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HYPOTHETICAL CASE STUDY

Renal Replacement Therapy in a Patient with Acute Kidney Injury following Subarachnoid Hemorrhage

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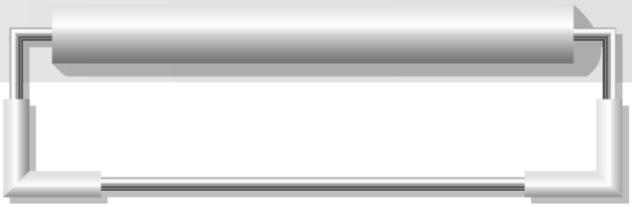
I INITIAL PRESENTATION



Patient presenting

- 46 y.o. female presenting to the Emergency Department with the worst headache of her life and increasing lethargy
- Non-contrast CT of the head demonstrates subarachnoid hemorrhage (SAH) with extension into the ventricles (Hunt Hess classification grade 4)
- Patient is immediately intubated stat at the bedside and taken to the cath lab where she underwent coiling of right ACOMM aneurysm
- Vitals: BP 125/72, HR 82, RR 14, Temp 98.2 F, O2 saturation on room air 97%
- Labs: Na 142, K 4.4, BUN 18, Cr 0.75, WBC 10.6, Hgb 14.2, Platelets 274K
- CXR clear
- Body weight: 68 kg

Medical history

- Unremarkable
- One C section delivery at the age of 35

Medications

- MVI

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I INITIAL PRESENTATION DISCUSSION

Management of Subarachnoid Hemorrhage (SAH)

A. Patients with aneurysmal subarachnoid hemorrhage (SAH) are at risk for vasospasm and typically remain in the ICU for at least 14 days to undergo close monitoring. [1]

B. Hypertonic saline and norepinephrine are administered to treat cerebral edema, prevent vasospasm and delayed cerebral ischemia, and improve prognosis. [1,2]

C. Development of acute kidney injury (AKI) following SAH can be associated with fluid delivery, vancomycin administration and clinical vasospasm. [3]

AKI is a serious complication of SAH [2,4,5]

A study of 260,885 hospital inpatients showed a 4% incidence of AKI following SAH. Nearly 7% of SAH patients who developed AKI required RRT. [4]

AKI doubles in-hospital mortality for SAH and increases the likelihood that patients will suffer poorer recovery. [4,5]

Despite improved management of SAH, AKI remains a serious complication that negatively affects patient outcomes and may require treatment with RRT. [4-7]

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II ICU DAY (Day 5)

Patient status

- Patient is in stable condition
- Intubated, PRVC TV 500 RR 14 FiO2 80% peep 5 cm H20
- 3% saline initiated @ 60 cc/hr to maintain serum sodium 150-155
- Norepinephrine initiated to maintain SBP >140
- Net fluid balance: 12 Liters

Signs and symptoms

- BP: 145/92 on norepinephrine drip
- HR: 100
- Temperature: 99.2 F
- Body weight: 78 kg

Test results

- Oxygen saturation: 100%
- SCr: 1.55 mg/dL
- BUN: 46 mg/dL
- Na: 151 mEq/L,
- Plasma potassium: 4.4 mEq/L
- Urine output: 5 cc/hour
- PAC CVP: 16 mm Hg, Wedge: 23 mm Hg, CO: 4.8 L/min

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III ICU DAY (Day 5) DISCUSSION

The 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/hr for 6–12 hours
2	2.0–2.9 times baseline	<0.5 mL/kg/hr 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 per 1.73 m^2	<0.3 mL/kg/hr for ≥24 hours or anuria for ≥12 hours

Several factors influence choice of renal replacement therapy

A. Extent of fluid overload
B. Need to maintain hemodynamic stability and control intracranial pressure
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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IV INITIATION OF DIALYSIS DISCUSSION

RRT after SAH or other acute brain injury is challenging [6]

Fluid overload is associated increased mortality in critically ill patients with AKI. [8,9] Positive fluid balance is also linked to adverse neurologic outcomes in SAH and other acute brain injuries. [10]

SAH patients are vulnerable to blood pressure fluctuations and osmotic shifts. [3,6,7,11,12] Optimizing hemodynamic stability and avoiding rapid shifts in osmolality are key to good outcomes. [3,6,7,11,12]

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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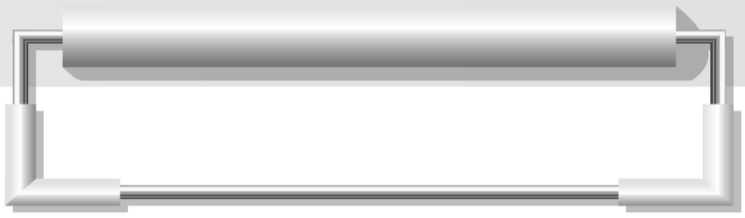
IV INITIATION OF CRRT



Prescription

- Body weight: 78 kg
- Dose: 35 ml/kg/hr*
- Filter:
- BFR: 180 ml/hr
- PBP: N/A
- Dialysate: CRRT Solution BGK4/2.5 (5000 ml)
- Replacement: no replacement
- Net fluid removal: 200 cc/hour
- Anticoagulation: heparin 200 units/hour

*Dose selected in accordance with KDIGO guidelines

Clinical Rationale for choice

Patients with the diagnosis of aneurysmal SAH are at increased risk of vasospasm (especially Days 3-14 post-bleed). Hemodynamic fluctuations can provoke vasospasm.

Clinical considerations

- Fluid removal without compromising blood pressure and cerebral blood flow
- Need for hemodynamic stability
- Need to avoid rapid osmotic shifts

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IV INITIATION OF CRRT DISCUSSION

CRRT is associated with improved hemodynamic stability and more controlled fluid balance compared with intermittent RRT [13-16]

While **intermittent RRT may cause considerable fluctuations in fluid balance,** CRRT is noted for its slow and steady removal of fluid and solutes [13,14]

In patients with acute brain injury, such as SAH, intermittent RRT may worsen neurologic status by impairing cerebral perfusion and increasing cerebral edema and intracranial pressure [3,6,7,11,12]

Current clinical practice guidelines recommend the use of continuous RRT in AKI patients with acute brain injury or other causes of increased intracranial pressure or brain edema [13,15,16]

KDIGO [15]	We suggest using CRRT, rather than intermittent RRT, for AKI patients with acute brain injury or other causes of increased intracranial pressure or generalized brain edema.
ADQI [13,16]	CRRT is recommended over intermittent hemodialysis for patients with ARF who have, or are at risk for, cerebral edema.

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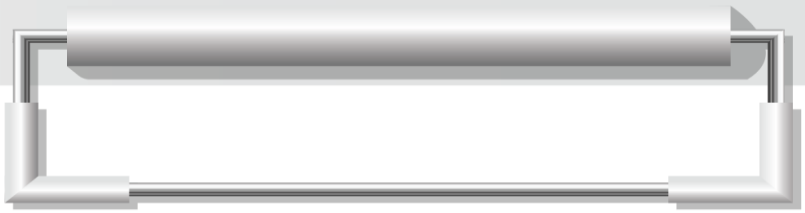
V ICU DISCHARGE



	Day 0	Day 1	Day 5	Day 10	Day 14
	Presentation	ICU arrival	CRRT started	CRRT completed	ICU discharge
SCr (mg/dL)	0.75	0.90	1.55	0.80	0.75
BUN (mg/dL)	18	26	46	21	21
K+ (mEq/L)	4.2	4.6	4.4	4.1	4.1
Urine output (mL/hr)	50	30	5	40	40
Body weight (kg)	68	70	78	72	70
BP (mmHg)	125/72	135/82	165/92	162/90	134/76
Wedge (mmHg)	N/A	N/A	23	12	N/A

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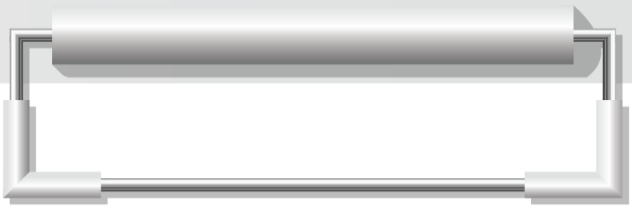

Patient status

The patient was monitored in the Neurosurgical ICU for vasospasm and other complications. Because of the hypertonic saline, the patient became overloaded. With the help of CRRT, the patient improved and was eventually extubated.

Signs and symptoms

- BP: 134/76
- HR: 72
- Body temperature: 98.2 F
- Body weight: 70 kg

Test results

- Oxygen saturation: 99% (RA)
- SCr: 0.75
- BUN: 21
- Plasma potassium: 4.1
- Urine output: 40 cc/hr

Discharge

Patient was discharged to rehab center with focus on neurological disorders. Follow up by PMD and neurosurgeon demonstrated patient was near baseline 2 weeks after discharge.

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V SUMMARY

Managing AKI in Subarachnoid Hemorrhage (SAH)

RISK

Development of AKI following SAH can result in fluid overload, which is associated with increased mortality and poorer neurologic recovery. [8-10]

HEMODYNAMIC STABILITY

Hemodynamic stability and control of intracranial pressure are critical to neurologic recovery after SAH and other acute brain injuries [3,6,7,11]

OPTIMIZING THERAPY

Clinical guidelines recommend CRRT over intermittent RRT for the treatment of AKI in patients with acute brain injury, including SAH. [13-16]

- Intermittent RRT can result in systemic and cerebral hemodynamic instability and increased intracranial pressure. [3,6,7,11]
- As a result of the slow, steady removal of fluid and solutes, CRRT supports stable hemodynamics and cerebral perfusion while avoiding rapid shifts in osmotic gradients that worsen cerebral edema. [3,6,7,11]

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ACRONYMS/ABBREVIATIONS/REFERENCES

ACOM, anterior communicating artery; **ADQI**, Acute Dialysis Quality Initiative; **AKI**, acute kidney injury; **BFR**, blood flow rate; **BP**, blood pressure; **BUN**, blood urea nitrogen; **CRRT**, continuous renal replacement therapy; **CXR**, chest x-ray; **CT**, computed tomography, **Hgb**, hemoglobin; **HR**, heart rate; **ICU**, intensive care unit; **IHD**, intermittent hemodialysis; **K+**, serum potassium level, **KDIGO**, Kidney Disease: Improving Global Outcomes, **MAP**, mean arterial pressure; **MVI**, multivitamin; **PBP,** pre-blood pump; **RRT**, renal replacement therapy; **SAH**, subarachnoid hemorrhage; **SCr**, serum creatinine; **SLED**, sustained low-efficiency dialysis; includes 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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