Clinical Cases: Problems with Hemodialysis Systems

SKC In-service

Sept 2017

Case #1

The Blood Circuit

Audience Question

In the case of needle dislodgement during a dialysis treatment session, safety mechanisms exist in dialysis machines whereby the blood pump will always stop if blood is lost from the circuit.

A) True

B) False

Audience Question

When a dialysis needle becomes dislodged during a treatment session:

A) Dropping venous pressure in the extracorporeal circuit will always stop the blood pump

B) Dropping systemic BP will trigger a stop of the blood pump

C) Arterial pressure will become less negative and always stop the blood pump

D) Venous pressure may not drop enough to trigger the alarm or stop the blood pump

Case Presentation

73 y/o F presents to the outpatient dialysis unit for routine dialysis treatment. She has underlying diabetic kidney disease, hypertension, hyperlipidemia and congestive heart failure. She is in her normal state of health and arrives to the dialysis unit 2kg above her prescribed dry weight. Vitals upon arrival are 143/72, HR 82, RR12, T 98.6 F. She is placed on dialysis at 7:14 AM and, as per her usual routine, lays back in her chair and quickly falls asleep.

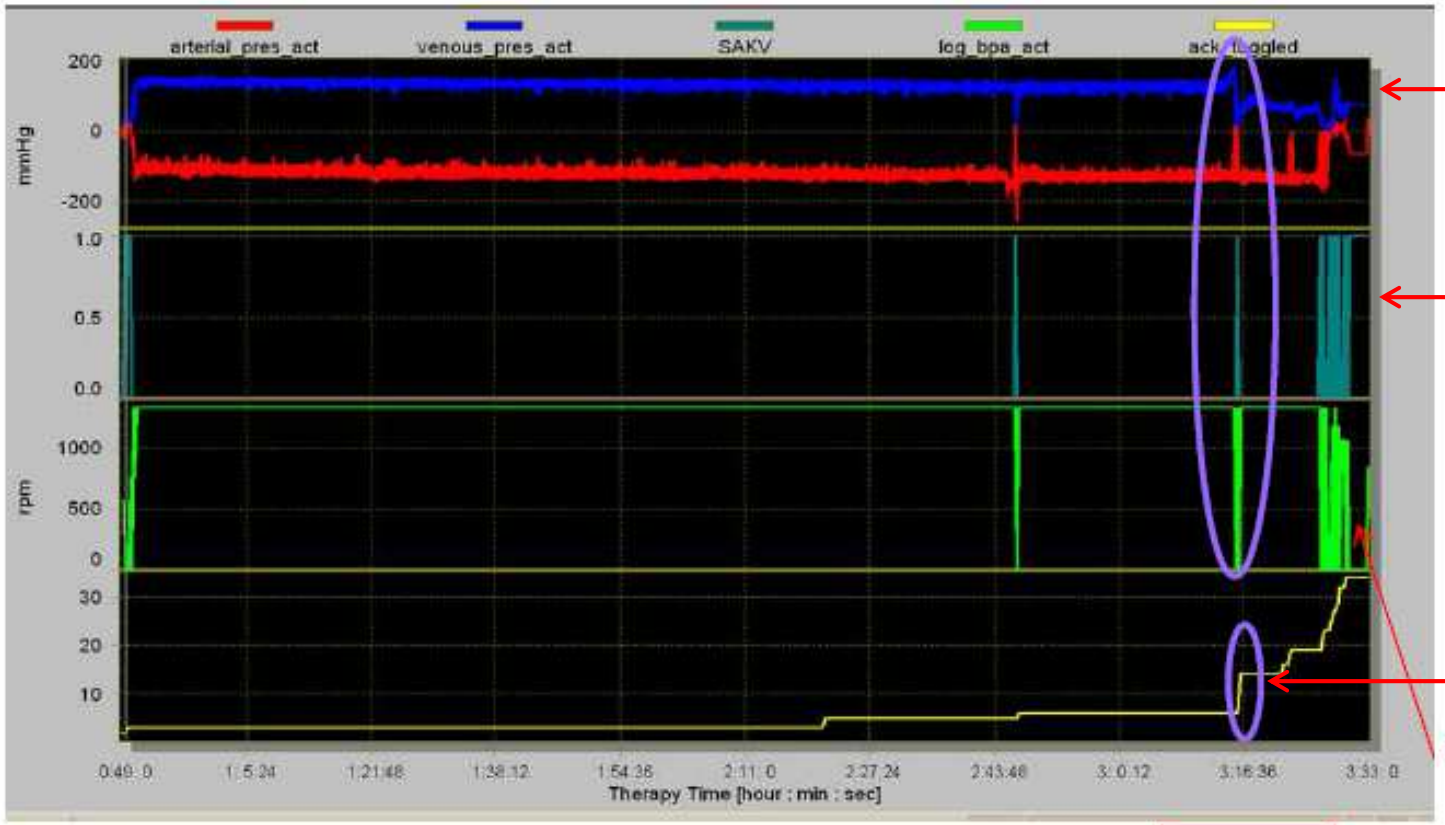
Case Presentation

At 9:53 the patient is taken off dialysis after it is noted that there is a puddle of blood below her dialysis chair. The connection between her dialysis tubing and needle is noted to be loose and briskly dripping blood. Systolic blood pressure is measured to be 73/41. The patient is woken from her sleep and noted to be confused. She is resuscitated with 1L of IV normal saline with improvement in her blood pressure and mental status. She is subsequently transferred to the emergency department for evaluation.

Case Presentation

During review of the case unit staff noted that they had little warning that the bleeding had occurred. They are concerned that the machine in use is defective. You pull the dialysis machine from the floor and investigate…


arterial_pres_act
venous_pres_act
SAKV
log_bpa_act
mmHg
200
0
-200
1.0
0.5
0.0
rpm
1000
500
0
30
20
10
Therapy Time [hour : min : sec]
Low VP
Venous clamp
Blood pump stops
Staff reset
7:14 AM
9:11 AM
9:40 AM



Venous pressure drops

Venous clamp engaged

Alarm cleared

Pump stops multiple times

9:40 AM

Saline given

9:40

Alarm limits reset, dialysis continues

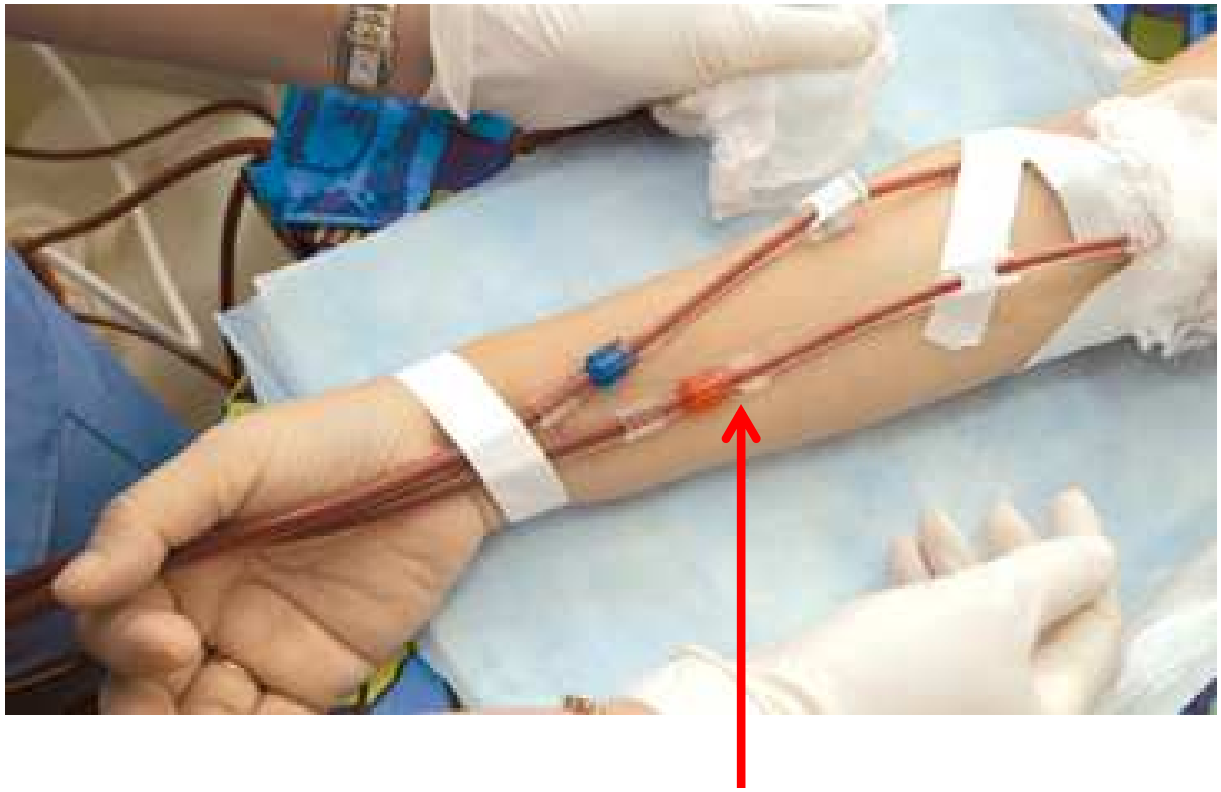
Low BP alarms reset

9:51

VP drops again, pump stopped multiple times

9:53

Bleeding recognized by unit staff
Dialysis is stopped



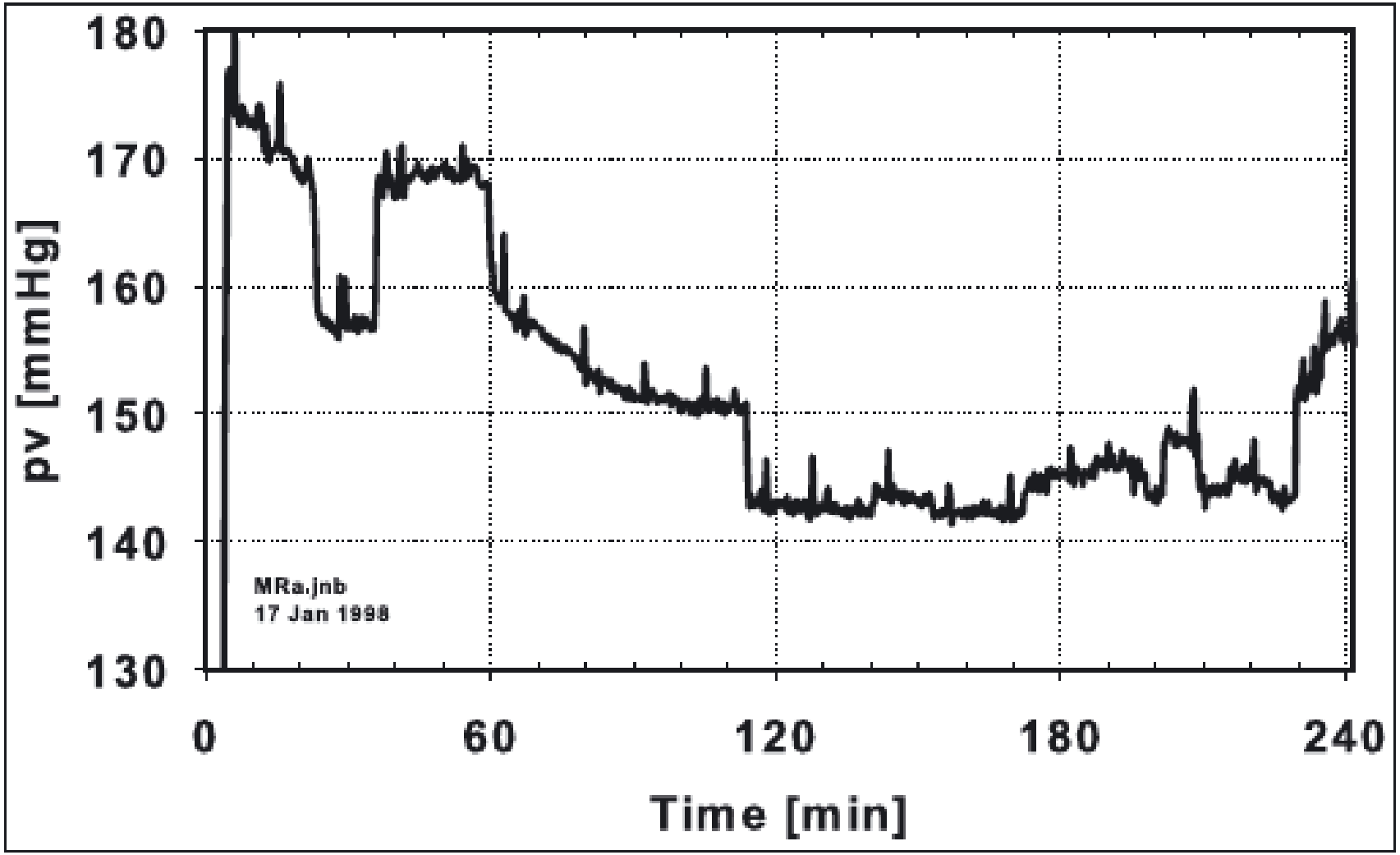
Case Summary

Loss of blood from needle to line connection was not noticed by the unit staff because the access was covered by a blanket during the dialysis run.

In this case, multiple alarms stopped the blood pump allowing intervention but the access was not evaluated and the dialysis machine allowed parameters to be reset allowing dialysis to continue despite exsanguination.

Blood loss and venous pressure

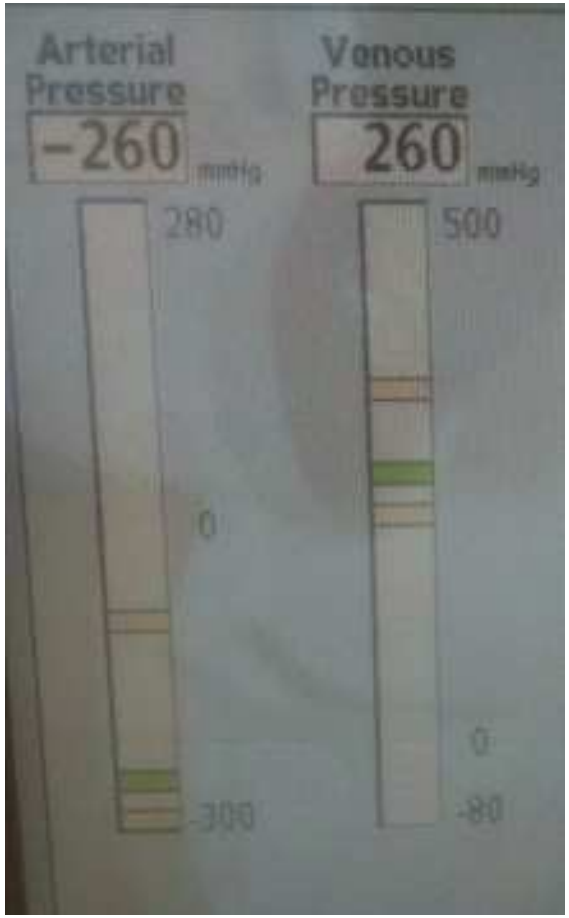
- Factors that affect the venous pressure:
  - Fistula pressure
  - Blood flow
  - Blood viscosity
  - Flow resistance in the blood circuit
  - Level difference between the fistula and the venous drip chamber
- Movement of the arm is most frequent cause of change in VP during dialysis. (moving 30cm vertically can increase VP by 22mmHg)



Polaschegg H.-D. (2010). Venous needle dislodgement: the pitfalls of venous pressure measurement and possible alternatives, a review. *Journal of Renal Care* **36**(1), 41-48.

Blood loss and venous pressure

- Alarm limits are often set with range of ~30-40mmHg to prevent false positive alarms
- Static fistula pressure ~15mmHg at venous needle ~27mmHg at arterial site. (Grafts ~50mmHg at arterial and ~35mmHg at venous)
- If needle is dislodged the pressure drop may fall within the acceptable range



Besarab A. & Frinak S. (1998). The prevention of access failure: pressure monitoring. *American Society for Artificial Internal Organs (ASAIO)* 44, 35-37.

Question Revisited

In the case of needle dislodgement during a dialysis treatment session, safety mechanisms exist in dialysis machines whereby the blood pump will always stop if a needle becomes dislodged.

A) True

B) False

Question Revisited

When a dialysis needle becomes dislodged during a treatment session:

A) Dropping venous pressure in the extracorporeal circuit will always stop the blood pump

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C) Arterial pressure will become less negative and always stop the blood pump

D) Venous pressure may not drop enough to trigger the alarm or stop the blood pump

Take home points: Needle Dislodgement

- There is no reliable monitor incorporated into hemodialysis machines for the detection of needle dislodgement or blood loss from the blood circuit
- Drop in venous pressure during a dialysis run can indicate needle dislodgement, however, this drop may or may not be significant enough to trigger a stop of the blood pump
- Alarm parameters can be easily / absent mindedly reset due to “alarm fatigue”
- The access and tubing should always be open and uncovered for staff to view during dialysis (blankets, blue pads, etc. can obstruct view of the access)
- Prior to clearing any alarms, the patient should be assessed and the access should be viewed

Case #2

The Dialysate Circuit

Audience Question

Which of the following methods is utilized by hemodialysis machines to confirm the appropriate electrolyte composition of the final dialysate:

A) Flame emission spectrophotometry

B) Ion specific electrodes

C) Conductivity

D) Atomic absorption spectrophotometry

Audience Question

37 y/o F with Diabetes Type 1 and ESRD presents to medical attention with the following serum chemistries:

Na: 120mEq/L, K: 3.8mEq/L, Cl: 112mEq/L, CO2: 12mEq/L, BUN: 68 mg/dl, Creat: 6.8 mg/dl, Glc 400 mg/dl

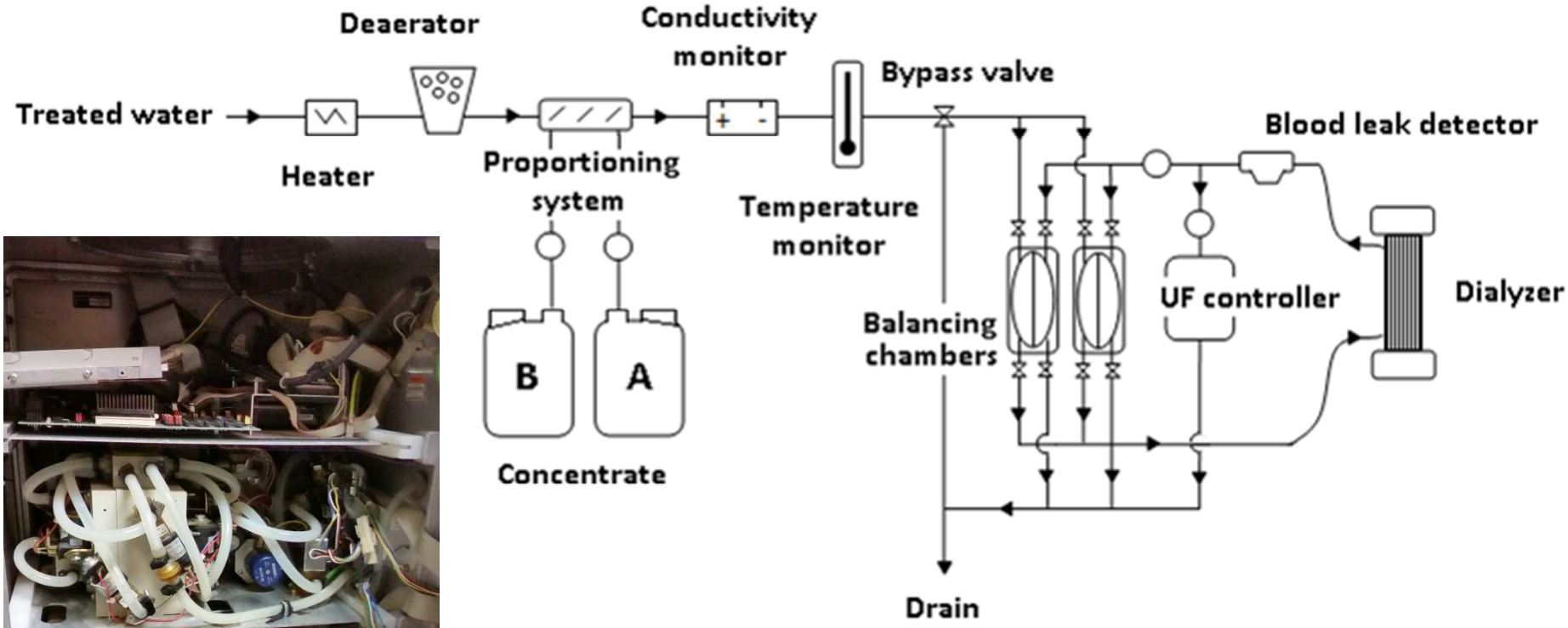
A dialysis prescription is written with a prescribed dialysate composition as below:

Na: 130mEq/L, K: 2mEq/L, HCO3: 45 mEq/L

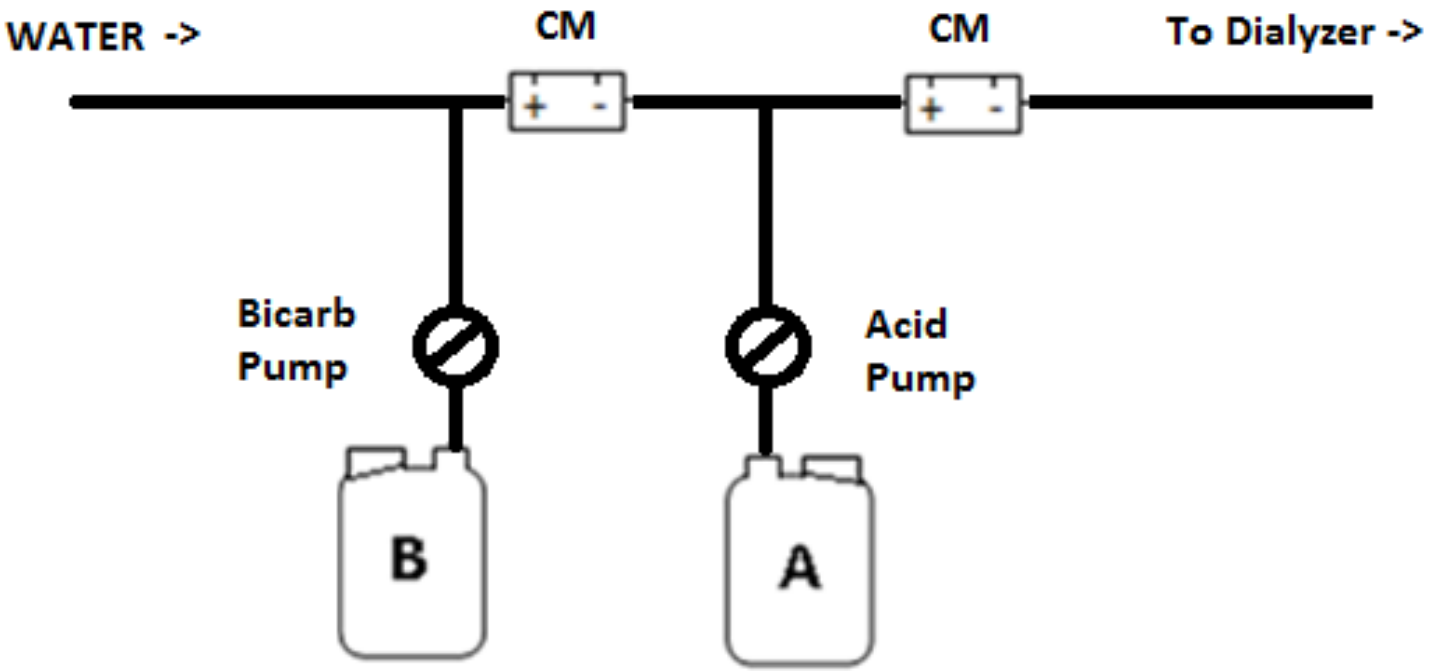
Based on this dialysis prescription, you would expect the delivered dialysate potassium to be:

A) = 2mEq/L
B) > 2 mEq/L
C) < 2 mEq/L

Dialysate Circuit

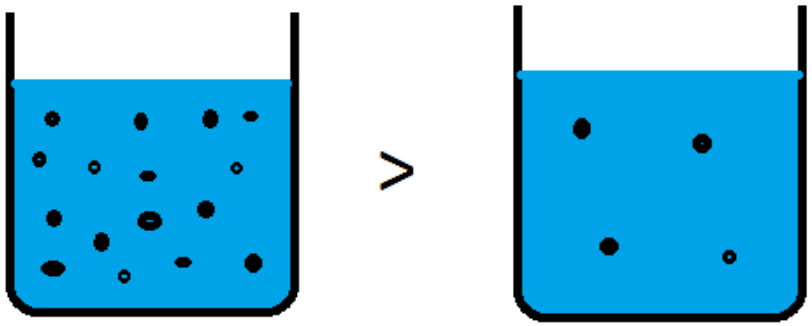


Proportioning System



Conductivity

- Measure of the ability of a material to conduct electric current
- Directly proportional to amount of solute dissolved in liquid



- Sodium is present in higher concentration than other dialysate solutes, therefore, it is the main contributor to conductivity of dialysate. (conductivity of 13.5 mS/cm ~ Na of 135)
- Conductivity measurement can be variable, accuracy relies on proper calibration
- Conductivity of the solution is independent of the pH of the solution

“A” Concentrate

2.0 K GRANUFLO® 2.5 Ca

NaturaLyte® Dry Acid Concentrate For Bicarbonate Dialysis

45X

62.5 LITER MIX (16.5 GAL)

NON-PYROGENIC

WARNING: Acid concentrate is formulated to be used in a three-stream hemodialysis machine calibrated to an acid concentrate dilution of 1:44. Use with other equipment may result in patient injury. NOT FOR PARENTERAL USE. For use only with NaturaLyte® 4000 Series Bicarbonate or equivalent (refer to label). **Use of this Acid Concentrate without associated bicarbonate concentrate may cause patient injury or death. Check conductivity and pH of dialysate just prior to dialysis treatment and each time new concentrate is supplied to the machine.**

Acetate contributes to the Total Buffer because it is rapidly converted to bicarbonate by the liver. This is in addition to the prescribed bicarbonate. Over prescribing bicarbonate and the resulting Total Buffer (bicarbonate + acetate) can lead to alkalosis in the patient, a significant risk factor associated with cardiopulmonary arrest. Under prescribing bicarbonate and the resulting Total Buffer (bicarbonate + acetate) can lead to acidosis, a significant risk factor associated with bone loss and increased risk of death.

IONIC CONTRIBUTION OF ACID CONCENTRATE: (Nominal Dilution 1:44)

SODIUM	100 mEq/L
POTASSIUM	2.0 mEq/L
CALCIUM	2.5 mEq/L
MAGNESIUM	1.0 mEq/L
ACETATE	8.0 mEq/L
CHLORIDE	101.50 mEq/L
DEXTROSE	100 mg/dL

CHEMICAL COMPOSITION

Total 21.7 kg

NaCl	15.8 kg
KCl	0.419 kg
$CaCl_2*2H_2O$	0.517 kg
$MgCl_2*6H_2O$	0.286 kg
$CH_3COONa–CH_3COOH$	1.60 kg
$C_6H_{12}O_6•H_2O$	3.09 kg

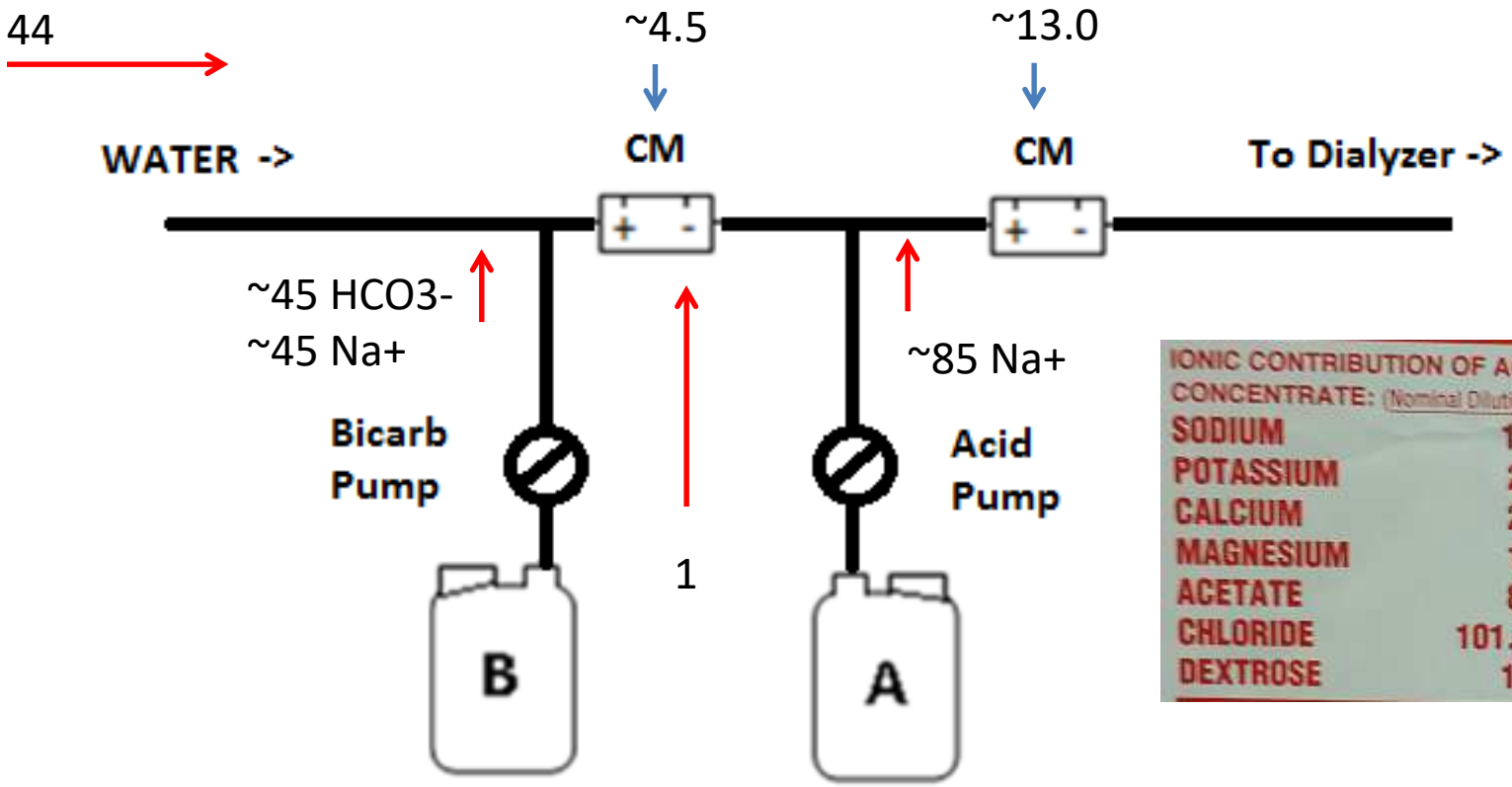
DILUTION INSTRUCTIONS

(The contents may clump or harden which does not affect product chemical composition)

1) **Use water that meets or exceeds current ANSI/AAMI hemodialysis water quality standards.** Water temperature should be 20°– 30° C to optimize dissolving.

Proportioning example

Dialysate Rx: Na: 130mEq/L, K: 2mEq/L, HCO3: 45 mEq/L



85% of rest of A bath components delivered ➔ 1.7 mEq/L of potassium

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C) < 2 mEq/L

Take Home Points: Dialysate Proportioning

- Hemodialysis machines rely on conductivity to proportion dialysate
- Conductivity of a solution is independent of the pH of a solution. Accidentally using the wrong solution can lead to acidosis or alkalosis without change in conductivity
- Changes in the sodium or bicarbonate level in the dialysate will have impact on all the rest of the dialysate constituents drawn from the A bath
- In general it is a good idea to adjust the sodium and bicarbonate in the same direction when prescribing dialysate chemistry

The End