CSL Behring

Applicability and development of artificial intelligence in critical patients

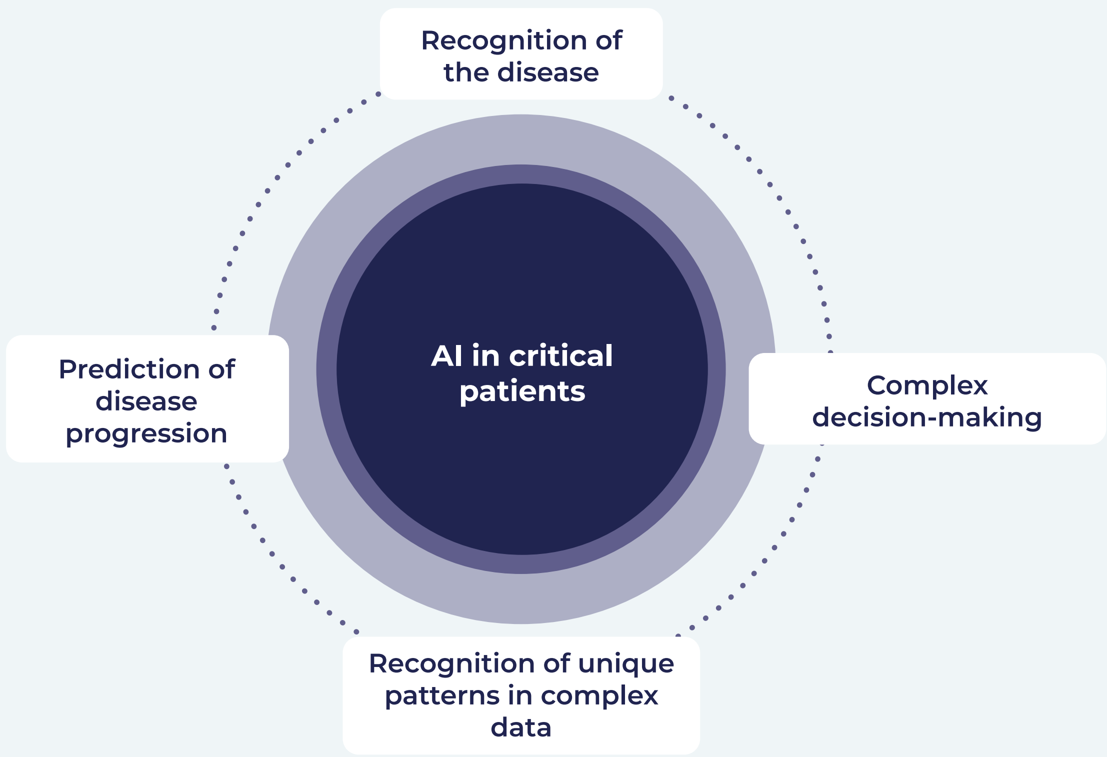
Moderator: Miguel Ángel Taberna Izquierdo

Monday, May 13, 2024

1. WHAT DIRECTIONS DO WE HAVE IN TERMS OF ARTIFICIAL INTELLIGENCE?

Juan José Beunza Nuin

Artificial intelligence (AI) has the ability to transform the ICU at different levels[1]:



Patient monitoring / sensorization (Internet of Medical Things)

- Automation
- Streaming (machine learning and real-time)
- There are many monitorable variables and variables susceptible to monitoring[2,3]
- AI helps reduce the number and duration of false alarms and promotes effective monitoring[4]

Prediction of disease progression[5-8]

Support in clinical decision

- Early detection
- Predictive models
- Precision medicine

Using generative AI

- Ability to create new ideas and contents, beyond machine learning

RECOMMENDATIONS:

1. Training with own data is fundamental:

- The similarities and discrepancies between cohorts used for training and the local population have to be considered.
- Clinical validation is essential (at the beginning and then regularly).

2. Smaller models with texts and specific clinical tasks provide better results (as well as local, cheaper, more private) than general large language models (LLM)[9,10].

3. It is essential to train clinicians in the use of AI.

4. This should be an interprofessional endeavor: clinicians together with IT experts and linguists. Intensivists should be involved in the process from the start.

CHALLENGES POSED BY AI IN THE ICU:

- **Interpretability**
- **Lower clinical preparation**
- **Privacy and data exchange**
- **Suboptimal compliance with standards**

CONSIDERATIONS GOING FORWARD:

- Efficient data transfer
- Data de-identification
- Fast processing
- Quality assurance
- Decentralized federated learning

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2. PRACTICAL APPLICATION OF ARTIFICIAL INTELLIGENCE IN CRITICAL PATIENTS

Federico Gordo Vidal

AI is the ability of machines to simulate human intelligence.

Creating systems that can learn, reason and make decisions in a similar way to a human.
Thus, AI comprises mathematical models that depend on the data they analyze in an advanced manner and that they use to generate answers.

AI is present in daily activities in the ICU and around critical patient care. However, its applications will grow exponentially and the whole healthcare model will change:

- Early detection and admission assessment
- Score follow-up and severity evolution
- Detection of sepsis
- Identification of phenotypes with different approaches
- Monitoring or imaging systems embedded in medical equipment
- Generative AI for the development of studies, protocols, etc
- Search of clinical information

Currently, the best application of AI has to do with clinical decision-making assistance systems and task simplification.

Characteristics of intensive medicine that make AI particularly necessary in the ICU[11]:

- Complexity
- High costs
- Uncertainty in results
- Need for prediction
- Variability
- Need to reduce adverse effects
- Volume of data stored in real time

BENEFITS VERSUS DRAWBACKS OF AI

Drawbacks:

- Ethical considerations (equal availability between areas or sites, transfer of data to private companies)
- Privacy and security
- Personnel training and need for new profiles

Benefits:

- Customization of care and higher efficiency and precision
- Process optimization (automation and load reduction)

MODELS USED BY AI*

Supervised learning	Unsupervised learning	Neural networks
Model training with labeled data to perform precise predictions	Unlabeled data processing and pattern discovery with no previous guide	Mimic the human brain function

* Not all generated models are applicable outside of the environment where they were trained.

Critical steps in the implementation of AI in clinical practice[12]:

1. Creating reliable, cooperative, accessible databases.

- Are quality data really accessible in the ICU?

2. Connection of fully integrated equipment and systems that speak the same language and can transfer information in real time.

3. Incorporation of professional profiles that allow working with AI systems and data in an interdisciplinary manner.

Standardization processes and ethical approaches are required to use AI. Besides, for the time being, all decisions must be supervised by a specialist.

LITERATURE

1. Saqib M, Iftikhar M, Neha F, Karishma F, Mumtaz H. Artificial intelligence in critical illness and its impact on patient care: a comprehensive review. Front Med (Lausanne) [Internet]. 2023 [cited 2024 May 27];10. Available from: https://pubmed.ncbi.nlm.nih.gov/37153088/

2. Duranteau J, De Backer D, Donadello K, Shapiro NI, Hutchings SD, Rovas A, et al. The future of intensive care: the study of the microcirculation will help to guide our therapies. Crit Care [Internet]. 2023 Dec 1 [cited 2024 May 27];27(1). Available from: https://pubmed.ncbi.nlm.nih.gov/37193993/

3. Lafuente JL, González S, Puertas E, Gómez-Tello V, Avilés E, Albo N, et al. Development of a urinometer for automatic measurement of urine flow in catheterized patients. PLoS One [Internet]. 2023 Aug 1 [cited 2024 May 27];18(8). Available from: https://pubmed.ncbi.nlm.nih.gov/37651353/

4. Li B, Yue L, Nie H, Cao Z, Chai X, Peng B, et al. The effect of intelligent management interventions in intensive care units to reduce false alarms: An integrative review. Int J Nurs Sci [Internet]. 2023 Jan 1 [cited 2024 May 27];11(1):133–42. Available from: https://pubmed.ncbi.nlm.nih.gov/38352290/

5. Wegner FK, Plagwitz L, Doldi F, Ellermann C, Willy K, Wolfes J, et al. Machine learning in the detection and management of atrial fibrillation. Clinical Research in Cardiology [Internet]. 2022 Sep 1 [cited 2024 May 27];111(9):1010. Available from: /pmc/articles/PMC9424134/

6. Stivi T, Padawer D, Dirini N, Nachshon A, Batzofin BM, Ledot S. Using Artificial Intelligence to Predict Mechanical Ventilation Weaning Success in Patients with Respiratory Failure, Including Those with Acute Respiratory Distress Syndrome. Journal of Clinical Medicine 2024, Vol 13, Page 1505 [Internet]. 2024 Mar 5 [cited 2024 May 27];13(5):1505. Available from: https://www.mdpi.com/2077-0383/13/5/1505/htm

7. Fleuren LM, Klausch TLT, Zwager CL, Schoonmade LJ, Guo T, Roggeveen LF, et al. Machine learning for the prediction of sepsis: a systematic review and meta-analysis of diagnostic test accuracy. Intensive Care Med [Internet]. 2020 Mar 1 [cited 2024 May 27];46(3):383–400. Available from: https://pubmed.ncbi.nlm.nih.gov/31965266/

8. Zhao X, Lu Y, Li S, Guo F, Xue H, Jiang L, et al. Predicting renal function recovery and short-term reversibility among acute kidney injury patients in the ICU: comparison of machine learning methods and conventional regression. Ren Fail [Internet]. 2022 [cited 2024 May 28];44(1):1326–37. Available from: https://pubmed.ncbi.nlm.nih.gov/35930309/

9. Soroush A, Glicksberg BS, Zimlichman E, Barash Y, Freeman R, Charney AW, et al. Large Language Models Are Poor Medical Coders — Benchmarking of Medical Code Querying. NEJM AI [Internet]. 2024 Apr 19 [cited 2024 May 28];1(5). Available from: https://ai.nejm.org/doi/full/10.1056/AIdbp2300040

10. Saab K, Tu T, Weng WH, Tanno R, Stutz D, Wulczyn E, et al. Capabilities of Gemini Models in Medicine. ‡ Technical Lead, † Senior Lead. 2024;

11. Martin GS. The Intersection of Big Data, Artificial Intelligence, Precision and Predictive Medicine to Create the Future of Critical Care. ICU Manag Pract.

12. Gordo Vidal F, Gordo Herrera N. Análisis avanzado de datos y medicina intensiva. Med Intensiva [Internet]. 2024 Jan 1 [cited 2024 May 28];48(1):1–2. Available from: http://www.medintensiva.org/es-analisis-avanzado-datos-medicina-intensiva-articulo-S0210569123002139

CSL Behring

Patient blood management (pbm): beyond anemia in chronic critical patients

Moderator: Milagros Sancho González

Monday, May 13, 2024

1. PATIENT BLOOD MANAGEMENT (PBM): FROM MYTHOS TO LOGOS

Manuel Quintana Díaz

The introduction of PBM started in 2007-2012 at the University of Western Australia[1].

PBM has shown extensive benefits in terms of patient outcomes and cost reduction1. PBM focuses on patient safety and does not only contemplate blood management, blood being such a scarce resource. Unlike the optimal use of blood, the goal of which was to minimize effective doses of blood products, PBM focuses on improving health outcomes.

PBM is mainly about promoting a (very) good management of patients and donors.

All **three pillars of PBM** lead to the following objectives:

- Increasing tolerance to anemia
- Optimizing erythropoiesis
- Minimizing bleeding and coagulopathy

Plus, all of them entail better clinical outcomes.

PBM responds to **3 WHO challenges**:

- Insufficient supply of safe, effective, transfusion quality blood products.
- Insufficient availability of plasma-derived medicinal products.
- Suboptimal clinical practices in blood product transfusion.

These are the **5 reasons to implement PBM**:

SITUATION IN SPAIN

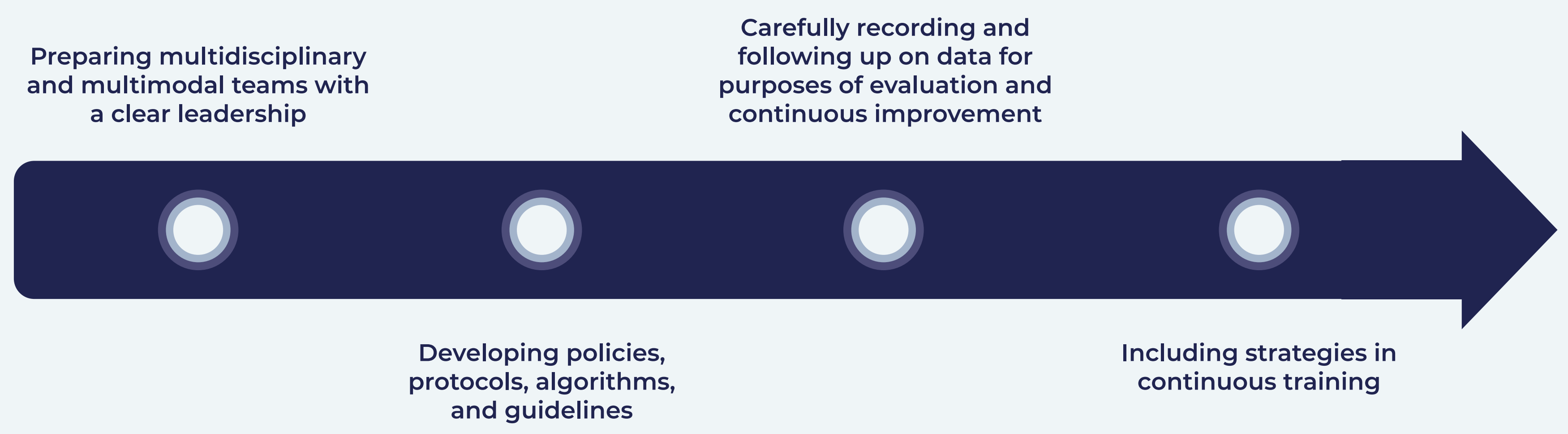
In Spain, there is currently a substantial interregional transfusion variability2, with significant differences in the transfusion rate between regions:

Red blood cells	Platelets	Plasma
> 70%	> 200%	> 300%

Furthermore, the national survey on PBM in intensive care has revealed that just over 20% of hospitals where the responders were located have implemented PBM programs.

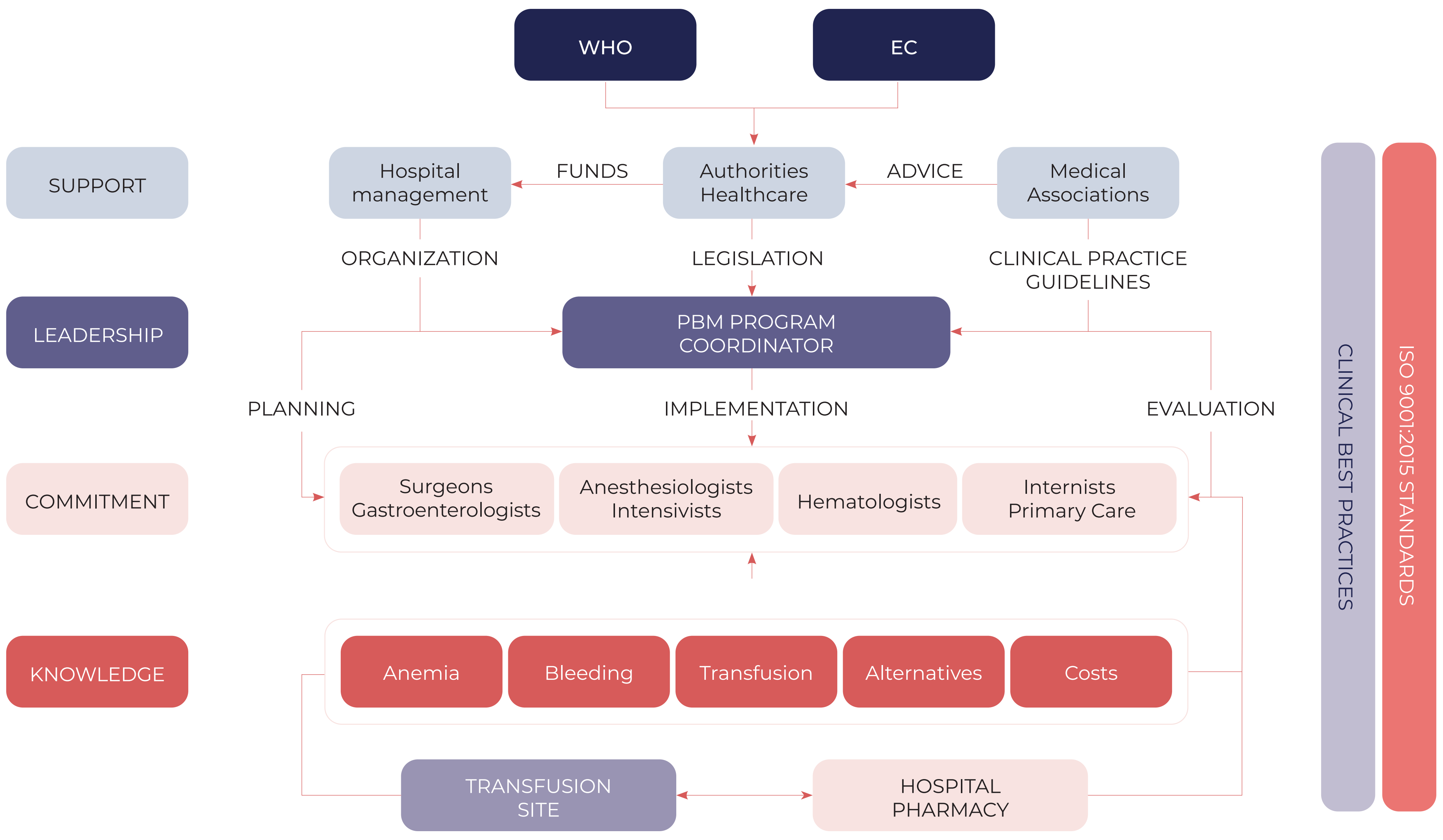
In Spain, anesthesiologists are the main players in the development of PBM programs, given their application in surgical patients. Nevertheless, PBM is also applicable to another type of patients, namely, critical patients, and intensivists need to be involved. In fact, according to the WHO, healthcare services should implement Multidisciplinary and Multimodal programs to manage these patients, based on the three pillars of PBM.

In order to start and implement PBM programs, the next steps must be followed[3]:



Obtaining support from people in charge of healthcare systems or institutions, which may come before or after the start of this process.

MULTIDISCIPLINARY ORGANIZATION OF PBM PROGRAMS[4]



It is relevant for intensivists to exercise this leadership as PBM program coordinators.

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Patient blood management (pbm): beyond anemia in chronic critical patients

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2. TRANSFUSION THRESHOLDS: ARE THERE EXCEPTIONS TO THE RESTRICTIVE POLICY? ARE THEY REAL?

Blanca Furquet López

ICU anemia management figures

Patients with anemia on admission	Patients with anemia on the 8th day	Patients receiving transfusions	Average red blood cell units per stay	Transfusions of red blood cells with in o Hb decrease
60%	97%	30-50%	5	40-90%

Currently there is enough evidence to assure that restrictive transfusion strategies are safe in critical patients with anemia[5]. According to a survey that determined transfusion habits in several countries, most participants considered transfusion in critical patients if hemoglobin was below 7 g/dL[6].

However, there are doubts in patients with the following conditions:

- Acute myocardial infarction
- Cardiovascular disease
- Heart surgery
- Major vascular surgery
- Neurocritical patients

These exceptions to a restrictive transfusion policy are real and they are found in a high proportion of clinical settings.

ACUTE CORONARY SYNDROME

There is an insufficient delivery of O_2 to the myocardium (due to thrombosis or stenosis) ➔ DO_2 supply/demand unbalance.

- Overtransfusion can worsen the extraction of O_2 ➔ SHUNT.
- Transfusion can lead to heart failure due to volume overload.
- Anemia is a risk factor independent from adverse cardiovascular events.

Guidelines recommend a liberal strategy (9-10 g/dL)[5] or do not lean towards any of the options[7].

Available evidence from RCTs:	
Carson et al, NEJM, 2023[8]	Liberal strategy versus restrictive strategy: · No reduction of risk of reinfarction or death within 30 days. · Lower mortality for cardiac causes. · Higher clinical benefit.
Ducrocq et al, JAMA, 2021[9]	Restrictive strategy versus liberal strategy: · Major adverse cardiovascular event ratio not lower after 30 days. · Potential clinical damage cannot be ruled out, since this is a non-inferiority study.

STABLE CARDIOVASCULAR DISEASE

An alteration of compensatory mechanisms occurs, to supply O_2 to tissues in case of acute disease or anemia.

Available evidence from meta-analysis:	
Cortés-Puch et al, Transfus Med, 2018[10]	Liberal strategy versus restrictive strategy: · Reduction of relative risk of adverse coronary event, both when CVD is known and when it is not. · Reduction of mortality. · Catheterization or surgery to correct the cardiovascular defect cancel the benefit of the liberal strategy.

HEART SURGERY

Limit cardiac reserve + hemodilution ➔ higher risk of anemia-induced tissue hypoxia.

- Transfusion involves a risk factor of death and worse outcomes.

Guidelines recommend a restrictive strategy (7.5 g/dL)[5].

Available evidence from RCTs:	
Mazer et al, NEJM, 2017[11]	Restrictive strategy versus liberal strategy: · Not inferior in the combined outcome of death by any cause, myocardial infarction, stroke, or outbreak of renal failure with dialysis.
Murphy et al, NEJM, 2015[12]	Restrictive strategy versus liberal strategy: · Not superior in morbidity or costs.
Hajjar et al, JAMA, 2010[13]	Restrictive strategy versus liberal strategy in perioperative setting: · Not inferior in the combined outcome of death by any cause after 30 days and severe morbidity.

MAJOR VASCULAR SURGERY

The ability to fulfill the increased O_2 demand due to surgical trauma depends on the ability to increase the cardiac output.

- Both results and practices in cardiac surgery are extrapolated.

Guidelines recommend a hemoglobin threshold of 7.5-8 g/dL[5].

Available evidence from RCTs:	
Møller et al, NEJM, 2019[14]	Low threshold (<8 g/dL) versus High threshold (< 9.7 g/dL): · Increase in mortality and major vascular complications and lower survival · Worse clinical outcomes

NEUROCRITICAL PATIENTS

There is an inverse relationship between hematocrit and cerebral blood flow (due to increase in viscosity), and the risk of ischemia can be increased.

- It is necessary to maintain an adequate cerebral perfusion with the highest delivery of O2 to the brain tissue (optimal hematocrit)[15].

Guidelines do not take a stance on restrictive or liberal strategies[5].

Available evidence from RCTs:	
Gobatto et al, Crit Care, 2019[16]	Liberal strategy vs. Restrictive strategy: · Lower mortality · Better neurological outcome · Lower incidence of post-traumatic vasospasm
Robertson et al, JAMA, 2014[17]	High target (>10 g/dL) vs. Low target (>7 g/dL) vs.: · Increase in thromboembolic complications

In conclusion:

- A more comprehensive study is needed on subgroups in these exceptions to identify which patients may benefit from more restrictive strategies and which patients are high risk and require higher transfusion thresholds.
- Methods to quantify the demand and release of O^2 in tissues should be improved, in order to identify patients that may better benefit from transfusion.
- Transfusion best practices should be based not only on hemoglobin concentration, but also on considering the signs and symptoms experienced by patients, their comorbidities, the rate of bleeding, and their preferences.
- Transfusion limits in neurocritical patients or with acute coronary syndrome are not clearly established.

LITERATURE

1. Leahy MF, Hofmann A, Towler S, Trentino KM, Burrows SA, Swain SG, et al. Improved outcomes and reduced costs associated with a health-system–wide patient blood management program: a retrospective observational study in four major adult tertiary-care hospitals. Transfusion (Paris) [Internet]. 2017 Jun 1 [cited 2024 May 8];57(6):1347–58. Available from: https://onlinelibrary.wiley.com/doi/full/10.1111/trf.14006

2. Sistema Nacional para la Seguridad Transfusional SNST.

3. Sadana D, Pratzer A, Scher LJ, Saag HS, Adler N, Volpicelli FM, et al. Promoting High-Value Practice by Reducing Unnecessary Transfusions With a Patient Blood Management Program. JAMA Intern Med [Internet]. 2018 Jan 1 [cited 2024 Jun 10];178(1):116–22. Available from: https://pubmed.ncbi.nlm.nih.gov/29159367/

4. Ripollés-Melchor J, Jericó-Alba C, Quintana-Díaz M, García-Erce JA. Del ahorro de sangre al patient blood management. Med Clin (Barc) [Internet]. 2018 Nov 9 [cited 2024 Jun 10];151(9):368–73. Available from: https://www.elsevier.es/es-revista-medicina-clinica-2-articulo-del-ahorro-sangre-al-patient-S002577531830174X

5. Vlaar AP, Oczkowski S, de Bruin S, Wijnberge M, Antonelli M, Aubron C, et al. Transfusion strategies in non-bleeding critically ill adults: a clinical practice guideline from the European Society of Intensive Care Medicine. Intensive Care Med [Internet]. 2020 Apr 1 [cited 2024 May 28];46(4):673–96. Available from: https://link.springer.com/article/10.1007/s00134-019-05884-8

6. de Bruin S, Eggermont D, van Bruggen R, de Korte D, Scheeren TWL, Bakker J, et al. Transfusion practice in the bleeding critically ill: An international online survey—The TRACE-2 survey. Transfusion (Paris) [Internet]. 2022 Feb 1 [cited 2024 Jun 10];62(2):324–35. Available from: https://onlinelibrary.wiley.com/doi/full/10.1111/trf.16789

7. Carson JL, Stanworth SJ, Guyatt G, Valentine S, Dennis J, Bakhtary S, et al. Red Blood Cell Transfusion: 2023 AABB International Guidelines. JAMA [Internet]. 2023 Nov 21 [cited 2024 Jun 10];330(19):1892–902. Available from: https://pubmed.ncbi.nlm.nih.gov/37824153/

8. Carson JL, Brooks MM, Hébert PC, Goodman SG, Bertolet M, Glynn SA, et al. Restrictive or Liberal Transfusion Strategy in Myocardial Infarction and Anemia. N Engl J Med [Internet]. 2023 Dec 28 [cited 2024 Jun 10];389(26):2446–56. Available from: https://pubmed.ncbi.nlm.nih.gov/37952133/

9. Ducrocq G, Gonzalez-Juanatey JR, Puymirat E, Lemesle G, Cachanado M, Durand-Zaleski I, et al. Effect of a Restrictive vs Liberal Blood Transfusion Strategy on Major Cardiovascular Events Among Patients With Acute Myocardial Infarction and Anemia: The REALITY Randomized Clinical Trial. JAMA [Internet]. 2021 Feb 9 [cited 2024 Jun 10];325(6):552–60. Available from: https://pubmed.ncbi.nlm.nih.gov/33560322/

10. Cortés-Puch I, Wiley BM, Sun J, Klein HG, Welsh J, Danner RL, et al. Risks of restrictive red blood cell transfusion strategies in patients with cardiovascular disease (CVD): a meta-analysis. Transfus Med [Internet]. 2018 Oct 1 [cited 2024 Jun 10];28(5):335–45. Available from: https://pubmed.ncbi.nlm.nih.gov/29675833/

11. Mazer CD, Whitlock RP, Fergusson DA, Hall J, Belley-Cote E, Connolly K, et al. Restrictive or Liberal Red-Cell Transfusion for Cardiac Surgery. N Engl J Med [Internet]. 2017 Nov 30 [cited 2024 Jun 10];377(22):2133–44. Available from: https://pubmed.ncbi.nlm.nih.gov/29130845/

12. Murphy GJ, Pike K, Rogers CA, Wordsworth S, Stokes EA, Angelini GD, et al. Liberal or Restrictive Transfusion after Cardiac Surgery. New England Journal of Medicine [Internet]. 2015 Mar 12 [cited 2024 May 9];372(11):997–1008. Available from: https://www.nejm.org/doi/full/10.1056/NEJMoa1403612

13. Hajjar LA, Vincent JL, Galas FRBG, Nakamura RE, Silva CMP, Santos MH, et al. Transfusion requirements after cardiac surgery: the TRACS randomized controlled trial. JAMA [Internet]. 2010 Oct 13 [cited 2024 Jun 10];304(14):1559–67. Available from: https://pubmed.ncbi.nlm.nih.gov/20940381/

14. Møller A, Nielsen HB, Wetterslev J, Pedersen OB, Hellemann D, Winkel P, et al. Low vs high hemoglobin trigger for transfusion in vascular surgery: a randomized clinical feasibility trial. Blood [Internet]. 2019 Jun 20 [cited 2024 Jun 10];133(25):2639–50. Available from: https://pubmed.ncbi.nlm.nih.gov/30858230/

15. Pendem S, Rana S, Manno EM, Gajic O. A review of red cell transfusion in the neurological intensive care unit. Neurocrit Care [Internet]. 2006 [cited 2024 Jun 10];4(1):063–7. Available from: https://pubmed.ncbi.nlm.nih.gov/16498197/

16. Gobatto ALN, Link MA, Solla DJ, Bassi E, Tierno PF, Paiva W, et al. Transfusion requirements after head trauma: a randomized feasibility controlled trial. Crit Care [Internet]. 2019 Mar 12 [cited 2024 Jun 10];23(1). Available from: https://pubmed.ncbi.nlm.nih.gov/30871608/

17. Robertson CS, Hannay HJ, Yamal JM, Gopinath S, Goodman JC, Tilley BC, et al. Effect of erythropoietin and transfusion threshold on neurological recovery after traumatic brain injury: a randomized clinical trial. JAMA [Internet]. 2014 Jul 2 [cited 2024 May 28];312(1):36–47. Available from: https://pubmed.ncbi.nlm.nih.gov/25058216/

CSL Behring

Refractory cardiogenic shock

Moderators: María de los Ángeles Rodríguez Esteban, Juan Carlos Ruiz Rodríguez

Wednesday, May 15, 2024

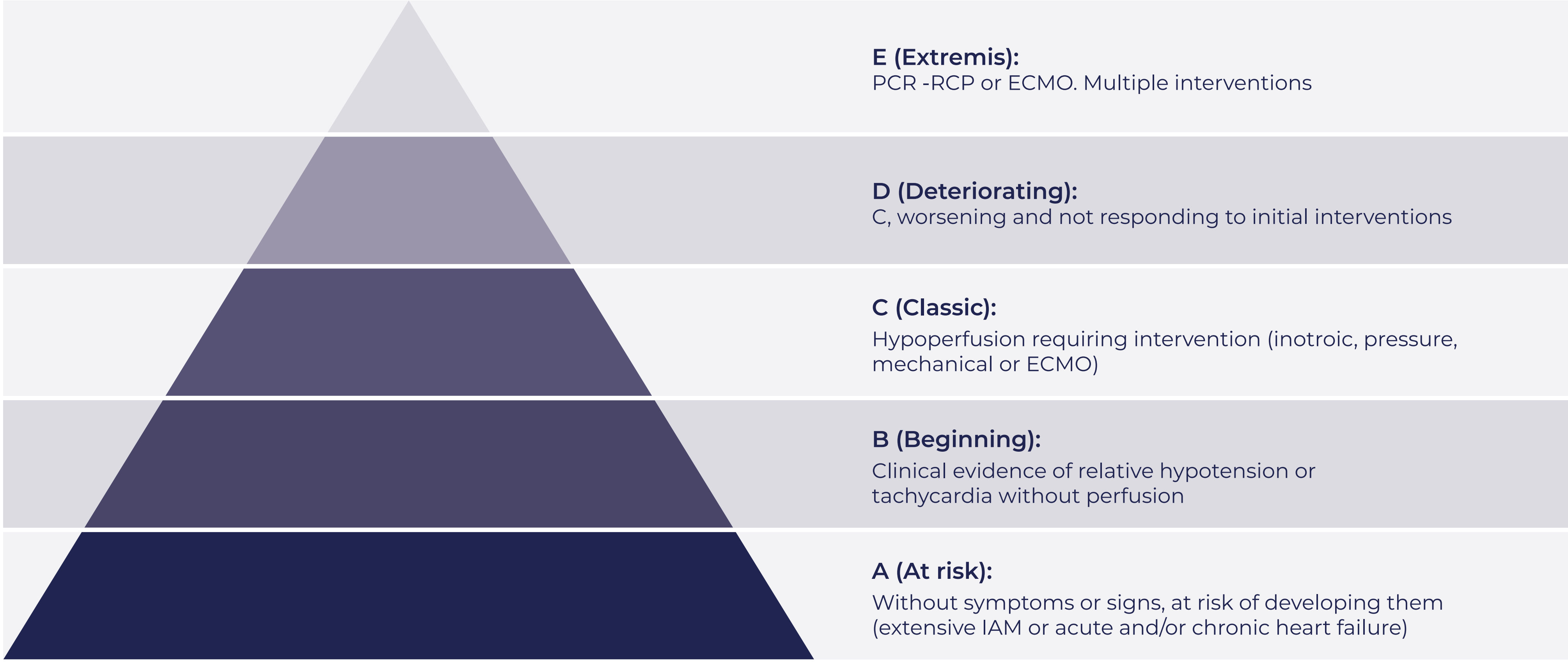
1. WHEN DO WE HAVE A REFRACTORY SHOCK?

Celina Llanos Jorge

DEFINITION OF REFRACTORY SHOCK

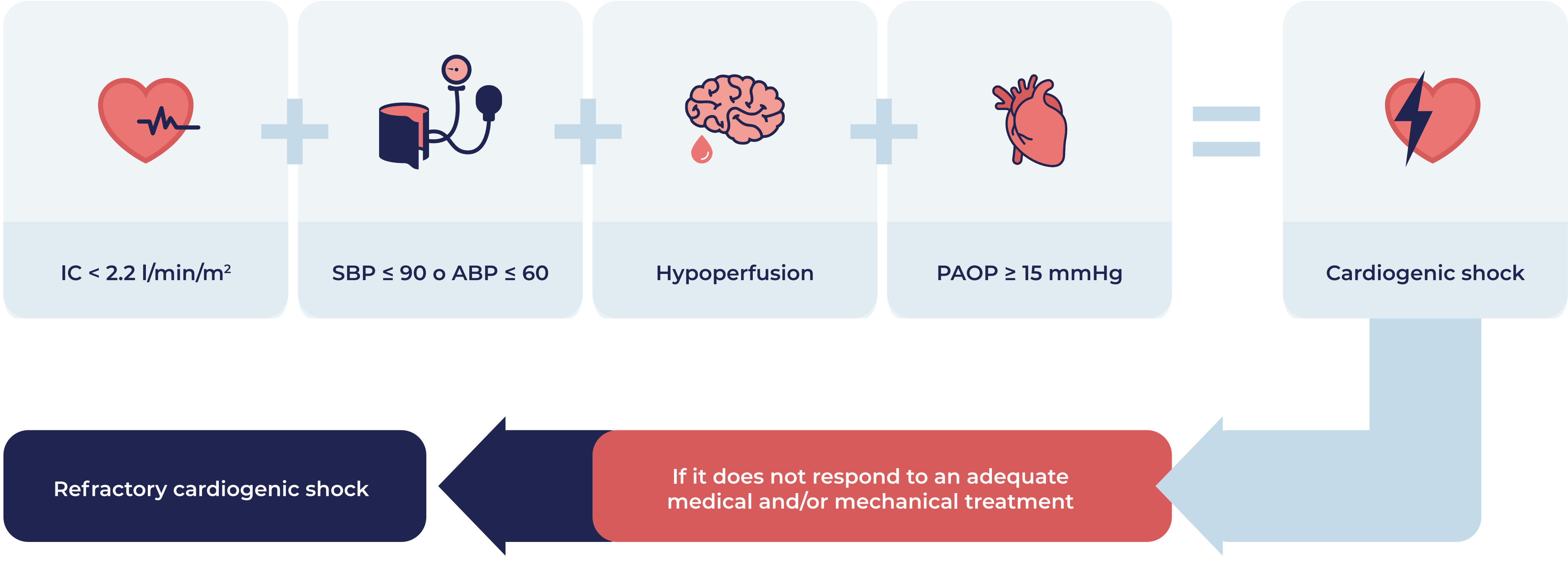
Clinical syndrome caused by an unbalance between the tissue requirement for oxygen and the ability of the cardiovascular system to meet that requirement, due to an acute cardiac dysfunction[1]. This a complex syndrome leading to the occurrence of tissue and organ hypoperfusion.

CLASSIFICATION OF CARDIOGENIC SHOCK[2]



DEFINITION OF REFRACTORY CARDIOGENIC SHOCK

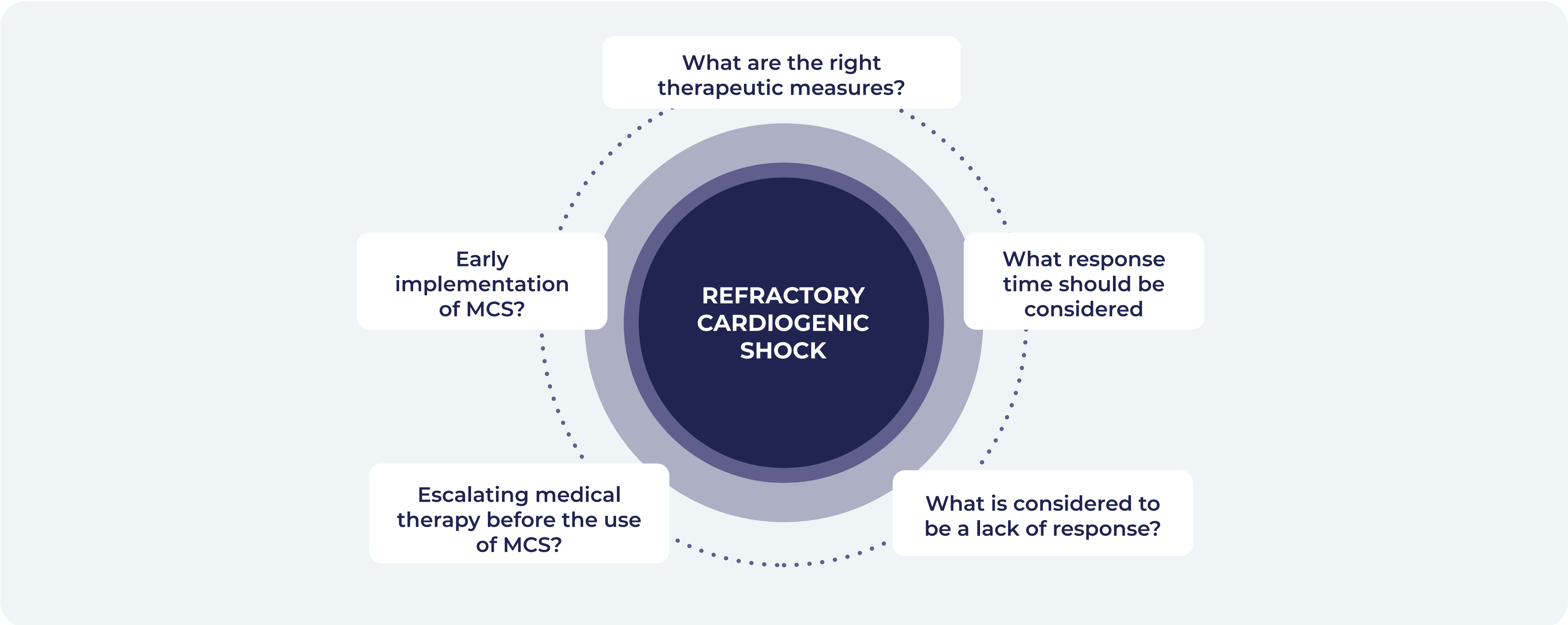
It is characterized by the persistence of hypoperfusion despite a proper therapeutic approach[3].



There is no consensus as to the definition or diagnostic criteria, and even the criteria used to define the population with refractory cardiogenic shock vary between clinical trials[4]. Anyway, it should be understood as a continuous, and an early approach is key to avoid progression.

Zapata et al. 2024[1]	Hypoperfusion + multiorgan failure despite the etiological treatment and adequate support
Sarma et al. 2024[3]	Hemometabolic shock: multiorgan failure + acidosis, refractory to stabilization measures
Naidu et al. 2022[5]	· SCAI D (Deteriorating): C stage, but with more decline, due to lack or response · SCAI E (Extremis): need to quickly escalate support up to very high levels, with no response

SCAI: Society for Cardiovascular Angiography and Intervention



MCS: Mechanical Circulatory Support.

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Refractory cardiogenic shock

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2. DIAGNOSTIC APPROACH AND HEMODYNAMIC MANAGEMENT OF SHOCK WITH ECHOCARDIOGRAPHY

Ana Ochagavía Calvo

In order to properly diagnose shock, it is essential to consider aspects related to it physiology and hemodynamic monitoring. This will allow us to answer clinical questions and be able to make the right decisions.

Echocardiography is a useful tool in the assessment of the cardiovascular function of critical patients. It is a non-invasive or minimally invasive technique, for bedside application, providing real-time anatomical data. Its main indication in the ICU (40% of cases) is the assessment of the cardiocirculatory function in patients in shock[6].

A basic level of knowledge in echocardiography should allow the etiological diagnosis of typical cases-severe left ventricular failure, severe right ventricular failure, cardiac tamponade, massive valve insufficiency, or hypovolemia.

Current recommendations suggest a more advanced performance and interpretation of echocardiography when the treatment response is Insufficient or when there is a need to delve deeper into the pathophysiology[7].

When faced with a patient with cardiogenic shock, it is essential to ask ourselves what the relevant parameters are and choose hemodynamic monitoring accordingly[1]. Echocardiography allows to assess a great deal of parameters.

RELEVANT UTILITY PARAMETERS

Cardiac output (CO)

Pulmonary artery occluded pressure (PAOP)

- Semiquantitative estimation

Assessing volume responsiveness (leg elevation)

- Variation in aortic peak flow velocity
- Diastolic blood pressure
- Vena cava variation
- Kissing walls

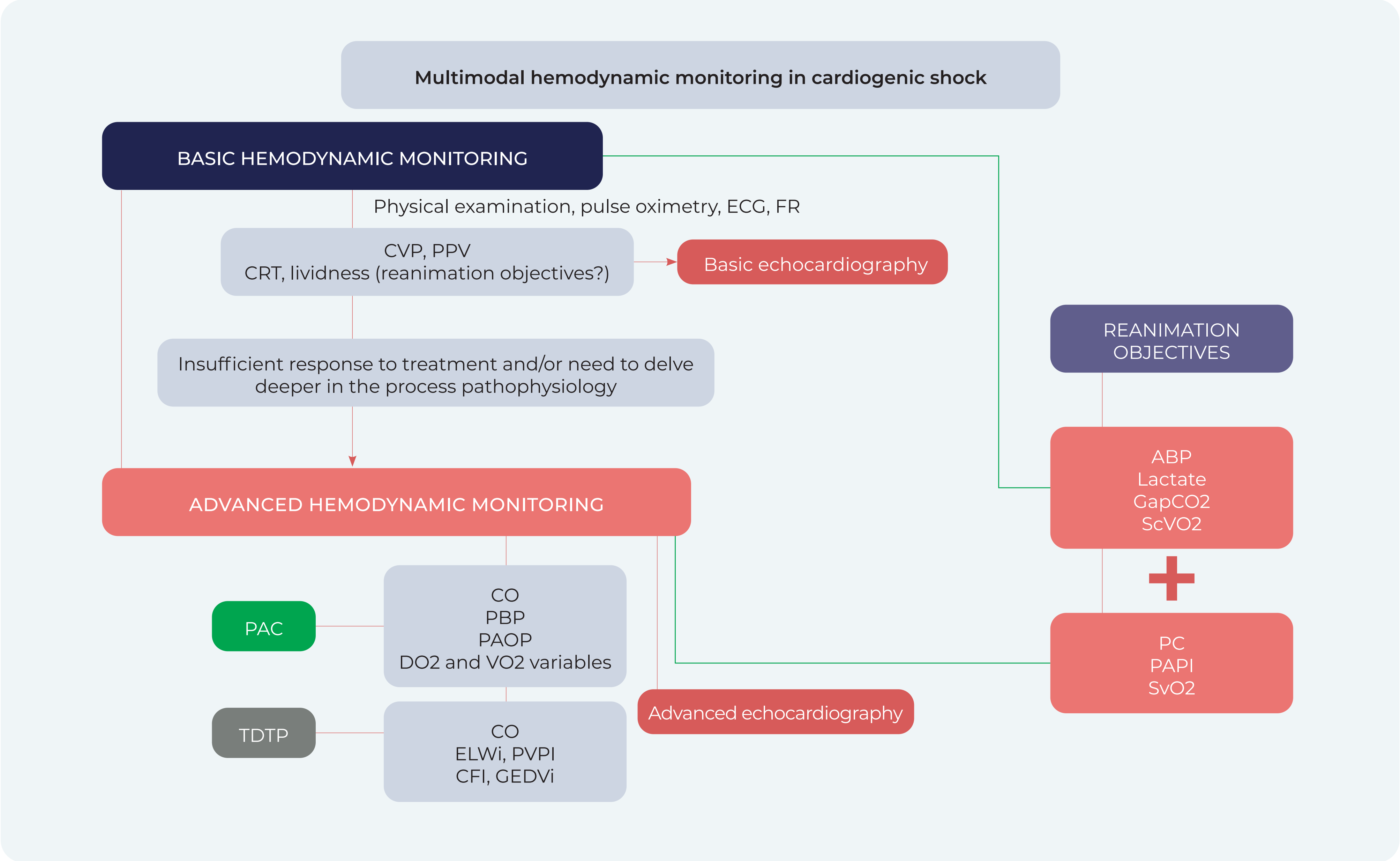
Cardiac power

Pulmonary Artery Pulsatility Index (PAPI)

LIMITATIONS OF ECHOCARDIOGRAPHY

- There is interobserver variability:
  - An adequate training is necessary
  - Different skill levels: basic and advanced
- It is not a continuous hemodynamic monitoring tool

HEMODYNAMIC MONITORING ALGORITHM OF CARDIOGENIC SHOCK:



Multimodal monitoring in cardiogenic shock[8]

PAC: pulmonary artery catheterization. CP: Cardiac power DO_2: Oxygen delivery. ELWi: extravascular lung water index. $GapCO_2$: pCO_2 veno-arterial difference. CO: cardiac output. CFI: cardiac function index. PAPI: pulmonary artery pulsatility index. PVPI: pulmonary vascular permeability index. ABP: average blood pressure. PBP: pulmonary blood pressure. PAOP: pulmonary artery occlusion pressure. CVP: central venous pressure. $ScVO_2$: central venous O_2 saturation. SvO_2: mixed venous O_2 saturation. TPTD: transpulmonary thermodilution. CRT: capillary refill time. VO_2: O_2 consumption. PPV: pulse pressure variation. GEDVi: global end-diastolic volume index.

Refractory cardiogenic shock

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3. MEDICAL MANAGEMENT OF REFRACTORY SHOCK

Luis Martín Villén

Refractory cardiogenic shock is a condition with different etiologies and a changing process that evolves over time. Consequently, its management is complex and it depends on the origin and stage. Furthermore, treatment must be applied based on clinical and hemodynamic parameters.

The intervention of cardiac intensive medicine specialists is essential, and it has an impact on mortality[9].

These are the main therapeutic interventions in cardiogenic shock:

1. Revascularization

- Over 50% of cardiogenic shocks occur in the context of acute coronary syndrome. Therefore, coronary revascularization is a fundamental element.
- The evolution of mortality in cardiogenic shock is time-dependent.

2. Antithrombotic treatment

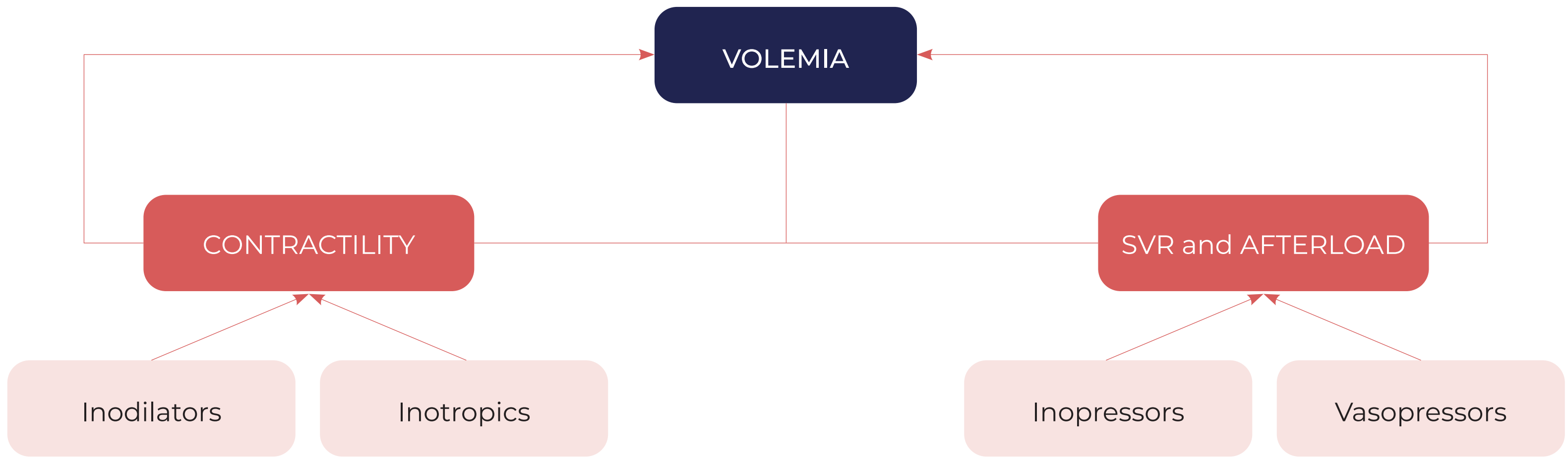
- Intestinal absorption of antiplatelet drugs may be diminished or be insufficient in patients with cardiogenic shock10. Therefore, the risk-benefit ratio of that treatment should be assessed in order to choose the antithrombotic strategy.

3. Management of arrhythmias

- The question arises whether they are the cause or consequence of shock before approaching its treatment[10,11].

4. Fluid therapy and vasoactive drugs

- Based on the stage of myocardial damage and the observed parameters[12].



- Management using *fluid challenge* must be performed once the patient is properly categorized and standardized and not systematically[13].

5. Volume depletion by diuretics

- Pharmacologic therapy applied through a stepped algorithm better preserves kidney function, and it is associated with less adverse events than ultrafiltration[14].
- Using hemofiltration exclusively in these cases of established acute kidney failure[15,16].

6. Vasoactive drugs

- This is the basic support treatment for cardiogenic shock, although more evidence is required[17,18]. It includes vasopressors and inotropes.
- The goal should be ABP < 65 mmHg / SBP > 90 mmHg[19].
- There is no evidence of superiority for any of the inotropic drugs.
- Levosimendan could be useful in beta-blocked patients and with SCAI C or lower. The evidence supporting its use comes from older studies not including high-severity patients[20].
- A stepper approach is necessary when using vasoactive drugs, following the right algorithms[21,22].

7. Respiratory support

- The effects of mechanical ventilation, both beneficial and deleterious, need to be known to optimize their use[23].

8. Temperature control

9. Analgesia and sedation

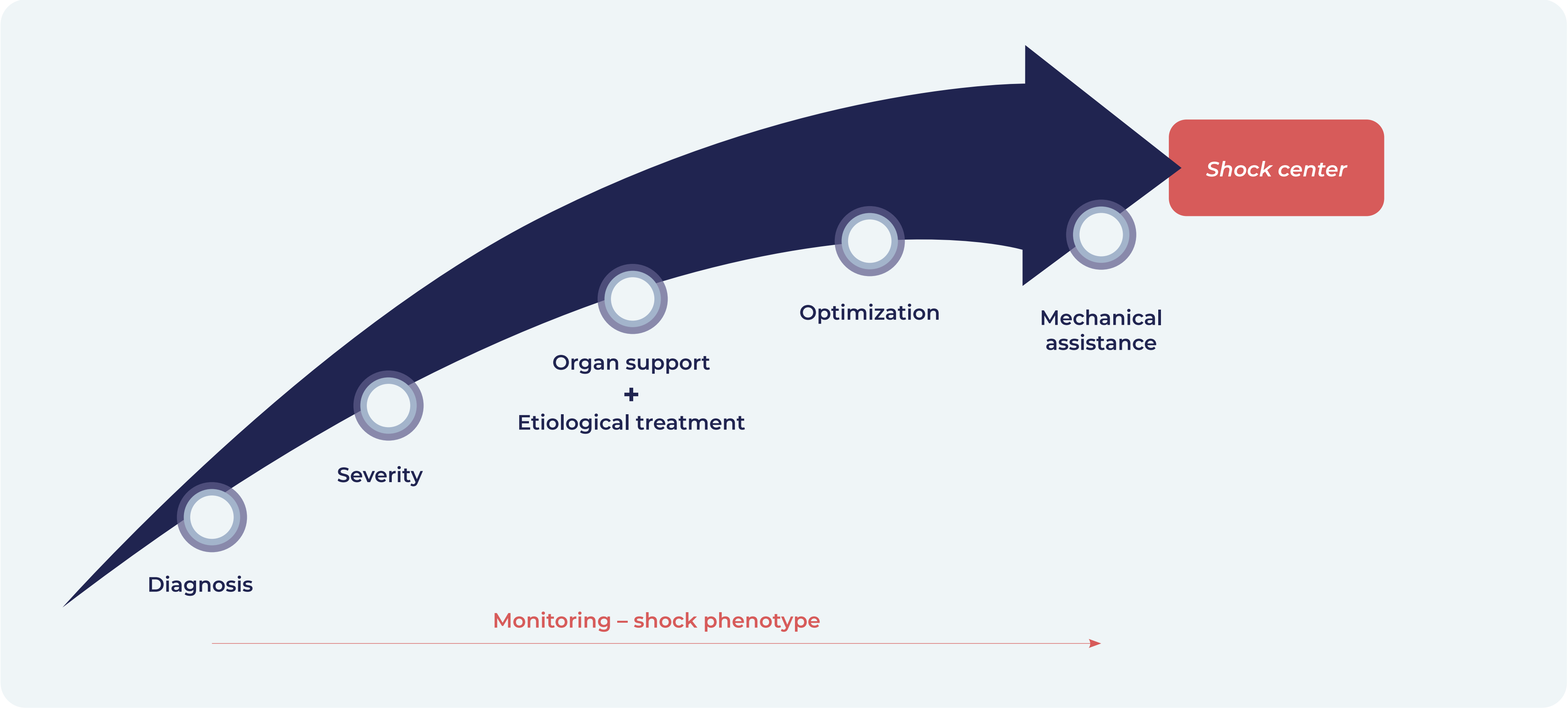
Refractory cardiogenic shock

Moderators: María de los Ángeles Rodríguez Esteban, Juan Carlos Ruiz Rodríguez — Wednesday, May 15, 2024

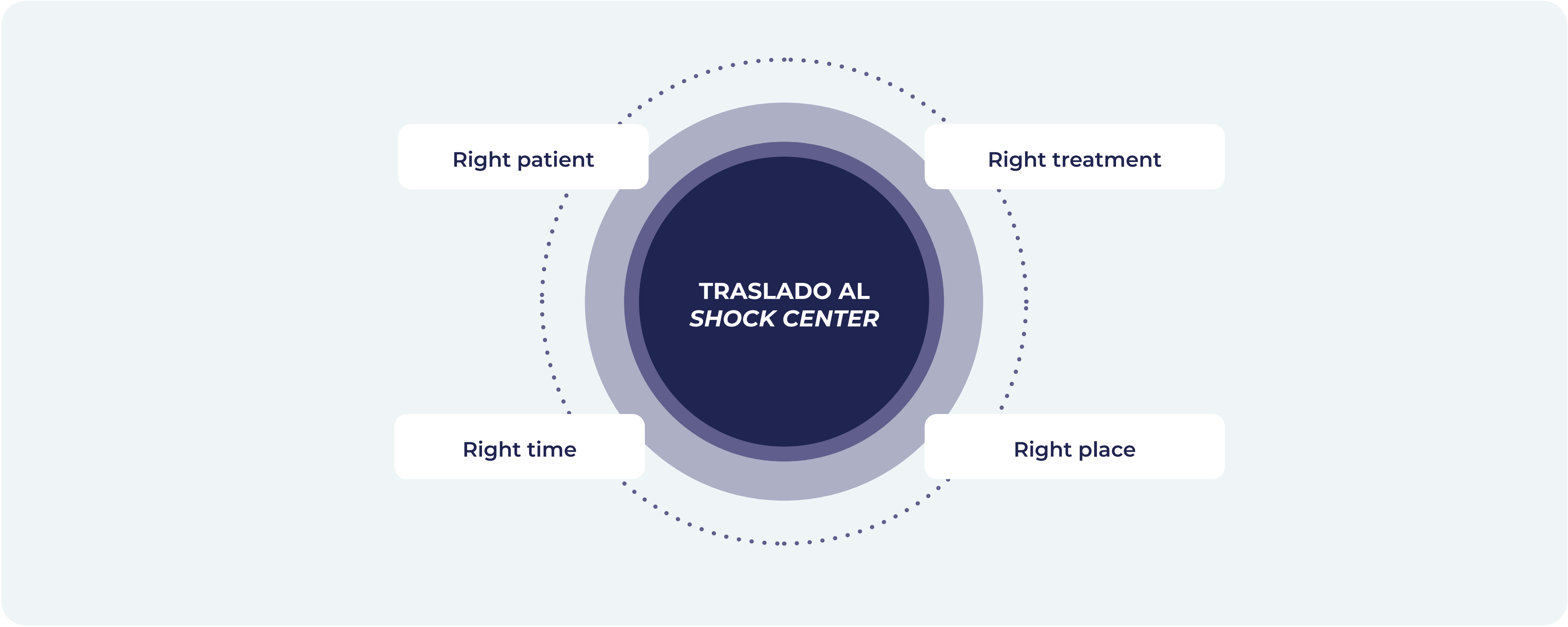
4. WHEN SHOULD I REFER MY PATIENT TO A SHOCKCENTER

María Paz Fuset Cabanes

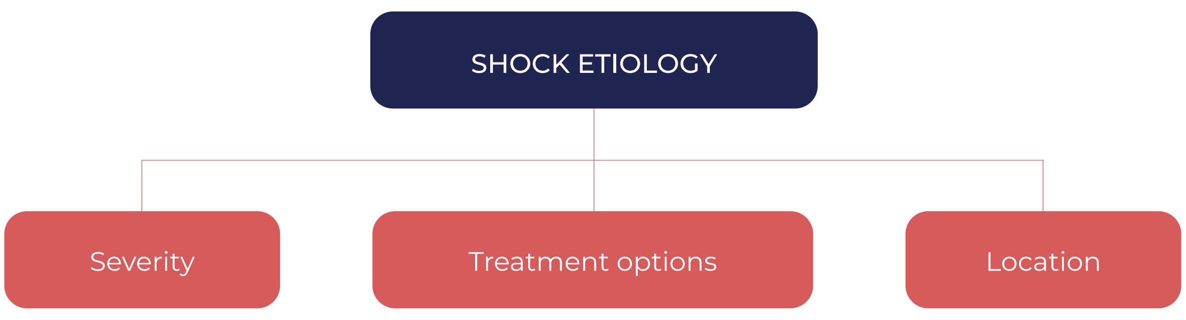
The therapeutic strategy in cases of cardiogenic shock is the following:



Even though patients should be transferred in the last step of that strategy, they may also have to be transferred in previous steps because no more treatments can be provided at our hospital. Anyway, when managing shock, the following is essential:



Factors to be considered when referring cardiogenic shock patients to a *shock center*.



Determination of severity in two ways:

- **SCAI:** in stages A and B the patients can be optimized; in stage C as well, but mechanical intervention may be necessary, and we may not have it available.
- **VIS (Vasoactive-Inotropic Score):** higher scores are related to a higher mortality[24], and in surgical patients, besides, with the incidence of acute kidney damage, the duration of mechanical ventilation and the duration of hospital stay, among others[25]. **It is recommended to transfer patients with a score ≥ 21 to a center where they can access all potentially necessary interventions**[25].

When choosing candidate patients to mechanical circulatory support it is important to critically assess available publications and to take into account that they are endorsed by the brands marketing each device[26].

RELEVANT ASPECTS:

- Creating *shock teams* to make multidisciplinary agreed decisions.
- Creating interhospital networks and obtaining institutional support.
- Developing interhospital transfer protocols.
- Registering and studying potential improvements.
- Reclaiming the role of intensivists in the following aspects:

Diagnosis

Stratification

- SCAI
- Baseline VIS
- Monitoring according to severity

Start of organ support

Planning of etiological treatment

Reevaluation

- VIS
- Lactate
- Multiorgan failure

Definition of the therapeutic strategy

Contact with other specialties and/or centers

Transfer planning

In summary, patients should be referred in the following cases:

1. Impossibility of patient optimization within 6-12 hours

2. Need for a specific treatment:

- Etiological
- For complications
- For poor evolution

LITERATURE

1. Zapata L, Gómez-López R, Llanos-Jorge C, Duerto J, Martin-Villen L. El shock cardiogénico como problema de salud. Fisiología, clasificación y detección. Med Intensiva. 2024 May 1;48(5):282–95.

2. Baran DA, Grines CL, Bailey S, Burkhoff D, Hall SA, Henry TD, et al. SCAI clinical expert consensus statement on the classification of cardiogenic shock. Catheter Cardiovasc Interv [Internet]. 2019 Jul 1 [cited 2024 May 29];94(1):29–37. Available from: https://pubmed.ncbi.nlm.nih.gov/31104355/

3. Sarma D, Jentzer JC. Cardiogenic Shock: Pathogenesis, Classification, and Management. Crit Care Clin [Internet]. 2024 Jan 1 [cited 2024 May 29];40(1):37–56. Available from: https://pubmed.ncbi.nlm.nih.gov/37973356/

4. Arrigo M, Blet A, Morley-Smith A, Aissaoui N, Baran DA, Bayes-Genis A, et al. Current and future trial design in refractory cardiogenic shock. Eur J Heart Fail [Internet]. 2023 May 1 [cited 2024 May 29];25(5):609–15. Available from: https://pubmed.ncbi.nlm.nih.gov/36987926/

5. Naidu SS, Baran DA, Jentzer JC, Hollenberg SM, van Diepen S, Basir MB, et al. SCAI SHOCK Stage Classification Expert Consensus Update: A Review and Incorporation of Validation Studies. J Am Coll Cardiol [Internet]. 2022 Mar 8 [cited 2024 May 29];79(9):933–46. Available from: https://pubmed.ncbi.nlm.nih.gov/35115207/

6. Colreavy FB, Donovan K, Kok YL, Weekes J. Transesophageal echocardiography in critically ill patients. Crit Care Med [Internet]. 2002 [cited 2024 May 30];30(5):989–96. Available from: https://pubmed.ncbi.nlm.nih.gov/12006793/

7. Ochagavía A, Baigorri F, Mesquida J, Ayuela JM, Ferrándiz A, García X, et al. Monitorización hemodinámica en el paciente crítico. Recomendaciones del Grupo de Trabajo de Cuidados Intensivos Cardiológicos y RCP de la Sociedad Española de Medicina Intensiva, Crítica y Unidades Coronarias. Med Intensiva. 2014;38(3):154–69.

8. Ochagavía A, Palomo-López N, Fraile V, Zapata L. Hemodynamic monitoring and echocardiographic evaluation in cardiogenic shock. Med Intensiva. 2024;

9. Na SJ, Chung CR, Jeon K, Park CM, Suh GY, Ahn JH, et al. Association Between Presence of a Cardiac Intensivist and Mortality in an Adult Cardiac Care Unit. J Am Coll Cardiol [Internet]. 2016 Dec 20 [cited 2024 May 30];68(24):2637–48. Available from: https://pubmed.ncbi.nlm.nih.gov/27978948/

10. Shirakabe A, Matsushita M, Shibata Y, Shighihara S, Nishigoori S, Sawatani T, et al. Organ dysfunction, injury, and failure in cardiogenic shock. J Intensive Care [Internet]. 2023 Dec 1 [cited 2024 May 30];11(1):1–9. Available from: https://jintensivecare.biomedcentral.com/articles/10.1186/s40560-023-00676-1

11. Chyou JY, Barkoudah E, Dukes JW, Goldstein LB, Joglar JA, Lee AM, et al. Circulation Atrial Fibrillation Occurring During Acute Hospitalization: A Scientific Statement From the American Heart Association. Circulation [Internet]. 2023 [cited 2024 May 30];147:676–98. Available from: www.ahajournals.org/journal/circe676Supplementalmaterialisavailableathttps://www.ahajournals.org/doi/suppl/10.1161/CIR.0000000000001133.

12. Tehrani BN, Truesdell AG, Psotka MA, Rosner C, Singh R, Sinha SS, et al. A Standardized and Comprehensive Approach to the Management of Cardiogenic Shock. JACC Heart Fail [Internet]. 2020 Nov 1 [cited 2024 May 30];8(11):879–91. Available from: https://pubmed.ncbi.nlm.nih.gov/33121700/

13. Vincent JL, Cecconi M, De Backer D. The fluid challenge. Crit Care [Internet]. 2020 Dec 1 [cited 2024 May 30];24(1):1–3. Available from: https://ccforum.biomedcentral.com/articles/10.1186/s13054-020-03443-y

14. Bart BA, Goldsmith SR, Lee KL, Givertz MM, O'Connor CM, Bull DA, et al. Ultrafiltration in decompensated heart failure with cardiorenal syndrome. N Engl J Med [Internet]. 2012 Dec 13 [cited 2024 May 30];367(24):2296–304. Available from: https://pubmed.ncbi.nlm.nih.gov/23131078/

15. Li SY, Yang WC, Chuang CL. Effect of early and intensive continuous venovenous hemofiltration on patients with cardiogenic shock and acute kidney injury after cardiac surgery. J Thorac Cardiovasc Surg [Internet]. 2014 Oct 1 [cited 2024 May 30];148(4):1628–33. Available from: https://pubmed.ncbi.nlm.nih.gov/24929801/

16. Gaudry S, Hajage D, Schortgen F, Martin-Lefevre L, Pons B, Boulet E, et al. Initiation Strategies for Renal-Replacement Therapy in the Intensive Care Unit. N Engl J Med [Internet]. 2016 Jul 14 [cited 2024 May 30];375(2):122–33. Available from: https://pubmed.ncbi.nlm.nih.gov/27181456/

17. Hu K, Mathew R. Inotrope and vasopressor use in cardiogenic shock: what, when and why? Curr Opin Crit Care [Internet]. 2022 Aug 1 [cited 2024 May 30];28(4):419–25. Available from: https://pubmed.ncbi.nlm.nih.gov/35792520/

18. Shankar A, Gurumurthy G, Sridharan L, Gupta D, Nicholson WJ, Jaber WA, et al. A Clinical Update on Vasoactive Medication in the Management of Cardiogenic Shock. Clin Med Insights Cardiol [Internet]. 2022 Feb 1 [cited 2024 May 30];16. Available from: https://pubmed.ncbi.nlm.nih.gov/35153521/

19. Parlow S, Di Santo P, Mathew R, Jung RG, Simard T, Gillmore T, et al. The association between mean arterial pressure and outcomes in patients with cardiogenic shock: insights from the DOREMI trial. Eur Heart J Acute Cardiovasc Care [Internet]. 2021 Sep 1 [cited 2024 May 30];10(7):712–20. Available from: https://pubmed.ncbi.nlm.nih.gov/34382063/

20. Mebazaa A, Nieminen MS, Packer M, Cohen-Solal A, Kleber FX, Pocock SJ, et al. Levosimendan vs dobutamine for patients with acute decompensated heart failure: the SURVIVE Randomized Trial. JAMA [Internet]. 2007 May 2 [cited 2024 May 30];297(17):1883–91. Available from: https://pubmed.ncbi.nlm.nih.gov/17473298/

21. Shankar A, Gurumurthy G, Sridharan L, Gupta D, Nicholson WJ, Jaber WA, et al. A Clinical Update on Vasoactive Medication in the Management of Cardiogenic Shock. Clin Med Insights Cardiol [Internet]. 2022 Feb 1 [cited 2024 May 30];16. Available from: https://pubmed.ncbi.nlm.nih.gov/35153521/

22. Bloom JE, Chan W, Kaye DM, Stub D. State of Shock: Contemporary Vasopressor and Inotrope Use in Cardiogenic Shock. J Am Heart Assoc [Internet]. 2023 Aug 1 [cited 2024 May 30];12(15):29787. Available from: https://www.ahajournals.org/doi/abs/10.1161/JAHA.123.029787

23. Alviar CL, Miller PE, McAreavey D, Katz JN, Lee B, Moriyama B, et al. Positive Pressure Ventilation in the Cardiac Intensive Care Unit. J Am Coll Cardiol [Internet]. 2018 Sep 25 [cited 2024 May 30];72(13):1532–53. Available from: https://pubmed.ncbi.nlm.nih.gov/30236315/

24. Song J, Cho H, Park DW, Moon S, Kim JY, Ahn S, et al. Vasoactive-Inotropic Score as an Early Predictor of Mortality in Adult Patients with Sepsis. J Clin Med [Internet]. 2021 Feb 1 [cited 2024 May 31];10(3):1–12. Available from: https://pubmed.ncbi.nlm.nih.gov/33572578/

25. Sun Y ting, Wu W, Yao Y tai. The association of vasoactive-inotropic score and surgical patients' outcomes: a systematic review and meta-analysis. Syst Rev [Internet]. 2024 Dec 1 [cited 2024 May 31];13(1). Available from: /pmc/articles/PMC10770946/

26. Montisci A, Panoulas V, Chieffo A, Skurk C, Schäfer A, Werner N, et al. Recognizing patients as candidates for temporary mechanical circulatory support along the spectrum of cardiogenic shock. Eur Heart J Suppl [Internet]. 2023 Dec 1 [cited 2024 May 31];25(Suppl I):I3–10. Available from: https://pubmed.ncbi.nlm.nih.gov/38093765/

CSL Behring

Transfusion strategies In brain injured patients

Moderator: Juan Antonio Llompart Pou

Monday, May 13, 2024

1. TRANSFUSION STRATEGIES IN BRAIN INJURED PATIENTS

Fabio Silvio Taccone

Anemia can worsen secondary cerebral hypoxia after a traumatic brain injury (TBI)[1,2]. However, red blood cell transfusion has also been associated to worse outcomes[3].

Clinical practice guidelines indicate the following in terms of applicable hemoglobin thresholds:

British[3]
- **TBI or cerebral ischemia**
  Target Hb 9 g/dL
- **Subarachnoid hemorrhage**
  Target Hb > 8-10 g/dL

European[4]
- Without recommendations in terms of thresholds

In practice, it has been observed that the use of thresholds varies between countries:

- USA: 8.2-8.9 g/dL
- Canada: 7 g/dL
- Sweden: > 10 g/dL

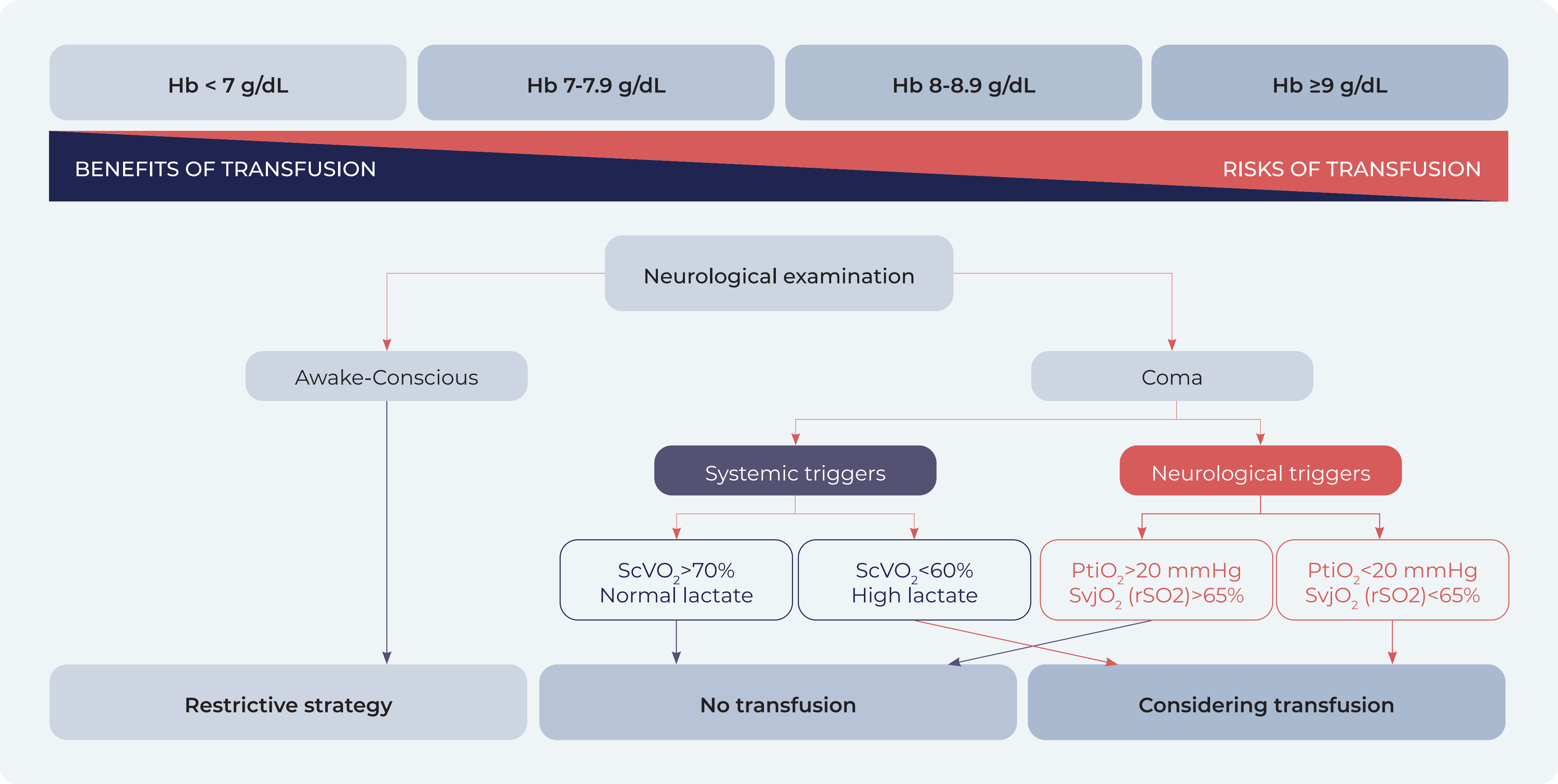
APPROACH: RED BLOOD CELL TRANSFUSION

Its effect on brain oxygenation is unclear, as well as its efficacy and safety (variability between studies):

- **Naidech et al. (2010):** Similar safety to liberal management in patients with subarachnoid hemorrhage[6].
- **Desjardins et al (2012):** There is not enough evidence to confirm differences as to the effect between restrictive and liberal targets in neurocritical patients[7].
- **Robertson et al (2014):**): In patients with TBI, liberal management does not improve neurological outcomes after 6 months and it is associated with a higher incidence of adverse events[8].
- **Yamal et al (2015):** No clinically significant differences or effects on long-term neurological outcomes or in mortality between liberal and restrictive management[9].
- **Vedantam et al (2016):** Potential adverse effects with liberal management after a severe TBI[10].
- **Gobatto et al (2019):** Lower hospital mortality and better neurological status after 6 months with liberal rather than restrictive management in patients with TBI[11].

INDIVIDUALIZATION OF THE APPROACH

Fixed hemoglobin targets should not be used to make decisions, but transfusion triggers[12,13].



Hb: hemoglobin. $ScVO_2$: central venous O_2 saturation. $PtiO_2$: O_2 tissue pressure. $SvjO_2$: O_2 jugular saturation.

NEED FOR RESEARCH AND DATA

Further randomized controlled trials are needed to assess the usefulness of red blood cell transfusion to increase hemoglobin in patients with TBI. The following studies are currently ongoing:

Taccone FS, et al. TRansfusion strategies in Acute brain INjured patients (**TRAIN**): a prospective multicenter randomized interventional trial protocol. Trials. 2023 Jan 7;24[1]:20. doi: 10.1186/s13063-022-07061-7.

Turgeon AF, et al; HEMOTION Trial Team, the Canadian Critical Care Trials Group, the Canadian Perioperative Anesthesia Clinical Trials Group and the Canadian Traumatic Brain Injury Research Consortium. Haemoglobin transfusion threshold in traumatic brain injury optimisation (**HEMOTION**): a multicentre, randomised, clinical trial protocol. BMJ Open. 2022 Oct 10;12[10]:e067117.

doi: 10.1136/bmjopen-2022-067117.

English SW, et al; Canadian Critical Care Trials Group. Aneurysmal SubArachnoid Hemorrhage-Red Blood Cell Transfusion And Outcome (**SAHaRA**): a pilot randomised controlled trial protocol. BMJ Open. 2016 Dec 7;6[12]:e012623.

doi: 10.1136/bmjopen-2016-012623.

LITERATURE

1. Oddo M, Milby A, Chen I, Frangos S, MacMurtrie E, Maloney-Wilensky E, et al. Hemoglobin concentration and cerebral metabolism in patients with aneurysmal subarachnoid hemorrhage. Stroke [Internet]. 2009 Apr 1 [cited 2024 May 28];40(4):1275–81. Available from: https://pubmed.ncbi.nlm.nih.gov/19265059/

2. Weiskopf RB, Kramer JH, Viele M, Neumann M, Feiner JR, Watson JJ, et al. Acute severe isovolemic anemia impairs cognitive function and memory in humans. Anesthesiology [Internet]. 2000 [cited 2024 May 28];92(6):1646–52. Available from: https://pubmed.ncbi.nlm.nih.gov/10839915/

3. Utter GH, Shahlaie K, Zwienenberg-Lee M, Muizelaar JP. Anemia in the setting of traumatic brain injury: the arguments for and against liberal transfusion. J Neurotrauma [Internet]. 2011 Jan 1 [cited 2024 May 28];28(1):155–65. Available from: https://pubmed.ncbi.nlm.nih.gov/20954887/

4. Retter A, Wyncoll D, Pearse R, Carson D, Mckechnie S, Stanworth S, et al. Guidelines on the management of anaemia and red cell transfusion in adult critically ill patients. Br J Haematol [Internet]. 2013 Feb [cited 2024 May 28];160(4):445–64. Available from: https://pubmed.ncbi.nlm.nih.gov/23278459/

5. Vlaar AP, Oczkowski S, de Bruin S, Wijnberge M, Antonelli M, Aubron C, et al. Transfusion strategies in non-bleeding critically ill adults: a clinical practice guideline from the European Society of Intensive Care Medicine. Intensive Care Med [Internet]. 2020 Apr 1 [cited 2024 May 28];46(4):673–96. Available from: https://link.springer.com/article/10.1007/s00134-019-05884-8

6. Naidech AM, Shaibani A, Garg RK, Duran IM, Liebling SM, Bassin SL, et al. Prospective, randomized trial of higher goal hemoglobin after subarachnoid hemorrhage. Neurocrit Care [Internet]. 2010 Dec [cited 2024 May 28];13(3):313–20. Available from: https://pubmed.ncbi.nlm.nih.gov/20717750/

7. Desjardins P, Turgeon AF, Tremblay MH, Lauzier F, Zarychanski R, Boutin A, et al. Hemoglobin levels and transfusions in neurocritically ill patients: a systematic review of comparative studies. Crit Care [Internet]. 2012 Apr 2 [cited 2024 May 28];16(2):R54. Available from: /pmc/articles/PMC3681381/

8. Robertson CS, Hannay HJ, Yamal JM, Gopinath S, Goodman JC, Tilley BC, et al. Effect of erythropoietin and transfusion threshold on neurological recovery after traumatic brain injury: a randomized clinical trial. JAMA [Internet]. 2014 Jul 2 [cited 2024 May 28];312(1):36–47. Available from: https://pubmed.ncbi.nlm.nih.gov/25058216/

9. Yamal JM, Rubin ML, Benoit JS, Tilley BC, Gopinath S, Hannay HJ, et al. Effect of Hemoglobin Transfusion Threshold on Cerebral Hemodynamics and Oxygenation. J Neurotrauma [Internet]. 2015 Aug 15 [cited 2024 May 28];32(16):1239–45. Available from: https://pubmed.ncbi.nlm.nih.gov/25566694/

10. Vedantam A, Yamal JM, Rubin ML, Robertson CS, Gopinath SP. Progressive hemorrhagic injury after severe traumatic brain injury: effect of hemoglobin transfusion thresholds. J Neurosurg [Internet]. 2016 Nov 1 [cited 2024 May 28];125(5):1229–34. Available from: https://pubmed.ncbi.nlm.nih.gov/26943843/

11. Gobatto ALN, Link MA, Solla DJ, Bassi E, Tierno PF, Paiva W, et al. Transfusion requirements after head trauma: a randomized feasibility controlled trial. Crit Care [Internet]. 2019 Mar 12 [cited 2024 May 28];23(1). Available from: https://pubmed.ncbi.nlm.nih.gov/30871608/

12. Leal-Noval SR, Arellano-Orden V, Muñoz-Gómez M, Cayuela A, Marín-Caballos A, Rincón-Ferrari MD, et al. Red Blood Cell Transfusion Guided by Near Infrared Spectroscopy in Neurocritically Ill Patients with Moderate or Severe Anemia: A Randomized, Controlled Trial. J Neurotrauma [Internet]. 2017 Sep 1 [cited 2024 May 28];34(17):2553–9. Available from: https://pubmed.ncbi.nlm.nih.gov/28486023/

13. Okonkwo DO, Shutter LA, Moore C, Temkin NR, Puccio AM, Madden CJ, et al. Brain Oxygen Optimization in Severe Traumatic Brain Injury Phase-II: A Phase II Randomized Trial. Crit Care Med [Internet]. 2017 Nov 1 [cited 2024 May 28];45(11):1907–14. Available from: https://pubmed.ncbi.nlm.nih.gov/29028696/