CARDIOVASCULAR DISEASES · LEADING CAUSE OF DEATH GLOBALLY

Today, cardiovascular (CV) diseases are among the most common diseases of the population, the occurrence of which increases with age causing many complications.

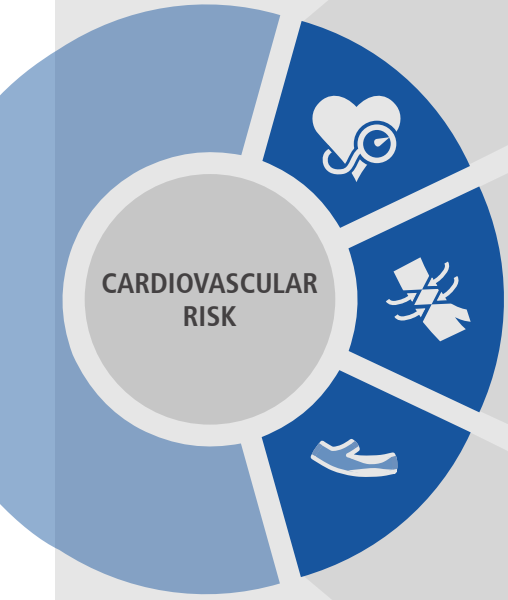
In the course of the development of the disease, hypertension, as well, as thickening and stiffening of the vessel walls (due to fatty degeneration and calcification) arise, which lead to constrictions (stenoses). Therefore, hypertension and vascular changes are closely linked and increase the likelihood of myocardial infarction, stroke, sudden death and heart failure.

Causes
include (i.a.)

- movement deficit
- obesity
- smoking
- diabetes
- elevated blood cholesterol level
- increased stress in everyday life

For a long time, hypertension guidelines focused on blood pressure (BP) values as the only, or main, variables determining the need for treatment. In 1994, the European Society of Cardiology (ESC), European Society of Hypertension (ESH) and European Atherosclerosis Society (EAS) developed joint recommendations on the prevention of coronary heart disease (CHD) in clinical practise, and emphasized that prevention of CHD should be related to the evaluation of total CV risk. The majority of the hypertensive population does not have BP elevation alone, but exhibits additional risk factors. Furthermore, BP and other CV risk factors may potentiate each other. Finally, in high-risk individuals, BP control is more difficult and the therapeutic approach should consider total CV risk in order to maximize the cost-effectiveness of hypertension management.

Since 2007, ESH/ESC Guidelines for the management of arterial hypertension[1] have included measurements of pulse wave velocity (arterial stiffness) and ankle-brachial-index (ABI) in the investigation of asymptomatic organ damage as recommended tests.



HYPERTENSION

Hypertension is a long-term medical condition in which the blood pressure in the arteries is persistently elevated. The overall prevalence of hypertension appears to be around 30-40% of the general population, with a steep increase with ageing. High blood pressure itself is usually asymptomatic, meaning that patients do not experience any direct symptoms of the condition. This is why hypertension is often referred to as "the silent killer", as it can quietly cause damage to the cardiovascular system. Hypertension can also lead to problems in the organs affected by high blood pressure. Long-term hypertension can cause complications through arteriosclerosis, where the formation of plaques results in the narrowing of blood vessels.

ARTERIAL STIFFNESS

With increasing age, as well as under the influence of further risk factors, there is an increase in vascular stiffness. The pulse wave velocity is an indicator of the elasticity or stiffness of the arterial vessels. Its determination allows the assessment of already existing damage in the vascular system. Thus, increased pulse wave velocity is added to the list of factors influencing the prognosis of CV risk as an early index of artery stiffening (2007 ESH/ESC Guidelines)[1].

CV predictive value	Availability	Reproducibility	Cost-effectiveness
+++	++	+++	+++

[a]

PERIPHERAL ARTERIAL OCCLUSION

Peripheral arterial occlusive disease (PAOD) is a disease of the arterial vessels caused by arteriosclerosis. The ankle-brachial-index is determined for the assessment of the overall cardiovascular risk and for the early detection and follow-up of a PAOD. A low ankle to brachial blood pressure ratio (ABI < 0.9) is listed as a relatively easy to obtain marker of atherosclerotic disease and increased total CV risk (2007 ESH/ESC Guidelines)[1].

CV predictive value	Availability	Reproducibility	Cost-effectiveness
+++	+++	+++	+++

[a]

[a] Predictive value, availability, reproducibility and cost-effectiveness of arterial stiffness (pulse wave velocity) and ankle-brachial-index from 2013 ESH/ESC Guidelines for the management of arterial hypertension.[1] Scores are from + to ++++.

ABI	Ankle-brachial-index
BP	Blood Pressure
CHD	Coronary Heart Disease
CV	Cardiovascular
ESC	European Society of Cardiology
ESH	European Society of Hypertension
PAOD	Peripheral arterial occlusive disease

Reference:
1 | Mancia G, Fagard R, Narkiewicz K, Redón J et al.
2013 ESH/ESC Guidelines for the management of arterial hypertension: the Task Force for the management of arterial hypertension of the European Society of Hypertension (ESH) and of the European Society of Cardiology (ESC). J Hypertens. 2013;31(7):1281-1357.

V 1.1

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CARDIOVASCULAR ASSESSMENT · COMPREHENSIVE, QUICK, SIMPLE AND RELIABLE

CardioScreen 2000®

A unique device for cardiovascular diagnosis and screening.

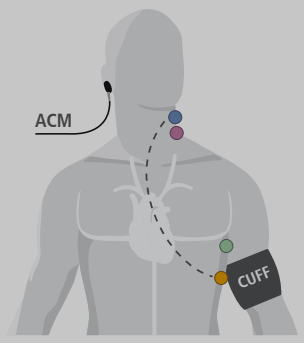
It incorporates 3 measuring methods which are simple, non-invasive and comfortable for the patient:

- Impedance Cardiography (ICG) for optimised hypertension management
- aortic Pulse Wave Velocity (PWVao) for evaluation of arterial stiffness
- ankle-brachial-index (ABI) for diagnosis of PAOD

The computer controlled examinations are standardised and operator independent. The evaluation of the results is automated.

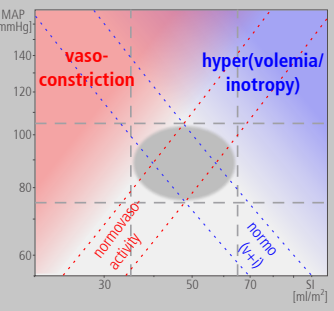
A few minutes are sufficient to obtain a lot of information about the cardiovascular condition of a patient.

HYPERTENSION

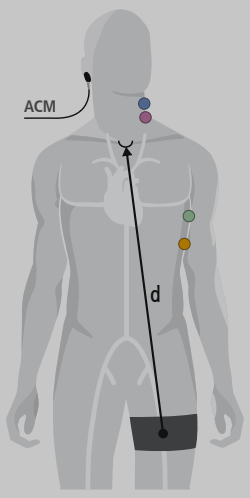


OPTIMAL HYPERTENSION MANAGEMENT

ICG facilitates the measurement of haemodynamic parameters such as heart rate, stroke volume, systemic vascular resistance and others. Therefore, ICG permits the determination of haemodynamic modulators. With this knowledge, the ICG offers individualised therapy of hypertension with the proper class of drugs in optimal dosage for each patient, in order to achieve both **normal blood pressure and normal perfusion**.

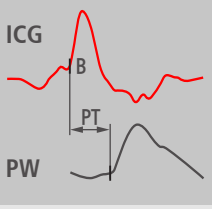


ARTERIAL STIFFNESS



PWVao · AORTIC PULSE WAVE VELOCITY

The opening of the aortic valve, when the blood is pumped into the aorta, is defined as the B-point in the ICG signal. On the upper leg a pressure cuff is placed to measure the arrival of the arterial Pulse Wave (PW) and to define its Propagation Time (PT). Taking into consideration the distance (d) between aortic valve and pressure cuff location the aortic Pulse Wave Velocity (PWVao) can be calculated to evaluate arterial stiffness for cardiovascular risk stratification and assessment of "vascular age".



$$PWVao = \frac{d}{PT}$$

B Opening of aortic valve
PT Propagation Time
d Distance between middle of cuff and Jugulum

PERIPHERAL ARTERIAL OCCLUSION

ABI · ANKLE-BRACHIAL-INDEX (oscillometric)

Four cuffs are placed on the upper arms and the ankles and the blood pressures are measured simultaneously using an oscillometric measuring method. Ankle-brachial-index (ABI) is calculated to diagnose peripheral arterial occlusive diseases. Additional peripheral pulse wave parameters help to confirm the diagnosis. Furthermore, fully-automated oscillometric ABI measurement is operator independent and enables an easy screening to detect vascular changes in an early stage among high risk patients (e.g. diabetics). The oscillometric ABI is suitable to evaluate the stroke risk easily and fast.

$$ABI = \frac{\text{Systolic Ankle Pressure}}{\text{Highest Systolic Brachial Pressure}}$$

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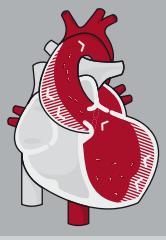
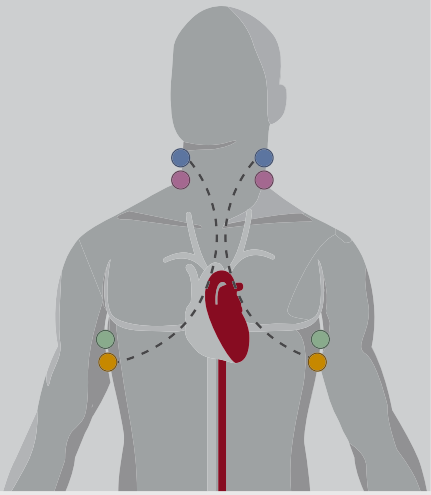
ARTERIAL COMPLIANCE MODULATION · THE NEW IMPEDANCE TECHNOLOGY

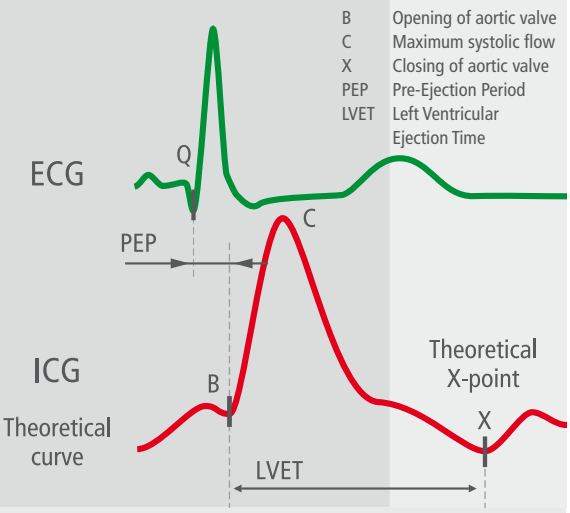
THEORY

BASICS OF IMPEDANCE CARDIOGRAPHY ICG



Stroke Volume is calculated by measuring changes in electrical impedance caused by the increasing blood volume in the aorta and the orientation of the erythrocytes when the blood is pumped out of the left ventricle of the heart. The opening and the closing of the aortic valve and the signal amplitude are determined.



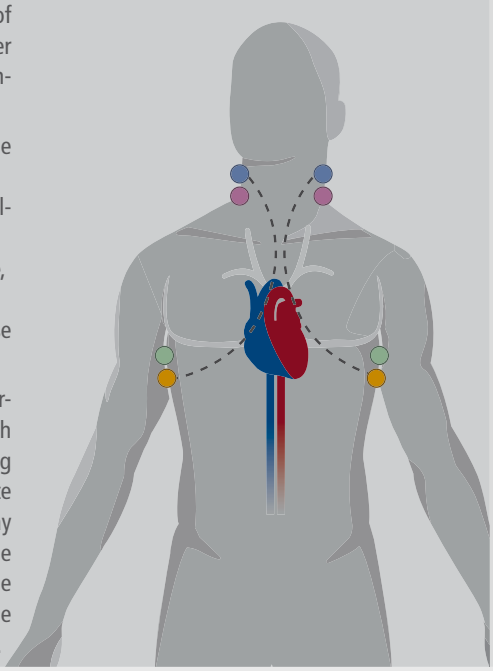


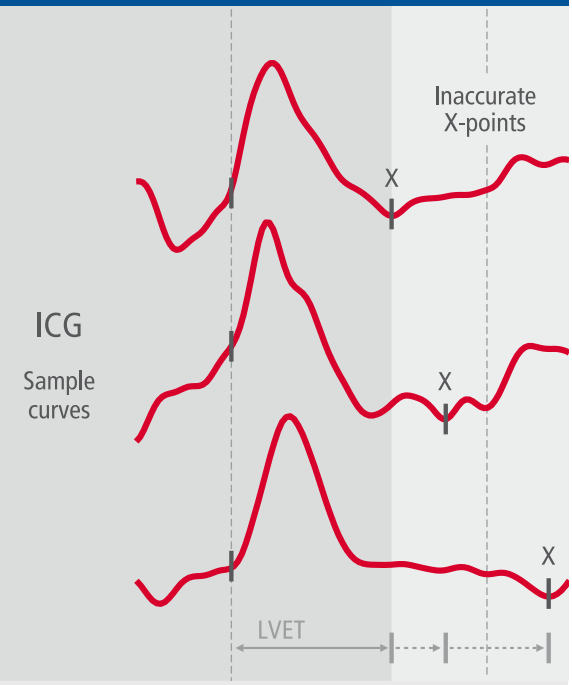
REALITY

The wave form of the pumping function of the left ventricle is superimposed by other processes which can cause measuring inaccuracies. Such processes are

- the activity of the right ventricle and the pulmonary system
- the asynchronous work of aortic and pulmonary valves
- the early reflection of arterial pulse wave, especially, in case of arterial stiffness
- the decrease of signal amplitude in case of reduced elasticity of aorta

These influences often result in the appearance of points in the ICG curve which could be, falsely, interpreted as the closing of the aortic valve. Therefore, an accurate determination of the real valve closing may not be possible and an inaccurate value of SV will be registered. For example, the variation of LVET and, consequently, of the Stroke Volume can be in the range of 15%.



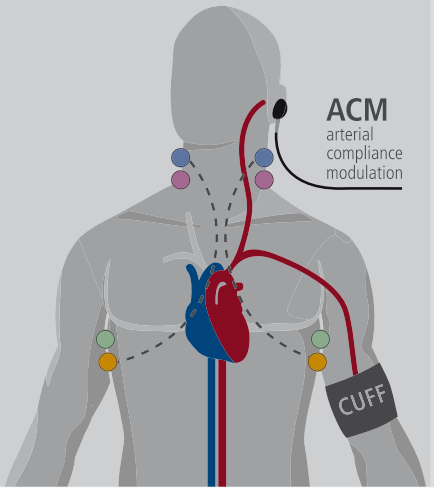


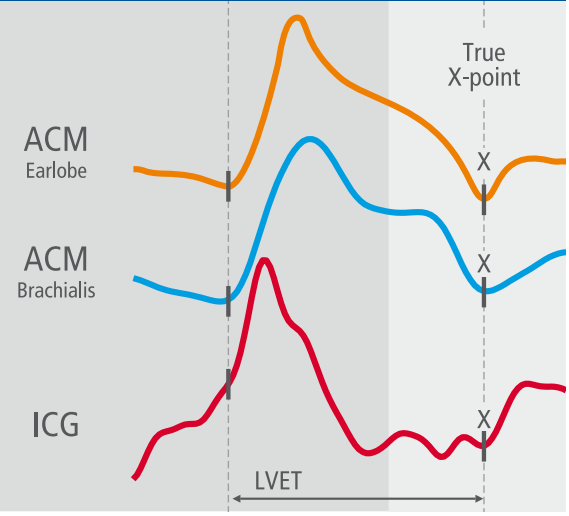
SOLUTION BY ACM TECHNOLOGY

The accuracy of Stroke Volume calculation can be greatly increased when the arterial pulse waves taken from the ear and/or the upper arm are used in **addition** to the standard ICG signal to detect the true x-point (closing of the aortic valve) and to negate the effects of arterial stiffness on the signal.

Medis has developed the Arterial Compliance Modulation module which has now been integrated into the CardioScreen/Niccomo algorithms.

ACM is another step forward in our continuing effort to supply the physician with practical and accurate hemodynamic information for improved patient monitoring.





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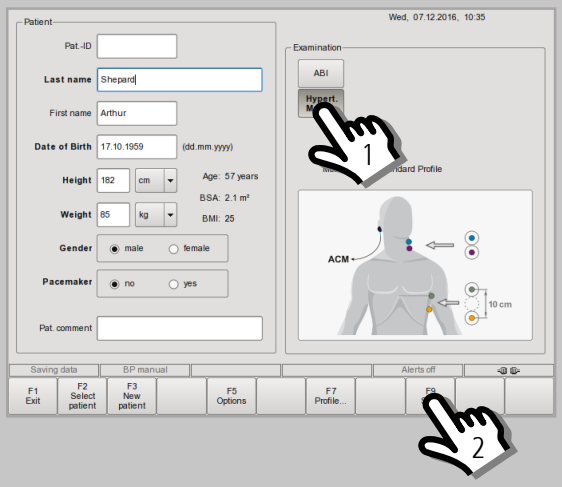
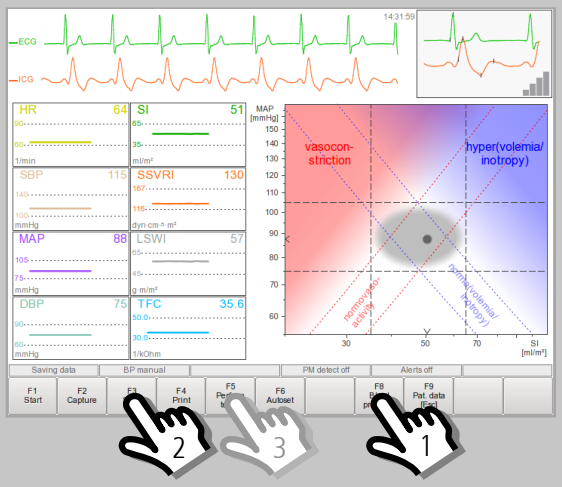
HYPERTENSION MANAGEMENT · GOAL DIRECTED THERAPY

1 PREPARE MEASUREMENT



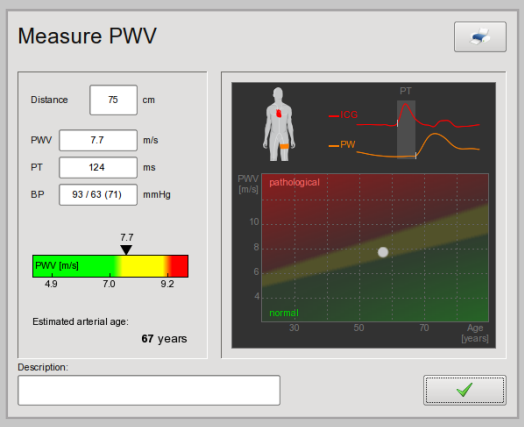
Patient in supine position, relaxed ▸ Enter patient data » Select "Hypert. Manag." (1) ▸ Apply electrodes ▸ Press "Start" (2)

2 IDENTIFY HAEMODYNAMIC STATE



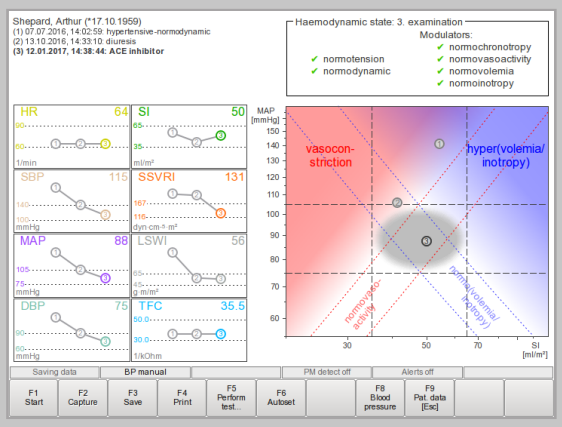
Measure blood pressure (1) ▸ Wait for stable parameters ▸ Press "Save" (2) ▸ Optional PWV measurement (3)

3 OPTIONAL PWV MEASUREMENT



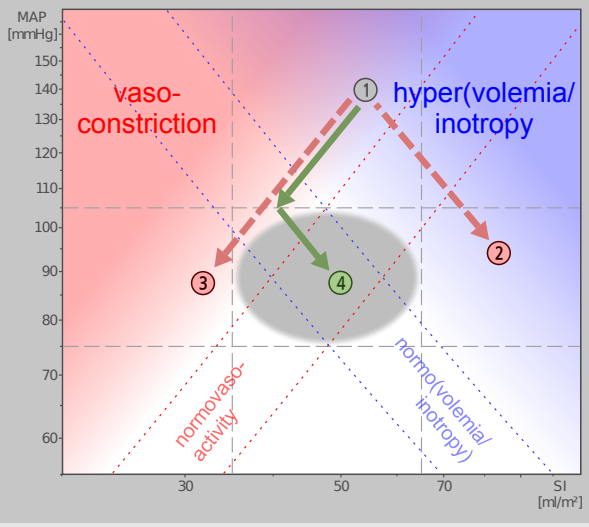
Measure and enter distance ▸ Press "Start" ▸ Get Result

4 GET RESULT



Overview of the results and its history

5 EVALUATION OF HYPERTENSION MANAGEMENT STRATEGIES



Example:

① Patient is **hyper**tensive and **normo**dynamic (43% vasoconstriction, 82% hypervolemia, normoinotropy)

ACE inhibitor → ② **normo**tensive BUT **hyper**dynamic → high workload on myocardium

Diuretica → ③ **normo**tensive BUT **hypo**dynamic → increased HR or low perfusion

Wrong treatment

Diuretica & ACE inhibitor → ④ **normo**tensive & **normo**dynamic

Correct treatment

6 PRINT DOCUMENTATION

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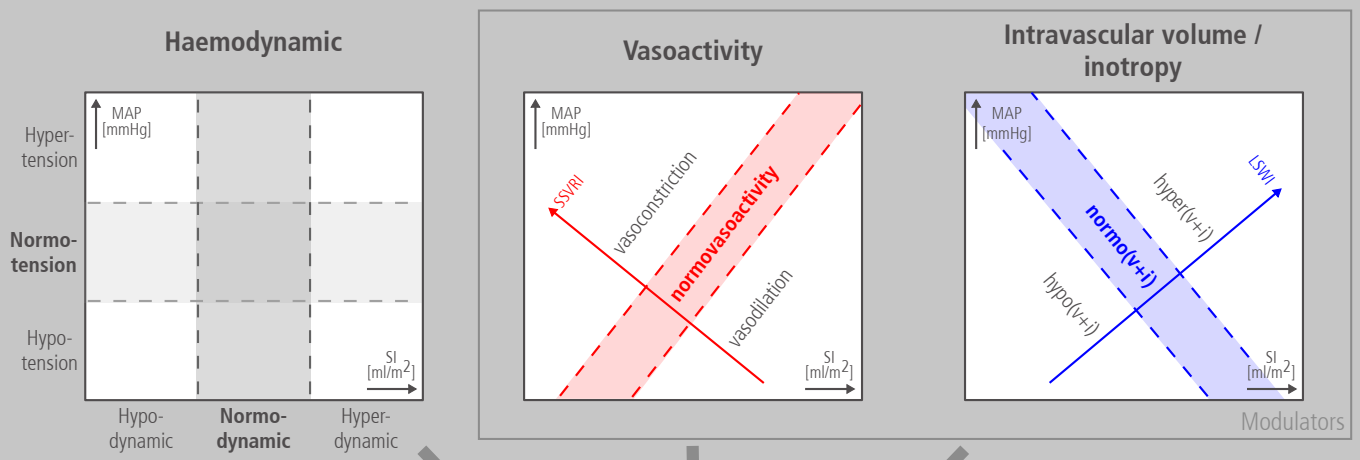
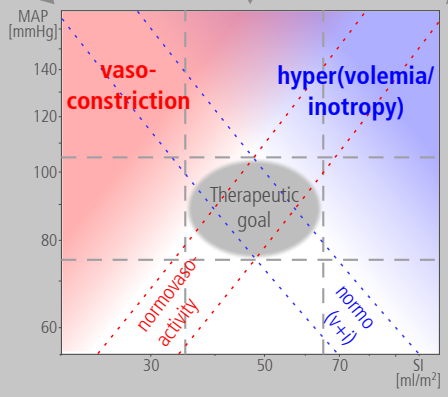
HYPERTENSION THERAPY · BLOOD PRESSURE ALONE IS INADEQUATE

HAEMODYNAMIC CHART



The haemodynamic chart visualizes the relationship between haemodynamic state (SI and MAP) and its three haemodynamic modulators (vasoactivity, intravascular volume and inotropy) for resting, supine adults.
A patient's current haemodynamic state is indicated by a point in the haemodynamic chart.

SI - Stroke Index
MAP - Mean Arterial Pressure
SSVRI - Stroke Systemic Vascular Resistence Index
LSWI - Left Stroke Work Index



According to the three diagramms above, there is only one field in the combined haemodynamic chart which can be considered as therapeutic goal (normohaemodynamic state). Thus, there are two fields of haemodynamic states where the patient is normotensive but hypo- or hyperdynamic. This will cause either low perfusion / increased heart rate (hypodynamic) or high workload on myocardium (hyperdynamic).
Consequently, in hypertension therapy it is necessary to focus not only on blood pressure alone, but also to evaluate the haemodynamic state and its modulators as a whole.

DEFINE THE OPTIMAL THERAPY

Often, hypertension is treated by optimizing blood pressure with trial and error strategy. However, for a goal directed therapy the following steps are recommended:

1. Identify patient's haemodynamic state and its position in haemodynamic chart: Therapy necessary?
2. Determine which modulators are in abnormal range and what are the deviations (%)
3. Accordingly, define drug or (if necessary) combination of drugs
4. The recommended dose correlates with deviation (%) of corresponding modulator
5. Check if dosage was correct and patient's vectorial response during therapy leads to normohaemodynamic state

ACEI - angiotensin-converting enzyme inhibitors, ARB - angiotensin II receptor blocker, BB - beta blocker, CCB - calcium channel blocker, VD - vasodilator

Haemodynamic modulators

Modulators	Therapy	
Vasoactivity → Afterload	**Vasoconstriction** Vasodilators e.g. ACEI, ARB, CCB, VD	↘ [1]
	Vasodilation Vasokonstrictors	↖
Intravascular volume → Preload	**Hypervolemia** Diuretics	↙
	Hypovolemia Volume expanders	↗
Inotropy → Myocardial contractility	**Hyperinotropy** Negative inotropes e.g. BB, CCB	↙
	Hypoinotropy Positive inotropes	↗
Chronotropy → Perfusion blood flow	**Hyperchronotropy** Negative chronotropes e.g. BB	
	Hypochronotropy Positive chronotropes	

[1] Pictogramms show direction of vectorial response during haemodynamic management

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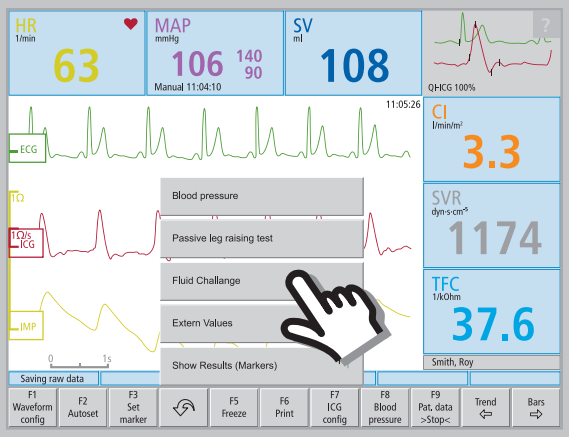
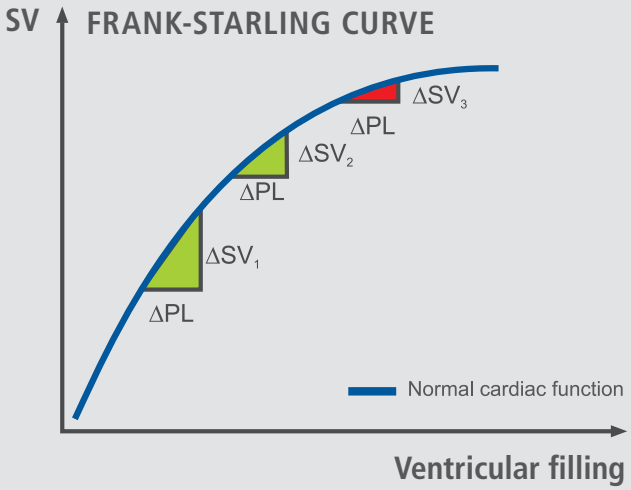
FLUID CHALLANGE · 100% NON-INVASIVE THROUGH ICG TECHNOLOGY

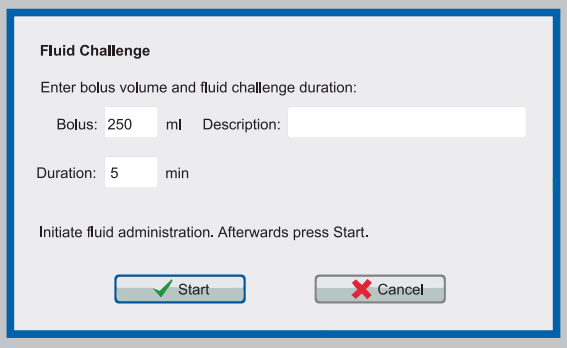
1 SELECT TEST



» Start ICG measurement » Press "Measure..." button » Select "Fluid Challange"

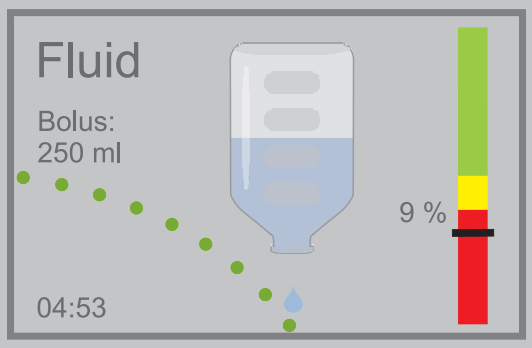


2 DEFINE PROCEDURE



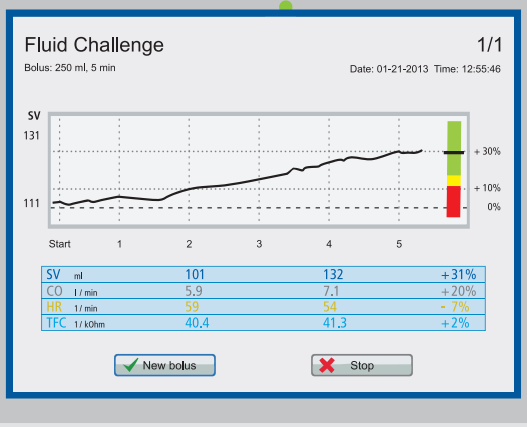
» Enter bolus volume » Enter infusion duration » Start recording and infusion

3 MONITOR PROCESS

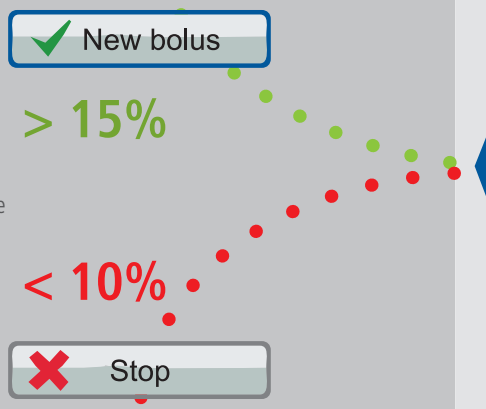


Stroke Volume change is recorded over the selected time periode

4 GET RESULTS



5 DECIDE



Depending on Stroke Volume change continue or stop fluid administation

6 STOP

Stop fluid administration

References:

Al-Khafaji A, Webb AR. Fluid resuscitation. Cont. Edu. in Anaesthesia Crit Care & Pain, Vol. 4 No. 4, 2004

Vincent JL, Weil MH. Fluid challenge revisited. Crit Care Med 2006 Vol. 34, No. 5

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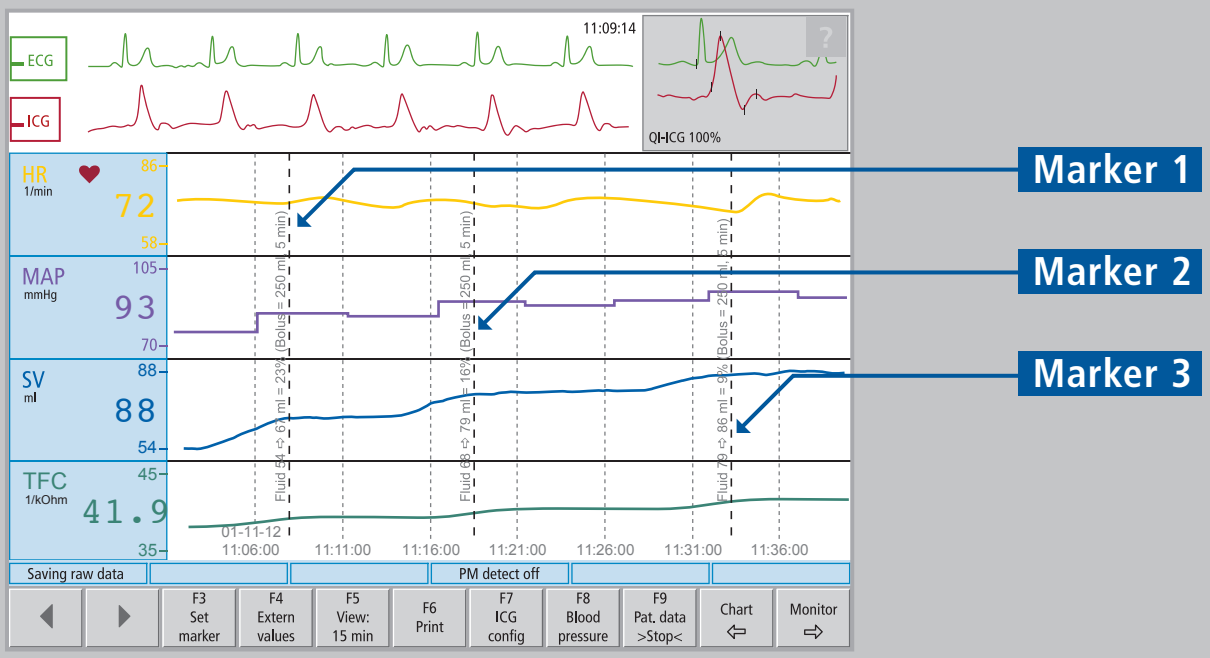
AUTOMATIC RECORDING



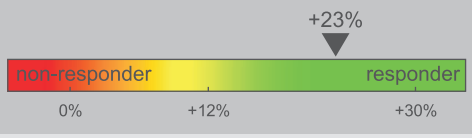
PRINT DOCUMENTATION

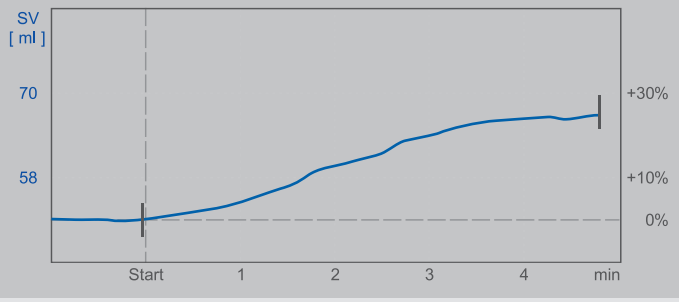
FLUID CHALLANGE

Date: 01.11.2012 Time: 11:08:12 Bolus: 250 ml, 5 min

1

SV	ml	54	→	67	= +23%
CO	l/min	3.9	→	4.7	= +20%
HR	1/min	72	→	70	= -3%
TFC	1/kOhm	38.2	→	39.4	= +3%

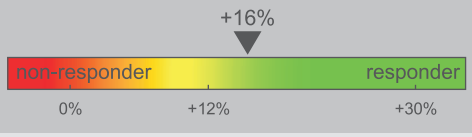


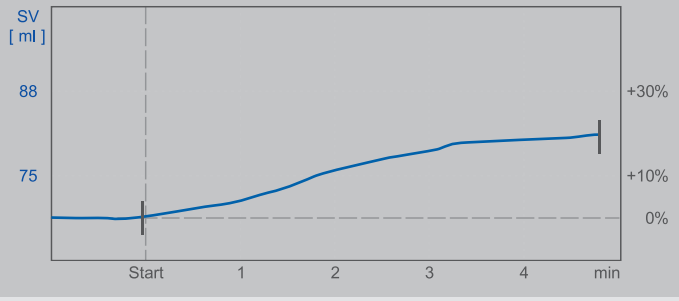


Date: 01.11.2012 Time: 11:18:27 Bolus: 250 ml, 5 min

2

SV	ml	68	→	79	= +16%
CO	l/min	4.6	→	5.5	= +19%
HR	1/min	68	→	70	= +3%
TFC	1/kOhm	39.3	→	40.5	= +4%

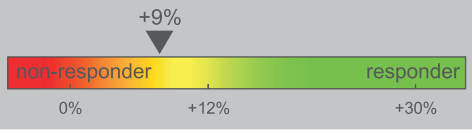


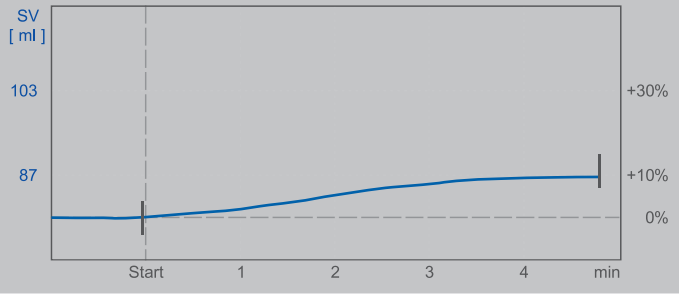


Date: 01.11.2012 Time: 11:33:17 Bolus: 250 ml, 5 min

3

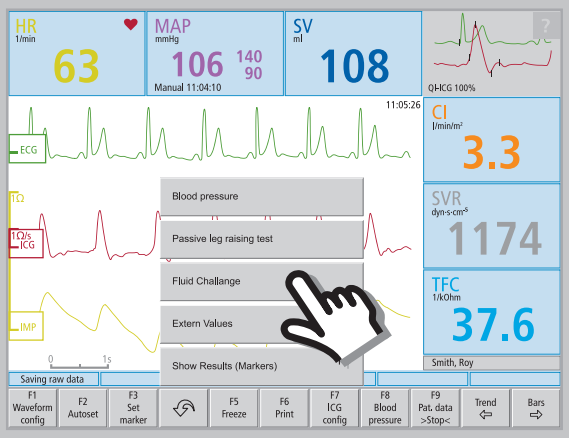
SV	ml	79	→	86	= +9%
CO	l/min	5.6	→	5.8	= +4%
HR	1/min	71	→	68	= -4%
TFC	1/kOhm	40.4	→	41.9	= +4%



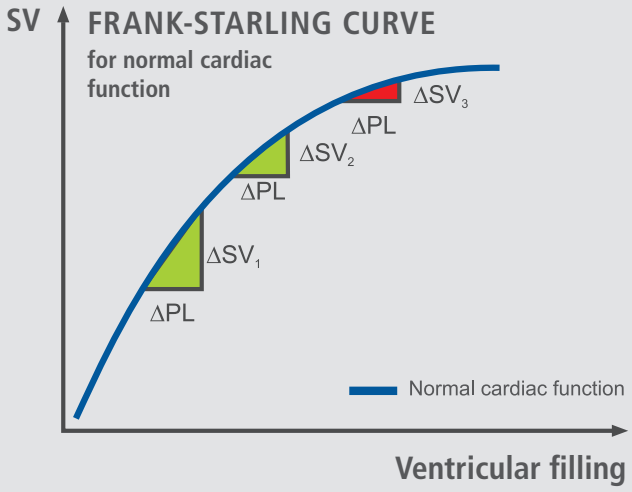


PASSIVE LEG RAISING TEST · FLUID CHALLANGE WITHOUT INFUSION

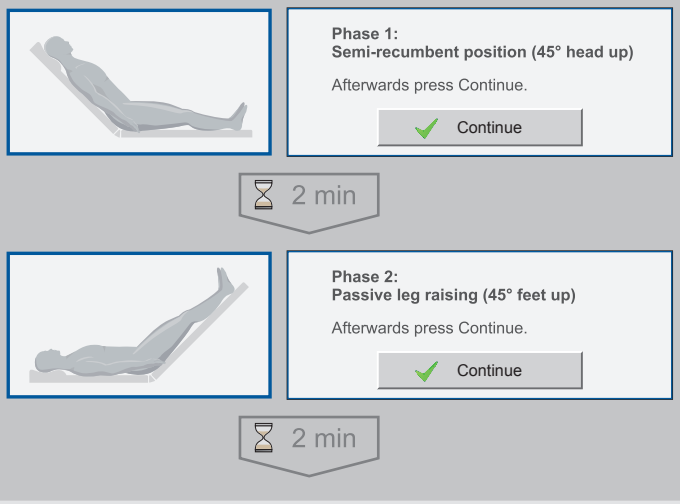
1 SELECT TEST



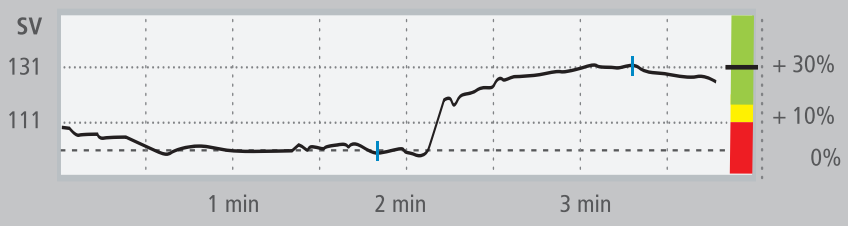
» Start ICG measurement » Press "Measure..." button » Select "Fluid Challange"



2 PERFORM MEASUREMENT



3 GET RESULTS



Patient fluid responsive

Patient not fluid responsive

References:
Monnet X, Richard C Teboul JL. Passive Leg Raising.
Intensive Care Medicine, Vol. 34, Issue 4, 2008

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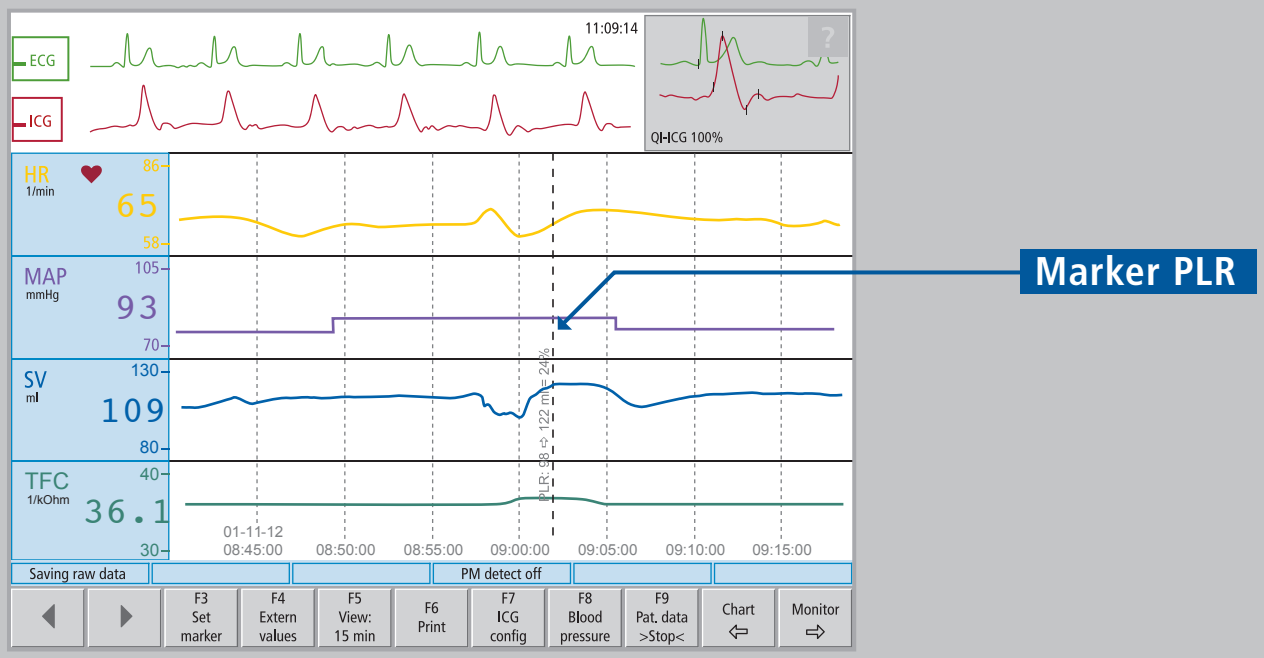
AUTOMATIC RECORDING



PRINT DOCUMENTATION

PASSIVE-LEG-RAISING-TEST

Date: 15.01.2013 Time: 09:10:12

1

SV	ml	98	→	122	=	+24%
CO	l/min	6.3	→	7.2	=	+14%
HR	1/min	64	→	59	=	-7%
TFC	1/kOhm	36.1	→	36.7	=	+2%