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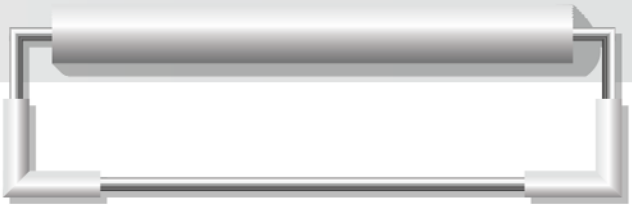
HYPOTHETICAL CASE STUDY

CSA-AKI Patient, Clinical and Logistical Considerations

I INITIAL PRESENTATION



Patient presenting

62-year-old Caucasian male undergoing CABG surgery

- BMI: 32 kg/m^2
- Body weight: 102 kg
- BP: 140/90 mmHg
- LDL: 3.9 mmol/L
- Triglycerides: 205 mg/dL
- HbA_{1C}: 7.1%
- SCr: 1.0 mg/dL
- Other vital signs and urine output normal

Medical history

- Type 2 diabetes for past 17 years
- Stents placed 4 years previously, after acute myocardial infarction
- Increasing chest pain and shortness of breath in the past 3 months → PCI
- Diagnosis: two of the stents are clotted
- No history of kidney injury

Medications

- Metformin
- ß-blocker
- Statin

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I INITIAL PRESENTATION DISCUSSION

Should this patient with no current existing kidney issues have any special considerations regarding kidney function?

A. No precautions are necessary unless the patient shows signs or symptoms of AKI

B. From baseline, monitor SCr and urine output

C. Avoid hyperglycemia and discontinue nephrotoxic agents if possible

D. Both b and c

AKI is a common and serious complication of cardiac surgery [1-10]

AKI occurs in ~ 20-40% of patients after cardiac surgery; [1-7] **~ 1-9%** of patients with CSA-AKI require RRT [5-7]

In patients who undergo cardiac surgery, the development of AKI is associated with an **increased risk of morbidity and mortality** [2-4,7-10]

ADQI recommends the **ROUTINE IMPLEMENTATION OF VALIDATED CLINICAL RISK-PREDICTION MODELS** in the preoperative assessment of all patients undergoing cardiac surgery[11]

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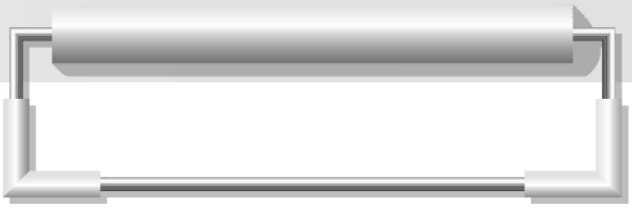
II POSTOPERATIVE DAY 1



Patient status

- Intraoperatively, the patient experienced a poor MAP, and was difficult to stabilize
- The patient was intubated and ventilated, and is stable in the ICU
- Dopamine administered at 30 µg/kg/min

Signs and symptoms

- BP: 100/68 mmHg
- HR: 112 beats/min
- Temperature: 37°C
- Body weight increased 8 kg postoperatively

Test results

- Oxygen saturation: 96%
- SCr: 2.2 mg/dL
- BUN: 14 mg/dL
- Plasma potassium: 5.0 mEq/L
- Urine output: 0.7 mL/kg/h

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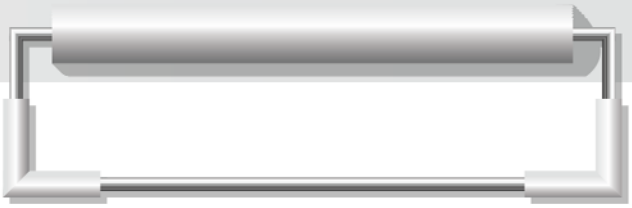
III POSTOPERATIVE DAY 3



Patient status

- Patient was weaned from mechanical ventilation after 48 hours, with 2 L/min oxygen provided via nasal cannulation
- Shortness of breath evident, resulting in 10 L/min high-flow nasal cannula

Signs and symptoms

- BP: 100/65 mmHg
- HR: 118 beats/min
- Temperature: 38°C
- Body weight: increased 3 kg from postoperative day 1
- Peripheral edema is evident (2 +)
- Dopamine administered at 30 µg/kg/min, reduced at 24 hours to 10 µg/kg/min; MAP > 65 mmHg

Test results

- Chest X-ray: right-sided infiltrates
- Oxygen saturation: 96%
- SCr: 4.0 mg/dL
- Plasma potassium: 5.9 mEq/L
- Urine output: diminished to < 0.5 mL/kg/h for the last 24 hours

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III POSTOPERATIVE DAY 3 DISCUSSION

After his surgery, this patient meets KDIGO criteria for Stage 2 AKI [12]

AKI Stage	SCr	Urine output
1	1.5-1.9 times baseline or ≥ 0.3 mg/dL (≥ 26.5 µmol/L) increase	< 0.5 mL/kg/h for 6-12 hours
2	2.0-2.9 times baseline	< 0.5 mL/kg/h for ≥ 12 hours
3	3.0 times baseline or increase in SCr to ≥ 4.0 mg/dL (≥ 353.6 µmol/L) or initiation of RRT or in patients < 18 years, decrease in eGFR to < 35 mL/min /1.73 m^2	< 0.3 mL/kg/h for ≥ 24 hours or anuria for ≥ 12 hours

What factors would influence therapy choice as you address rising SCr levels? (Choose all that apply)

A. Extent of fluid overload
B. Need for hemodynamic stability
C. Available resources in terms of dialysis machines and trained staff
D. Ability to coordinate dialysis with other therapies including antibiotic therapy

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III POSTOPERATIVE DAY 3 DISCUSSION

The goals for a CABG patient with sustained AKI include: [11]

Preventing
AKI progression

Promoting
renal recovery

Treating
consequences of AKI

PERIOPERATIVE and **POSTOPERATIVE HEMODYNAMIC STABILITY** and **AVOIDANCE OF FLUID OVERLOAD** are potential modifiable targets to optimize renal recovery [11]

Management of perioperative hemodynamic instability may lead to a positive fluid balance after cardiac surgery [7,11,13,14]

In cardiac surgery patients, hemodynamic instability and fluid overload are independently associated with an increased risk of mortality [15-17]

In patients with CSA-AKI, fluid removal by RRT can be challenging due to the risk of worsening hemodynamic status [11,12,17]

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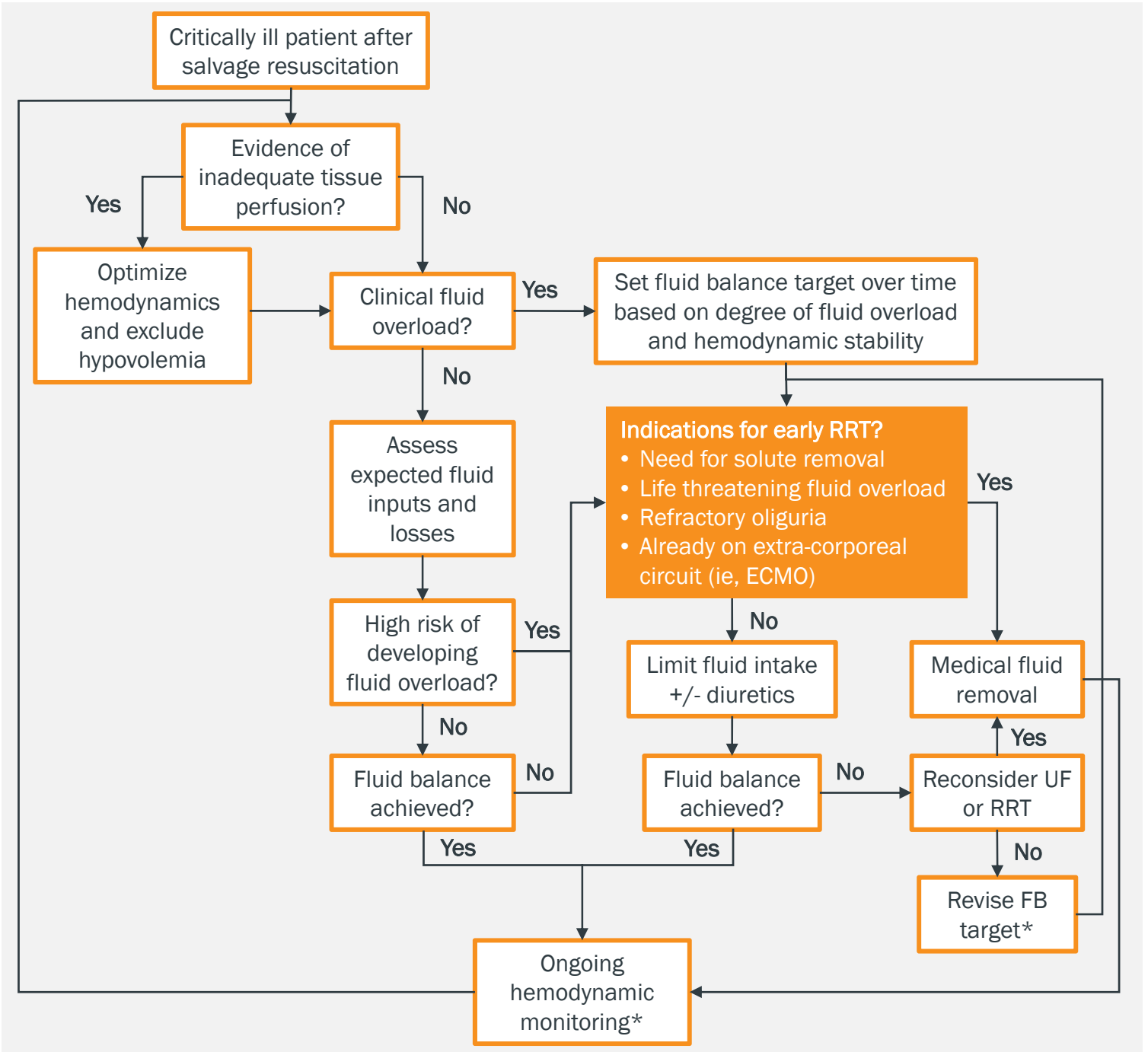
III POSTOPERATIVE DAY 3 DISCUSSION

ADQI provides mechanical fluid removal strategies in critically ill patients [11]



*During therapy, hemodynamic and intravascular volume status should be monitored and fluid removal rate and fluid balance targets reassessed regularly, aiming for clinical stability and tolerance of fluid removal

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IV INITIATION OF DIALYSIS DISCUSSION

The treatment of CABG-related AKI may include initiation of RRT [11]

ADQI recommends not using natriuretic peptide, fenoldopam, diuretics, dopamine, or mannitol for the treatment of CSA-AKI [11]

Decisions about RRT initiation and prescription should be individualized and should not be based solely on renal function or AKI stage [11,12]

What modality of RRT might you use for this patient? Why?

A. CRRT
B. SLED*
C. Intermittent hemodialysis
D. Other

*Includes sustained or slow low-efficiency dialysis, slow extended dialysis, sustained low-efficiency daily dialysis, and sustained low-efficiency daily diafiltration

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IV INITIATION OF CRRT

Prescription

- Body weight: 110 kg
- Dose: 30 mL/kg/h*
- Filter: M150
- BFR: 250 mL/min
- PBP: Renal replacement solution BGK 2/3.5 at 1000 mL/h
- Dialysate solution: BGK 4/2.5 at 1300 mL/h
- Renal replacement solution BK 4/2.5 at 1000 mL/h
- Net fluid removal: 100 mL/h
- Anticoagulation: heparin

*Dose selected in accordance with KDIGO guidelines

Rationale for choice

- Fluid overload with left- and right-sided infiltrates and shortness of breath
- Patient still requires vasoactive substances
- PVCs due to hyperkalemia

Clinical considerations

- Guideline recommendations for patients with fluid overload
- Need for hemodynamic stability

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IV INITIATION OF CRRT DISCUSSION

Current clinical practice guidelines recommend the use of CRRT in AKI patients who are hemodynamically unstable [11,12]

While **intermittent RRT may cause considerable fluctuations in fluid balance,** CRRT is noted for its slow and steady fluid removal [11,12,17-19]

The 20th ADQI International Consensus Conference for CSA-AKI **recommends the use of continuous therapies** in patients with hemodynamic instability and in situations where shifts in fluid balance are poorly tolerated [11]

A meta-analysis suggests that CRRT may be associated with better hemodynamic stability and more controlled fluid balance compared with intermittent RRT [20]

- Bagshaw and colleagues conducted a systematic review and meta-analysis of nine randomized trials in critically ill adult patients with AKI (n = 1403) [20]
- Initial RRT modality was not associated with significant changes in mortality or recovery to RRT independence [20]
- Use of CRRT was associated with fewer episodes of hemodynamic instability and better control of fluid balance [20]

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IV INITIATION OF CRRT DISCUSSION

Selection of RRT modality requires careful consideration of patient-specific and logistical factors [12,17]

Continuous vs intermittent therapies provide different fluid flow rates and have **different treatment duration limits** [12,21-23]

AKI is associated with an increased risk of long-term dialysis dependence; [24] compared with IHD, use of **CRRT for AKI management has been associated with a lower risk** of this complication [25]

While CRRT solutions are typically commercially prepared,[26] water treatment and quality testing may contribute to **increased monitoring when using solutions prepared online for intermittent therapies** [27,28]

Water treatment equipment may add to the footprint of intermittent therapy systems, potentially decreasing treatment mobility and impacting spacing considerations [29-32]

At this point in postoperative recovery, what dialysis options would be available to your patients?

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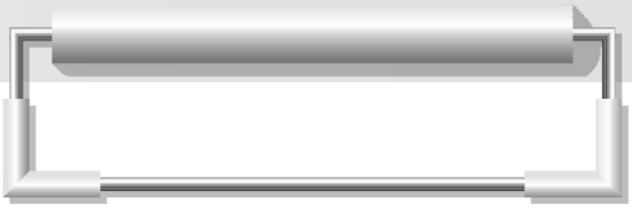
V ICU DISCHARGE



	Day 0	Day 1	Day 3	Day 8	Day 13
	CABG	ICU arrival	CRRT started	CRRT completed	ICU discharge
SCr (mg/dL)	1.0	2.2	4.0	1.8	1.5
BUN (mg/dL)	18	14	28	21	19
K+ (mEq/L)	4.7	5.0	5.9	4.1	4.5
Urine output (mL/kg/h)	Not taken	0.7	< 0.5	~ 60	~ 65
Body weight (kg)	102	110	113	104	100
BP (mmHg)	140/90	100/68	100/65	128/75	130/80

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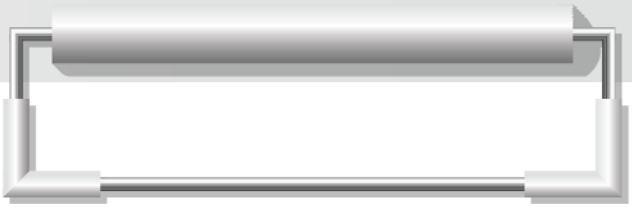
V ICU DISCHARGE



Patient status

- Patient received 5 days of CRRT, which was stopped 5 days ago
- Patient no longer receives supplemental oxygen and shows no shortness of breath during physical therapy
- No infiltrations in X-ray

Signs and symptoms

- BP: 130/80 mmHg
- HR: 100 beats/min
- Body temperature: 37°C
- Body weight: 100 kg

Test results

- Oxygen saturation: 98%
- SCr: 1.5 mg/dL
- BUN: 19 mg/dL
- Plasma potassium: 4.5 mEq/L
- Urine output: increased to ~ 1500 mL/day

Discharge

- Patient is considered stable enough for transfer out of ICU to a lower acuity care unit
- Patient will be reassessed prior to hospital discharge for nephrology follow-up and future RRT requirements

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V SUMMARY

Managing AKI after cardiac surgery

RISK

- Patients undergoing **cardiac surgery are at an increased risk of developing AKI** [1-7]
- CSA-AKI patients are at an **increased risk of morbidity and mortality** [2-4,7-10]

HEMODYNAMIC STABILITY

- **Management of perioperative hemodynamic instability may lead to a positive fluid balance** after cardiac surgery [7,11,13,14]
- Fluid overload and hemodynamic instability are associated with an **increased risk of mortality** [15-17]

OPTIMIZING THERAPY

- In patients with CSA-AKI, **fluid removal by RRT can be challenging** due to the risk of worsening hemodynamic status [11,12,17]
- The 20th ADQI International Consensus Conference for CSA-AKI recommends the use of **continuous therapies** in patients with hemodynamic instability and in situations where shifts in fluid balance are poorly tolerated [11]
- While the selection of RRT modality requires careful consideration of numerous patient-specific and logistical factors,[12,17] **CRRT is a preferred RRT** by many clinicians for AKI patients who are hemodynamically unstable [12,26]

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ACRONYMS/ABBREVIATIONS/REFERENCES

ADQI, Acute Dialysis Quality Initiative; **AKI**, acute kidney injury; **BFR**, blood flow rate; **BMI**, body mass index; **BP**, blood pressure; **BUN**, blood urea nitrogen; **CABG**, coronary artery bypass graft; **CRRT**, continuous renal replacement therapy; **CSA**, cardiac surgery-associated; **ECMO**, extra-corporeal membrane oxygenation; **eGFR**, estimated glomerular filtration rate; **FB**, fluid balance; **HbA_{1C}**, hemoglobin A1C protein from the surface of red blood cells; **h**, hour; **HR**, heart rate; **ICU**, intensive care unit; **IHD**, intermittent hemodialysis; **K+**, serum potassium level; **KDIGO**, Kidney Disease: Improving Global Outcomes; **LDL**, low-density lipoprotein; **MAP**, mean arterial pressure; **PBP,** pre-blood pump; **PCI**, percutaneous coronary intervention; **PVC**, premature ventricular contraction; **RRT**, renal replacement therapy; **SCr**, serum creatinine; **SLED**, sustained low-efficiency dialysis, including sustained or slow low-efficiency dialysis, slow extended dialysis, sustained low-efficiency daily dialysis, and sustained low-efficiency daily diafiltration; **UF**, ultrafiltration

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