B waves: a systematic review of terminology, characteristics and analysis methods

Martinez Tejada, Isabel; Arum, Alexander; Wilhjelm, Jens E.; Juhler, Marianne; Andresen, Morten

Publication date: 2019

Document Version
Publisher's PDF, also known as Version of record

Link back to DTU Orbit

Citation (APA):

General rights
Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.
B waves: a systematic review of terminology, characteristics, and analysis methods

Isabel Martinez-Tejada1,2, Alexander Arum1, Jens E. Wilhjem2, Marianne Juhrer1 and Morten Andreassen1
1Department of Neurosurgery, Rigshospitalet, Blegdamsvej 9, DK-2100, Copenhagen Ø
2Department of Health Technology, Technical University of Denmark, Building 349, DK-2800, Kongens Lyngby

Introduction

- B waves in intracranial pressure (ICP) were first described by Lundberg in 1960. These classical B wave patterns continue to be seen in the intensive care unit (ICU) setting and in severe disease states. Less prominent waveforms categorized as B waves appear today as patients undergo ICP monitoring for milder degrees of disease.

- Today’s B waves differ in amplitude and visual appearance from those defined by Lundberg, and they usually appear in an irregular pattern. Current diverging waveform definitions fail to adequately describe these patterns seen in daily clinical practice and hamper efforts to automate B wave detection.

- We still lack consensus on precise definitions, terminology, amplitude, frequency or origin of B waves. Several competing terms exist, addressing either their probable physiological origin or their physical characteristics. This diverging range of B wave definitions has not yet been formally classified, hindering their automatic identification in diagnostic or therapeutic scenarios.

Objective

To assess the various terms and definitions used to describe classical B waves.

Methods

A literature search was carried out using PubMed/MEDLINE, with the following search terms: B waves + review filter, slow waves + review filter, ICP B waves, slow ICP waves, slow vasogenic waves, Lundberg B waves, MOCAIP. A total sum of 816 paper abstracts were preliminarily screened for content relevance. 124 papers were included in the search review.

Results

Terminologies

- A total of 19 terminologies were found to describe B waves. The most common terms being B waves and (ICP) slow waves.

- The choice of terminology is often related to the ongoing etiology discussion: 22 articles include the word vasogenic.

Table 1. Major morphological B wave subclasses. B waves were measured based on their shape, prominence of plateau, frequency and amplitude. The shape is considered symmetrical if the duration of ascending and descending phases is the same. B waves are categorized into different subclasses if they have distinct shapes and/or if their amplitude is different.

<table>
<thead>
<tr>
<th>Class (Min. 2 times)</th>
<th>Description</th>
<th>Image</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asymmetrical</td>
<td>With or without plateau</td>
<td>![Image](Figure 1)</td>
</tr>
<tr>
<td>Symmetrical</td>
<td>With plateaux</td>
<td>![Image](Figure 2)</td>
</tr>
<tr>
<td>Other</td>
<td>Without plateau</td>
<td>![Image](Figure 3)</td>
</tr>
</tbody>
</table>

Figure 1. Frequency of terminology usage in the reviewed papers. Terminologies using the same name with/without including the term ICP were grouped as one. No importance was given to the order of words. Hyphens were removed. Terminologies in singular form were given to the order of words. Hyphens were removed. Terminologies in singular form were included as ‘Other.’

Figure 2. Presentation of different B waves sub-classification patterns. Each is illustrated by two examples: column A from ICP recordings and column B from a theoretical model. Examples on rows 2 and 2 exhibit B waves with symmetrical shape and amplitude lower and higher than 10 mmHg, respectively. Examples of row 3 correspond to symmetrical B waves with plateau. The last row shows examples for asymmetrical B waves.

Conclusion

This study demonstrates the lack of agreement with regard to the terminology and characteristics used to define B waves. Two future lines of action are possible for exploiting the role of macro-patterns in ICP signals and automate their detection:

1. Achieving strict agreement on morphological characteristics of "traditional" A and B waveform.
2. Starting new with a fresh computerized approach for recognition of new clinically relevant patterns.

References