Неінвазивний моніторинг серцевого викиду

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Київ
25 квітня 2013

No conflicts of interest

Despite improvements in resuscitation and supportive care, progressive organ dysfunction occurs in a large proportion of patients with acute, life-threatening illnesses and those undergoing major surgery.

Sakr Y et al. Crit Care Med 32:1825-1831, 2004

Early aggressive resuscitation of critically ill patients may limit and/or reverse tissue hypoxia and progression to organ failure and improve outcome.

Shapiro NI et al. Crit Care Med 34:1025-1032, 2006


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ORIGINAL ARTICLE

Early Goal-Directed Therapy in the Treatment of Severe Sepsis and Septic Shock

Emanuel Rivers, M.D., M.P.H., Bryant Nguyen, M.D., Suzanne Havstad, M.A., Julie Ressler, B.S., Alexandria Muzzin, B.S., Bernhard Knoblich, M.D., Edward Peterson, Ph.D., and Michael Tomlanovich, M.D. for the Early Goal-Directed Therapy Collaborative Group

N Engl J Med 2001; 345:1368-1377 | November 8, 2001 | DOI: 10.1056/NEJMoa010307

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Abstract | Article | References | Citing Articles (2479)

BACKGROUND

Goal-directed therapy has been used for severe sepsis and septic shock in the intensive care unit. This approach involves adjustments of cardiac preload, afterload, and contractility to balance oxygen delivery with oxygen demand. The purpose of this study was to evaluate the efficacy of early goal-directed therapy before admission to the intensive care unit.

Full Text of Background ...

MEDIA IN THIS ARTICLE

FIGURE 2

Protocol for Early Goal-Directed Therapy.

protocol of early goal-directed therapy reduces organ failure and improves survival in patients with severe sepsis and septic shock

Rivers E a. N Engl J Med 345:1368-1377, 2001

Optimization of cardiac output (CO) in patients undergoing major surgery has been shown to reduce postoperative complications and the length of stay.

Hamilton MA, Cecconi M, Rhodes A: Anesth Analg 112:1392-1402, 2011

Excessive fluid resuscitation has been associated with increased complications, increased lengths of intensive care unit and hospital stay, and increased mortality.

…only about 50% of hemodynamically unstable patients are volume responsive.

Boyd JH et al. Crit Care Med 39:259-265, 2011

Выводы

If the fluid challenge does not increase the SV, volume loading serves the patient no useful benefit and is likely to be harmful.

The measurements of SV and CO are fundamental to the hemodynamic management of critically ill and injured patients and unstable patients in the operating room.

Both fluid challenges and the use of inotropic agents/vasopressors should be based on the response of the SV to either of these challenges.

Adolf Eugen Fick
(1829-1901)

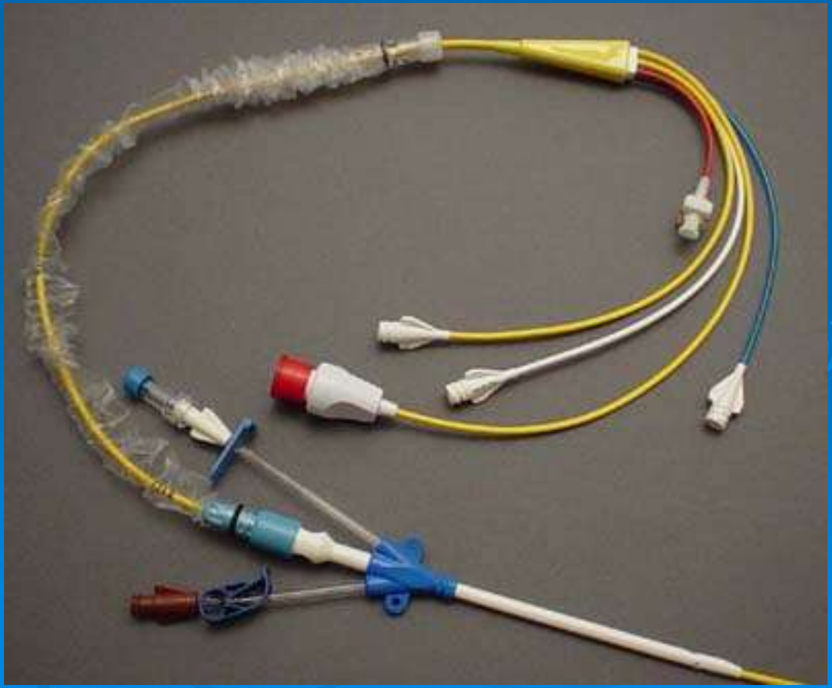
Adolph Fick described the first method of CO estimation in 1870

$$\dot{Q} = \dot{V}O_2/(Ca_{O_2} - C\bar{v}_{O_2})$$

the reference standard of determining CO until the introduction of the PAC in the 1970s

PAC in the 1970s

Swan-Ganz Catheter

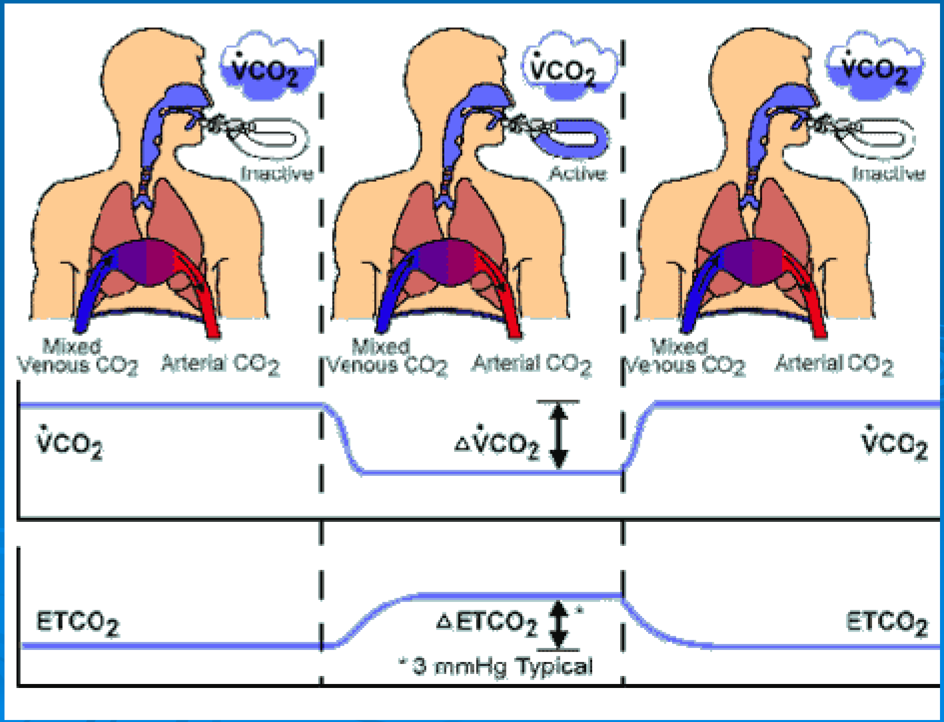


gold standard for the measurement of CO and is the reference standard used to compare noninvasive technologies

CO AS MEASURED BY CARBON DIOXIDE REBREATHING

the modified Fick equation
NICO (Respironics, Murraysville, PA)

A limitation of the rebreathing CO2 CO method is that it only measures pulmonary capillary blood flow (ie, the nonshunted portion of the CO)



hyperventilation
low minute ventilation,
high shunt fraction
high CO

Considering the limitations of this technology and the potential inaccuracies, the routine use of the CO_2 rebreathing technique to guide fluid and vasopressor therapy cannot be recommended.

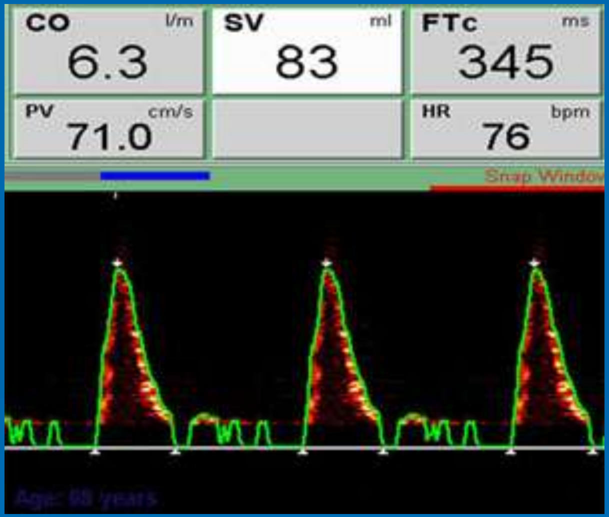
Paul E. Marik. Journal of Cardiothoracic and Vascular Anesthesia, Vol 27, No 1 (February), 2013: pp 121-134

ESOPHAGEAL DOPPLER

the resulting waveform is highly dependent on correct positioning

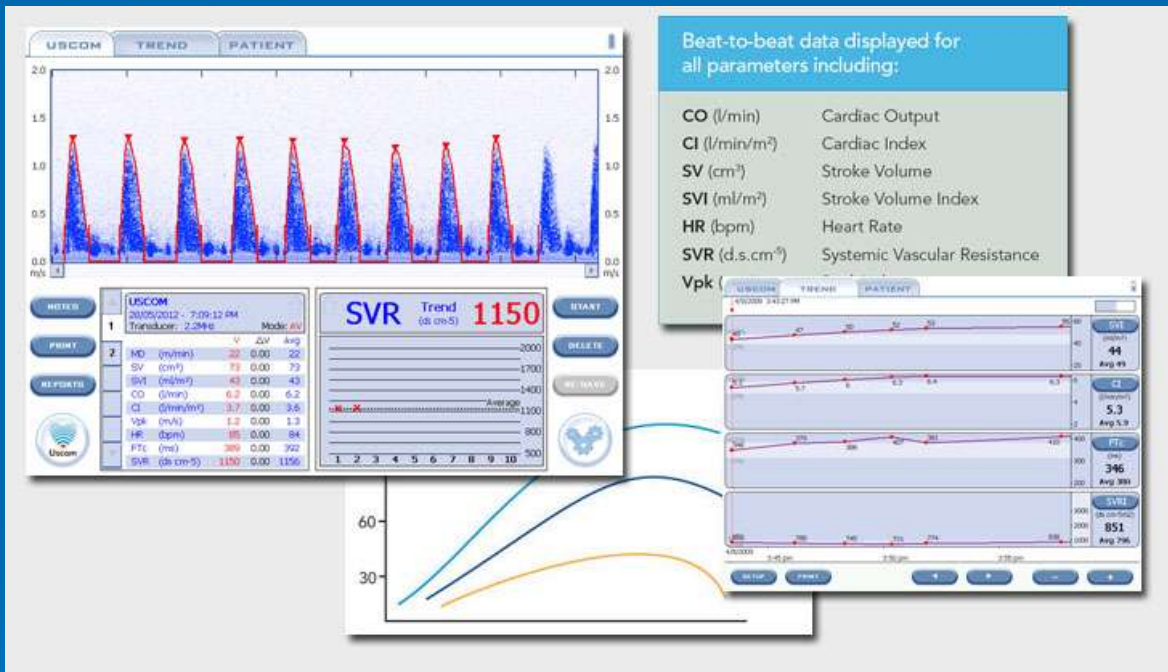
A major limitation of esophageal Doppler monitoring is the assumption that a fixed percentage of the CO is directed to the head and descending aorta.

The clinician must adjust the depth, rotate the probe, and adjust the gain to obtain an optimal signal.



..in hemodynamically unstable patients the increase in blood flow velocity in the descending aorta may not correlate well with the increase in the SV.

completely noninvasive Doppler technology, the ultrasound CO monitor (USCOM, Sydney, Australia)

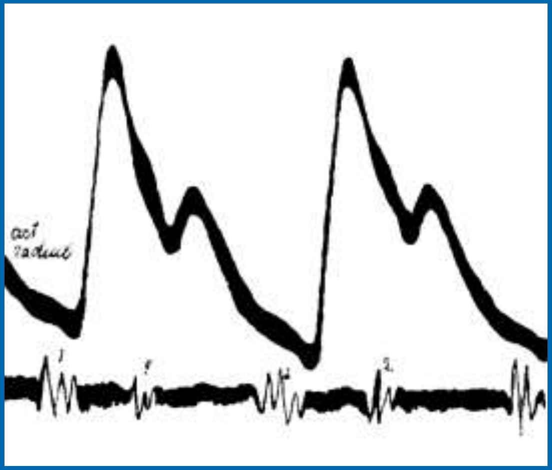


limitation of this technique is that it is not conducive to continuous monitoring

PULSE CONTOUR ANALYSIS

relation among:

- blood pressure
- SV
- arterial compliance
- systemic vascular resistance (SVR)



3 categories:

(1) pulse contour analysis requiring an indicator dilution CO measurement to calibrate the pulse contour (LiDCO System; LiDCO, Cambridge, UK; and PiCCO System; Pulsion, Munich, Germany)

(2) pulse contour analysis requiring patient demographic and physical characteristics for arterial impedance estimation (ie, FloTrac System; Edwards Lifesciences, Irvine, CA)

(3) pulse contour analysis that does not require calibration or preloaded data (ie, MostCare System; Vyetech Health, Padua, Italy).

LIMITS

The differences in blood pressure among different sites may be large, and in conditions of intense vasoconstriction, the radial blood pressure may underestimate the true aortic blood pressure, giving a falsely low CO value.

Furthermore, it has been shown that in volume-responsive patients there is selective redistribution of blood flow to the cerebral circulation with a significantly smaller percentage increase in blood flow in the brachial artery.

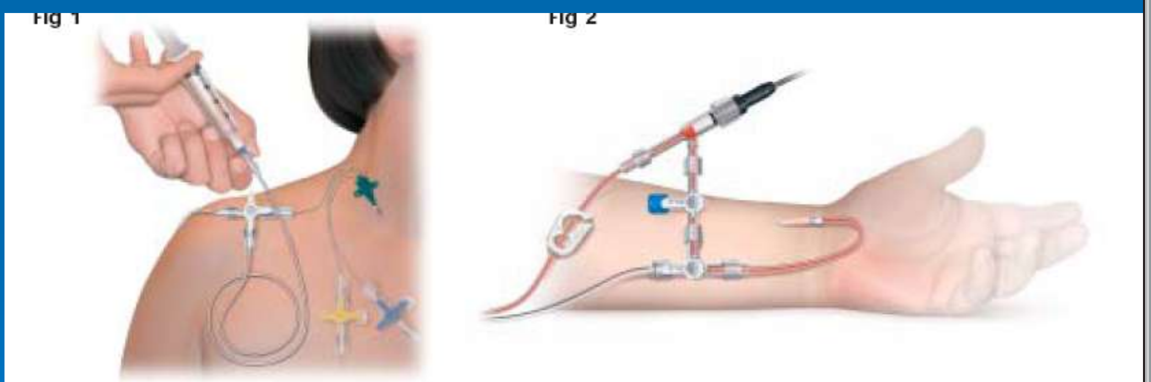
This may lead to a significant error when the radial pulse is used for pulse contour analysis.

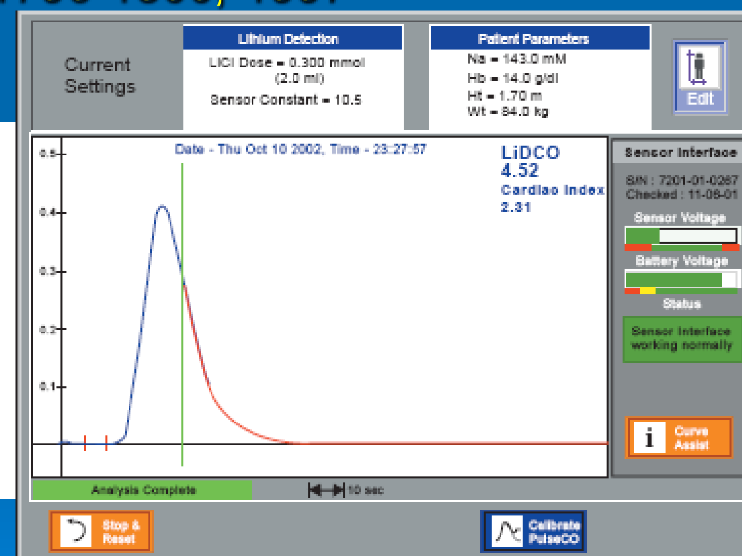
Marik PE et al. Ann Crit Care 2012

Lithium Dilution and Pulse Contour Analysis

The LiDCO …. to be at least as reliable as other thermodilution methods over a broad range of CO in a variety of patients.

Bein B et al. J Cardiothorac Vasc Anesth 18:185-189, 2004
Mora B et al. J Anesth 66:675-681, 2011
Garcia-Rodriguez C et al. Crit Care Med 30:2199-2204, 2002
Linton R et al. Crit Care Med 25:1796-1800, 1997





Cardiac Output = (Lithium Dose x 60)/(Area x (1-PCV))

Recalibration should be performed after acute hemodynamic changes and after any intervention that alters vascular impedance.

Transpulmonary Thermodilution and Pulse Contour Analysis

PiCCO

via continuous pulse contour analysis

- Continuous pulse contour cardiac analysis (PCCO)
- Arterial blood pressure (AP)
- Heart rate (HR)
- Stroke volume (SV)
- Stroke volume variation (SVV)
- Systemic vascular resistance (SVR)
- Index of left ventricular contractility

Transpulmonary Thermodilution and Pulse Contour Analysis

PiCCO

via intermittent transpulmonary thermodilution

- Transpulmonary cardiac output (C.O.)
- Intrathoracic blood volume (ITBV)
- Extravascular lung water (EVLW)
- Cardiac function index (CFI)

In a randomized controlled trial, Mutoh et al. showed an improved clinical outcome for patients with subarachnoid hemorrhage randomized to a PiCCO-based hemodynamic algorithm as compared with the “standard of care,” which used a PAC algorithm.

Mutoh T. Stroke 40:2368-2374, 2009

Pulse Contour Requiring Patient Demographic and Physical Characteristics and No Calibration

FloTrac sensor

Vigileo monitor

The basic principle of the system is the linear relation between the pulse pressure and the SV.

$$SV = SD_{AP} \times X_{l}$$

The factor X_{l} represents the conversion factor that depends on:

- arterial compliance
- the mean arterial pressure
- waveform characteristics

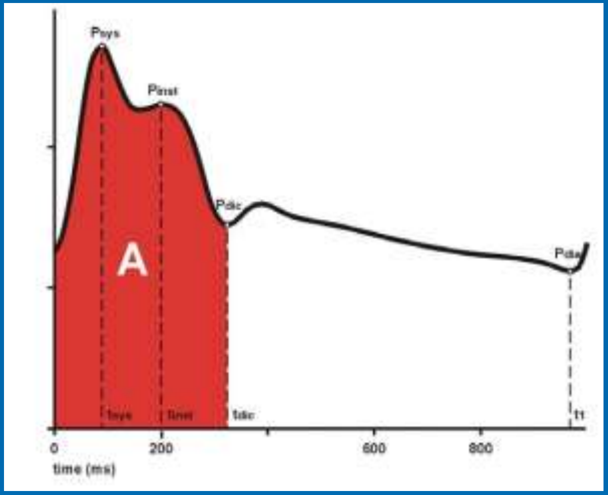
Limit: the system does not track changes in the SV accurately after a volume challenge or after the use of vasopressors

Pulse Contour Requiring No Patient Data and No Calibration

The MostCare system

the pressure recording analytic method (PRAM)

The area under the curve of the arterial waveform



The accuracy of this system:

- the patent holder’s group showing good results
- independent studies have shown mixed results

Table 1. Overview of the Pulse Contour-Based Hemodynamic Monitoring Devices[43]

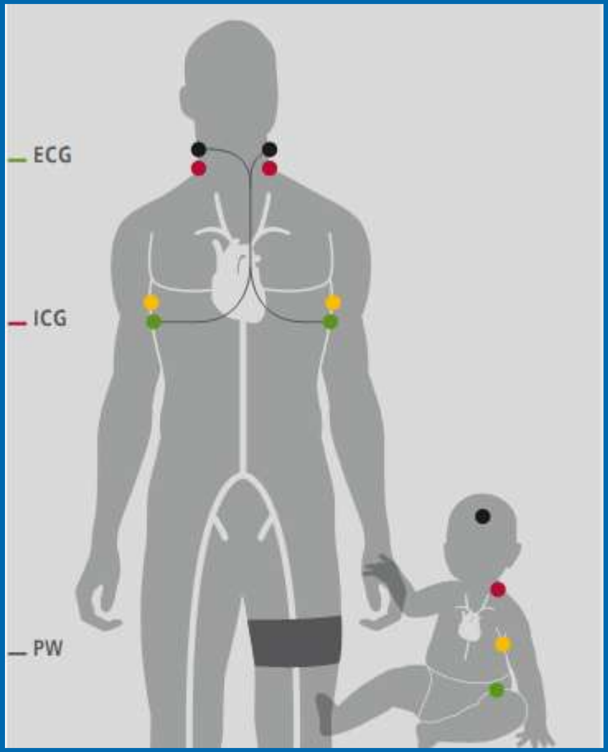
System Characteristic	FloTrac System	PiCCO System	LiDCO System	PRAM
Arterial waveform analysis	SD of 2000 arterial waveform points	Area under the systolic portion of the arterial waveform	RMS method applied to the arterial pressure signal	Area under curve
Requirements	Peripheral or central arterial catheter	Central arterial catheter and subclavian or IJ CVC	Peripheral or central arterial catheter	Peripheral or central arterial catheter
Calibration	Uncalibrated/internal	Transpulmonary thermodilution	Lithium indicator dilution Manual	Uncalibrated/internal Automatic
Recalibration	Automatically		Manual	
Indicator	None	Saline	Lithium	None
Additional parameters		SVV	SVV, PPV, GEDV, EVLW, SVR	SVV, PPV
Advantages	Minimally invasive Operator independent Easy to use	Broad range of hemodynamic parameters More robust during hemodynamic instability	Minimally invasive More robust during hemodynamic instability	Minimally invasive
Disadvantages	Inaccurate especially in vasoplegic patients Does not accurately track changes in SV	More invasive	Requires lithium	Few validation studies

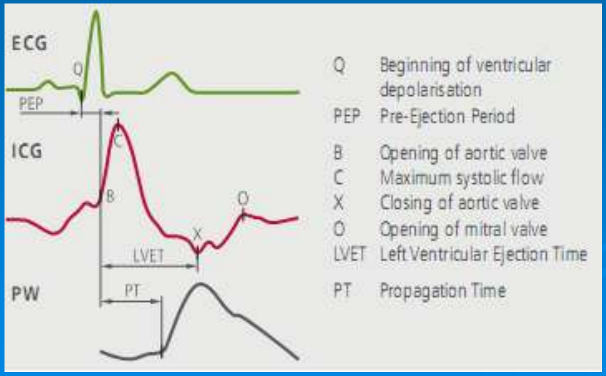
Adapted with permission.[43]

Abbreviations: CVC, central venous catheter; GEDV, global end-diastolic volume; EVLW, extravascular lung water; IJ, internal jugular; RMS, root mean square.

Montenij LJ, de Waal EE, Buhre WF: Arterial waveform analysis in anesthesia and critical care. Curr Opin Anaesthesiol 24:651-656, 2011

THORACIC BIOIMPEDANCE





SV is proportional to the product of maximal rate of the change of Zo (dZo/dtmax) and ventricular ejection time (VET).

THORACIC BIOIMPEDANCE

PARAMETERS

FLOW		
HR	Heart Rate	Heart beats per minute
BP	Blood Pressure	Pressure exerted by the blood on arterial walls
SV SI	Stroke Volume Stroke Index	Amount of blood pumped by the left ventricle with each heart beat
CO CI	Cardiac Output Cardiac Index	Amount of blood pumped by the heart in one minute
CONTRACTILITY		
VI	Velocity Index	Reflects the peak velocity of blood flow in the aorta during systole
ACI	Acceleration Index	Reflects the maximum acceleration of blood flow in the aorta during systole
HI	Heather Index	Contractility indicator
PEP	Pre-Ejection Period	Duration of electrical systole equal to isovolumetric contraction phase
STR	Systolic Time Ratio	Ratio of electrical systole to mechanical systole
FLUID		
TFC	Thoracic Fluid Content	Indicator of chest fluid status
TFCI	TFC index	TFC, normalised to body size
VASCULAR		
PT	Propagation Time	Propagation time of the pulse wave
PWVao	Pulse Wave Velocity	Velocity of the aortic pulse wave
SVR	Systemic Vascular Resistance	The force the ventricle must overcome to eject blood into the aorta, estimate of "afterload"
SVRI	SVR index	SVR, normalised to body size
TAC	Total Arterial Compliance	Indicator of the degree of peripheral arterial stiffness / compliance
TACI	TAC index	TAC, normalised to body size

Bioimpedance has been found to be inaccurate in the intensive care unit and other settings in which significant electric noise and body motion exist and in patients with increased lung water.

Raue W et al. Eur J Anaesthesiol 26:1067-1071, 2009

…this technique is sensitive to:

- the placement of the electrodes
- variations in patient body size
- the skin temperature and humidity

Wang DJ, Gottlieb SS. Curr Cardiol Rep 8:180-186, 2006

BIOREACTANCE

NICOM device (Cheetah Medical, Portland, OR)

bioreactance - the phase shift in voltage across the thorax

ПАРАМЕТРЫ

Обозначение	Наименование параметра	Границы	ед.изм.
CO	Сердечный выброс	0-99.0	л/мин
CI	Сердечный индекс	0-99.0	л/мин/м^2
SV	Ударный объем	0-999	мл/удар
SVV	Изменение ударного объема	0-99	%
SVI	Индекс ударного объема	33-47	мл/м^2/удар
HR	Частота сердечных сокращений	0-240	уд/мин
NBP	Неинвазивное артериальное давление	20-260	мм рт.ст.
TPR	Общее периферическое сопротивление	0-9999	NIBP/CO; дин*сек/см^5
Z	Грудной импенданс	0-99	Ом
TFC	Внутригрудное содержание жидкости	0-999	1000/Ом
VET	Время изгнания левого желудочка	0-999	млсек

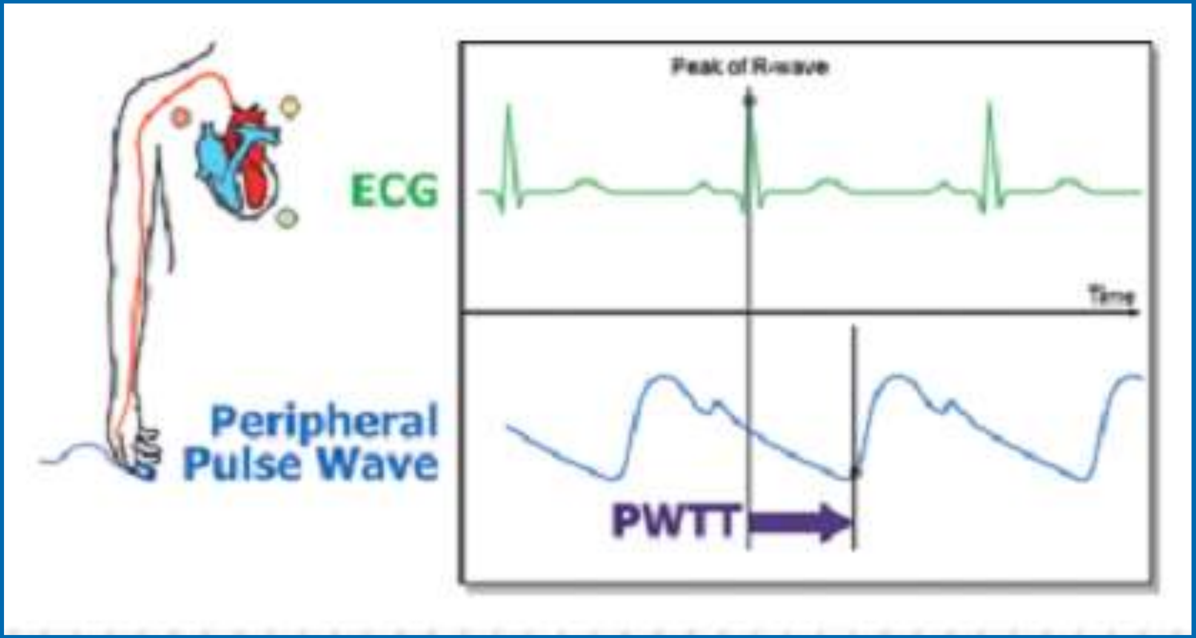
Гемодинамический экран


Экран трендов программы обработки данных

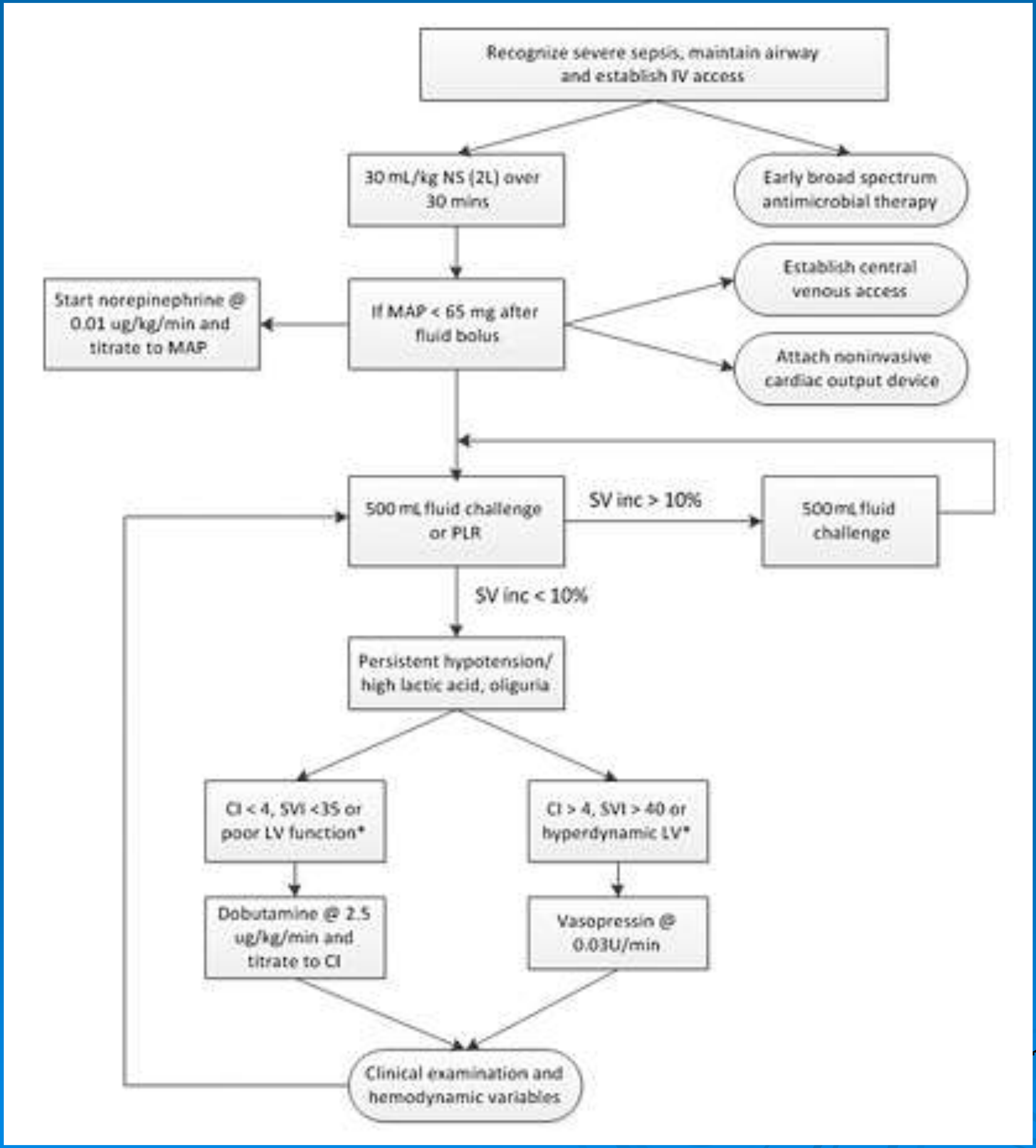
Additional studies are required to confirm the accuracy, reliability, and versatility with this device and to show improved patient outcomes.

- in ventilated and nonventilated patients
- In patients with atrial and ventricular arrhythmias
- in the emergency room, intensive care unit, and operating room

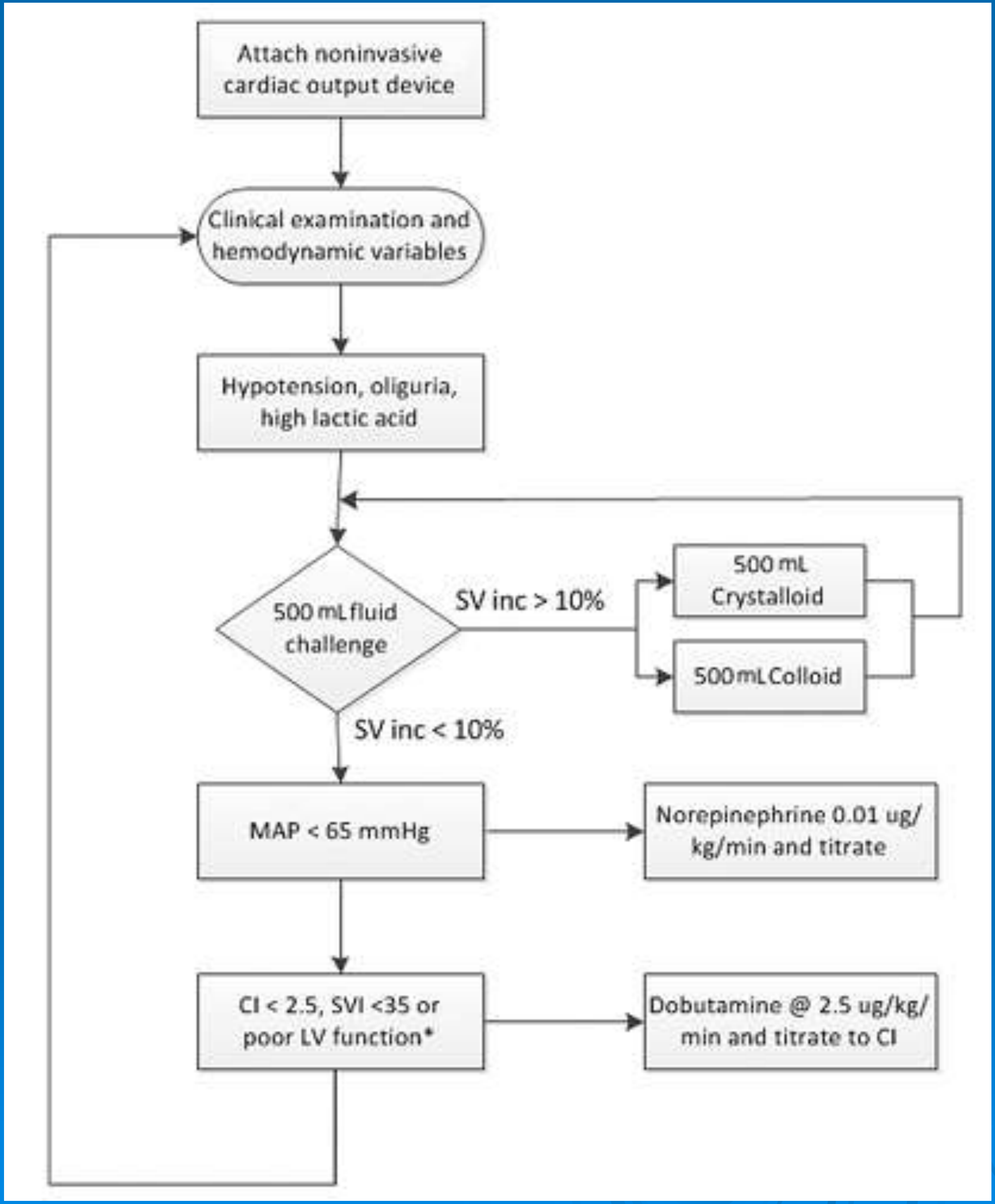
Estimated Continuous Cardiac Output esCCO



CO = SV x HR = K X (α x PWTT x β) x HR = esCCO



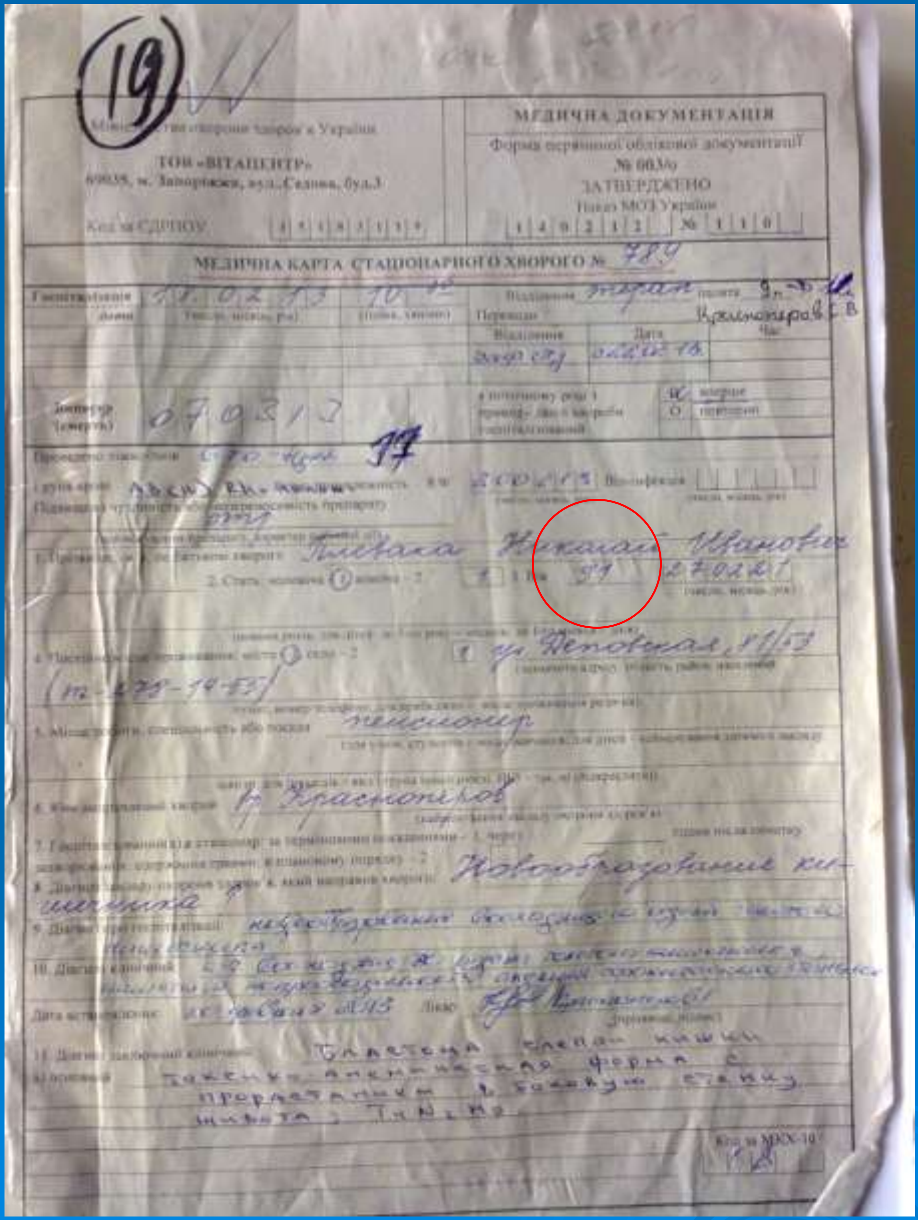
The protocol for early goal-directed resuscitation of patients with sepsis.



The protocol for hemodynamic optimization in the operating room.

Неинвазивное измерение СВ у больных старческого возраста

- Клиника хирургии ЗГМУ
- 01.09.2012 – 23.04.2013
- Хирург Клименко В.Н., Завгородний С.Н.
- Анестезиолог Воротынцев С.И.
- Лапаратомии
- Средний возраст 82 ± 6 лет [77 - 92]
- 12 пациентов
- 11 пациентов выписаны, 1 пациент в стационаре



МЕДИЧНА ДОКУМЕНТАЦІЯ

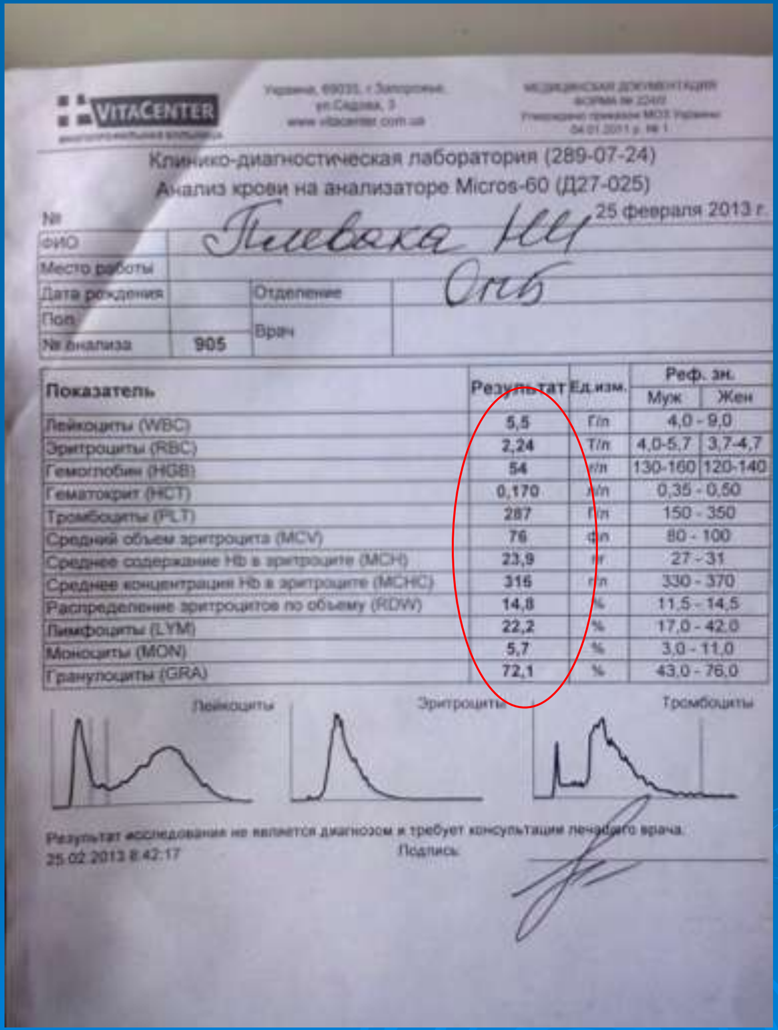
ТОВ «ВІТАЦЕНТР»

МЕДИЧНА КАРТА СТАЦІОНАРНОГО ХВОРОГО № 789

Плевака Николай Иванович

Новообразование кишечника

Бластома слепой кишки, [illegible] форма с [illegible]



VITACENTER

Клинико-диагностическая лаборатория (289-07-24)

Анализ крови на анализаторе Micros-60 (Д27-025)

25 февраля 2013 г.

№

ФИО: Плевака НИ

Место работы

Дата рождения | Отделение: Онб

Пол | Врач

№ анализа: 905

Показатель	Результат	Ед.изм.	Реф. зн. Муж	Реф. зн. Жен
Лейкоциты (WBC)	5,5	Г/л	4,0 - 9,0	
Эритроциты (RBC)	2,24	Т/л	4,0-5,7	3,7-4,7
Гемоглобин (HGB)	54	г/л	130-160	120-140
Гематокрит (HCT)	0,170	л/л	0,35 - 0,50	
Тромбоциты (PLT)	287	Г/л	150 - 350	
Средний объем эритроцита (MCV)	76	фл	80 - 100	
Среднее содержание Hb в эритроците (MCH)	23,9	пг	27 - 31	
Среднее концентрация Hb в эритроците (MCHC)	316	г/л	330 - 370	
Распределение эритроцитов по объему (RDW)	14,8	%	11,5 - 14,5	
Лимфоциты (LYM)	22,2	%	17,0 - 42,0	
Моноциты (MON)	5,7	%	3,0 - 11,0	
Гранулоциты (GRA)	72,1	%	43,0 - 76,0	

Результат исследования не является диагнозом и требует консультации лечащего врача.

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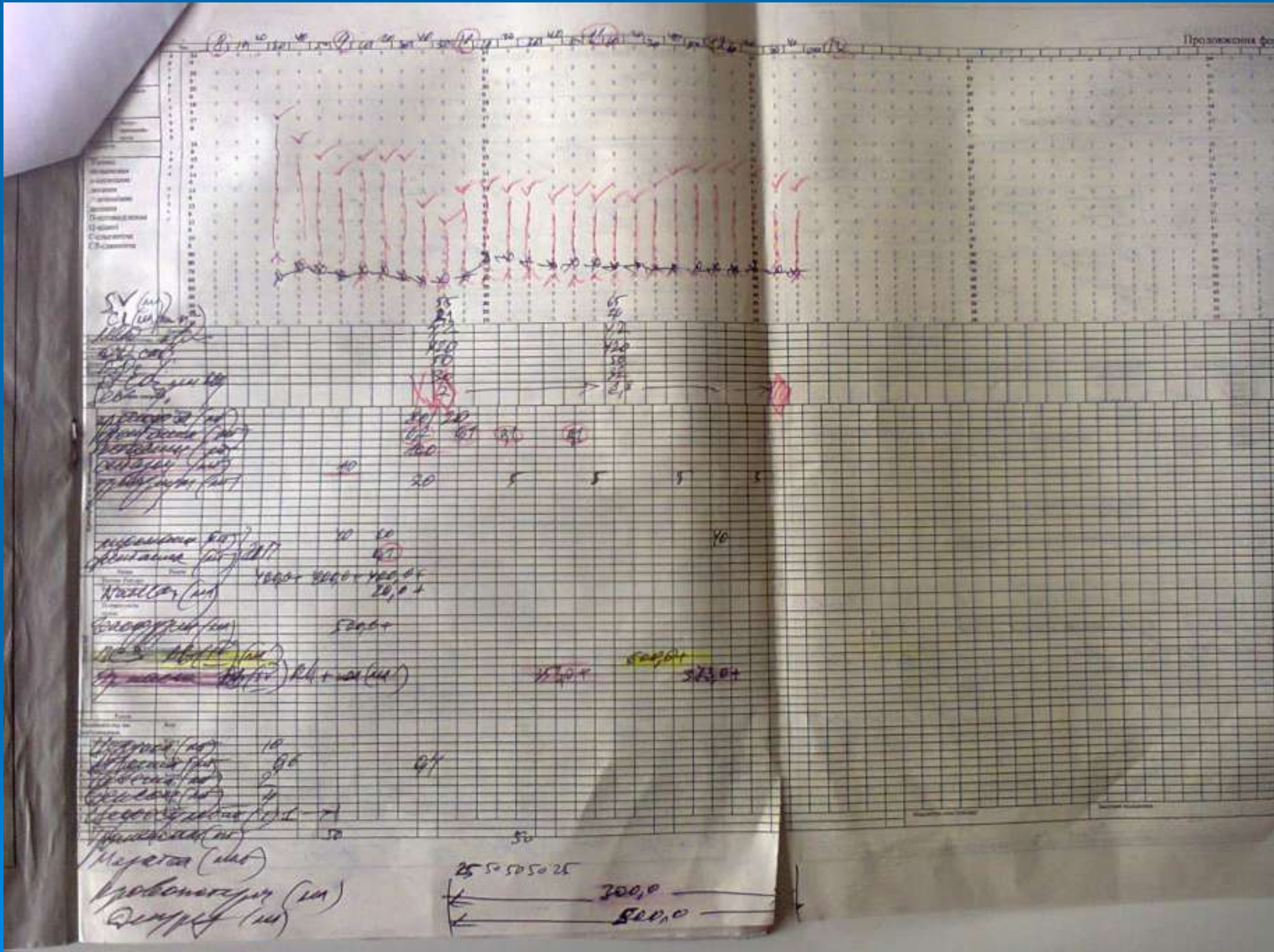
Подпись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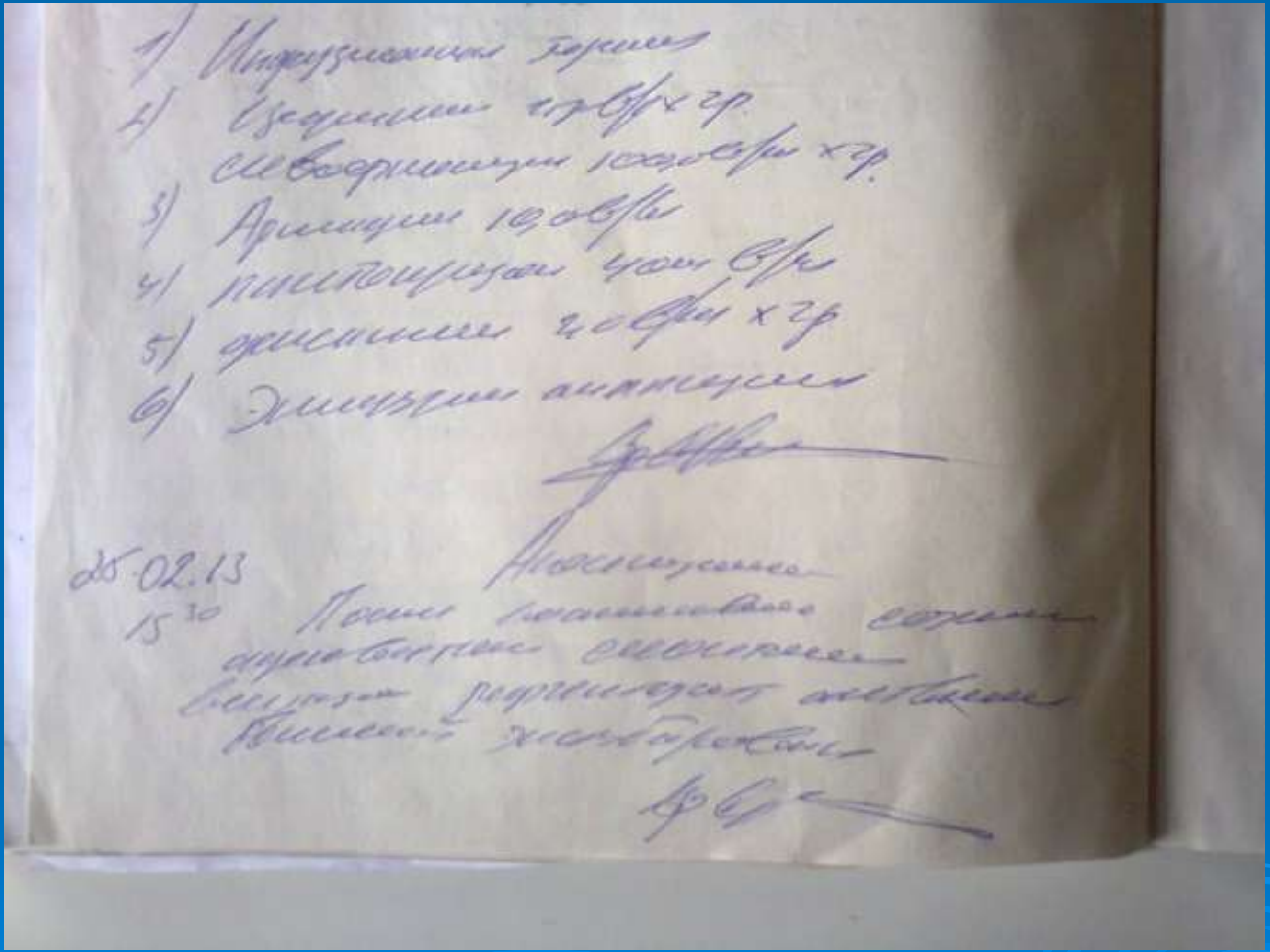
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In conclusion

Неинвазивное измерение СВ - еще один мониторируемый параметр, обеспечивающий безопасность пациентов, путем рационального использования жидкости, инотропов и вазоактивных препаратов.

Дякую за увагу