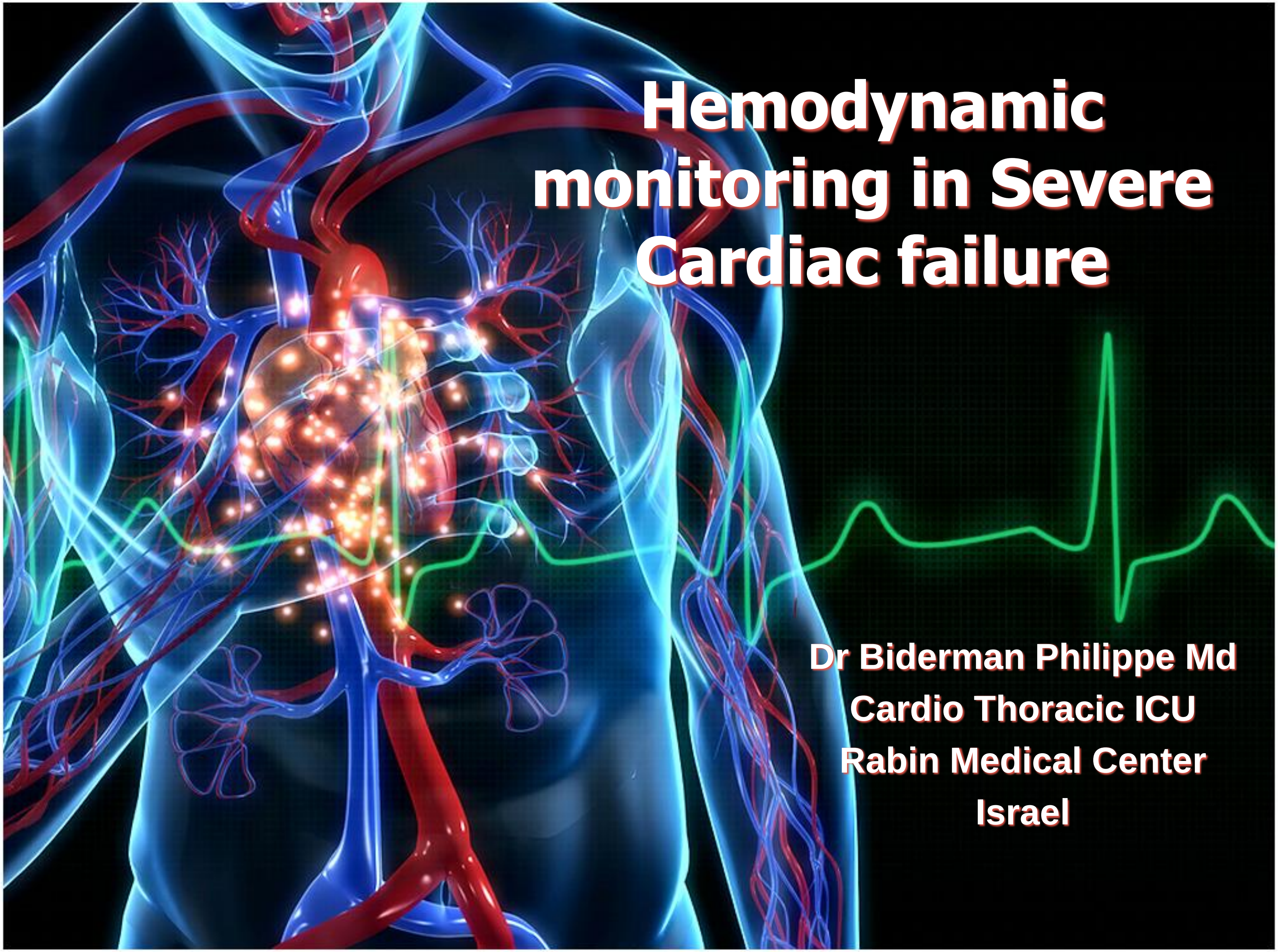

Hemodynamic monitoring in Severe Cardiac failure

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Israel

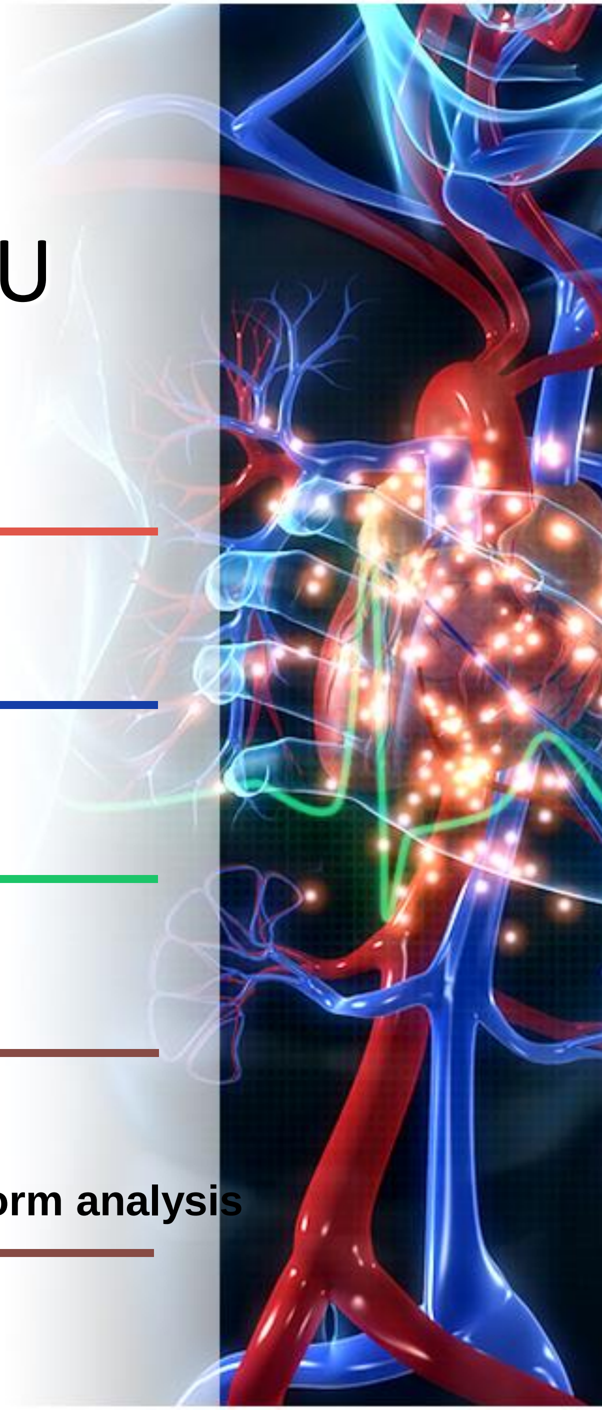
Disclosure :Potential of conflict of interest

Edwards company : Lectures and Hemodynamic products formation

RABIN MEDICAL CENTER
BEILINSON • HASHARON

Hemodynamic monitoring in ICU

1. INTRODUCTION , Hemodynamic Market
2. Rules concerning hemodynamic monitoring
3. Swan Ganz
4. ScVO2
5. Trans-pulmonary indicator dilution and waveform analysis



Introduction

- Hemodynamic monitoring have an essential role in ICU’s .
- Conventional monitoring (BP,ECG,sAO2) is often not enough to understand the hemodynamic status of the patient
- To treat patient in shock :

  should I give more fluids ?

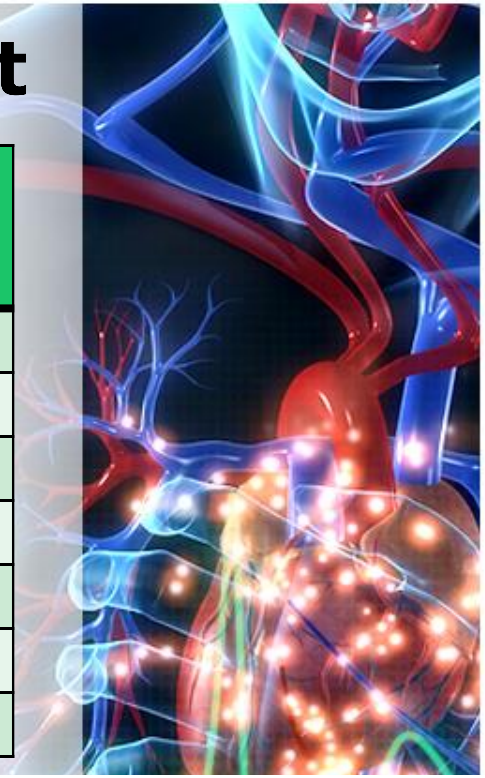
  Is the cardiac function is Ok ?

  Should we give Vasopressors

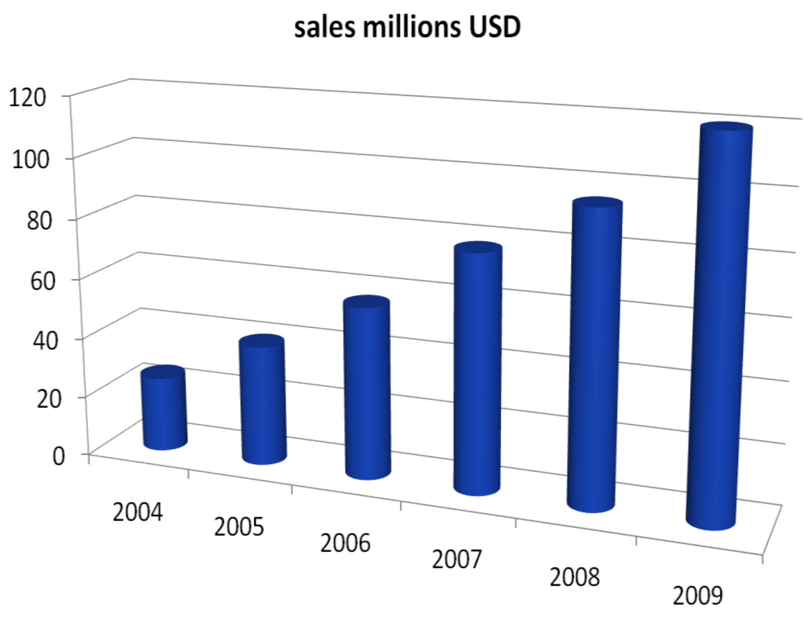
  or and inotropes ? .
- **But also to prevent worsening before catastrophic event .**

Hemodynamic monitoring US Market

year	PAC sales M $	Annual change %	Other cardiac ouput monitoring	Annual change %	Total sales M $
2006	100.4		22.5		122.9
2007	98.1	-2.3	31.5	40	129.6
2008	95.8	-2.3	38	20.6	133.8
2009	93.7	-2.2	45	18.4	138.7
2010	91.6	-2.2	52	15.6	143.6
2011	89	-2.8	60	15.4	149.0
2012 E	85.7	-3.7	69	15	154.7



less invasive monitoring products world sales



Clinical review: Update on hemodynamic monitoring - a consensus of 16

Jean-Louis Vincent1*, Andrew Rhodes2, Azriel Perel3, Greg S Martin4, Giorgio Della Rocca5, Benoit Vallet6,
Michael R Pinsky7, Christoph K Hofer8, Jean-Louis Teboul9, Willem-Pieter de Boode10, Sabino Scolletta11,
Antoine Vieillard-Baron12, Daniel De Backer1, Keith R Walley13, Marco Maggiorini14 and Mervyn Singer15

Key principles of hemodynamic monitoring

- **Principle 1: no hemodynamic monitoring technique can improve outcome by itself**

- **Principle 2: monitoring requirements may vary over time and can depend on local equipment availability and training**

- **Principle 3: there are no optimal hemodynamic values that are applicable to all patients .**

- **Principle 4: we need to combine and integrate variables**

  Any variable on its own provides relatively little information it is just one piece of a large puzzle.

- **Principle 5: measurements of SvO2 can be helpful** SvO2 reflects the balance between oxygen consumption

- **Principle 6: a high cardiac output and a high SvO2 are not always best .**

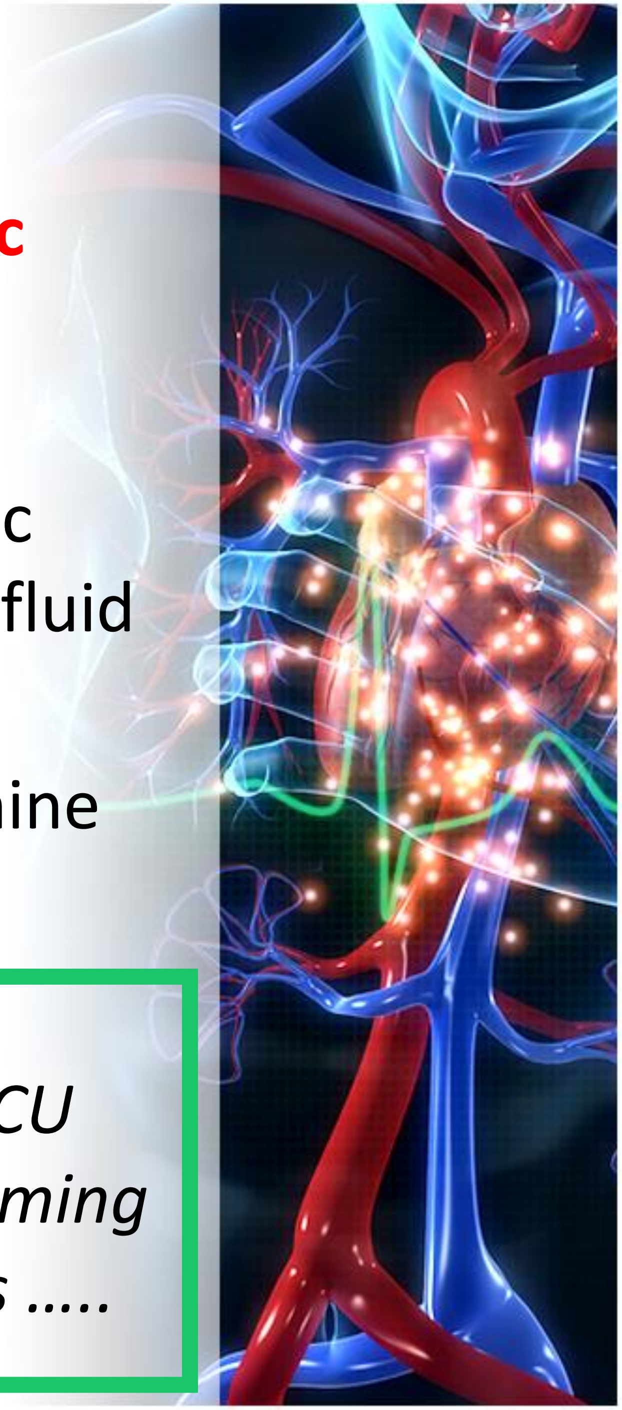
Excessive fluid administration to increase cardiac output may result in fluid overload with massive edema ,giving inotropic agents in the presence of coronary artery disease is like **trying to stimulate a tired horse.**

- **Principle 7: cardiac output is estimated, not measured .**

A measurement obtained by a less invasive technique may be preferable if it can be obtained more rapidly and easily, even if it is slightly less accurate

- **Principle 8: monitoring hemodynamic changes over short periods of time is important**
- Monitoring of acute changes in cardiac output can be important, to separate fluid responders from non-responders.
- Evaluating the response to a dobutamine or to a nitrate infusion

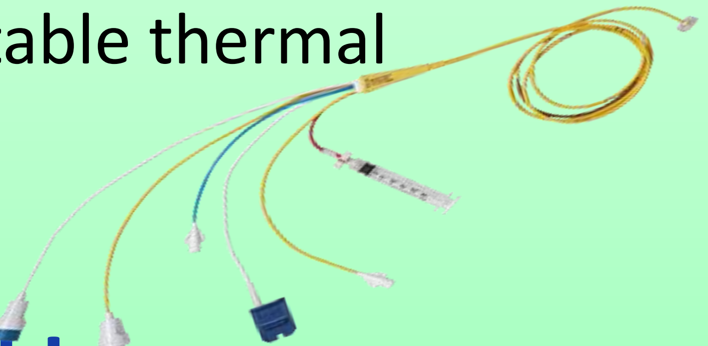
Is Cardiac echocardiography really an ICU monitoring ? :Availability , time consuming , operator dependency ,acute changes …..



PA catheter

- Intermittent thermo-dilution technique
  (not continuous) is still recognize as a gold standard .

- The newest PA catheter with thermal filament   with warming of blood in the SVC and thermistor a the PAC tip (Vigilance) are allowing a more continuous CO measurement each few minutes (stable thermal conditions) .

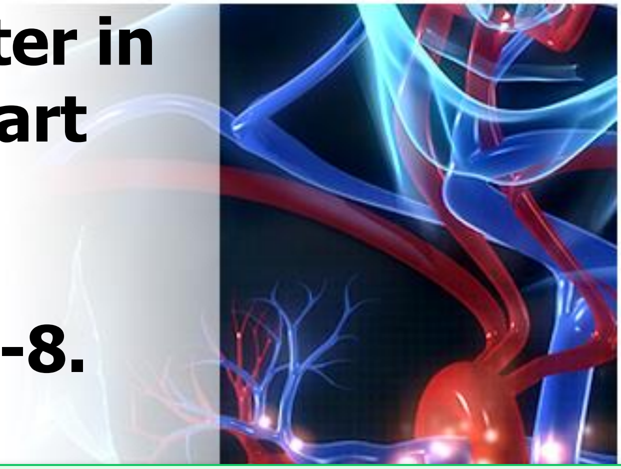


Direct PA measurement and true continuous Svo2 !

Role of the pulmonary artery catheter in diagnosis and management of heart failure.

Kahwash R, Leier CV, Miller L.

Cardiol Clin. 2011 May;29(2):281-8.



- The current guidelines reserve the use of a pulmonary artery catheter for the management of refractory heart failure and select conditions.
- **The pulmonary artery catheter remains a useful instrument in clinical situations when clinical and laboratory assessment alone is insufficient** in establishing the diagnosis and pathophysiologic condition, and in guiding effective, safe therapy

The pulmonary artery catheter 2008

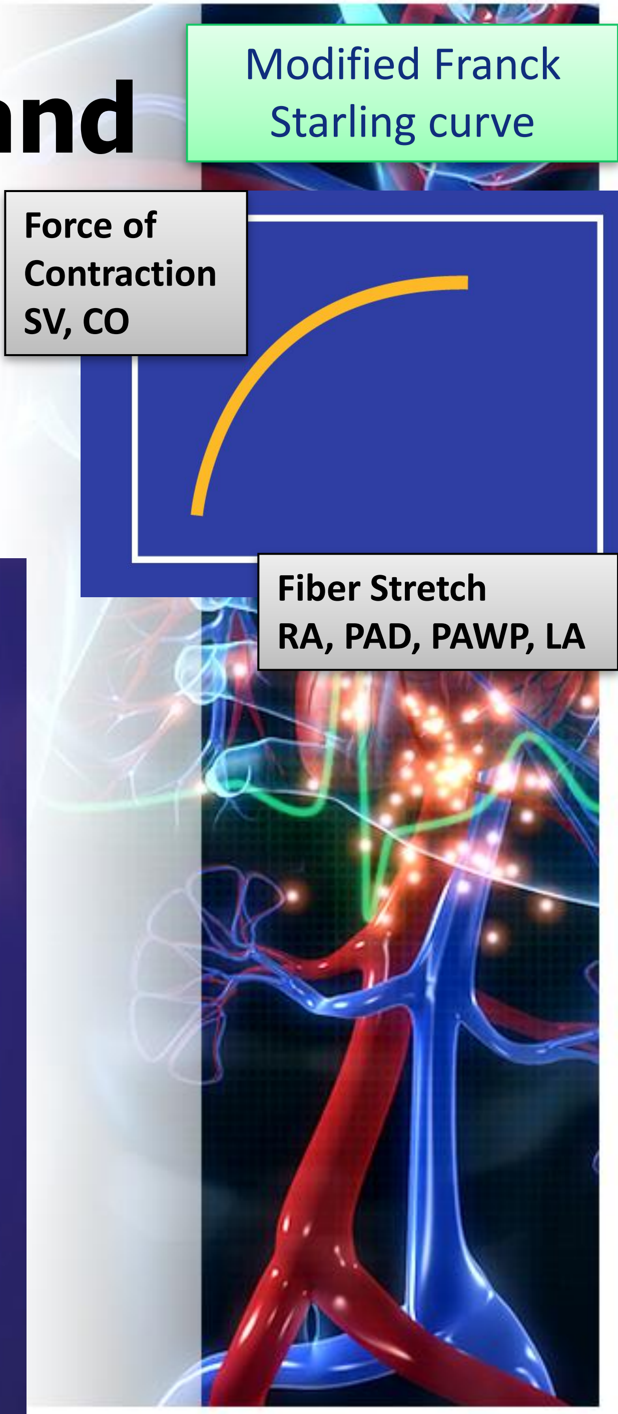
- Vincent JL, Pinsky MR, Sprung CL, Levy M, Marini JJ, Payen D, Rhodes A, Takala J.
- **OBJECTIVE:** To clarify the role of the pulmonary artery catheter in the intensive care unit.
- Based largely on clinical experience and assessment of the relevant published literature and in response to recent articles attacking the pulmonary artery catheter, we propose that the **pulmonary artery catheter is still a valuable tool for the hemodynamic monitoring of patients with complex disease processes** in whom the information obtained from the pulmonary artery catheter may influence management..

- **CONCLUSION:**

The pulmonary artery catheter is still a valuable tool for hemodynamic monitoring when used in **selected patients and by physicians adequately trained** to correctly interpret and apply the data provided.

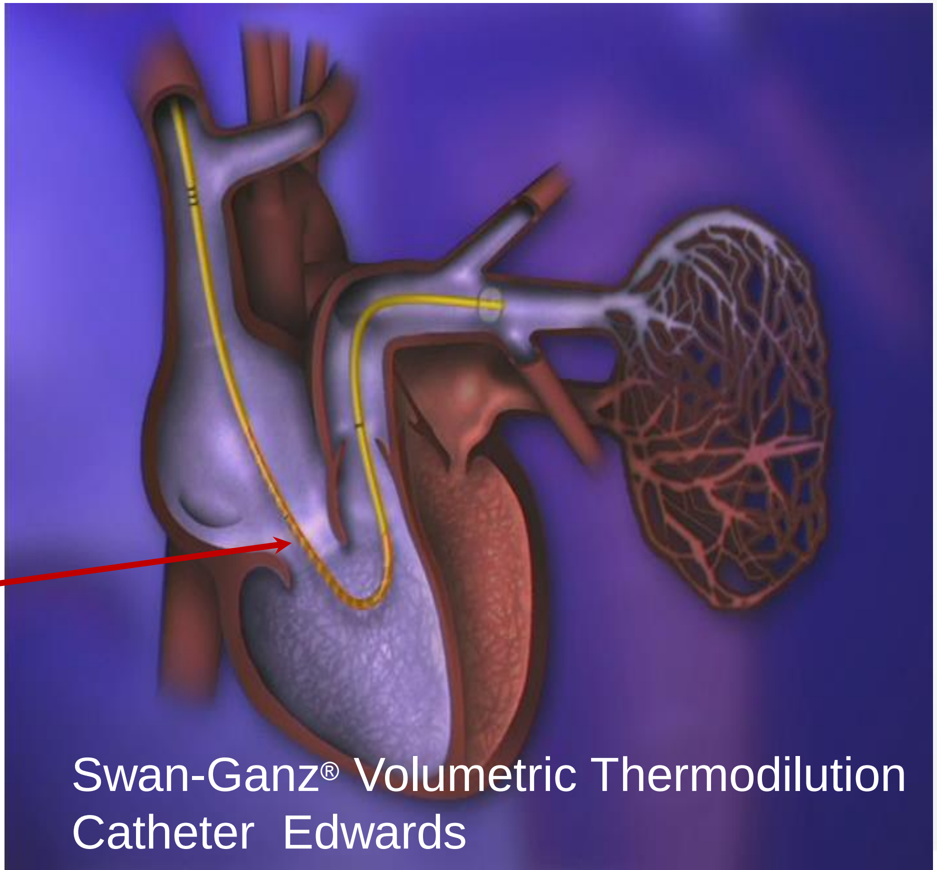
RV end diastolic volume and Ejection Fraction

- Normal RVEDV: 100-160ml = RV Preload
- Normal RVEF: 40% - 60%



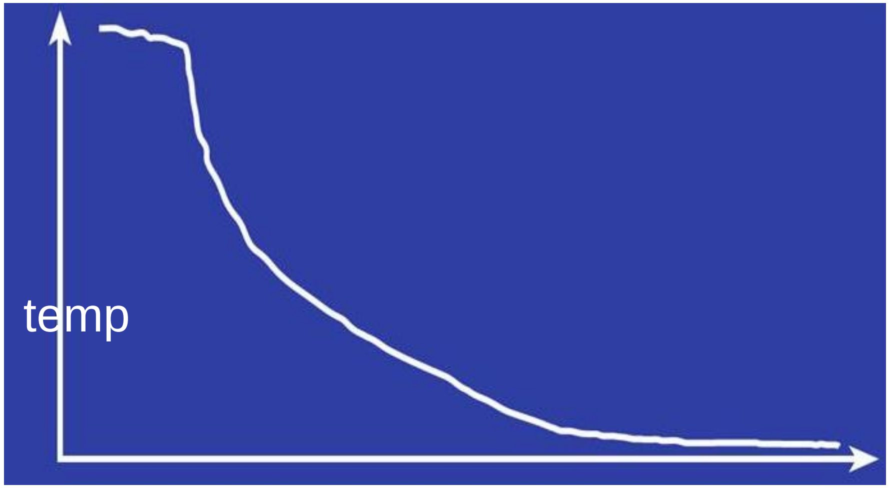
Thermal Filament

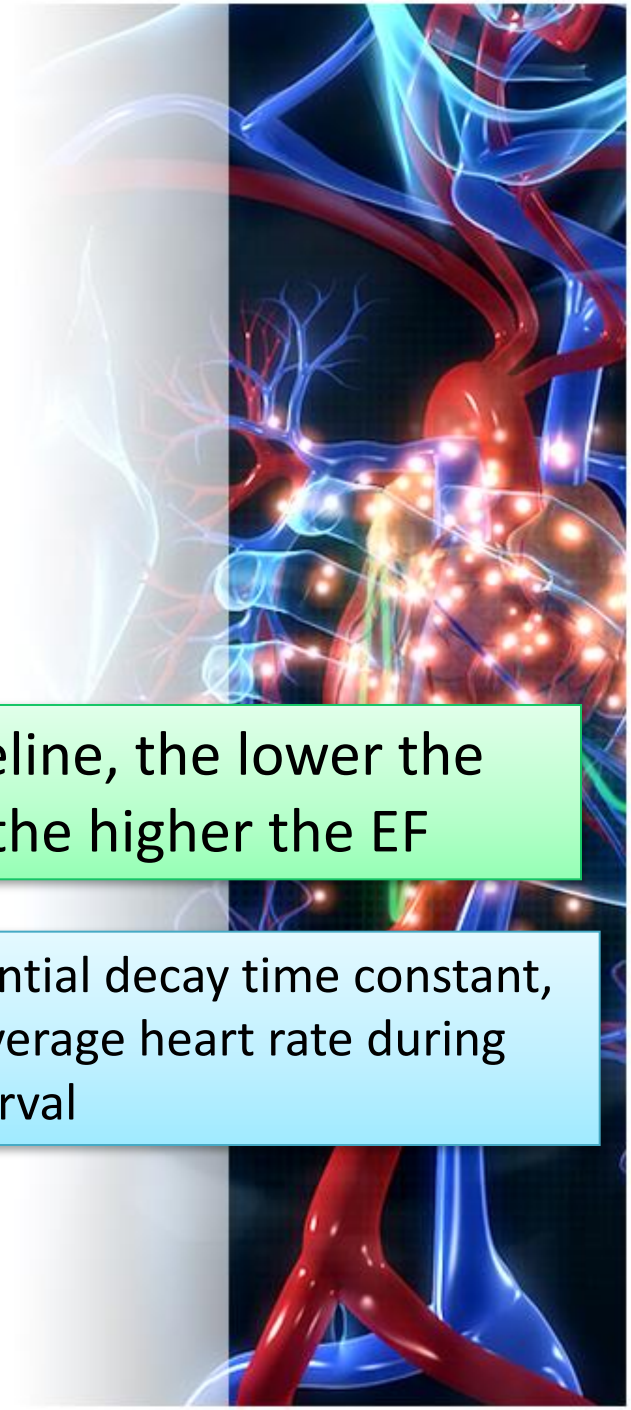
- 10 cm in length
- 14-25 cm from tip
- Rests between RA & RV



Swan-Ganz® Volumetric Thermodilution Catheter Edwards

RV:EDV and EF CEDV Algorithm





The longer it takes the decay curve to reach baseline, the lower the ejection fraction (EF) The steeper the curve, the higher the EF

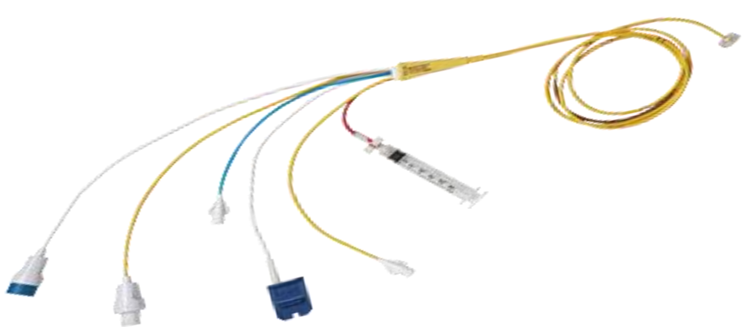
$EF = 1 - \exp(-60 / (\tau * HR))$

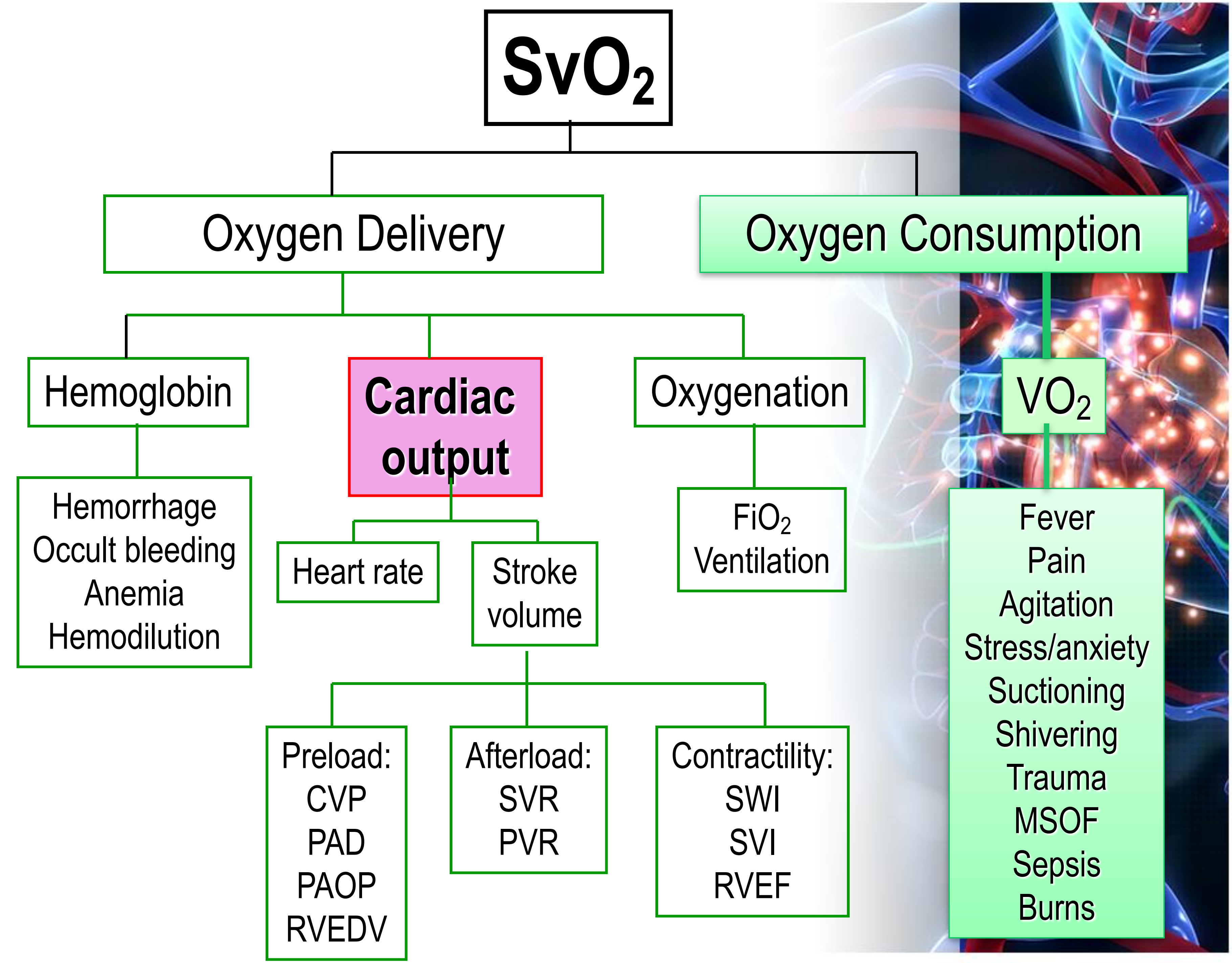
τ is the exponential decay time constant, and HR is the average heart rate during the R-wave interval

EDV = SV / EF

Indication of SWAN GANZ CATHETER ?

1. Cardiogenic shock or severe heart failure , resistant to therapy .
2. RV Failure to monitor after-load of the RV (PA pressure)
3. Cardiac transplantation, Lung Transplantation , LVAD.
4. “Multi-factorial shock” :example patient with cardiac failure and sepsis .
5. High risk patients for cardiac or non cardiac surgery.




SvO_2
Oxygen Delivery
Oxygen Consumption
Hemoglobin
Cardiac output
Oxygenation
VO_2
Hemorrhage
Occult bleeding
Anemia
Hemodilution
Heart rate
Stroke volume
FiO_2
Ventilation
Fever
Pain
Agitation
Stress/anxiety
Suctioning
Shivering
Trauma
MSOF
Sepsis
Burns
Preload:
CVP
PAD
PAOP
RVEDV
Afterload:
SVR
PVR
Contractility:
SWI
SVI
RVEF

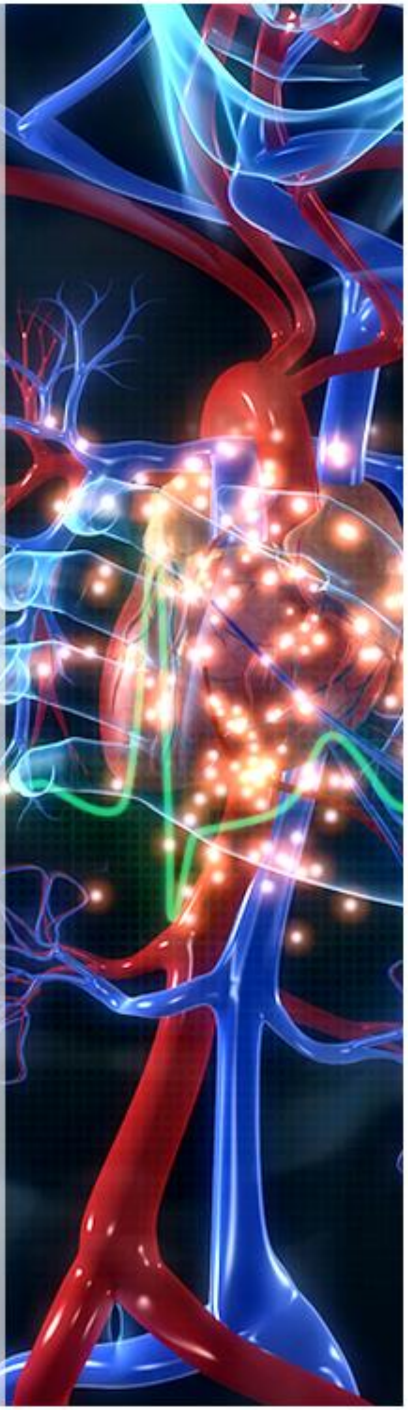
Continuous ScvO2 monitoring with oximetry catheter

- **can reveal occult tissue hypoxia that traditional vital signs can miss.** The prognostic value of ScvO2 has been demonstrated in post-op high-risk surgeries, trauma, sepsis, **cardiac failure in CHF and recovery in cardiac arrest .**

Guides therapy and enables early intervention

- Continuous ScvO2 is a more sensitive indicator of tissue perfusion compared to intermittent sampling and traditional vital signs alone .

- Continuous ScvO2 monitoring reveals the true adequacy of tissue oxygenation, enabling early detection and assessment of clinical response to intervention



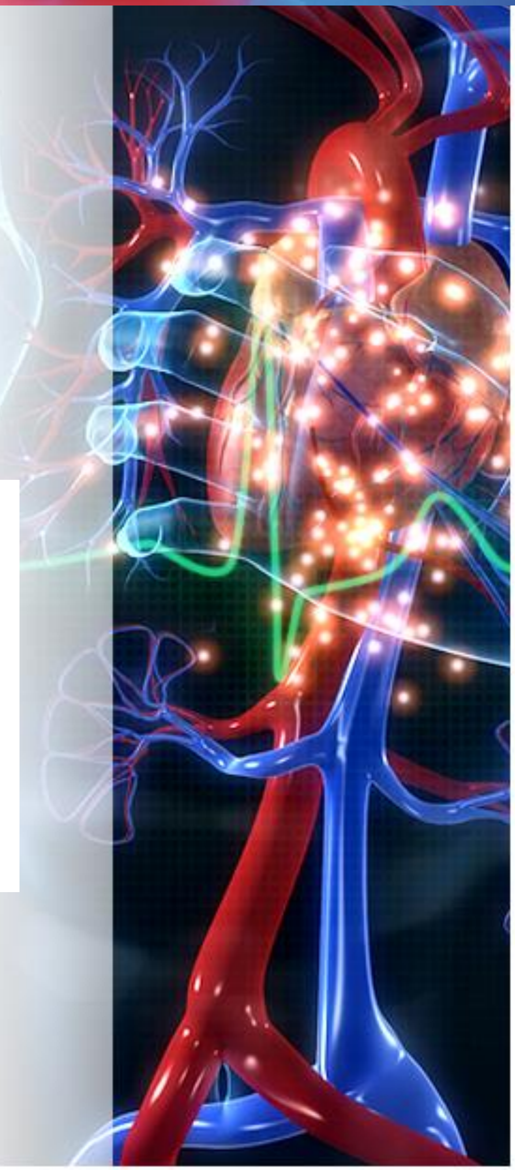
Cardiology Research and Practice
Volume 2012, Article ID 370697, 7 pages
doi:10.1155/2012/370697

Review Article

Should We Monitor $ScVO_2$ in Critically Ill Patients?

Sophie Nebout[1] and Romain Pirracchio[2]

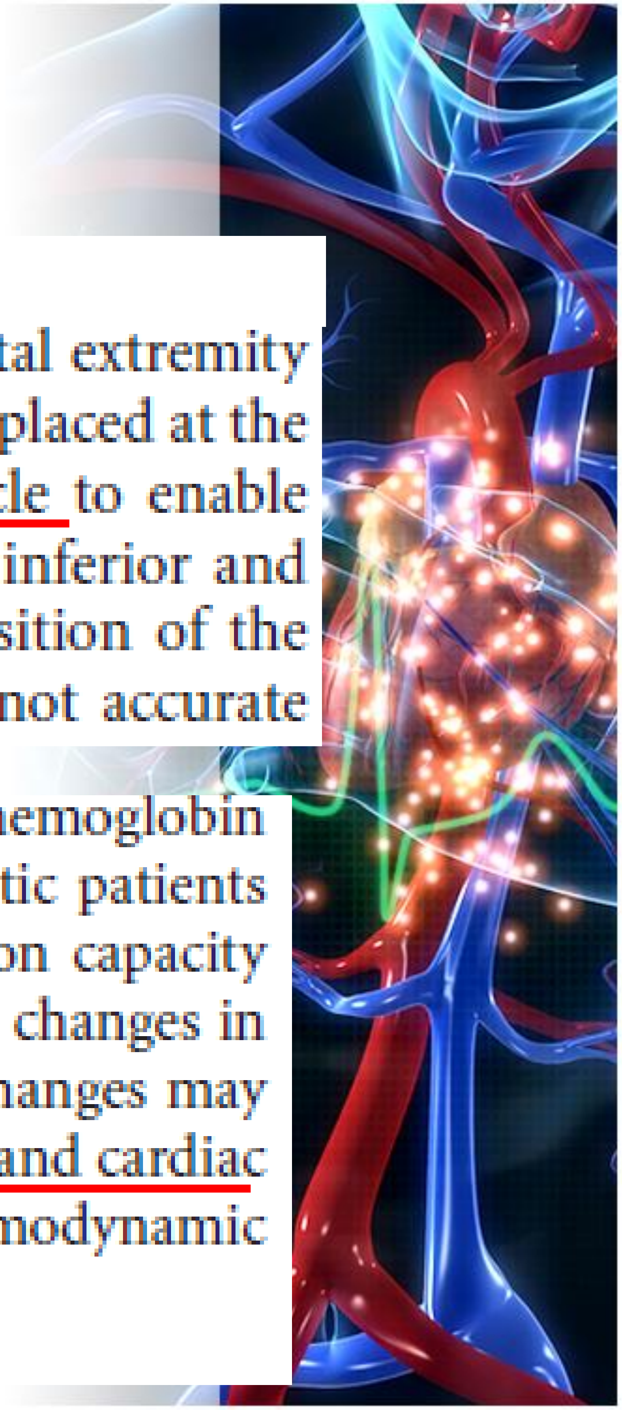
$ScvO_2$ is considered as a suitable prognosis factor in many clinical situations in the critically ill patients. The Surviving Sepsis Campaign [33], gathering all European guidelines regarding severe sepsis and sepsis shock patients management, suggested including $ScvO_2$ as a goal parameter in the first 6 hours of management ($ScvO_2$ >70%).



SCVO2 limitation

theoretically, the distal extremity of the central venous catheter is supposed to be placed at the joining point of vena cava and the right auricle to enable a suitable assessment of tissue oxygenation of inferior and superior territories. However, checking the position of the catheter's distal extremity with chest X-ray is not accurate

$ScvO_2$ depends on tissue oxygen extraction and hemoglobin affinity for oxygen. Experiments report that septic patients could suffer from a decrease in oxygen extraction capacity [34, 35], a rise in capillary shunt [34], as well as changes in hemoglobin affinity for oxygen [36]. All these changes may alter the theoretical relationship between $SvcO_2$, and cardiac output, such as $ScvO_2$ interpretation, to guide hemodynamic therapy becomes more complex.

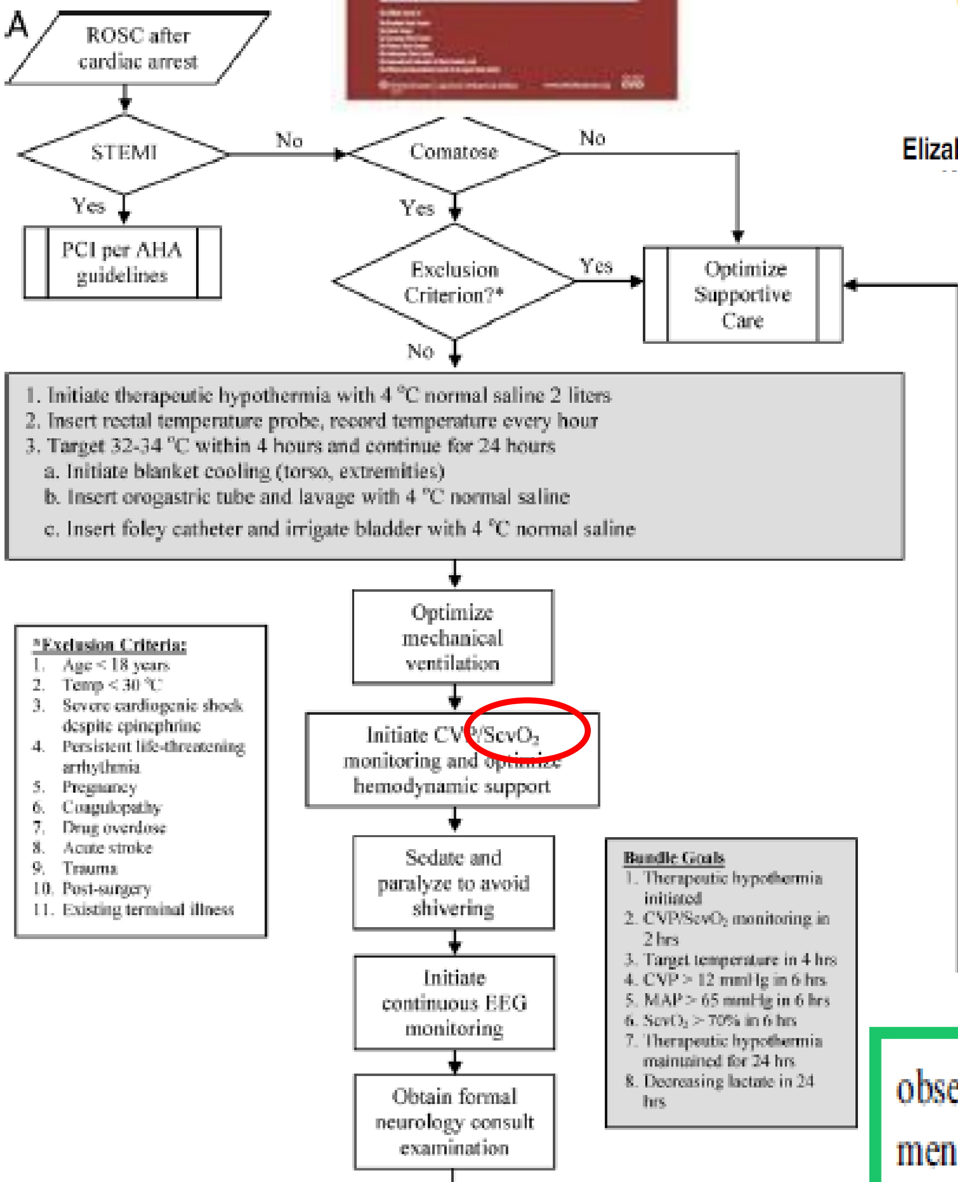


SHOCK, Vol. 35, No. 4, pp. 360–366, 2011

IMPLEMENTATION OF A POST–CARDIAC ARREST CARE BUNDLE INCLUDING THERAPEUTIC HYPOTHERMIA AND HEMODYNAMIC OPTIMIZATION IN COMATOSE PATIENTS WITH RETURN OF SPONTANEOUS CIRCULATION AFTER OUT-OF-HOSPITAL CARDIAC ARREST: A FEASIBILITY STUDY

Elizabeth Lea Walters,* Kyle Morawski,† Ihab Dorotta,‡ Davinder Ramsingh,‡

A



B

1. Therapeutic hypothermia initiated
2. CVP/$ScvO_2$ monitoring in 2 hours
3. Target temperature in 4 hours
4. CVP > 12 mmHg in 6 hours
5. MAP > 65 mmHg in 6 hours
6. $ScvO_2$ > 70% in 6 hours
7. Therapeutic hypothermia maintained for 24 hours
8. Decreasing lactate in 24 hours

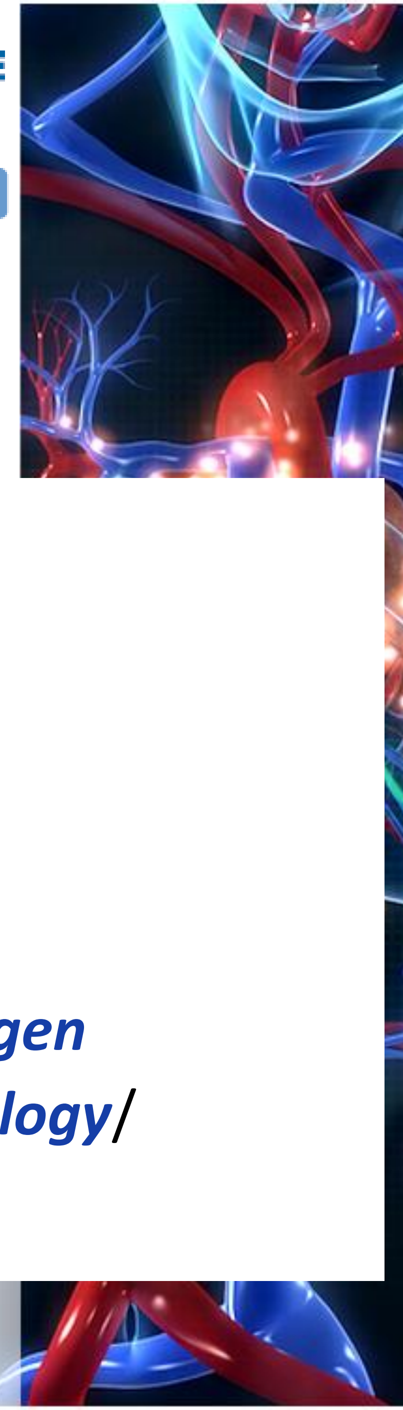
observed a 14% lower mortality during the bundle implementation phase compared with the prebundle period. As this

Mebazaa *et al. Critical Care* 2010, 14:201
http://ccforum.com/14/2/201

CRITICAL CARE

REVIEW

Clinical review: Practical recommendations on the management of perioperative heart failure in cardiac surgery



Assessing optimal volume status

Heart failure cannot be ascertained unless volume loading is optimal. The evaluation of effective circulating blood volume is more important than the total blood volume. Signs of increased sympathetic tone and/or organ hypoperfusion (increased serum lactate and ***decreased mixed venous saturation (SvO_2) or central venous O_2 saturation ($ScvO_2$)) indicate increased oxygen extraction secondary to altered cardiovascular physiology***/ hypovolaemia.

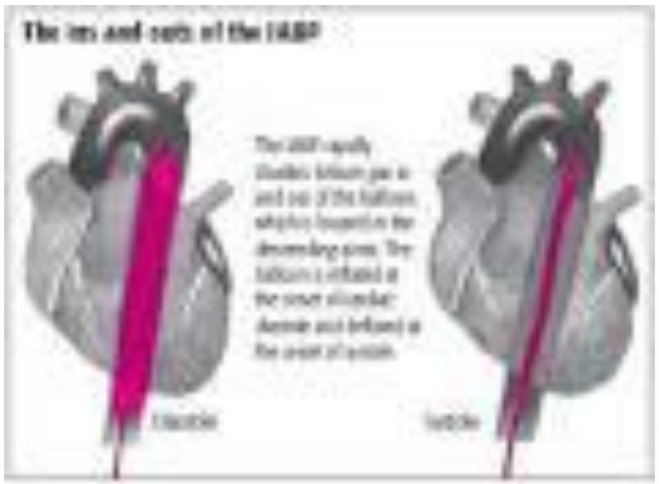
Using Central venous Oxygenation to facilitate the weaning of IABP in MI related Acute Heart Failure

Ho-Tsung Hsin , Cardiovascular Intensive care unit

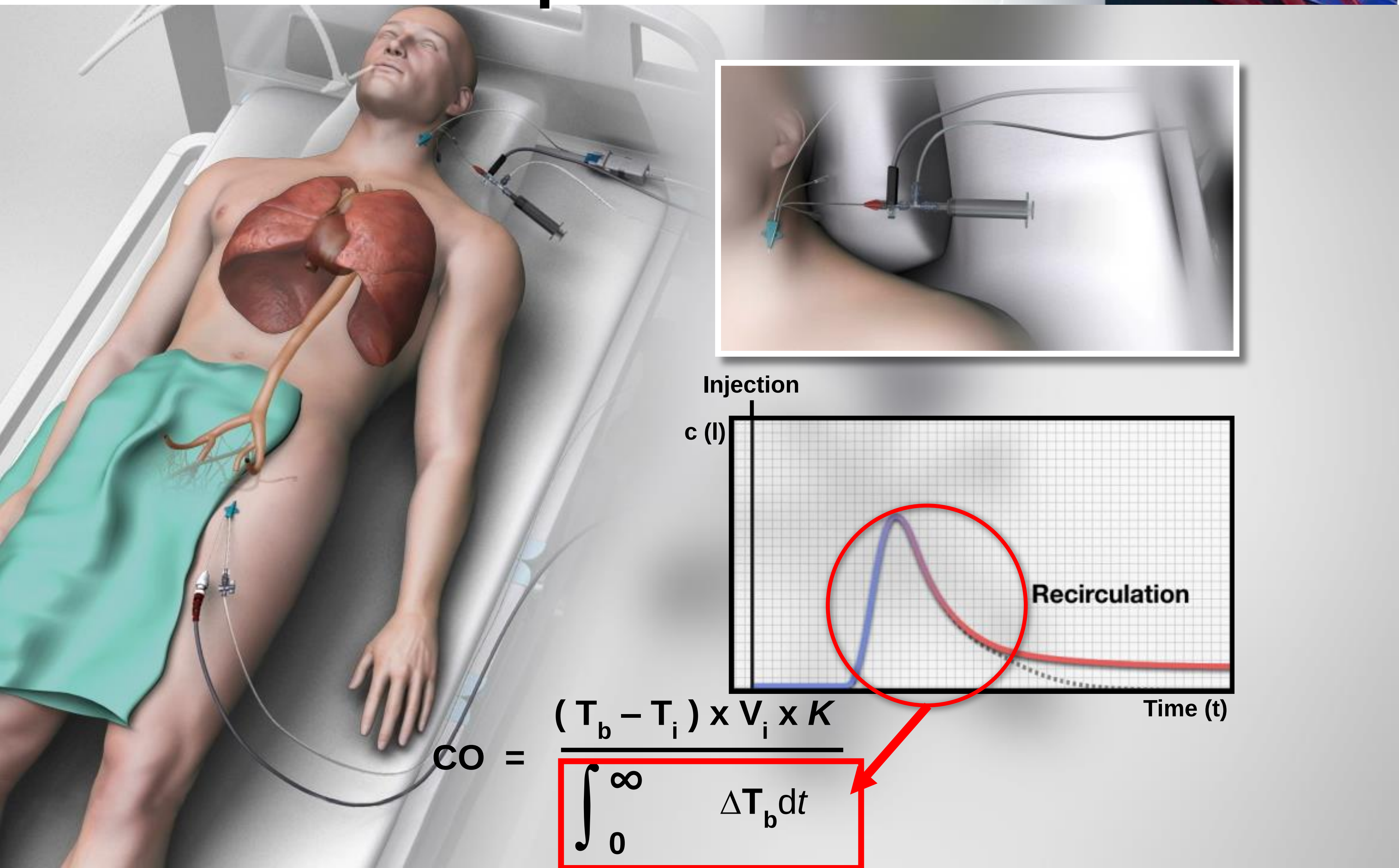
Far Eastern Memorial Hospital

New Taipei city, Taiwan

"Scvo2 offered an Objective index to guide the weaning process of IABP and made rapid decision possible "



Transpulmonary Thermodilution Technology
Cardiac Output Calculation



$$CO = \frac{(T_b - T_i) \times V_i \times K}{\int_0^{\infty} \Delta T_b \, dt}$$

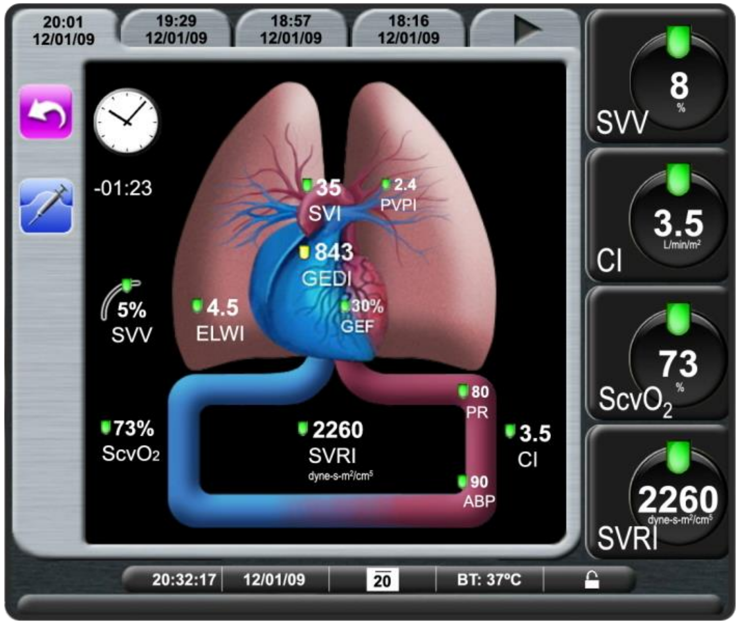
Transpulmonary thermodilution monitoring of CO : Validation ?

Transpulmonary thermodilution-derived cardiac function index identifies cardiac dysfunction in acute heart failure and septic patients: an observational study

Simon Ritter, **Alain Rudiger*** and **Marco Maggiorini**

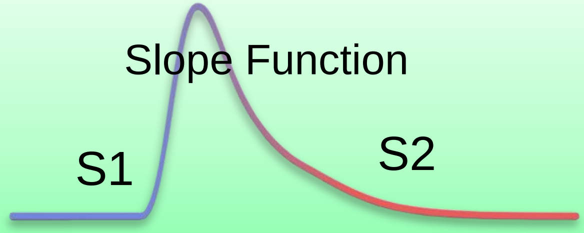
Conclusion : In critically ill medical patients, assessment of cardiac function using transpulmonary thermodilution technique is an alternative to the PAC.

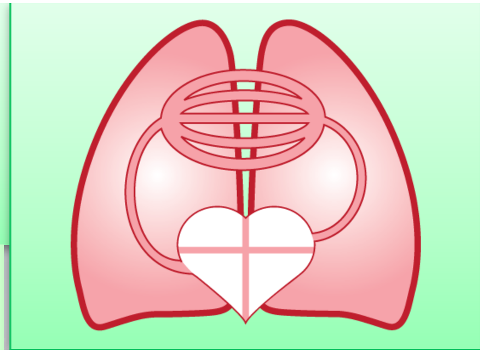
A low CFI identifies cardiac dysfunction .in both AHF and septic patients.



Calculating GEDV

Global End Diastolic Volume



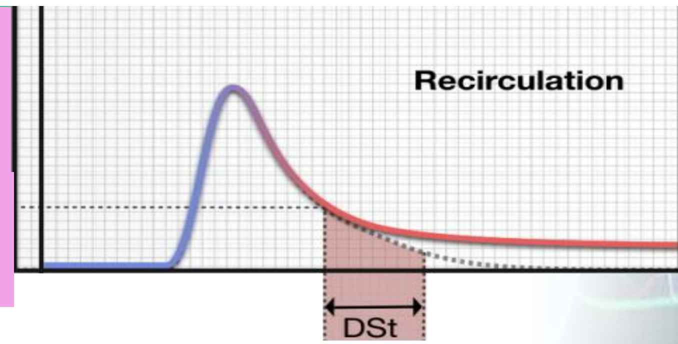


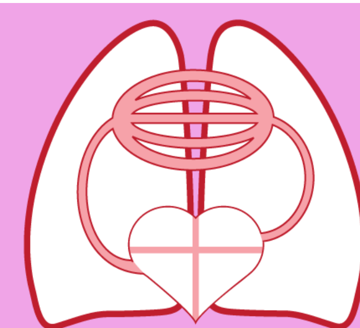
GEDV = slope function * ITTV

PTV

Pulmonary Thermal Volume

PTV = CO * DSt

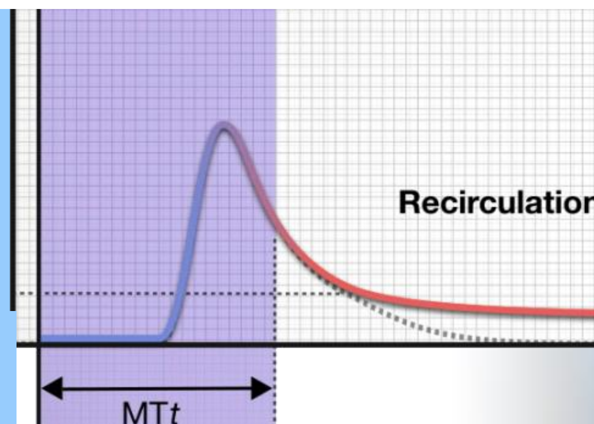


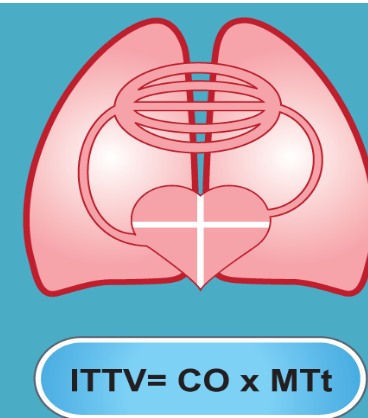


Calculating (ITTV)

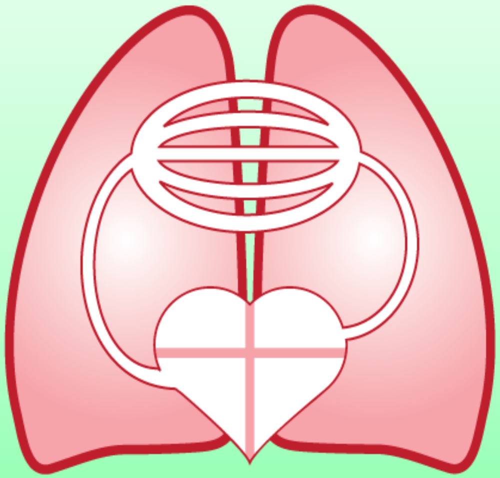
Intra Thoracic blood volume

ITTV = CO * MT*t*





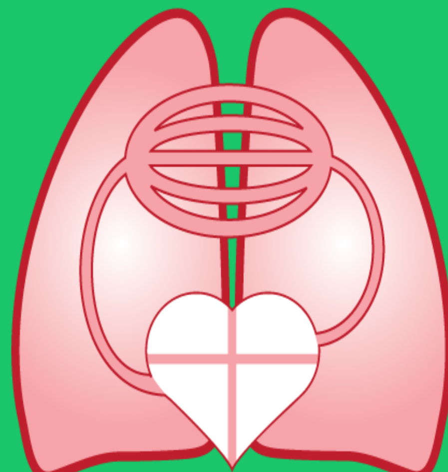
EVLW (extra vascular lung water) :Pulmonary edema



EVLW

thermal volume within the lungs

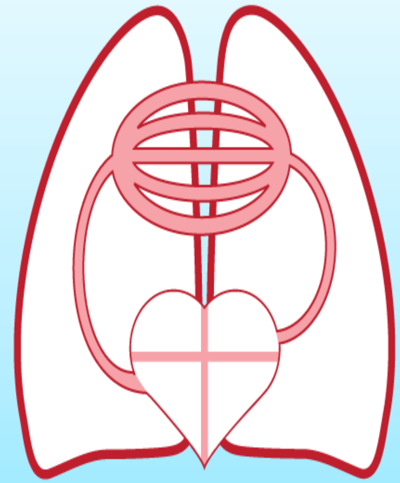
=



PTV

Pulmonary Thermal Volume

−

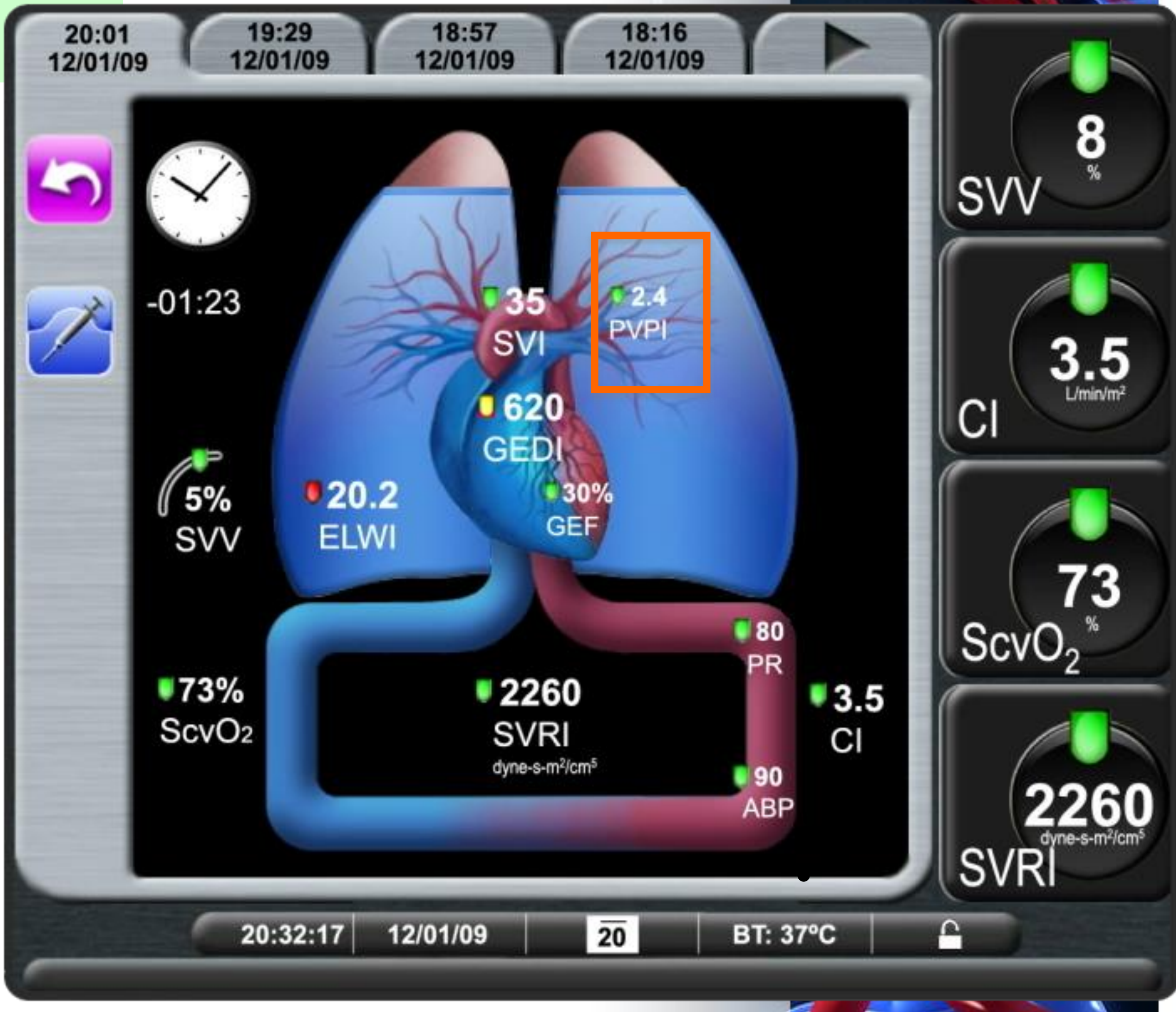


PBV

Pulmonary Blood Volume

High Pressure pulmonary edema VS ARDS :PVPI

PVP = EVLW / PBV



CO from Arterial waveform

- There is 2 different methods , sometimes mixed in the same device
  Calibrated CO : the reference is the CO calculated by thermodilution (EV 1000 , Picco) or Lidco .

  a Thermodilution study should be performed each few hours .

It is important to understand that the Arterial line waveform is not only proportional to the CO but that the vascular tone and the compliance are leading to modification of the waveform .

- Non calibrated CO : the device is analyzing the waveform , with the ability to analysize of the vascular tone and vessel compliance

  Exemple : Vigileo (Edwards)

Automatic Vascular Tone Adjustment

CO = HR * SV

where

SV = χ* σ_{BP}

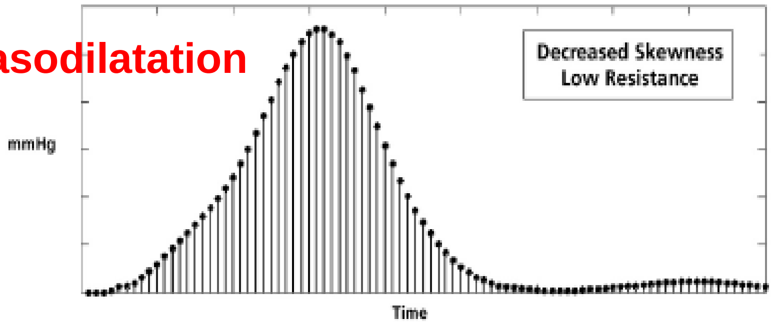
$$\chi = f\left(HR, BSA, C(P)_{Lang}, MAP, \sigma_{AP}, \mu_{3AP}, \ldots \mu_{4T}\right)$$

Khi is made up of a fraction of complex variables, each describing a different aspect of waveform conformation. Khi factor automatically calculates the effect of changes in vascular tone & compliance, and resistance on stroke volume.

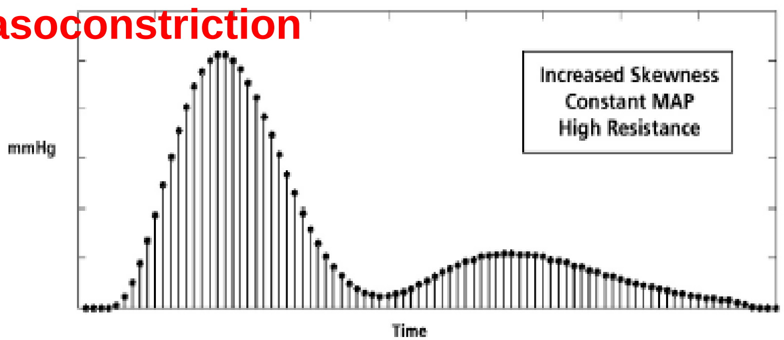
Detailed analysis of the waveform shape **continuously** assesses patient specific effects of vascular tone on flow.

Skewness

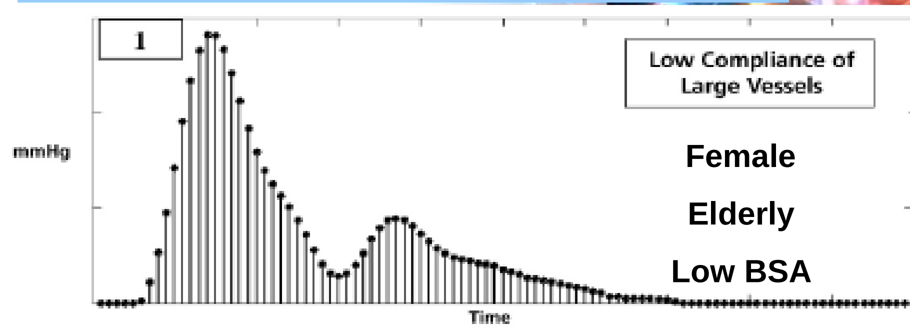
Vasodilatation

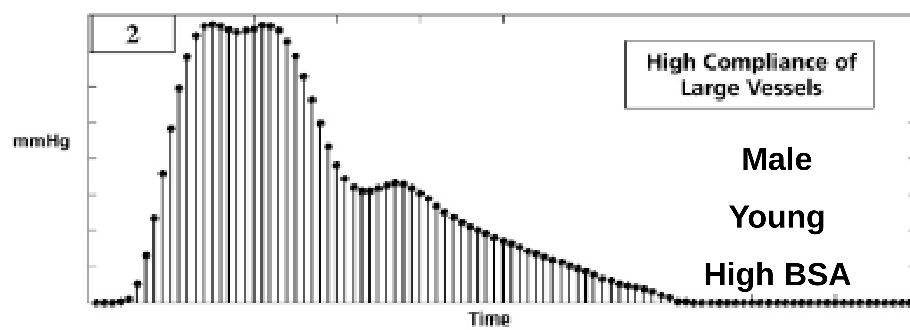


Vasoconstriction

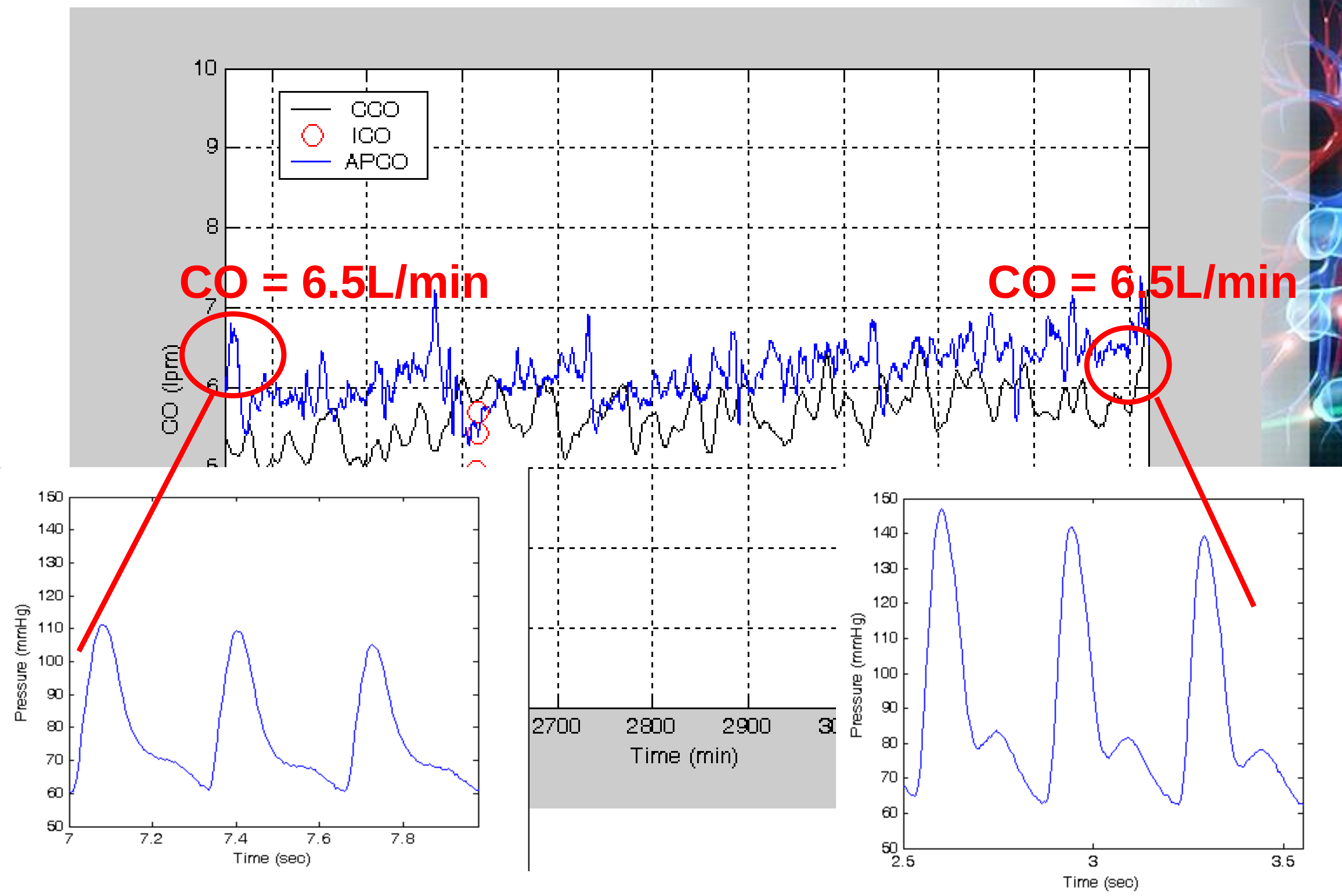


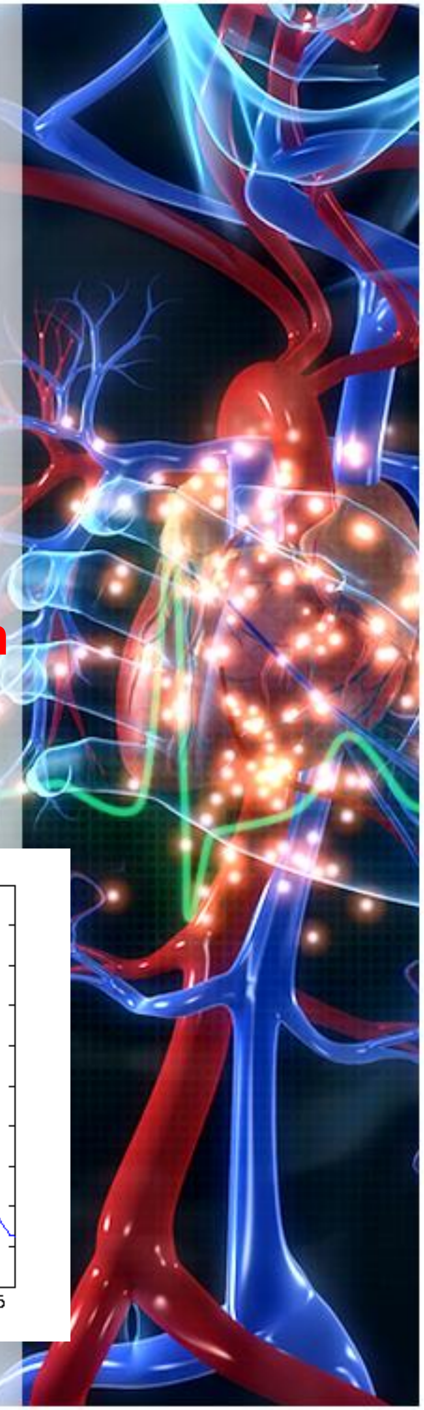
“peaks and valleys" Kurtosis





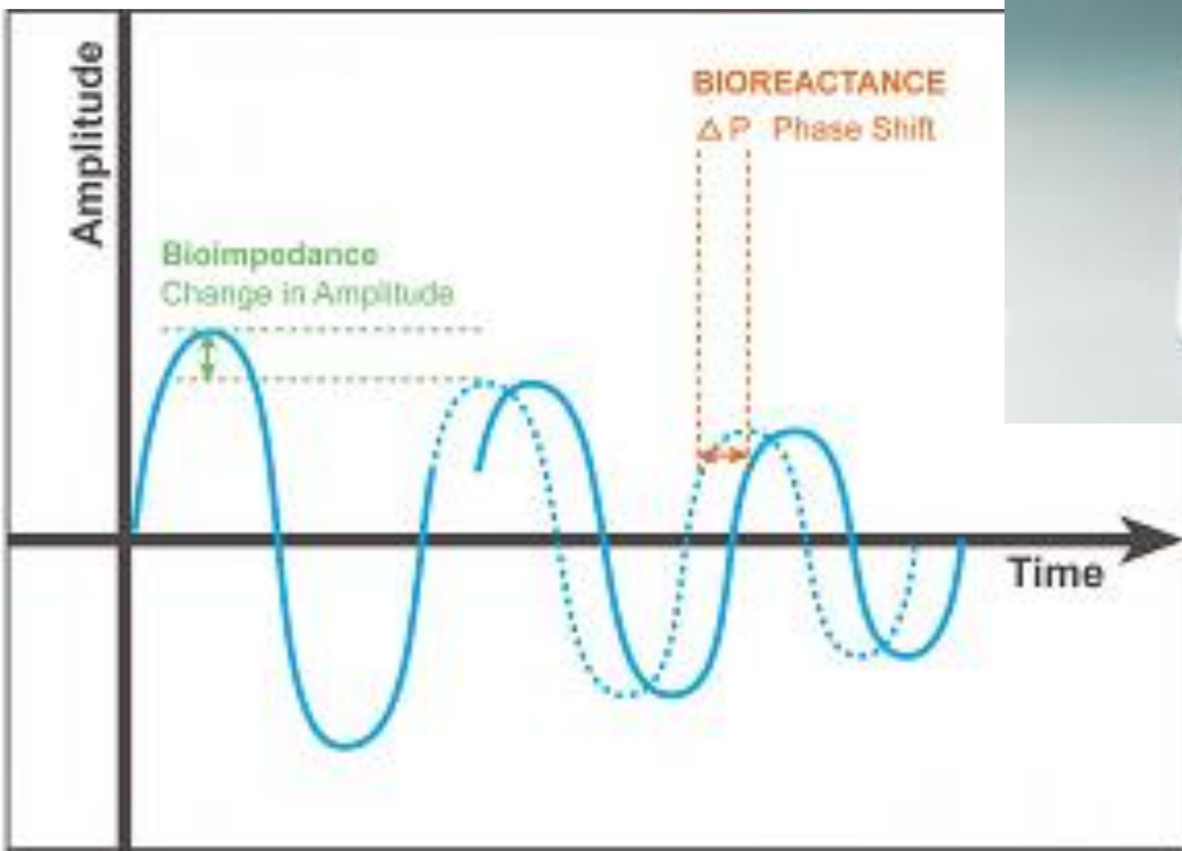
Example of Effect of χ

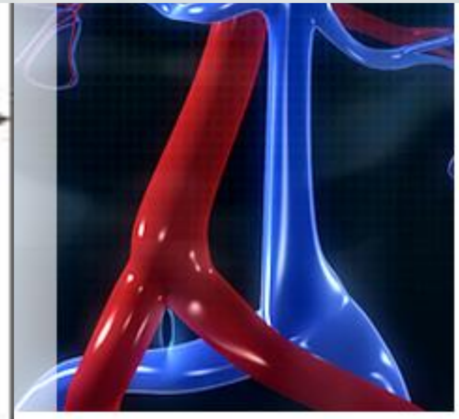




Bioreactance

- Inspired from the Bioimpedance , but measure changes in frequency of the electrical currents traversing the chest rather than change of impedance .





Geometry of the heart

The size of the heart may have an important weight concerning hemodynamic management :

- We probably target the GEDI or the wedge pressure higher for a patient with severe LV hypertrophia .

  Patient with LV dilatation will need more higher filling pressures as well .

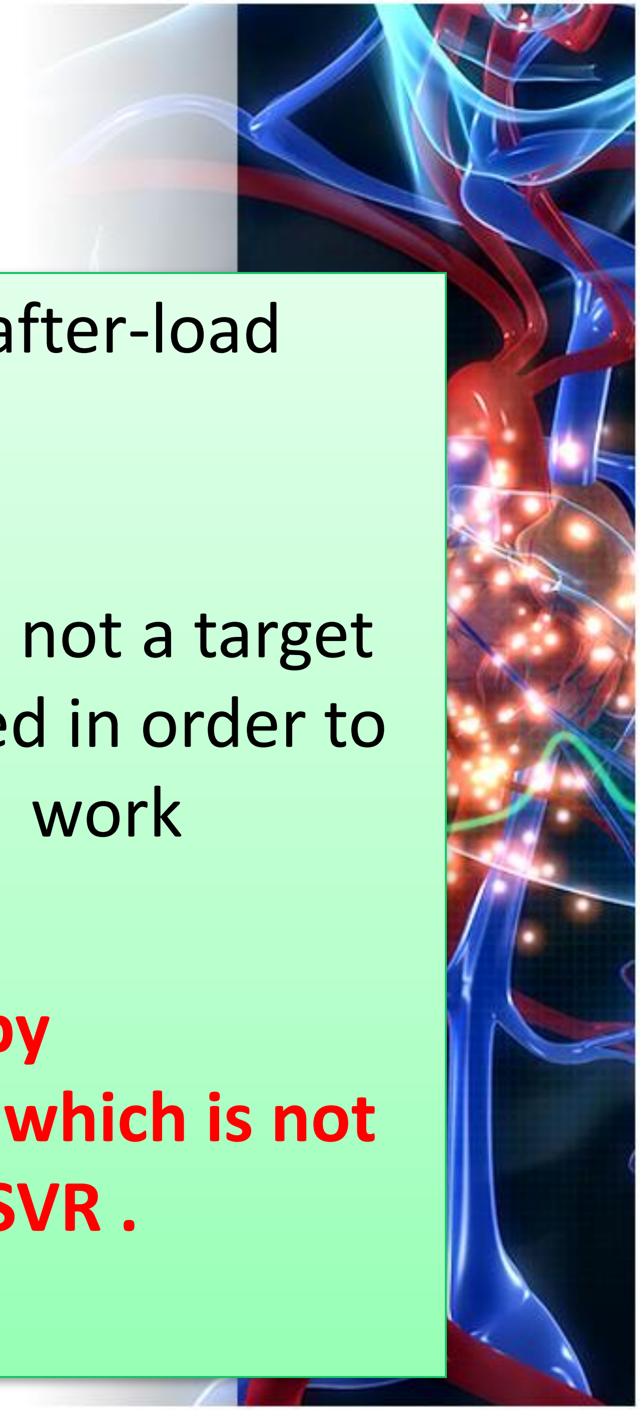
- We will make a different interpretation of the SVR In a patient with a dilated LV .

SVR ??????

- SVR is use in clinical practice as the after-load parameter .

- The measurement of the after-load is not a target by himself . But a parameter measured in order to maintain BP and also to ease the LV work

- **The LV after-load is best reflected by measurement of the LV wall tension which is not always in good correlation with the SVR .**



LV wall tension

Can be measured with TTE or TEE

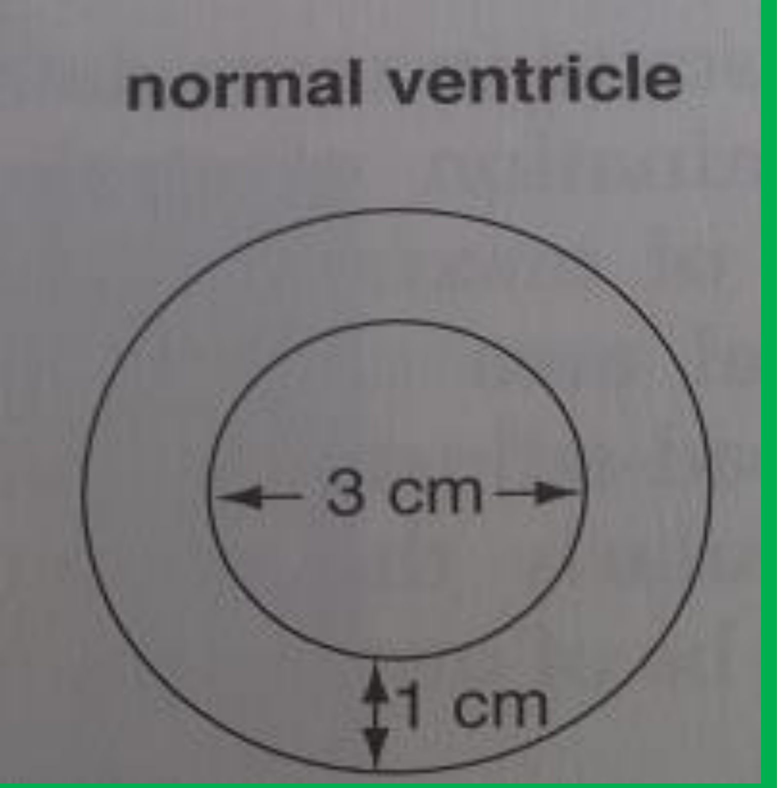
TEE : ES : BP systolic x (LV – ESA)

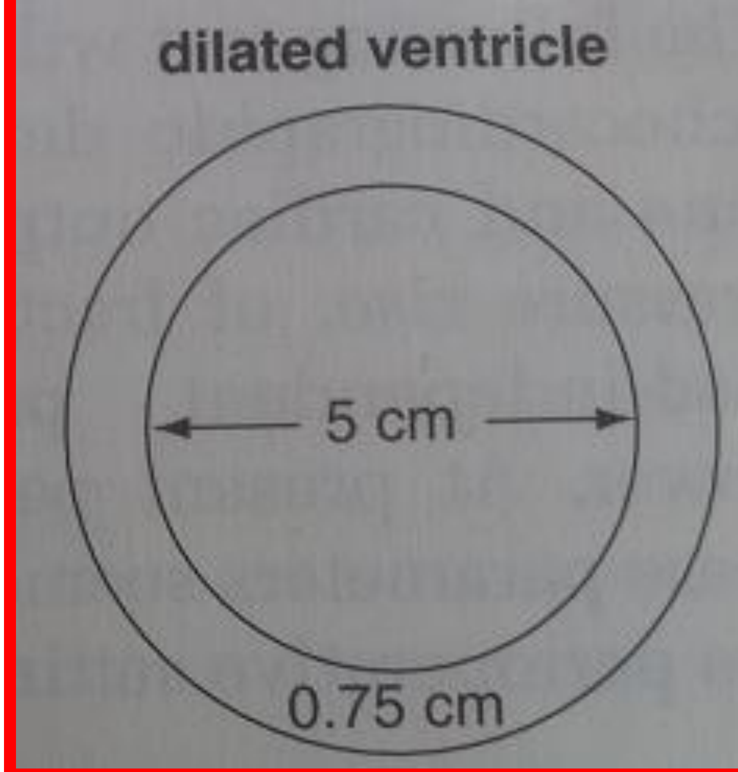
end systolic cross sectional LV area

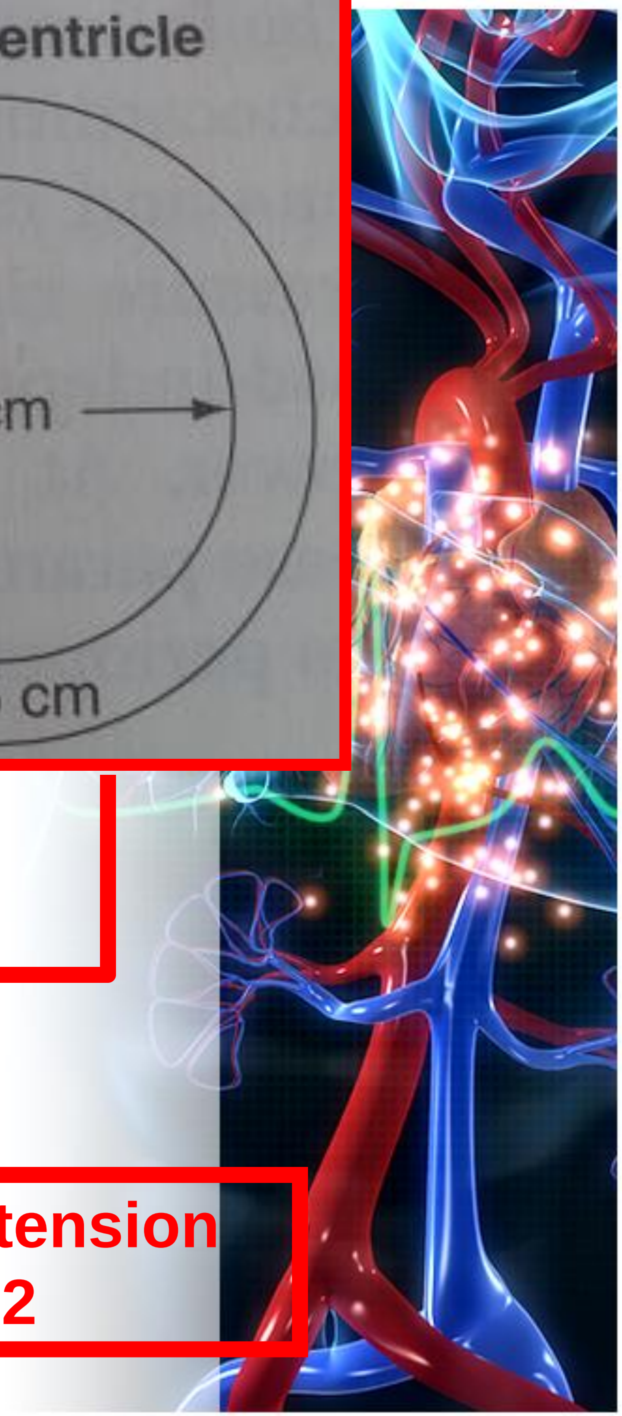
TTE : 0 = 1.35 x BP X LVID / 4h(1+h/LVID)

Where LVID = LV internal diameter

h = end systolic wall sickness







P syst	100 mmHg
Pmean	75 mmHg
CO	5 l/mn -1
SVR	1200 mmHg/s/cm-5

Wall surface tension
76 dyne /cm2

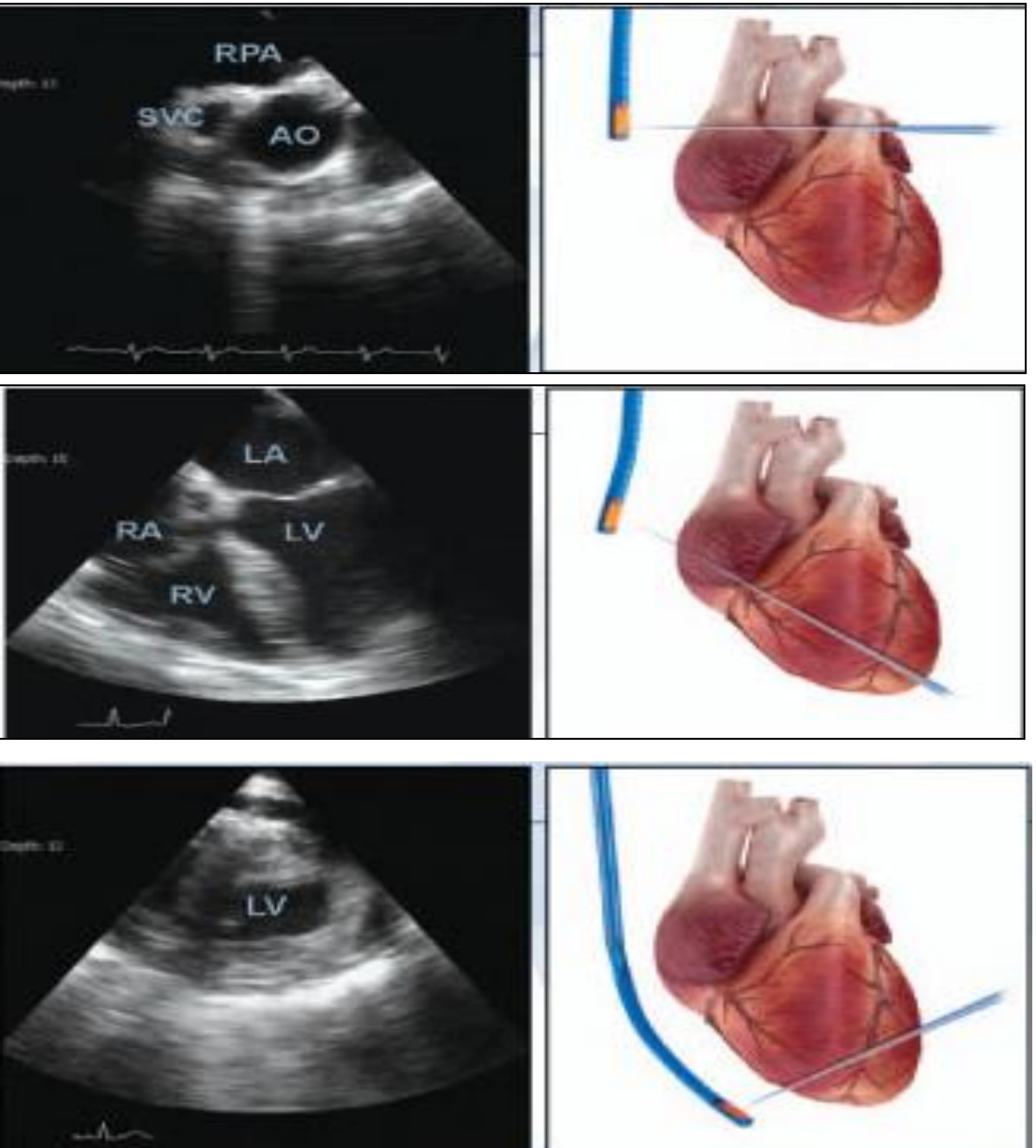
Wall surface tension
196 dyne /cm2

- **For a distended LV : a ‘’ normal ‘’ SVR value can lead to high wall tension and then to cardiac failure .**

- **It mean that we have to implement geometrical factors in the analysis of afterload conditions ! (as well for fluid Therapy) .**

Continuous TEE Monitoring

Single use TEE probe

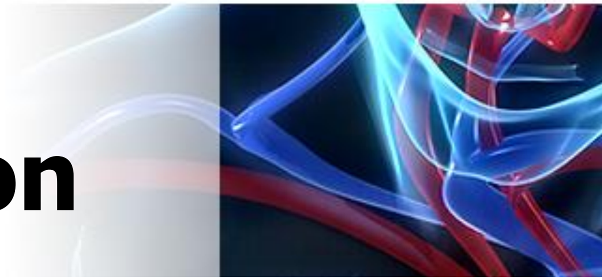


Superior vena cava : to evaluate fluid responsiveness

Mid-esophageal 4 chambers: To evaluate Biventricular size and function

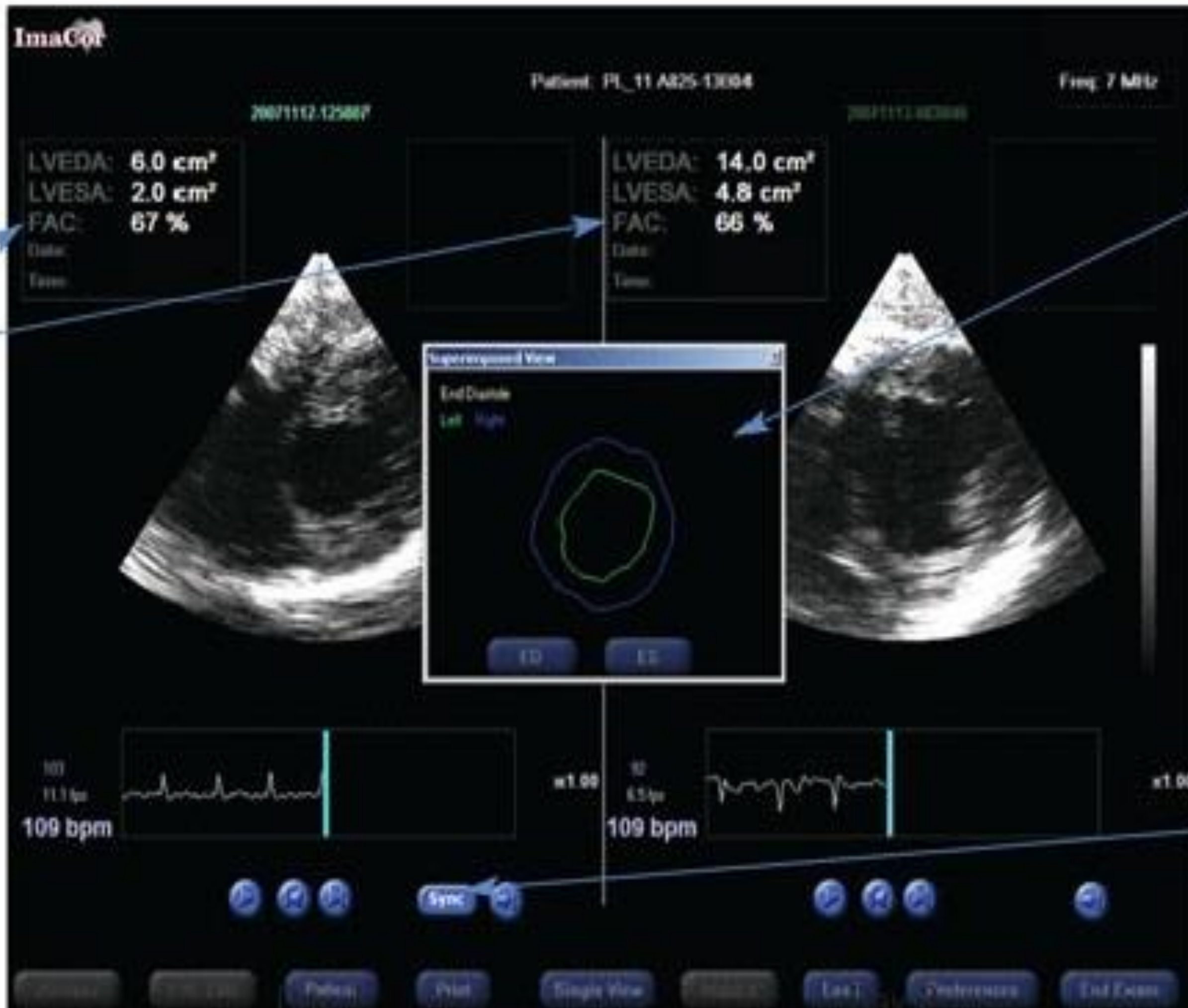
Trans-gastric short axis : to assess preload and contractility

Automatic wall detection



Transgastric short axis view of the left ventricle

Software tool for calculating fractional area change



Software tool for comparing LV size over time

Software tool for synchronizing cineloops

Example of multi -modality monitoring

Trans-pulmonary indicator monitoring

Cardiac function

Cardiac failure

Normal or good enough :Follow on same treatment and monitoring

Cardiac echography

RV Failure

LV Failure

Inotropic support

Dobutamin ..

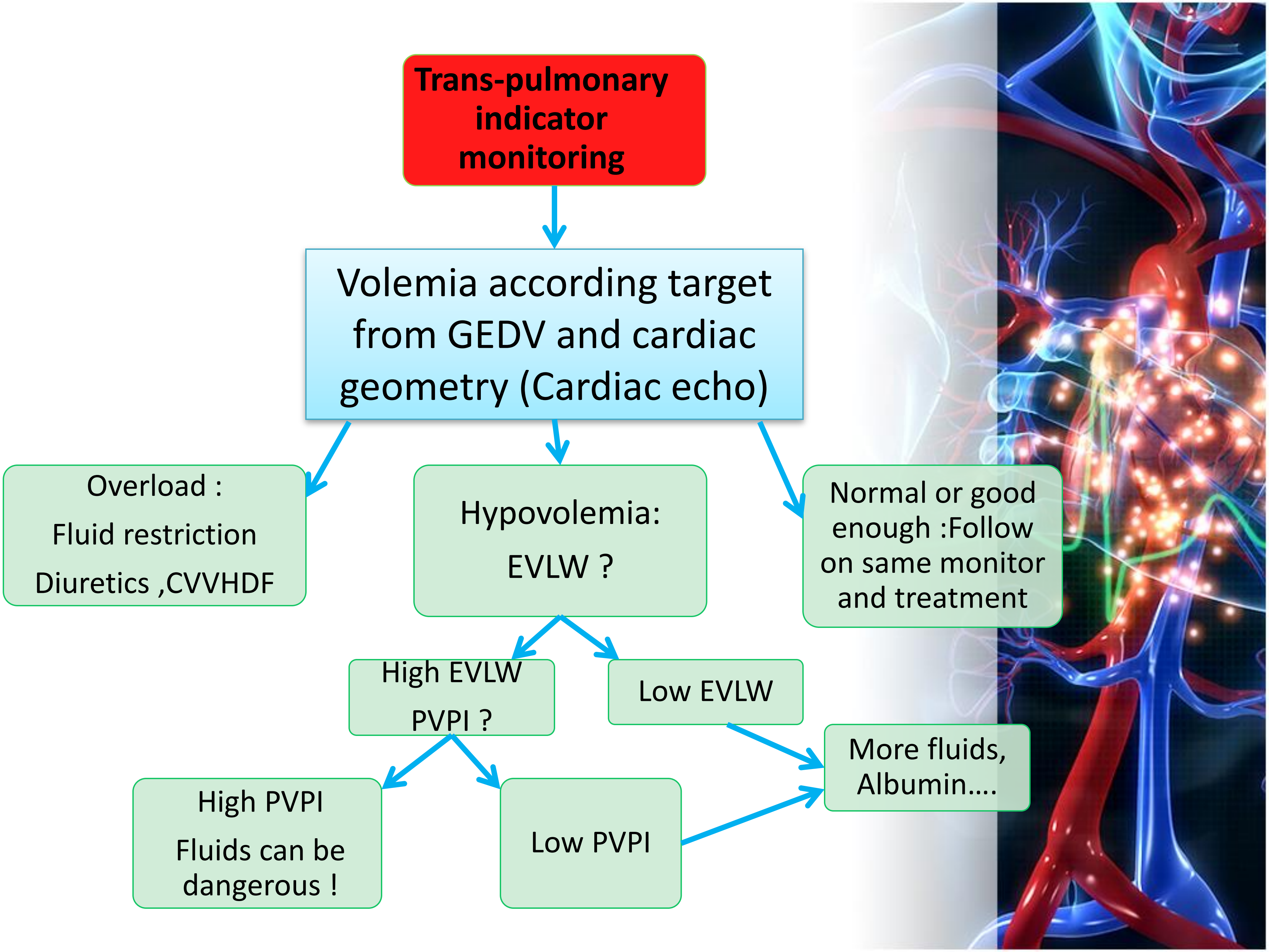
IABP ECMO VAD …

Consider Swan Ganz SCVO2 and RVEF

Pulmonary hypertension : NO , Ventavis , Milrinone , ECMO …..

Conclusion

- Use hemodynamic monitoring for difficult patients !
- Continuous SVO2 monitoring is an excellent warning system
- Use of PAC in selected patients
- Use of less invasive monitoring seems to be very helpful in the management of severe Heart failure .


Trans-pulmonary indicator monitoring
Volemia according target from GEDV and cardiac geometry (Cardiac echo)
Overload :
Fluid restriction
Diuretics ,CVVHDF
Hypovolemia:
EVLW ?
Normal or good enough :Follow on same monitor and treatment
High EVLW
PVPI ?
Low EVLW
More fluids, Albumin….
High PVPI
Fluids can be dangerous !
Low PVPI

Trans-pulmonary indicator monitoring

After load : Target according cardiac geometry (cardiac echography)

Normal (goal directed)

No change

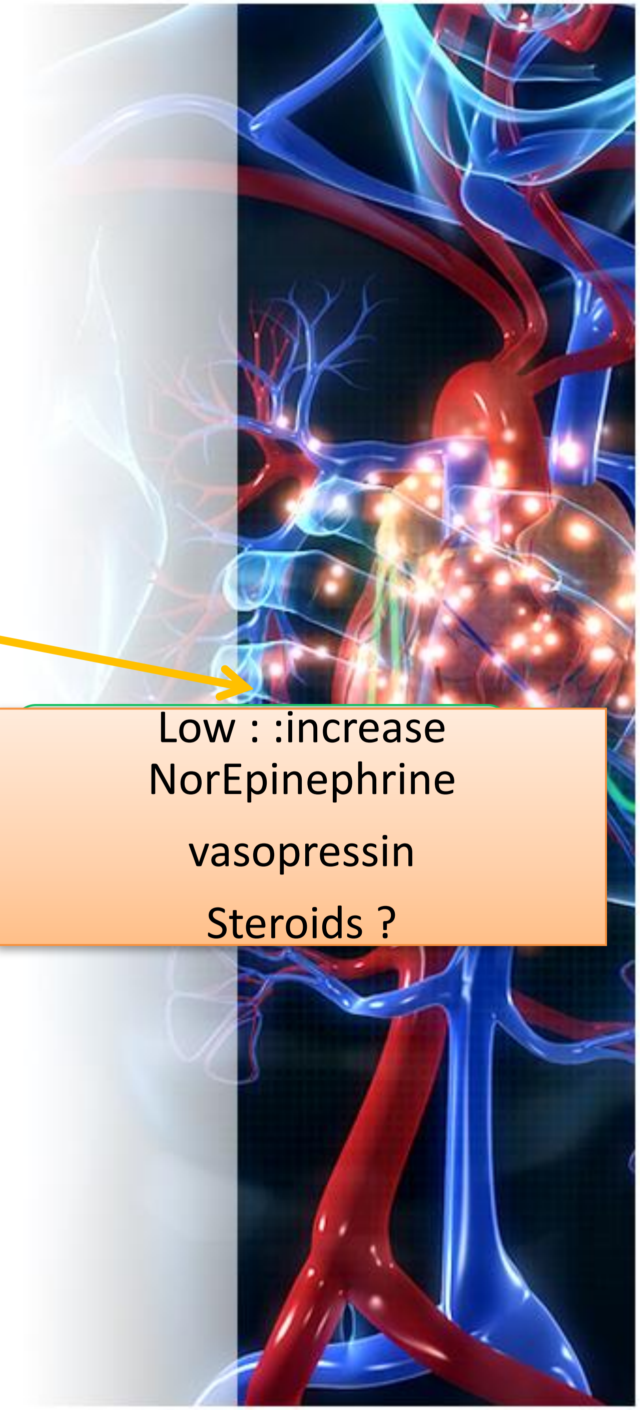
High :decrease vasoconstrictors

Hypovolemia ??

Low : :increase NorEpinephrine

vasopressin

Steroids ?



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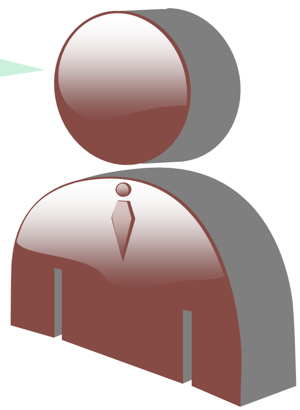

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Comparison

Advantages and disadvantages

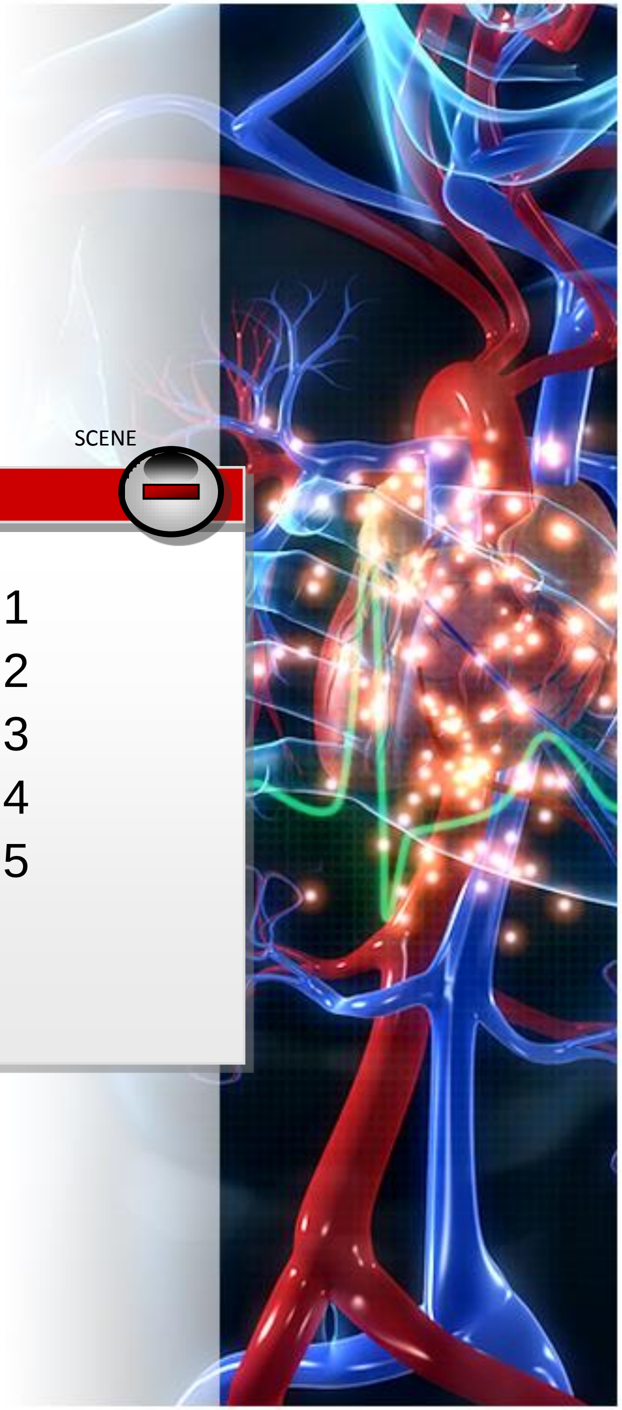
SCENE

Positive

- positive argument 1
- positive argument 2
- positive argument 3
- positive argument 4
- positive argument 5

Negative

- negative argument 1
- negative argument 2
- negative argument 3
- negative argument 4
- negative argument 5



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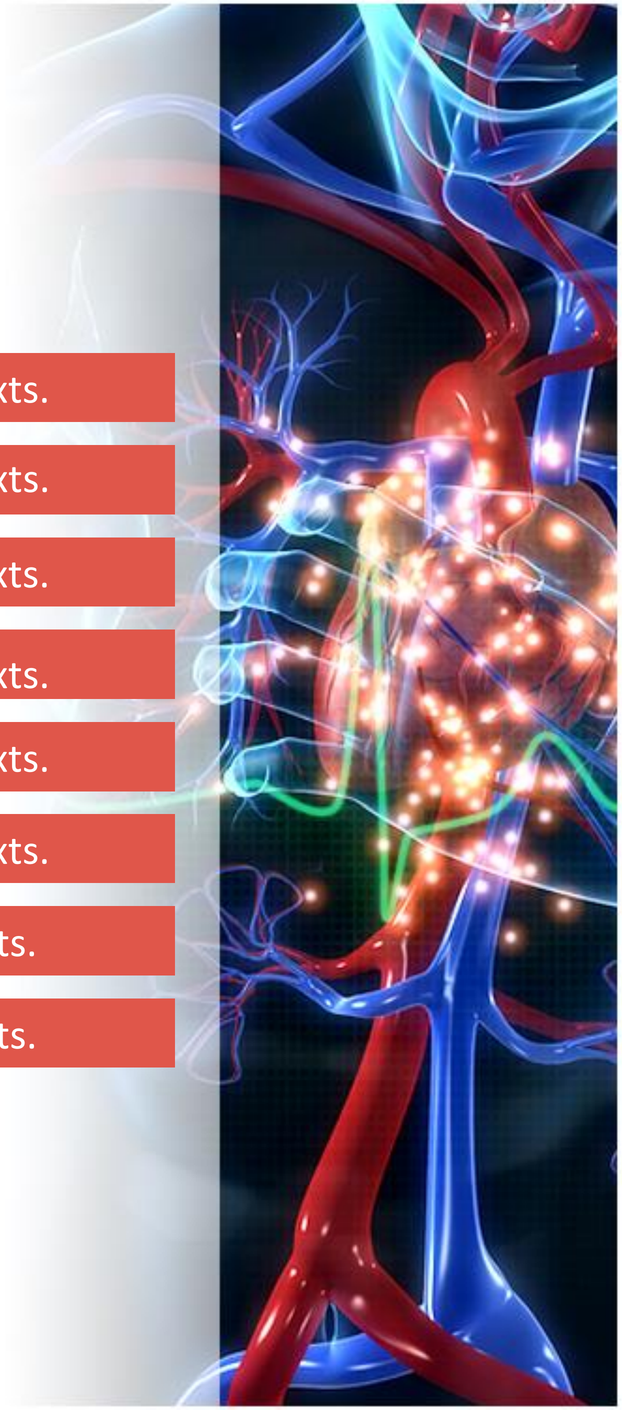

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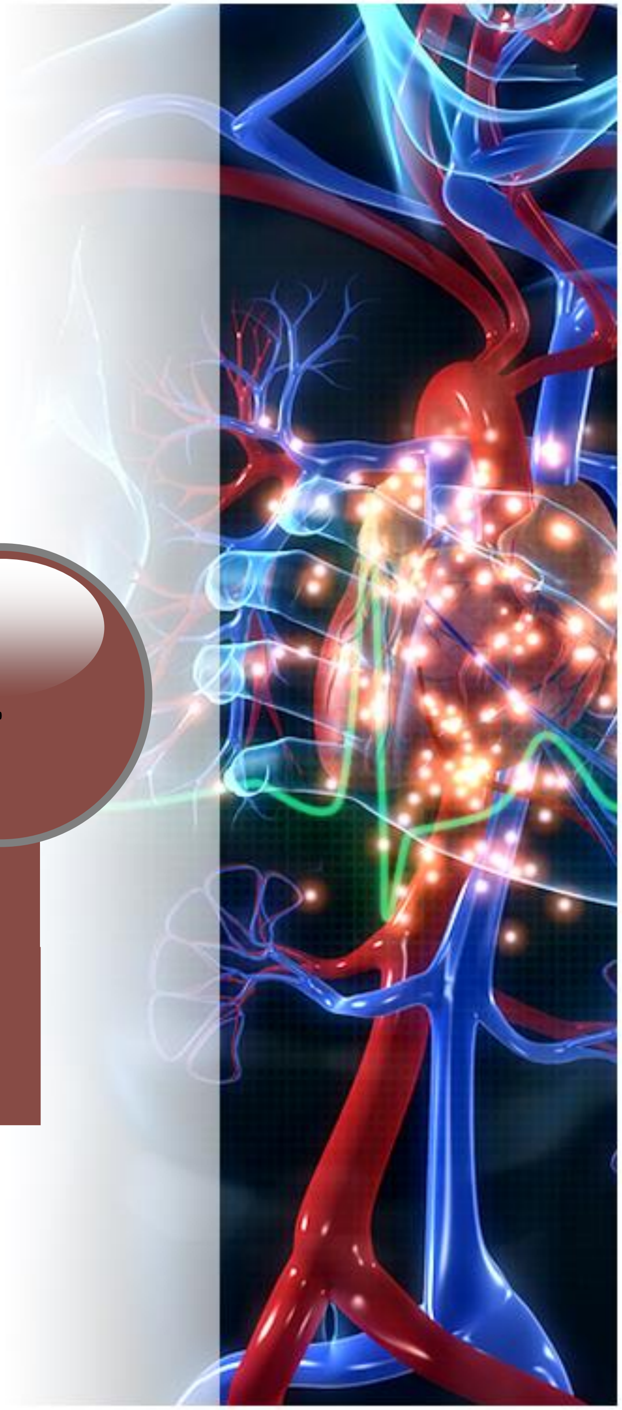

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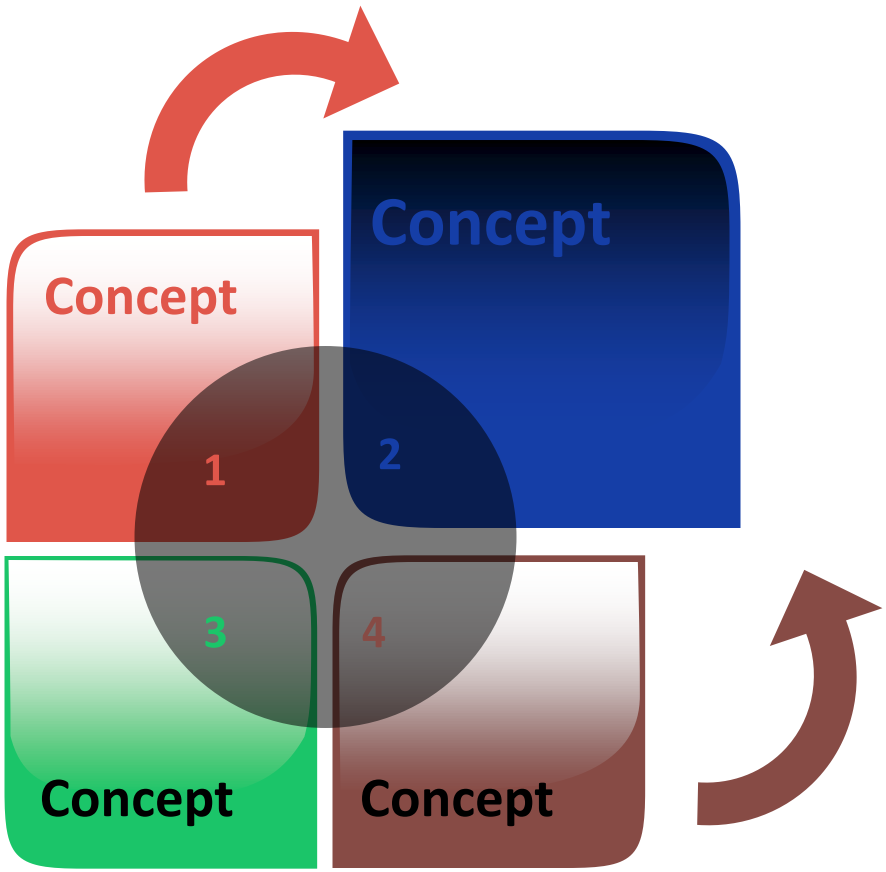
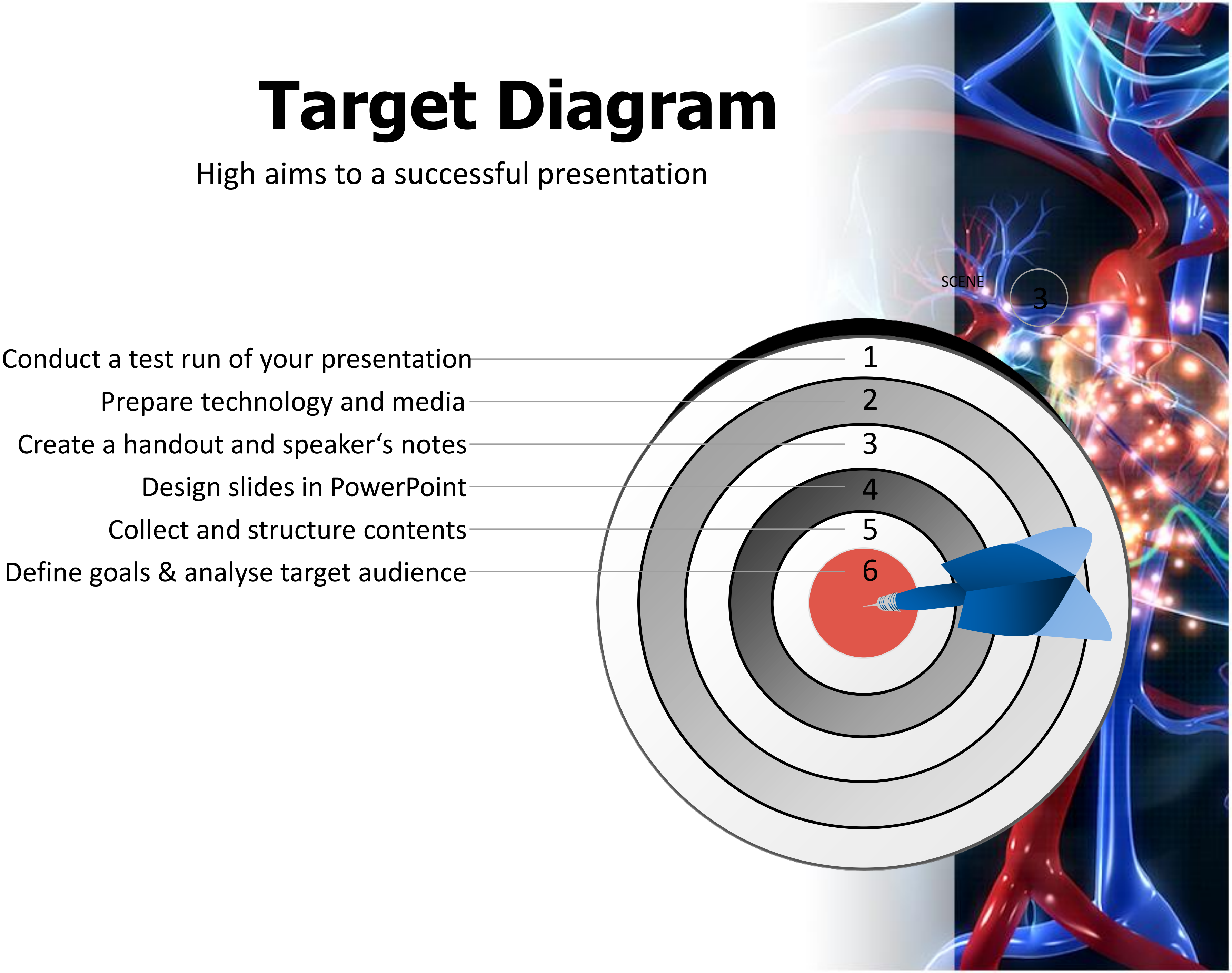


Target Diagram

High aims to a successful presentation



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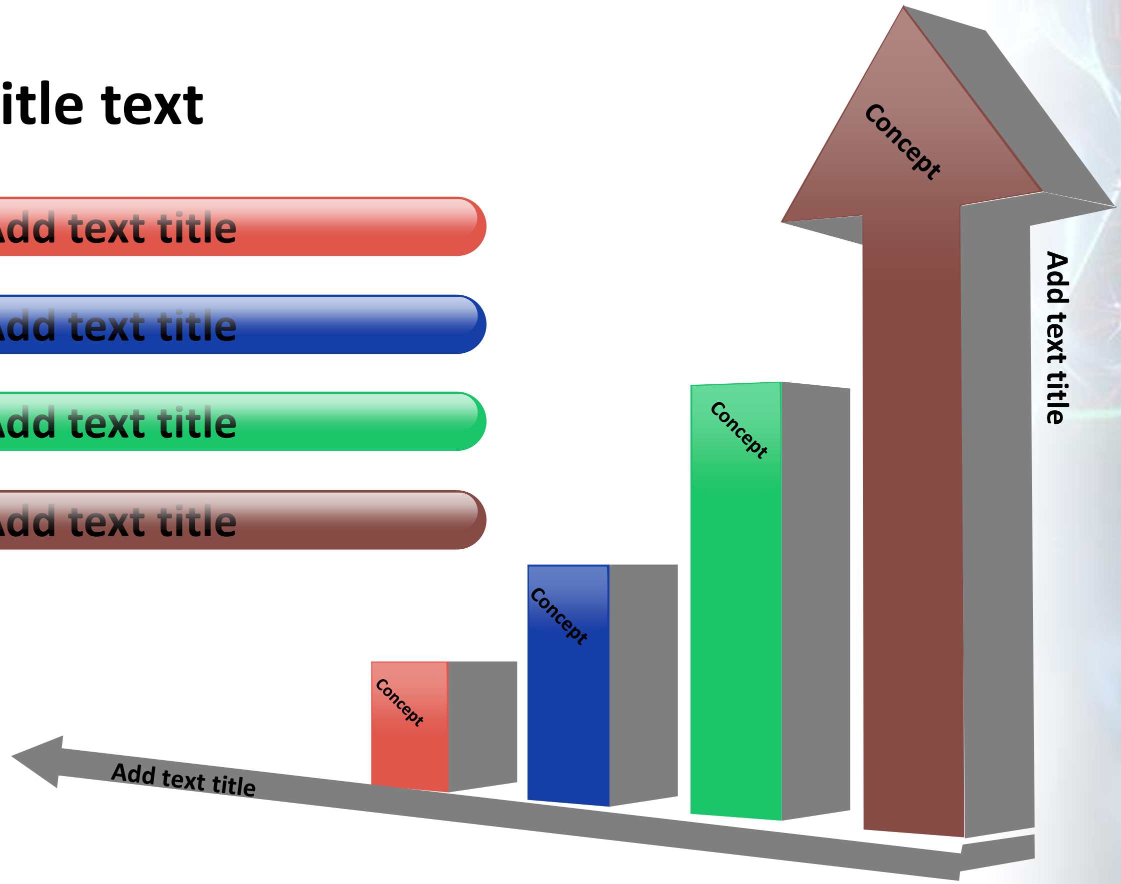
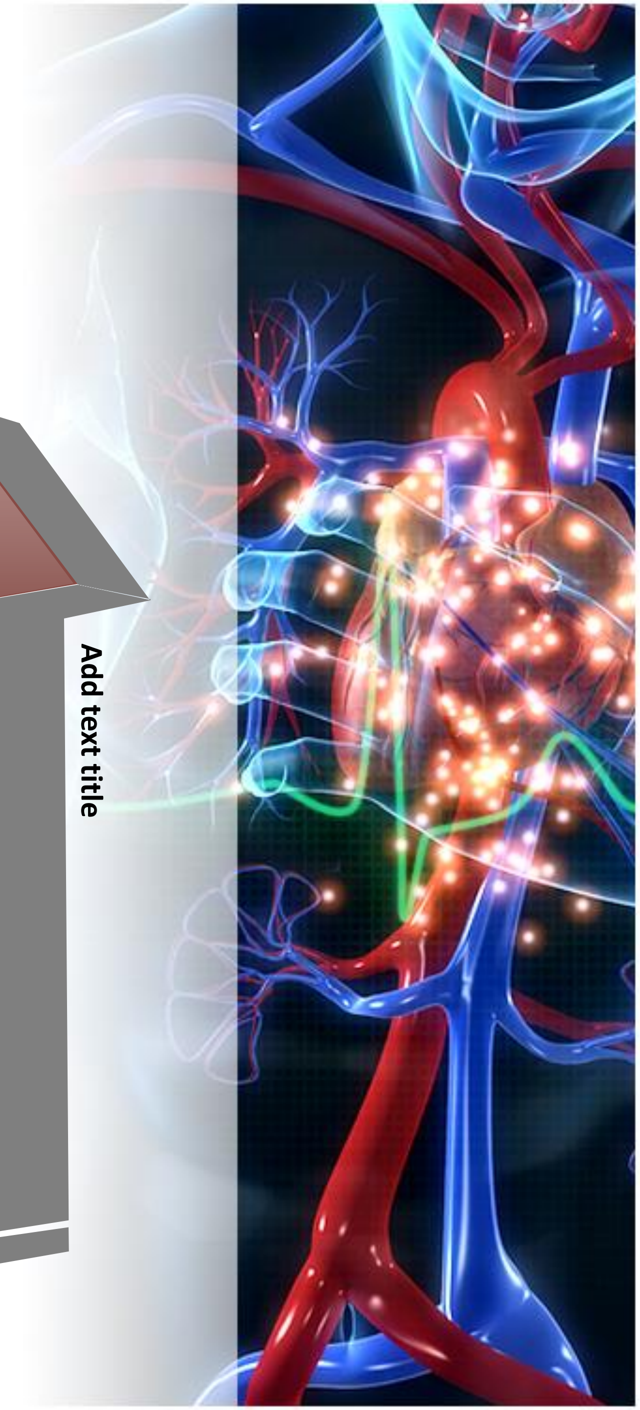
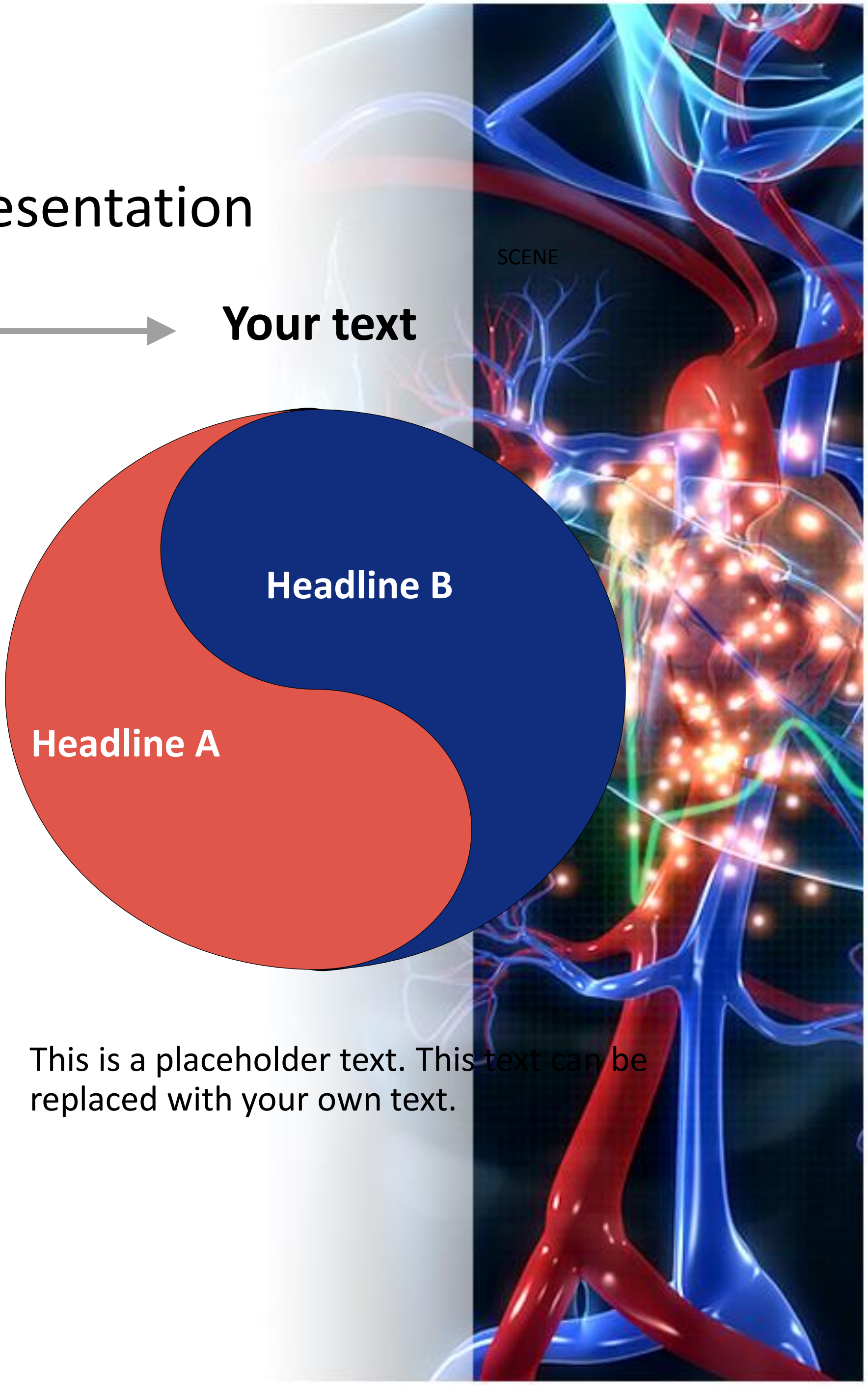




Ying and Yang for your presentation

Common symbols for clear illustrations ↔ **Your text**



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- This text can be replaced with your own text. This is a placeholder text.
- The text you type keeps the same style and formatting as the placeholder text. This text can be replaced with your own text.

This is a placeholder text. This text can be replaced with your own text.

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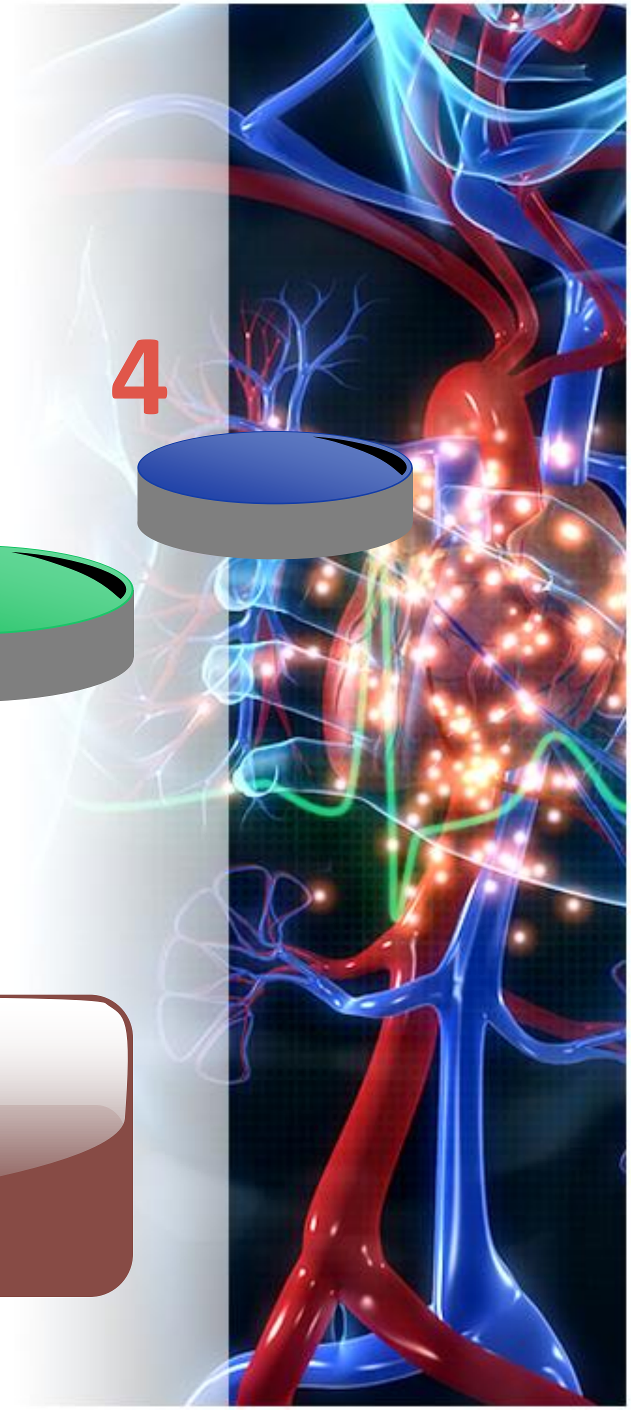
Concept



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- **Add text 3**

Hereon, you should pay attention:

Fast and effective creation of your presentation

- Apply a collection of regularly used slides.
- Pay attention to a clear and comprehensible file deposition, so that contents can be found at any time.

Appealing visualization of your contents

- Use colors and the layout of your corporate design.
- Create of text slides and numbers descriptive graphics and „pictures“.

Improved performing

- Practice a convincing appearance.
- Personal speech and interaction with the audience.

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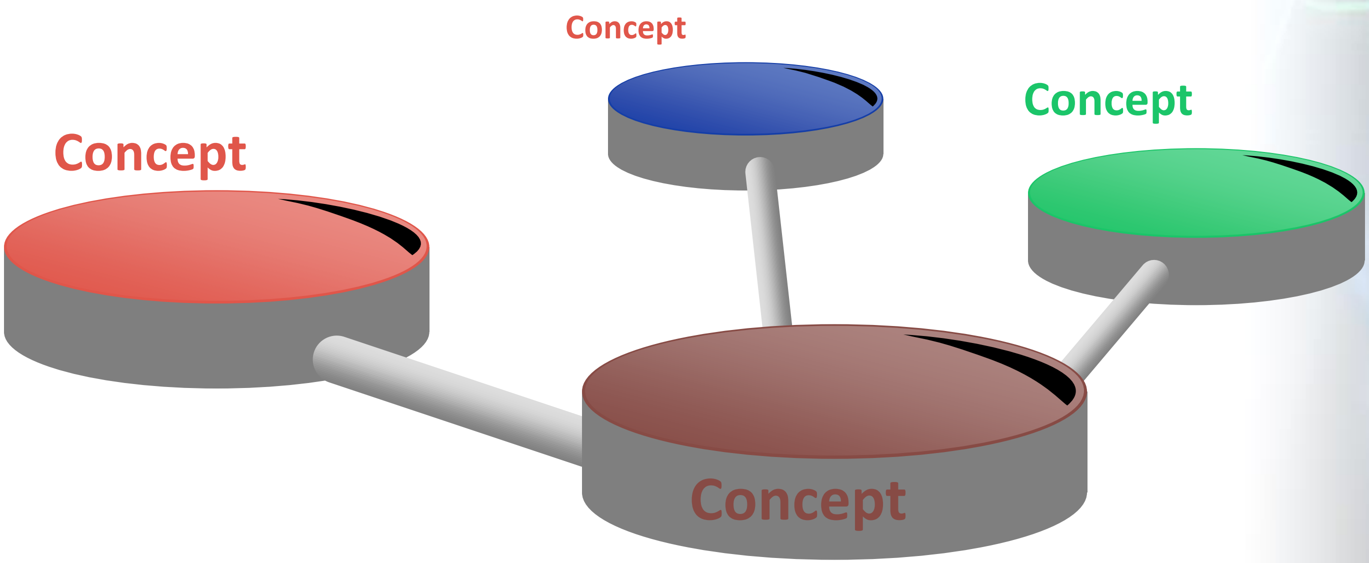

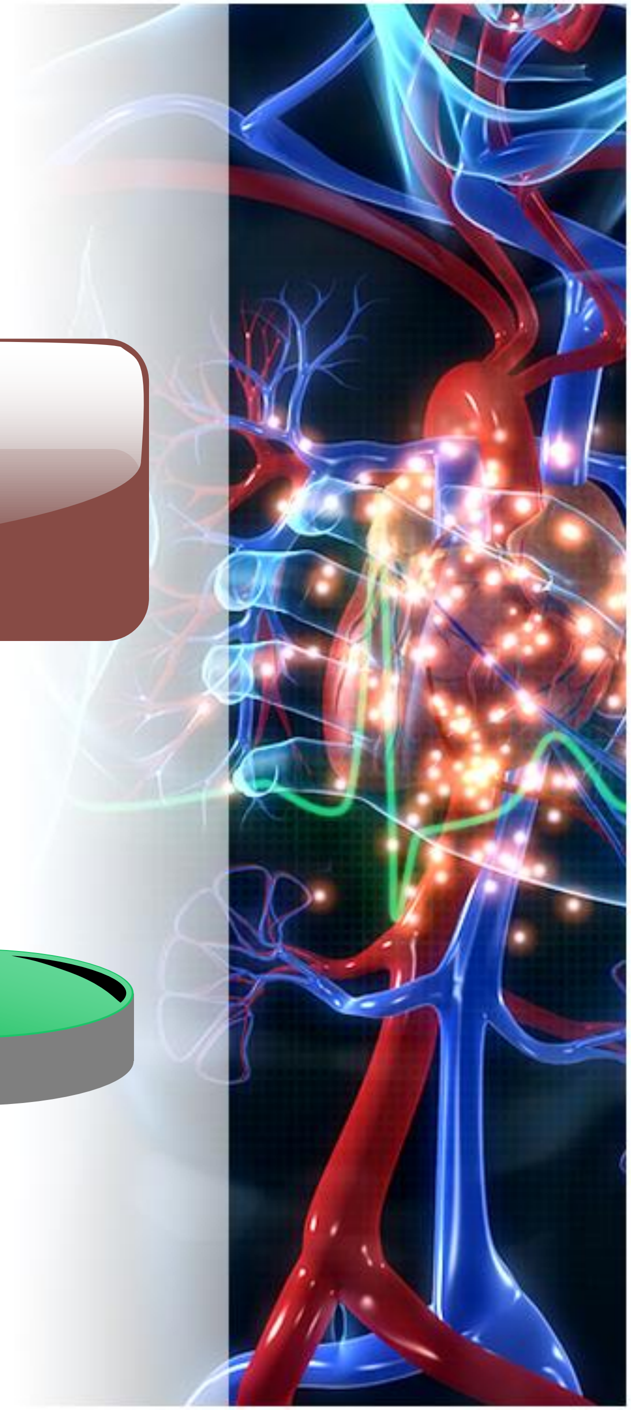

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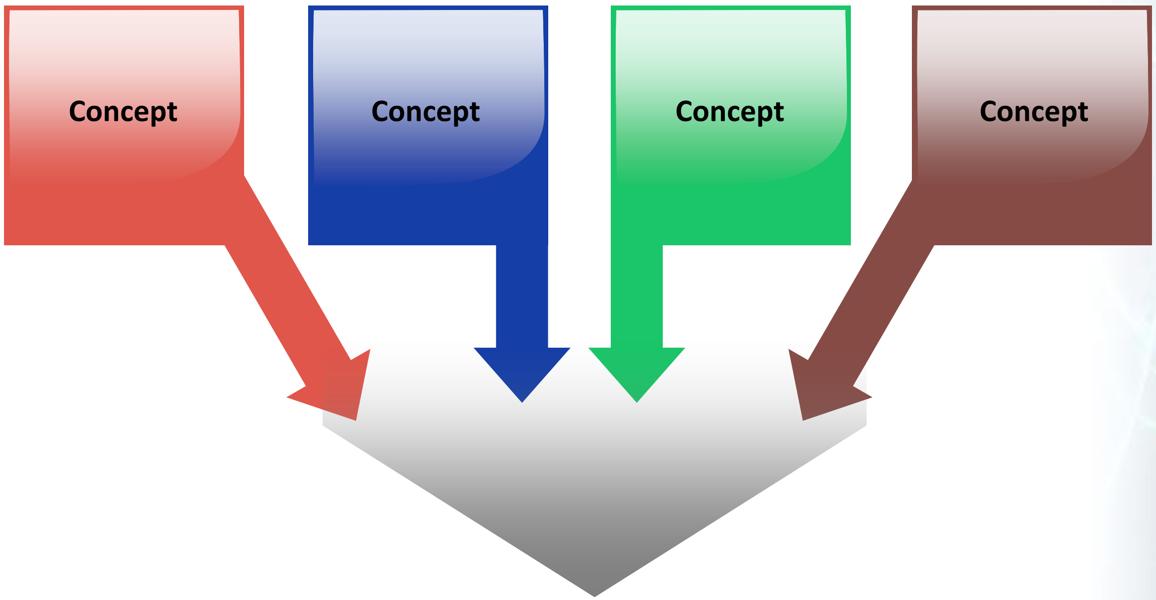

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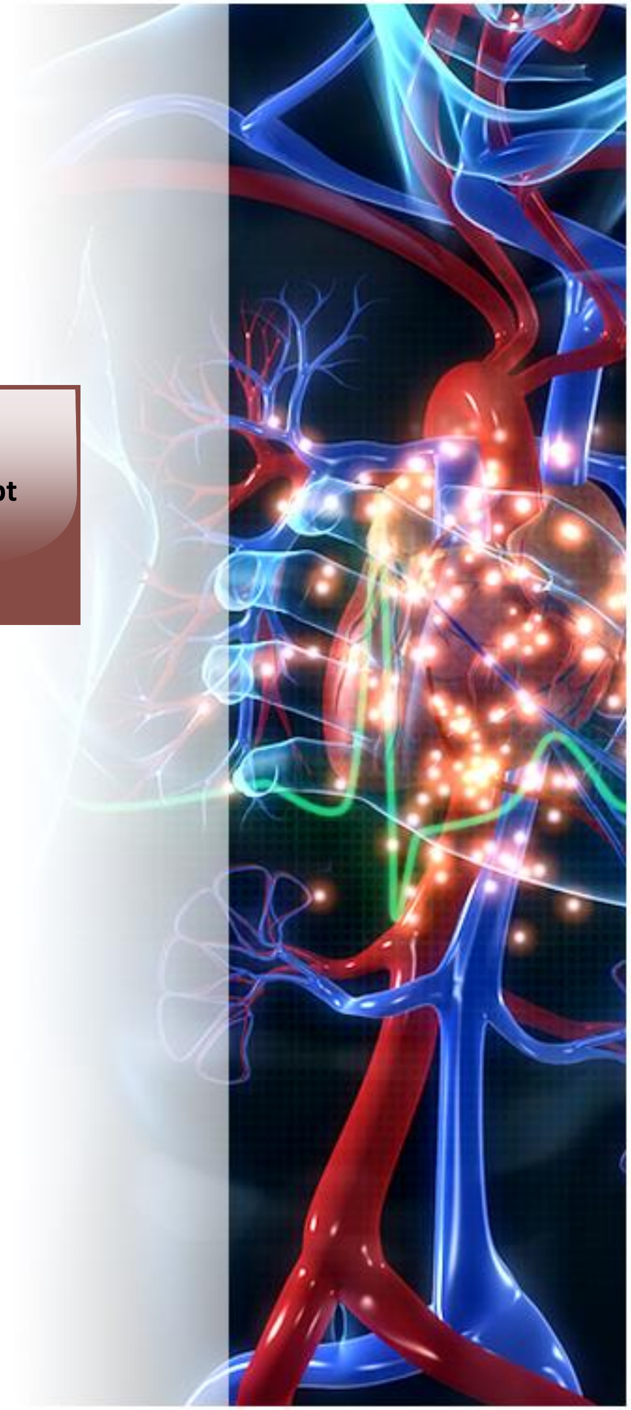
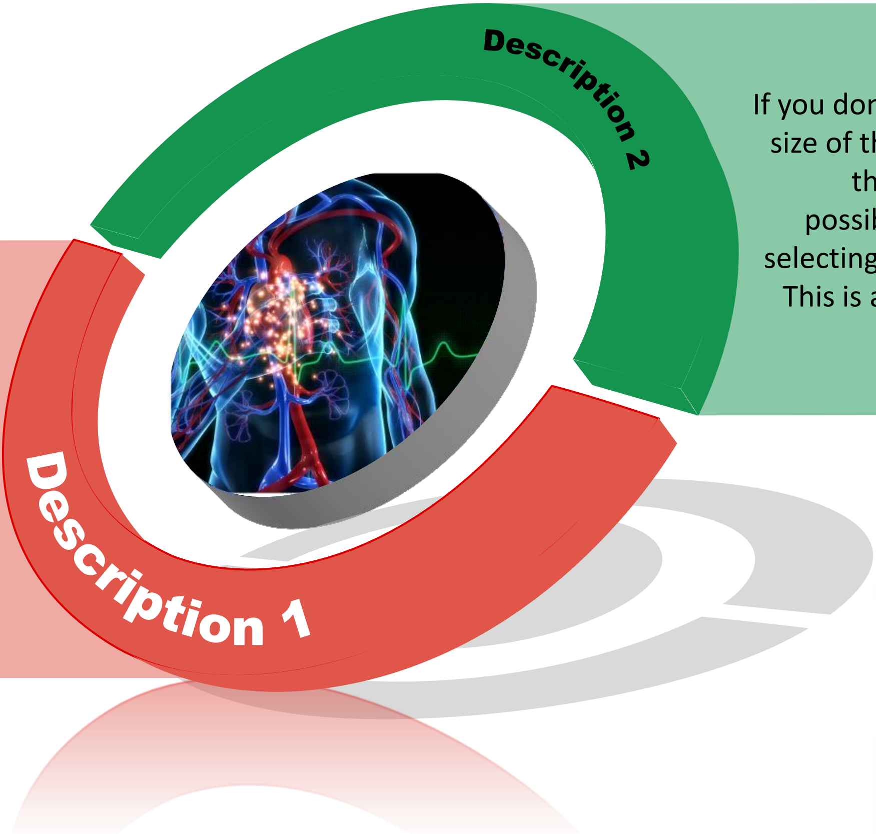


Comparison

Impress your audience with clear 3D shapes.



Placeholder

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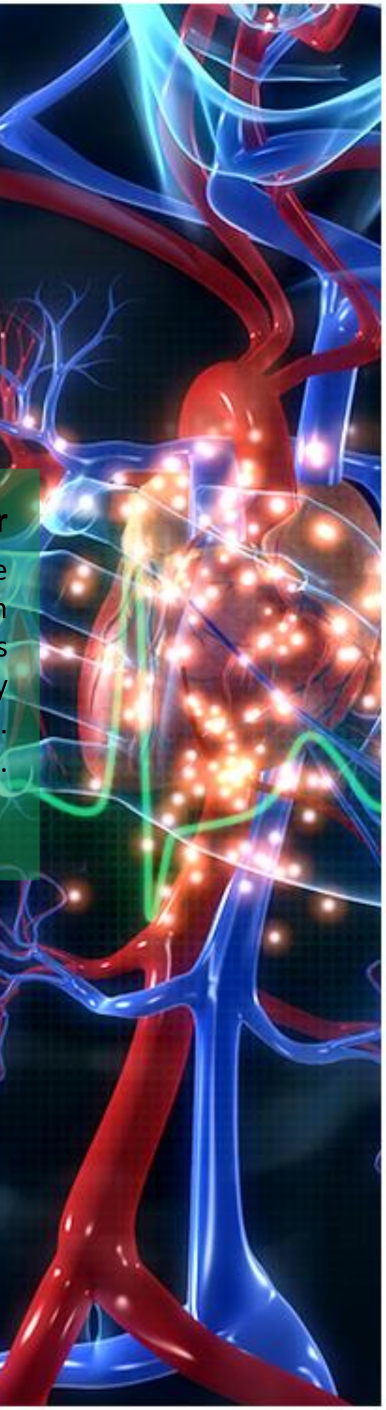


Placeholder

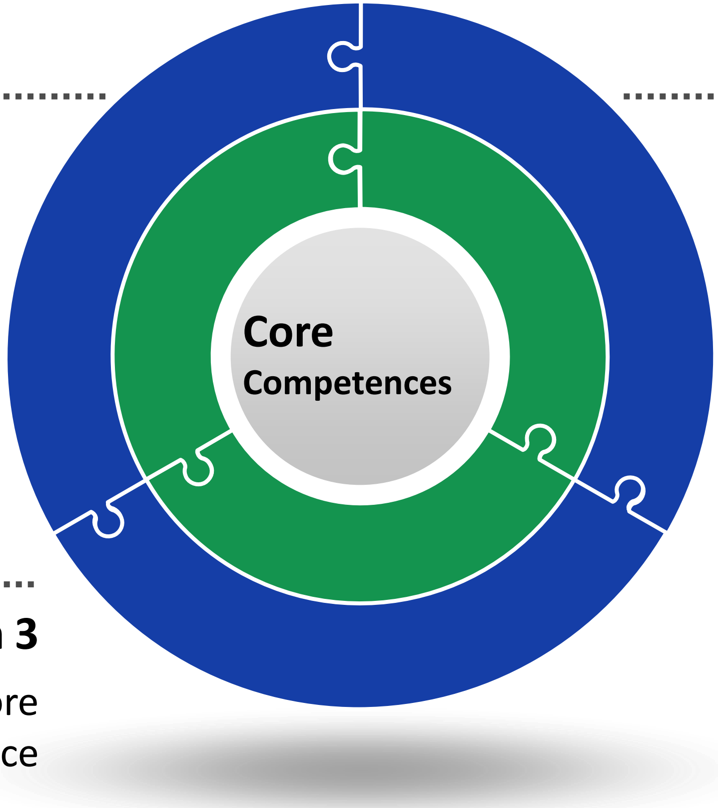
The text you type keeps the same style and formatting as the placeholder text.
This text can be replaced with your own text. This is a placeholder text.

Demonstrate with charts business areas to your customers

Your profile illustrated as puzzle

Division 1

Describe e. g. your business



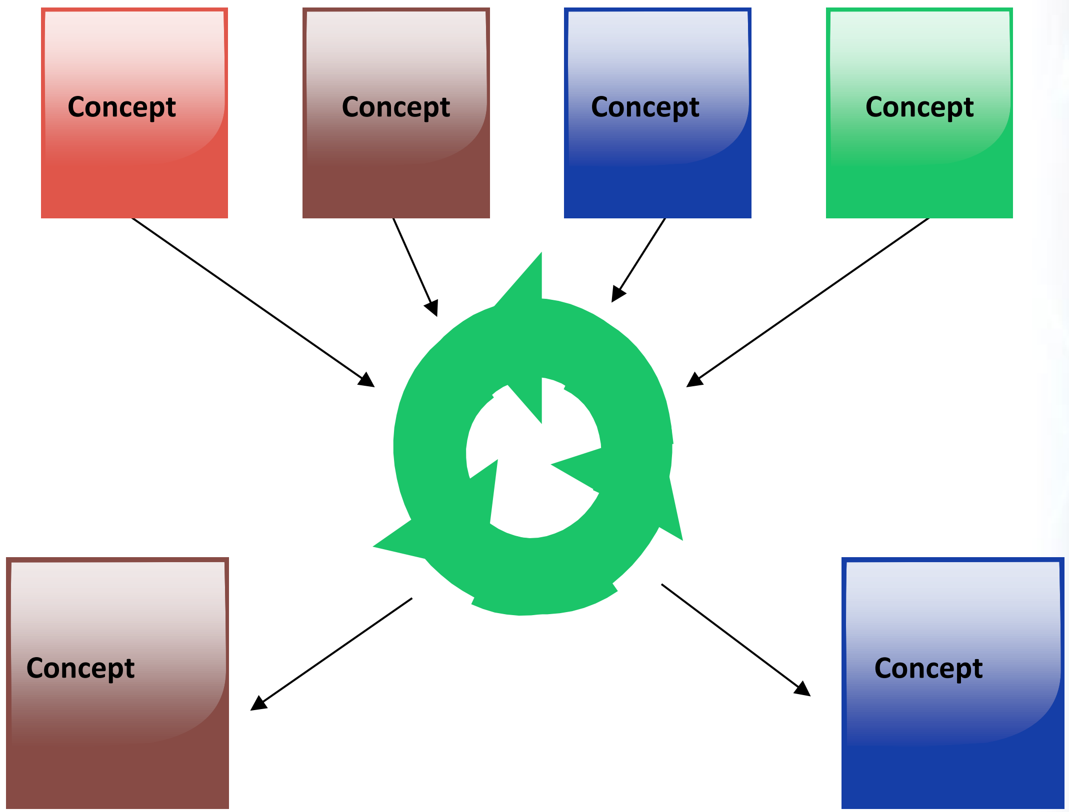
Division 2

Departments and service areas can be visualized with an image

Division 3

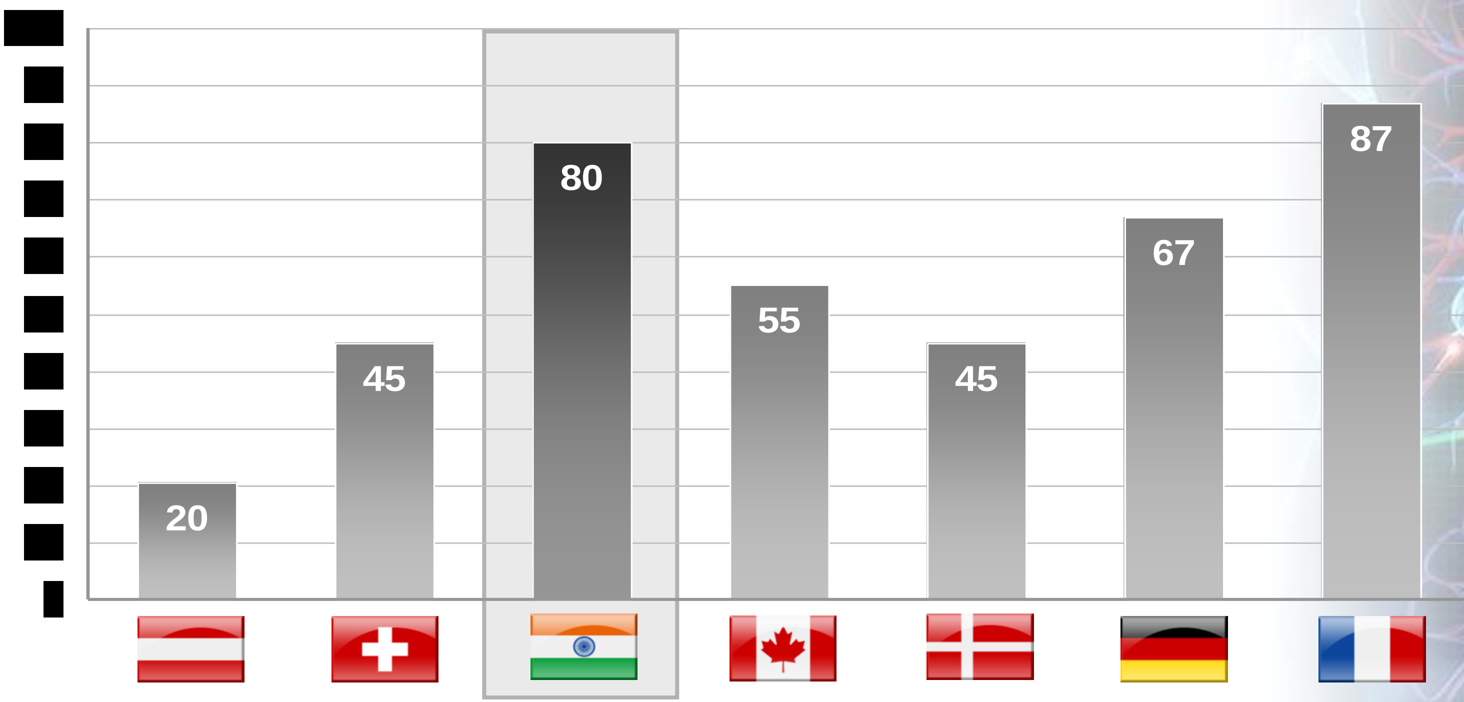
Demonstrate your core competence

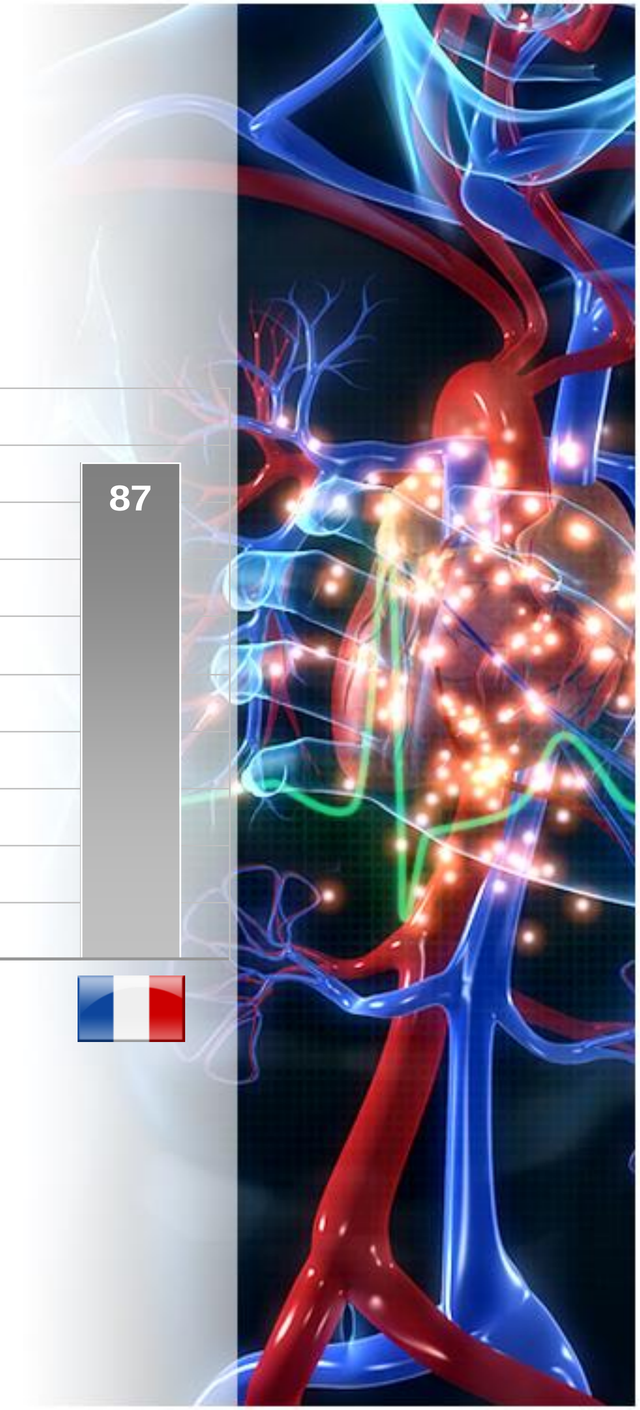
Your Text Here



Diagrams indicated with flags

Layout sample for banners and flags





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Arrow Process

Make strong and visual PowerPqaoint presentations in less time

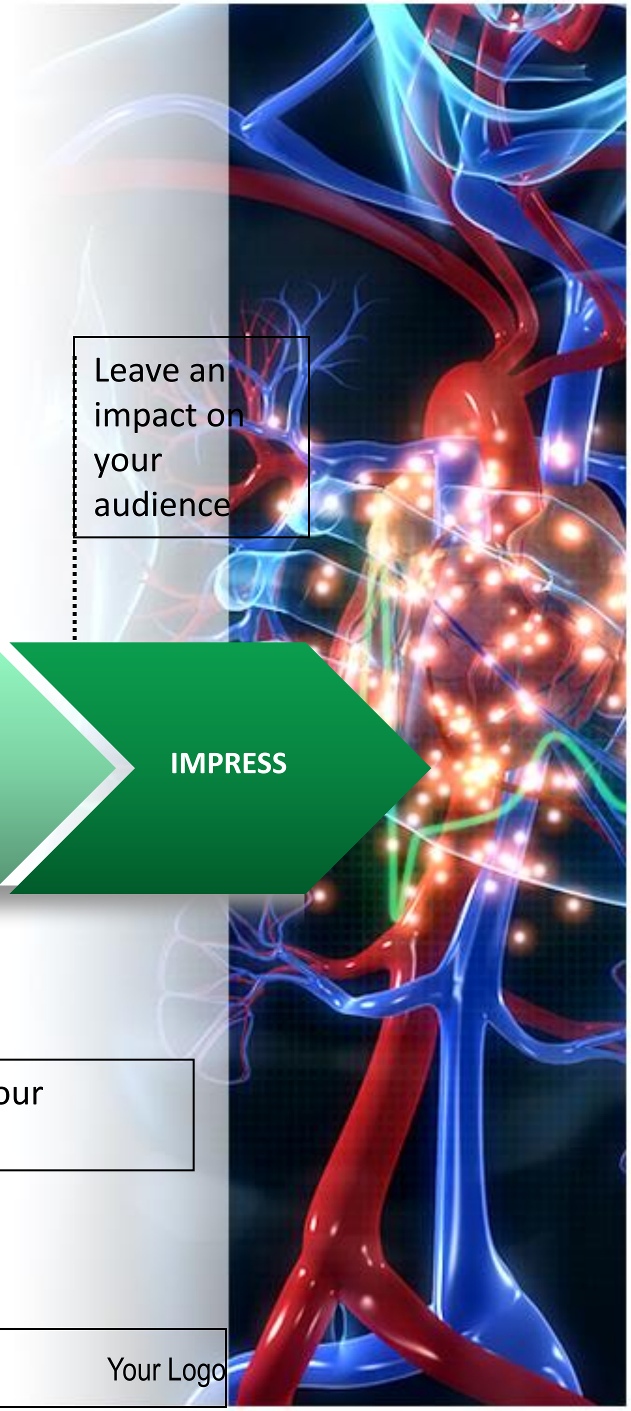
Customize the graphics to fit your need

Leave an impact on your audience

SAVE TIME → PROFESSIONAL → EASE TO USE → ENGAGE → IMPRESS

Support your message with professional graphics

Capture your audience



Your Logo

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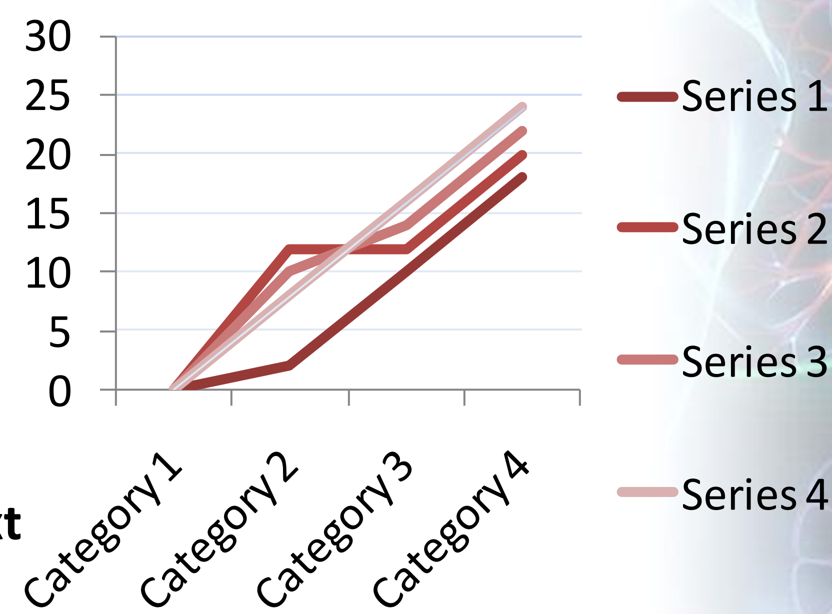

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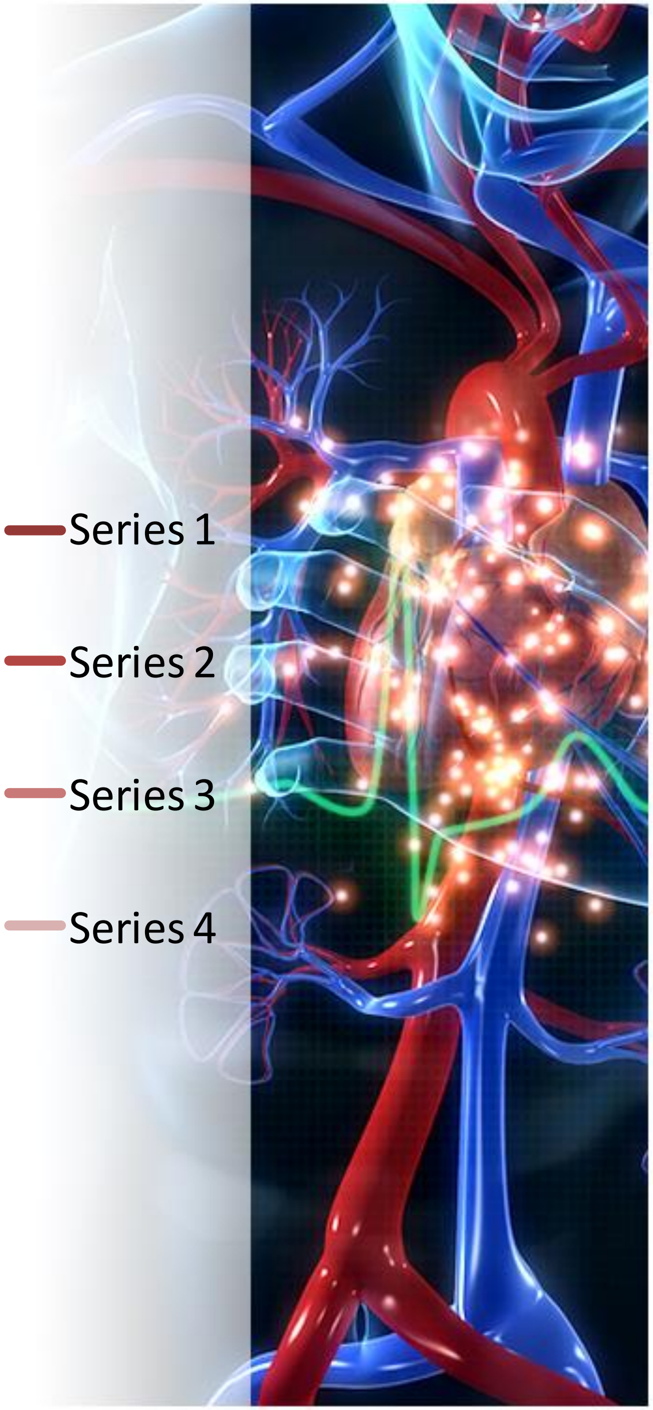

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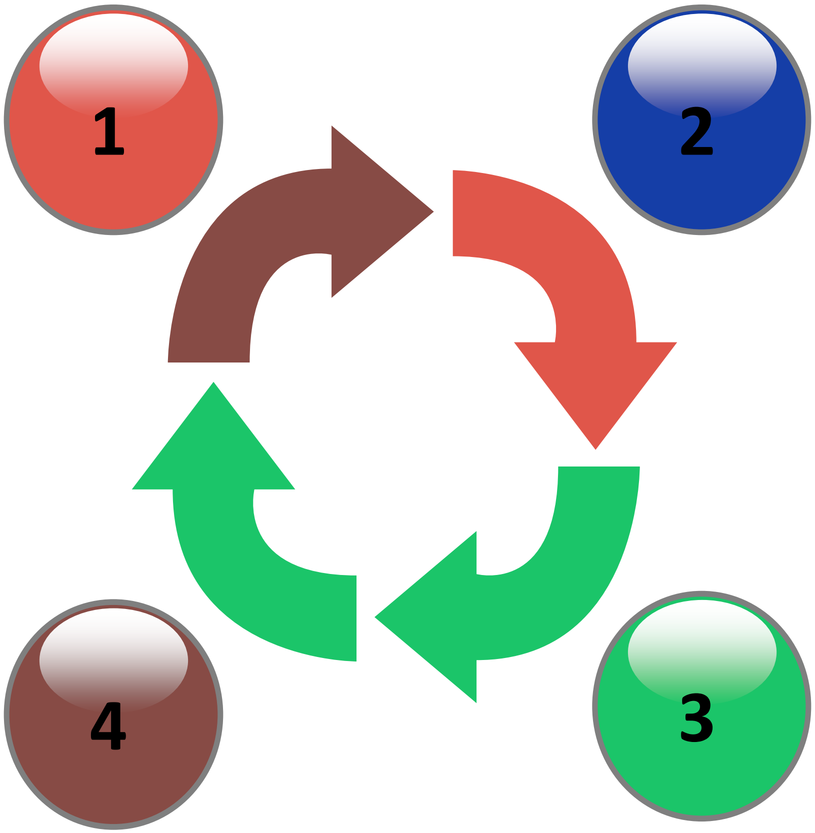

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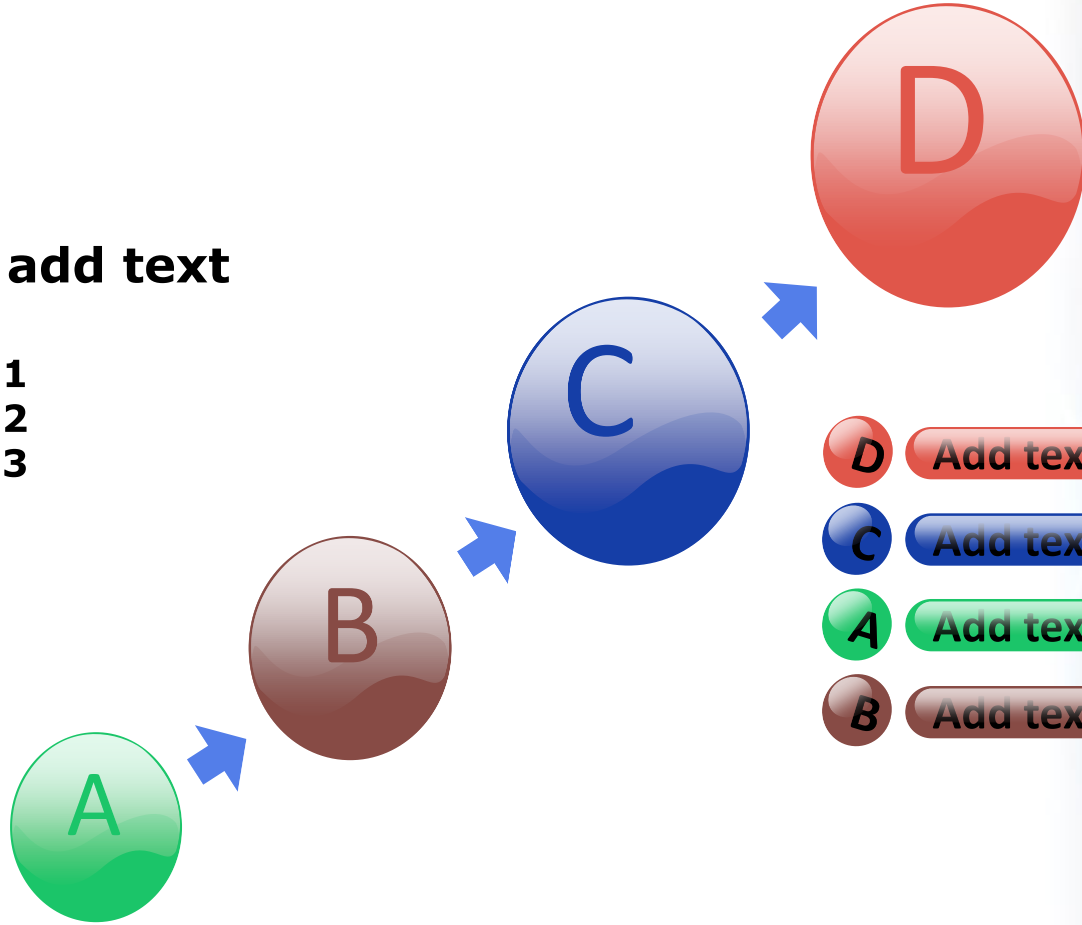

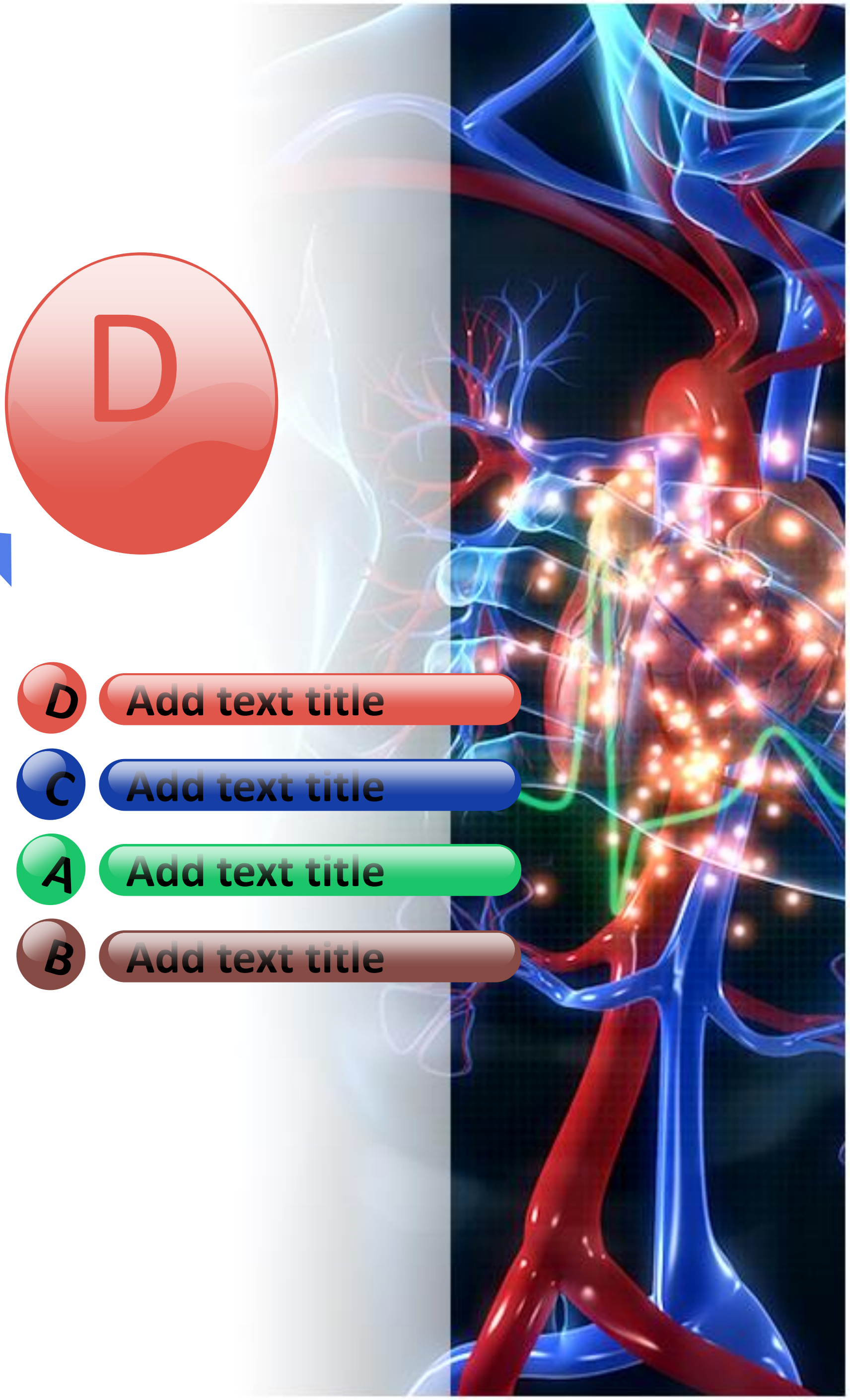

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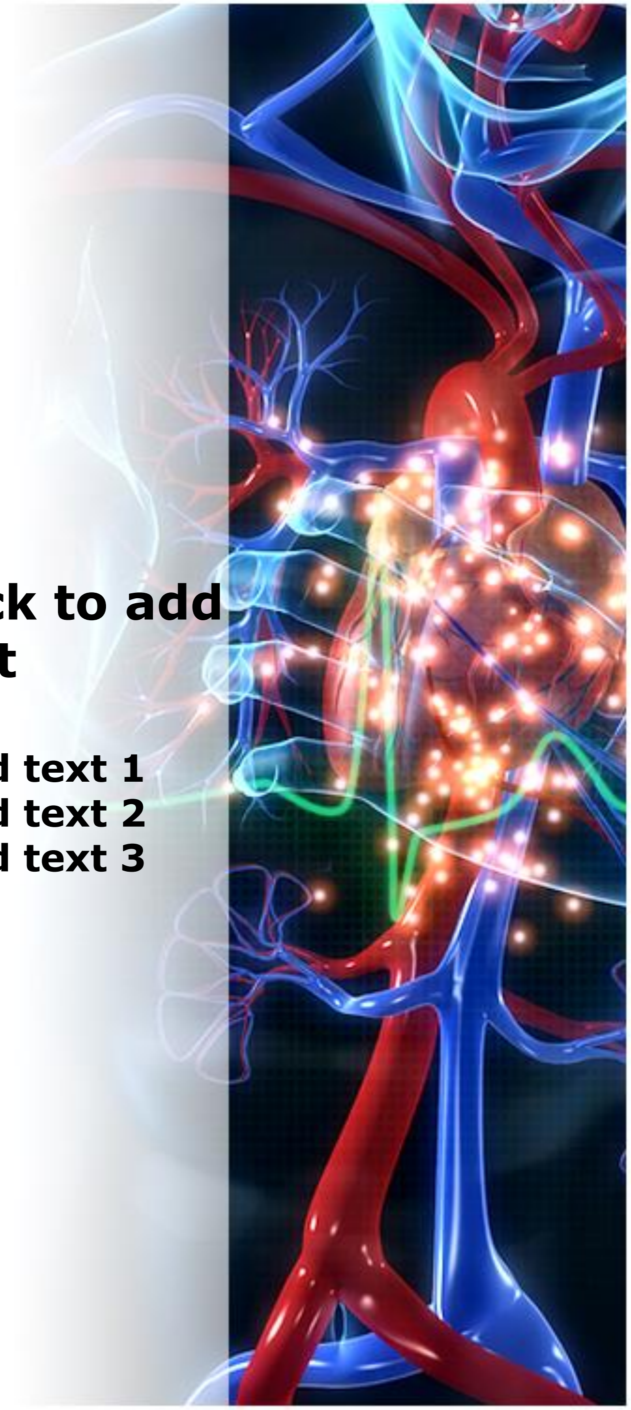

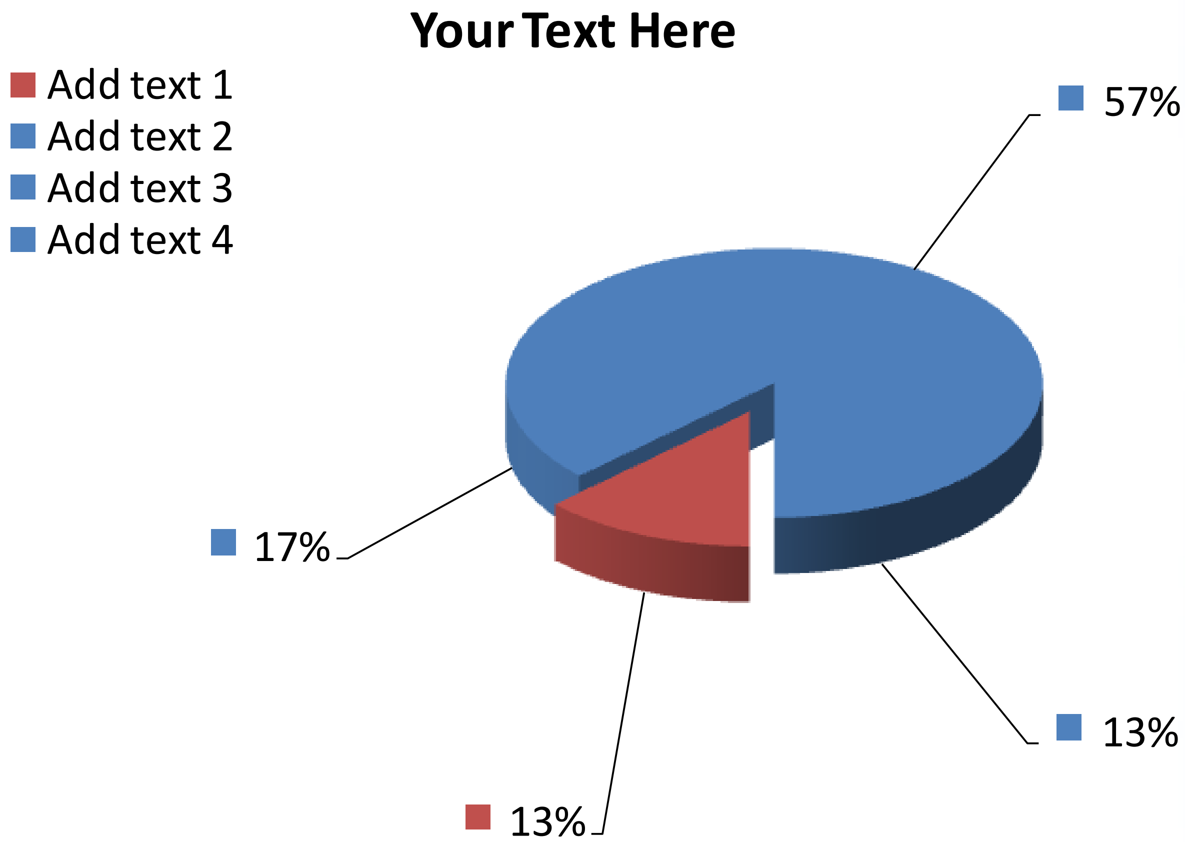
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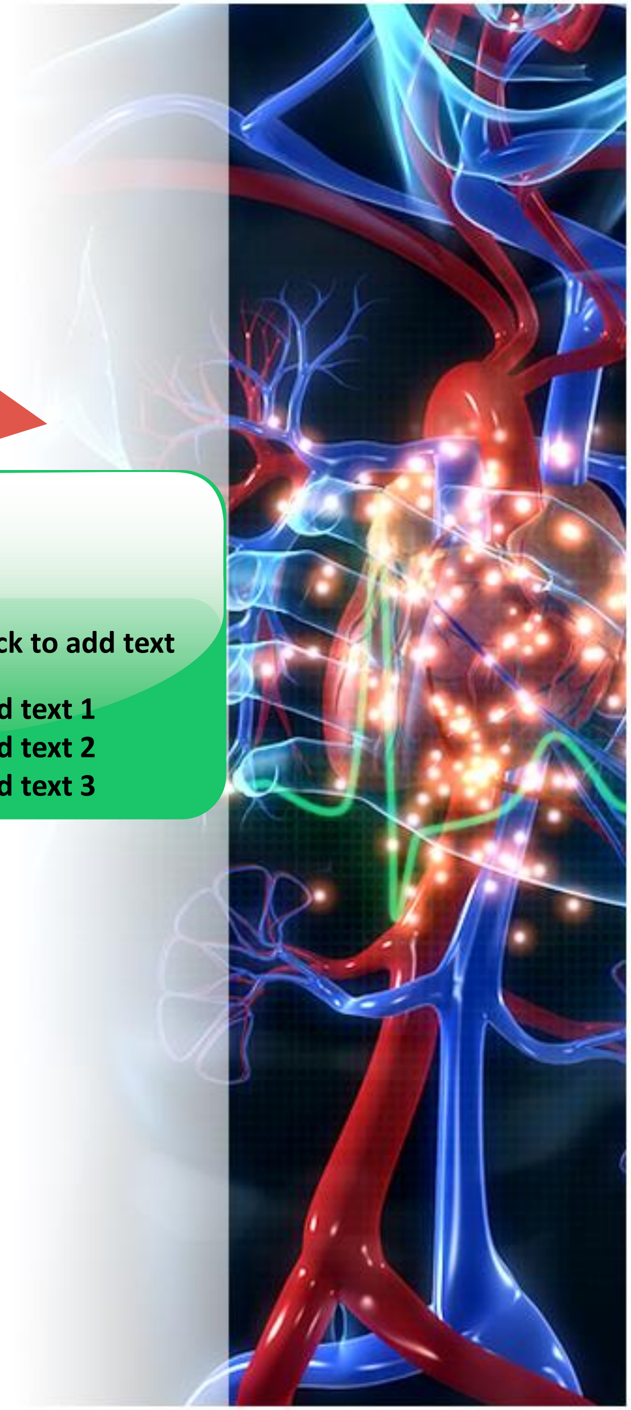

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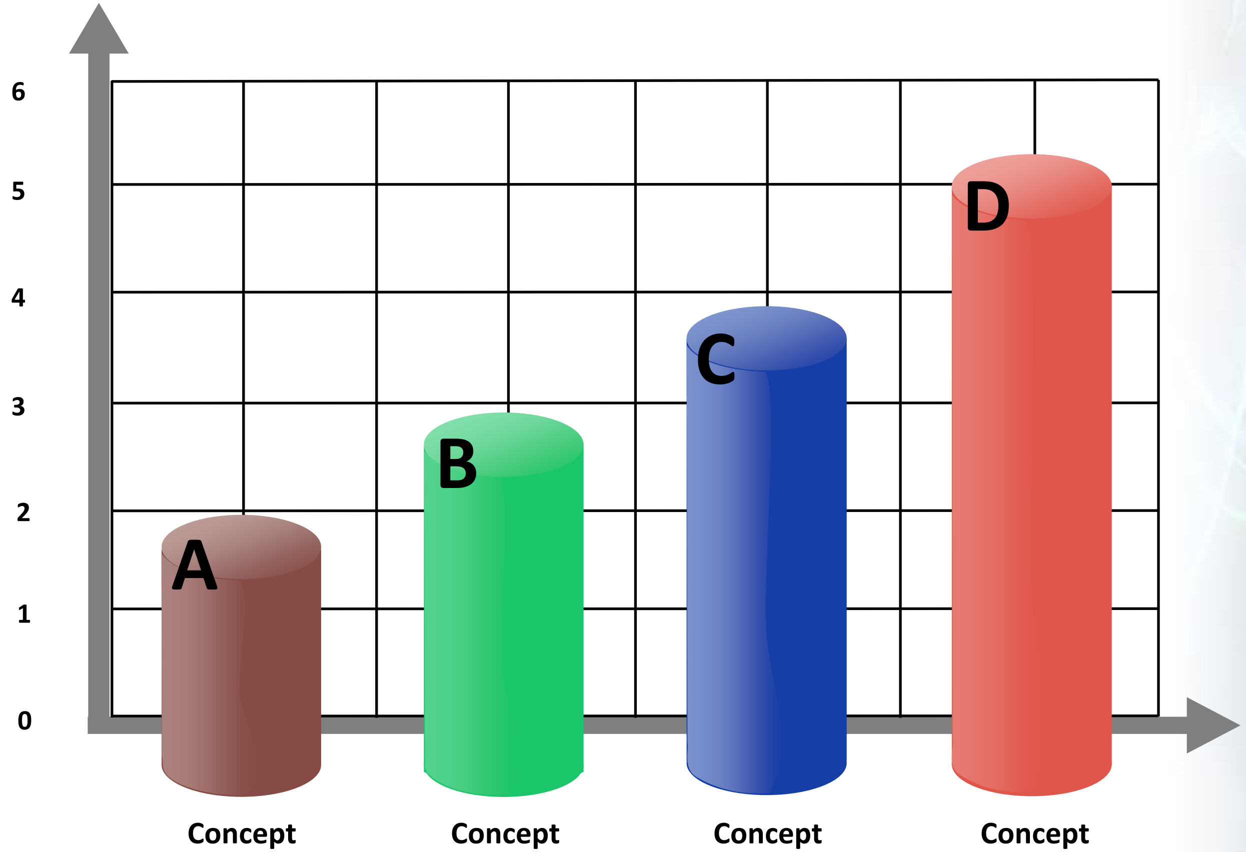

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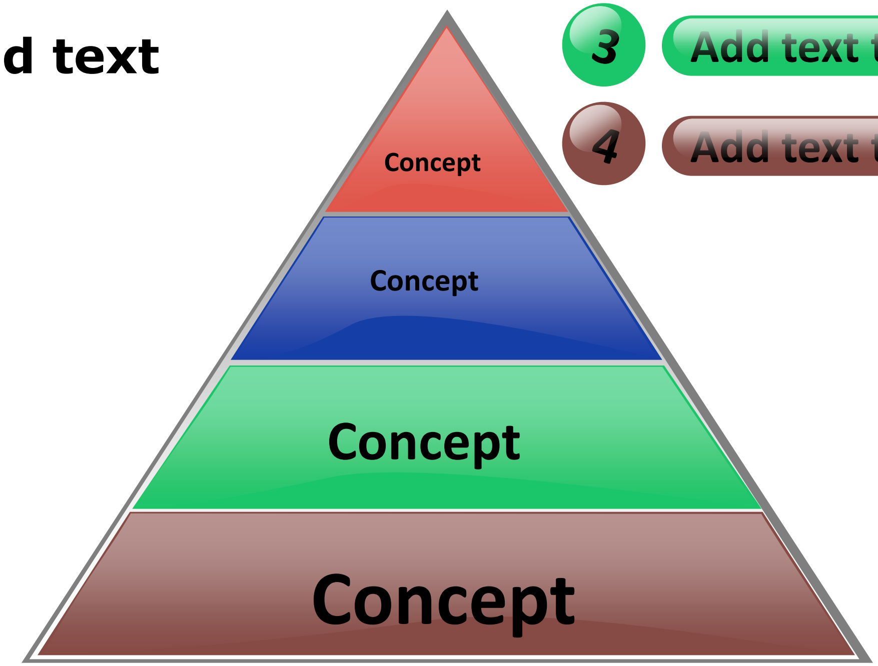

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