A simple and feasible method to determine absolute blood volume in haemodialysis patients in clinical practice

Susanne Kron[1], Daniel Schneditz[2], Til Leimbach[3], Sabine Aign[3], Joachim Kron[3]

[1]Department of Nephrology, Charite, Universitätsmedizin Berlin, Germany, [2]Institute of Physiology, Medical University Graz, Austria,
[3]KfH Kidney Centre Berlin-Köpenick, Berlin, Germany

Volume management is a central issue of dialysis pursuing the normalisation of patient´s total body water. But intravascular volume is most significant for haemodynamic stability . A technique to measure absolute blood volume has not been available in clinical practice so far. We developed a simple method to determine absolute blood volume during haemodialysis in everyday clinical practice and examined its features with regard to volume overload, clinical relevance, and accuracy.

Theory of the method:

Relative blood volume (RBV) monitoring is a standard feature of modern dialysis devices. Furthermore, defined volumes of ultra-pure dialysate can automatically be injected into the extracorporeal circulation without direct manipulation of fluids and blood lines as an emergency function.
The dilution of blood and the calculated increase in relative blood volume (in %) caused by the infusion of ultra-pure dialysate can be used to determine the absolute blood volume (V, in L) at the time of infusion as:

$$\text{absolute blood volume (in mL)} = \frac{\text{bolus volume (240 mL)} \times 100\ \%}{\text{increase in relative blood volume in \%}}$$

Clinical procedure:

- start of dialysis treatment without ultrafiltration (UF)
- after having attained a stable relative blood volume reading:
- **infusion of 240 mL dialysate on-line bolus** by pressing the emergency button on the keypad of the dialysis machine 5008 (FMC, Bad Homburg, Germany)
- relative blood volume data before and after bolus administration were manually recorded from the blood volume monitor and absolute blood volume was calculated using equation above
- UF start (prescribed UF + bolus volume)

Clinical results:

In 30 stable chronic haemodialysis patients absolute blood volume was

at tratment start

6.50 ± 1.70 L = 80.1 ± 12.8 mL/kg dry weight

at treatment end

5.84 ± 1.61 L = 72.0 ± 12.1 mL/kg dry weight

Based on clinical judgment 11 patients appeared either volume overloaded (n=6) or “too dry” (n=5) but had previously refused to have their “dry weight” adjusted:

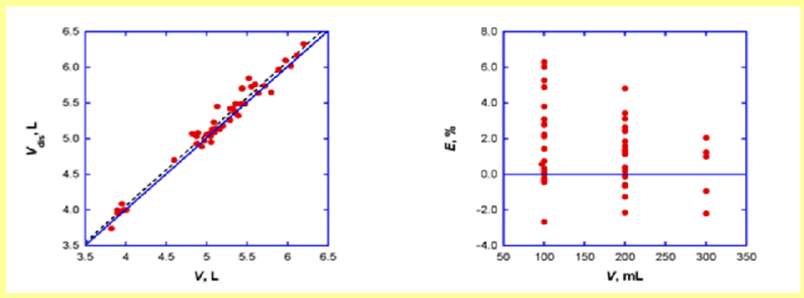
Absolute blood volume (aBV) and volume excess measured by bioimpedance (VE) in relation to clinical volume status

	Overloaded (n=6)	Euvolaemic (n=19)	“Too dry” (n=5)
aBV, mL/kg			
beginning	96.7±9.2*	78.6±9.3†	66.2±5.0
end of dialysis	87.3±8.5*	70.7±8.9†	58.6±5.7
VE, L			
Pre-dialysis	3.97±1.13#	2.29±1.30	1.30±0.92

*p<0.001 compared with the other groups, † p<0.01 compared with “to dry” patients, #compared with clinical euvolaemic patients p<0.01 and with “too dry” patients p<0.01.

In vitro studies

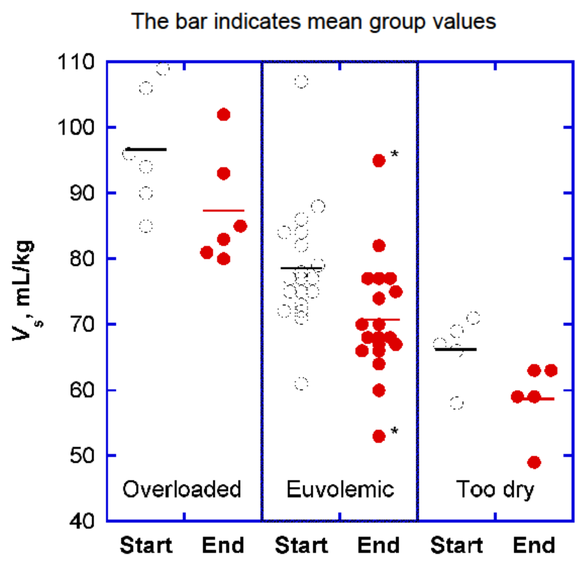
Additionally, in vitro studies were done to check the accuracy of the technique. **Bovine blood** was placed in a thermostat bath. The volume of the blood was measured at the beginning of the test. The volumes of the primed blood lines (145 mL) and the dialyzer blood compartment (82 mL) were added to this volume to determine the initial test volume. The test volume was subsequently corrected for any added bolus volume. 49 dilutions were done in five experimental setups using bolus volumes of 100, 200, and 300 mL . The mean difference between calculated and measured volumes was **1.29 ± 2.07 %** (n=49). Linear regression analysis gave the following relationship: Vcalc=1.014*Vmeas-0.004; **r^2=0.97** (left panel). The relative error of the measurement decreased as bolus volume increases (right panel).



Bolus volume of 240 ml proved to be a reasonable compromise between accuracy, volume load and technical possibilities of the dialysis machine.

Clinical reproducibility (tested in 10 patients three times in the same treatment session) was very high (coefficient of variation of **3.97 %**).

Absolute blood volume (in mL/kg) at the beginning and at the end of dialysis



Intradialytic morbid events occured in 5 of 8 patients with blood volume below **65 ml/kg** at the end of treatment:

Patient	Symptoms	aBV, mL/kg
#1	None	64
#2	Nausea	63
#3	Mild cramps	63
#4	None	60
#5	Cramps, nausea	59
#6	Mild cramps	59
#7	None	53
#8	Loss of voice	49

Intradialytic morbid events were absent above 65 mL/kg.

IN CONCLUSION, the described method is simple, safe, accurate, inexpensive, noninvasive, and feasible using current dialysis technology in everyday clinical practice. The technique has the potential for complete automation with appropriate modifications in system software. Additional changes in hardware are not required.

THEREFORE, WE CALL UPON MANUFACTURERS TO IMPLEMENT THIS TECHNIQUE INTO MACHINES USED FOR TREATMENT OF BOTH CHRONIC AND ACUTE RENAL FAILURE.

IN PERSPECTIVE, routine use of our method might initiate the concept of "dry blood volume“ instead the current concept of "dry weight“. A target blood volume can be prescribed and automatic feedback control may prevent blood volume from falling below a critical threshold by continuously adjusting the ultrafiltration rate to reach this target blood volume. At the end of every dialysis session blood volume would be in the optimum state of lowest cardiovascular strain for the patient. This would substantially improve patient’s long-term outcome.

51ERA-EDTA
415--MP
M) Dialysis. M1) Extracorporeal dialysis: techniques and adequacy.
Susanne Kron
DOI: 10.3252/pso.eu.51era.2014
Poster presented at: 51 ERA-EDTA CONGRESS AMSTERDAM 2014
PosterSessionOnline.com