Evidence Based Fluid Management in ICU

An Essay

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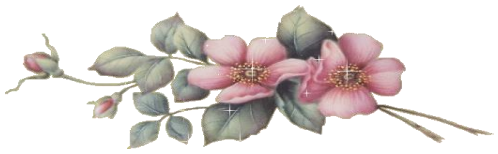

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List of Abbreviations

Abb.	Meaning
ARDS	Acute respiratory distress syndrome
ARISE	Australian resuscitation in sepsis variation
cIVC	Collapsibility of inferior vena cava
CO	Cardiac output
CO_2	Carbon dioxide
O_2	Oxygen
CVP	Central venous pressure
dIVC	Dispensability index of inferior vena cava
ECF	Extra cellular fluid
ED	Emergency department
FNHTR	Febrile non-haemolytic transfusion reaction
FT	Flow time
FTc	Flow time corrected for heart rate
GEBV	Global end diastolic blood volume
HES	Hydroxyethylstarch
HLA	Human leucocytic Antigen
ICF	Intracellular fluid
ITBV	Intrathoracic blood volume
LV	Left ventricle
LVEDV	Left ventricular end diastolic volume
LVEPP	Left ventricular end diastolic pressure
MSFP	Mean systemic filling pressure
No	Nitric oxide
NS	Normal saline
PAC	Pulmonary artery catheterization

List of Abbreviations

Abb.	Meaning
PAOP	Pulmonary artery occlusion pressure
Pa-vO2	Arterial to central venous PO_2 gradient
PPV	Pulse pressure variation
Pv-Aco2	Central venous to arterial PCO_2 gradient
PVI	Plethysomgraphy variability index
RAP	Right atrial pressure
RL	Ringer lactate
RRT	Renal replacement therapy
RV	Right ventricle
SAFE	Saline vs albumin evaluation
SOFA score	Sequential organ assessment score
SV	Stroke volume
SvO2	Mixed venous oxygen saturation
SVV	Stroke volume variation
TBSA	Total body surface area
TRALI	Transfusion related acute lung injury
TTD	Transpulmonary thermodilution
UOP	Urinary output
VTI	Velocity time integral

Abstract

As the limitations of static measures became evident, changes in preload induced by intrathoracic pressure changes during mechanical ventilation as predictors of volume responsiveness were suggested in pulse pressure variations as a dynamic index.

Other dynamic indices include stroke volume variations and plethysmography variability index, stroke volume variation and dynamic echo. Limitations of some of these methods include mechanical ventilation and strict use criteria.

The fluid management of septic shock and burn were discussed, including the guide lines for septic shock management and two popular formulas for burn management; the parkland and Muir and Barclay formula.

Key words: Total body surface area, Transfusion related acute lung injury, Transpulmonary thermodilution, Urinary output, Velocity time integral

INTRODUCTION

Intravenous fluid therapy has evolved significantly over time, to improve patient outcomes, moreover fluids used in ICU could be broadly classified into crystalloids and colloids ***(Reddy et al., 2016).***

Resuscitation fluids are broadly categorized into colloid and crystalloid solutions. Colloid solutions are suspensions of molecules within a carrier solution that are relatively incapable of crossing the healthy semipermeable capillary membrane owing to the molecular weight of the molecules. Crystalloids are solutions of ions that are freely permeable, containing concentrations of sodium and chloride that determine the tonicity of the fluid ***(Nicholas, 2011).***

Volume expansion is one of the most frequent clinical decisions performed every day by anesthesiologists.volume expansion aims to increase left ventricular stroke volume and cardiac output, consequently; increasing oxygen delivery to the tissues, while avoiding tissue oedema and decrease in oxygen delivery. From here, rise the importance of reliable predictors of fluid responsiveness ***(Vincent, 2008).***

Historically, static parameters of fluid responsiveness were used, static parameters basically are preload parameters such as central venous pressure, pulmonary capillary wedge pressure, and/or left ventricular end-diastolic area .More

recently, dynamic parameters of fluid responsiveness relying on cardiopulmonary interactions in patients under general anesthesia and mechanical ventilation have been demonstrated to be the best predictors of fluid responsiveness in this setting ***(Lansdorp et al., 2012).***

The goal of fluid resuscitation in intensive care unit patients is to restore effective tissue perfusion and oxygen delivery. Fluid resuscitation must be started as a first-line treatment in the management of septic shock. Fluid administration should be titrated to clinical endpoints of perfusion; such as capillary refill and urine output and also to macrocirculatory parameters of global perfusion, assessment of the adequacy of resuscitation requires attention to both the macro and the microcirculation. Microcirculatory dysfunction is a central abnormality in septic shock ***(Barrett, 2012).***

Adequate perfusion is a must as under resuscitation results in inadequate organ perfusion, while over resuscitation increased the morbidity and mortality, moreover hypovolemia isn't the only cause of hypotension and in more than half of the critically ill patients fluid boluses fail to augment blood pressure, as they fail to augment cardiac output, therefore fluid resuscitation must be coupled with indices reflecting its effectiveness ***(Marik et al., 2009).***

Aim Of The Work

To highlight on the different fluids used in ICU and their application, and discussing the updates of fluid management according to the underlying diseases on evidence basis.

PHYSIOLOGY OF THE MICROCIRCULATION

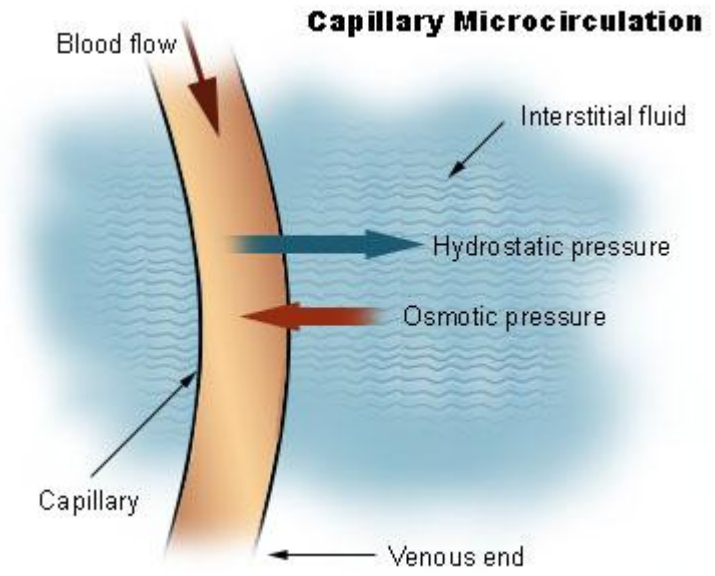

Figure (1-1): The microcirculation ***(Barrett, 2012)***

Microcirculation is the circulation of the blood in the small blood vessels, which is embedded within organ tissues. The microcirculation is composed of terminal arterioles, capillaries, and venules. The arterioles are well innervated, surrounded by smooth muscle cells, and are 10-100 µm in diameter, carrying the blood to capillaries, which are not innervated, have no smooth muscle, and are about 5-8 µm in diameter. The venules, have little smooth muscle and are 10-200 µm. The microcirculation include lymphatic capillaries and collecting ducts ***(Barrett, 2012).***

The main functions of the microcirculation are the delivery of oxygen (O2) and nutrients and the removal of carbon dioxide (CO_2). It also serves to regulate blood flow and tissue perfusion and thus affecting blood pressure and responses to inflammation including oedema. Most vessels of the microcirculation are lined by flattened cells of the endothelium and many of them are surrounded by contractile cells called pericytes ***(Fiorenzo, 2010).***

Endothelial Cells are widely heterogeneous, where endothelium can be classified structurally to continuous endothelium, fenestrated endothelium and discontinuous endothelium ***(Dore and Kristen, 2011).***

Continuous endothelium is found in most arteries, veins and capillaries of the brain, skin, lung, heart and muscle. The cells are coupled by tight junctions and anchored to a continuous basal membrane. Fenestrated endothelium is also associated with a continuous basal membrane and is characterized by the presence of trans-cellular 50–60 nm wide pores, which are sealed by a 5- to 6-nm-thick diaphragm. This is observed in tissues with an elevated trans-endothelial transport or an increased filtration role, such as endocrine and exocrine glands, gastrointestinal tract, kidney glomeruli ***(Pries and Kuebler, 2006)***.

The discontinuous endothelium is associated with a poorly structured basal membrane and is characterized by the

presence of large 100- to 200-nm-wide fenestrations without diaphragm. This occurs in sinusoidal vascular beds in the liver, predominantly, but also in the spleen and bone marrow ***(Aird, 2007).***

The endothelial cells are involved in different tasks. Endothelial cells in general regulate hemostasis, where endothelium-derived products, maintain blood fluidity and, are involved in the coagulation cascade and the formation of blood clots, other important functions include permeability, leukocyte trafficking, regulation of vascular tone, angiogenesis, and immunity ***(Pober and Sessa, 2007).***

Pericytes are contractile cells surrounding the endothelial cells of capillaries and venules throughout the body, they are embedded in a basement membrane where they communicate with endothelial cells by means of both direct physical contact and paracrine signaling, and are a key component of the neurovascular unit, which includes endothelial cells, astrocytes, and neurons, where their deficiency in the nervous system can cause the blood brain barrier to break ***(Birbrair et al., 2015).***

Functions of pericytes include the regulation of capillary blood flow, the clearance and phagocytosis of cellular debris, and the permeability of the blood–brain barrier. Pericytes stabilize and monitor the maturation of endothelial cells by means of direct communication between the cell membrane as well as through paracrine signaling ***(Bergers and Song, 2005).***