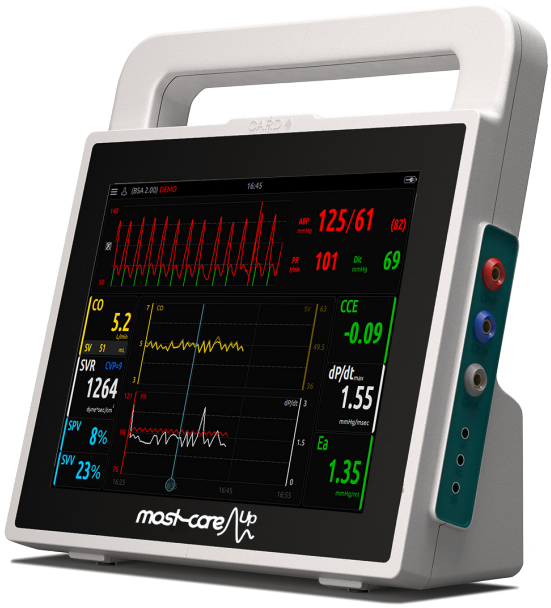
MEDICAL EQUIPMENT

Haemodynamic monitoring



Introduction to most-care Up applications

VYGON

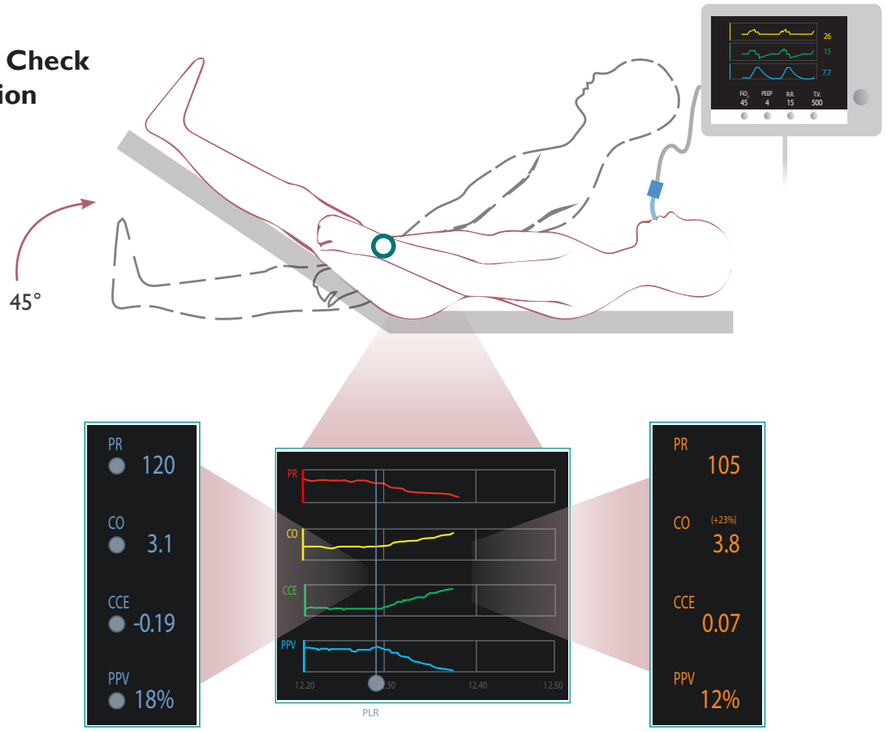
Value Life

Haemodynamic monitoring is crucial in surgical and critically ill patients. It can help physicians and nurses in identifying the cardiovascular and pathophysiological status of a patient, allowing operators to choose the most appropriate therapy (e.g. vasopressor, fluid, or inotropic drugs). Also, haemodynamic monitoring allows pre-emptive therapy to be initiated early, before a deterioration of clinical conditions can occur (e.g. detection of low output state or hypovolemia).
Standard monitoring procedure in operating theatres and intensive care units includes the measurement of heart rate, blood pressure and oxygen saturation. However, these variables are not sufficiently sensitive to drive treatment protocols. For managing patients using goal directed therapy, an advanced and continuous haemodynamic monitor, which provides additional, sensitive and predictive haemodynamic parameters, is required.

A basic haemodynamic monitor, which provides only the values of heart rate, blood pressure and indirect preload (e.g. CVP), does not allow the clinician to define in detail the variations of individual cardiovascular profiles that follow one another, for example in the septic patient. However a monitor that provides **continuous and advanced haemodynamic variables** including cardiac output and oxygen delivery, systemic vascular resistances, arterial elastance, indicators of myocardial contractility and efficiency of the cardiac cycle, allows the clinician to use the **haemodynamic information** and, adapt therapy to reflect the different haemodynamic requirements of the septic patient.

Unlike technologies that require external calibration or the use of anthropometric data to calculate Z (t) or impedance, MostCareUp uses high definition 1000Hz measurement of the arterial pressure wave to calculate Z(t), making MostCareUp ideal for any patient who requires constant or occasional haemodynamic monitoring. Especially those high-risk patients with haemodynamic instability or the presence of acute clinical variations.

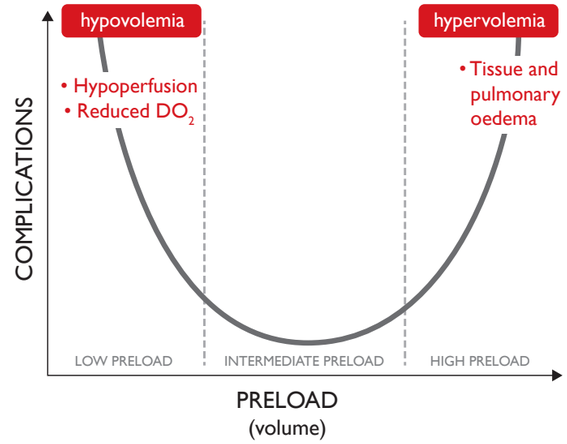
Do & Check function



Img. 1 – MostCareUp Do&Check function

Perioperative haemodynamic optimisation

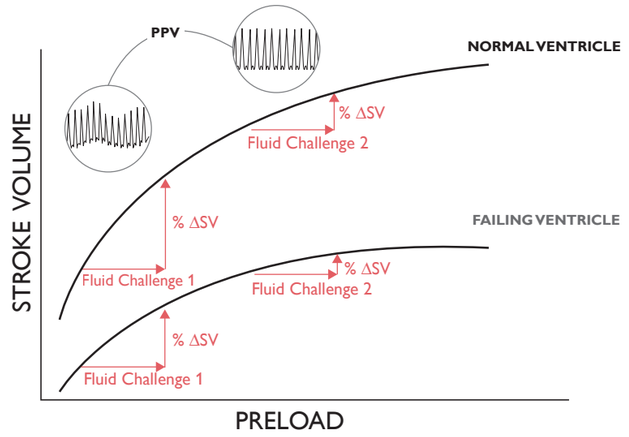
One of the important factors influencing the preoperative outcome is **surgical stress**, which leads to increased oxygen demand. An unfavourable outcome is responsible for increased patient **stay** time and **cost for the hospital.**
Usually therapeutic intervention is a function of actual haemodynamic impairment (reactive approach). On the contrary, the use of a "goal directed therapy" protocol allows a **"proactive"** strategy that provides monitoring and optimisation of haemodynamic variables and early intervention **in order to prevent haemodynamic impairment**. The final aim is to improve tissue oxygen delivery and remove the risk of oxygen depletion from surgical stress. The above has proved to be particularly important in patients with a moderate to **high surgical risk**.



Img. 2 – Classic U-curve

One of the most frequent causes of tissue hypoperfusion is linked to hyper or hypovolemia. In the first case, tissue and pulmonary oedema, in the second case, reduced oxygen delivery, are responsible for organ damage, expressed by the classic U-curve. Adequate venous return to the heart is essential to support optimal Stroke Volume and hence Cardiac Output. Hypovolaemia may be harmful to patients and excessive fluid administration may also be harmful.

GDT-based guidelines recommend the use of functional haemodynamic monitoring and do not recommend the use of static variables (CVP, PAOP) to guide fluid therapy. **Dynamic variables** PPV, SVV and SPV which are based on heart lung interactions during mechanical ventilation have been shown to be accurate predictors of fluid responsiveness. Fluid responders are patient's whose CO (or SV) increases > 10-15% after a fluid challenge or passive leg raising.

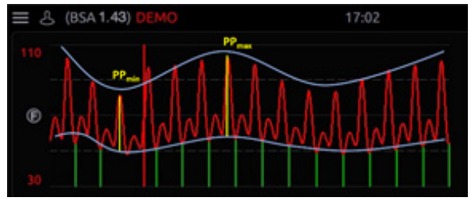


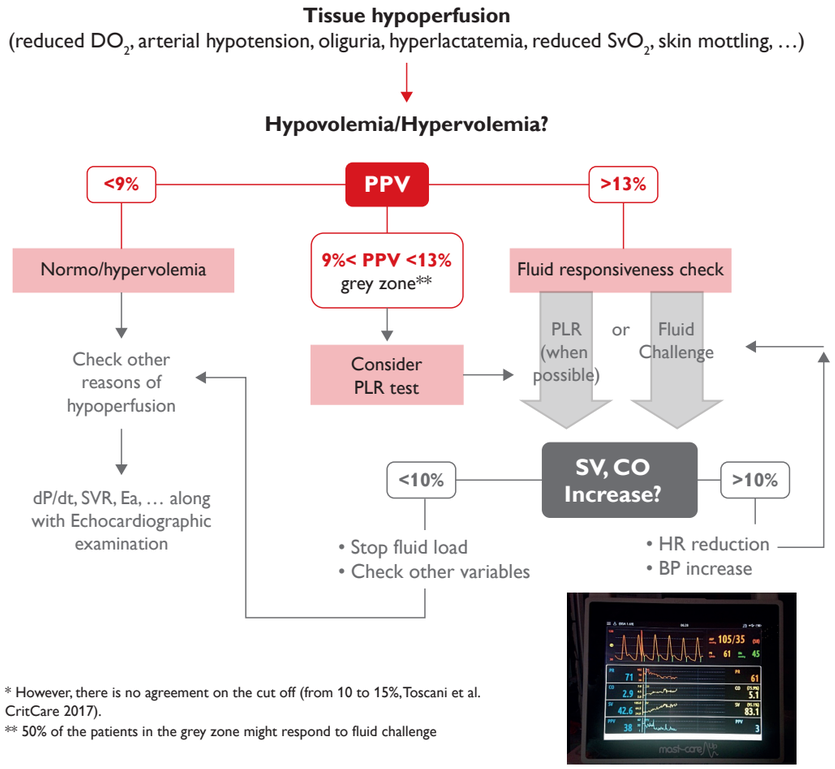
Img. 3 – Frank-Starling curve

The increase in intrathoracic pressure induced by a positive pressure breath during mechanical ventilation induces a change in Pulse Pressure, Stroke Volume and Systolic Pressure when the healthy heart is working in the ascending part of the Frank-Starling Curve. PPV is often preferred to SVV because it is measured and not calculated. It is important to appreciate that PPV, SVV and SPV are only validated for use as predictors of fluid responsiveness in specific conditions, including mechanically ventilated patients with no spontaneous breathing and who are in normal sinus rhythm.

When the PPV value is **less than 9%** administration of fluid is unlikely to lead to an increase in cardiac output (i.e. not fluid responsive). When the PPV is **greater than 13%** administration of fluid is likely to lead to an increase in CO. (i.e. patient is fluid responsive e).

When PPV is in the **grey zone (9-13%)** response to fluid administration cannot be predicted.





* However, there is no agreement on the cut off (from 10 to 15%, Toscani et al. CritCare 2017).
** 50% of the patients in the grey zone might respond to fluid challenge

Img. 4 - A typical algorithm of perioperative GDT focused on fluid responsiveness

1. Bellamy MC. Wet, dry or something else? British Journal of Anaesthesia 2006; 97:755-7
2. Jhanji S, Thomas B, Ely A, Watson D, Hinds CJ, Pearse RM. Mortality and utilisation of critical care resources amongst high-risk surgical patients in a large NHS trust. Anaesthesia. 2008 Jul;63(7):695-700
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6. Brienza N, Biancofiore G, Cavaliere F, Corcione A, De Gasperi A, De Rosa RC, Fumagalli R, Giglio MT, Locatelli A, Lorini FL, Romagnoli S, Scolletta S, Tritapepe L. Clinical guidelines for perioperative hemodynamic management of non cardiac surgical adult patients. Minerva Anestesiol. 2019.

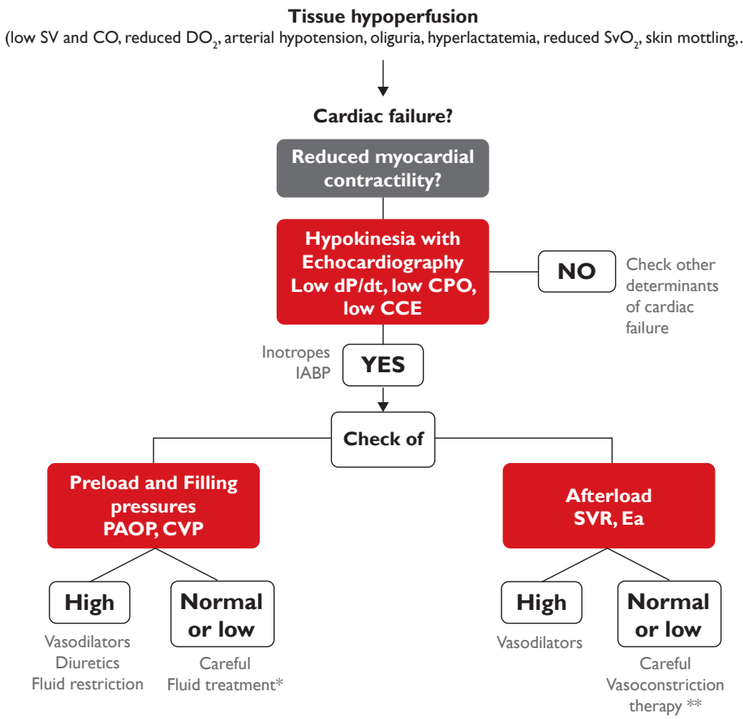
Cardiac failure: cardiovascular function evaluation and optimisation

Cardiac failure leads to a reduction in oxygen delivery resulting in tissue hypoperfusion, multi-organ dysfunction (MODS) and multi-organ failure (MOF). There can be many causes for cardiac failure, including ischaemia and myocardial infarction, arrhythmias, myocarditis, valvopathies and idiopathic cardiomyopathies.

Left ventricular systolic insufficiency, is characterized by a reduction in contractility resulting in a reduction in stroke volume, arterial hypotension and an increase in filling pressures (LVEDP and CVP). The **clinical consequences** may be pulmonary oedema, venous stasis and increased afterload as a compensatory mechanism. Also, poor cardiac contractility may be accompanied by unsuccessful weaning from mechanical ventilation and organ hypoperfusion. These **comorbidities** are responsible for a prolonged stay in intensive care.

Whilst echocardiography allows us to diagnose the nature of heart failure, it does require experience, is not always instantly available and is not designed for continuous monitoring.

Continuous haemodynamic monitoring has the advantage of allowing the clinician to obtain information on the cardiovascular status of the patient on a continuous basis and thus facilitating **control of the effectiveness of therapy over time**; using trending variables, thereby reducing the risk of a deterioration in the patient clinical condition.



*aim to keep normovolemia and avoid overload and pulmonary oedema
** aim to keep adequate afterload and optimal A_V coupling

Img. 5 - A typical example of haemodynamic monitoring-based therapy

1. Cecconi M, Reynolds TE, Al-Subaie N, Rhodes A. Haemodynamic monitoring in acute heart failure. Heart Fail Rev. 2007 Jun;12(2):105-11
2. Vincent JL, De Backer D. Circulatory shock. N Engl J Med. 2013 Oct 31;369(18):1726-34.
3. Cecconi M, De Backer D, Antonelli M, Beale R, Bakker J, Hofer C, Jaeschke R, Mebazaa A, Pinsky MR, Teboul JL, Vincent JL, Rhodes A. Consensus on circulatory shock and hemodynamic monitoring. Task force of the European Society of Intensive Care Medicine. Intensive Care Med. 2014 Dec;40(12):1795-815
4. De Backer D, Bakker J, Cecconi M, Hajjar L, Liu DW, Lobo S, Monnet X, Morelli A, Myatra SN, Perel A, Pinsky MR, Saugel B, Teboul JL, Vieillard-Baron A, Vincent JL. Alternatives to the Swan-Ganz catheter. Intensive Care Med. 2018 Jun;44(6):730-741.

Septic patient: haemodynamic derangement and assessment

Sepsis is a complex syndrome that represents a **major challenge** for the intensivist, as it is quite frequent in intensive care leading to multiple organ complications and mortality.

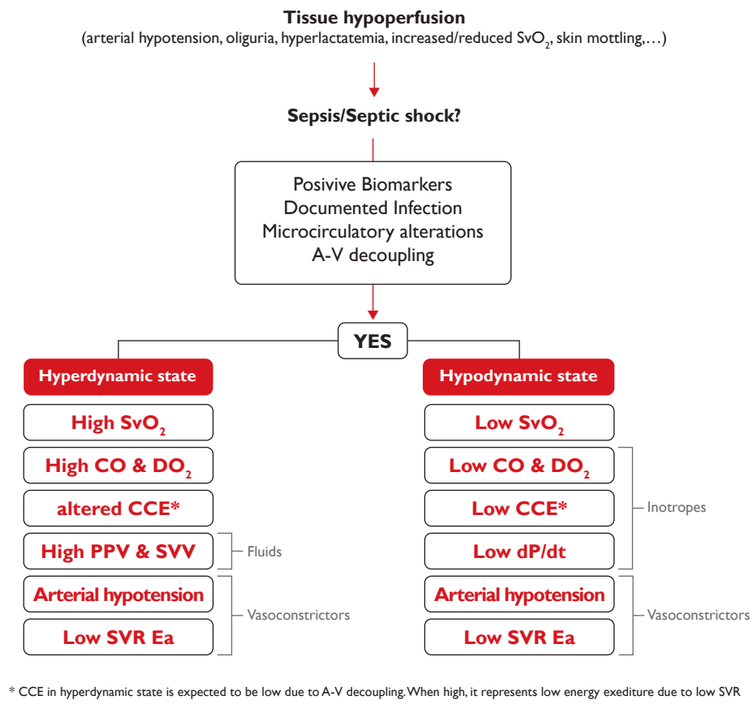
The clinical complexity of this syndrome derives mainly from the p**rofound haemodynamic changes** that characterise sepsis itself and septic shock. These alterations include a typical triad: hypovolemia, decrease of vascular tone and myocardial depression. These conditions are also accompanied by abnormal redistribution of blood flow between the various organs due to multiple microcirculatory derangement.

The most evident clinical and haemodynamic manifestation of the septic patient is **arterial hypotension,** often resistant to pharmacological treatment. It is linked to the three cardiovascular alterations previously reported:

a) **hypovolaemia**, mainly linked to fluid shift due to increased vascular permeability (absolute hypovolemia), and determined by reduced vascular tone and increased venous capacity (relative hypovolemia);

b) **decrease in vascular tone,** linked to reduced or loss of adrenergic response by smooth muscle cells of the vascular wall;

c) **myocardial depression,** which may appear later because it recognizes complex mechanisms and slower to establish (e.g. mitochondrial dysfunction, metabolic and autonomic alterations, ...) and which involves a reduced cardiac output and a low tissue oxygen delivery.
When microcirculatory dysfunction prevails over macrodynamic alterations, the oxygen delivery can be increased due to the high cardiac output, although oxygen peripheral extraction is decreased.



Img. 6 - A typical example of haemodynamic monitoring-based therapy in a septic patient

These complex haemodynamic alterations mean that sepsis can occur, for example, with a haemodynamic state called **"hyperdynamic"**. This condition of hyper-dynamism (high flow rate) is characterized by low systemic vascular resistance, reduced arterial elastance, arterial hypotension and high cardiac output.

In other cases, the haemodynamic profile of the septic patient may be characterized by a **"hypodynamic"** state, which manifests itself with low vascular resistance, arterial hypotension and low cardiac output, the latter resulting from myocardial dysfunction. In both cases, the tissue use of oxygen is very low and haemodynamic variations are characterized by a decoupling between vascular tone and ventricular contractility **(A-V decoupling)**.

1. De Backer D, Scolletta S. Clinical management of the cardiovascular failure in sepsis. Curr Vasc Pharmacol. 2013 Mar 1;11(2):222-42.
2. Guarracino F, Ferro B, Morelli A, Bertini P, Baldassarri R, Pinsky MR. Ventriculoarterial decoupling in human septic shock. Crit Care. 2014 Apr 24;18(2):R80
3. Perner A, Gordon AC, De Backer D, Dimopoulos G, Russell JA, Lipman J, Jensen JU, Myburgh J, Singer M, Bellomo R, Walsh T. Sepsis: frontiers in diagnosis, resuscitation and antibiotic therapy. Intensive Care Med. 2016 Dec;42(12):1958-1969.
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CRITICAL CARE

For further information, please contact: questions@vygon.com

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