Which is the critical absolute blood volume for intradialytic morbid events?

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Concerning haemodynamic stability blood volume is of most significance. Inadequate reduction of blood volume leads to intradialytic hypotension. A simple and feasible technique to measure absolute blood volume (aBV) has not been available in clinical practice so far. Recently, we presented a simple method to determine absolute blood volume during routine haemodialysis (1). Information regarding aBV could be of particular interest to prevent intradialytic morbid events (IME). Therefore, we studied now **patients who were prone to intradialytic morbid events** with the aim to identify the critical threshold for absolute blood volume.

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 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)

Relative blood volume was continuously recorded during the treatment session by the blood volume monitor integrated into the dialysis machine. Absolute blood volume at any other time, and especially at occurrence of intradialytic morbid events, is given as:

aBV (t) = aBV (0) at beginning x RBV (t) in %/100

Absolute blood volume data were normalized for body mass at dry weight (in mL/kg).

Patients:

The study was done in maintenance haemodialysis patients of the institutional dialysis program in a single center (n=201 haemodialysis patients). All patients with a double needle access were included who had two or more IME in the preceding 2 weeks. Patients with single needle or catheter access were excluded, furthermore, patients with interdialytic weight gain of more than 4 kg (overall n=9). One patient did not consent for the study.

The remaining 12 patients were observed during a single dialysis session with regard to IME.

Results:

10 out of 12 patients became symptomatic at an aBV between 65 and 56 ml/kg (mean 62 ml/kg).

In 8 of 10 IME medical intervention (in addition to changes in body position etc.) was necessary so that the prescribed treatment target was not achieved.

In 2 patients no symptoms were observed in the examined treatment sessions. One of these patients had an aBV of 58 ml/kg at the end of dialysis. However, severe symptomatic hypotension had occurred in every dialysis session in the last two weeks. So it can be assumed that the patient had reached the critical aBV in those sessions. The twelfth patient was volume overloaded. Cardiac dysfunction seems to have caused the IME in this patient.

Absolute blood volume at the onset of symptoms:

Patient	Symptoms	ABV at IM (ml/kg)	Additional therapy
1	symptomatic hypotension, severe cramps	64	240 ml infusion
2	symptomatic hypotension	63	UF stop
3	symptomatic hypotension severe cramps	61	untimely termination of dialysis session
4	loss of voice	56	
5	cramps	59	UF stop
6	cramps	63	
7	symptomatic hypotension	63	UF stop
8	cramps	64	120 ml infusion
9	symptomatic hypotension	65	240 ml infusion
10	severe cramps	64	120 ml infusion
11	none (symptomatic hypotension in every dialysis in the last 2 weeks)	58*	
12	none	78*	

* In Patients 11 and 12 ABV at dialysis end.

IN CONCLUSION, an absolute blood volume of 65 ml/kg seems to represent the threshold for volume-dependent intradialytic morbid events.

Current on-line haemodiafiltration machines equipped with a blood volume monitor and an online bolus function can be used to determine absolute blood volume in clinical practice. With a software modification this technique could be completely automated without altering the hardware of the dialysis device. Present integrated feedback-controlled systems for automated blood volume-controlled ultrafiltration should be adapted to this critical absolute blood volume. If such technology would be available, volume-dependent IME could be almost completely avoided.

Therefore, we call upon manufacturers to implement this modification into their on-line haemodiafiltration machines.

1. Kron J, Schneditz D, Leimbach T, Aign S, Kron S: A simple and feasible method to determine absolute blood volume in hemodialysis patients in clinical practice. Blood Purif 2014; 38: 180-187.

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L1) Dialysis. Extracorporeal dialysis: techniques and adequacy.
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DOI: 10.3252/pso.eu.52era.2015
ePosters supported by F. Hoffmann- La Roche Ltd.