Research Article

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Tympanometric Patterns among HIV-Positive Patients Attending a General Hospital in North-Central Nigeria

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ABSTRACT

Middle-ear dysfunction is a common but easily overlooked complication of HIV, and tympanometry offers an objective, low-cost means of detecting it. However, data on tympanometric evaluation for adults living with HIV in north-central Nigeria are scarce. This study determined the tympanometric patterns among HIV-positive adults attending a general hospital in Abuja and examined their relationship with clinical and demographic factors. In a hospital-based cross-sectional study, 110 consecutively recruited adults on follow-up at the HIV clinic of Kubwa General Hospital underwent a structured interview, otoscopy and tympanometry. Tympanograms were classified according to the Jerger system, with type A considered normal and types As, Ad, B, and C considered abnormal. Associations were tested with chi-square or Fisher's exact tests and with t or Mann-Whitney tests at $p < 0.05$. The participants had a mean age of 40.2 ± 8.7 years; 68.3% were women and 92.4% were on antiretroviral therapy. Type A accounted for 52.9% of 206 ears, and abnormal tympanograms were present in 47.1% of ears and 57.1% of patients (95% CI 47.6 to 66.2). The commonest abnormality was the reduced-compliance type As pattern (26.2% of ears), and findings were largely bilateral and symmetrical. Only 27.3% of patients reported any otological symptoms, and otoscopy showed poor agreement with tympanometry (kappa 0.218). No demographic or HIV-related variable was significantly associated with abnormality, although serious HIV-related infection showed a non-significant trend. Middle-ear dysfunction was common and largely subclinical, and tympanometry merits routine use as a screening tool in HIV care in similar resource-limited settings.

Keywords

HIV, Tympanometry, Middle-ear function, Otitis media with effusion, Hearing screening, Nigeria.

Introduction

The Human Immunodeficiency Virus (HIV) remains one of the defining health challenges of our era. By the end of 2024, an estimated 40.8 million people were living with HIV worldwide, and sub-Saharan Africa accounted for roughly two-thirds of that burden [1]. Nigeria contributes a substantial share, with about 1.9 million people living with the virus and a national adult prevalence of 1.3% [2]. Wider access to antiretroviral therapy has made HIV a chronic, manageable condition, and the clinical focus has shifted from acute opportunistic disease to the long-term consequences of infection and its treatment across organ systems. The ear is among the structures affected. HIV is now an established risk factor for hearing impairment, acting through several routes that include direct viral injury to the auditory pathway, opportunistic infection, and the ototoxic potential of some antiretroviral and antituberculous agents [3,4]. Otological and head and neck manifestations are reported in the majority of patients at some point in the disease course, and they span the external, middle, and inner ear [5]. Within this spectrum, the middle ear deserves particular attention because dysfunction there is common, often silent, and, in principle, reversible if detected.

Middle-ear disease in HIV is largely driven by eustachian tube dysfunction. Nasopharyngeal lymphoid hyperplasia, recurrent upper respiratory infections, allergic and inflammatory mucosal changes, and impaired mucociliary clearance all compromise

ventilation of the middle-ear cleft, predisposing to negative middle-ear pressure and effusion [6,7]. The result ranges from subtle reductions in tympanic membrane compliance to frank otitis media with effusion, and, at the severe end, chronic suppurative otitis media, an association now recognised in the literature [7]. Because conductive loss from these processes adds to any sensorineural deficit, it compounds the communication difficulties already faced by patients navigating lifelong care. Detecting middle-ear dysfunction is not straightforward on history and otoscopy alone. Symptoms are often absent or vague, and the tympanic membrane can look unremarkable even when the middle ear is not ventilating normally. Tympanometry addresses this gap. It is an objective, rapid, inexpensive and non-invasive measure of middle-ear status that grades the mobility of the tympanic membrane and ossicular system, and it is recommended as a first-line test for middle-ear assessment [7]. The Jerger classification remains the standard framework, distinguishing the normal type A from the shallow type As, the hypermobile type Ad, the flat type B of effusion or perforation, and the type C of negative middle-ear pressure [8]. These properties make tympanometry well suited to a high-volume, resource-limited HIV clinic, where audiometry may be unavailable but middle-ear screening would still add value.

Evidence on tympanometric patterns in adults living with HIV in Nigeria is limited. The few Nigerian studies that have examined the middle ear report a significant burden of effusion and abnormal tympanograms, yet they are concentrated in the south of the country and have not consistently examined how objective dysfunction relates to patients' symptoms, clinical stage, or treatment status [9,10]. North-central Nigeria and the general hospital setting, where most people actually receive HIV care, are under-represented. A recurring and clinically important question is the disconnect between what patients report and what objective testing reveals, since a screen that uncovers silent disease would justify routine use. This study was therefore designed to characterise middle-ear function in HIV-positive adults attending a general hospital in north-central Nigeria using tympanometry. The aim was to determine the tympanometric patterns among HIV-positive patients attending the facility.

Methods

Study design and setting

This was a hospital-based descriptive cross-sectional study of adults living with HIV attending the antiretroviral therapy clinic of Kubwa General Hospital, Abuja, Nigeria. The hospital is a secondary-care facility in Kubwa, Bwari Area Council of the Federal Capital Territory, and provides comprehensive HIV services, including antiretroviral therapy, routine clinical follow-up, laboratory monitoring and counselling, to patients drawn from the Territory and neighbouring states.

Study population and eligibility

The study population comprised adults aged 18 years and above with confirmed HIV infection who were attending the clinic during the study period and who gave written informed consent.

Sample size and sampling

The minimum sample size was set at 100 participants, which was considered adequate for a descriptive cross-sectional design and feasible within the study period; 110 participants were enrolled. A consecutive sampling technique was used, with eligible patients recruited in order of presentation until the target was reached.

Data collection

Data were collected with a structured, interviewer-administered questionnaire. Information obtained included socio-demographic characteristics; HIV-related clinical history covering duration of HIV infection, antiretroviral therapy status and duration, most recent viral load, and history of serious HIV-related or opportunistic infection; and otological symptoms including hearing loss, tinnitus, aural fullness or blockage, otalgia, ear discharge and previous ear infection. CD4 cell counts were not consistently available in the clinic records and were therefore not analysed; the most recent viral load served as the available marker of disease control, with virological suppression defined as fewer than 1000 copies/mL.

Otoscopic examination

Both ears were examined with a standard video otoscope by the principal investigator. The external auditory canal and tympanic membrane were assessed for cerumen impaction, perforation, retraction, middle-ear effusion, inflammation and other abnormalities. Patients with impacted cerumen underwent cerumen removal before tympanometry.

Tympanometric assessment

Middle-ear function was assessed with a calibrated clinical tympanometer (Amplivox model) using a 226-Hz probe tone, recording ear-canal volume, peak static (compensated) acoustic admittance, and peak middle-ear pressure. Tympanograms were classified by the Jerger system as type A (normal middle-ear function), type As (reduced compliance with normal pressure), type Ad (hypermobile tympanic membrane), type B (flat trace, consistent with effusion or a non-intact drum), and type C (negative middle-ear pressure). For analysis, type A was taken as normal middle-ear function and types As, Ad, B and C as abnormal. Each ear was classified individually, and a patient was considered to have abnormal middle-ear function if either ear yielded a non-type-A trace; for the patient-level summary, the more abnormal ear was used, ranked as A, As, Ad, C, or B.

Outcome measures

The primary outcome was the distribution of tympanometric patterns among patients. Secondary outcomes were the prevalence of abnormal tympanograms, inter-aural symmetry of findings, and associations between abnormal tympanometry and age, sex, marital status, education, duration of HIV infection, antiretroviral status and duration, viral-load category, and history of serious HIV-related infection.

Data analysis

Data were entered into Microsoft Excel, cleaned, and analysed in Python 3 (pandas, SciPy and statsmodels). Free-text entries were harmonised before analysis: duration fields were collapsed into ordered bands, viral-load entries were converted to copies/mL with undetectable results treated as suppressed, and near-duplicate otoscopy descriptions were merged. Categorical variables were summarised as frequencies and percentages, and continuous variables as mean and standard deviation or median and interquartile range, as appropriate. Proportions were compared using the chi-square test or Fisher's exact test when expected cell counts were small, and the 95% confidence interval for the principal prevalence was estimated using the Wilson method. Continuous variables were compared using the Student t-test or the Mann-Whitney U test, depending on the distribution. Inter-aural agreement was assessed using Cohen's kappa, and symmetry using the McNemar test. Analysis used available cases for each variable, with denominators reported throughout, and statistical significance was set at $p < 0.05$, two-tailed.

Ethical considerations

Ethical approval was obtained from the FCT Health Research Ethics Committee before the study commenced, and written informed consent was obtained from each participant before enrolment. Confidentiality was maintained by assigning unique identification numbers to participants and by excluding personal identifiers from the study record.

Results

A total of 110 HIV-positive patients were studied. Participants were predominantly in early to middle adulthood, with a mean age of 40.2 ± 8.7 years (range: 22 to 65). Just over seven in ten were aged 30 to 49, the age band with the heaviest HIV burden in this setting. Women made up just over two-thirds of the sample (71 of 104, 68.3%), and most patients were married (62.4%). Educational attainment was generally modest, with secondary schooling the most common level (49.5%), and only 1.9% reported no formal education. The cohort was overwhelmingly treatment-experienced: 92.4% were on antiretroviral therapy, and 63.2% had lived with HIV for six years or longer. Virological control was good where measured, with 92.0% of the 88 patients with a recent result suppressed below 1000 copies/mL. However, the viral-load distribution was strongly right-skewed by a few high values. A serious HIV-related infection was documented in 13.3%, with tuberculosis the most frequent (See Table 1).

Socio-demographic and clinical characteristics

Table 1: Socio-demographic and HIV-related clinical characteristics of the participants.

Characteristic	n (%)
Age (years), mean ± SD	40.2 ± 8.7
Age range, years	22–65
Age group (n=104)	
<30	13 (12.5)
30-39	35 (33.7)
40-49	39 (37.5)
>=50	17 (16.3)
Sex (n=104)	
Female	71 (68.3)
Male	33 (31.7)
Marital status (n=109)	
Married	68 (62.4)
Single	26 (23.9)
Divorced	8 (7.3)
Widowed	7 (6.4)
Educational level (n=107)	
No Formal Education	2 (1.9)
Primary	14 (13.1)
Secondary	53 (49.5)
Tertiary	38 (35.5)
Duration of HIV infection (n=106)	
<1 year	7 (6.6)
1-5 years	32 (30.2)
6-10 years	41 (38.7)
>10 years	26 (24.5)
Currently on ART (n=105)	
Yes	97 (92.4)
No	8 (7.6)
Duration on ART (n=99)	
<1 year	7 (7.1)
1-5 years	31 (31.3)
6-10 years	35 (35.4)
>10 years	26 (26.3)
Most recent viral-load category (n=88)	
Suppressed (<1000)	81 (92)
Unsuppressed (>=1000)	7 (8)
Serious HIV-related infection (n=105)	
Yes	14 (13.3)
No	91 (86.7)

Note: Percentages use the non-missing denominator shown for each variable. Viral load was available for 88 patients (20.0% missing); median 19 copies/mL (IQR 19–65, range 0–2830000). Among the 14 patients with a serious HIV-related infection, the recorded conditions were tuberculosis (3), oral thrush (1), chronic diarrhoea (1) and staphylococcal infection (1), with 8 unspecified. ART, antiretroviral therapy; SD, standard deviation; IQR, interquartile range.

Otological symptoms and history

Table 2: Self-reported otological symptoms and relevant history.

Symptom / history	Assessed (n)	Present, n (%)
Hearing loss	110	14 (12.7)
Ear pain	108	9 (8.3)
Ear discharge	108	4 (3.7)
Tinnitus	108	11 (10.2)
Ear blockage	108	15 (13.9)
History of ear infection	107	5 (4.7)
URTI in past 3 months	104	6 (5.8)
Previous ear surgery	103	1 (1)
Family history of hearing loss	92	7 (7.6)

Note: Each symptom uses its own non-missing denominator. "Present" denotes a "yes" response.

Otological complaints were uncommon and, where present, mild. Ear blockage (13.9%) and hearing loss (12.7%) were the most frequently reported, followed by tinnitus (10.2%) and ear pain (8.3%). Ear discharge was rare (3.7%), as were a history of ear infection (4.7%), recent upper respiratory tract infection (5.8%) and previous ear surgery (1.0%). A family history of hearing loss was noted in 7.6%. Taken together, 30 of 110 patients (27.3%) reported at least one otological symptom, meaning roughly seven in ten were symptom-free at presentation (see Table 3). This low symptom burden becomes important when set against the tympanometric findings that follow.

Otoscopic findings

Table 3: Otoscopic findings in the right and left ears.

Otoscopic finding	Right ear (n=104)	Left ear (n=103)
Normal	88 (84.6)	85 (82.5)
Dull TM	13 (12.5)	14 (13.6)
Wax	2 (1.9)	1 (1)
Retracted TM	1 (1)	1 (1)
Perforated TM	0 (0.0)	2 (1.9)

Note**:** TM, tympanic membrane. Percentages use the ear-specific denominator.

On otoscopy, the tympanic membrane was normal in the great majority of ears, 84.6% on the right and 82.5% on the left. The commonest abnormality was a dull, lustreless drum, seen in 12.5% of right ears and 13.6% of left ears, a sign that often accompanies middle-ear effusion. Impacted wax, retraction and frank perforation were each infrequent, and perforation was confined to two left ears (see Table 4). The otoscopic picture, therefore, suggested largely healthy-looking drums, a point worth holding in mind because tympanometry told a different story.

Tympanometric patterns

Table 4: Distribution of Jerger tympanometric types by ear and per patient.

Type	Right ear n (%)	Left ear n (%)	All ears n (%)	Per patient n (%)
A	53 (51.5)	56 (54.4)	109 (52.9)	45 (42.9)
As	28 (27.2)	26 (25.2)	54 (26.2)	32 (30.5)
Ad	10 (9.7)	6 (5.8)	16 (7.8)	10 (9.5)
B	6 (5.8)	7 (6.8)	13 (6.3)	8 (7.6)
C	6 (5.8)	8 (7.8)	14 (6.8)	10 (9.5)

Note**:** Right and left ear n = 103 each; all ears pooled n = 206; per-patient column classifies each of 105 patients by the more abnormal ear, ranked A < As < Ad < C < B. Type A, normal; As, reduced compliance with normal pressure; Ad, hypermobile; B, flat (effusion or perforation); C, negative middle-ear pressure.

Type A, the normal tracing, accounted for just over half of all ears (109 of 206, 52.9%) and was similarly common on each side (right 51.5%, left 54.4%). The remaining ears were spread across the abnormal types. The shallow Type As pattern, denoting a stiff but normally pressurised middle ear, was the most frequent abnormality, occurring in 26.2% of ears, followed by the hypermobile Type Ad at 7.8%. Flat Type B tracings, which point to effusion or a non-intact drum, were found in 6.3% of ears, and Type C, indicating negative middle-ear pressure from eustachian tube dysfunction, in 6.8%. When each patient was summarised by the more affected ear, only 42.9% were Type A in both ears, while As (30.5%), C (9.5%), Ad (9.5%) and B (7.6%) made up the rest (see Table 5 and Figure 1). The patterns therefore cluster at the milder, compliance-reducing end of the spectrum rather than the effusion end.

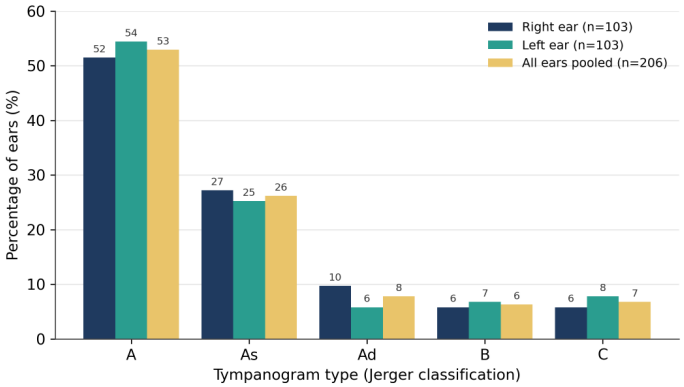

Figure 1: Distribution of tympanometric types in the right ear, left ear and all ears pooled.

Middle-ear function: normal versus abnormal

Table 5: Normal (Type A) versus abnormal (non-A) middle-ear function at the ear and patient level.

Level	Assessed (n)	Normal, n (%)	Abnormal, n (%)
Right ear	103	53 (51.5)	50 (48.5)
Left ear	103	56 (54.4)	47 (45.6)
All ears pooled	206	109 (52.9)	97 (47.1)
Per patient (≥1 abnormal ear)	**105**	**45 (42.9)**	**60 (57.1)**

Note**:** Abnormal = any non-Type-A tympanogram. The patient-level prevalence of abnormality was 57.1% (95% Wilson CI 47.6–66.2).

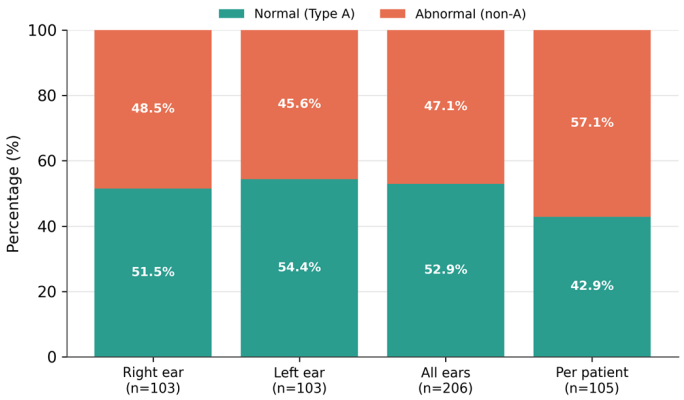

Figure 2: Proportion of normal and abnormal tympanograms at ear and patient level.

Abnormal middle-ear function was common. At the ear level, 97 of 206 ears (47.1%) were non-Type-A, with little difference between

the right (48.5%) and left (45.6%) sides. The burden was higher when the patient, rather than the ear, was the unit of analysis: 60 of 105 patients (57.1%, 95% CI 47.6-66.2) had at least one abnormal ear (see Table 6 and Figure 2). In other words, although only about three in ten patients reported any ear symptoms, nearly six in ten had objective evidence of middle-ear dysfunction, a gap that underscores the value of tympanometry as a screening tool in this population.

Inter-aural symmetry of tympanometric patterns

Table 6: Cross-classification of right-ear by left-ear tympanometric type.

Right \ Left	A	As	Ad	B	C	Total
A	**42**	8	0	1	1	**52**
As	6	**17**	1	1	2	**27**
Ad	4	0	**5**	0	1	**10**
B	0	1	0	**5**	0	**6**
C	2	0	0	0	**4**	**6**
Total	**54**	**26**	**6**	**7**	**8**	**101**

Note: n = 101 patients with both ears classified. Diagonal cells (bold) are concordant pairs. Cohen's kappa for right–left type agreement = 0.568. McNemar's exact test for asymmetry in abnormal/normal status, p = 0.832.

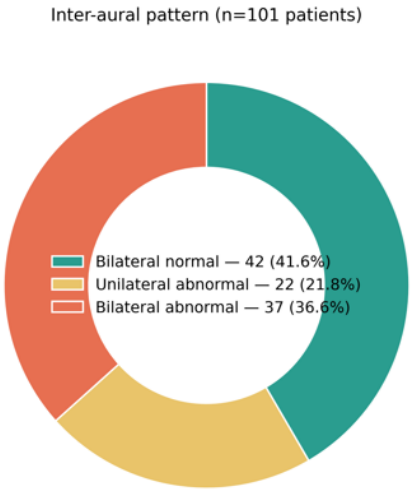

Figure 3: Distribution of bilateral-normal, unilateral-abnormal and bilateral-abnormal patterns.

The two ears tended to behave alike. Agreement on the exact Jerger type was moderate (Cohen's kappa 0.568), and the most heavily populated cells lay on the diagonal: 42 patients were Type A in both ears and 17 were As in both. Categorising patients by side, 42 (41.6%) had two normal ears, 37 (36.6%) had bilateral abnormality, and 22 (21.8%) had a single affected ear. Abnormality was thus bilateral more often than not. The direction of any discordance was even-handed: the right ear was the worse side in 12 patients, and the left in 10, and McNemar's test showed no systematic right-left asymmetry (p = 0.832). This symmetry is consistent with a systemic rather than a one-sided local cause. See Table 7 and Figure 3.

Tympanometric abnormality and socio-demographic variables

None of the socio-demographic variables was significantly associated with tympanometric abnormality. Abnormal tympanograms were somewhat more frequent in women than in men (61.2% vs 48.5%), but the difference was not statistically significant (p = 0.321). The proportion abnormal varied little across age groups (p = 0.894), and the mean age was almost identical in the normal and abnormal groups (p = 0.568). Marital status and education showed no clear gradient; the apparently high abnormality among widowed patients (6 of 7) rested on very small numbers. Middle-ear dysfunction in this cohort was therefore broadly distributed and not explained by demographic profile. See Table 8.

Table 7: Association between abnormal tympanometry (per patient) and socio-demographic variables.

Variable	n	Abnormal n (%)	Test statistic	p
Age group			*$\chi^2 = 0.61$, df = 3*	0.894
<30	12	7 (58.3)		
30-39	35	21 (60)		
40-49	37	19 (51.4)		
>=50	15	8 (53.3)		
Sex			*$\chi^2 = 0.98$, df = 1*	0.321
Female	67	41 (61.2)		
Male	33	16 (48.5)		
Marital status			*$\chi^2 = 3.02$, df = 3*	0.388
Married	65	34 (52.3)		
Single	25	15 (60)		
Divorced	7	4 (57.1)		
Widowed	7	6 (85.7)		
Education			*$\chi^2 = 2.14$, df = 3*	0.543
No Formal Education	2	1 (50)		
Primary	13	6 (46.2)		
Secondary	50	32 (64)		
Tertiary	37	19 (51.4)		

Note: Outcome is presence of at least one abnormal (non-A) ear. Fisher's exact test was used for 2×2 tables with any expected count <5; for larger tables with sparse cells the chi-square statistic is reported and read with caution. Mean age did not differ between patients with normal and abnormal tympanograms (40.5 ± 8.4 vs 39.5 ± 8.7 years; t = 0.57, p = 0.568).

Tympanometric abnormality and HIV-related clinical parameters

No HIV-related parameter reached statistical significance, although the direction of several associations was clinically coherent. Patients not yet on antiretroviral therapy were more often abnormal than treated patients (75.0% vs 54.8%), and those with an unsuppressed viral load were more often abnormal than those with a suppressed viral load (71.4% vs 54.5%). However, both comparisons were based on small unexposed groups and were non-significant (p = 0.460 and p = 0.458). Neither the duration of HIV infection nor the time on treatment showed any trend. The clearest signal involved serious HIV-related infection: 11 of 14 such patients (78.6%) had abnormal tympanograms, compared with 54.0% of those without, a difference that was also not statistically significant (chi-square = 2.05, p = 0.152). Viral load, analysed as a continuous variable, likewise did not separate the groups (p = 0.231). See Table 9 and Figure 4.

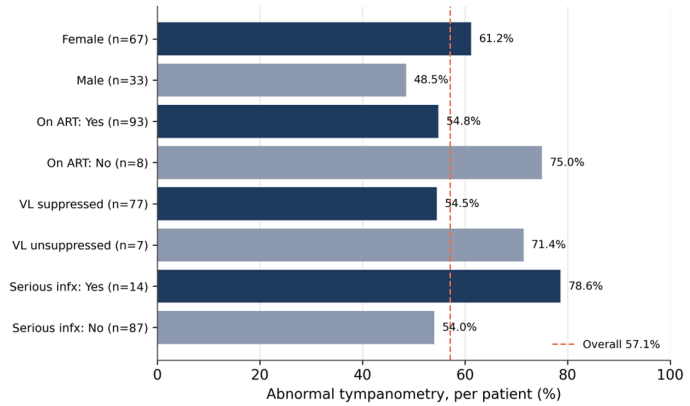

Figure 4: Prevalence of abnormal tympanometry across sex and HIV-related clinical subgroups.

Table 8: Association between abnormal tympanometry (per patient) and HIV-related clinical parameters.

Variable	n	Abnormal n (%)	Test statistic	p
Duration of HIV			*χ^2 = 0.75, df = 3*	0.860
<1 year	7	4 (57.1)		
1-5 years	32	20 (62.5)		
6-10 years	38	20 (52.6)		
>10 years	24	13 (54.2)		
On ART			*Fisher's exact*	0.460
Yes	93	51 (54.8)		
No	8	6 (75)		
Duration on ART			*χ^2 = 0.39, df = 3*	0.942
<1 year	7	4 (57.1)		
1-5 years	31	19 (61.3)		
6-10 years	33	18 (54.5)		
>10 years	24	13 (54.2)		
Viral load category			*Fisher's exact*	0.458
Suppressed (<1000)	77	42 (54.5)		
Unsuppressed (>=1000)	7	5 (71.4)		
Serious HIV-related infection			*χ^2 = 2.05, df = 1*	0.152
Yes	14	11 (78.6)		
No	87	47 (54)		

Note: Outcome as in Table 8. Median most-recent viral load did not differ between groups (normal 19 vs abnormal 20 copies/mL; Mann–Whitney U = 741.5, p = 0.231). Fisher's exact test for 2×2 tables with sparse cells; chi-square otherwise.

Symptom concordance and otoscopy–tympanometry agreement

Symptoms were a weak guide to middle-ear status. Patients reporting an otological complaint were abnormal on tympanometry in 69.0% of cases, against 52.6% of asymptomatic patients, a difference in the expected direction that did not reach significance (p = 0.186); the great majority of abnormal results (40 of 60) occurred in patients who reported no symptom at all. Otoscopy was similarly limited. Agreement between an abnormal drum and an abnormal tympanogram was only slight (kappa = 0.218): although ears that looked abnormal were usually abnormal on tympanometry (23 of 28), 68 of 171 normal-looking ears also returned a non-Type-A trace. Tympanometry detected dysfunction that neither history nor otoscopy reliably captured. See Table 9.

Table 9: Tympanometric abnormality by reported symptoms (patient level) and by otoscopic appearance (ear level).

Subgroup	Assessed (n)	Abnormal tympanometry, n (%)
Reported ≥1 otological symptom		
Symptom present	29	20 (69.0)
Symptom absent	76	40 (52.6)
Otoscopic appearance (ear level)		
Otoscopy abnormal	28	23 (82.1)
Otoscopy normal	171	68 (39.8)

Note: Symptom comparison: Fisher's exact p = 0.186. Otoscopy–tympanometry agreement (abnormal vs normal): Cohen's kappa = 0.218 (slight), Fisher's exact p = <0.001; n = 199 ears.

Discussion

This study set out to characterise middle-ear function in HIV-positive adults attending a general hospital in north-central Nigeria, and it shows that middle-ear dysfunction in this group is both common and largely hidden. Abnormal, non-type-A tympanograms were present in 47.1% of ears and in 57.1% of patients (95% CI 47.6 to 66.2). Tympanometry reflects the mechanical efficiency of the tympanic membrane and ossicular chain, so a rate of this magnitude indicates that more than half of the patients had a measurable departure from normal middle-ear mechanics [8]. This figure falls within the internationally described range. Luque and colleagues found significant differences in tympanometric static admittance between HIV-infected adults and uninfected controls in the United States [4], and Nigerian studies from Port Harcourt and Benin have likewise documented a substantial burden of middle-ear abnormalities on tympanometry [9,10]. Not every series agrees. A large Tanzanian study found middle-ear measures were broadly similar between infected and uninfected groups, attributing most auditory difficulties to central processing rather than the middle ear [11], while an Ilorin series reported bilateral serous otitis media in roughly two-thirds of patients on examination, a far higher effusion burden than in ours [12]. The variation probably reflects differences in disease stage, treatment coverage, and case mix, placing our cohort, mostly treated and virally suppressed, towards the milder end of that spectrum.

The shape of the abnormality is as informative as its frequency. The predominant deviation was the type As pattern, seen in 26.2% of ears, while the flat type B of effusion and the type C of negative pressure were each present in fewer than 7%. Type As denotes a middle ear that is normally pressurised but abnormally stiff, with reduced compliance of the tympanic-ossicular system. This fits an early or low-grade process, since mucosal thickening, incipient or resolving effusion, and tympanosclerotic change all reduce compliance before they produce the flat trace of established effusion [6]. The contrast with Port Harcourt and Benin, where type B predominated [9,10], is instructive. The findings in our study may have been due to improved disease control, as patients were on antiretroviral therapy and mostly had stable disease. A cohort

with good viral control and few symptoms would be expected to show milder, compliance-reducing change rather than established effusion, and that is what we observed. The predominance of As points to a population captured earlier in the natural history of middle-ear involvement, which is precisely the group in whom monitoring might alter outcomes. Abnormality was symmetrical in the majority of patients. Agreement between the two ears on the exact Jerger type was moderate (kappa 0.568), bilateral abnormality was commoner than unilateral disease (36.6% versus 21.8%), and there was no systematic right-left difference (McNemar $p = 0.832$). Symmetry of this kind argues against a one-sided local cause such as isolated trauma or a unilateral nasopharyngeal lesion, and points instead to a systemic driver acting on both eustachian tubes at once. That interpretation is consistent with the systemic mucosal and immune disturbance of HIV and with the wide range of otological manifestations reported across African series [5]. For the clinician, this means that an abnormal trace in one ear should prompt careful assessment of the other ear.

The most clinically consequential finding is the gap between what patients reported and what tympanometry revealed. Only 27.3% of patients reported any otological symptoms, yet 57.1% had an abnormal tympanogram, and agreement between an abnormal-appearing tympanic membrane on otoscopy and an abnormal tympanogram was only slight (kappa = 0.218). Most middle-ear dysfunction in this cohort was therefore subclinical and invisible to routine examination. This mirrors a wider observation that HIV-positive patients may carry auditory abnormalities that standard clinical assessment underestimates [13]. The implication is practical. If history and otoscopy miss the majority of cases, an objective screen is needed to find them, and tympanometry is well suited to the task because it is quick, inexpensive, requires no soundproof room and can be performed by trained non-specialist staff [7]. In a busy Nigerian general hospital HIV clinic, where formal audiometry is often unavailable, this is a realistic addition to care. Against this background, the absence of significant associations with socio-demographic and HIV-related variables deserves measured interpretation. Neither age, sex, marital status, nor education was related to abnormal tympanometry, and neither duration of HIV infection, antiretroviral status, time on treatment, nor viral-load category was statistically significant. Part of this reflects limited contrast within the sample, since 92% of those tested were virally suppressed and most were established on treatment, leaving little variation against which to detect an effect. Of note, and only as a hypothesis, relates to participants with serious HIV-related infection, where 78.6% of affected patients had abnormal tympanograms compared with 54.0% of the rest, a difference that, though not statistically significant, was marked ($p = 0.152$). The direction is consistent with Nigerian audiometric work linking lower CD4 counts and higher viral load to worse hearing [14], and with the finding that retroviral positivity strongly predicts ototoxicity during treatment for drug-resistant tuberculosis [15]. Together, these suggest that more advanced or complicated disease may carry greater otological risk. The contrast with studies of treatment-naive patients, who show high rates of hearing loss before therapy [16], further supports the view that disease activity rather than treatment alone drives much of the otological burden.

This study has some limitations. Its cross-sectional design captures a single point in time and cannot establish temporality or causation. It was conducted at a single general hospital, which limits generalisability, and it lacked an HIV-negative control group, so the abnormalities cannot be attributed to HIV with certainty rather than to background population rates. CD4 cell counts were not available, so immunological staging is incomplete, and pure-tone audiometry was not performed, so the conductive and sensorineural components of any hearing deficit could not be separated or quantified. These constraints temper the conclusions but do not undermine the central, robust observation of a high and largely silent burden of middle-ear dysfunction.

Conclusion

Middle-ear dysfunction is common among HIV-positive adults attending this north-central Nigerian general hospital, affecting more than half of patients. It is largely subclinical and characterised by the reduced-compliance type As pattern, with symmetrical involvement of both ears. History and otoscopy detect only a minority of cases, making objective testing necessary to identify the dysfunction. We recommend incorporating tympanometry as a simple, low-cost screening tool within routine HIV care in resource-limited settings, with clear referral pathways for patients who screen abnormal. Larger, controlled and longitudinal studies that include CD4 counts and pure-tone audiometry are needed to clarify the determinants of middle-ear dysfunction in this population and to test the signal linking it to more advanced disease.

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