

# ICU中的动脉血压

# Monitoring in the Intensive Care

- **is essential** to the daily care of ICU patients
- **Goal:** improve patients' survival;  
fuel mitochondrial respiration and life.
- **Methods:** supply of oxygen to tissues according to their metabolic needs
- **Contents:** oxygenation and perfusion;  
(hemodynamic, ventilation, temperature, nutrition, and metabolism)

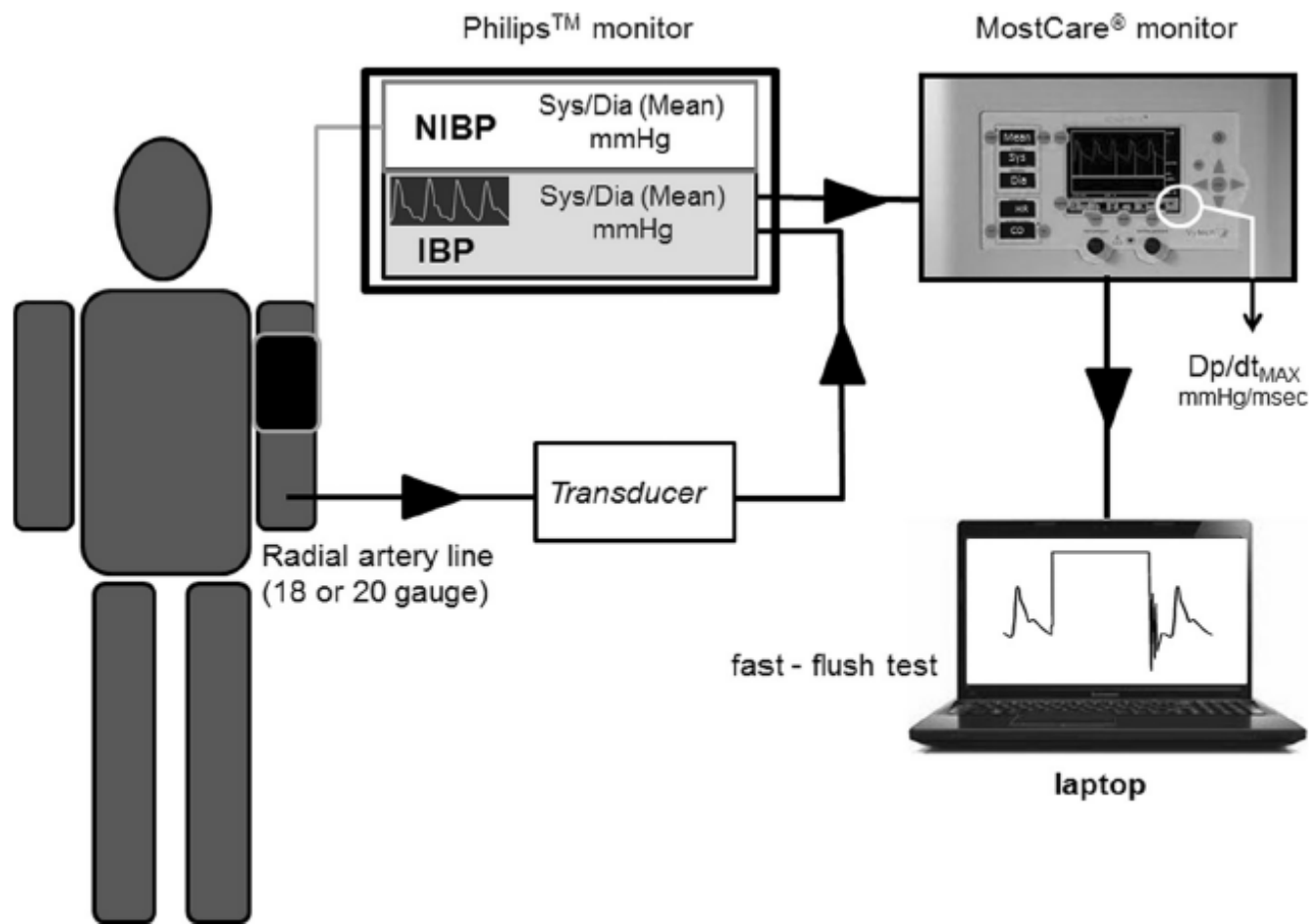
# Traditional, hemodynamic monitoring

- **noninvasive methods** of hemodynamic monitoring pertained solely to physical examination.
- **Invasive methods** included **arterial**, central venous and pulmonary artery catheterization mostly.

# Blood pressure monitoring

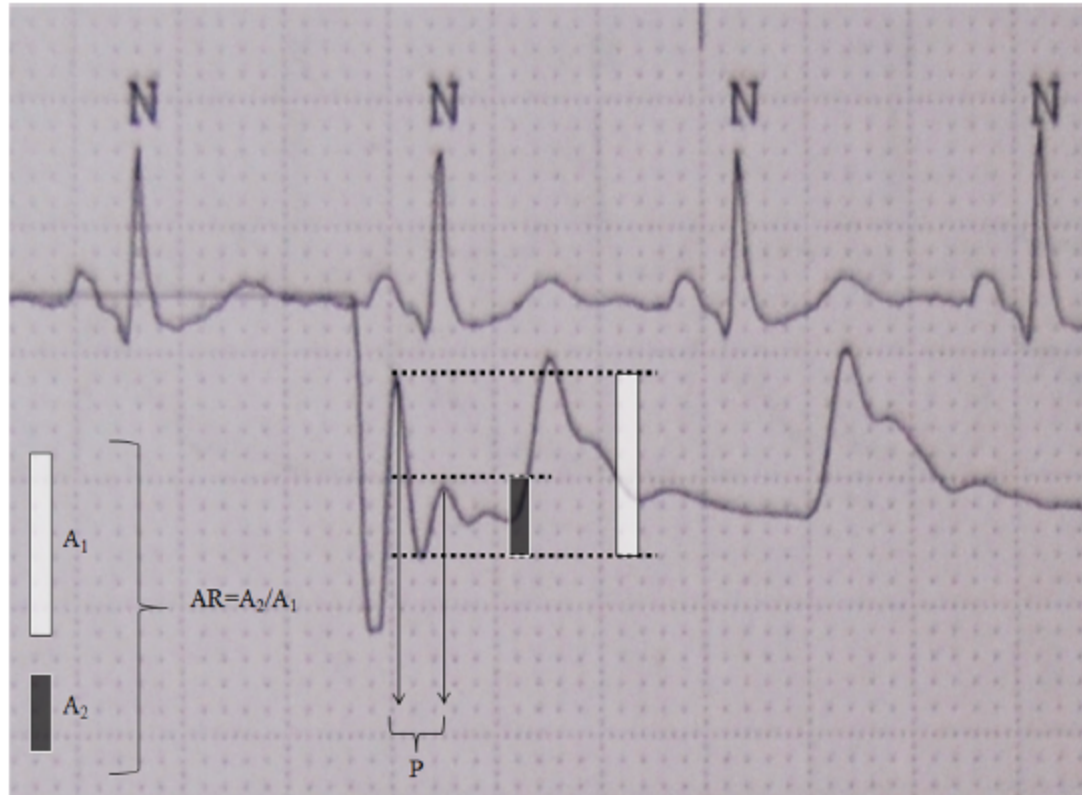
- is essential in managing **hemodynamically unstable ICU patients**
- as accurate as possible
- Methods:
  - IAP**( invasive arterial blood pressure): Invasive measurement from an arterial line
  - NIBP**( noninvasive blood pressure): oscillometric techniques

# What are they?



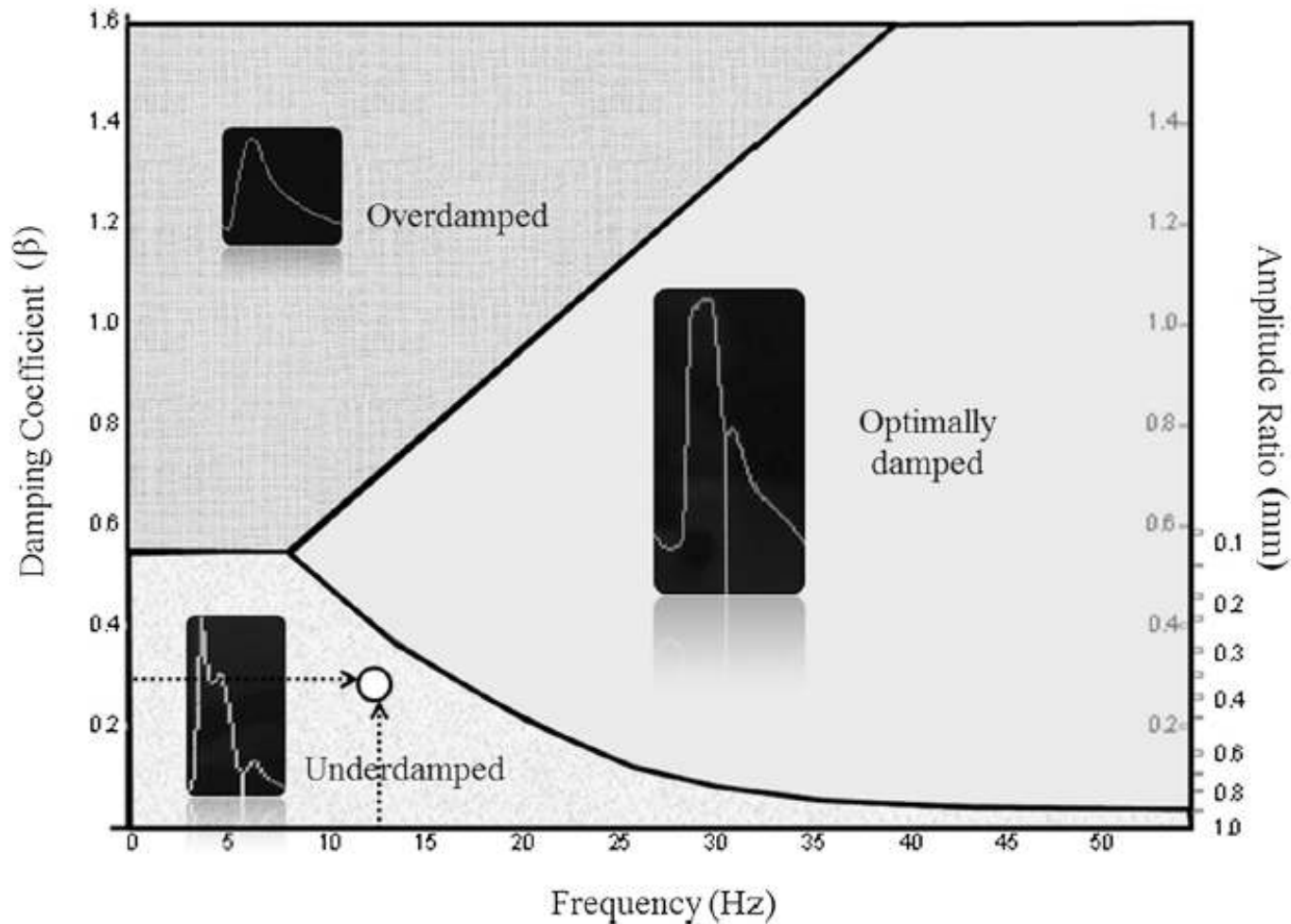
**Figure 1** Schematic representation of the patient's connection to the Philips™ monitor for invasive blood pressure (IBP) and non-invasive blood pressure (NIBP) monitoring. MostCare® is connected via an analog output for the continuous recording, at 1,000 Hz, of the systemic arterial pressure waves and  $DP/dt_{MAX}$  computation. The analog pressure signals are recorded on a personal computer for fast-flush test registration and analysis. Sys, systolic; Dia, diastolic;  $DP/dt_{MAX}$ : maximal pressure-time ratio.

# Invasive



**Figure 2 Fast-flush test.** Amplitude ratio (AR):  $A_2$  (3 mm)/ $A_1$  (7 mm) = 0.43. The corresponding damping coefficient is 0.28 [9]. P identifies the period (peak-to-peak distance) necessary for the natural frequency calculation: paper speed/P. In the example, 25 (mm/sec)/2 mm = 12.5 Hz; these data can be then plotted into the diagram showed in Figure 3. N: normal QRS complex.

# invasive



**Figure 3** Diagram showing the three areas for underdamped, overdamped, and optimally damped blood pressure signal. The black arrows indicate the natural frequency and the damping coefficient of the example showed in Figure 2. The white point identifies an underdamped/resonant arterial pressure signal.



# Non-invasive

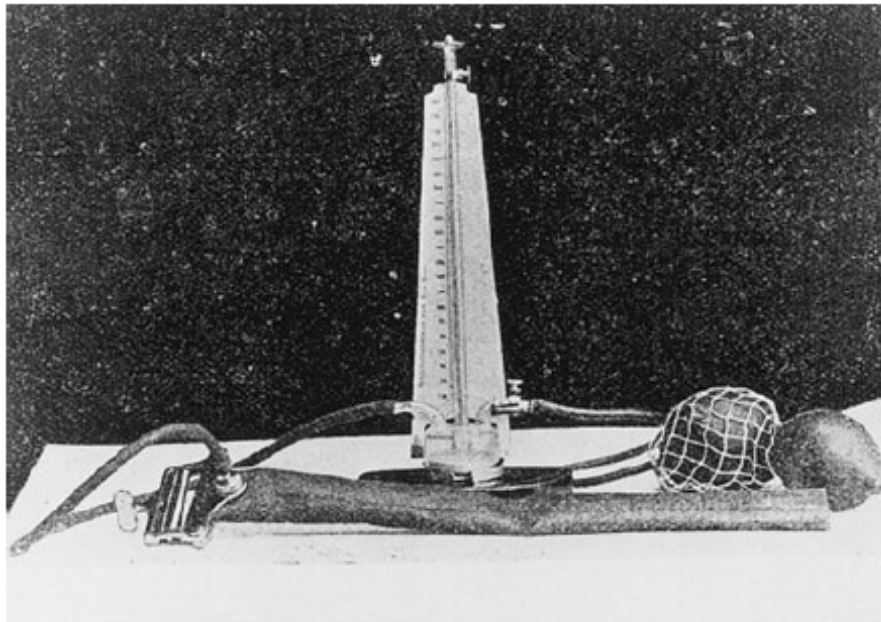


Fig. 5 In 1905, Korotkoff, a Russian surgeon, discovered the method in use for over a century — the auscultatory method — which required the inflatable blood pressure cuff and stethoscope.

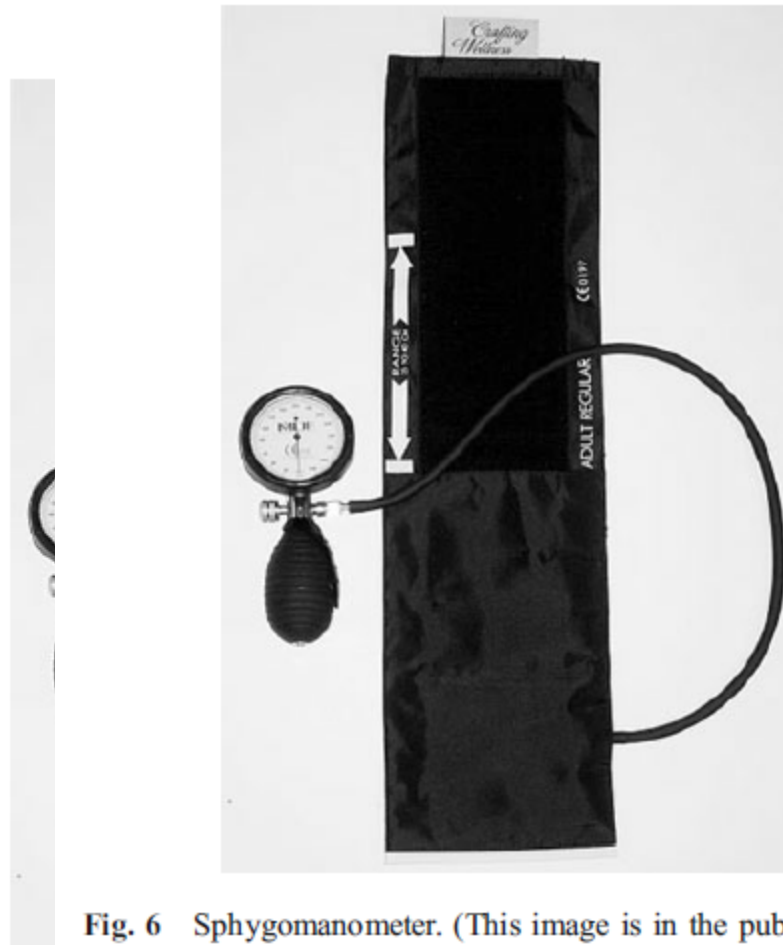


Fig. 6 Sphygmomanometer. (This image is in the publ

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# Advantages and disadvantages (invasive)

- Advantages
  - as **accurate** as possible
  - allowing **beat-by-beat measures** even in patients receiving inotropic or vasoactive drugs, or in cases of abrupt changes in blood volume or arterial tone, or those with arrhythmias
- disadvantages
  - over- or underdamping
  - calibration errors
  - movement artifacts

# Advantages and disadvantages (non-invasive)

- Advantages :
  - avoid bleeding and infection risk
  - can be used outside the ICU
- Disadvantages:
  - Not continuous**
  - during hemodynamic instability, severe hypotension, in conditions of increased arterial stiffness and in obese patients, this technique is expected to **be less accurate than the invasive one**

# gold standard

- The “gold standard” for blood pressure measurements is the invasive arterial line which typically consists of a cannula inserted into a peripheral artery.

Why does invasive blood pressure become “gold standard” for blood pressure measurements ?



# Methods of Blood Pressure Measurement in the ICU

*Crit Care Med 2013; 41:34–40*

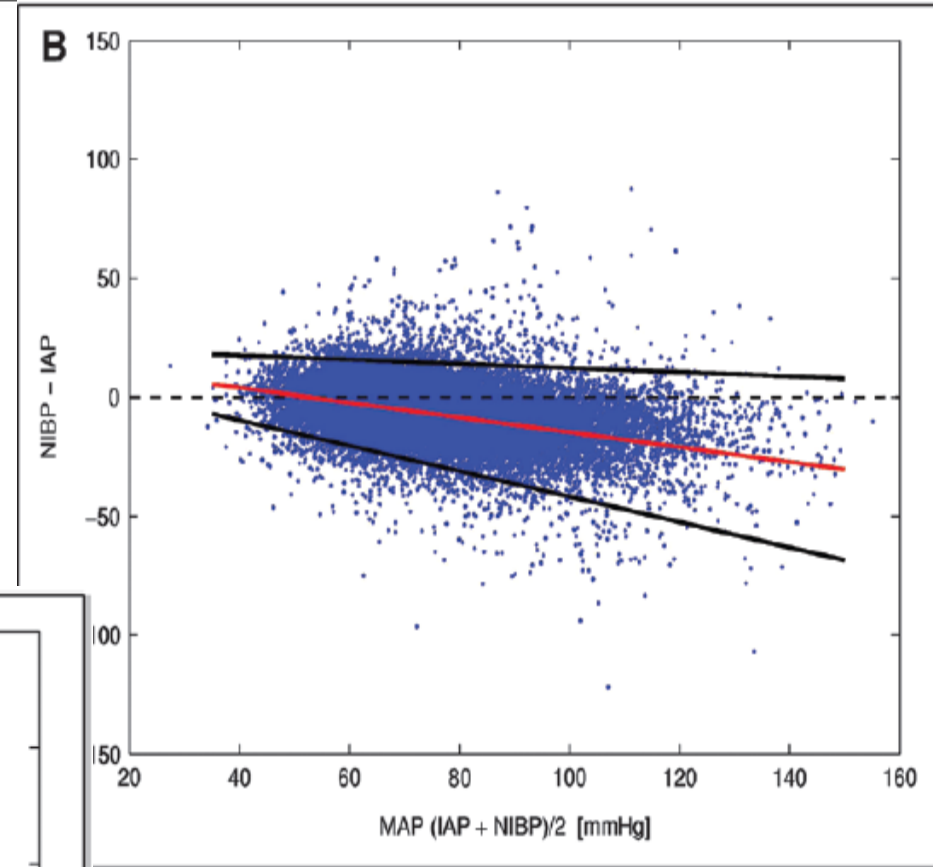
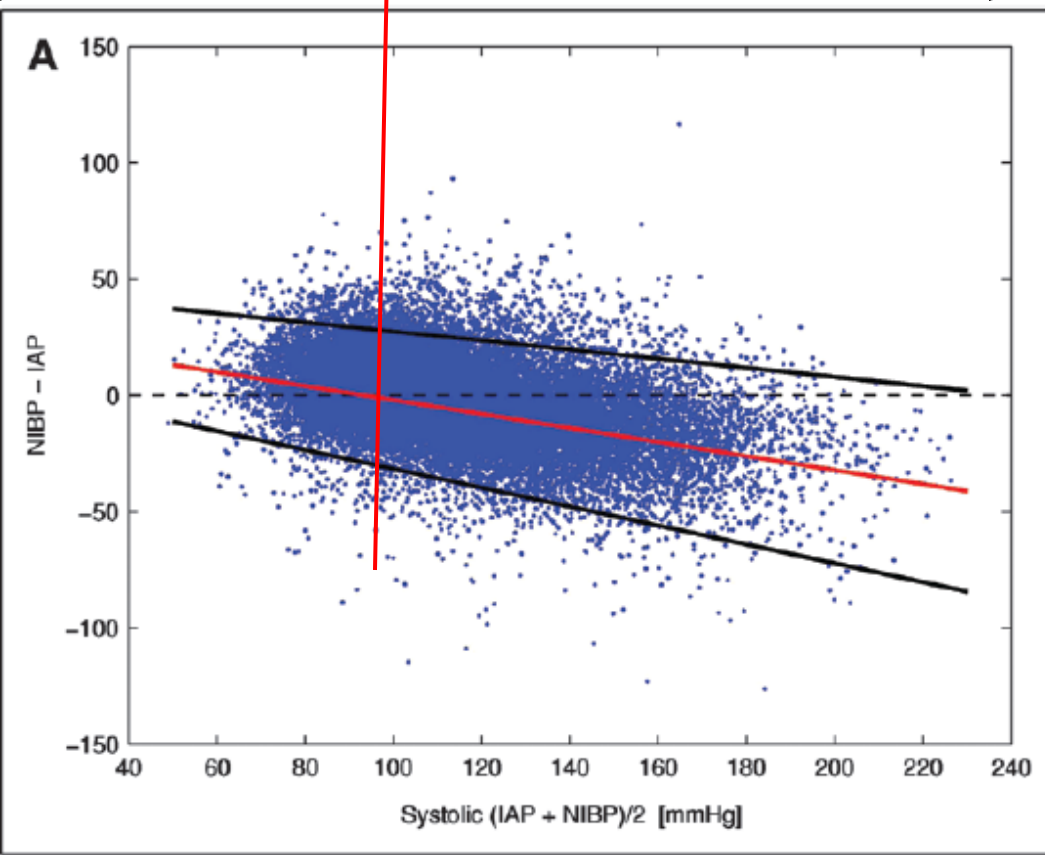
- **a retrospective study** comparing invasive arterial blood pressure and noninvasive blood pressure measurements using a large ICU database.

# Methods of Blood Pressure Measurement in the ICU

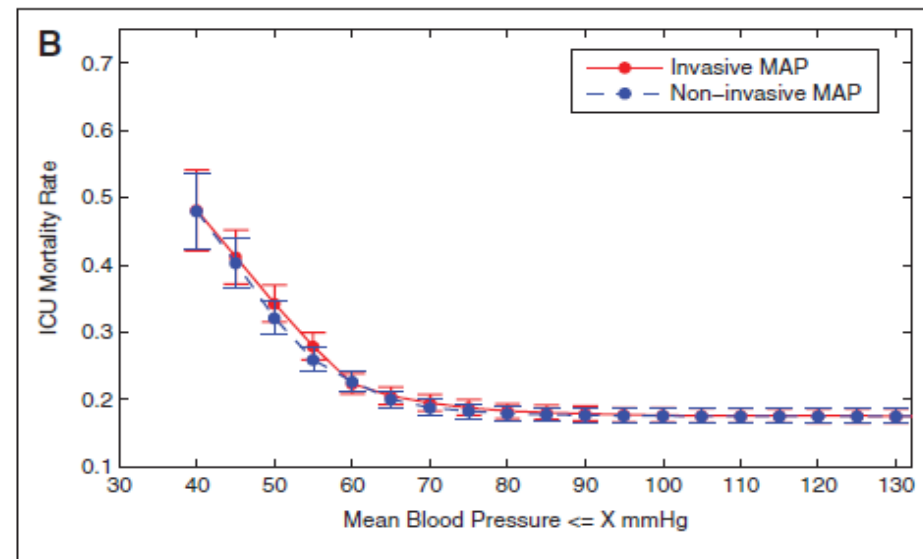
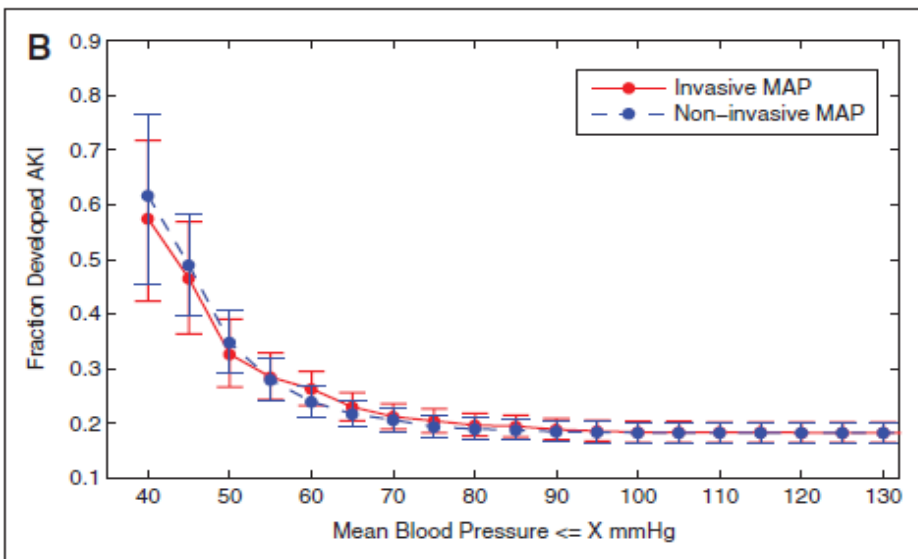
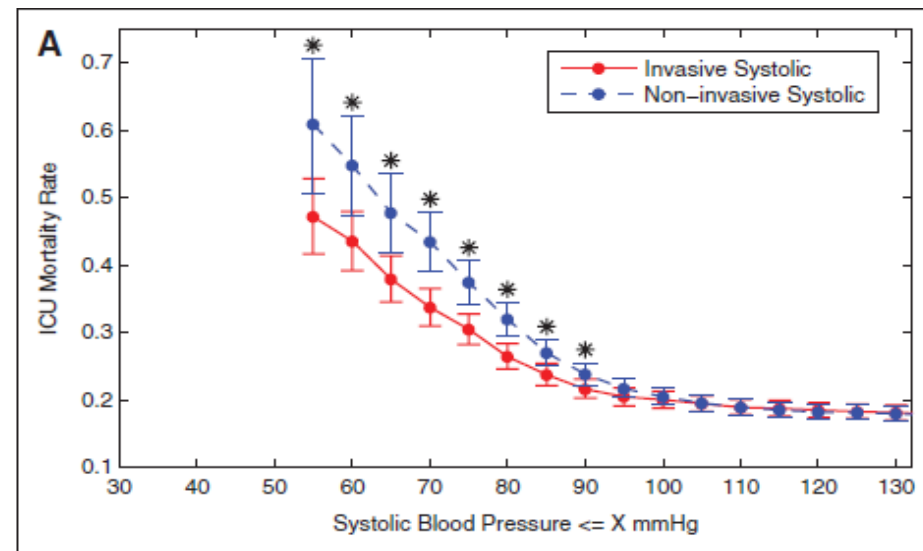
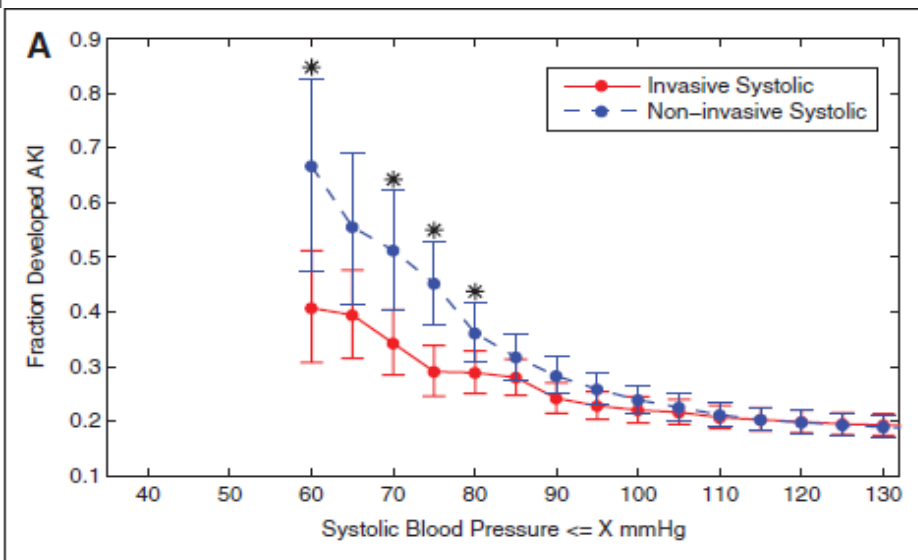
- **Result1** : Pairwise analysis of 27,022 simultaneously measured invasive arterial blood pressure/noninvasive blood pressure pairs indicated that noninvasive blood pressure **overestimated systolic** invasive arterial blood pressure **during hypotension**.
- Noninvasive **MAP** conformed reasonably well to its invasive counterpart in the hypotensive range



# Result1



# Methods of Blood Pressure Measurement in the ICU Result2:



**Figure 2.** Prevalence of acute kidney injury (AKI) as a function of minimum (concurrently time-stamped) systolic blood pressure (A) and mean

**Figure 3.** ICU mortality as a function of minimum (concurrently time-stamped) invasive and noninvasive systolic blood pressure (A) and mean

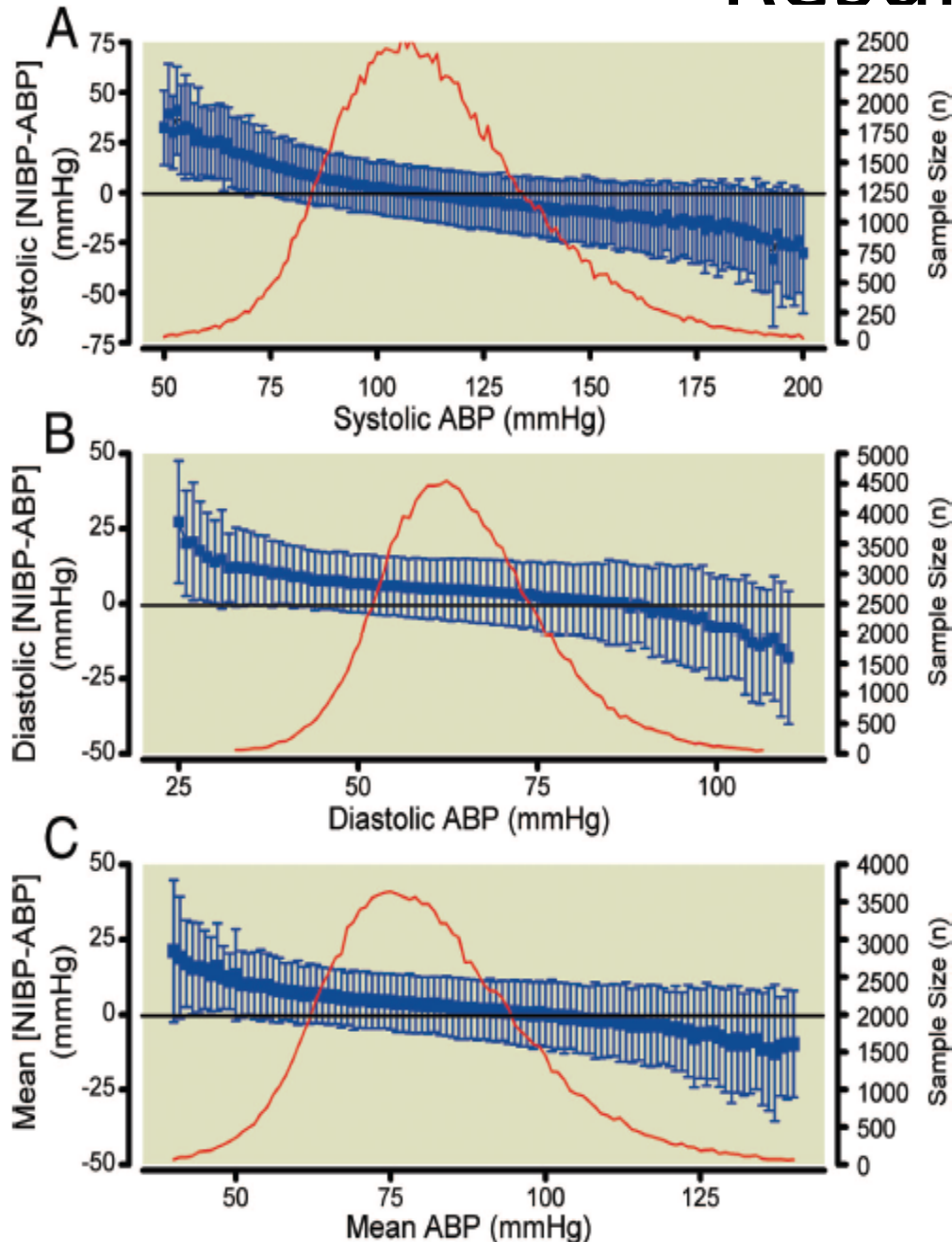
# Invasive and Concomitant Noninvasive Intraoperative Blood Pressure Monitoring

## *Observed Differences in Measurements and Associated Therapeutic Interventions*

David B. Wax, M.D.,\* Hung-Mo Lin, Ph.D.,\* Andrew B. Leibowitz, M.D.†

- Among 24,225 cases, 63% and 37% used [ABP+NIBP] and [ABP], respectively.

# Result 1



- Difference between oscillometric cuff and radial artery catheter measurements of blood pressure. Average difference (SD) between simultaneous noninvasive (NIBP) and invasive radial artery (ABP) systolic (A), diastolic (B), and mean (C) blood pressure measurements in 24,225 adult patients during noncardiac surgery and anesthesia, as well as a total sample size of data pairs for each ABP value (bell-shaped curve and right-side Y-axis).

# result2

Variable	[ABP+NIBP] (n = 2,828)		[ABP] (n = 4,261)		P Value
	Mean, Median, or %	SD, Range	Mean, Median, or %	SD, Range	
Age (yr)	56.8	15.7	60.3	15.4	<0.01
Body mass index (kg/m <sup>2</sup> )	26.7	6.1	27.0	6.5	0.09
Starting hematocrit (%)	38	5.8	36	6.4	<0.01
ASA physical status	—	—	—	—	<0.01
1	4.8%	—	1.9%	—	—
2	32.6%	—	21.1%	—	—
3	52.9%	—	56.7%	—	—
4	9.5%	—	19.1%	—	—
5	0.2%	—	1.2%	—	—
Inpatient (yes)	29.8%	—	40.6%	—	<0.01
A-line <i>in situ</i> on arrival to OR (yes)	1.4%	—	5.5%	—	<0.01
A-line before anesthesia induction (yes)	10.1%	—	21.7%	—	<0.01
Emergency case (yes)	22.4%	—	24.2%	—	0.08
Average systolic ABP (mmHg)	106	10	112	12	<0.01
Procedure duration (h)	4.33	0.25–14.7	4.03	0–19.4	<0.01
Estimated blood loss (ml)	400	5–18,500	400	0–26,500	<0.01
Pretransfusion average SBP (mmHg)	107	10	113	12	<0.01
Pretransfusion SBP SD (mmHg)	16	4–57	18	2–63	<0.01
Erythrocyte transfusion (yes)	29.1%	—	47.2%	—	<0.01

# In summary

- we found statistically and clinically significant differences between blood pressures measured invasively and non-invasively, with NIBP generally higher than ABP when ABP was low, and lower when ABP was high.
- The use of NIBP measurement to supplement ABP measurements was associated with decreased use of blood transfusions, vasopressor or inotrope infusions, and antihypertensive medications compared with use of ABP measurement alone.



# Non-invasive blood pressure

## (history)

Front. Med. 2013, 7(1): 91–101



Fig. 1 The first description of blood pressure is often attributed to a country parson, Reverend Stephen Hales, in the 18th century.

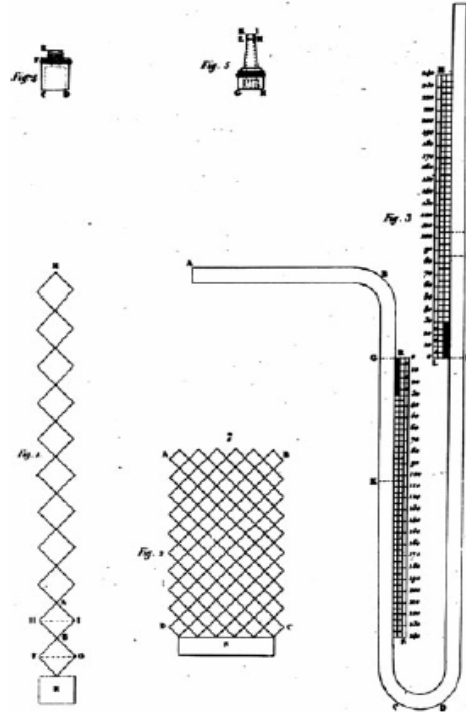


Fig. 2 Mercury manometer developed by Poiseuille. (Th

It was not until the 1820s that Poiseuille, a physician physicist created the mercury manometer

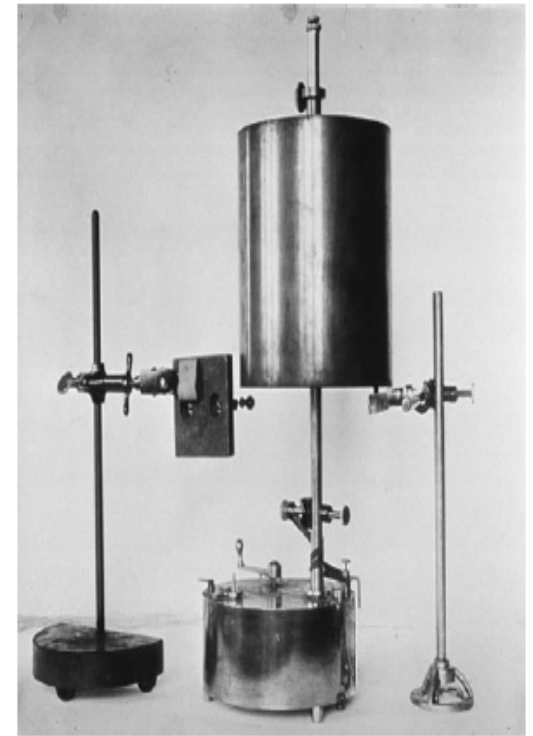


Fig. 3 Kymograph developed by Ludwig in 1847. (This image

This then enabled Carl Ludwig (Fig. to develop the kymograph in 1847.

- Reverend Stephen Hales 于18世纪对血压进行第一次描述

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