Comparison of Auditory Brainstem Response Systems in the NICU Population

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ABSTRACT

Completing auditory electrophysiologic recordings in preterm infants while in a NICU environment is a challenging procedure. Completion of a QI project can assist in determining whether investment in new technology is cost-effective. This project revealed that the Vivosonic Integrity obtained lower threshold levels in this noisy environment, and was comparable to the Bio-logic NavigatorPRO in classifying type and degree of hearing status.

INTRODUCTION

The Neonatal Intensive Care Unit (NICU) is an electrically hostile environment, with electrical signals in the frequency range of the Auditory Brainstem Response (ABR), which is much lower in amplitude than these extraneous noise sources. The NICU is also acoustically hostile, and the infant produces myogenic activity as well as respiration and vascular noise, which all can interfere with ABR recordings , particularly at low stimulus intensities.

Priorities for effective and efficient ABR Systems in the NICU include:

- **Ability to manage electrical artifact**
- **Ability to filter patient movement**
- **Ability to easily achieve acceptable impedance on infants with poor skin integrity**
- **Ease and efficiency of testing (i.e. data collection screens, protocol set up, data analysis, printing)**

- **NICU ABR challenge: Acoustic noise (low signal) + EMI (high noise) = low SNR → poor detection → false outcomes**

- **The Vivosonic Integrity™ system (Toronto, ON) aims to reduce electrical, ECG and EOG interference through an in-situ amplifier (Amplitrode™) mounted on the ground electrode, and to reduce myogenic artifacts through weighted averaging known as Kalman weighted averaging, through optimized signal buffering, and a Signal to Noise-adaptive filter.**

AIMS

1. Assess effectiveness of the Vivosonic Integrity™ system head to head with the Bio-logic NavigatorPro ABR system for click and toneburst ABR recordings.

2. Compare thresholds obtained for both systems to determine if responses could be improved using the Bluetooth amplifier, Kalman weighting and other features of the Vivosonic system.

METHODS

Participants:

- 28 infants tested in NICU with one or both instruments
- 20 ears provided click thresholds for both instruments
- 8 ears provided tone burst thresholds for both instruments at 1, 2 or 4 kHz

Hearing Status Categories (n=ears):

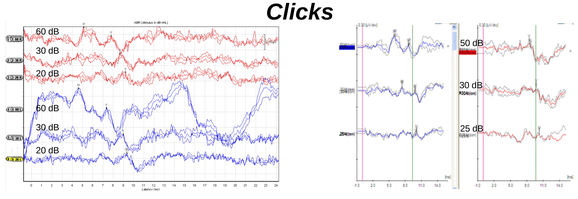
Normal = 11
Mild = 6
Mild to Moderate = 2
Profound = 2 (excluded from comparison)
Neural = 2 (excluded from comparison)

Procedures:

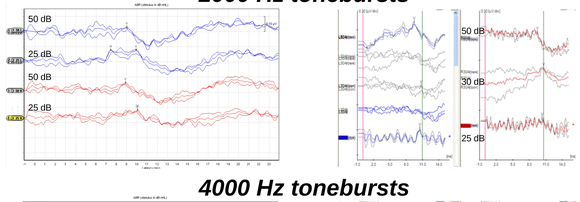
All tests were performed by an audiologist with over 10 years of experience assessing infants in the NICU with threshold ABR. Thresholds were independently verified by a second investigator. ABR protocol for the two systems is as follows:

Vivosonic Integrity	*Bio-logic NavigatorPro*
• Clicks Alternating: 37.1/s	• Clicks Alternating: 37.1/s
• Response filter: 100-3000 Hz	• Response filter: 100-3000 Hz
• Tones Alternating: 37.1/s	• Tones Alternating: 37.1/s
• Response Filter: 30-1500	• Response Filter: 70-1500

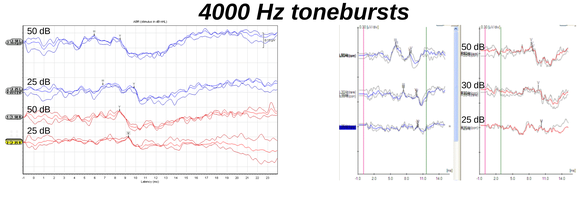
Clicks



2000 Hz tonebursts



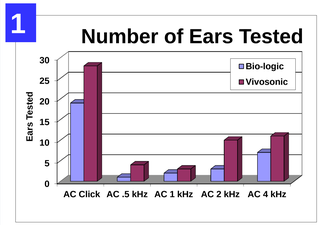
4000 Hz tonebursts



Individual click and tone burst responses from a single subject

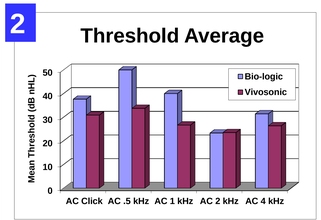
RESULTS

1



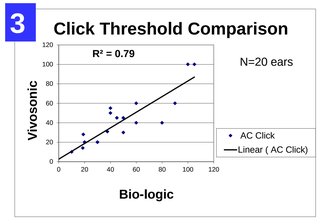
This figure shows the number of ears in which testing was completed for each unit by stimulus type.

2



For infants tested with both units, thresholds obtained with the Vivosonic were equal to or lower than the Bio-logic. Clicks were significantly different (p=0.04) and a similar trend for tone bursts was shown, but Ns were to small to show a significant difference.

3



The click thresholds were shown to be highly correlated between the two units.

Inter-Test Agreement for Bio-logic and Vivosonic:

- Within 10 dB = 15/20 (75%)
- >10 dB, less than 20 dB = 5/20 (25%)
- >20 dB = 0

Qualitative Advantages of Vivosonic compared to Bio-logic

- Reduction of electrical artifact
- Ease of achieving acceptable impedances
- Waveform integrity maintained with infant movement
- Ability to test in lighter sleep states/quiet alert states
- Ability to mark waves while testing and view both absolute and interpeak intervals in the test screen

Qualitative Disadvantages of Vivosonic Compared to Bio-logic

- Inability to switch between ears during testing
- Lack of split screen option
- Need a better neonatal electrode – smaller with flexible material
- Need more options on protocol settings – starting intensity, polarity
- Saving waveforms after 20 runs interrupts testing
- Cannot delete selected blocks of waves while testing
- Intensity selection – both in protocol screen and test screen
- Lengthy software initialization

SUMMARY

- The number of thresholds obtained for Bio-logic and Vivosonic were equivalent for clicks and tone bursts.
- Threshold averages were significantly better for the clicks using Vivosonic compared to Bio-logic. Similar trends were shown for tone bursts but Ns were to small to show a difference.
- Correlation between Bio-logic and Vivosonic thresholds for clicks was high (R^2 = .79).
- Majority of hearing status conclusions were within 10 dB (75%).
- 10-20 dB threshold differences occurred in 25% of ears.
- In 4/5 cases, Vivosonic showed lower (better) thresholds.

Limitations:

- Infants were in an NICU environment and thus limited time was available for full head to head comparison at all frequencies.
- Time and electrical artifact often precluded a full test with both instruments, therefore, head-head data on the same infant is limited.
- Bone conduction testing was lower priority due to environment and critical status.

CONCLUSION

1) The number of thresholds responses obtained for the two instruments was similar.
2) Wave V threshold level for the Vivosonic instrument was significantly better for clicks.
3) Clinical decisions about hearing status were the same or better in 95% of ears with Vivosonic.
4) Vivosonic was preferred for ease of obtaining results in noisy and awake infants.
5) Bio-logic was preferred for ease of software use .

REFERENCES

1. Leski,JM. Robust weighted averaging. (2002) IEEE Transactions on Biomedical Engineering, 49:796-804.

ACKNOWLEDGEMENTS

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