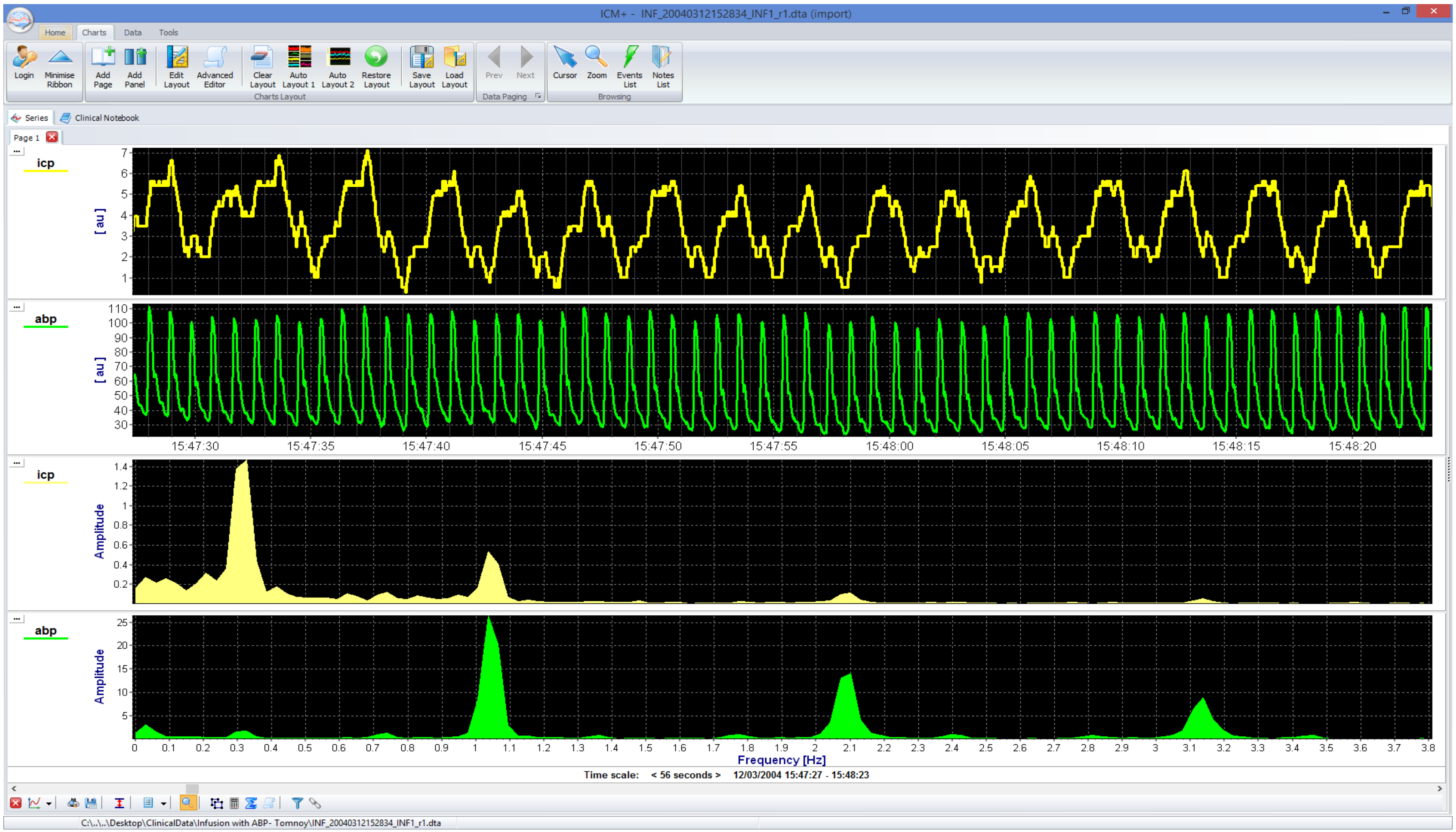
Lumbar

Checking the waveform of ICP signal

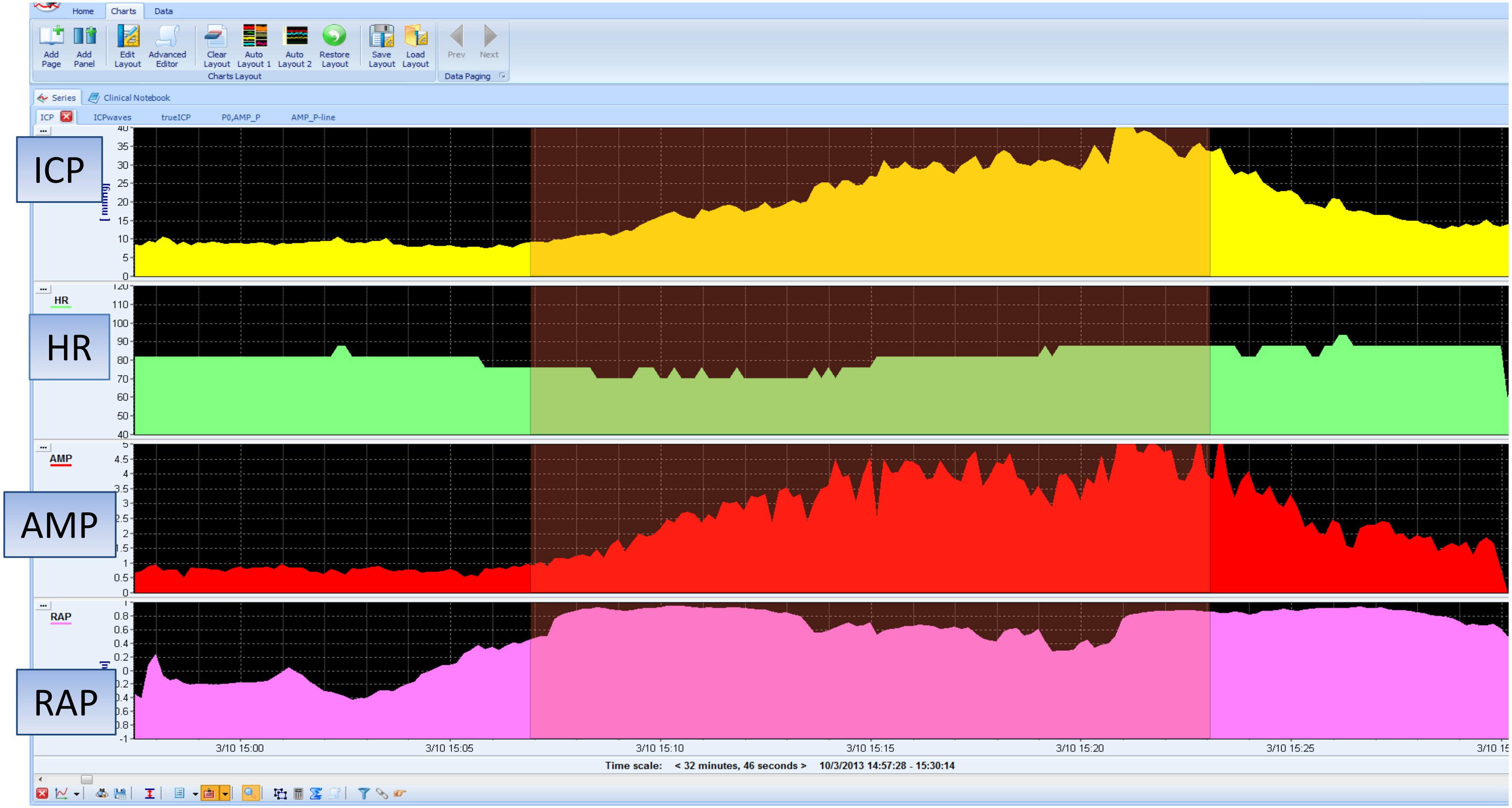


When the pulse waveform is weak,

looking at **the spectrum of ABP** helps



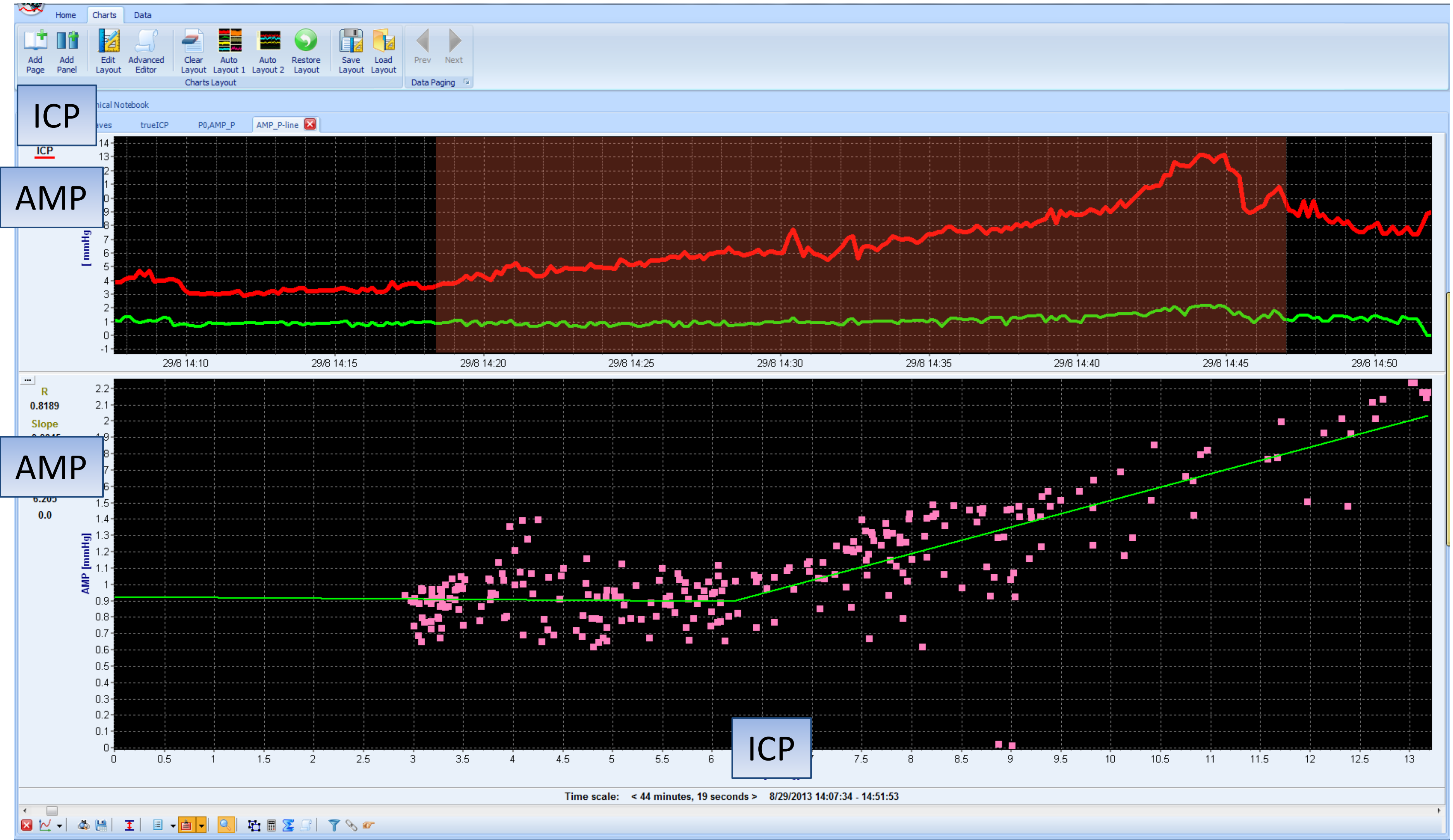
INFUSION TEST

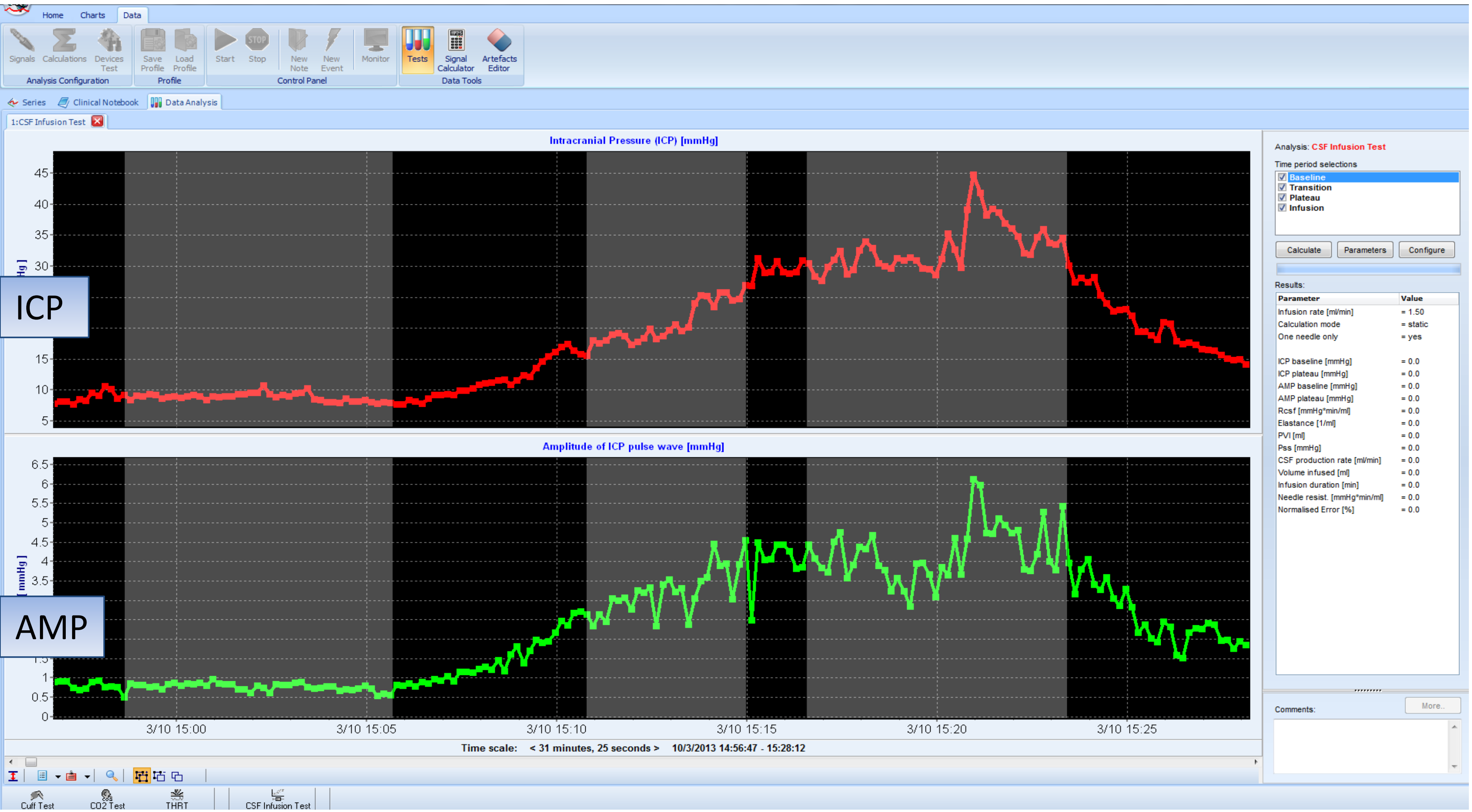


Real time observation of trends of mean ICP, heart rate, pulse amplitude of ICP and RAP index during the study.

Always mark start, end of infusion!

Lower breakpoint of AMP-P characteristic



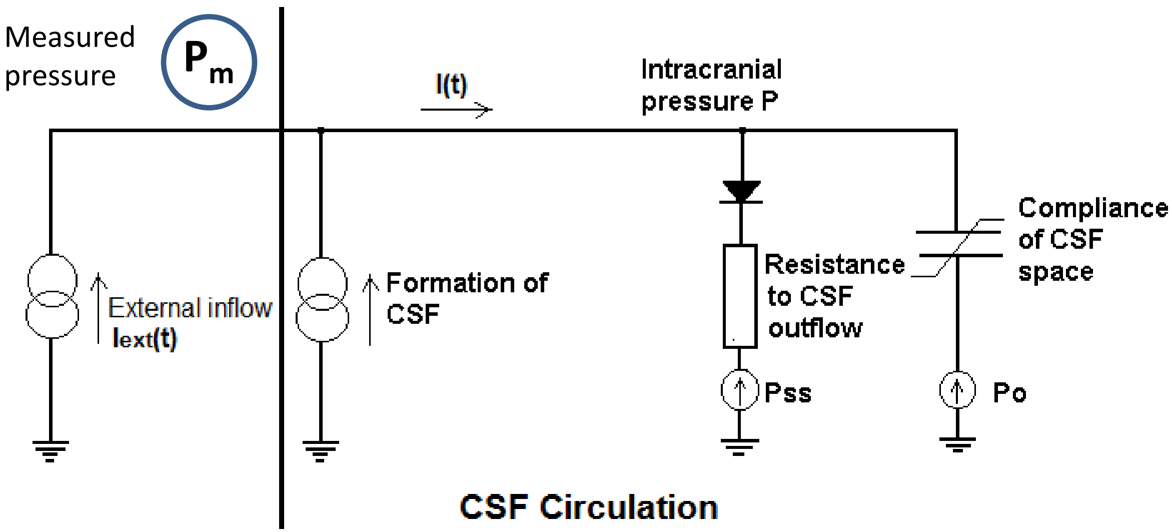


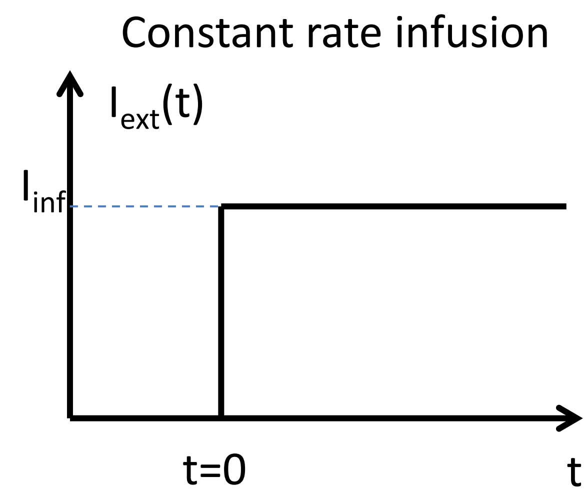
After study is finished: **Analysis of the Marmarou model**

First: mark baseline, transition and end-plateau periods.

Introduce infusion rate and press ‘calculate’

Constant rate CSF infusion challenge

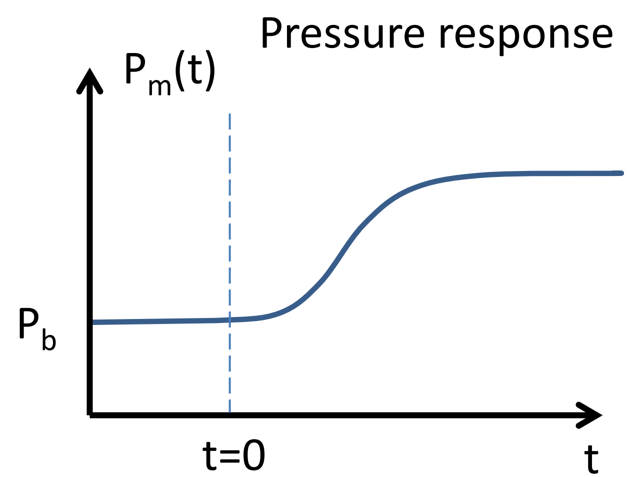




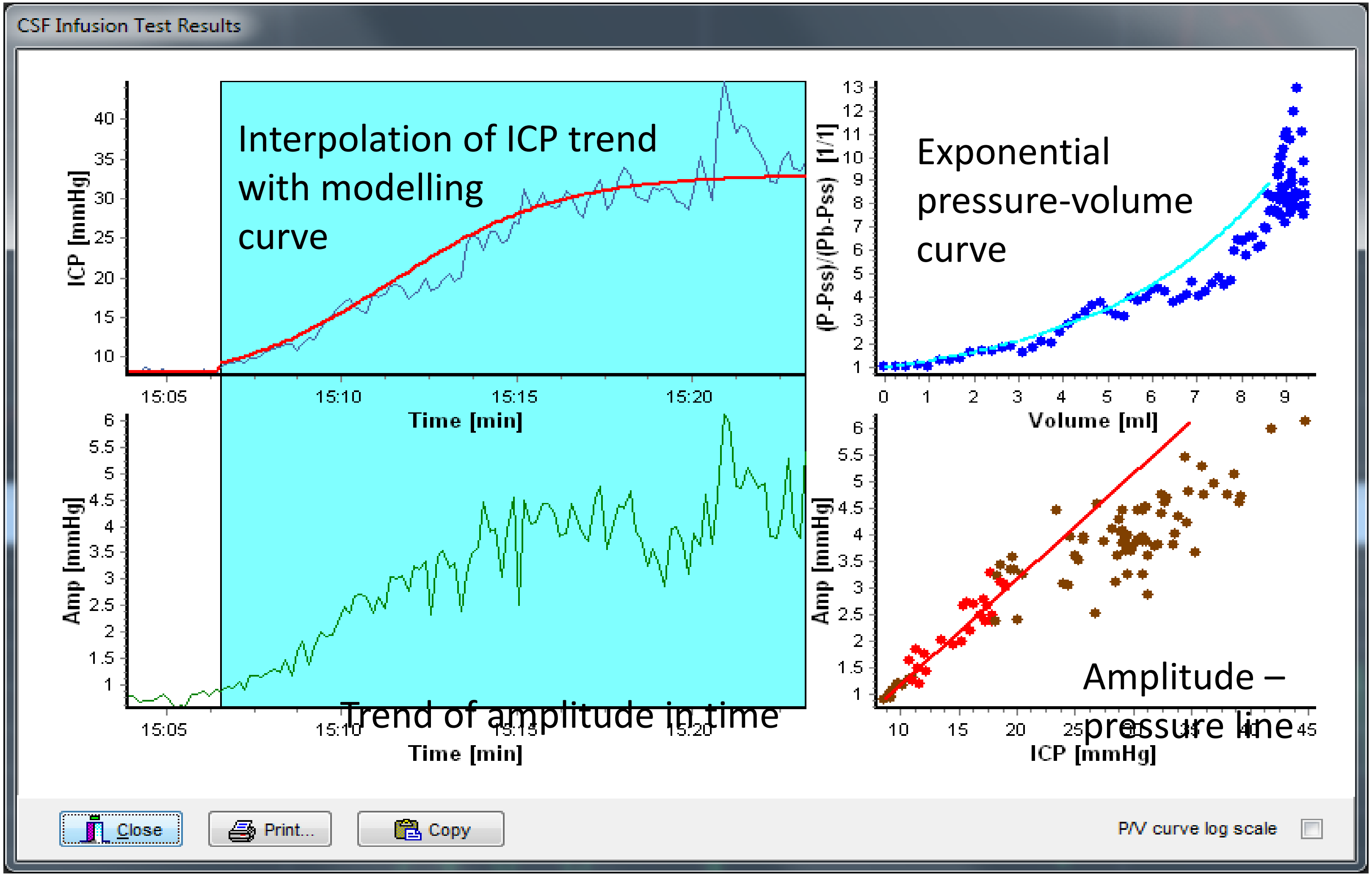
$$I_{ext}(t) = \frac{1}{E * (P - P_0)} * \frac{dp}{dt} + \frac{P - P_b}{R_{csf}}$$

$$I_b = \frac{P_b - P_{ss}}{R_{csf}} \qquad P_{ss} \approx P_0$$

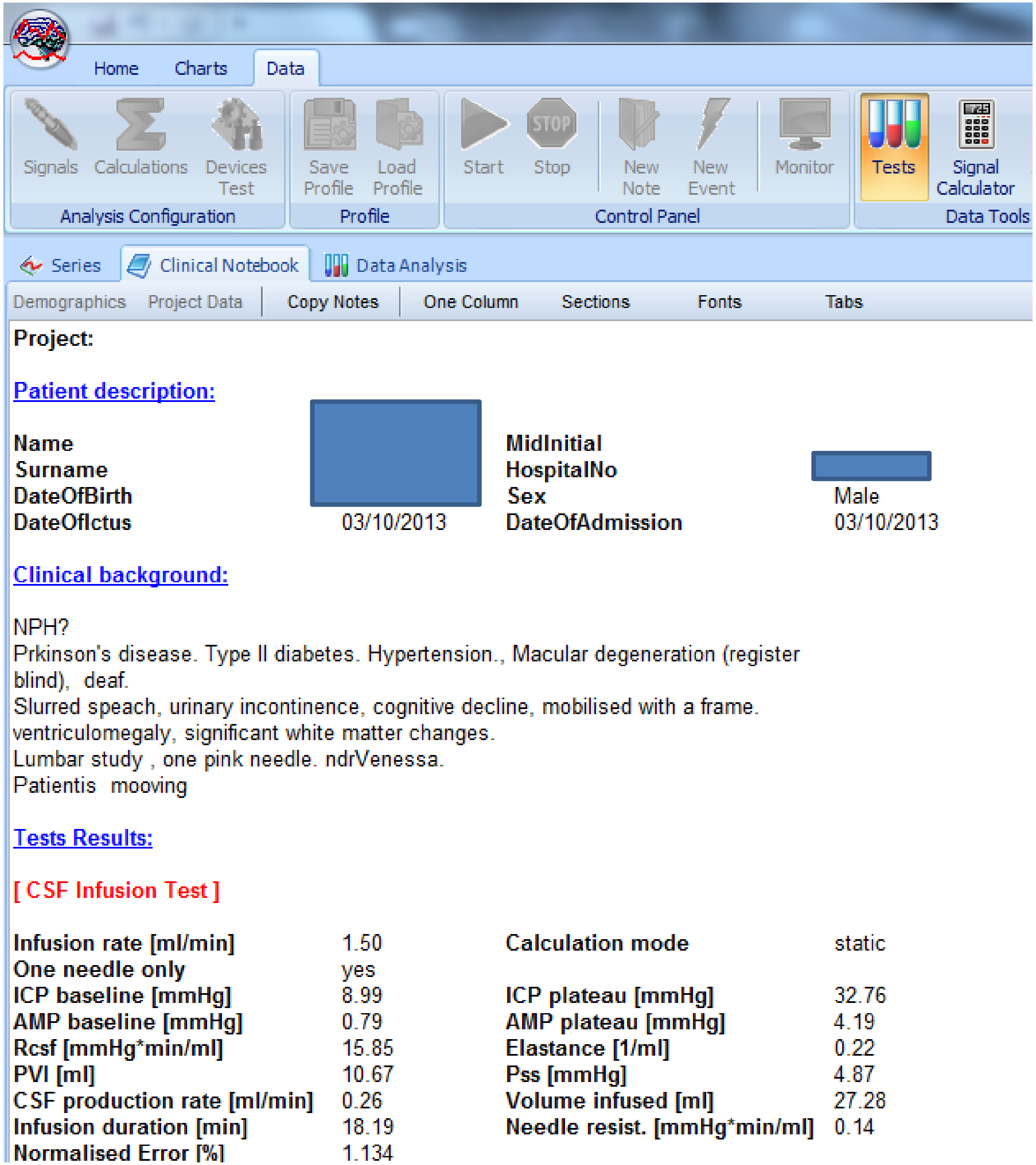
$$P_m(t) = \frac{\left(I_b + I_{inf}\right) * (P_b - P_0)}{I_b + I_{inf} * e^{-E*\left(I_b + I_{inf}\right)*t}} + P_0$$



Click 'more' and you see:



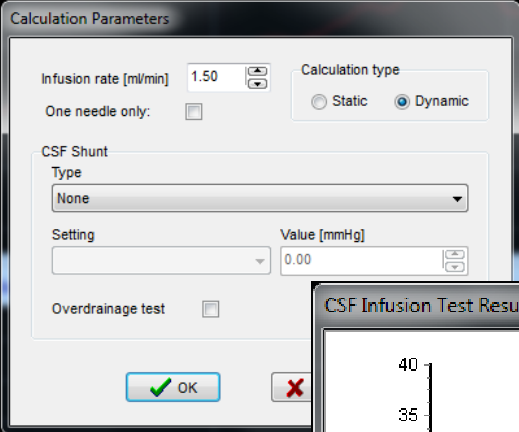
I use this screen to assess visually **quality of identification** of the model



If everything looks OK, you can **display report** and copy/ paste it to WORD

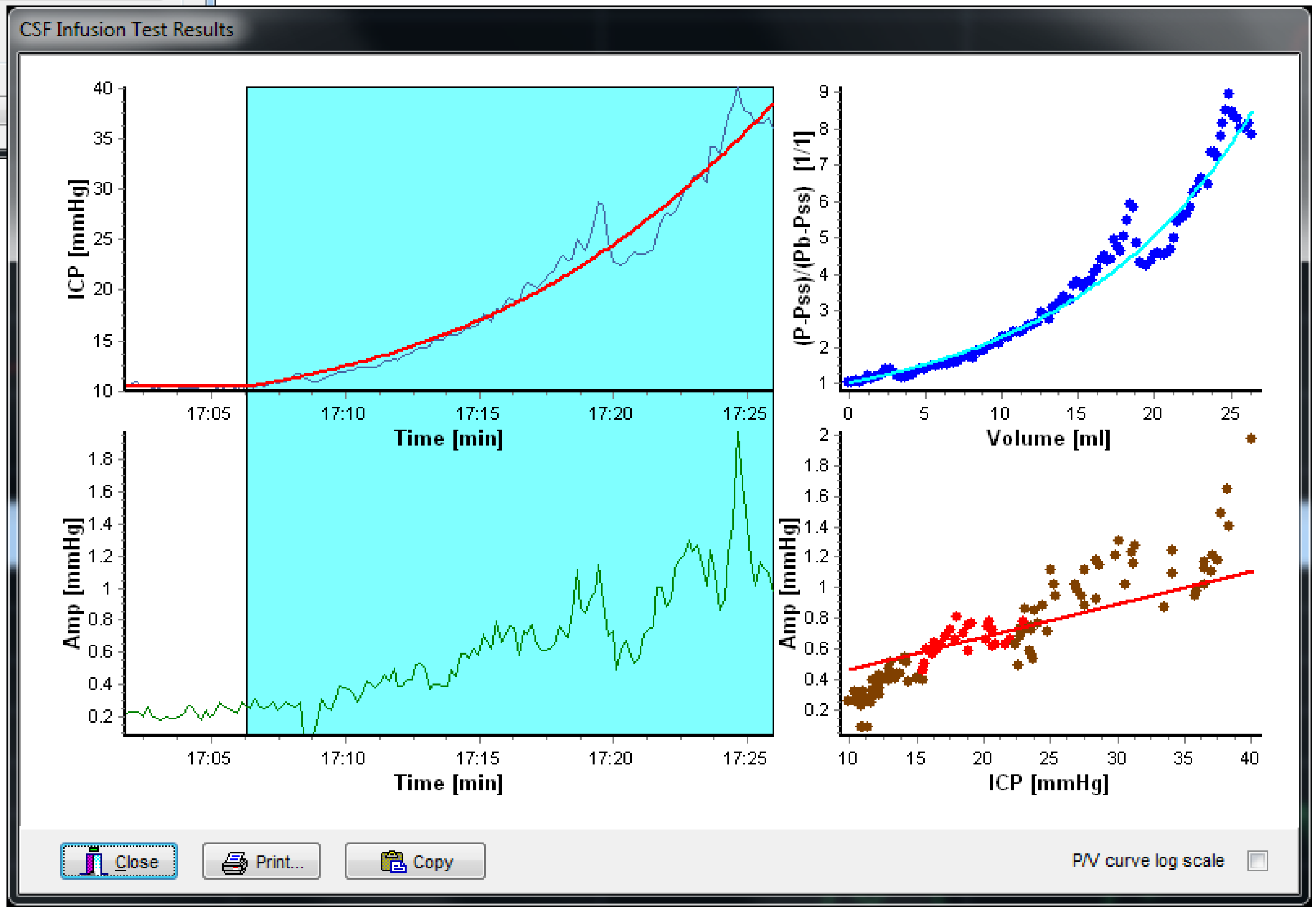
Test ‘unfinished’

- if pressure increases to 40 mm Hg without reaching plateau

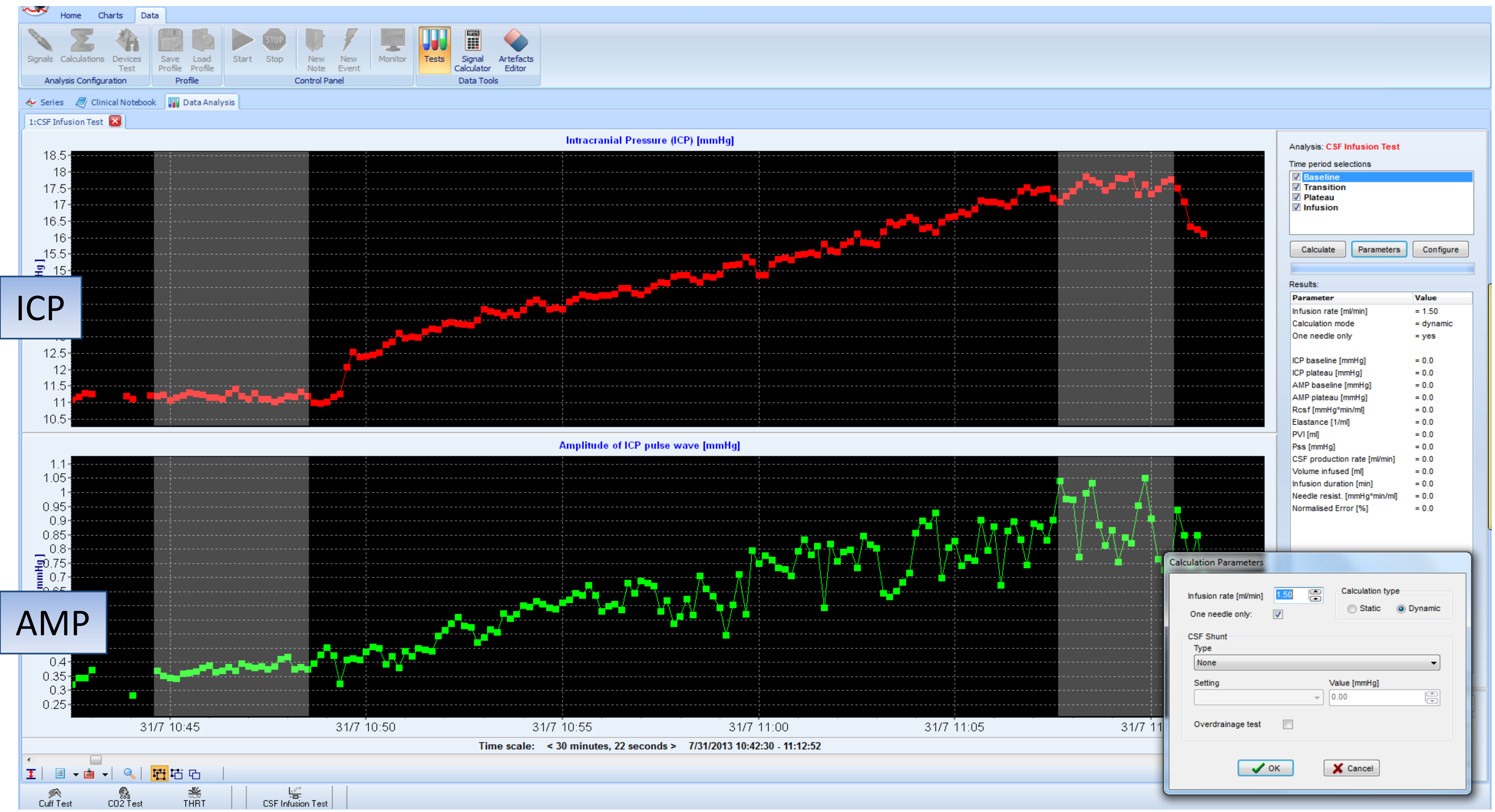


R= 77 mmHg/(ml/min)

Automatic analysis may predict plateau



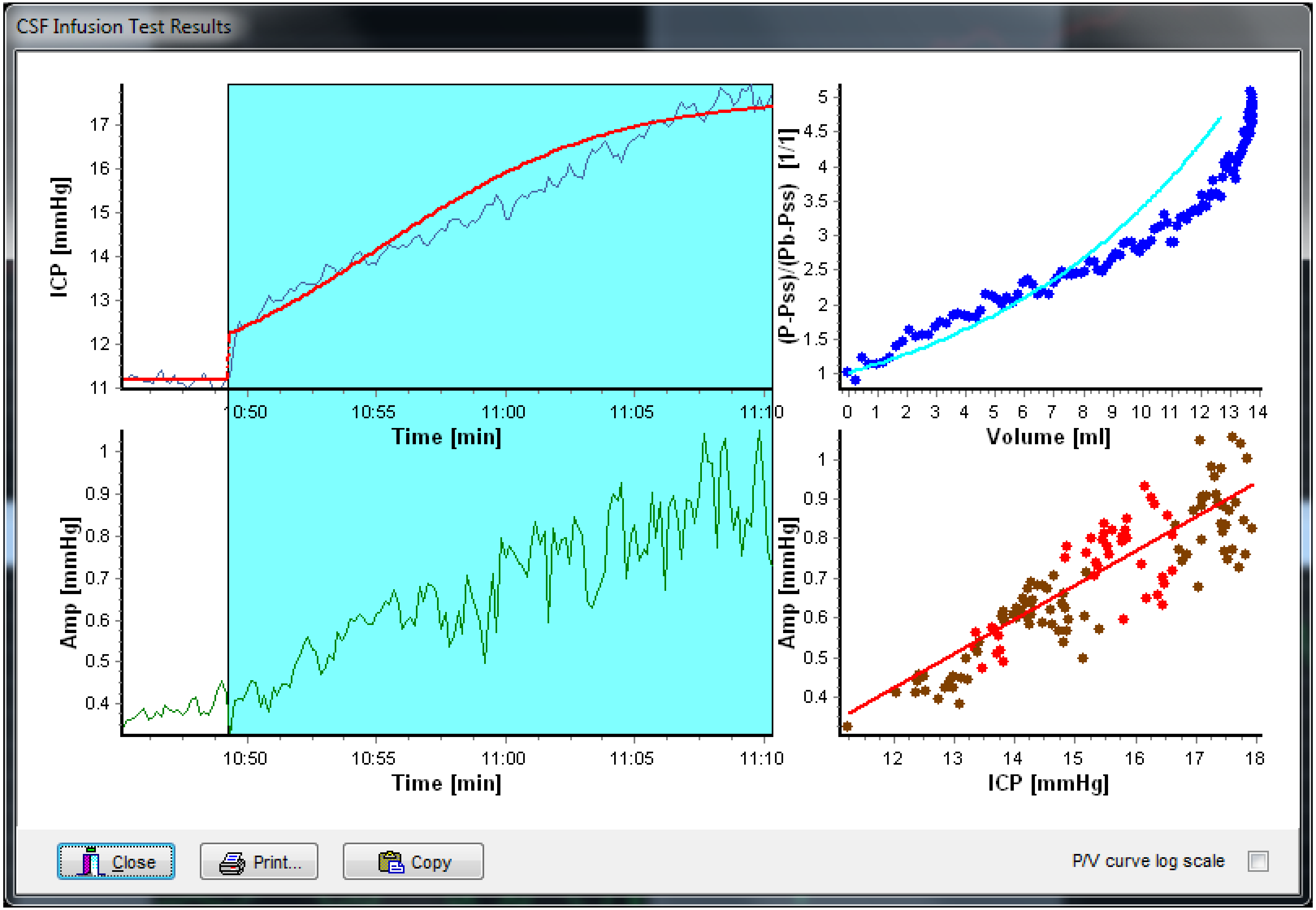
1. I never use ‘dynamic’ when plateau is good and long
2. I never use ‘dynamic’ in shunted patients



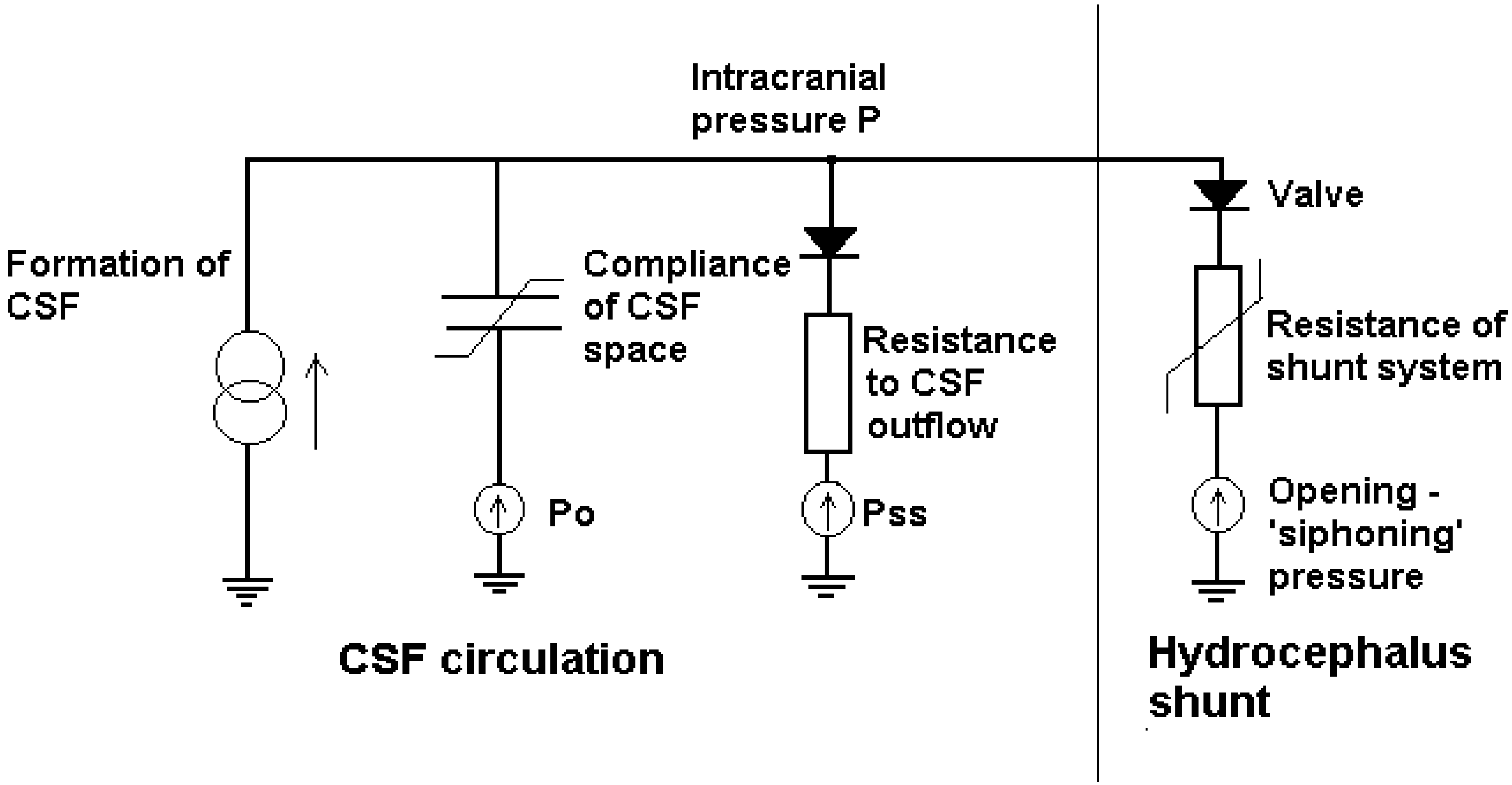
One needle test: we usually observe rapid increase of ICP just after start of infusion, not reflected by increase in AMP.

Tick in ‘Parameters’ ‘one needle’ option and problem of higher resistance of the needle may be solved automatically...

Step-rise of ICP is accounted for and eliminated from its potential influence on CSF compensatory parameters



CSF circulation with shunt in situ



Czosnyka ZH et al.. Shunt testing in-vivo: A method based on the data from the UK Shunt Evaluation Laboratory. Acta Neurochir. Suppl. 81. 2 001 (in press)

Shunt evaluation laboratory

Review: Cerebrospinal fluid dynamics R61

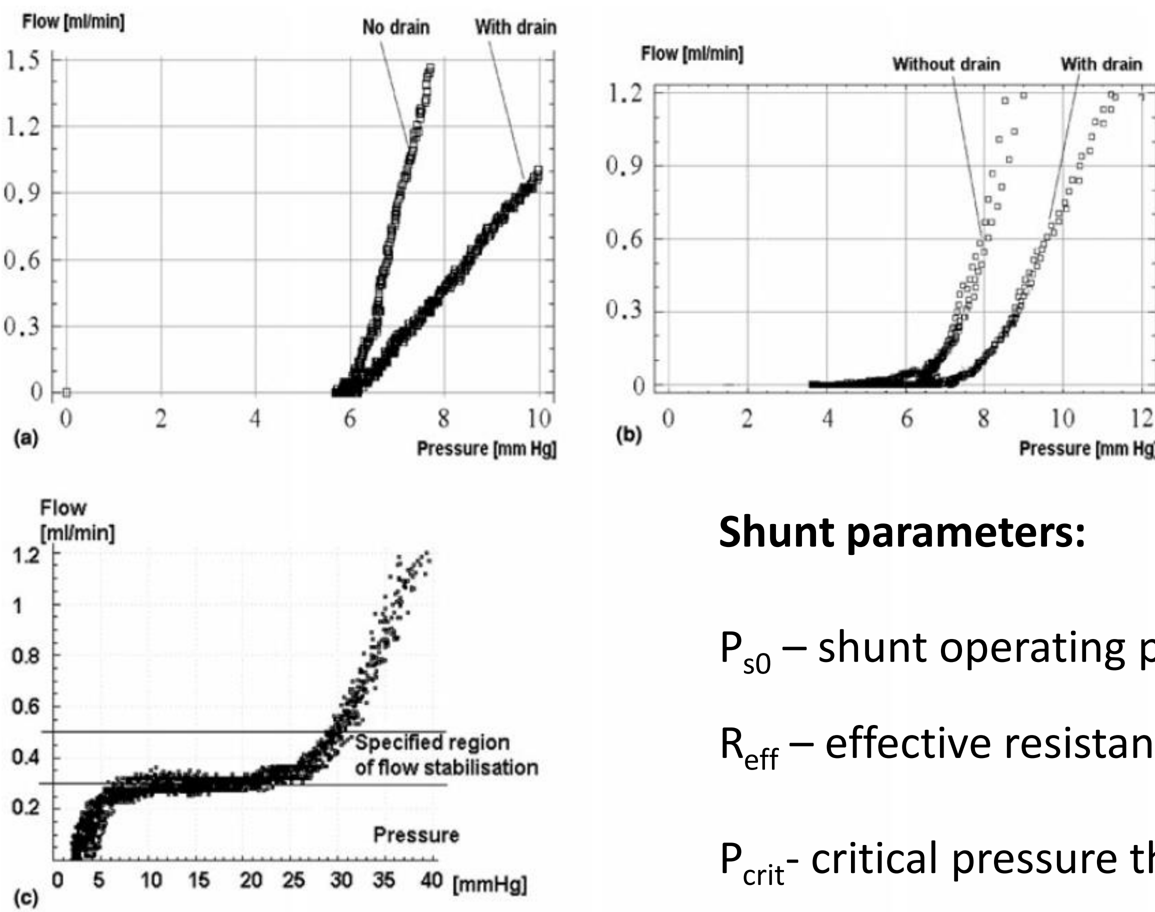


Figure 5. Examples of the pressure–flow curves of three valves: (a) almost linear: ball-on-spring valve; (b) parabolic shape of silicone membrane valve; (c) highly nonlinear 'autoregulating' Orbis–Sigma valve.

INSTITUTE OF PHYSICS PUBLISHING PHYS

Physiol. Meas. 25 (2004) R51–R76 PII:

TOPICAL REVIEW

Cerebrospinal fluid dynamics

Marek Czosnyka[1], Zofia Czosnyka, Shahan Momjian and John D Pickard

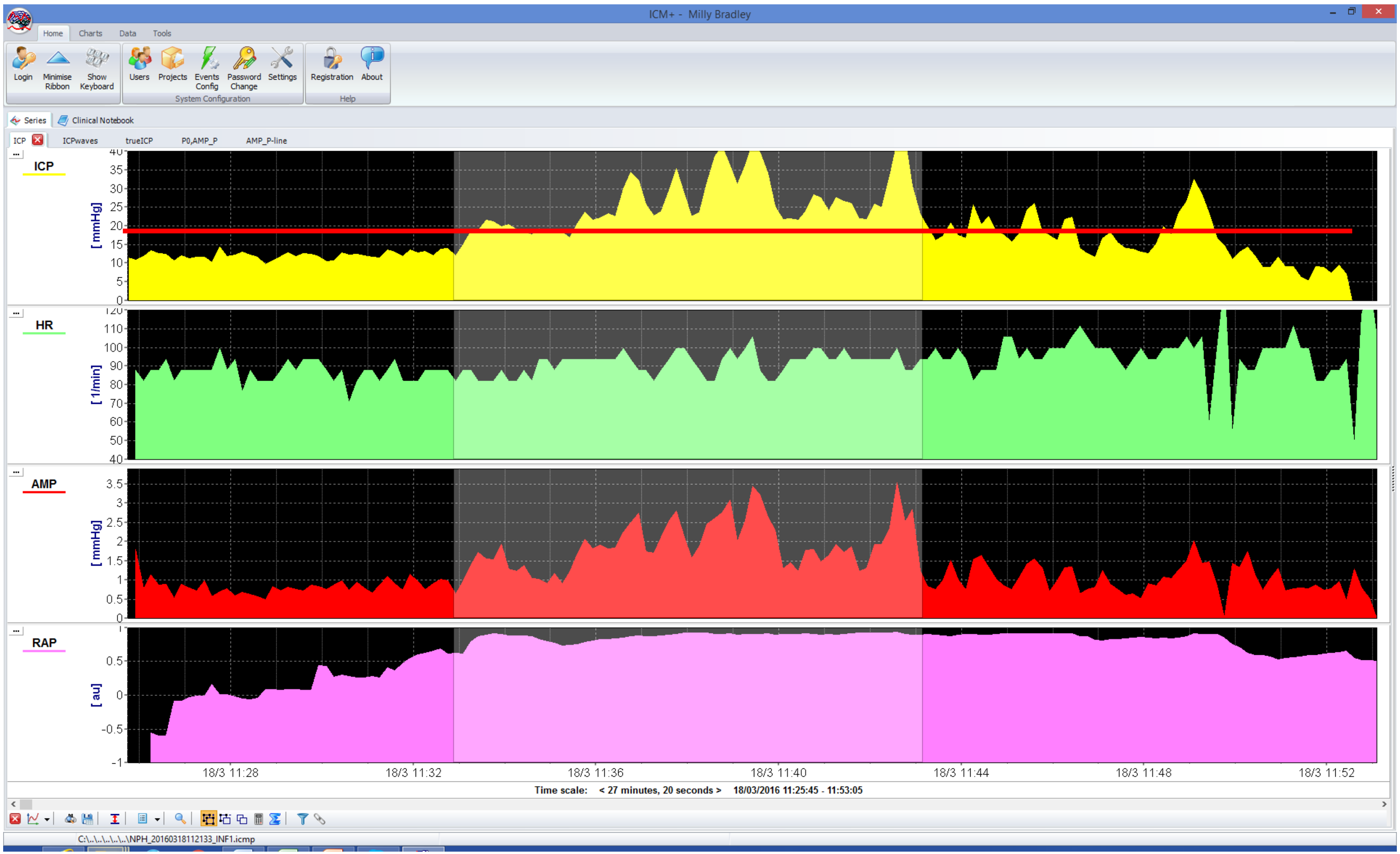
Shunt parameters:

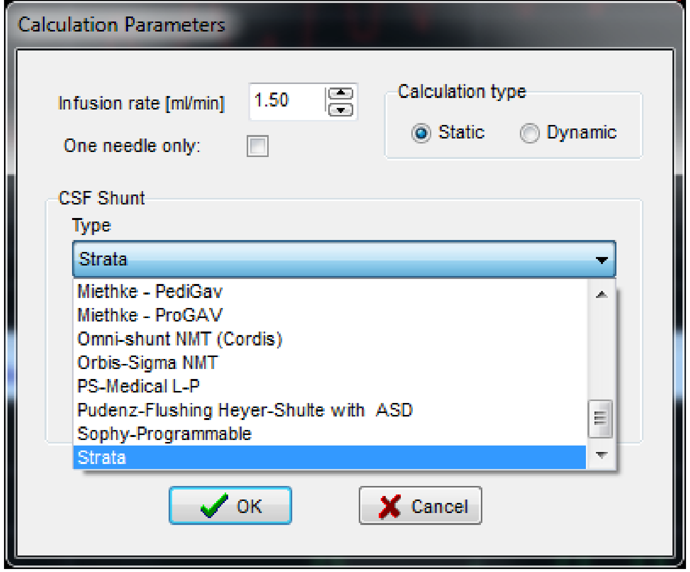
P_{s0} – shunt operating pressure (could be a formula)

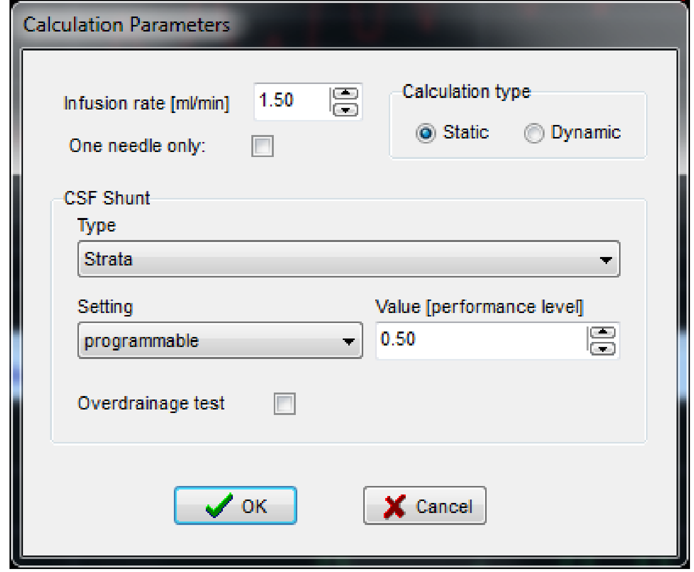
R_{eff} – effective resistance

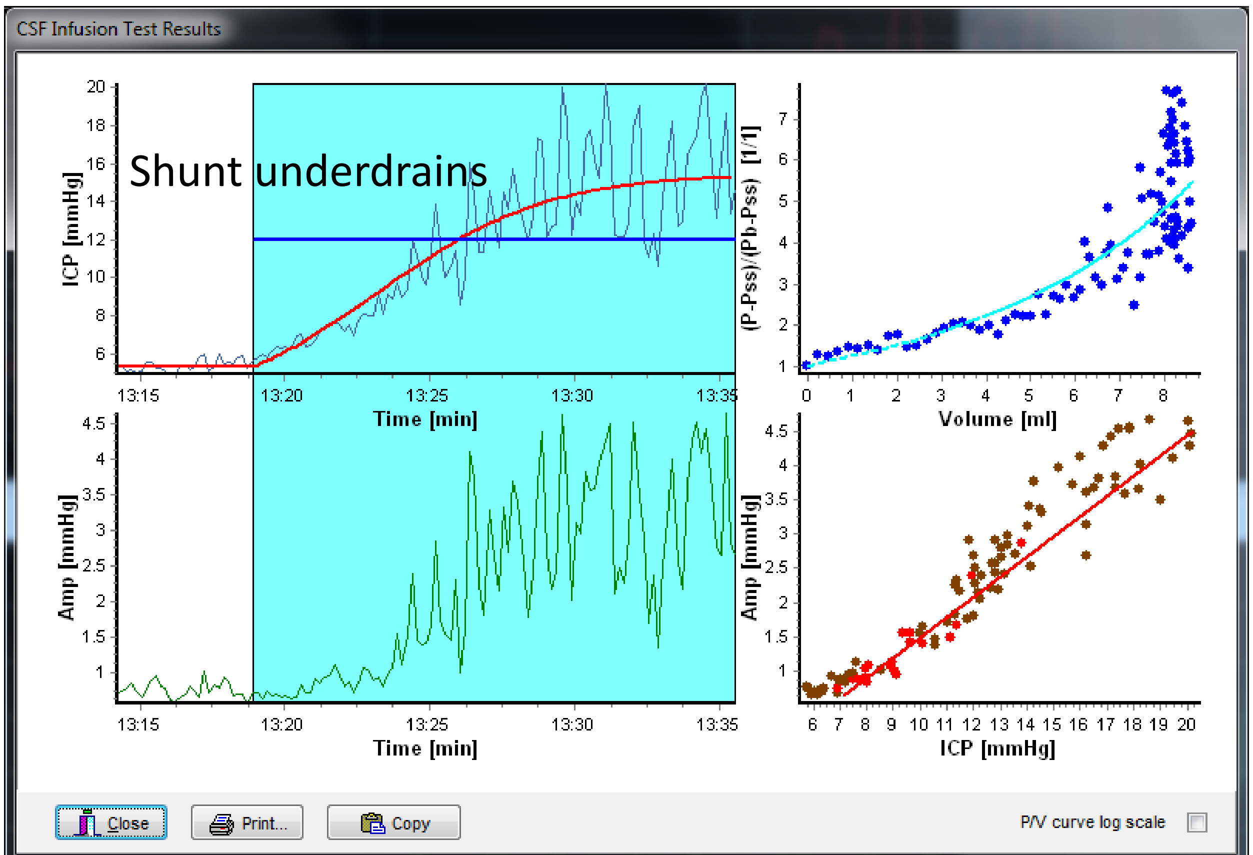
P_{crit}- critical pressure threshold formula

Shunt tested as ‘blocked’ distally. Too high resistance to outflow, prominent vasogenic waves. During the revision broken distal drain (at chest) was found.



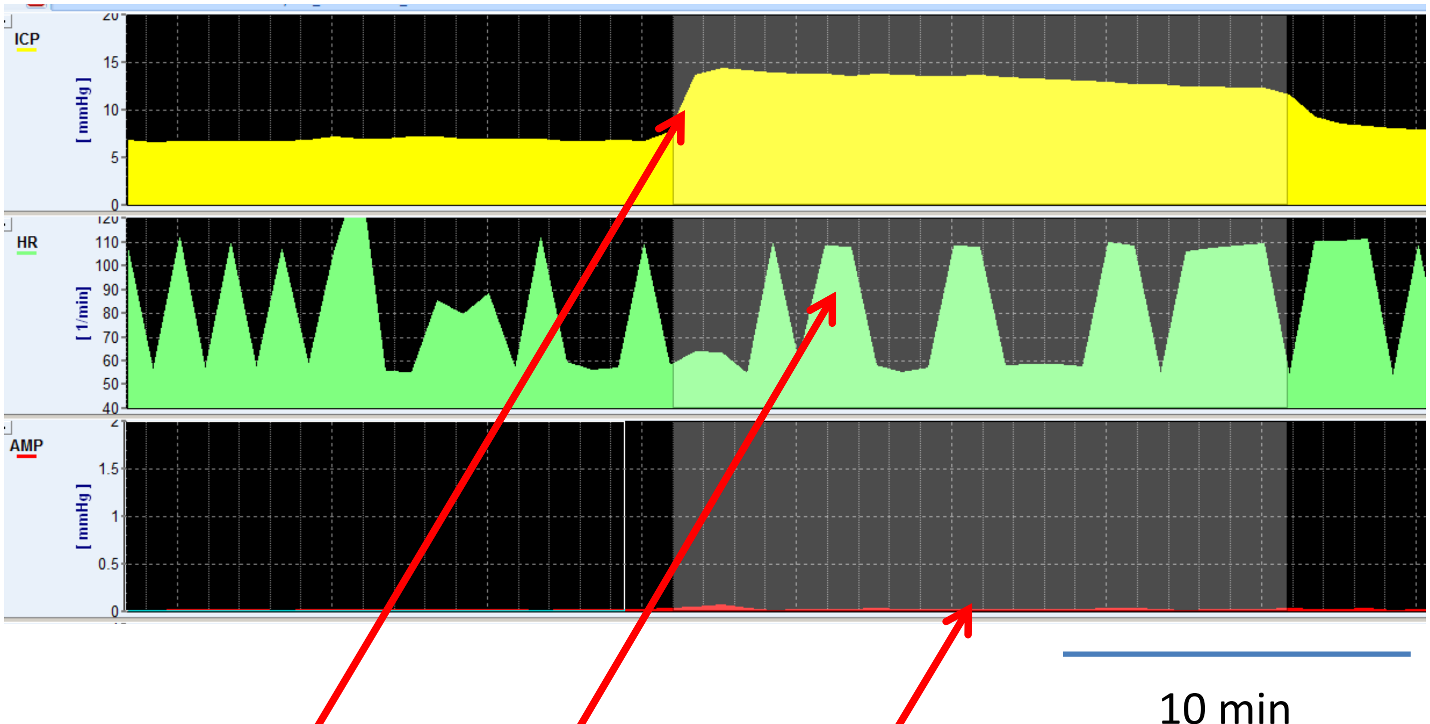






ICM+ has a database of shunt parameters from Cambridge Shunt Lab. Every shunt at given performance level has a limit above which pressure should not rise during infusion of given rate (1ml/min or 1.5 ml/min). If pressure exceeds this limit (blue horizontal line), it indicates that shunt underdrains.

Blockage of ventricular catheter- view of ICM file



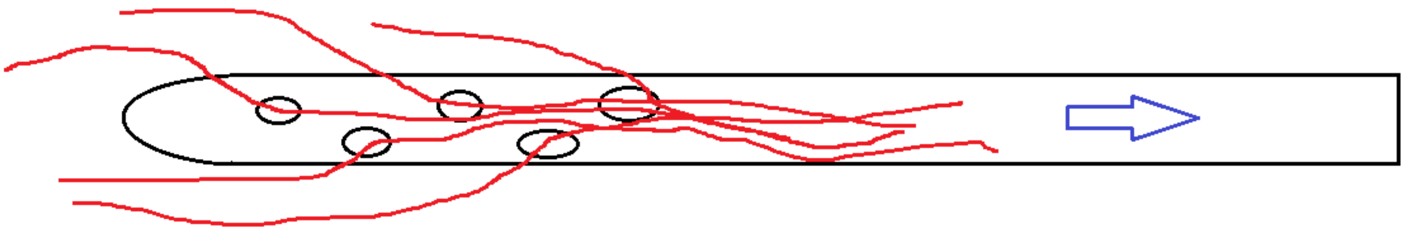
Fast rise of recorded
Pressure just after
Start of infusion

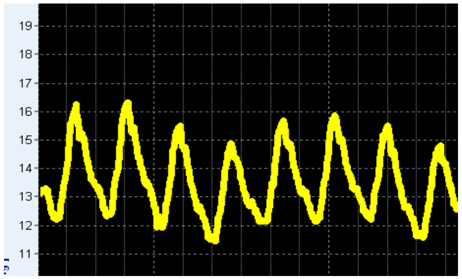
Invalid detection of heart rate
from ICP waveform

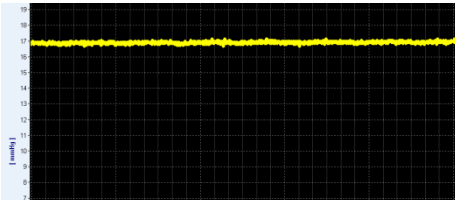
Very low (<0.1 mm Hg) pulse amplitude
of ICP calculated

Choroid plexus in-growing int ventricular catheter

Possibly fluent CSF flow at baseline, aspiration possible, ICP pulsation visible



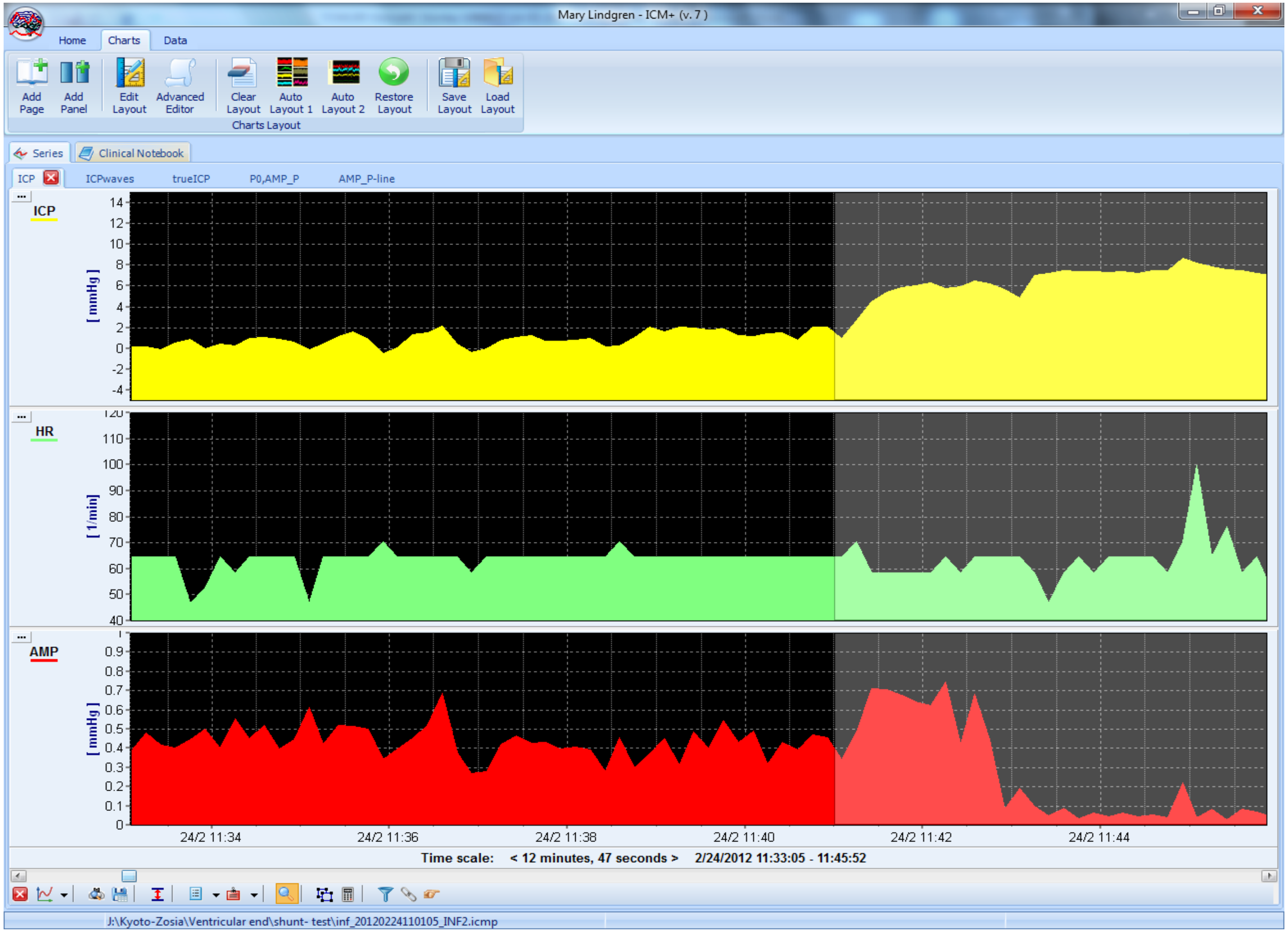




After start of infusion in-growing plexi jam dynamically ventricular catheter, all infused fluid flows distally, pressure pulsations dissapear

Partially blocked ventricular end

by in-growing choroid plexi – ICP waveform diminishes after start of infusion



Happy infusion studies!