AIR-BONE GAP

Authored by

mohammad looti

November 10, 2025

RECOMMENDED CITATION

mohammad looti (2025). *AIR-BONE GAP*. PSYCHOLOGICAL SCALES. Retrieved from https://scales.arabpsychology.com/?p=69389

AIR-BONE GAP

Primary Disciplinary Field(s): Audiology, Otolaryngology, Neurophysiology

1. Core Definition

The Air-Bone Gap (ABG) is a fundamental concept in clinical audiometry, representing the numerical difference between the measured hearing threshold obtained via **air conduction** (AC) and the threshold obtained via **bone conduction** (BC) at specific pure-tone frequencies. This calculation is vital for differential diagnosis in hearing assessment, as the presence of a significant gap definitively points toward a pathology affecting the outer or middle ear--the components responsible for sound transmission through the air pathway.

Mathematically, the ABG is calculated by subtracting the bone conduction threshold (in decibels Hearing Level, dB HL) from the air conduction threshold (in dB HL) for a given frequency. A substantial ABG is conventionally defined as a difference of 10 dB or more between the AC and BC thresholds, signifying that sound transmitted through the air is attenuated or blocked before reaching the cochlea, while sound transmitted directly to the inner ear via vibration remains relatively intact. This diagnostic disparity provides critical information regarding the location and often the severity of the auditory impairment.

The core utility of the ABG lies in its ability to isolate the source of hearing impairment into two major categories: conductive or sensorineural. If the bone conduction threshold is within normal limits (indicating a healthy inner ear) and the air conduction threshold is elevated (indicating hearing loss), the resulting gap confirms a **conductive hearing loss** (CHL). Conversely, if both the AC and BC thresholds are equally elevated (no significant ABG), the pathology is localized to the inner ear or auditory nerve, classifying the impairment as **sensorineural hearing loss** (SNHL).

2. Physiological Basis of Conduction

Understanding the ABG requires a firm grasp of the distinct physiological pathways of sound transmission utilized during audiometric testing. **Air conduction** simulates the natural hearing process, whereby sound waves travel through the external auditory canal, vibrate the tympanic membrane (eardrum), and are mechanically amplified by the ossicles (malleus, incus, stapes) within the middle ear before being transferred to the fluid-filled cochlea. This pathway is susceptible to obstructions or damage in the outer or middle ear.

In contrast, **bone conduction** bypasses the entire outer and middle ear mechanism. During testing, a specialized vibrator is placed typically on the mastoid process or forehead, transmitting vibrations directly through the skull bone to the cochlea. This method stimulates the inner ear directly, effectively measuring the sensory capability of the cochlea, auditory nerve, and central auditory pathways, independent of the conductive mechanism. Because bone conduction directly assesses the functionality of the inner ear, it establishes the maximum potential hearing ability of that ear--often referred to as the **cochlear reserve**.

When a conductive pathology exists--such as fluid behind the eardrum, a perforation, or ossicular stiffness--it impedes the efficient transfer of energy via the air conduction pathway, leading to elevated AC thresholds. However, since the bone conduction pathway bypasses this impairment and stimulates the healthy cochlea directly, the BC thresholds remain at or near normal levels. It is this fundamental difference in sound transmission efficiency between the two pathways, caused by middle ear impedance, that creates the measurable **Air-Bone Gap**.

3. Measurement and Interpretation in Audiometry

The measurement of the ABG is standardized through **pure-tone audiometry**, a highly controlled procedure essential for diagnostic purposes. Air conduction thresholds are obtained using supra-aural headphones or insert earphones across standard audiometric frequencies (typically 250 Hz to 8000 Hz). Bone conduction thresholds are then measured using a bone oscillator placed on the mastoid or forehead, following specific protocols to ensure accurate stimulation of the inner ear.

Accurate interpretation of the ABG is paramount and relies heavily on the proper execution of masking procedures. Because bone conduction vibrations can easily transmit across the skull, stimulating the contralateral (non-test) cochlea, masking noise must be introduced to the non-test ear whenever a significant difference in sensitivity exists between the ears, or when the bone conduction threshold of the test ear is markedly better than the air conduction threshold of the non-test ear. Failure to apply appropriate masking can lead to "shadow hearing," resulting in a falsely small or nonexistent ABG, potentially misdiagnosing the patient's condition.

The magnitude of the gap directly correlates with the severity of the conductive component. A small gap (e.g., 10-15 dB) might indicate a minor issue, such as negative middle ear pressure or mild tympanic membrane stiffness. Conversely, a large gap, often exceeding 30-40 dB, strongly suggests a profound mechanical failure, such as a complete ossicular chain disarticulation or advanced otosclerosis. Specialists rely on the precise frequency-specific pattern of the ABG to hypothesize the anatomical location of the middle ear lesion.

4. Clinical Significance: Identifying Conductive Hearing Loss

The primary clinical significance of the **Air-Bone Gap** is its definitive role in confirming and quantifying **conductive hearing loss** (CHL). In audiology, the ABG serves as the hallmark indicator that sound transmission to a healthy cochlea is impaired due to mechanical issues in the outer or middle ear. It separates cases requiring medical or surgical intervention (CHL) from those requiring amplification or rehabilitation (SNHL).

For conditions like otitis media with effusion (middle ear fluid), the presence of fluid increases the mass and stiffness of the middle ear system, particularly affecting the transmission of lower frequencies. This results in a conductive hearing loss pattern, identified by an ABG that is often larger in the lower frequencies (250 Hz and 500 Hz). The ABG is essential for the otologist to monitor the progression or resolution of the effusion, as the gap typically closes as the fluid drains or is medically treated.

In cases of otosclerosis--a bony growth fixing the stapes footplate in the oval window--the ABG usually presents with a characteristic pattern. While the gap confirms the conductive component, the associated bone conduction thresholds often exhibit the **Carhart notch**, a temporary dip at 2000 Hz. Although the notch technically appears on the BC curve, the overall ABG confirms that the stapes fixation is the primary cause of the transmission blockage, guiding the decision toward stapedectomy surgery.

5. Differential Diagnosis Using the ABG

The characteristics and frequency-specific shape of the **Air-Bone Gap** provide valuable clues that aid in the differential diagnosis of various middle ear pathologies. An ABG that is relatively flat across all frequencies (e.g., 30 dB AC loss at all tested frequencies, with normal BC) is often associated with significant fluid accumulation or a large tympanic membrane perforation, where the entire transmission system is equally hampered.

Conversely, a high-frequency bias in the ABG, though less common for traditional conductive losses, may occasionally point toward specific issues. A classic acoustic reflex pattern often complements the ABG findings. For instance, in **ossicular chain discontinuity** (a break in the tiny bones of the middle ear), the ABG is typically large (often 40-60 dB) because the lever action of the ossicles is completely lost. This profound gap confirms the need for surgical repair, such as tympanoplasty or ossicular reconstruction.

Furthermore, the ABG is used to distinguish between congenital and acquired disorders. In congenital aural atresia (missing or underdeveloped ear canal), the physical blockage results in a maximal conductive loss, producing a large ABG. The ABG therefore serves as a baseline measurement of hearing loss severity before surgical intervention is considered. By systematically evaluating the size and spectral shape of the gap, clinicians can narrow down the potential anatomical causes with high accuracy.

6. Factors Influencing the Air-Bone Gap Magnitude

Several physiological and methodological factors contribute to the measured magnitude of the ABG, necessitating careful clinical consideration during testing. The physical characteristics of the middle ear pathology are the primary determinant. For example, the mass and compliance of the conductive system directly influence the AC threshold. A rigid, stiff system (like otosclerosis) generally yields a larger low-frequency ABG, whereas a mass-dominated system (like a heavy tumor) might slightly influence higher frequencies.

The integrity of the tympanic membrane is also a major factor. A small perforation might create a minor ABG, but a large perforation, particularly when accompanied by middle ear infection, significantly increases the gap due to the substantial disruption of the pressure mechanics necessary for efficient sound transmission. The size of the gap can also be influenced by the pressure differences between the middle ear and ambient environment; significant negative pressure (e.g., due to Eustachian tube dysfunction) pulls the eardrum inward, increasing stiffness and often creating a measurable, though usually temporary, ABG.

Crucially, methodological factors such as transducer type and placement can influence BC measurements, thereby subtly affecting the calculated ABG. The "occlusion effect" is a procedural consideration wherein covering the ear (as with headphones during air conduction) significantly improves the bone conduction threshold for low frequencies (250 Hz and 500 Hz) in normal ears or ears with SNHL. If this effect is not accounted for during masking in CHL cases, it can distort the true ABG magnitude, making the conductive component appear slightly smaller than it is, especially in the lower frequency range.

7. Limitations and Clinical Nuances

While the **Air-Bone Gap** is an exceptionally powerful diagnostic tool, its interpretation is subject to certain limitations and clinical nuances that must be considered by the specialist. One primary limitation involves the maximum output limits of bone conduction oscillators. Since the BC vibrator cannot deliver sound levels exceeding approximately 70 dB HL (due to distortion and physical limitations), maximal conductive losses (those exceeding 60 dB) often result in a "maximal ABG," where the true magnitude of the conductive impairment cannot be precisely measured because the BC threshold is already at the equipment's maximum limit.

Another area of complexity is the potential for confounding factors in mixed hearing loss (MHL), where both conductive and sensorineural components coexist. In MHL, the ABG confirms the presence of the conductive component (AC thresholds are worse than BC thresholds), but the BC thresholds themselves are elevated (indicating SNHL). Interpreting the contribution of each component requires careful scrutiny, as surgical repair of the conductive component can only improve hearing up to the level of the existing bone conduction threshold.

Finally, the accuracy of the ABG is highly dependent on the strict execution of interaural attenuation and masking protocols. If masking is inadequate, the results may reflect the hearing of the better ear rather than the test ear, leading to a false interpretation of the gap. Experienced audiologists must carefully adhere to established clinical standards to ensure the ABG truly reflects the conductive pathology of the specific ear under evaluation and not an artifact of cross-hearing.

Further Reading

Air conduction (Wikipedia)
Bone conduction (Wikipedia)
Audiometry (Wikipedia)
Conductive hearing loss (Mayo Clinic)
AIR-BONE GAP (Psychology Dictionary)