

GDP[®]
Goal-Directed Perfusion



Assisting in implementing the Goal-Directed Perfusion
Therapy with the Connect™ GDP Monitor

Goal-Directed Perfusion and the CONNECT™ GDP Monitor

LivaNova, alongside leading clinicians who have studied the clinical benefits and improved patient outcomes associated with the application of Goal-Directed Perfusion (GDP), is at the forefront of creating global awareness on the advantages of this therapy. Furthermore, LivaNova implements and transparently provides the GDP formulas patented by Dr. Marco Ranucci into the Connect GDP Monitor.

With the GDP Monitor, information about oxygen delivery, oxygen consumption, and carbon dioxide production can be monitored, in particular:



DO₂i

DO₂ = OXYGEN DELIVERY (ml/min), or oxygen supply, is the amount of oxygen delivered to the body from arterial blood flow. It is calculated from cardiac output/pump flow and arterial oxygen content.

DO₂i = INDEXED OXYGEN DELIVERY (ml/min/m²) is the oxygen delivery divided by the Body Surface Area (BSA).

VO₂i

VO₂ = OXYGEN CONSUMPTION (ml/min), or oxygen uptake, is the volume of oxygen consumed by the tissues. Under aerobic metabolic conditions, oxygen is consumed to generate energy so VO₂ corresponds to the metabolic rate. VO₂ can be derived from cardiac output/pump flow and the difference between arterial and venous oxygen contents.

VO₂i = INDEXED OXYGEN CONSUMPTION (ml/min/m²) is the oxygen consumption divided by the Body Surface Area (BSA).

VCO₂i

VCO₂ = CARBON DIOXIDE PRODUCTION (ml/min), is the amount of carbon dioxide produced by the tissues and removed by the lungs or the oxygenator.

VCO₂i = INDEXED CARBON DIOXIDE PRODUCTION (ml/min/m²), is the carbon dioxide production divided by the Body Surface Area (BSA).

VO₂i / DO₂i

VO₂i / DO₂i = OXYGEN EXTRACTION RATIO (O₂ER) is the ratio of oxygen consumption and oxygen delivery VO₂i/DO₂i, and represents the fraction of oxygen taken up by the tissues.

DO₂i / VCO₂i

DO₂i / VCO₂i = Indexed oxygen delivery divided by indexed carbon dioxide production. It is reported in the literature as a marker correlated to Acute Kidney Injury (AKI) and Hyperlactatemia (HL)¹.

IMPLEMENTING GOAL-DIRECTED PERFUSION^{2,3,4}

Oxygenation Profile

OXYGEN DELIVERY INDEX (DO₂i)

GOAL

Manage blood flow selection based on current hematocrit (HCT) or hemoglobin concentration to maintain the DO₂i > 280 ml/min/m².

RELEVANCE

Critical DO₂i represents the value of oxygen delivery below which aerobic metabolism cannot be maintained and anaerobic metabolism is, instead, instigated. In the articles quoted in the reference section, the value of **Critical DO₂i** is defined between 262 and 280 ml/min/m².^{5,6}

When **DO₂i is above critical DO₂i**, the patient is in an aerobic metabolism condition, which is associated with a lower likelihood of Acute Kidney Incidence (AKI), lower levels of blood lactate and a reduction in the length of stay in the hospital and in the Intensive Care Unit "ICU".^{1,2}

OXYGEN CONSUMPTION INDEX (VO₂i)

GOAL

None specific

RELEVANCE

Monitors the impact of perfusion management on patient oxygen demand, such as:

- Changes in temperature;
- Changes in anesthetic management;
- Changes in systemic vascular resistance, vasoactive agent use, loss of perfused capillary density;
- Identify patients with high oxygen demands (infection, etc.).

OXYGEN CONSUMPTION INDEX TO OXYGEN DELIVERY INDEX RATIO (VO₂i/DO₂i)

GOAL

A VO₂i /DO₂i (O₂ER) greater than 39% and a venous oxygen saturation (SVO₂) below 68% can be used to guide red blood cell transfusions during CPB instead of just hematocrit alone.⁷

RELEVANCE

If the DO₂i is below critical DO₂i, the patient's VO₂i is dependent on DO₂i (DO₂ dependence), and the patient increases extraction of oxygen to meet demand.

Carbon Dioxide Profile

CARBON DIOXIDE PRODUCTION INDEX (VCO_{2i})

GOAL Maintain $VCO_2 < 60$ ml/min/m²

RELEVANCE

- VCO_{2i} is a critical measure of metabolic rate.
- An increase in carbon dioxide production along with an increase in oxygen consumption is normal in aerobic respiration.
- An increase in carbon dioxide production with a stable or decreasing oxygen consumption may indicate anaerobic respiration.

OXYGEN DELIVERY INDEX TO CARBON DIOXIDE PRODUCTION RATIO (DO_{2i}/VCO_{2i})

GOAL Maintain > 5

RELEVANCE

- Monitors if the oxygen delivery is adequate for the current metabolic rate.
- It is an indicator of lactate production and anaerobic metabolism². If VCO_{2i} is increasing, while DO_{2i} and VO_{2i} are constant, anaerobic metabolism might be developing.
- When the DO_{2i}/VCO_{2i} is above the critical threshold, a reduced likelihood of AKI occurrence¹ and lower levels of blood lactate² have been reported.

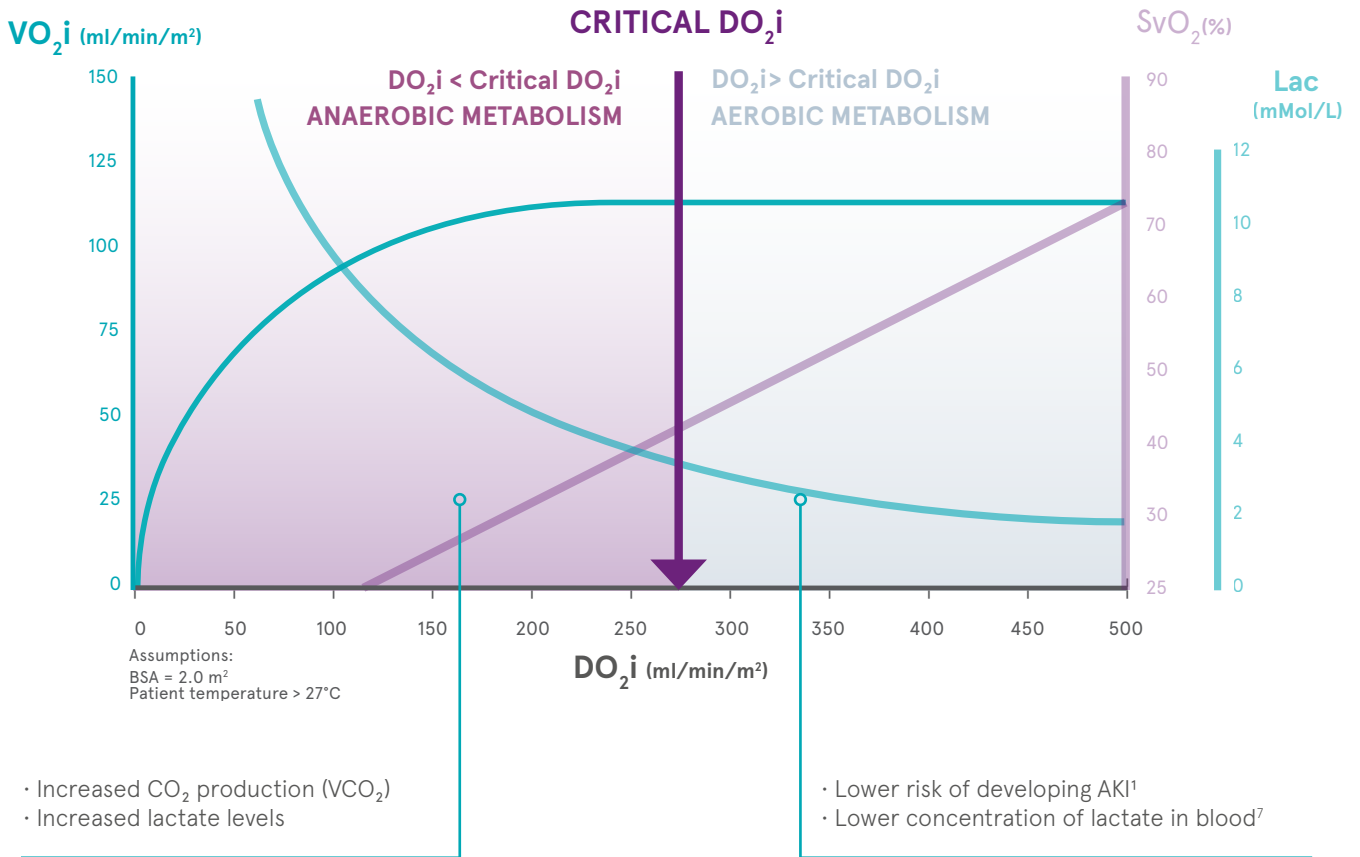
RESPIRATORY QUOTIENT (VCO_{2i}/VO_{2i})

GOAL Alert when > 0.9

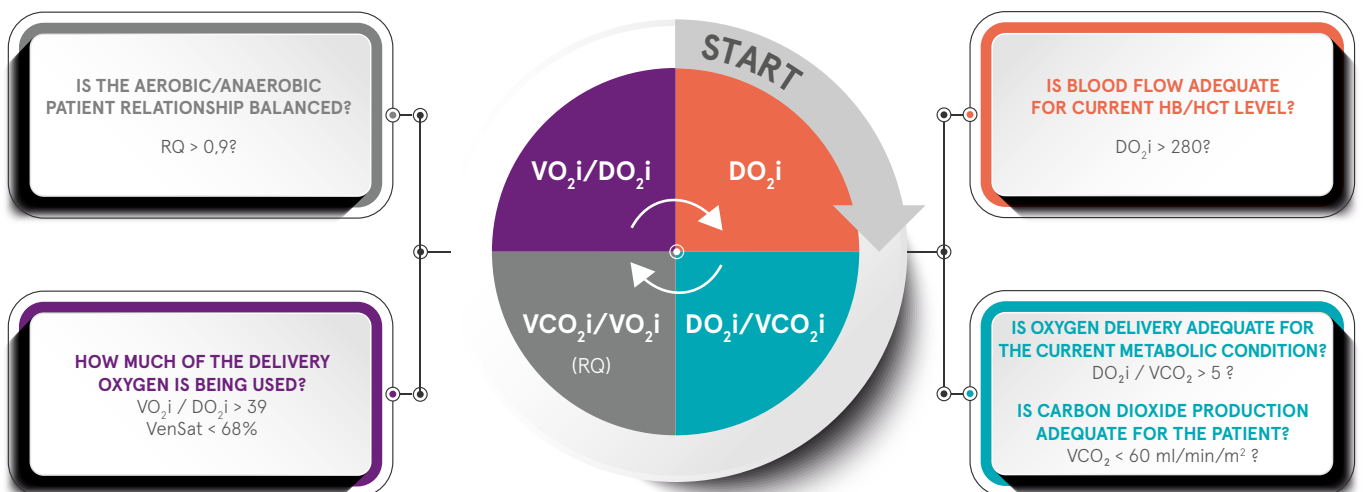
RELEVANCE

- Monitors the balance of carbon dioxide production to oxygen consumption.
- Has been demonstrated to be an early predictor of lactate development.
- May indicated if a blood flow distribution problem is developing.
- It is an important tool in GDP to help manage distribution of blood flow and possibly recruit microcapillary perfusion.

AEROBIC AND ANAEROBIC METABOLISM DURING PERFUSION



GDP MANAGEMENT DURING CPB PROCEDURE



REFERENCES

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Ranucci M. et al. - *J Thorac Cardiovasc Surg*. 2018 Nov;156(5):1918–1927.e2. - *Only free abstract available: <https://doi.org/10.1016/j.jtcvs.2018.04.045>*
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Ranucci M. et al. - *Perfusion*. 2011 Jul;26(4):327–33.

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The LivaNova Deutschland GmbH Quality System complies with:
EN ISO13485:2016

CE 0123 According to Annex II (Full Quality System) of
MDD 93/42/EEC as amended by directive 2007/47/EEC

Please always refer to the Instructions For Use (IFU) manual provided with each product for detailed information, warnings, precautions and possible adverse side effects.

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