Effects of sodium changes on measuring relative blood volume: Comparisons between three haemodialysis devices

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Recording the relative blood volume is a standard feature of modern dialysis devices. Removal of plasma volume leads to an increase in the relative hemoglobin concentration thus causing changes in absorption or reflection of near-infrared light or the speed of ultrasonic sound.

Three different measurement systems are incorporated in currently available dialysis machines:

The Gambro-Hospal group (**Integra**, **AK 200**, **Artis**) features a blood volume monitor based on **optical method**. An optoelectronic instrument measures the absorption of near-infrared monochromatic light transmitted through blood. The amount of **absorption** is directly related to the hemoglobin concentration

The Nikkiso **DBB series** feature a blood volume monitor based on **optical method**. In the Nikkiso system near-infrared monochromatic light is transmitted through blood likewise. The blood volume is deduced from the **reflected** light measured by a light-receiving element.

The dialysis machines **4008** and **5008** perform blood volume monitoring with an **ultrasonic method**. Blood volume is assessed by measuring the transit time of an ultrasonic pulse transmitted through blood. The speed of sound in whole blood depends on the total protein concentration which is the sum of plasma proteins and hemoglobin.

On grounds of clinical evidence suggesting a malfunction of the optical methods in the presence of sodium changes, we compared the three systems under major osmotic changes.

Method:

Six stable chronic hemodialysis patients underwent dialysis sessions with the **AK 200**, the FMC **5008**, and the Nikkiso **DBB-07** machine. The treatment conditions were identical in all three sessions. To induce rapid osmotic changes, **10 ml of hypertonic saline (20%NaCl)** were administered as a bolus injection into the venous blood line after 2 hours of treatment. The data recorded by the blood volume monitors of the three dialysis devices were compared.

Results:

One minute after the bolus injection, the 3 monitors show the following displays:

AK 200:

- 8.7 % **(± 4.6 %, range -17.4 to -5.3 %)**

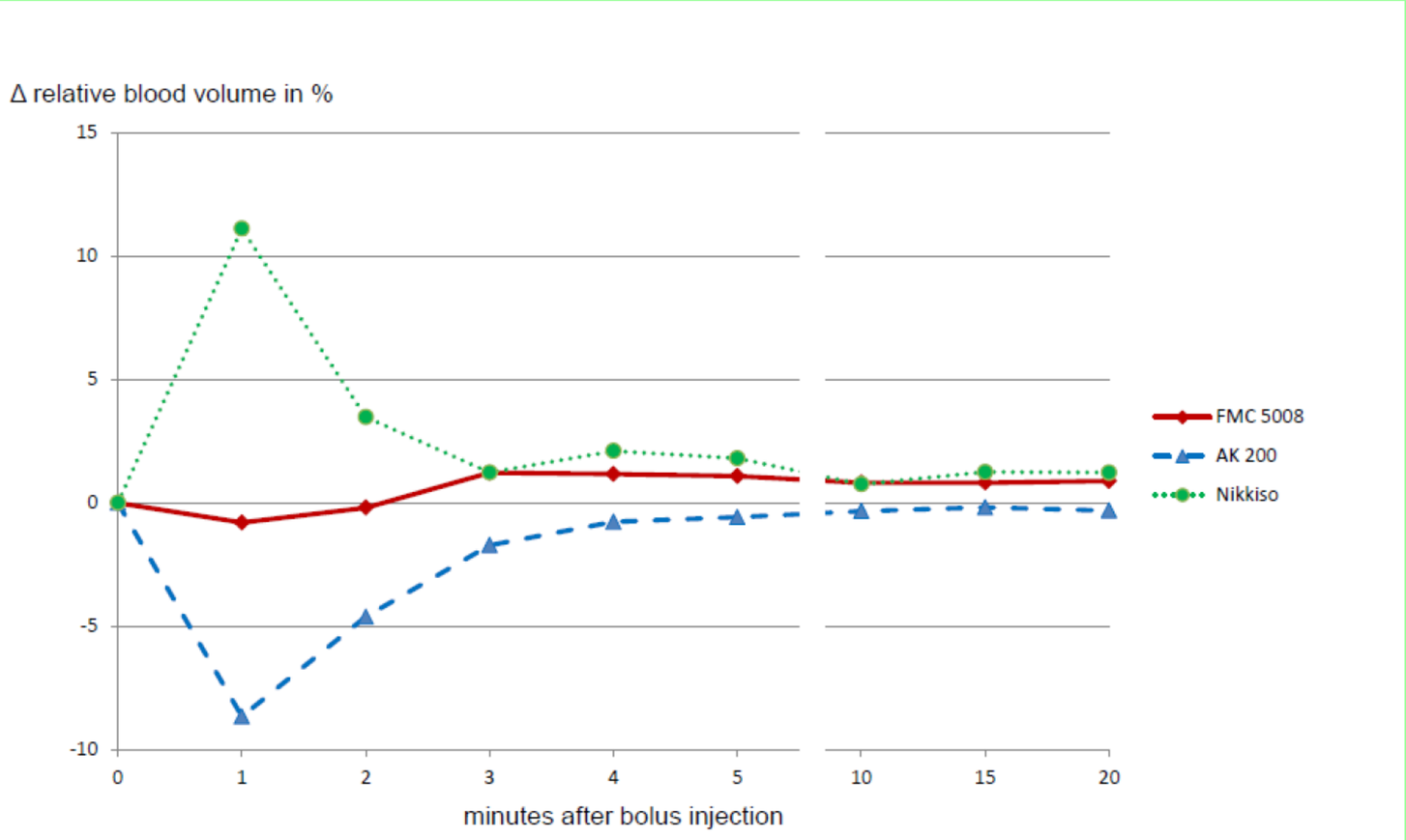
Nikkiso DBB-07:

+11.1 % **(± 3.1 %, range +7.2 to +15.8 %)**

5008:

-0.8 % **(± 0.9 %, range -1.8 to +0.5 %)**

After 3 minutes, the ultrasonic and the optical reflection devices displayed the same results, whereas the absorbance monitor showed still significant differences to the other two methods after 20 minutes (p=0.046).



Major osmotic changes alter the ratio of scattered and crossing light most likely due to changes of the red cell surface. They affect the measurement by optical devices to an extraordinary extent. Under the tested conditions, both optical systems show opposite and non-plausible courses of blood volume changes in the first minutes. The ultrasonic system seems to be less susceptible to osmotic changes.

Devices used for relative blood volume measurement in haemodialysis should be insensitive to osmosis-induced changes in red blood cell volume, especially if they are included in sodium changing feedback-control systems.
It is noteworthy that the both examined optical systems are incorporated in feedback-control systems (Hemocontrol™, Haemo-Master™) which based to a part on changes of dialysate conductivity.
Therefore, the reliability of sodium changing feedback-control systems featuring these tested optical monitors have to be critically reviewed.

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