Aarhus University Hospital
Validation Tempus600®
Transport system for blood tube samples

Pediatric blood samples

Department of Clinical Biochemistry, SKS
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Validation of Tempus 600® transport system for blood tube samples

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Abstract
Tempus600®[1] is a transport system dedicated for transporting blood sample tubes. After drawing the blood sample, the tubes are placed in the Tempus600® rack and loaded in the Tempus600® launch unit. The Tempus600® system was installed at Aarhus University Hospital, Skejby in November 2012. The launch unit is placed in the pediatrics ward and the point of delivery is the laboratory, Department of Clinical Biochemistry. The transport pipes are ø25, placed above the lowered ceilings. The system is the first of its kind in Denmark, transporting blood samples tubes, covering a distance of 406 meters, with a speed of 10 m/s.

Fig. 1 Launch unit
Fig. 2 Point of delivery in the lab.

Daily use
The blood tube sample transport system is handled by the biomedical laboratory technicians and nurses, with the aim of securing fast delivery of blood samples of acute care patients, mainly from the mother and children’s departments.

Methods and materials

Patients
20 patients for chemistry analysis were included in the validation.

The samples were drawn in the daytime 19th December 2012. The patients were randomly chosen among patients in the department’s phlebotomy clinic.

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Validation
The Tempus600® system was examined with a view to assess to what extent the blood samples were affected by the transport. Physical impact, such as shaking, acceleration, speed or G-forces, might destroy the blood cells, especially erythrocytes (the red blood cells) and give an incorrect test result[2]. 2 blood samples were drawn from each patient. One sample tube was sent by routine courier transport to the laboratory (reference) and the second one was sent with Tempus600®. Both sample batches were centrifuged as soon as possible upon arrival in the laboratory.

Blood analysis
The blood samples were tested for:

Biochemical tests (Roche Cobas6000 Analyzer)
- Plasma Potassium and Lactate dehydrogenase (LD) tests are influenced by erythrocyte destruction. The concentration of potassium and LD in erythrocytes are higher compared to content in plasma.
- Plasma Alkaline phosphatase has shown to be ascending by haemolysis[3]
- Haemolytic index (H-index) determines the level of free haemoglobin in plasma, as a measurement for erythrocyte destruction. We have established limits for allowable haemolysis in the samples (changes < 10%), expressed by H-index. H-index limits are <100 for Potassium, <15 for Lactate dehydrogenase and <200 for Alkaline phosphatase.

Blood collection
Becton Dickinson tubes were used for blood collection
- Fig. 3: Lithium heparin plasma, 4ml, catalog number. 368884 (blood tests adults)
- Fig. 3: Lithium heparin plasma, 2ml, catalog number. 368494 (blood tests children)
  - same length as 4 ml tube, but with reduced vacuum.
- Fig. 4: Microtube Microvette catalog number 201345100
  - The microtubes were placed in 14 ml Sarsted tubes (catalog number 55538 and push cap catalog number 65816), with Sarsted 3.5 ml tube (catalog number 55484) placed on top for stability.

Fig. 3

Fig. 4
Statistical procedures
We used Microsoft Excel 2003 with additional Analyze-IT program, for all statistical analyses. Comparisons of Tempus600® and routine courier transport (reference) were done by using Bland-Altmann difference plots (fig. 5). Two-sided F- and T-test were done to test for significant differences of Tempus600® and reference data. When p-value is less than the significance level 0.05, the result is said to be statistically significant. See below table.

Results

Table

<table>
<thead>
<tr>
<th>Tubes (children)</th>
<th>Unit</th>
<th>Tempus mean</th>
<th>Reference mean</th>
<th>bias</th>
<th>bias %</th>
<th>p-value</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium</td>
<td>mmol/l</td>
<td>137.60</td>
<td>137.60</td>
<td>0.00</td>
<td>0.00%</td>
<td>1.00</td>
<td>20</td>
</tr>
<tr>
<td>Potassium</td>
<td>mmol/l</td>
<td>3.90</td>
<td>3.91</td>
<td>-0.01</td>
<td>-0.26%</td>
<td>0.93</td>
<td>20</td>
</tr>
<tr>
<td>LD</td>
<td>UI</td>
<td>186.40</td>
<td>182.80</td>
<td>3.60</td>
<td>1.96%</td>
<td>0.83</td>
<td>20</td>
</tr>
<tr>
<td>Alkaline Phosphatase</td>
<td>UI</td>
<td>62.40</td>
<td>79.25</td>
<td>3.15</td>
<td>3.90%</td>
<td>0.77</td>
<td>20</td>
</tr>
<tr>
<td>H-index</td>
<td>mg/dl</td>
<td>4.35</td>
<td>6.70</td>
<td>-1.85</td>
<td>-22.00%</td>
<td>0.16</td>
<td>20</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Microtubes</th>
<th>Unit</th>
<th>Tempus mean</th>
<th>Reference mean</th>
<th>bias</th>
<th>bias %</th>
<th>p-value</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium</td>
<td>mmol/l</td>
<td>139.95</td>
<td>139.95</td>
<td>0.00</td>
<td>0.00%</td>
<td>1.00</td>
<td>20</td>
</tr>
<tr>
<td>Potassium</td>
<td>mmol/l</td>
<td>3.91</td>
<td>3.90</td>
<td>0.01</td>
<td>0.31%</td>
<td>0.87</td>
<td>20</td>
</tr>
<tr>
<td>LD</td>
<td>UI</td>
<td>180.30</td>
<td>173.10</td>
<td>7.20</td>
<td>4.25%</td>
<td>0.58</td>
<td>20</td>
</tr>
<tr>
<td>Alkaline Phosphatase</td>
<td>UI</td>
<td>76.10</td>
<td>76.30</td>
<td>0.20</td>
<td>-0.26%</td>
<td>0.98</td>
<td>20</td>
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<tr>
<td>H-index</td>
<td>mg/dl</td>
<td>4.45</td>
<td>0.95</td>
<td>3.5</td>
<td>129.63%</td>
<td>0.005</td>
<td>20</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Tubes (adults)</th>
<th>Unit</th>
<th>Tempus mean</th>
<th>Reference mean</th>
<th>bias</th>
<th>bias %</th>
<th>p-value</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium</td>
<td>mmol/l</td>
<td>138.3</td>
<td>138.6</td>
<td>0.20</td>
<td>0.14%</td>
<td>0.76</td>
<td>20</td>
</tr>
<tr>
<td>Potassium</td>
<td>mmol/l</td>
<td>3.95</td>
<td>4.00</td>
<td>-0.05</td>
<td>-1.20%</td>
<td>0.86</td>
<td>20</td>
</tr>
<tr>
<td>LD</td>
<td>UI</td>
<td>186.70</td>
<td>200.05</td>
<td>-1.35</td>
<td>-6.68%</td>
<td>0.37</td>
<td>20</td>
</tr>
<tr>
<td>Alkaline Phosphatase</td>
<td>UI</td>
<td>61.70</td>
<td>62.45</td>
<td>-0.75</td>
<td>-0.91%</td>
<td>0.96</td>
<td>20</td>
</tr>
<tr>
<td>H-index</td>
<td>mg/dl</td>
<td>3.70</td>
<td>4.85</td>
<td>-1.15</td>
<td>-26.50%</td>
<td>0.05</td>
<td>20</td>
</tr>
</tbody>
</table>

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Sample tubes for adults and children
No significant differences were found between routine transport and Tempus600® transport (p-values <0.05). When transporting the blood sample tubes using Tempus600® the tendency for hemolyses in the samples were less, compared to routine transport. The Tempus600® transport improved the quality of the results.

Microtubes
Significant differences were found between routine transport and Tempus600® transport for H-index (p-value <0.05). When transporting the blood sample tubes using Tempus600® the H-index went up approx. 3.5 mg/dl, compared to routine transport (min. 1 to max. 18 mg/dl). One sample exceeded the limit for H-index (15 mg/dl) during Tempus600® transport. Overall the higher values for the H-index were acceptable for the blood sample testing. For the other analyses no significant difference was noticed between routine transport and Tempus600® transport. (p-values > 0.05).

Conclusion
The validation of Tempus600® has shown very satisfying results. Based on the findings it is recommended using Tempus600® for transporting blood sample in different tubes.

References
1. www.tempus600.com
Fig 5: Bland-Altman difference plots

**Children**

**H-index**

![H-index Children Reference](image)

**Plasma Sodium**

![Sodium Children Reference](image)

**Plasma Potassium**

![Potassium Children Reference](image)

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Plasma Alkaline Phosphatase

Plasma Lactate Dehydrogenase

Microtubes

H-index
Plasma Sodium

Plasma Potassium

Plasma Alkaline Phosphatase
Plasma Lactate Dehydrogenase

![Graph showing the relationship between LD Microtube Tempus and LD Microtube Reference. The graph includes an identity line (A=B) and a scatter plot showing the difference between methods as a percentage.]

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