Acute decompensated heart failure in the pediatric ICU Diagnosis and assessment

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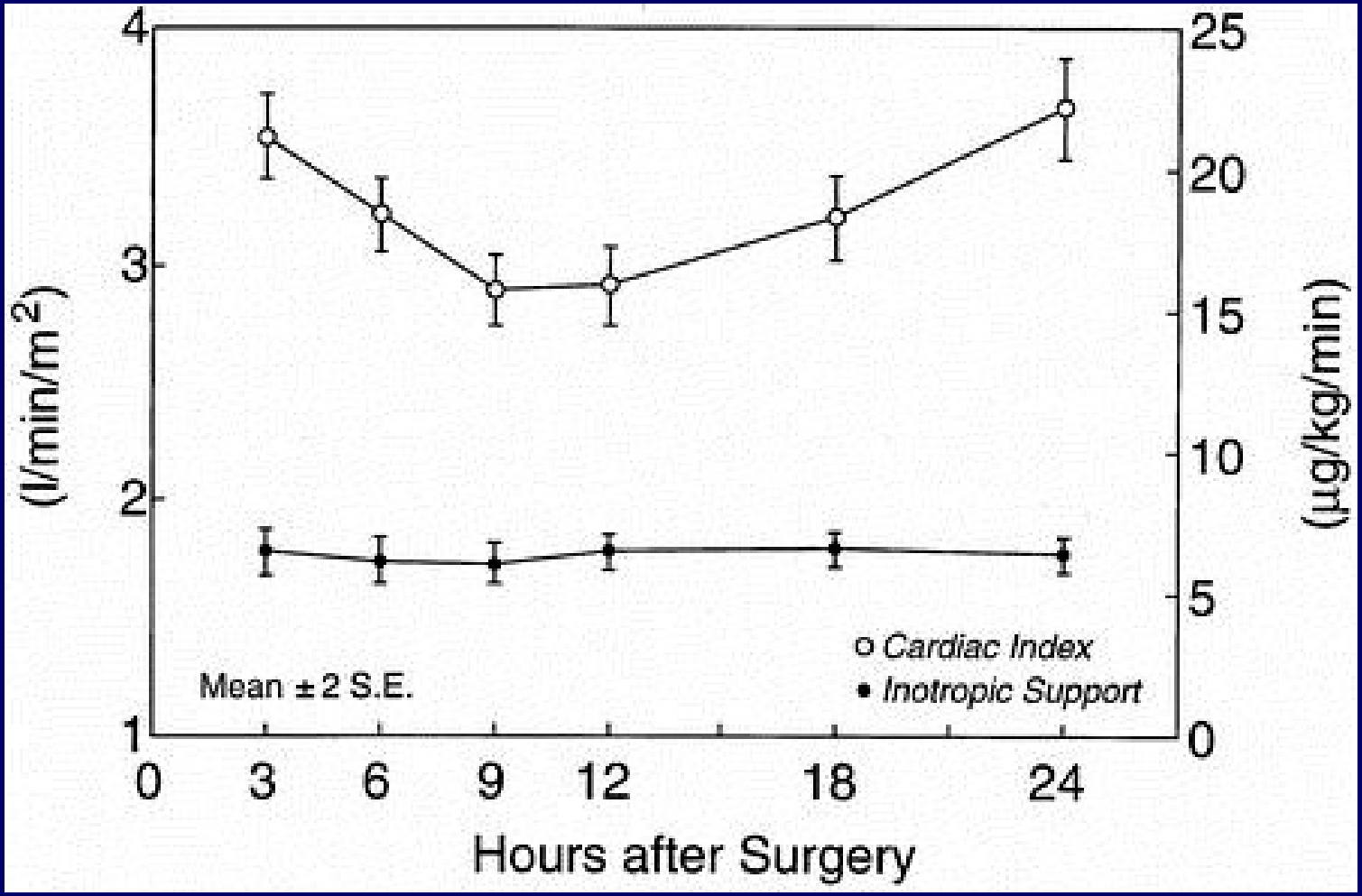
Definition

- Circulatory dysfunction arises when the cardiovascular system is unable to deliver oxygen and nutrients to the tissues to fulfill its metabolic needs. The demand exceeds the supply
- Low cardiac output syndrome (LCOS) is a common complication of neonatal heart surgery.

Low cardiac output after correction of TGA



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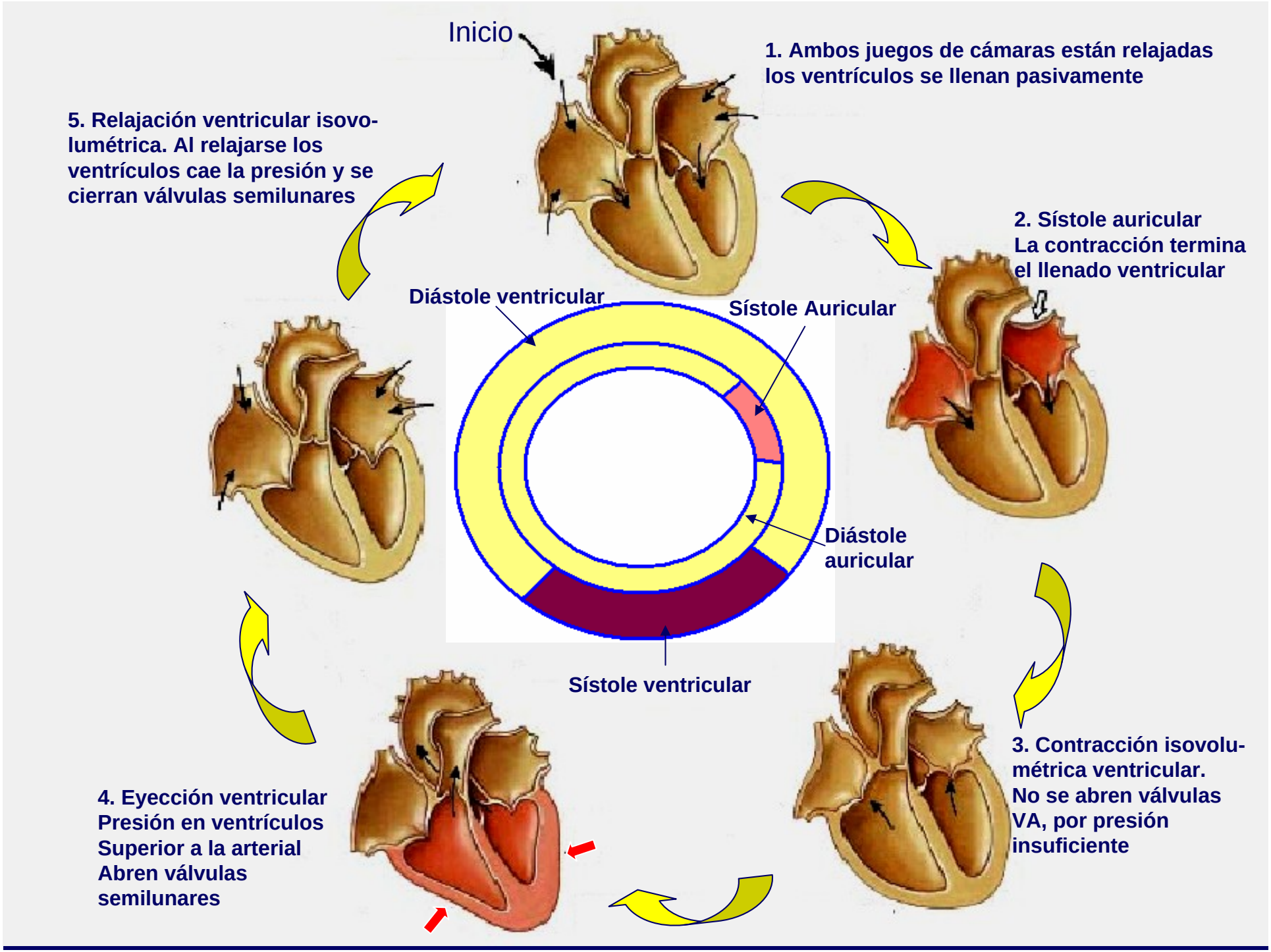

Inicio
1. Ambos juegos de cámaras están relajadas los ventrículos se llenan pasivamente
2. Sístole auricular
La contracción termina el llenado ventricular
3. Contracción isovolu-métrica ventricular.
No se abren válvulas VA, por presión insuficiente
4. Eyección ventricular
Presión en ventrículos Superior a la arterial
Abren válvulas semilunares
5. Relajación ventricular isovo-lumétrica. Al relajarse los ventrículos cae la presión y se cierran válvulas semilunares
Diástole ventricular
Sístole Auricular
Diástole auricular
Sístole ventricular

Causes of postoperative myocardial dysfunction

- Residual defects
- Prolonged cross clamp time
- Ischemia/reperfusion injury
- Profound hypothermia
- Myocardial stunning
- Arrhythmias

Acute decompensated heart failure

- Diagnosis
  - Physical examination
  - Non-invasive monitoring
  - Invasive monitoring
  - Laboratory evaluation

Acute decompensated heart failure

- *Physical examination*

  Pallor

  Cyanosis

  Poor capillary refill

  Decreased or absent peripheral pulses

  Diaphoresis

  Dyspnea

  Increased temperature gradient from core to periphery

  Urine Output

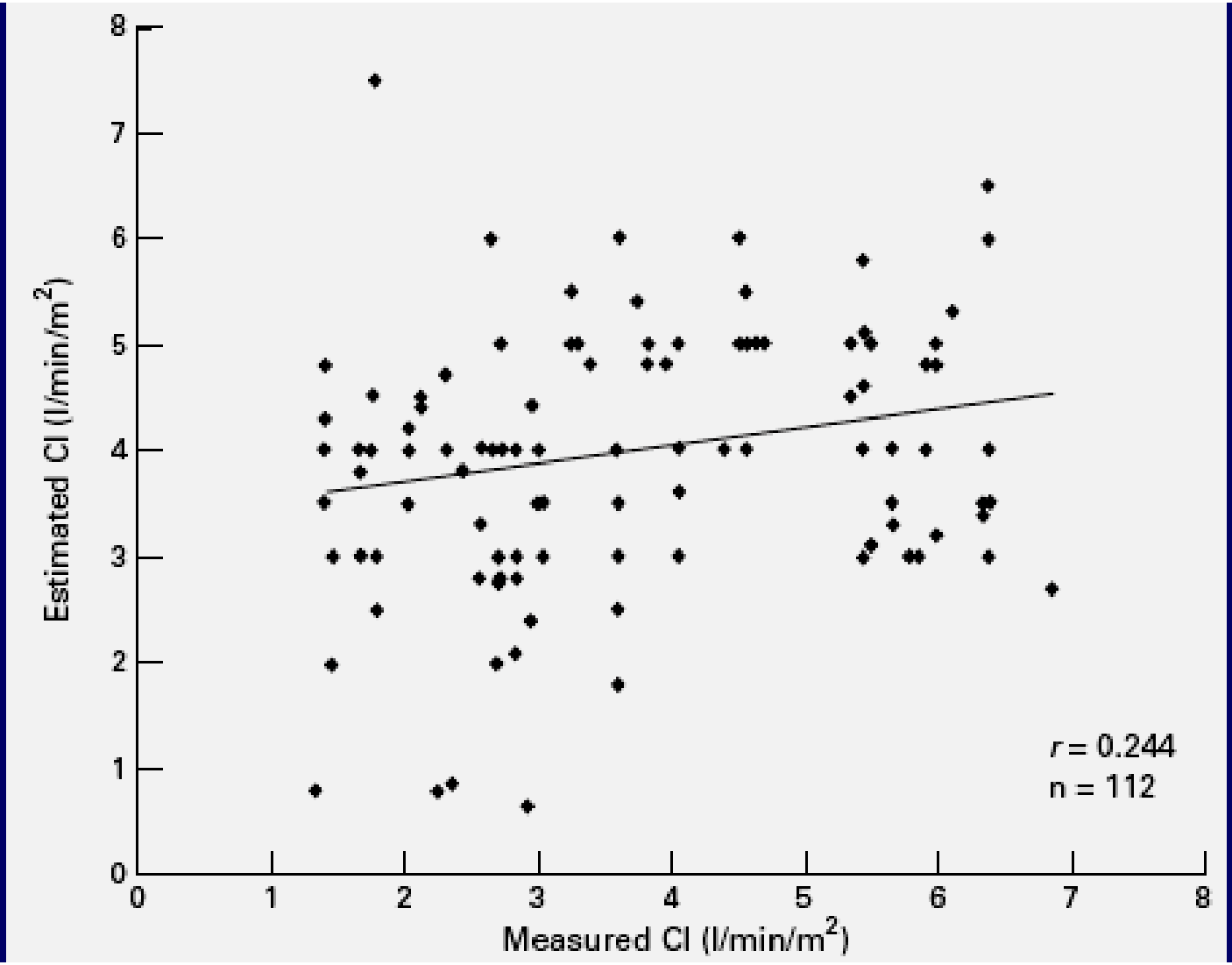
Acute decompensated heart failure

It is difficult to establish a good correlation between cardiac output and physical findings in ventilated children

Clinicians' abilities to estimate cardiac index in ventilated children and infants

Shane M Tibby, Mark Hatherill, Michael J Marsh and Ian A Murdoch

Arch. Dis. Child. 1997;77;516-518



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$\kappa = 0.09$	Estimated CI				
Weighted $\kappa = 0.169$	Low	Low to normal	High to normal	High	Total
Measured CI					
Low	12	13	17	5	47
Low to normal	3	5	5	6	19
High to normal	0	2	4	7	13
High	1	12	8	12	33
Total	16	32	34	30	112

Strength of agreement for κ: < 0.20 poor; 0.21–0.40 fair; 0.4–0.60 moderate; 0.61–0.80 good; 0.81–1.00 very good.

Clinical findings

- Pallor can result from peripheral vasoconstriction, but not necessarily low cardiac output.
- Peripheral cyanosis can be the result of peripheral vasoconstriction.
- But central cyanosis usually reflects low cardiac output

Clinical findings

- Wide peripheral pulses not always indicate a normal or high cardiac output, it can result from an PDA, AV shunt or aortic insufficiency.
- Weak pulses can be found with vasoconstriction or low cardiac output

Non-invasive monitoring

Non-invasive blood pressure monitoring

The most common method is the oscillatory.

Systolic pressure occurs at the point of the rapid increase in oscillation, mean pressure at the maximum point of oscillation, and diastolic pressure when oscillation starts to fade.

Non-invasive monitoring

Non-invasive blood pressure monitoring

- In patients without edema, values obtained by non-invasive arterial blood pressure monitoring are very close to the values of invasive pressure measurements.
- The principal cause of non reliable values with non-invasive pressure measurement is selecting a non-appropriate size of the cuff.

Non-invasive monitoring

Pulse oximetry

- Pulse oximetry is not accurate with low or very high values (below 80% or with values above 90%-95%).

  In the high values range the dissociation curve is flat, big changes in arterial PaO_2 will have small changes in saturation.
- In the presence of abnormal hemoglobins can give false lectures

Non-invasive monitoring

Echocardiography

Calculates the cardiac output using, the blood flow at aortic root, times the heart rate and the angle of the transducer

- Evaluates the systolic and diastolic function.
- Measures the ejection fraction.
- Cardiac output measurements are close to the measured by thermodilution technique.
- Tissue Doppler analysis.
- Trans-esophageal doppler

Acute decompensated heart failure

Invasive monitoring

- Arterial blood pressure
- Central venous pressure
- Left atrial pressure
- Thermodilution catheters
- Mix venous blood gases

Invasive monitoring

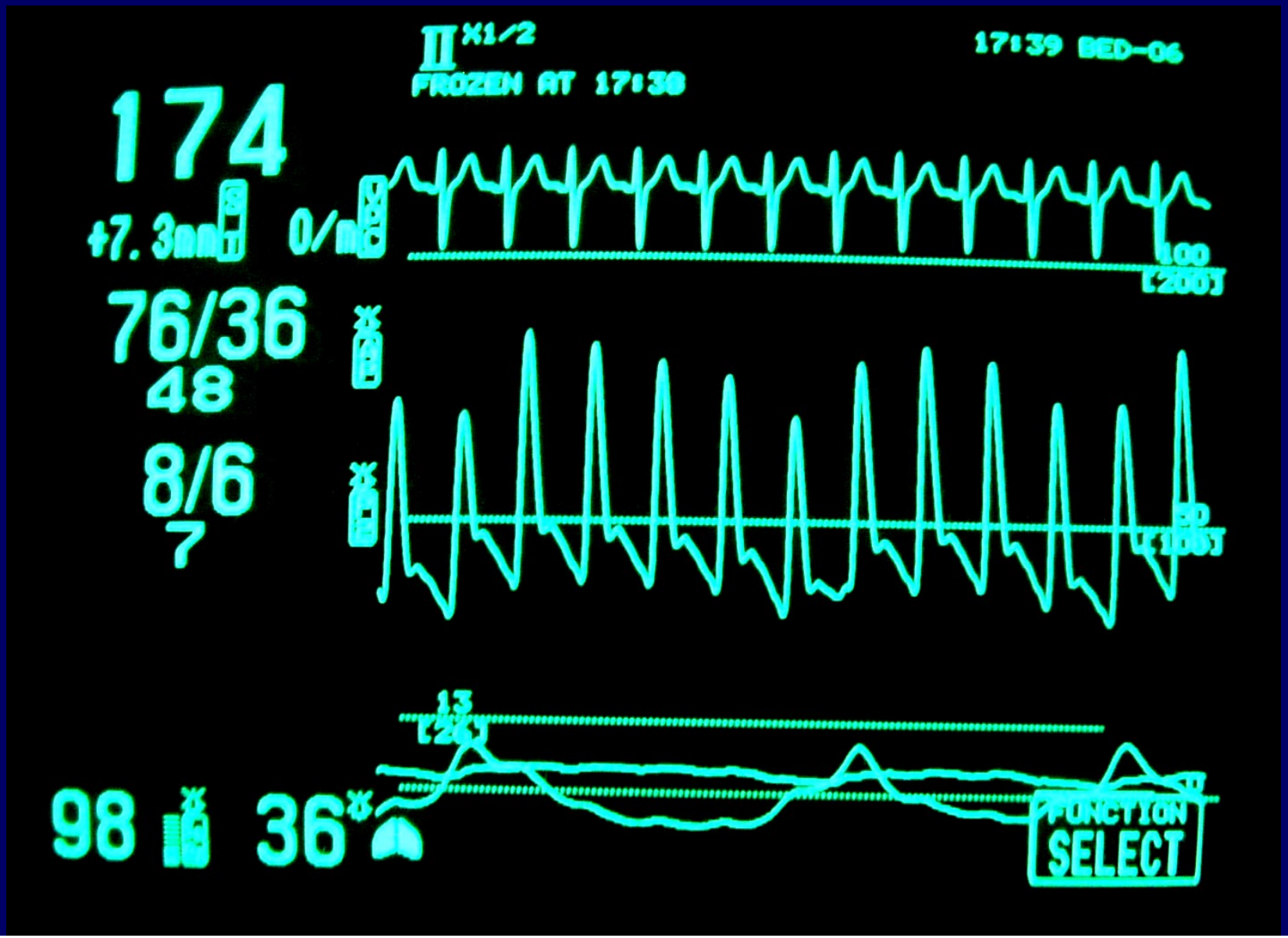
Arterial blood pressure

Hypotension is always pathologic and indicative of dysfunction of the cardiovascular system.

Central venous pressure

- In some patients LCO is secondary to a poor preload, it is necessary to see the response to fluid challenges.

Delta of systolic blood pressure



Direct cardiac output measurements

Thermodilution catheters

Measures the change in blood temperature in the tip of a catheter placed in the pulmonary artery after injecting a known amount of cold water in the right atrium. Needs good mixings of the blood and the cold water

- Is not useful in the presence of intracardiac or great vessels shunts or valve insufficiency between the injection site and the thermistor.
- Is not available in many ICUs
- Difficult to use in small babies

Direct cardiac output measurements

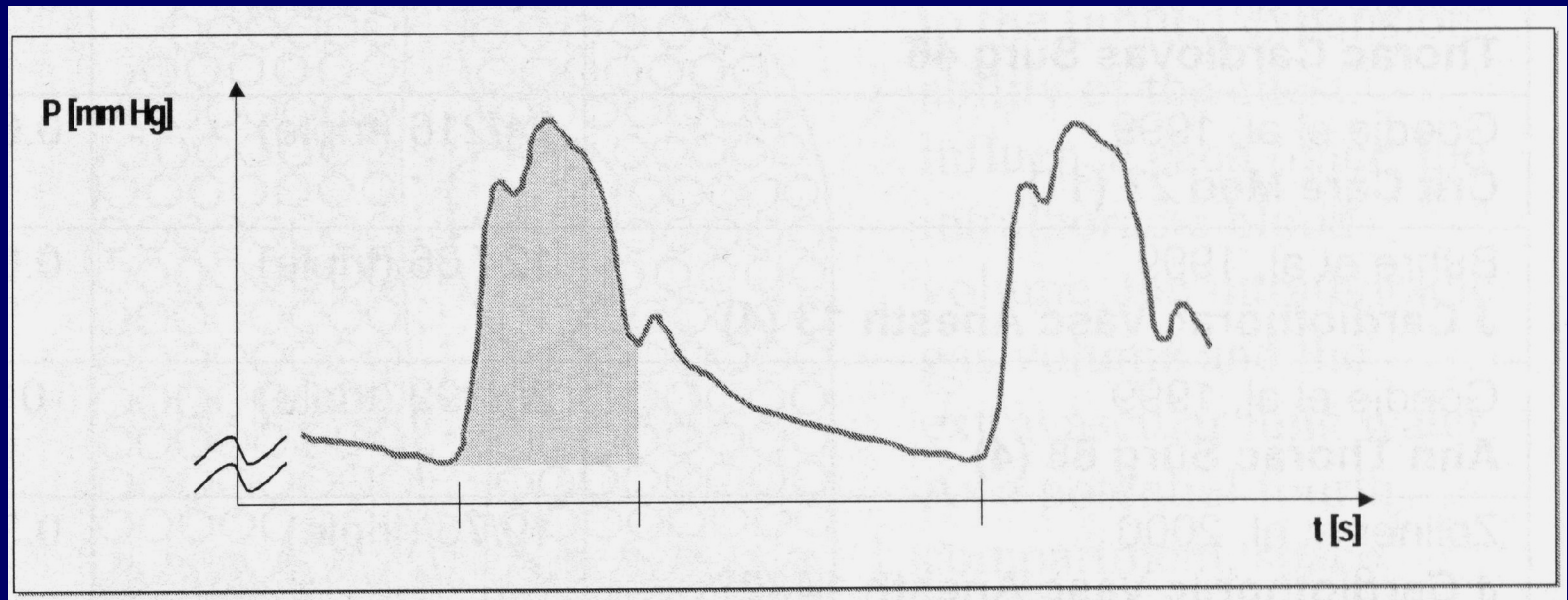
Pulse contour analysis

- PiCCO

  Uses the area under the curve (pulse pressure), heart rate, compliance and shape of the curve.

- Needs a central venous line and an arterial catheter placed in a big artery (femoral, brachial)

Calculation of pulse contour cardiac output



$$PCCO = cal \cdot HR \cdot \int_{Systole} \left(\frac{P(t)}{SVR} + C(p) \cdot \frac{dP}{dt} \right) dt$$

- cal: Patient-specific calibration factor (determined with thermodilution)
- HR: Heart rate
- P(t)/SVR: Area under pressure curve
- C(p): Compliance
- dP/dt: Shape of pressure curve

Laboratory analysis

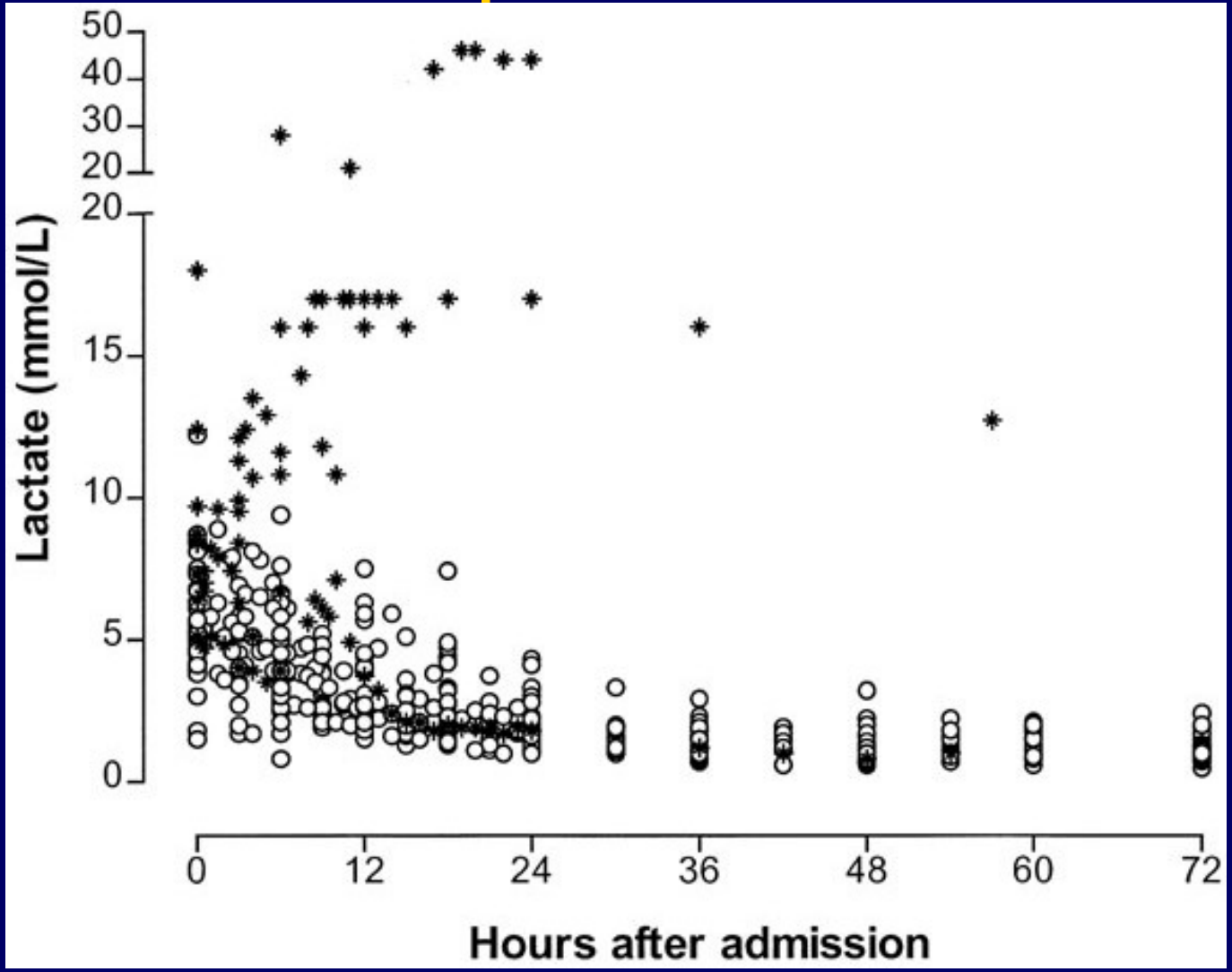
- Blood Lactate

  Used as an indicator of tissue perfusion.

  A poor tissue perfusion correlates with low cardiac output.

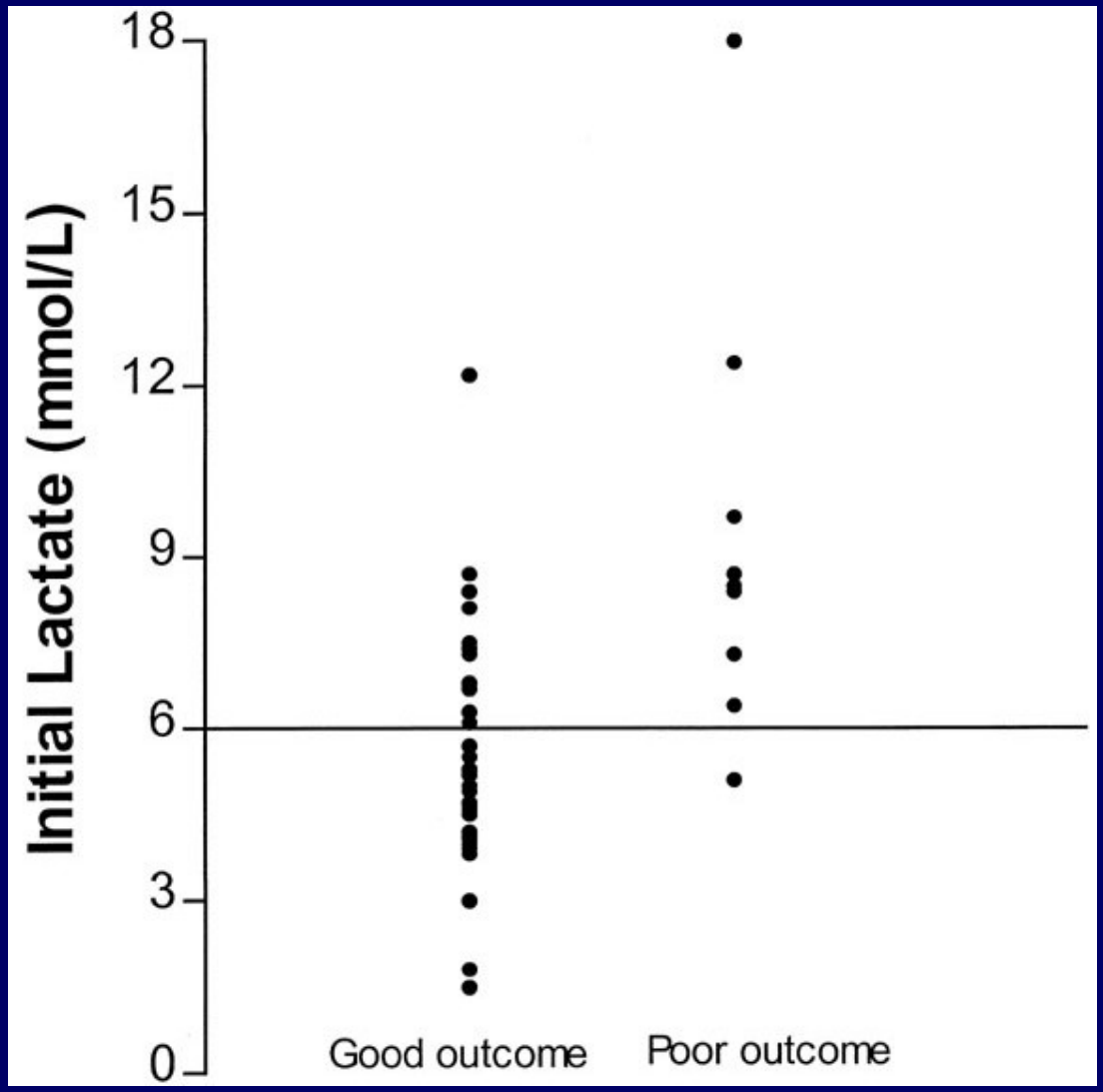
  The trends are more important than the initial values alone for predicting mortality in postoperative cardiac patients.

Lactate in postoperative cardiac patients



Charpie, JR, et al J Thorac Cardiovasc Surg 2000;120:73-80

Lactate and outcome



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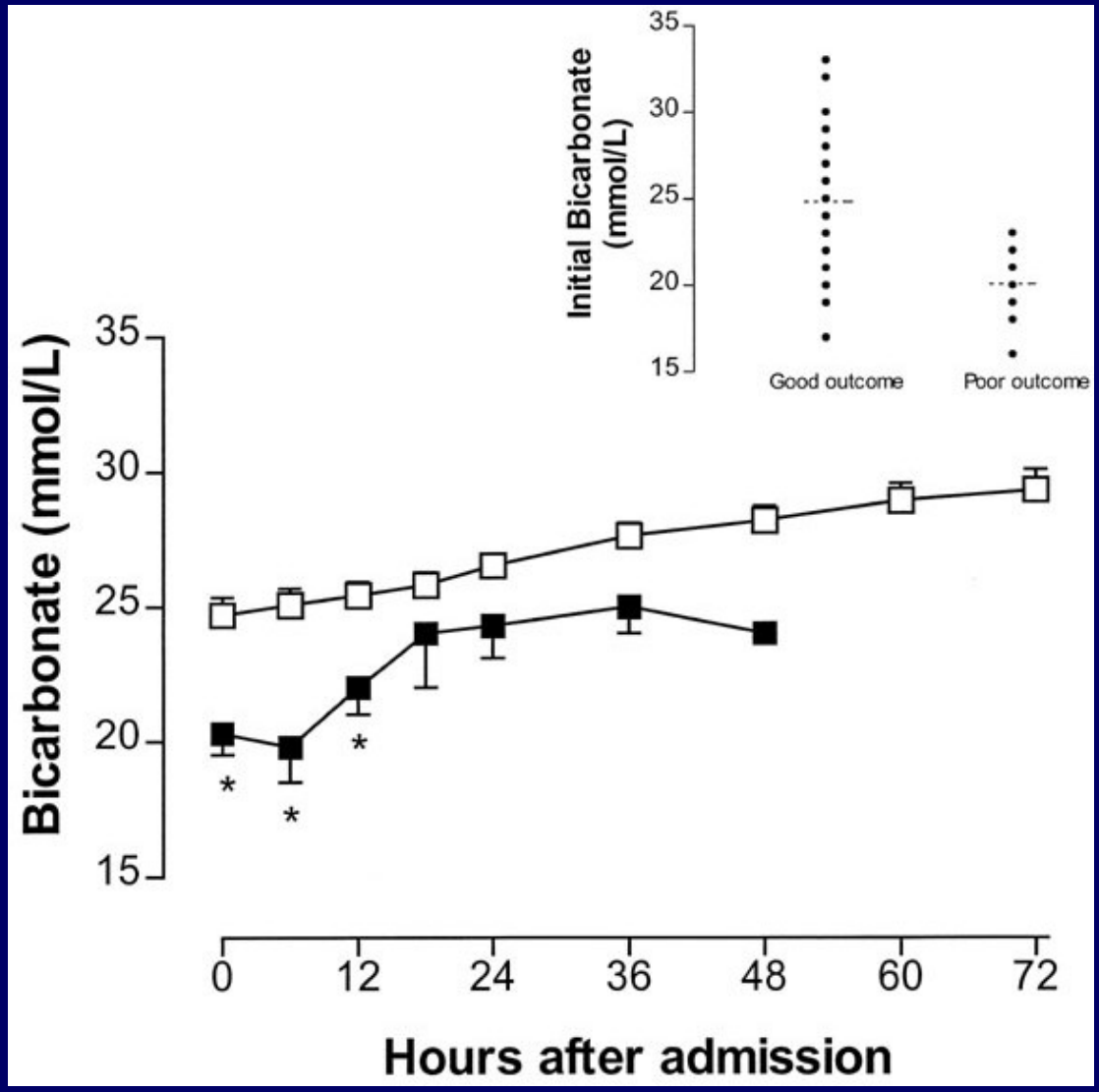
Bicarbonate and outcome



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Mix venous blood gases

Fick method

$CO = VO_2/C(a\text{-}v)O_2$

Oxygen consumption is variable and difficult to measure in the ICU

A wide $(a\text{-}v)O_2$ difference usually reflects a low cardiac output and large oxygen extraction

A narrow $(a\text{-}v)O_2$ difference usually reflects the opposite

With decreased tissue oxygen extraction the values are misleading