4-2016

Analysis of Breath-Holding Index as an Assessment of Cerebrovascular Reactivity

Allison P. Porter  
University of Nebraska - Lincoln, porterap3@yahoo.com

Madison Burger  
madison.burger@huskers.unl.edu

Mohammed Alwatban  
University of Nebraska-Lincoln

Benjamin Hage  
University of Nebraska-Lincoln

Greg Bashford  
University of Nebraska-Lincoln, gbashford2@unl.edu

Follow this and additional works at: http://digitalcommons.unl.edu/ucarereresearch

Part of the Bioelectrical and Neuroengineering Commons, Bioimaging and Biomedical Optics Commons, and the Other Biomedical Engineering and Bioengineering Commons

Porter, Allison P.; Burger, Madison; Alwatban, Mohammed; Hage, Benjamin; and Bashford, Greg, "Analysis of Breath-Holding Index as an Assessment of Cerebrovascular Reactivity" (2016). UCARE Research Products. 89.  
http://digitalcommons.unl.edu/ucarereresearch/89

This Poster is brought to you for free and open access by the UCARE: Undergraduate Creative Activities & Research Experiences at DigitalCommons@University of Nebraska - Lincoln. It has been accepted for inclusion in UCARE Research Products by an authorized administrator of DigitalCommons@University of Nebraska - Lincoln.
Cerebrovascular reactivity (CVR) is a key factor in regulating blood flow into the brain, and a marker for vascular disease. If the brain's regulatory system is not working, a patient may be in serious trouble. Testing of CVR is one method of assessing the brain's regulatory capabilities. Transcranial Doppler ultrasound (TCD) is one tool to measure CVR. In this method, carbon dioxide in the blood is transiently increased (such as with the holding of breath), and the resulting blood flow in the brain is measured. The measurements of CVR were then compared within subjects and across the population using standard deviation. This was done to determine the variability of CVR between trials of the same subject, as well as the variability of CVR across all subjects.

CVR was calculated using the formula:

\[
\frac{V_{\text{mean,b}} - V_{\text{mean,m}}}{V_{\text{mean,m}}} \times \text{time}
\]

Where \(V_{\text{mean,b}}\) is the mean blood flow velocity before breath-holding and \(V_{\text{mean,m}}\) is the maximum mean blood flow velocity during breath holding, and time is the time where \(V_{\text{mean,m}}\) occurs.

The measurements of CVR were then compared within subjects and across the population using standard deviation. This was done to determine the variability of CVR between trials of the same subject, as well as the variability of CVR across all subjects.

### Results

Table 1: Mean Blood Velocity (cm/s), CVR (s^{-1}), and mean arterial blood pressure (MAP, mmHg), for breath-holding each trial for each of the four subjects.

<table>
<thead>
<tr>
<th>Subject(Trial)</th>
<th>Mean Blood Velocity (cm/s)</th>
<th>CVR* (s^{-1})</th>
<th>Average CVR (s^{-1})</th>
<th>MAP (mmHg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1(1)</td>
<td>41.7</td>
<td>2.15</td>
<td>1.86</td>
<td>94</td>
</tr>
<tr>
<td>1(2)</td>
<td>40.3</td>
<td>1.62</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1(3)</td>
<td>40.8</td>
<td>1.8</td>
<td>93.33</td>
<td>-</td>
</tr>
<tr>
<td>2(1)</td>
<td>60</td>
<td>1.9</td>
<td>1.74</td>
<td>83.67</td>
</tr>
<tr>
<td>2(2)</td>
<td>60.2</td>
<td>1.8</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2(3)</td>
<td>62.5</td>
<td>1.52</td>
<td>89.33</td>
<td>-</td>
</tr>
<tr>
<td>3(1)</td>
<td>65</td>
<td>1.8</td>
<td>1.63</td>
<td>89</td>
</tr>
<tr>
<td>3(2)</td>
<td>70</td>
<td>1.5</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>3(3)</td>
<td>73</td>
<td>1.6</td>
<td>93.33</td>
<td>-</td>
</tr>
<tr>
<td>4(1)</td>
<td>75</td>
<td>2.4</td>
<td>1.7</td>
<td>99.33</td>
</tr>
<tr>
<td>4(2)</td>
<td>74</td>
<td>1.4</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>4(3)</td>
<td>76</td>
<td>1.3</td>
<td>91</td>
<td>-</td>
</tr>
</tbody>
</table>

### Discussion & Conclusion

Within the four subjects, the standard deviations of the CVR measurements are 0.27, 0.20, 0.15, and 0.61 respectively, with an overall standard deviation of 0.31 across the population. The standard deviation between the average CVR measurements of each subject is 0.09. The CVR measurement is usually higher after the first breath-holding for each subject, with the following two CVR measurements being lower and less variable. There is no significant increase or decrease in the mean arterial blood pressure (MAP) before or after breath-holding.

In conclusion, the breath-holding maneuver is a convenient and well-tolerated screening method for CVR. However, this experiment showed a high variability in this measurement. To obtain an accurate result, three breath-holding indices need to be taken and averaged for each subject.

### References & Acknowledgements

- Markus, H. S., & Harrison, M. J. (1992). Estimation of cerebrovascular reactivity using transcranial Doppler, including the use of breath-holding as the vasodilatory stimulus. Stroke; a Journal of Cerebral Circulation, 23(5), 668–673. [http://dx.doi.org/10.1161/01.STR.23.5.668](http://dx.doi.org/10.1161/01.STR.23.5.668)

- I would like to thank Marissa Nitz for the use of her TCD headband device in this experiment.

![Average Velocity](image-url)