# Non-invasive ICPM for heart failure monitoring: guide for acute decompensated heart failure therapy

- ICPM measures contemporary bi-ventricular filling pressures: LVEDP and RVEDP - major CHF markers
- ICPM monitors CHF to prevent DHF events and improve patients life quality and life expectancy
- **ICPM is capable to optimize HF therapy for complex patients** estimating non-invasively LVEDP, LAP/ RVEDP, RAP **guiding the (combined) diuretic and after-load reduction therapy** for NYHA stage III & IV of Heart Failure patients.

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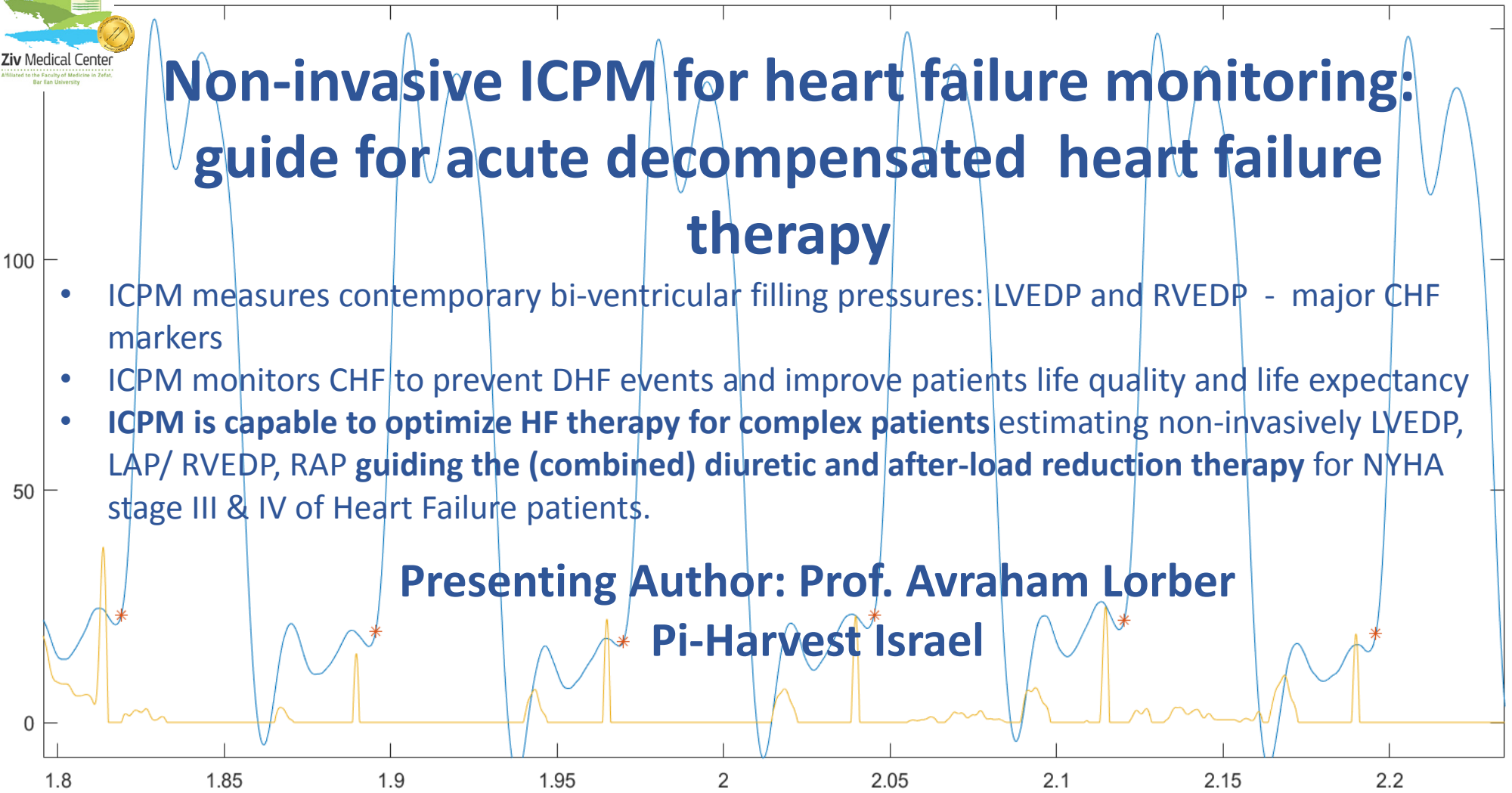
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Ziv Medical Center
Affiliated to the Faculty of Medicine in Zefat.
Bar Ilan University

$\times 10^4$

100

50

0

1.8   1.85   1.9   1.95   2   2.05   2.1   2.15   2.2

OBJECTIVE

To develop a real-time system
- providing a non-invasive measurement, calculation and prediction of pressures
    - in cardiac chambers,
    - assessing left and right ventricular/atrial pressures , in particular:
        - end diastolic pressures (LVEDP and RVEDP),
        - systolic/end systolic (LV/E/SP and RV/E/SP),
    - Left/Right ventricular pressure
        - rise
        - descend
    - and their derivatives forming a self-contained set of markers for CHF
    - describing the major cardiac cycle points connected with
        - ventricular preload, filling, ejection and afterload.
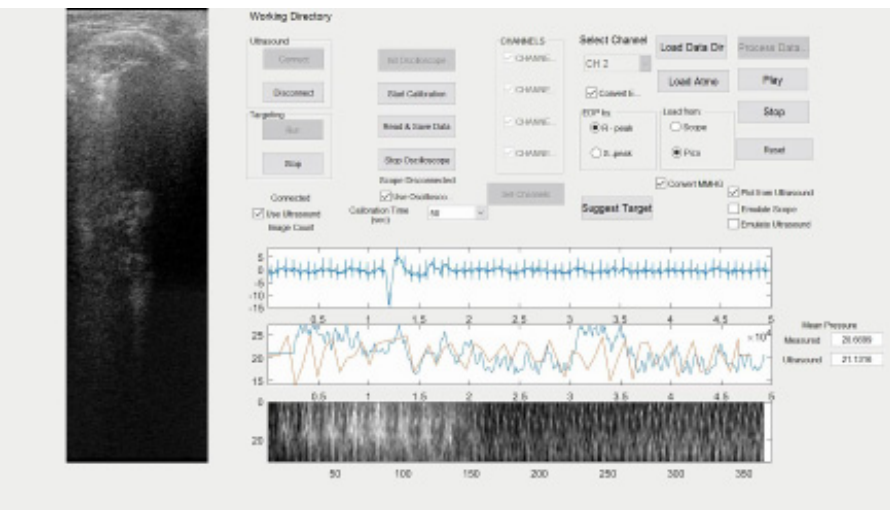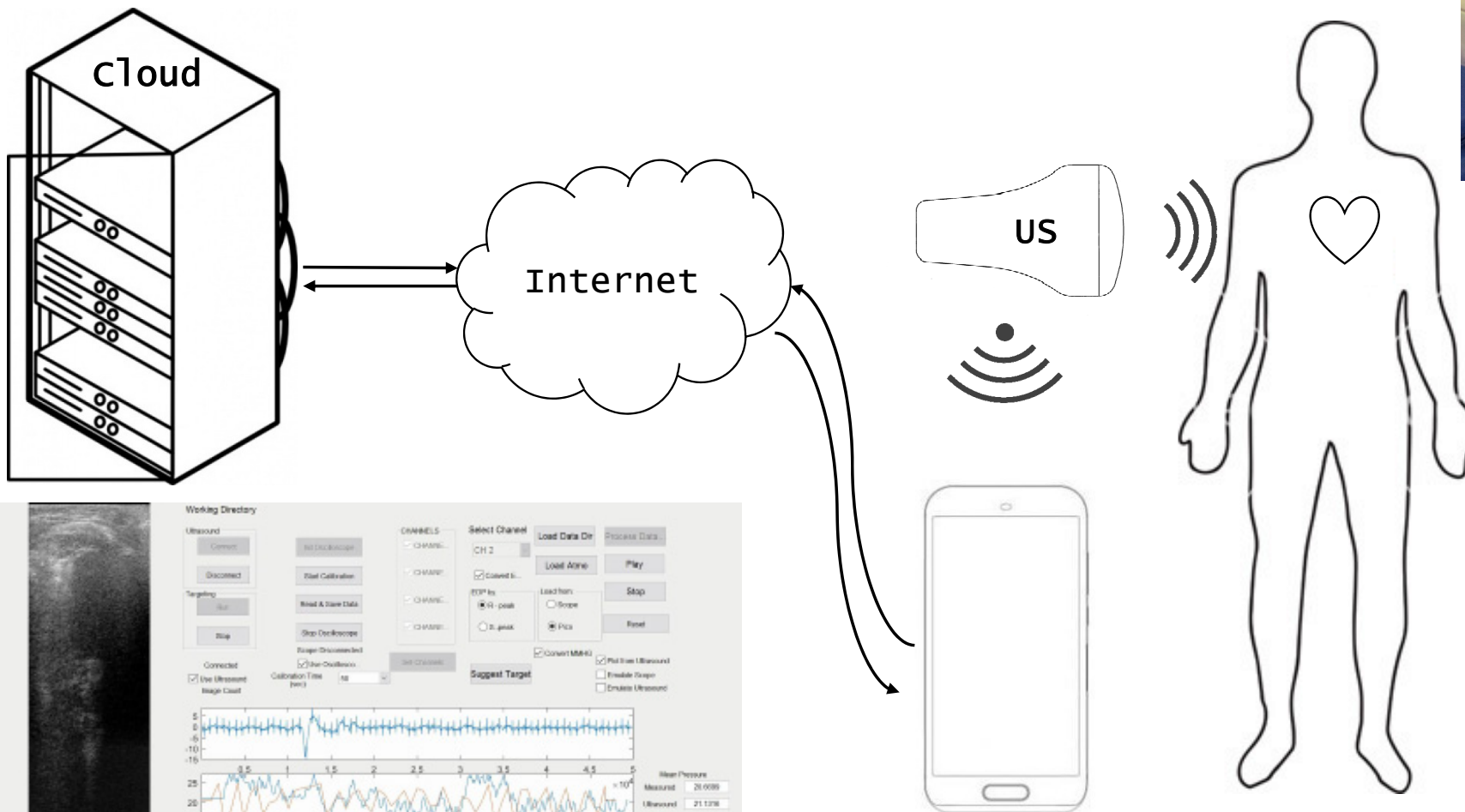
$$dP/dt_{max,L/R}$$
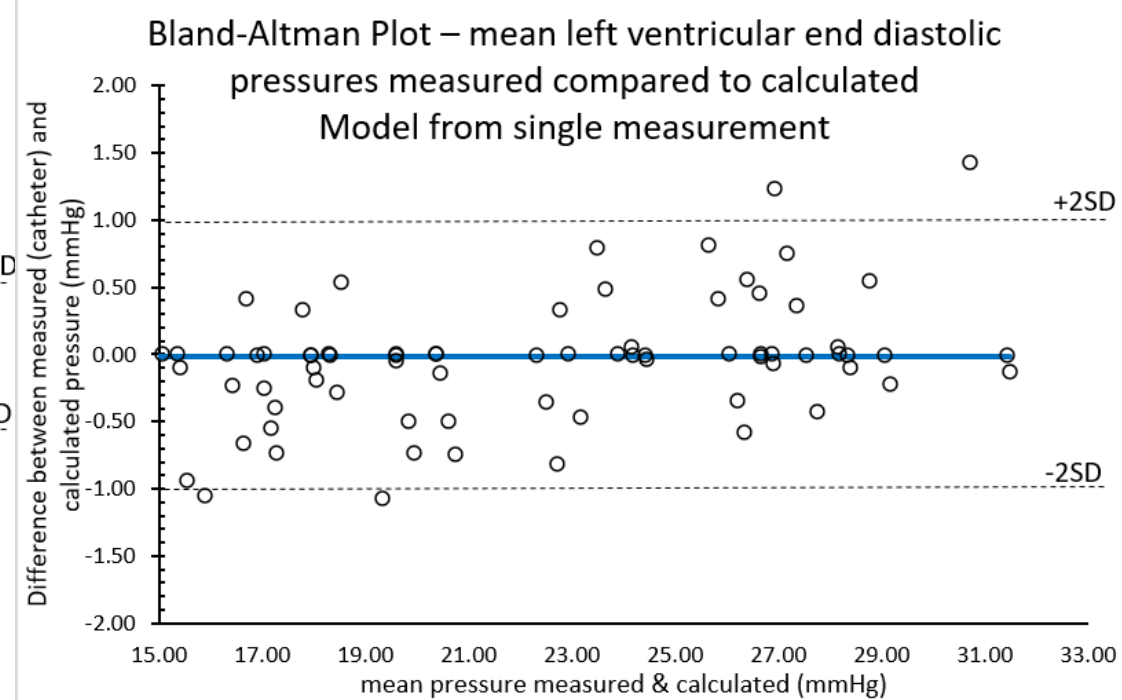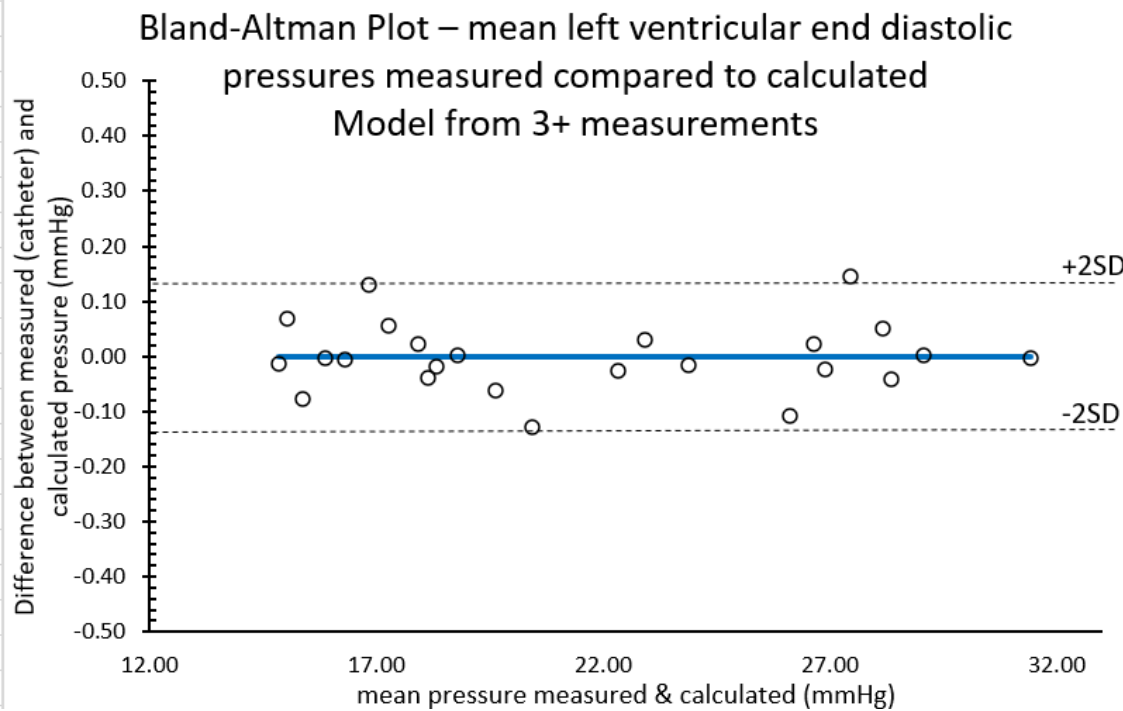
$$dP/dt_{min,L/R}$$

Methods

System Calibration
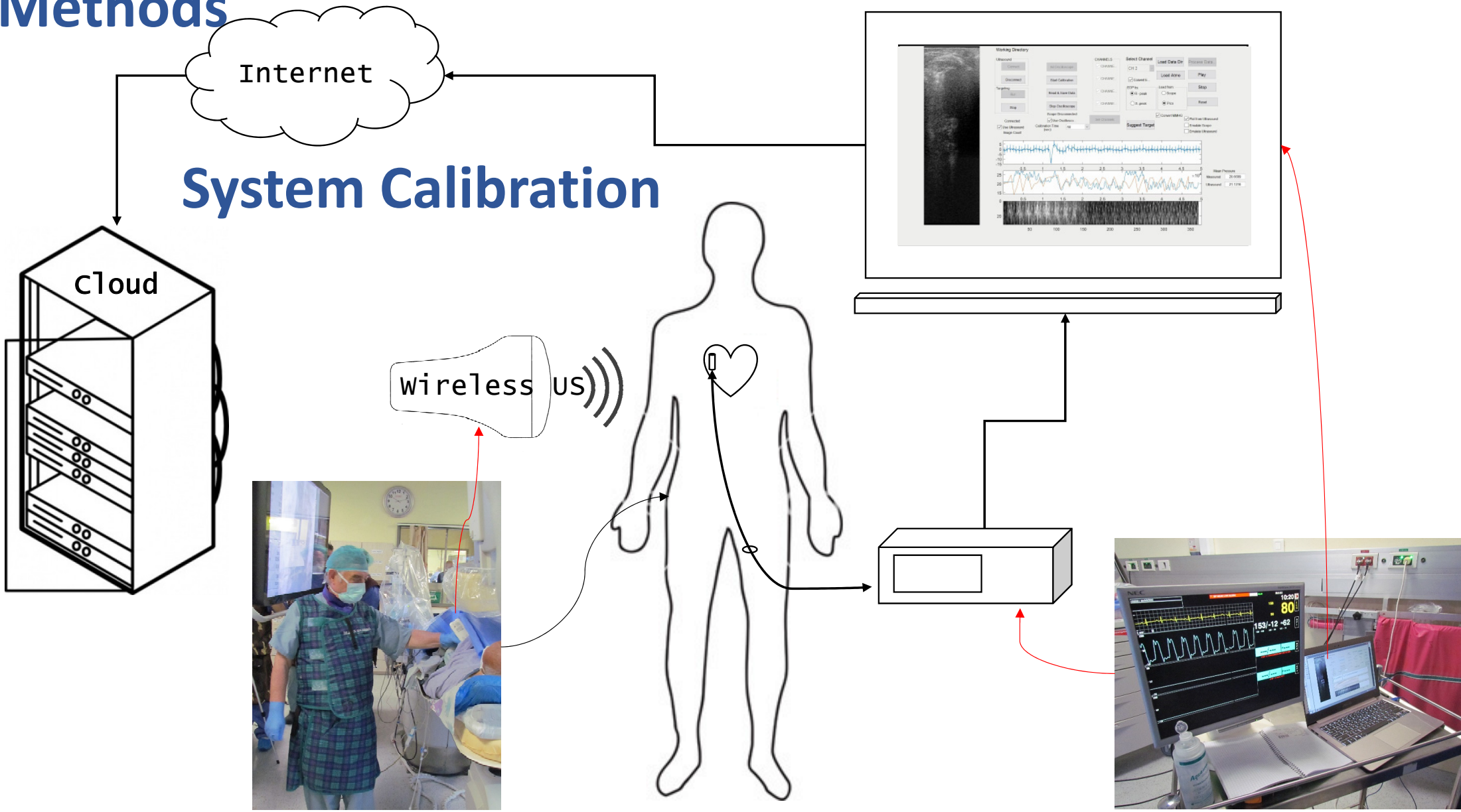
Methods: Follow Up
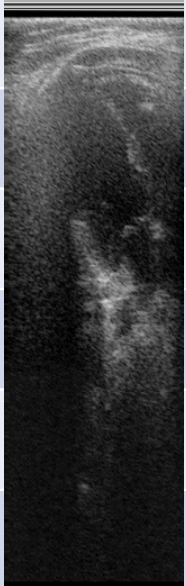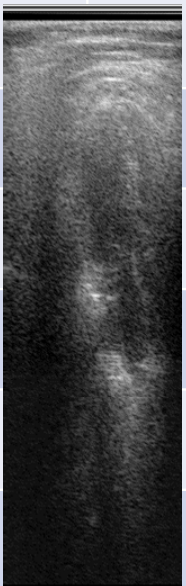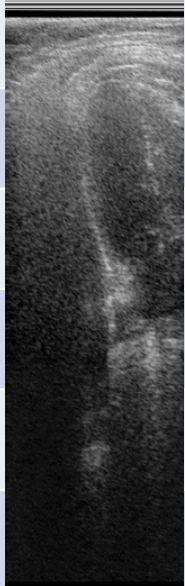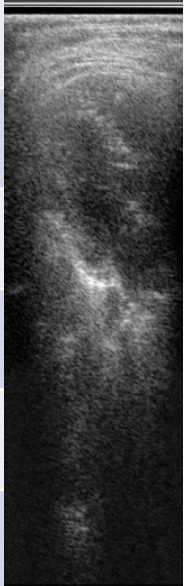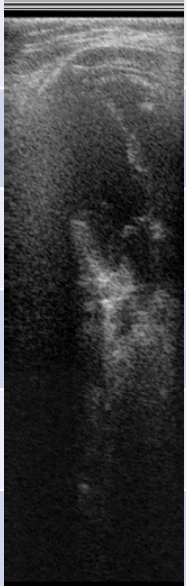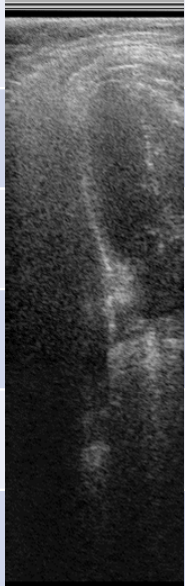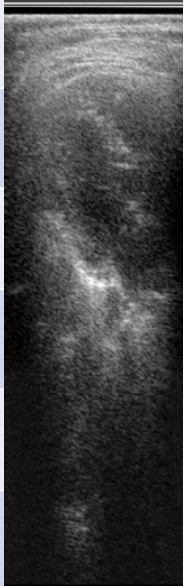
ICPM in Action: LVEDP model

Bland – Altman diagrams for different calibration models

Bland-Altman Plot – mean left ventricular end diastolic pressures measured compared to calculated. Model from 3+ measurements

Bland-Altman Plot – mean left ventricular end diastolic pressures measured compared to calculated. Model from single measurement

Non-ST elevation (NSTEMI) myocardial infarction: before and after Coronary Stent Insertion
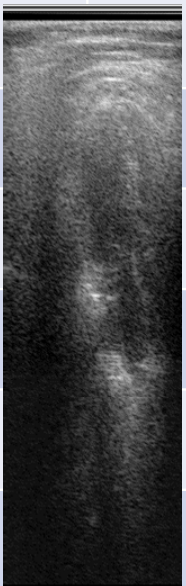
Patient	26	4-Aug-2019 11_26_31_8750	4-Aug-2019 11_43_54_5190	4-Aug-2019 12_43_52_5530	4-Aug-2019 12_46_02_6899	4-Aug-2019 12_47_57_0810
Record	1	LV	2 LV	5 LV	6 LV	7 LV
LVEDP Measured	30.73		28.98	24.03	22.69	19.14
LVEDP Calculated	31.24		27.95	24.48	22.82	19.07

ICPM in Action: LVEDP Cross - Calibration

- The results were confirmed during ongoing human study of
40 patients conducted under the approval of an ethical committee.

- The ultrasound elaborated pressure data functions are of high precision
and accuracy corresponding to the catheter derived pressures and
are valid for most of cardiac dysfunctions

- The further markers capable to differentiate NSTEMI Myocardial
infarction with preserved and reduced ejection fraction are discovered.

| Patient	8	LVEDP Comparison (mmHg)			
	Measured LVEDP	Calculated LVEDP			
Test	Pressure from LVP	Prediction by 1	Prediction by 2	Prediction by 3	Prediction by 4
1	20.60	20.60	20.72	20.67	20.36
2	21.10	21.08	21.11	21.20	20.77
3	19.09	19.18	19.57	19.08	19.15
4	17.67	17.46	18.18	17.16	17.67

ICPM in Action: LA-LVEDP pairing

- LVEDP can be assessed from LA recordings
- LVEDP pressure value corresponds to the first LA pressure peak after ECG peak
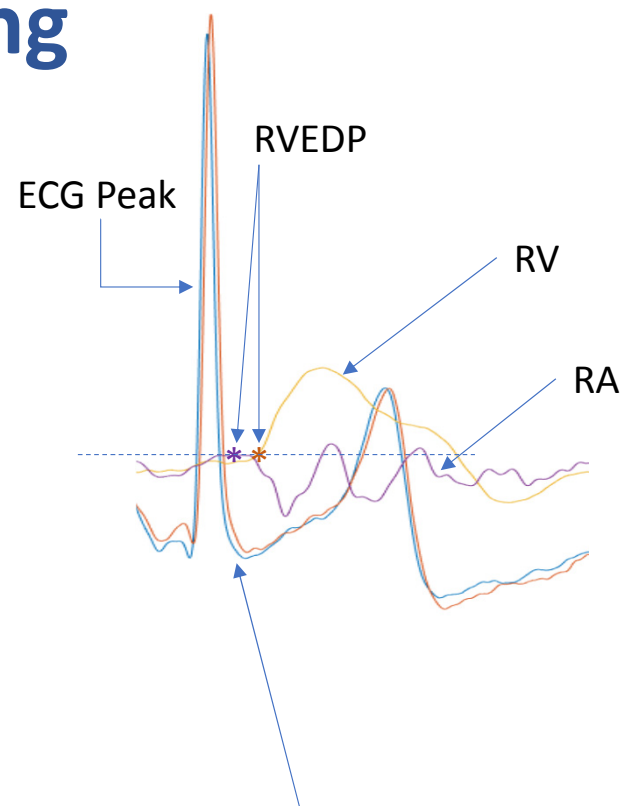
LVEDP from LV
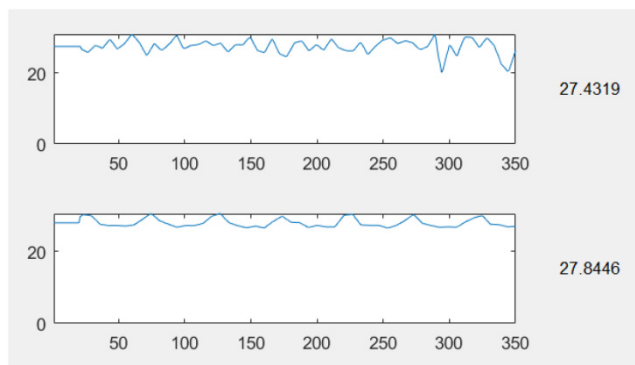
LVEDP from LA

Patient	Comparison (mmHg)	
	LVEDP from LA	LVEDP from LV
4	27.84	27.43
34	16.23	17.71
35	12.90	13.04

LVEDP

ECG Peak

LVEDP

LV

LA
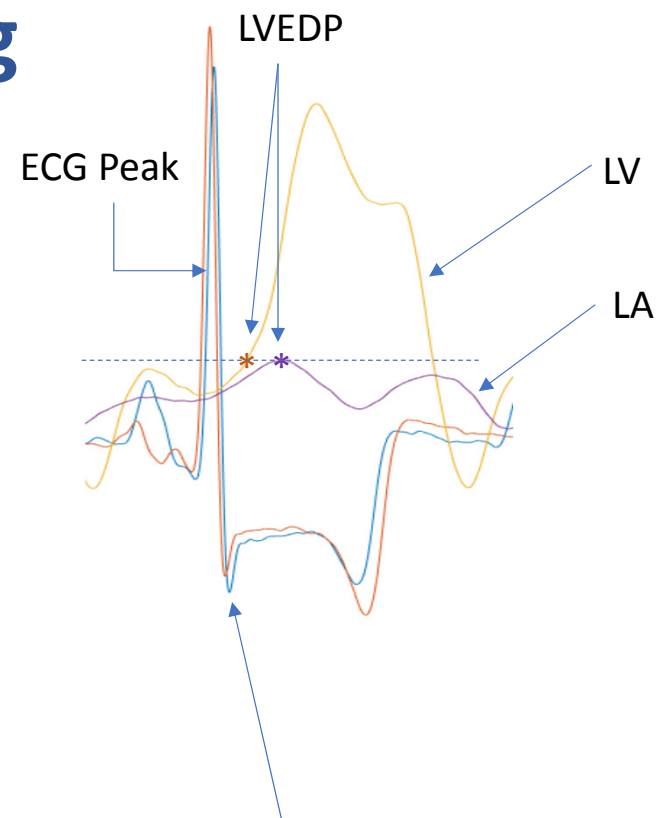
LA and LV recordings were not simultaneous, hence aligned by ECG

ICPM in Action: RA-RVEDP pairing

- Similarily, RVEDP can be assessed from RA recordings
- RVEDP pressure value corresponds to the first RA pressure peak after ECG peak
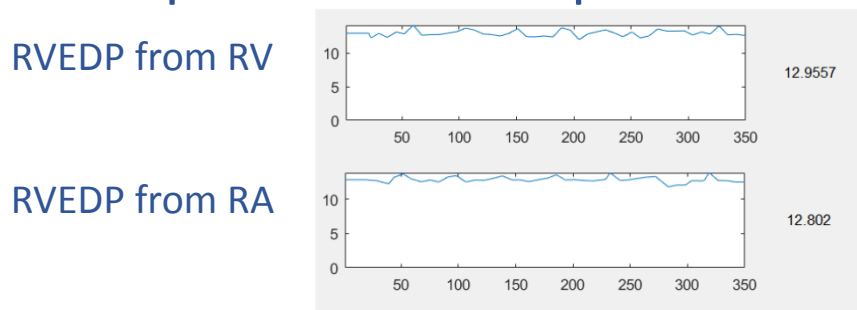
RVEDP from RV

RVEDP from RA

Patient	Comparison (mmHg)	
	RVEDP from RA	**RVEDP from RV**
3	12.80	12.95
17	10.76	10.23
34	13.65	14.45
35	8.7	8.84

ECG Peak

RVEDP

RV

RA

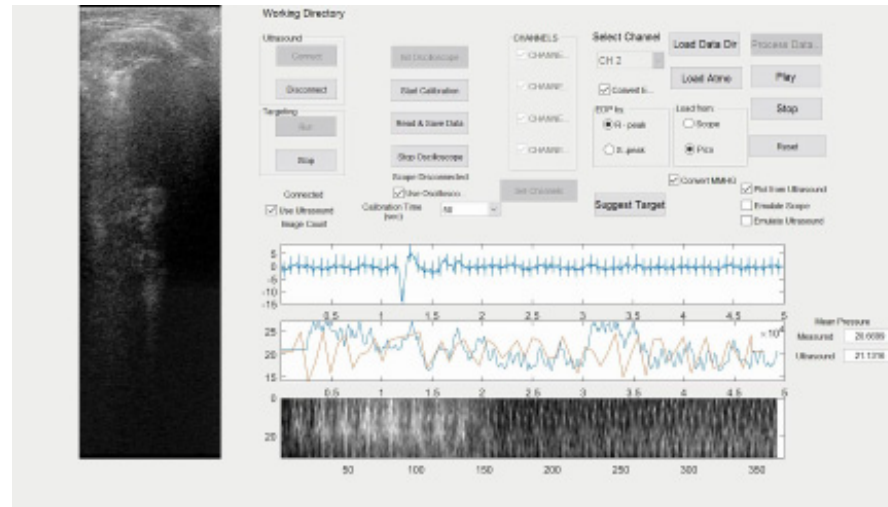RA and RV recordings were not simultaneous, hence aligned by ECG

Conclusion

Realtime estimation of

- LAP and LVEDP

as well as

- RAP and RVEDP

are valuable tools to **optimize HF therapy for complex patients guiding the (combined) diuretic and after-load reduction therapy** for NYHA stage III & IV of Heart Failure patients.

- The proprietary algorithm for automatic LVEDP/RVEDP extraction from LVP/RVP is validated via the simple algorithm of LVEDP/RVEDP extraction from LAP/RAP