MADSEN AccuScreen®

AccuScreen
ABR Screener

Test Methods

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Technical support
Please contact your supplier.

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1 Test Methods

1.1 About Auditory Brainstem Response (ABR)

Sounds are processed by the different parts of the ear and transformed by the auditory sensory cells to a series of action potentials, which are transmitted to the brain by neural conduction. On their way to the auditory cortex the action potentials pass a number of regions called nuclei, where the coded acoustic information is filtered, processed, compared to other information, and distributed to different pathways. These nuclei are the origin of „bursts" of synchronous multiple cell discharges, which cause electro-magnetic „far-field potentials", which can be tested via scalp electrodes. The potentials picked up by the electrodes are called Auditory Evoked Potentials (AEP) or auditory responses.

There are different AEP-producing regions between the cochlea and the primary auditory cortex. However, the responses of the brainstem (ABRs) are particularly well suited for hearing tests in new-borns, infants and children. Reasons for this include:

- The responses are not influenced by state, and can thus be tested during sleep. This is the ideal state to test ABRs because it minimises influence of potentials from muscular activity, which could make a good measurement difficult.
- Many investigations have shown that the behavioural hearing threshold correlates strongly with the response threshold of the brainstem. In other words: If an ABR can be tested as a response to an acoustic stimulus, it is nearly certain that the individual can hear this stimulus. It would only be in rare cases of damage to the midbrain or auditory cortex that this would not hold true.

Care must be taken during testing and evaluation in order to avoid false results. The amplitude of the electric response to a 30 or 40 dB stimulus is frequently below 100 nV and therefore considerably lower than the scalp electroencephalogram (EEG) and electromyogram (EMG).

1.1.1 How AccuScreen determines a *PASS* in ABR testing

The Auditory Brainstem Response (ABR) is a low-amplitude signal usually buried in the electric brain and muscle activity (EEG and EMG). It can only be extracted by applying special filtering techniques. "Averaging" is the procedure most commonly used to make it visible: the stimulus is presented repeatedly - up to several thousand times - and the signal from the electrodes, which follow the stimulus, is summed continuously until the response can be detected. Visual detection and interpretation of such a signal requires a great deal of expertise.

For screening purposes, the decision to pass or refer must be performed quickly and automatically. As a consequence, a different evaluation approach must be used for screening. A statistical approach determines the ABR PASS criterion.

The procedure involves the application of a template and weighted averaging. Each recorded sweep of raw EEG data is first cross-correlated with the template that represents a typical newborn ABR response. The resulting sweep is then weighted with a factor according to its amplitude. Since raw data is dominated by EEG and EMG noise, the amplitude of a raw sweep can be considered as a noise measure. Sweeps with high amplitude are weighted low, and sweeps with low amplitude are weighted high.

The resulting, averaged waveform is shown continuously, and statistical analysis is done periodically to issue a PASS or REFER result. The statistics involve calculating the amplitude of the waveform in the region that corresponds to the typical latency of a newborn ABR. This amplitude is then compared to an expected value for a no-response recording. The region where the amplitude is analyzed is shown as a box in the waveform display.

The waveform, because it has been processed with the template, does not feature a typical ABR pattern anymore. Instead, for a stable recording, it will show one major peak, that corresponds to the correlation function.

Because the shape of the ABR response waveform changes with age, the detection algorithm is optimised accordingly by pre-filtering the recorded signals with a typical pattern for infants up to one year old. Although this does not preclude testing older children and adults with AccuScreen, the sub-optimal fit may result in longer test times for these patients.

1.1.2 How AccuScreen performs simultaneous binaural ABR tests

Because the electrodes are placed on the forehead and nape, they record ABR signals regardless of which ear is being stimulated. However, the brain generates a huge amount of other signals at the same time, which act as noise in the ABR recording, because they are not synchronized with the acoustic stimulus.

The same mechanism can be used for a simultaneous recording of ABR on both ears: If both ears are stimulated at different stimulus rates, the opposite ear's ABR response can be treated as an uncorrelated signal and will disappear during averaging.

The AccuScreen uses a so-called jitter to randomize the stimulus rates when recording ABR anyway. For simultaneous recording, this randomization is done independently for both ears, and ABR is recorded in synchronization with each stimulus sequence independently.

The statistical evaluation for both ears is identical to the one that is used for testing only one ear, therefore the performance in sensitivity is equal. The overall gain in test time will, however, not be the ideal factor of two, because usually the two ears will need a different number of averages to pass due to statistical distribution. The simultaneous test has to wait for the "slower" ear, making the gain in test time somewhat lower, but still significant.

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