

# In-vitro laboratory evaluation of the hemolytic effects of the finger peristaltic drive module of a CODAN ARGUS volumetric infusion pump

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## Background

Blood cells pumped by technical systems are exposed to non-physiological mechanical stress. Hemolysis or subhemolytic damage may occur. Interaction between cells and the artificial material as well as the shear stress are the main reasons for this traumatization. In this in-vitro laboratory evaluation the effects of the finger peristaltic pump action as exerted by a drive module as used in the CODAN ARGUS volumetric pumps on red blood cells (RBC) was measured. As indicators for hemolytic effects three markers highly sensitive for hemolytic changes were selected to be compared before and after the pump process: free potassium (K), lactate dehydrogenase (LDH) and aspartate aminotransferase (ASAT).

## Methods

### *Experimental Setup*

A blood transfusion was simulated in the laboratory setting. For three experiments an erythrocyte concentrate (packed red cells) bag (Blutspendedienst SRK Bern AG, Bern, Switzerland) was attached 80 cm above the lab table after warming it to room temperature for at least 8 hours (previously stored at 4 to 8°C). After drawing a blank sample directly from the bag a CODAN transfusion set with 200 µm filter (CODAN Medizinische Geräte GmbH & Co KG, Lensahn, Germany) was inserted in the RBC bag. The line was then flushed with at least twice the volume of the complete set. Thereafter the second blank was drawn from the end of the line where a 3 way stop cock was attached. The infusion line was then placed into the volumetric pump (ARGUS 707V SN 6138632, V4.30, with finger peristaltic drive module nr. 280.0005.08.A, CODAN ARGUS AG, Heimberg, Switzerland) on the lab table and the drip counter was attached to the drip chamber according to manufacturer's guidelines. The pump was then started to deliver 400 ml/h (high rate) and pumped the blood via a 18G needle attached to the infusion line approximately 20 cm above the pump to simulate a 15 mmHg venous pressure. The pumping into the waste container was maintained until the downstream line (as seen from pump) was flushed twice. For the subsequent sampling the needle was inserted through the membrane of a s-monovette which was fixed in an upright position and slightly opened to avoid pressure buildup. The same procedure was then repeated for an infusion rate of 20 ml/h (low rate). For both infusion rates 3 samples were collected for the analysis of the 3 different markers.

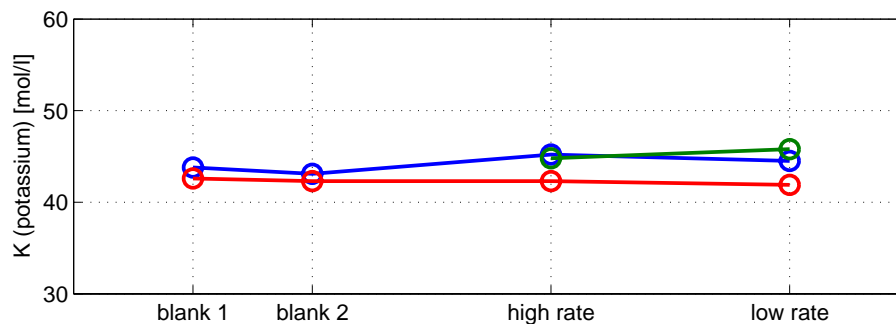
### *Probe Handling and Analysis*

All samples were drawn into a 5 ml s-monovette containing 90 I.U. heparin (Sarstedt, Nürnberg, Germany) and were immediately cooled to 0 – 4°C. The handling of the samples

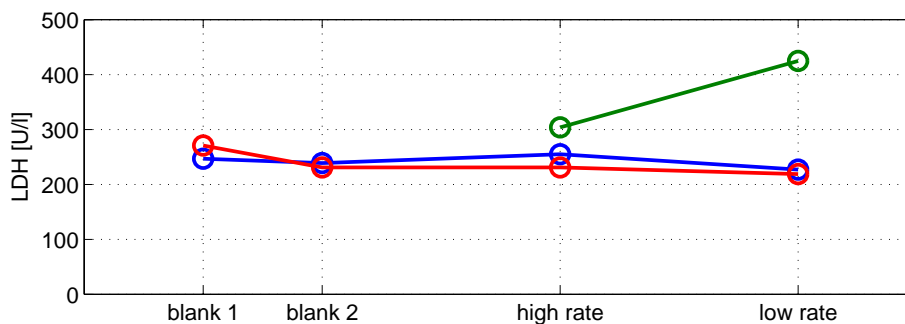
was as gentle as possible to avoid unintentional mechanical stress. All samples were then centrifuged at 4°C with 2000g for 30 minutes. The supernatant of the erythrocyte concentrate was then pipetted off the blood cells and put into test vials. The samples were then analyzed by the Institute of Clinical Chemistry (University Hospital, Bern, Switzerland) for free potassium (K), lactate dehydrogenase (LDH) and aspartate aminotransferase (ASAT).

## Results

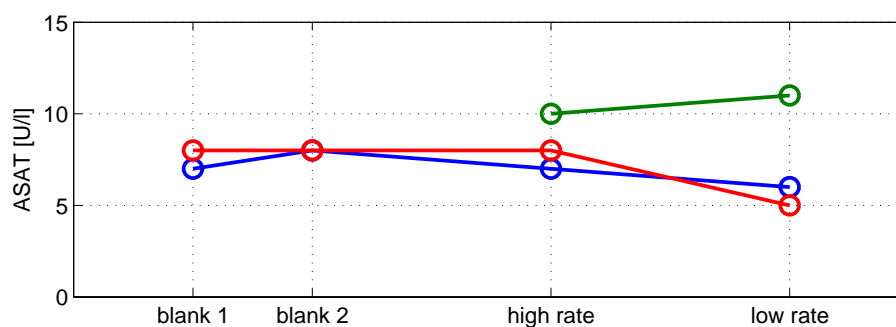
Three experiments with 3 different RBC-bags were conducted. The bags were all 26 days old on the day of the experiments and all with blood group 0+. Figures 1 to 3 show the results for the different markers. In the second of the three experiments the blanks could not be analyzed because there was no useful amount of supernatant available for analysis.



**Figure 1:** Free potassium as measured for 2 initial blanks and after pumping at 20 ml/h (low rate) and 400 ml/h (high rate). Blue, green, red colors for 1., 2. and 3. experiment respectively



**Figure 2:** Lactate dehydrogenase (LDH) as measured for 2 initial blanks and after pumping at 20 ml/h (low rate) and 400 ml/h (high rate). Blue, green, red colors for 1., 2. and 3. experiment respectively



**Figure 3:** Aspartate aminotransferase (ASAT) as measured for 2 initial blanks and after pumping at 20 ml/h (low rate) and 400 ml/h (high rate). Blue, green, red colors for 1., 2. and 3. experiment respectively

## Conclusions

It is important to compare the baseline values of the blanks with actual physiological values as shown in the table below. The column 'Blanks' shows the average values of all markers of all blanks drawn, the 'column 'Pumped' shows the average values of all the markers where we had matching blanks of all samples for both high and low infusion rates.

Marker	Standard *)	Blanks	Pumped
Potassium [mmol/l]	4.03 (95% C.I. 3.5 – 4.6)	43.0	43.5
LDH [U/l] men	331 ± 55	247	233
women	346 ± 65		
ASAT [U/l] men	11.3 (95% C.I. 6.2 - 20.8)	7.8	6.5
women	9.4 (95% C.I. 5.1 - 17.5)		

\*) Wissenschaftliche Tabellen Geigy, 8. Auflage 1979

Clearly the values for potassium are already elevated in the blood product because of its prior processing and mainly because of aging: the low storage temperature inhibits the activity of the sodium/potassium pump therefore  $K^+$  ions enter the stabilizing solution (up to 60 mmol/l at maximum storage period). The values for LDH and ASAT are a bit reduced but for ASAT still within the 95% confidence interval of its physiological values. The pump process shows no statistically significant changes in the values observed.

In summary we conclude that the pump mechanism shows no influence on the selected markers and can therefore be safely used for transfusion of blood products such erythrocyte concentrate (packed red cells).