RENAL REPLACEMENT THERAPY IN CARDIOVASCULAR SURGERY

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Anestesiólogo

El cirujano!  El anestesiólogo

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Acute Renal Injury - Definition

Acute loss of renal function (hours, few days)
Acute renal injury is a common complication of critically ill patients in today’s intensive care units.

- **Three types**
  - Pre-renal: decline in renal blood flow resulting in decreased renal perfusion
  - Intra-renal: injury to kidneys by nephrotoxins resulting in tubular cell injury
  - Post-renal: obstruction to outflow

- **In the ICU most ARI is associated with prerenal and intrarenal failure.**
Main cause

- reduced perfusion of the kidneys (shock, post-operative, sepsis, multi-organ-failure)

Other causes (examples)

- destruction of the glomeruli by immune-complexes
- nephrotoxic substances
- obstruction of the tubuli, e.g. by myoglobin
RIFLE / AKIN classifications

**RIFLE**

- **Risk**
  - Increased creatinine x 1.5
- **Injury**
  - Increased creatinine x 2
- **Failure**
  - Increased creatinine x 3 or creatinine ≥ 4mg/dl (with an acute rise of ≥ 0.5mg/dl)
- **Loss**
  - Persistent ARF** = complete loss of renal function > 4 weeks
- **ESRD**
  - End Stage Renal Disease

**Urine Output Criteria**

- Risk: UO < 0.5ml/kg/h x 6 hr
- Injury: UO < 0.5ml/kg/h x 12 hr
- Failure: UO < 0.3ml/kg/h x 24 hr or Anuria x 12 hrs

**AKIN**

- **R (I)**
  - Increased creatinine x 1.5 OR ≥ 0.3mg/dl
  - UO < 0.5ml/kg/h x 6 hr
- **I (II)**
  - Increased creatinine x 2
  - UO < 0.5ml/kg/h x 12 hr
- **F (III)**
  - Increased creatinine x 3 or creatinine ≥ 4mg/dl (Acute rise of ≥ 2.0mg/dl)
  - UO < 0.3ml/kg/h x 24 hr or Anuria x 12 hrs

**Urine Output Criteria**

- RRT Started
Increase in All-Cause Mortality in AKI according to RIFLE class

N=71,527 patients

- Non-AKI: RR for death = 1.00
- Risk: RR for death = 2.40
- Injury: RR for death = 4.15
- Failure: RR for death = 6.37

The RIFLE criteria and mortality in acute kidney injury: A systematic review

Z. Rezić¹, D. Cruz², and C. Ronco²

¹Department of Pediatric Cardiopulmonary, Sambodarri Hospital, Rome, Italy; ²Department of Nephrology, Dialysis and Transplantation, S. Giovanni Hospital, Vienna, Italy; and ³International Renal Research Institute Vienna (IRRI), Vienna, Italy
RIFLE/ AKIN association with

- Increasing mortality (in >600,000 pts)
- Increased length of stay (ICU, hospital)
- Increased health care costs (cardiac surgery)
- Less renal recovery (higher serum Cr at hospital discharge)
Risk factors

Preoperative factors
- Left ventricular dysfunction
- Diabetes
- Peripheral vascular disease
- Emergent surgery
- IABP
- Female sex
- Chronic kidney disease
- Elevated preoperative creatinine

Intra / post operative
- CBP time
- Administration of nephrotoxins in the presurgery period
Protective strategies

- **Avoidance** of nephrotoxic insult

- **Prevention** of renal hypoperfusion,

- **Urine flow** greater than 0.5 ml/Kg/h

- **Hyperoncontic solutions**

- **Titration** to a MAP of 85mmhg Vs 65
There are important limits to the usefulness of creatinine and creatinine clearance in identifying early AKI.

Observing changes in serum creatinine over short periods of time and the use of 6-hour creatinine clearance can be useful.

- MDRD

- New markers are
  - N-Gal,
  - Cysta-C,
RRT during AKI

<table>
<thead>
<tr>
<th>Intermittent</th>
<th>Continuous</th>
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</thead>
<tbody>
<tr>
<td>Hemodialysis (HD)</td>
<td>Peritoneal Dialysis (CAPD, CCPD)</td>
</tr>
<tr>
<td>- single pass</td>
<td>Ultrafiltration (SCUF)</td>
</tr>
<tr>
<td>- with sorbent</td>
<td>Hemofiltration (CAVH, CVVH)</td>
</tr>
<tr>
<td>Peritoneal Dialysis (PD)</td>
<td>Hemodialysis (CAVHD, CVVHD)</td>
</tr>
<tr>
<td>Hemofiltration (HF)</td>
<td>- single pass</td>
</tr>
<tr>
<td>Ultrafiltration (UF)</td>
<td>- with sorbent</td>
</tr>
<tr>
<td></td>
<td>Hemodiafiltration (CAVHDF, CVVHDF)</td>
</tr>
<tr>
<td></td>
<td>Hemofiltration (HF)</td>
</tr>
<tr>
<td></td>
<td>Ultrafiltration (UF)</td>
</tr>
</tbody>
</table>
The first uncontrolled study reported that RRT started on average 2.8 days after surgery and reduced mortality from a historical 66% to 40%.

Bellomo et al. Early and Intensive CRRT for severe renal failure after cardiac surgery

Ann Thorac Surg 2001;71:823-7
The second study involved an audit of 1264 cardiac patients, where there was a diagnosis of acute renal dysfunction made in 64 patients. A review of these cases allowed grouping into early or late CRRT. The early group received RRT on average of 0.78+-0.2 days whilst the late intervention group received RRT on average 2.5 +- 2.2 days, the mortality was reduced from 43% to 22% by early intervention.

*Elahi et al Early emofilytration improves survival in post-cardiotomy patients with acute renal failure* Eur J cardiothoracic Surgery 2004-;26:1027-31
In a similar study, RRT was commenced when urine output was less than 100ml for eight consecutive hours and unresponsive to furosemide. This group was compared to one where RRT was commenced when serum creatinine concentration reached 450 mmol/l or serum K+ was greater than 5.5. The elapsed time from surgery for the first group was 0.88 +/- 0.33 days compared to 2.56 +/- 1.67 days for the delayed group.

Hospital mortality was significantly different:

23.5% early VS 55.5% late p=0.016

Dermirkilic et al. Timing of CRRT for acute renal failure after cardiac surgery
J.Card.Surg 2004;121:1190-4
- **Semipermeable membrane**
  - a very fine sieve

- **Diffusion**
  - concentrations even out in the course of time

- **Ultrafiltration**
  - filtration of water due to pressure difference

- **Convection**
  - substances solved in the water are transported together with the water
When to start RRT?

Or how to learn the language of crying kidney?
Starting criteria for RRT

- Oliguria (urine volume: <200 ml/12 ore)
- Anuria (urine volume: 0-50 ml/12 ore)
- [K+] >6.5 mEq/l or rapidly increasing
- [BUN] >100 mg/dl
- Heavy metabolic acidosis (pH <7.1)
- Organ edema (mainly lung) clinically relevant
- Uraemic organ toxicity (pericarditis, encefalopathy, miopathy/neuropathy)
- Severe progressive dysnatremia (>160 o <115 mEq/l)
- Hyperthermia >39.5°C
- Coagulopathies with indications to intensive blood components supply in patients with or at risk of pulmonary edema or ARDS
- One criterion is sufficient to initiate RRT in critical ill patient
- Two criteria render it mandatory
- Combined alterations suggest the starting even if the abovementioned limits have not been exceeded

Guidelines SIN 2008
Proposed Algorithm for Initiation of Renal Replacement Therapy in Critically Ill Patients

1. **Patient admitted to ICU**
2. **Absolute indications?**
   - **YES**
   - **NO**
3. **AKI present?**
   - **YES**
   - **NO**
4. **Assess:**
   - AKI severity & trend
   - Illness severity & trajectory
   - Initial response to above therapy

5. **Optimize Resuscitation:**
   - Intravascular volume
   - Cardiac output
   - Mean arterial pressure
   - Intra-abdominal pressure

6. **Severe AKI?**
   - RIFLE-F/ AKIN III or Anuria
   - **YES**
   - **NO**

7. **Mild/Moderate AKI?**
   - RIFLE-R or I
   - AKIN 1 or II
   - **YES**
   - **NO**

8. **Consider adjuvant role of RRT**

9. **Consider initiating RRT**
   - **YES**
   - **NO**

10. **Any of the following?**
    - Rapidly worsening AKI
    - Illness severity
    - Refractory fluid overload
    - Permissive hypercapnia
    - Reduced renal reserve
    - Low probability for early renal recovery

11. **Potential non-renal indications?**
    - Refractory fluid overload
    - Refractory septic shock
    - Acute liver failure
    - Severe tumor lysis syndrome
    - Severe electrolyte disturbances
    - Cytokemia
    - Selected toxins

12. **Monitor and reassess clinical status**

*Bagshaw et al, Crit Care 2009, 13:317*
A summary of absolute or "rescue therapy" indications for Initiation of RRT in critically Ill patients

<table>
<thead>
<tr>
<th>Category</th>
<th>Characteristic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metabolic</td>
<td></td>
</tr>
<tr>
<td>Azotemia</td>
<td>Serum urea ≥36mmol/L (100 mg/dL)</td>
</tr>
<tr>
<td>Uremic complications</td>
<td>Encephalopathy, pericarditis, bleeding</td>
</tr>
<tr>
<td>Hyperkalemia</td>
<td>K+ ≥6 mmol/L and/or electrocardiogram abnormalities</td>
</tr>
<tr>
<td>Hypermagnesemia</td>
<td>≥4 mmol/L and/or anuria/absent deep tendon reflexes</td>
</tr>
<tr>
<td>Acidosis</td>
<td>Serum pH ≤7.15</td>
</tr>
<tr>
<td>Oligo-anuria</td>
<td>Urine output &lt;200mL/12 h or anuria</td>
</tr>
<tr>
<td>Fluid overload</td>
<td>Diuretic-resistant organ edema (that is, pulmonary edema) in the presence of acute kidney injury</td>
</tr>
</tbody>
</table>

Gibney N et al, for AKIN, CJASN 2008
Anticoagulation strategies

- HIT incidence from 0.1% to 5%
- Patients / NO
- Circuit / YES
<table>
<thead>
<tr>
<th>High risk of bleeding ppt.</th>
<th>CRRT without anticoagulation with predilution</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>regional anticoagulation with citrate</td>
</tr>
<tr>
<td></td>
<td>IHD without anticoagulation</td>
</tr>
<tr>
<td>Moderate risk of bleeding ppt.</td>
<td>UH or LMWH</td>
</tr>
<tr>
<td>HIT ppt.</td>
<td>citrate or Argatroban</td>
</tr>
</tbody>
</table>
Definition RIFLE/AKIN

Patient at risk

Prevention strategies

6 hours creatinine clearance, Ngal, Cista-C

Early starting CRRT

Using Ci-Ca for regional anticoagulation
GO KIDNEYS!

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