THE NEW FRONTIERS OF EXTRACORPOREAL PERFUSION

Aerospace technology in the operating room

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ABSTRACT

A new Heart-Lung Machine that integrated hardware systems of highest technological level and software that processes patient data provided by advanced non-invasive monitoring was born to improve the quality of care and the outcome of patients undergoing extracorporeal circulation. We are in era of "Goal Directed Perfusion" and the care of clinicians no longer based on theoretical calculations but on measured parameters whose values are limited to a very narrow therapeutic range (determined by scientific evidence) indexed for each patient in each particular clinical condition.

"What we do is never second best, and what we have done is never good enough".
This simple statement conceptualizes the passion of Spectrum Medical, a company with previous aerospace experience, for advanced technological development in healthcare especially in the field of Extracorporeal Perfusion.
Spectrum's idea was to create a new Heart-Lung Machine that integrated hardware systems of the highest technological level and an advanced non-invasive monitoring system. This allowed to rationalize the use of patient data and improved the quality of care and the outcome of patients undergoing extracorporeal circulation. The Spectrum Quantum Perfusion was born.

Let's take a step back to make everyone understand what we're talking about. Seventy years ago, the american surgeon John Gibbon successfully operated a nineteen year old girl by closing an atrial septal defect, through the support of his "Heart-Lung Machine" which allowed to exclude the heart and lungs from the blood circulation and at the same time to perfuse remaining parts of the body with artificially oxygenated blood. ***In the following years, the famous surgeon John Kirklin of the Mayo Clinic performed numerous open heart operations, using the Gibbon machine, laying the foundations of the pathophysiology of extracorporeal perfusion; in fact, it was necessary to establish what the ideal perfusion flows, the ideal levels of oxygenation and removal of CO2 from the blood should be. All this then had to be related to the patient's body temperature (which was decreased to reduce metabolic demands as occurs in hibernating animals)****.*

Although many years have passed since then, the clinical practice of most Perfusionists , is still based on Kirklin's calculated parameters supported by decades of clinical practice. However, we are in the Goal Directed Therapy (GDT) era which uses advanced monitoring techniques to help clinicians establish the appropriate patient care strategy in order to improve outcome. Many scientists in the field of perfusion have applied this concept to extracorporeal procedures so that the "Goal Directed Perfusion" is no longer based on theoretical calculations but on measured parameters (which should be determined by scientific evidence) whose values are limited to a very narrow therapeutic range, indexed for each patient in each particular clinical condition. To establish, for example, the ideal flow to keep in extracorporeal circulation, reference will no longer be made to the "popular" 2.2-2.5 l / min. / M2 of Kirklin (1) and an adequate perfusion will be associated with an optimal value of Oxygen Delivery (DO2i>

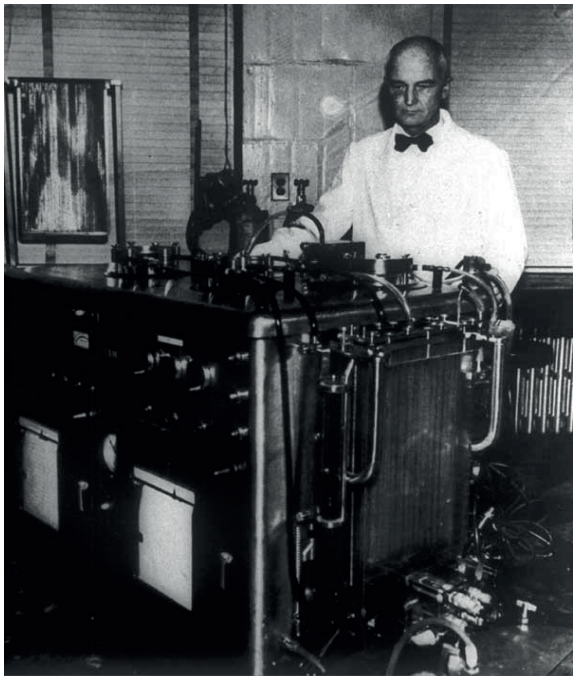

Fig. 1 - Gibbon's Heart-Lung Machine

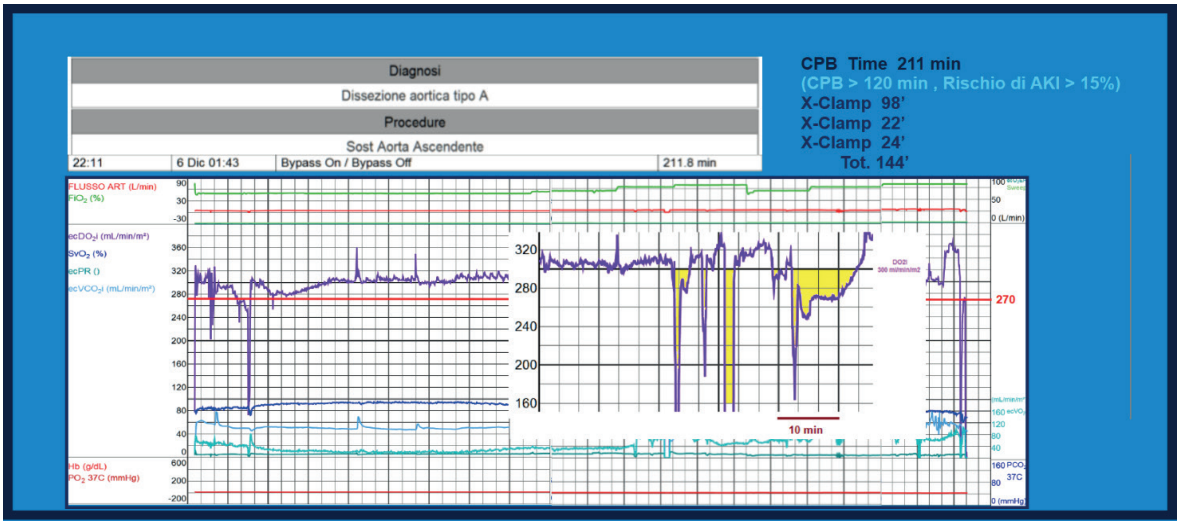

Fig. 2 - *Expansion of the O2 delivery (DO2i) graph recorded during an emergency cardiac surgery.*

272 ml / min / m2), such as to prevent postoperative acute kidney injury (AKI acute kidney injury) and the most common neurological complications such as delirium and cognitive impairment in coronary heart patients undergoing BPCP (5). Furthermore, the optimal Oxygen Delivery value must be associated with certain CO2 Production values (VCO2i) which will determine an adequate ratio between the aforementioned parameters (Perfusion Rate [PR] = DO2 ÷ VCO2 must be> 5). To obtain this optimal value, the synergy between perfusionist and anesthetist is necessary; the perfusionist is crucial to obtaining an adequate level of DO2 (which mainly depends on the pump flow and the hemoglobin value) while the anesthetist helps to keep the level of CO2 production low by deepening the narcosis.

Fig. 3 - *Quantum Perfusion at Sant'Anna e San Sebaastiano Hospital of Caserta.*

However, all of this, helps clinicians to establish the appropriate transfusion trigger is no longer based only on the intraoperative value of hemoglobin but also on parameters which, below a certain threshold value (PR <5), are predictive of the transition from aerobic to anaerobic metabolism. Evaluating these parameters during cardiopulmonary bypass helps prevent hyperlactataemia, significantly associated with increased morbidity and related to postoperative low cardiac output syndrome.

Recent scientific evidence has also demonstrated the effectiveness of a new parameter called DO2i AUC (Area Under the Curve), or DO2i TDR (Time-DoseResponse) which is useful in preventing acute kidney failure (AKI acute kidney injury). The relationship between the cumulative time of exposure to a low DO-i during cardiopulmonary bypass and the postoperative risk of developing AKI was therefore demonstrated . Patients that had an AUC that was negative (meaning that they had a greater integral of amount and duration of oxygen delivery during CPB below 270 mL/min/m^2) were 2.7 times more likely to experience AKI.

Spectrum Medical immediately developed with the "Best Practice App", the parameter relating to the area under the O2 delivery curve (DO2i). The DO2i TDR value is, therefore, recorded every second and then cumulated, so that it is possible to determine how much time it has gone below (DO2i debt) or above (DO2i surplus) the reference value of 272 ml / min / m2, providing information on perfusion quality.

The Spectrum Quantum Perfusion system (we cannot speak simplistically of Heart-Lung Machine) does all this and more. The Quantum Workstation (QWS) exploiting its great ability to interface with other devices and monitoring systems, can collect a lot of data that are processed and related to each other, through specific Applications (such as those of a smartphone) that allow you to analyze, quality of ExtraCorporeal Circulation and diagnose and prevent potentially dangerous situations for the patient.

This is an epochal breakthrough for extracorporeal perfusion! It is the first time that a monitoring system becomes "thinking". This is realized with

the possibility of customizing the "Apps", so that the clinician's experience and knowledge can meet with the engineering expertise of Spectrum Medical. (Figure 3 The "Quantum Perfusion")

In conclusion, we can say that the use of Quantum Perfusion system has positively changed the clinical practice of the entire cardiac surgery team and waiting to be able to appreciate all the possibilities offered by Spectrum Medical such as access to the statistical processing of data by the Vision Server, we increase, day after day, our passion for outcome-based-perfusion.

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