RRT
in
critically ill patients

F.YASSARI

SBMU NEPHROLOGIST

MASIH DANESHVARI HOSPITAL

RRT

in critically ill patients

Since the major functions of the kidney are to excrete uremic toxins and to control volume, electrolyte, and acid-base homeostasis, the failure of these functions can lead to urgent indications for RRT.

The main indication for RRT in patients with AKI is to provide sufficient control of metabolic derangements, which are associated with kidney failure.

RRT

in critically ill patients

- A significant proportion of critically ill patients with severe AKI, receive support with RRT.

- There is large variability between different studies due to variability in patient profiles (medical and surgical ICUs), definitions of AKI and multiple treatment modalities

- Acute kidney injury (AKI), is defined as an abrupt (within 48 hours) reduction in kidney function.
- The AKI network defines the reduction in kidney function as the presence of any one of the following:

1. An absolute increase in serum creatinine of ≥ 0.3 mg.dl -1(≥ 26.4 mcmol.l-1)
2. A percentage increase in serum creatinine of ≥ 50% (1.5-fold from baseline)
3. A reduction in urine output (< 0.5 ml.kg -1 per hour for more than six hours).

Table 1: RIFLE and AKIN classification [1, 25].

RIFLE			AKIN		
Category	Creatinine/GFR	Urine output (UO)	Stage	Creatinine	Urine output (UO)
Risk	Cr increase by x1.5 times or GFR decrease by ≥25%	UO ≤ 0.5 mL/kg/hr for 6 hrs	Stage 1	Cr increase by x1.5 times or ≥ 26 μmol/L	UO ≤ 0.5 mL/kg/hr for 6 hrs
Injury	Cr increase by x2 times or GFR decrease by ≥50%	UO ≤ 0.5 mL/kg/hr for 12 hrs	Stage 2	Cr increase by x2	UO ≤ 0.5 mL/kg/hr for 12 hrs
Failure	Cr increase by x3 times or GFR decrease by ≥75% or Cr ≥ 354 μmol/L (with acute rise ≥ 44 μmol/L)	UO ≤ 0.3 mL/kg/hr for 24 hrs or anuria for 12hrs	Stage 3	Cr increase by x3 or Cr ≥ 354 μmol/L (with acute rise 44 μmol/L) or RRT[1]	UO ≤ 0.3 mL/kg/hr for 24 hrs or anuria for 12 hrs
Loss (outcome)	Persistent ARF = complete loss of renal function > 4 weeks (but ≤3 months)	N/A	Nil		
ESRD (outcome)	Complete loss of renal function > 3 months	N/A	Nil		

RRT: renal replacement therapy.
[1]Patients requiring RRT are automatically considered stage 3 AKIN regardless of stage at time of RRT initiation.

- The indications for RRT in chronic kidney insufficiency patients with acute decompensation in ICU include:

- Presence of uremic symptoms
- Presence of hyperkalemia unresponsive to conservative measures
- Persistent extracellular volume expansion, despite diuretic therapy
- Acidosis refractory to medical therapy
- A bleeding diathesis

Journal of Anaesthesiology Clinical Pharmacology | July-September 2012 | Vol 28 | Issue 3

- Usual Indications For RRT Can Be “Renal” Or “Non-renal”

- Renal:

- **U**remia / azotaemia

  - uremic encephalopathy
  - uremic pericarditis
  - uremic haemorrhage
  - consider if urea >30-35 mM (no strict cut-off)

- Non-renal (TNT)
- **T**oxins/ drugs
  - small, non-protein bound agents such as toxic alcohols, lithium, salicylate, theophylline, valproate

controversial indications

Prevention of contrast nephropathy (no evidence!)
Sepsis — removal of cytokines by (HVHF) remains controversial
Rhabdomyolysis
MARS (“liver dialysis”)

- Newer indications for RRT include

- Cardiac failure
- Patients requiring a large amount of fluid,
- parenteral nutrition or blood products but at risk of developing pulmonary edema or ARDS
- SEPSIS

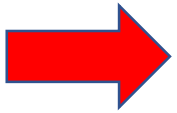
- RRT replaces nonendocrine kidney function in patients with kidney failure and is occasionally used for some forms of poisoning.

- Techniques include:
- continuous hemofiltration and hemodialysis
- intermittent hemodialysis
- peritoneal dialysis.

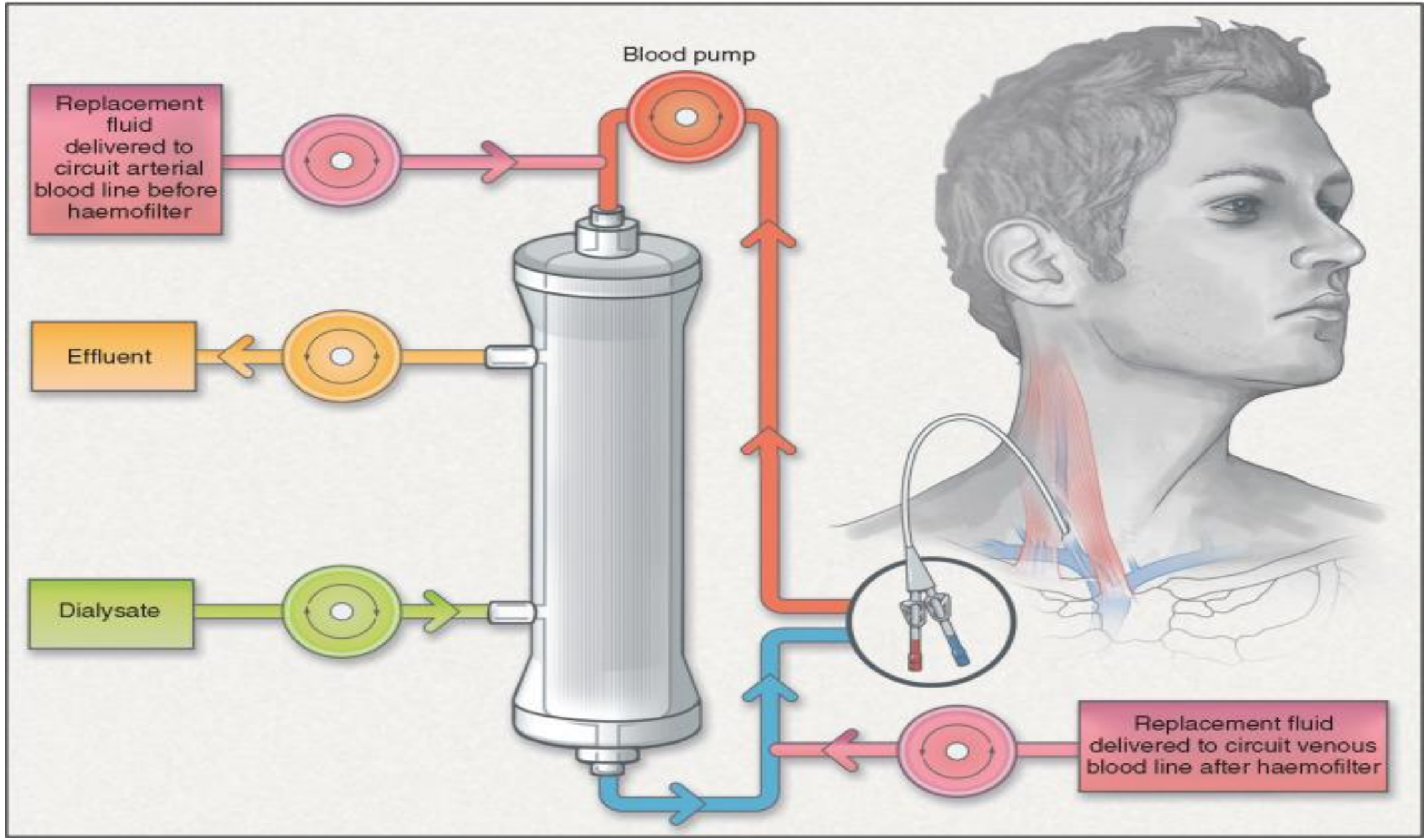
- All modalities exchange solute and remove fluid from the blood, using dialysis and filtration across permeable membranes.

- During dialysis, serum solute diffuses passively between fluid compartments down a concentration gradient (diffusive transport).

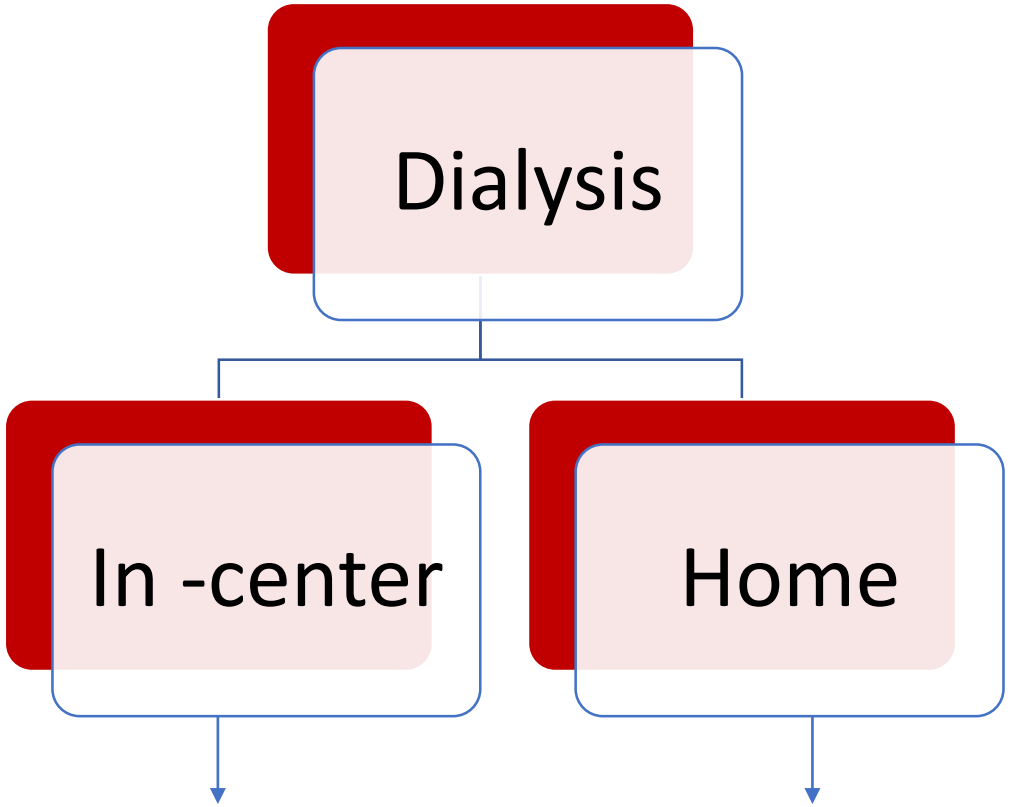
- During filtration, serum water passes between compartments down a hydrostatic pressure gradient, dragging solute with it (convective transport)

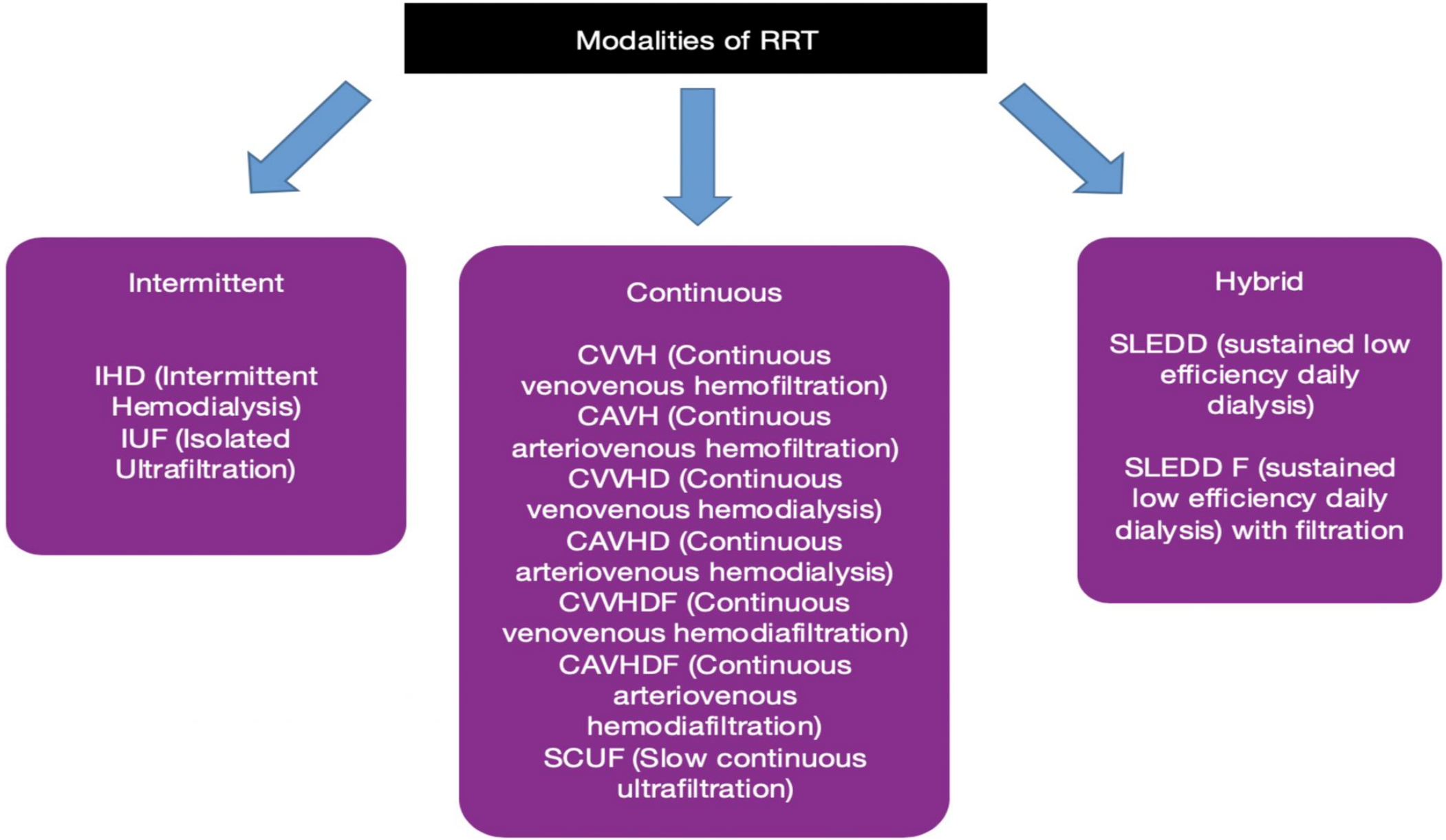
   hemodiafiltration.

- Hemoperfusion is a rarely used technique that removes toxins by flowing blood over a bed of adsorbent material.


Blood pump
Replacement fluid delivered to circuit arterial blood line before haemofilter
Effluent
Dialysate
Replacement fluid delivered to circuit venous blood line after haemofilter

- RRT
  - intermittent
  - continuous
- RRT
  - extracorporeal
  - paracorporeal


Dialysis
In -center
Home
HD
IHD
PIRRT
CRRT
PD
CAPD
CCPD


Modalities of RRT
Intermittent
IHD (Intermittent Hemodialysis)
IUF (Isolated Ultrafiltration)
Continuous
CVVH (Continuous venovenous hemofiltration)
CAVH (Continuous arteriovenous hemofiltration)
CVVHD (Continuous venovenous hemodialysis)
CAVHD (Continuous arteriovenous hemodialysis)
CVVHDF (Continuous venovenous hemodiafiltration)
CAVHDF (Continuous arteriovenous hemodiafiltration)
SCUF (Slow continuous ultrafiltration)
Hybrid
SLEDD (sustained low efficiency daily dialysis)
SLEDD F (sustained low efficiency daily dialysis) with filtration

- All forms of RRT except PD require vascular access; continuous techniques require a direct arteriovenous or venovenous circuit.

- The choice of technique depends on multiple factors

  - the primary need (solute or water removal or both) underlying indication (acute or chronic kidney failure, poisoning)
  - vascular access
  - hemodynamic stability
  - availability and local expertise
  - patient preference and capability .

NEFROLOGIA. 2021;41(2):102–114

nefrología

Revista de la Sociedad Española de Nefrología

www.revistanefrologia.com

Review

Renal replacement therapy in critically ill patients with acute kidney injury: 2020 nephrologist's perspective☆

María Valdenebro[a,b], *Leyre Martín-Rodríguez*[a,b], *Blanca Tarragón*[a], *Paula Sánchez-Briales*[a], *Jose Portolés*[a,b,*]

[a] *Servicio de Nefrología, Hospital Universitario Puerta de Hierro, Majadahonda, Madrid, Spain*
[b] *RedinRen RETIC ISCIII 16/009/009*

ARTICLE INFO

Article history:
Received 3 December 2019
Accepted 28 July 2020

ABSTRACT

Renal replacement therapies (RRT) as support for acute kidney injury in critically ill patients have become a routine and essential practice in their management, resulting in the widespread use of various techniques among these patients, such as intermittent hemodialysis (IHD), extended hemodialysis and continuous RRT (CRRT).

(KDIGO) guidelines recommend the following RRT modalities in critically ill patients: HD, continuous RRT, and PIRRT(hybrid) .ADQI *Workgroup* insists that it is important to know the functions and mechanisms of each technique that define the advantages and disadvantages for its use in each situation.

PD

- Advantages :technical simplicity, hemodynamic stability
- PD may compromise patient respiratory status due to increased abdominal pressure from instilled dialysate, cause hyperglycemia ‘
- PD is contraindicated in post-operative patients who need abdominal surgery or surgical drains.
- PD is a less effective modality in certain clinical situations like patients with poisoning, hypercatabolic states, and pulmonary edema.
- PD remains an acceptable alternative to IHD and CRRT especially in low and middle income countries where access to technology is difficult.

Intermittent hemodialysis

- Advantages of IHD include rapid solute and volume removal. This results in rapid correction of electrolyte disturbances.
- IHD also has a decreased need for anticoagulation
- The main disadvantage of IHD is the risk of systemic hypotension .
- . Rapid solute removal from the intravascular space can cause cerebral edema and increased intracranial pressure, limiting this therapy in patients with head trauma or hepatic encephalopathy.

CRRT

- The advantages of CRRT include hemodynamic tolerance caused by slower ultrafiltration and solute removal.
- allows administration of medications and nutrition with less concern for volume overload.
- there is less fluctuation of solute concentrations over time and better control of azotemia, electrolytes, and acid-base status.
- It does not raise intracranial pressure like IHD.
- The main disadvantages of CRRT include access and filter clotting and need for anticoagulation.
- Another disadvantage of CRRT is increased cost and demands on ICU nurse time compared with IHD.
- Continuous type of RRT is recommended in the state of body could not well tolerated on fluid balance shift and metabolic fluctuations.

CRRT

- There are two particular situations where CRRT is favored as a renal replacement modality.
- First, in patients with intracranial hypertension and/or head injuries.
- the second is fluid removal and achieving fluid balance targets in patients with excess fluid, including patients with congestive heart failure or acute pulmonary edema.
- CRRT provides slow and continuous fluid drainage at least to adjust the fluid intake.

PIRRT

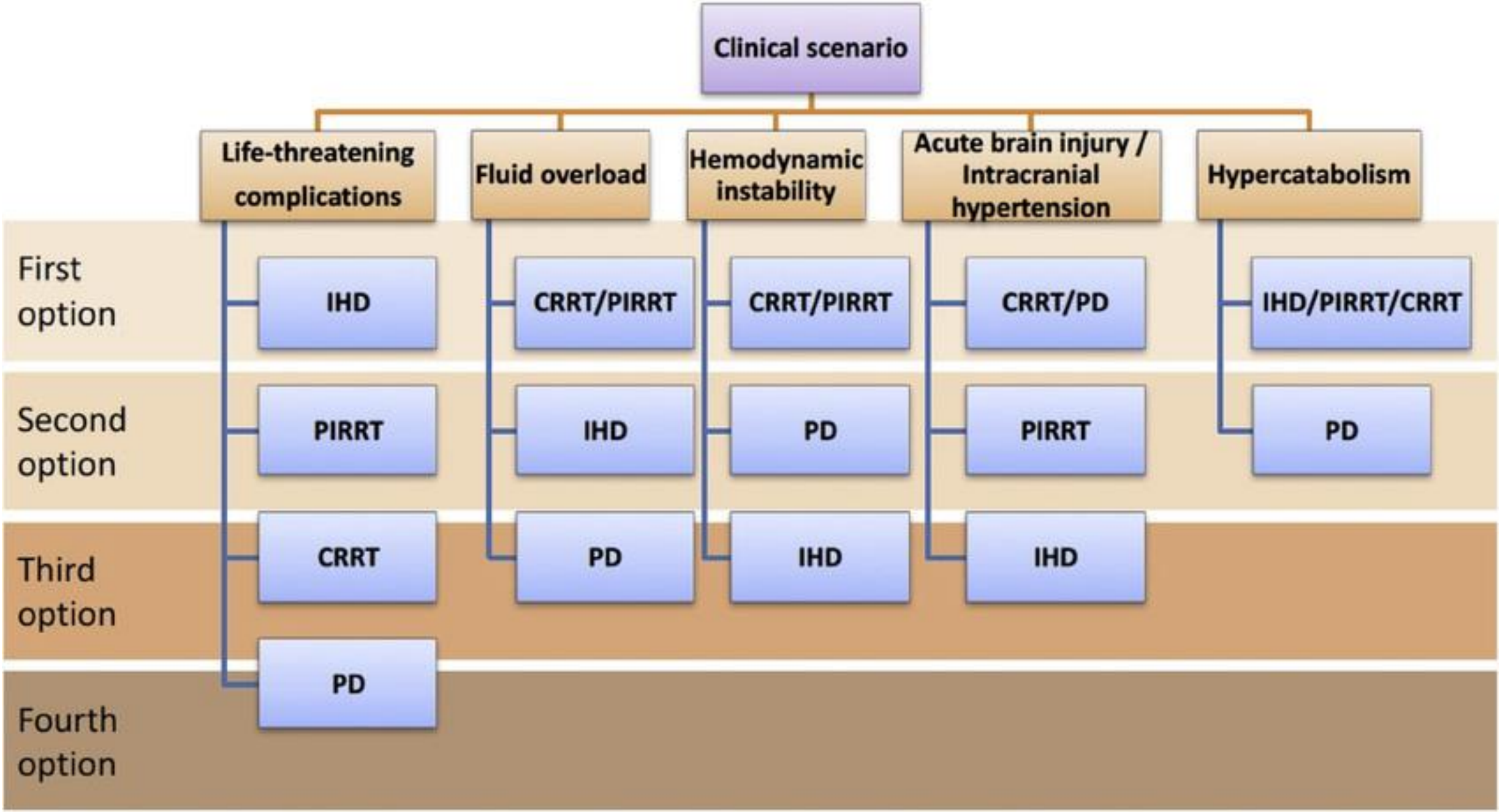
- Hybrid therapies are also known as PIRRT, (SLED), and (EDD).
- These therapies use conventional hemodialysis machines with lower blood-pump speeds and dialysate flow rates to provide solute and fluid removal slower than IHD but faster than conventional CRRT.
- they use low blood-pump speeds of 200 mL/min and low dialysate flow rates of 300 mL/min for 6 to 12 hours daily.
- PIRRT combines the advantages of CRRT and IHD.
- Because they can be done intermittently based on the needs of the patient, they also avoid the interruption of therapy for various diagnostic and therapeutic procedures that may be required in such patients.

PIRRT

- PIRRT is used to transition patients from CRRT to standard intermittent hemodialysis as hemodynamic stability improves.
- PIRRT allows for greater mobilization and rehabilitation of patients because of scheduled time off dialysis.

Table 2. Advantages and disadvantages of different modalities of renal replacement therapy

Modality	Advantages	Disadvantages
Intermittent haemodialysis	■ Allows more rapid removal of low molecular weight substances and toxins ■ Reduced anticoagulation exposure ■ Lower cost than continuous renal replacement therapy ■ More time for rehabilitation and mobilization	■ Hypotension with rapid fluid removal ■ Dialysis disequilibrium syndrome with risk of cerebral oedema ■ Usually not provided by intensive care unit team ■ More complex drug dosing ■ Possibly higher risk of long-term dialysis dependency ■ Loss of micronutrients
Sustained low efficiency dialysis	■ More haemodynamic stability than with intermittent haemodialysis ■ Decreased anticoagulation requirements ■ Time when not receiving treatment may be used for diagnostic or therapeutic procedures or rehabilitation	■ May not be tolerated by extremely unwell unstable patients
Slow continuous ultrafiltration	■ Gentler fluid removal and control of fluid balance in volume overload ■ Decreased anticoagulation requirements	■ No clearance of solutes or toxins ■ Can only be used in patient with fluid overload
Continuous renal replacement therapy	■ Haemodynamic stability as a result of gentler fluid removal ■ Continuous removal of toxins and better metabolic homeostasis ■ Gentler fluid removal and better control of fluid balance	■ Slower clearance of toxins ■ Need for anticoagulation ■ Risk of hypothermia ■ Higher costs than intermittent haemodialysis ■ Immobilization ■ Loss of micronutrients

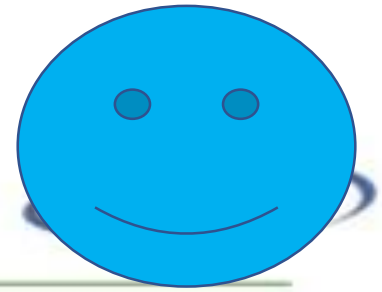

Clinical scenario
Life-threatening complications
Fluid overload
Hemodynamic instability
Acute brain injury / Intracranial hypertension
Hypercatabolism
First option
Second option
Third option
Fourth option
IHD
CRRT/PIRRT
CRRT/PIRRT
CRRT/PD
IHD/PIRRT/CRRT
PIRRT
IHD
PD
PIRRT
PD
CRRT
PD
IHD
IHD
PD

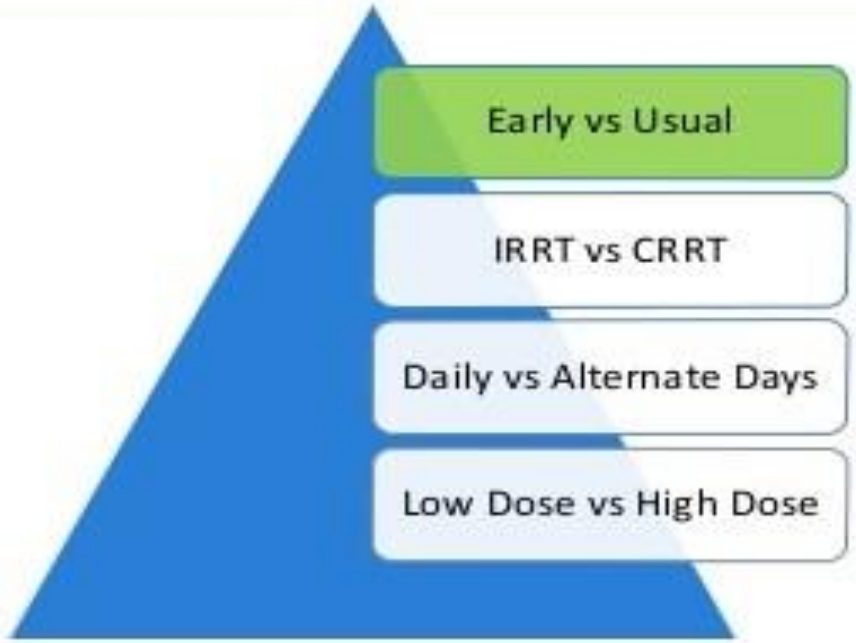
- Observational studies suggest initial treatment with CRRT may be associated with higher rates of renal recovery.
- IHD has some advantages over CRRT, among which include practicality and flexibility of application, limitation of expenses, and fewer bleeding complications.
- The hybrid modalities, sustained low efficiency daily dialysis (SLED) and extended daily dialysis (EDD), can provide adequate solute control (as IHD does) and require less intensive monitoring and time in comparison to CRRT.
-

- It is now recognized that more than one therapy can be utilized for managing patients with AKI.
- Transitions in therapy are common and reflect the changing needs of patients during their hospital course.
- patients in the ICU may initially start on CRRT when they are hemodynamically unstable, transition to SLED/EDD when they improve, and leave the ICU receiving IHD.

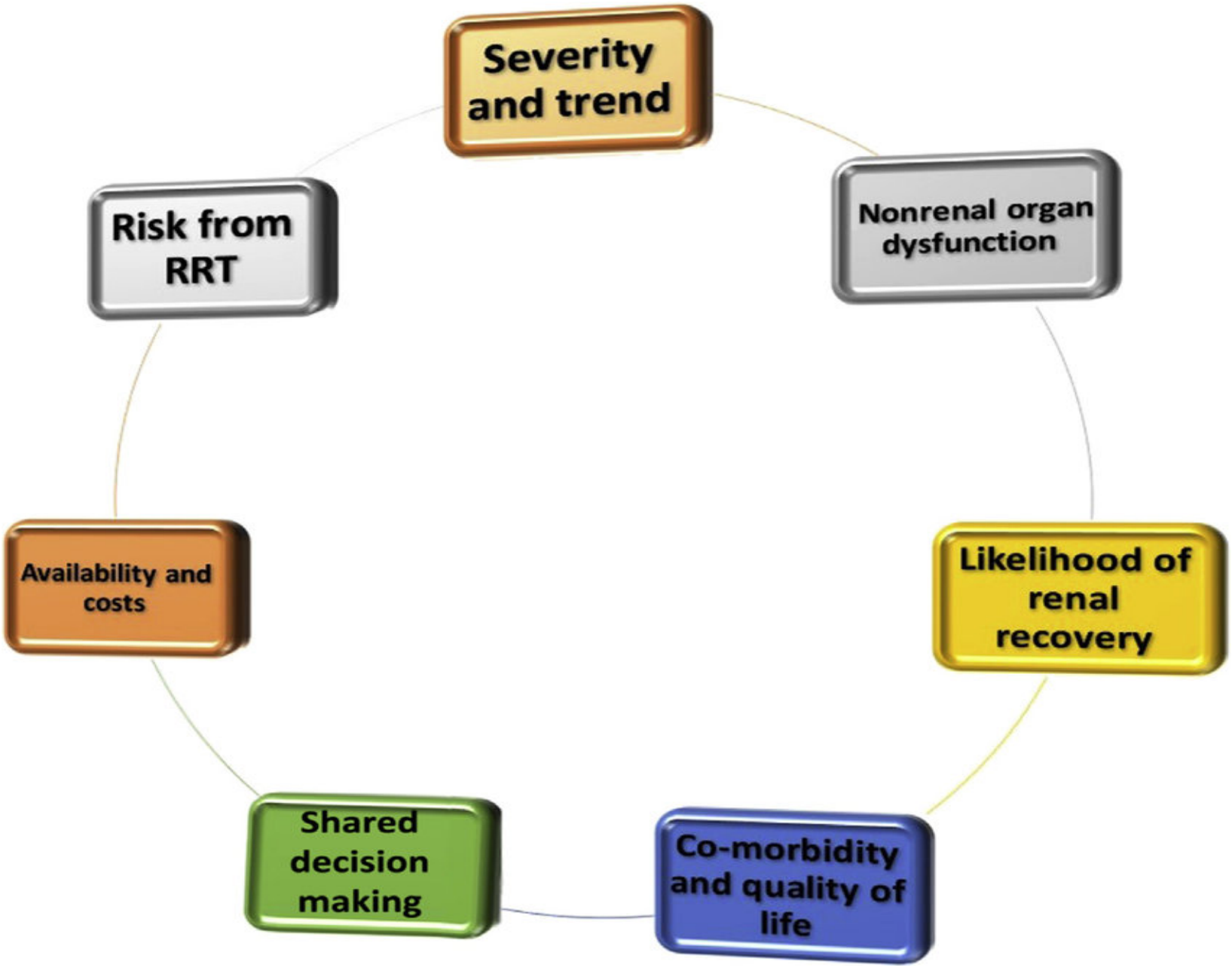
- we recommend utilizing the modality that will best support patients' needs should be utilized.
- Each modality has a role in the management of patients with AKI and should be tailored for each patient based on the dynamic need

Dialysis Strategies





Factors to consider for RRT initiation in acute kidney injury.



NEFROLOGIA. 2021;41(2):102–114

nefrología
Revista de la Sociedad Española de Nefrología
www.revistanefrologia.com

Review

Renal replacement therapy in critically ill patients with acute kidney injury: 2020 nephrologist's perspective☆

María Valdenebro[a,b], *Leyre Martín-Rodríguez*[a,b], *Blanca Tarragón*[a], *Paula Sánchez-Briales*[a], *Jose Portolés*[a,b,*]

[a] Servicio de Nefrología, Hospital Universitario Puerta de Hierro, Majadahonda, Madrid, Spain
[b] RedinRen RETIC ISCIII 16/009/009

ARTICLE INFO

Article history:
Received 3 December 2019
Accepted 28 July 2020

Keywords:
Acute kidney injury
Critical ill
Renal replacement therapy
Hemodialysis
Continuous hemofiltration

ABSTRACT

Renal replacement therapies (RRT) as support for acute kidney injury in critically ill patients have become a routine and essential practice in their management, resulting in the widespread use of various techniques among these patients, such as intermittent hemodialysis (IHD), extended hemodialysis and continuous RRT (CRRT).

In this review we aim to summarize current evidence of indication, choice of modality, timing of initiation, dosing and technical aspects of RRT. We carried out a narrative review based on guidelines, consensus documents by main working groups and the latest relevant clinical trials on RRT in the critically ill.

We did not find enough evidence of any RRT modality having superior benefits in terms of patient survival, length of intensive care unit/hospital stay or renal outcomes among critically ill patients, in spite of optimization of clinical indication, modality, timing of initiation and intensity of initial therapy. This is still a controverted matter, since only early start of high-flux CRRT has been proven beneficial over IHD among hemodynamically unstable postoperative patients.

Our objective is to portrait current RRT practices in multidisciplinary management of critically ill patients by intensive care and nephrology professionals. Implication of a nephrologist in the assessment of hemodynamic status, coexisting medical conditions, renal outcome expectations and management of resources could potentially have benefits at the time of RRT selection and troubleshooting.

DOI of original article:
https://doi.org/10.1016/j.nefro.2020.07.016.

Abbreviations: FRA, fracaso renal agudo; HD, hemodiálisis intermitente; TRR, terapia reemplazo renal; TRR cont, terapia reemplazo renal continua; UF, hemofiltración intermitente.

☆ Please cite this article as: Valdenebro M, Martín-Rodríguez L, Tarragón B, Sánchez-Briales P, Portolés J. Una visión nefrológica del tratamiento sustitutivo renal en el paciente crítico con fracaso renal agudo: horizonte 2020. Nefrologia. 2021;41:102–114.

* *Corresponding author.*
E-mail address: josem.portoles@salud.madrid.org (J. Portolés).

Indications for renal replacement therapy (to whc

Both AKI and volume overload are frequent complications of critically ill patients in the ICU that compromise their hemody namic and respiratory status, resulting in increased morbidity and mortality

Initiation of renal replacement therapy (when)

Many working groups have proposed to anticipate these factors with an almost preventive use of RRT, which does not have a clear scientific support in a generalized manner. Only in postoperative critical patients it has been possible to demonstrate a decrease in mortality and length of stay in the ICU when continuous high-flow RRT is prescribed early.

The NICE clinical practice guidelines

- a. Immediately discuss any potential indication of RRT with a nephrologists and/or a critical care specialist to ensure that the therapy is started as soon as needed.

- b.Immediately refer patients for RRT if any of the following are not responding to medical management: – Hyperkalemia – Metabolic Acidosis – Complications of uremia (e.g., pericarditis and encephalopathy) – Fluid overload – Pulmonary edema.

- c. Base the decision of when to start RRT on the condition of the patient as a whole rather than on isolated indicator such us the BUN, creatinine, or potassium level.

The KDIGO guidelines

- start RRT to the attending physician in the context of deterioration of kidney function or any worsening of the patient clinical condition, without any definitive recommendation.

سپاس