Evaluation of the Longitudinal Relaxation Rate of Blood in Neonates.

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Introduction

Critical illness in newborns may affect cerebral blood flow (CBF) through impaired autoregulation. This makes accurate perfusion quantification from utmost importance when evaluating brain perfusion in clinical studies. In an Arterial Spin Labeling (ASL) experiment the longitudinal relaxation rate of blood (T1b) determines how fast the tracer decays and as such should be obtained to accurately quantify CBF. Previously, techniques to measure the T1b in the neonatal population have been established1,2,3. In this study the T2-TRIR sequence was used to measure the T1b in a large cohort of neonates. The purpose of this research was to investigate the influence of the T1b on perfusion quantification and to find the relation between hematocrit and T1b.

Materials and methods

MR imaging (3.0T, Philips) was performed in 112 neonates with a mean gestational age at scan of 39 weeks (range: 30-54 weeks). The study was in line with institutional guidelines. Scan parameters of the T2-TRIR sequence were: TR/TEA/TI1=1500/20/150 ms, matrix 128x128, FOV 160x160, FA 95°, 2mm slice, SENSE=2.5, cTE=40,80 and 160ms and scan time 2:15. In addition, in a subset of the neonates pulsed ASL and 2D-PC-MRA were performed. The inversion recovery of venous blood perfusion was shown to be more accurate after implementing the T1b. In 77 neonates (69%) T1b-fitted CBF was investigated. In 13 neonates hematocrit was measured on a capillary blood sample (Htcc) and in 8 neonates Htc was measured on an arterial blood sample (Htc). The longitudinal relaxation rate of blood should be fitted in neonates when quantifying CBF. Previously, the longitudinal relaxation rate of blood (T1b) was found to be: R1b=0.27+0.334 (R2=0.298, p= 0.083) (Figure 2).

Results

In 77 neonates (69%) T1b fitting was successful. An overview of the subject characteristics and corresponding mean T1b values is given in Table 1. A significant difference between ASL-T1b-fitted CBF and ASL-T1b-fitted was shown (p=0.007, Wilcoxon signed-rank test). Mean % difference between ASL-T1b-fitted CBF and ASL-T1b-fitted CBF was 13% [range -12% to 37%] (Figure 1). Linear regression showed an R2 of 0.597 when comparing 2D-PC-MRA CBF to ASL-T1b-fitted CBF (p=0.005), R2 increased to 0.665 after implementing T1b-fitted (p=0.002) (Figure 1). The relation between R1b and Htc was found to be: R1b = 0.27Htc + 0.423 (R2=0.199, p= 0.000) and R1b = 0.577Htc + 0.334 (R2=0.298, p= 0.083) (Figure 2).

Discussion

A good performance of the T2-TRIR sequence to measure the T1b was shown. Perfusion was shown to be more accurate after implementing the T1b-fitted in the quantification model. The relation between Htc, arterial sampled, and the longitudinal relaxation constant of blood was similar to the one found by Varela et al; R1b =0.5. Htc + 0.37 3. However, the spread in our data was much wider and as such the relation was not significant. Noise in our fitting model may attributed to this. In addition, intrinsic noise in blood sampling might influenced this as well. In our data we did show that the relation between the longitudinal relaxation rate constant of blood and hematocrit was dependent on the sampling technique.

Conclusion

The longitudinal relaxation rate of blood should be fitted in neonates when quantifying ASL perfusion images. The relation between hematocrit and the longitudinal relaxation rate constant of blood is dependent on the sampling technique.

Acknowledgements

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References


Table 1: Subject characteristics, for subjects with successful T2-TRIR scan, are given. Subjects were categorized; infants scanned at preterm age, infants scanned at term-equivalent age (TEA), infants scanned at 3 months-equivalent age (3m), infants diagnosed with asphyxia (n=10) and others. Postconceptional age is age when born, corrected postconceptional age is age when MR imaging was performed Mean T1b-fitted and standard deviation for each category are shown.

<table>
<thead>
<tr>
<th>Postconceptional age</th>
<th>Corrected postconceptional age</th>
<th>T1b</th>
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</thead>
<tbody>
<tr>
<td>Preterm</td>
<td>13</td>
<td>27 [26-28]</td>
</tr>
<tr>
<td>TEA</td>
<td>40</td>
<td>28 [24-33]</td>
</tr>
<tr>
<td>3m</td>
<td>3</td>
<td>39 [37-40]</td>
</tr>
<tr>
<td>Asphyxia</td>
<td>10</td>
<td>39 [36-42]</td>
</tr>
<tr>
<td>Others</td>
<td>11</td>
<td>37 [34-54]</td>
</tr>
</tbody>
</table>

| Preterm             | 13                            | 27 [26-28] | 31 [30-31] | 1.827 [0.312] |
| TEA                 | 40                            | 28 [24-33] | 41 [40-43] | 1.928 [0.173] |
| 3m                  | 3                             | 39 [37-40] | 52 [50-53] | 1.274 [0.227] |
| Asphyxia            | 10                            | 39 [36-42] | 40 [37-42] | 1.760 [0.190] |
| Others              | 11                            | 37 [34-54] | 40 [39-54] | 1.731 [0.181] |

Figure 1: Left: ASL-T1b-fitted CBF is compared to ASL- T1b-fitted CBF. The zero line (x-axis) represents ASL-T1b-fitted CBF. The difference between both quantification models is given in %CBF and is shown for each subject. In most subjects ASL-T1b-fitted CBF was higher than ASL- T1b-fitted CBF, visualized here by a positive difference. Right: The relation between ASL CBF (x-axis) and 2D-PC-MRA CBF (y-axis) is shown. In blue ASL-T1b-fitted CBF and in green ASL- T1b-fitted CBF. The relation improves after fitting the T1b.

Figure 2: The trend line is a linear fit between the inverse of T1b and Htc. The trend line is a linear fit between the inverse of T1b and Htc.