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Review Article

Fluid Management for Critically Ill Patients, Based on the ROSE Concept, an Old Method but Effective Enough

Ayu Yesi Agustina [1], Calcarina Fitriani Retno Wisudarti[2], Untung Widodo[2]
[1] Fellow Intensive Care in Department of Anesthesiology and Intensive Care, Gadjah Mada University, Yogyakarta, Indonesia
[2] Department of Anesthesiology and Intensive Care, Gadjah Mada University, Yogyakarta, Indonesia

SUMMARY

Fluid therapy is one of the most essential things in managing critical patients, such as ICU patients. Although it seems simple, this is difficult to do in this group of patients. The fluid needs of ICU patients vary according to the course of the disease. Therefore, fluids must be given according to individual needs, and each phase of the disease must be reassessed. To support this, there is a conceptual model that explains fluid administration based on the phases of the disease that the patient is going through. The ROSE concept (resuscitation, optimization, stabilization, and evacuation) describes the phases of a patient's illness and how fluids should be administered. In the resuscitation phase, the goal is life-saving and is achieved by positive fluid balance. In the optimization phase, fluid balance is neutral and aims to save organs. In the stabilization phase, the fluid balance has started to move in a negative direction and aims to support the organs. Finally, in the evacuation phase, fluid balance is negative and organ repair has occurred. By implementing this model, it is hoped that ICU patients will have better outcomes.

Keywords: Critically ill, ROSE concept, fluid therapy, ICU

Correspondence:
Ayu Yesi Agustina, MD
Fellow Intensive Care
Department of Anesthesiology and Intensive Care, Gadjah Mada University,
Farmako Street, MO 55281,
Yogyakarta, Indonesia
e-mail:
ayuyesiagustina@ugm.ac.id

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INTRODUCTION

Fluid therapy is one of the most essential things in critical patient management, such as in intensive care unit (ICU) patients. Fluid balance in the body is regulated by the amount of water "in and out" in the body. While this may seem simple, it is difficult to do in this group of patients. ICU patients have predisposing factors that cause fluid distribution to be disrupted, and accelerated fluid loss conditions occur.[1] This is also accompanied by changes in patient conditions, where fluid needs can often change rapidly.

There are still many problems that occur regarding the administration of fluid therapy. Hoste et al. mentioned that as many as one in five patients receive inappropriate fluid therapy. Lack of fluid administration during resuscitation or rehydration can lead to tissue hypoperfusion, whereas overuse of intravenous fluids can lead to tissue edema and severe electrolyte disturbances. This leads to high morbidity rates, prolonged lengths of hospitalization, and even increased mortality.[2] Therefore, prevention of this is essential.

There is no universal rule of thumb when giving fluids to ICU patients. Indeed, the fluid needs of patients vary according to the course of their illness. Therefore, fluids must be given according to individual needs and reassessed at each phase of the disease.[3] To support this, there is a conceptual model that describes fluid administration based on the phases of the disease that the patient goes through. Malbrain et al.[4] formulated the ROSE conceptual model, which has the acronym Resuscitation, Optimisation, Stabilisation, and Evacuation. This concept can be used in ICU patients to assist fluid management so that patient outcomes will improve later.

DISCUSSION

Physiology of body fluids

In adults, water makes up 50% of the body components of men and 60% of women.[1] Total body water (TBW) is found in plasma, interstitial, and intracellular spaces. These intravascular and interstitial spaces are also called extracellular spaces. Two-thirds of TBW is in the intracellular space, and the remaining third is in the extracellular space.[5] TBW will decrease with aging due to loss of muscle mass. TBW comprises two compartments: extracellular fluid (ECF) and intracellular fluid (ICF). Sodium will affect the volume regulation of ECF, while the amount of water will affect the regulation of ICF. Hormonal and ECF volume sensors determine sodium excretion, while hypothalamic osmolar sensors regulate the body's water balance.[6] The example of the diagrams of the body fluid compartment in adults can be seen in **Figure 1**.

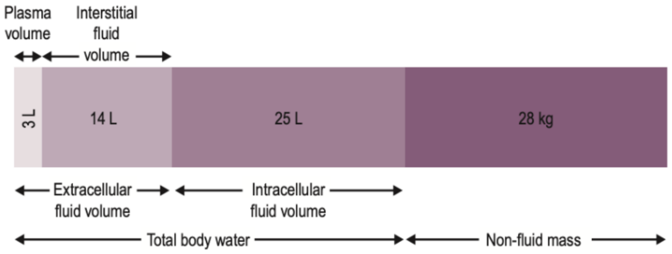

Figure 1. Body fluid compartments in a 70 kg male patient, assuming a body density of 1.0 kg/L.[6]

Extracellular fluid is all body fluids outside the cells and is divided into plasma and interstitial fluid volumes. ECF typically contains 40% TBW. In acute or chronic illness cases, there is typically a decrease in intracellular fluid (ICF) and an increase in extracellular fluid (ECF) within the patient's body. ECF volume itself is divided into plasma volume, ECF volume, and interstitial volume. Intracellular fluid is all the fluid inside the cell; in contrast to the ECF compartment, the water in the ICF compartment is homogeneous; it is multicompartmental, with different pH and ion content depending on the tissue or organ.[7] The amount of ICF is calculated from the TBW and ECF volume. ICF volume is approximately 60% TBW or equivalent to 35% TBW. Fluid in the transcellular space is fluid produced from active cellular transport. This fluid is naturally extracellular and is recognized as part of the interstitial volume. The amount varies widely between 1 L and 10 L, with high amounts of fluid occurring in severely ill patients (e.g., colon obstruction), and this fluid is formed from residual interstitial fluid and plasma volume.[6] Fluid compartment indication can be seen in **Table 1.**

Table 1. Fluid compartment indication for fluid administration.[6]

Fluid Compartment	Volume (mL/kg)	% Total Body Weight
Plasma volume	45	4.5
Blood volume	75	7.5
Interstitial volume	200	20
Extracellular fluid volume	250	25
Intracellular fluid volume	350	35
Total body fluid volume	600	60

Indication of Fluid Administration

The study by Malbrain et al. suggested three main indications for intravenous fluid administration: resuscitation, replacement, and maintenance. Resuscitative fluids primarily serve to treat acute hypovolaemia. In contrast, replacement fluids are used to prevent ongoing or sustained fluid deficits due to inadequate peroral fluid administration. In comparison, maintenance fluids are reserved for hemodynamically stable patients who cannot drink water to replace their water and electrolyte needs.[3]

1. Intravenous Fluids for Resuscitation

Fluid resuscitation focuses on rapidly restoring circulating volume. Increased venous return and increased volume during shock are the goals of fluid resuscitation. Appropriate fluid administration is expected to increase intravascular blood volume and increase the gradient of mean systemic filling pressure (MSFP) and central venous pressure (CVP), so it is expected that venous return can be improved. Elevated venous return can enhance cardiac output and cardiac index in individuals positioned on an ascending slope of the Frank-Starling curve.[4] Administration of resuscitative fluids containing normal saline should not be given in large quantities as it may increase the risk of hyperchloremic acidosis, acute renal failure, hypernatremia, and death.[8]

2. Intravenous Fluid for Replacement

The replacement fluid should have the same components as the lost fluid in volume and electrolytes. Causes of loss include vomiting, diarrhea, hypothermia, excessive diuresis, and adrenal hormone deficiency. Replacement fluids aim to prevent decompensation requiring resuscitation, restore electrolyte homeostasis, and maintain tissue perfusion.[1] Replacement fluids are usually balanced isotonic solutions. However, solutions containing high chloride content, e.g., NaCl 0.9%, can be used as replacement fluids in patients who experience fluid deficiency due to loss of gastric acid.[8]

3. Intravenous Fluid for Maintenance

Fluid maintenance aims to fulfill daily fluid, electrolyte, and glucose requirements. The basic daily fluid requirements are 25-30 mL/kg BW, sodium 1-1.5 mmol/kg per day, potassium one mmol/kg per day, and glucose 5%-10% as much as 1.4-1.6 grams/kg.[8] Criteria for critical patients who need assistance in meeting their nutritional needs regularly, such as patients with impaired gastrointestinal function, patients with neurological injuries in the form of dysphagia, or patients with diseases that make them unable to receive food. Self-care liquids are not recommended in patients still experiencing acute fluid loss or acute electrolyte disturbances or to provide nutritional support.[1]

Critically Ill Patient

According to Indonesian Ministry of Health Regulation No.519 of 2019 concerning guidelines for the implementation of intensive therapy services in hospitals, it is stated that critical patients are patients who have diseases accompanied by organ failure where this occurs due to acute complications of the disease or due to sequelae of the therapy regimen provided. The scope of critical patients in the ICU is vast but can be divided into two broad lines, namely trauma and non-trauma patients. Although the causes and pathophysiology of essential conditions of patients are vast and different, the result of the disease process will lead to a condition of multiple organ failure, one of which is the occurrence of cardiovascular failure. Cardiovascular failure is characterized by hypotension, hypoperfusion, metabolic acidosis, and edema due to capillary leakage.

Sepsis is a critical condition that often occurs in the ICU. Sepsis is a necessary condition characterized by organ dysfunction, resulting from an imbalanced host response to infection, and poses a life-threatening risk.[9] Septic shock is a subset of sepsis accompanied by circulatory and cellular/metabolic dysfunction. In sepsis conditions, capillary endothelial damage is accompanied by capillary leakage, in which the intravascular fluid volume will decrease, and the patient will show signs of hypovolaemia hypotension. Therefore, intravenous fluid administration or fluid resuscitation is considered the initial step in resuscitating critically ill patients with impaired organ perfusion.[4] In one study, 67% of patients using the protocol of early goal-directed therapy (EGDT) suffered from fluid overload after 24 hours and 48% continuously by the third day of hospital stay. In addition, sepsis patients with high cumulative fluid totals are at risk of acute respiratory distress syndrome (ARDS) and/or acute lung injury (ALI) and poorer outcomes.[4]

Fluid Administration in Critical Patients

In administering fluids to patients, it is essential to remember that both a lack and excess of fluids can adversely affect the patient. Different patients have different fluid requirements depending on various factors such as age, current diagnosis, and existing comorbidities. Insufficient fluid administration can lead to hypovolaemia, resulting in decreased cardiac output and decreased tissue perfusion. Hypovolaemia can lead to organ failure and even death. Conversely, too much fluid can cause edema, impairing organ function. One of the most clinically apparent organs affected by edema is the lungs, which disrupt gas exchange function, resulting in rapid blood gas changes.[10]

Positive fluid balance is known to be related to bad outcomes in ICU patients.[3] In their study, Malbrain et al. looked for associations of positive fluid balance with critical illness outcomes in adults.[4] Besides the restrictive fluid administration method, the cumulative fluid balance was 5.6 L more negative than the control patients after one week of ICU treatment.[4]

Excess fluid in the body is associated with adverse effects in severely ill patients, which can affect the function of the patient's organs.[11] In patients undergoing an inflammatory phase, such as those with sepsis, interstitial edema can occur due to various factors, such as vasodilation, endothelial glycocalyx degradation, and venous pooling. As a consequence, interstitial edema will affect organ function, including the central nervous system, lung, cardiovascular system, liver, kidney, and GI tract system.[4]

In septic shock, positive fluid balance is associated with increased patient mortality.[8] After the patient has experienced the first insult (trauma, infection, etc.), there will be increased organ dysfunction and increased capillary permeability due to the response of systemic inflammation. This is followed by the Ebb phase, which is triggered by fluid overload and interstitial edema. The Surviving Sepsis Campaign guidelines call for 30 mL/kg intravenous fluid administration over the first 3 hours of this initial phase.[9] In ICU patients, considering the interactions between organs, such as the lungs and kidneys, is essential. The lungs should generally be kept dry to minimize edema and maintain gas exchange, but the kidneys need adequate perfusion to perform their functions. In patients with fluid restriction, the lungs can survive more, while the kidneys suffer more damage.[10]

The Surviving Sepsis Campaign (SSC) 2016 recommends effective fluid administration in the early phase to stabilize hypoperfusion tissues due to sepsis or sepsis shock.[9] As prolonged hypotension is detrimental to multiple organs, fluid resuscitation in early sepsis should be initiated as soon as sepsis and/or hypotension is recognized and accompanied by elevated lactate levels. Intravenous fluid administration will increase intravascular plasma volume and increase the gradient of MSFP with an increase in right atrial pressure/ RAP, so it is expected to increase venous return.[4] In a healthy person, 85% of the crystalloid bolus will be redistributed to the interstitial compartment after four hours. In critically ill patients with endothelial injury and capillary leakage, less than 5% of the fluid bolus remains intravascular after 90 minutes.[13]

In 2023, the concept of fluid management in sepsis patients was updated. SSC Guideline 2023, the second point of management of sepsis patients is fluid resuscitation.[14] Sepsis, accompanied by severe vasoplegia, is a secondary problem due to the release of glycocalyx so that patients can experience distributive shock. Administration of drugs to improve hemodynamics is essential for the survival of patients with septic shock.[9] In previous guidelines, patients with sepsis were given copious fluids to stabilize hemodynamics.[15] Recently, the approach to management with lots of fluids administration has been questioned, as microvascular perfusion does not improve with stabilization of cardiovascular parameters. On the other hand, glycocalyx damage and endothelial dysfunction may be exacerbated by aggressive fluid administration.[16,17]

The exact amount of fluid administered to sepsis patients in the resuscitation phase is still debated until now. Based on the 2016 SSC, it is recommended that intravenous crystalloids be given to sepsis patients at a minimum of 30 mL/kg in the first 3 hours.[18] The administration of fluids in this amount has been debated in recent years. The study mentioned that the administration of resuscitation fluids to improve glycocalyx varies significantly from person to person, which depends on the fluids' tolerance (FT) and fluids' response (FR).[20] FT is defined as the tolerance level of fluid administration without causing organ dysfunction.[21] FR is an increase in stroke volume (SV) of at least 10% after administering a 200-500 mL fluid bolus for 10-15 minutes.[22] Another study suggested that excessive fluid administration can damage glycocalyx, resulting in poor outcomes.[23] Recently, several methods have been used to monitor FR (i.e., passive leg raising test/PLR, stroke volume calculation, and collapse index of inferior vena cava/CI-IVC).[24]

Some studies stated that experts prefer using fluids with dynamic rather than static methods.[20,24] It was also noted that the target of primary resuscitation is progressively improving microcirculation.[20] In 2018, Perner suggested that the administration of crystalloid fluid boluses can start at 250-500 mL with continuous FR monitoring, followed by the administration of vasopressors from the beginning if hemodynamics fail to improve.[25]

4D Concept in Fluid Management

1. Drug

Fluids are drugs with contraindications, indications, and side effects. Different types of fluids will be given on other indications. Replacement fluids should be similar to fluid loss; maintenance fluids should fulfill basic glucose metabolism needs, while resuscitation fluid administration focuses more on rapid intravascular volume return.[26] The study by Malbrain et al. mentioned that fluid administration that induces metabolic acidosis and contains excessive chloride can be avoided by giving balanced solutions.[3] Balanced solutions are crystalloid and colloidal fluids with minimal effect on extracellular compartment homeostasis, particularly on acid-base balance and electrolyte concentrations.

2. Dosing

The rate and duration of fluid administration are equally important. However, there is no general formula for calculating fluid requirements in patients. The amount of fluid varies considerably based on individual characteristics, individual hemodynamic conditions, and the patient in a particular phase.[10] If a patient is given 1 liter of fluid, only 10% of D10 fluid, 25-30% of the crystalloid fluid, and 100% of colloid fluid remain intravascular after 1 hour of administration.[8] During critical conditions, the need for fluid and the response to fluid administration will vary greatly. Dynamic tests such as passive leg raising or end-respiration occlusion tests can be performed to predict the response to fluid therapy.[26]

3. Duration

The longer fluid administration is delayed, the more severe microvascular hypoperfusion and organ damage will be. In the study of Murphy et al., a comparison was obtained between the group given adequate conservative fluids from the beginning and the group given inadequate fluids from the beginning, also comparing late conservative fluid administration with late liberal fluid administration. It was found that the best prognosis was for patients who received adequate and late conservative fluid administration at the beginning.[27] Another study found that using late conservative fluid management is more important than early adequate fluid administration.[8]

4. De-escalation

The next step in fluid therapy is the clinician's judgment of when to discontinue fluid resuscitation when they are no longer needed. It is important to remember that resuscitative fluid administration should be as short as possible and that administration should be gradually reduced as the shock is resolved.[8]

return to the heart, so cardiac output circulation and perfusion to critical organs will improve. The success of resuscitation can be assessed by clinical indicators tailored to the underlying cause, urine production $\geq$ 0.5 mL/kg/hour, mean arterial pressure (MAP) $\geq$ 65 mmHg, and patients can obtain lactate levels back to normal in sepsis.[1]

Fluid responsiveness can be assessed by looking at hemodynamic status, end-expiratory occlusion test, or passive leg raising test. Assessment can be done within 30 minutes. If resuscitation is inadequate, additional crystalloid fluids of 2-4 cc/kgBB may be given and re-evaluated. In critically ill patients with shock, fluid administration should be initiated along with vasopressor therapy. In patients with septic shock, hypotension is caused by decreased vascular tone, which cannot be corrected by giving fluid alone.[10] In this regard, it is important to remember that each patient has an individual approach. The goal of this phase is early adequate fluid management, which is positive fluid balance, and resuscitation targets: CI >2.5 L/min/m^2, MAP ≥65 mmHg, left ventricle end-diastolic area index (LVEDAI) >8cm/m,

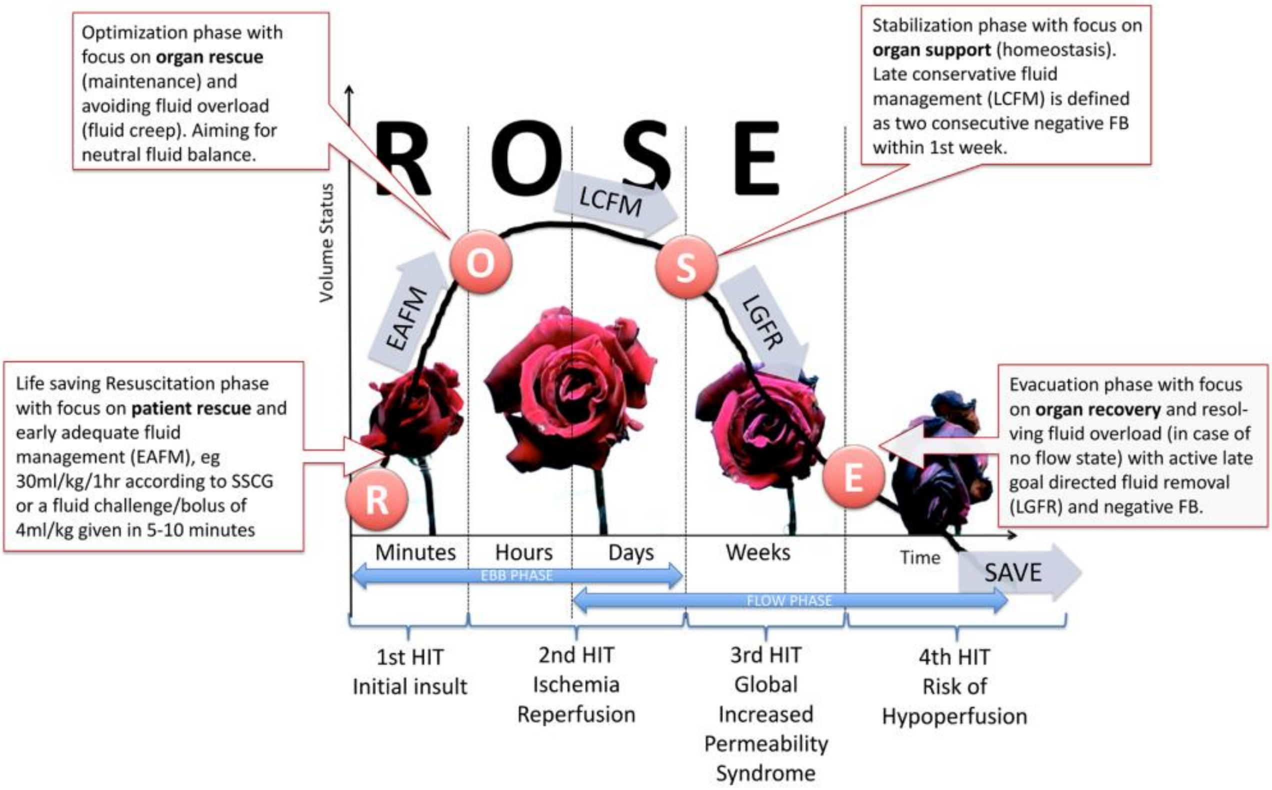

Figure 2. ROSE Concept Diagram[3]

ROSE Concept

The ROSE concept (resuscitation, optimization, stabilization, and evacuation) describes the phases of a patient's illness and how fluids should be administered. The summary of the ROSE concept can be seen in **Figure 2** and **Table 2.**

1. Resuscitation

Resuscitation aims to restore intravascular volume in patients with life-threatening shock and impaired organ perfusion. In the resuscitation phase, fluid management aims to replace lost blood volume, establishing a positive fluid balance.[3] Resuscitative fluid administration can be initiated when hemodynamic instability is characterized by hypotension, decreased urine output, tachycardia, or elevated lactate. If intravascular volume increases rapidly, it can increase venous

and pulse pressure variation (PPV) <12%. [28,29,30]

2. Optimisation

The optimization phase begins when the patient is no longer in a state of apparent absolute or relative hypovolaemia, but their hemodynamics are still unstable. The goals of the optimization phase are to maintain oxygenation to prevent organ damage and adequate tissue perfusion.[3] Fluids will be given according to the patient's condition and assessed using several assessments, such as fluid challenge techniques. Such a test should be used when it is doubtful whether the patient needs fluids.

It is also important to remember that there are four essential components to consider: Type of fluid (e.g., crystalloid), Rate (100-200 cc in 10 minutes), Objective (normal MAP or HR), and Limits (high CVP values).[3] The patient should also be closely monitored in this phase to get a picture of the patient's hemodynamic status. Monitors may utilize arterial catheters, echocardiography, CVP, and BGA. Other assessments may also be performed, such as hypoperfusion markers (e.g., lactate, CRT). If the patient requires routine maintenance with IV fluids, the limit is approximately 25-30 mL/kg/day (1 mL/kg/hour) of water, 1 mmol/kg/day of potassium, 1-1.5 mmol/kg/day of sodium, and 1 mmol/kg/day of chloride.[3] It is also expected that in this phase, the following parametric values will be achieved: mean arterial pressure (MAP) ≥65 mmHg, cardiac index (CI) >2.5 L/min/m2, pulse pressure variation (PPV) <14%, left ventricular end-diastolic area index 8-12/cm/m^2, intra-abdominal pressure <15 mmHg, abdominal perfusion pressure >55 mmHg, and preload was optimized with a global end-diastolic volume index of 640-800 mL/m^2.[28,30]

3. Stabilisation

If the patient's condition is stable, the stabilization phase begins. Some patients may experience ongoing losses (OGL) and other fluid redistribution issues (e.g., fluid loss from the GI with metabolic alkalosis). At this stage, fluid management aims to ensure that the amount of electrolytes and water can meet daily needs and maintain organ function. In this phase, it is expected to reach zero or slightly negative fluid balance.[3] If the patient has stabilized or when the patient no longer responds to fluid administration, aggressive fluid administration should be stopped, and the patient should be started on minimal maintenance fluids if needed.[10] If the patient has a persistent positive fluid balance, it is associated with poor outcomes. In a study conducted by Intensive Care Over Nation on 1808 sepsis patients in the ICU, it was explained that mortality would increase if patients had a positive cumulative fluid balance at 72 hours after ICU admission.[31]

4. Evacuation or De-Resuscitation

The last phase is the deresuscitation, de-escalation, or fluid evacuation process, which aims to remove excess fluid. This de-escalation phase can be spontaneous when the patient's

Table 2. Characteristics of the ROSE concept phase.[4]

	Resuscitation (R)	Optimisation (O)	Stabilisation (S)	Evacuation (E)	
HIT	First	Second	Second	Third	Fourth
Cause	Inflammatory insult (sepsis, SAP, burns, trauma, etc.)	Ischaemia and reperfusion	Ischaemia and reperfusion	GIPS	Hypoperfusion
Phase	Ebb	Flow	Flow/No Flow	No Flow	No Flow
Type	Severe shock	Unstable	Stable	Recover	Unstable
Example	Septic shock, major trauma, hemorrhagic shock, ruptured AAA, SAP, severe burns	Intra-and perioperative GDT, less severe burns (<25% TBSA), DKA, severe GI losses	Postoperative patient (NPO or combination of TEN/TPN), abdominal VAC, replacement of losses in less severe pancreatitis	Patients on full enteral feed in the recovery phase of critical illness, polyuric phase after recovering from ATN	Patient with cirrhosis and anasarca edema (GIPS) and no flow state, hepatosplanchnic hypoperfusion
Question	When to start fluid?	When to stop fluid?	When to stop fluid?	When to start unloading?	When to stop unloading?
Subquestion	Benefits of fluid?	Risks of fluid?	Risks of fluid?	What are the benefits of unloading?	Risks of unloading?
O_2 transport	Convective problems	Euvolemia, normal diffusion	Diffusion problem	Euvolemia, normal diffusion	Convective problem
Fluids	Mandatory	Biomarker of critical illness	Biomarker of critical illness	Toxic	
Fluid therapy	Rapid bolus (4 mL/kg 10-15 min)	Titrate maintenance fluids, conservative use of fluid bolus	Minimal maintenance if oral intake is inadequate; provide replacement fluids	Oral intake, if possible, avoid unnecessary IV fluids	Avoid hypoperfusion
Fluid Balance	Positive	Neutral	Neutral/ negative	Negative	Neutral
Results	Life-saving (rescue, salvage)	Organ rescue (Maintenance)	Organ support (Homeostasis)	Organ Recovery (Removal)	Organ Support
Targets	Macrohaemodynamics (MAP,CO); lactate; volumetric preload (LVEDAI); functional haemodynamics; fluid responsiveness (PLR, EEO)	Organ macroperfusion (MAP,APP,CO, $ScvO_2$), volumetric preload (GEDVI, RVEDVI); GEF correction; R/L shunts	Organ function (ELVWI, PVPI, IAP, APP); biomarkers (NGAL, cystatin-C, citrulline); capillary leak markers (COP, OSM, CLI, RLI); daily and cumulative FB, body weight	Organ function evolution (P/F ratio, EVLWI, IAP, APP, PVPI), body composition (ECW, ICW, TBW, VE)	Organ microperfusion (pH, $ScvO_2$, lactate, ICG-PDR); biomarkers; negative cumulative FB
Monitoring tools	A-line, CV-line, PPV or SVV (manual or via monitor), uncalibrated CO, TTE, TEE	Calibrated CO (TPTD, PAC)	Calibrated CO (TPTD); Balance; BIA	Calibrated CO (TPTD); Balance; BIA; De-escalation	LiMON, Gastric tonometry, Microdialysis
Goals	Correct shock (FAFM)	Maintenance tissue perfusion	Aim for zero or negative FB (LCFM)	Mobilise fluid accumulation (LGFR) = emptying or De-resuscitation	Maintain tissue perfusion
Timeframe	Minutes	Hours	Days	Days to weeks	Weeks

condition has stabilized by diuresis. However, in some patients who fail to experience spontaneous diuresis, patients can be given diuretics.[3] In patients with acute renal failure, the In patients with renal dysfunction, renal replacement therapy (RRT) is more effective than diuretics.[10] Malbrain et al. (2020) mentioned that five steps in de-escalation need to be considered, namely (1) determine clinical endpoints; (2) determine fluid balance goals (e.g., negative fluid balance); (3) determine prevention to secure kidneys and perfusion (e.g., vasopressor requirements); (4) reevaluate after 24 hours; (5) determine the next plan.[3] In patients with fluid overload or fluid accumulation that impairs organ function, fluid resuscitation should be considered. Fluid resuscitation is mandatory if the patient has a positive cumulative fluid balance with poor oxygenation (P/F ratio <200), increased capillary leakage with PVPI value >2.5, intra-abdominal pressure (IAP) >15 mmHg, extravascular lung water index (EVLWI) >12 ml/kgBB, abdominal perfusion pressure (APP) <50 mmHg, and high capillary leakage index (CLI).[31]

After the patient experiences a "second hit," there are two possibilities: First, they may recover further and enter the flow phase spontaneously by evacuating the excess fluid administered earlier. Some ICU patients who do not experience improvement in their condition are characterized by continued fluid accumulation due to capillary leakage so that the patient remains in the Ebb phase, followed by a "third hit" caused by globally increased permeability syndrome (GIPS). At this stage, excessive fluid administration will worsen the patient's outcome. Peripheral edema and anasarka are not an easy problem, but they are also detrimental to the patient as they can lead to organ administration of diuretics is associated with poor outcomes. However, when fluid overload occurs, diuretics still provide benefits to achieving negative fluid balance. In contrast, dysfunction.[26] Cordeman et al. suggest taking a PAL approach to de-suscitation[32]: Using high positive end-expiratory pressure (PEEP) for 30 minutes, this concept moves fluid from the alveoli to the interstitium.

- Administration of albumin (e.g., 2x100 ml of 20% albumin over 60 minutes on day 1, then titrated to albumin >30 g/L), used to draw fluid from the interstitium into the circulation
- Furosemide infusion is started 60 minutes after albumin administration. In patients with anuria, continuous renal replacement therapy (CRRT) can be added with ultrafiltration.

SUMMARY

Critical patients in the ICU require a different approach than regular patients in managing fluid therapy. The ROSE conceptual model, consisting of dynamic phases of fluid management such as resuscitation, stabilization, optimization, and evacuation, can be applied to ICU patients. In the resuscitation phase, a positive fluid balance is expected; in the stabilization and optimization phase, the balance is neutral or negative; and in the evacuation phase, it should already be negative. By applying this model, ICU patients are expected to have better outcomes.

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CONFLICT OF INTEREST

The author declares there is no conflict of interest.

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