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Listening to the Aging Brain: The Potential Role of In-Ear EEG in Geriatric Care

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Across hospitals worldwide, clinicians are caring for an ageing population with increasingly complex neurological needs. Older adults frequently present with delirium, seizures or cognitive decline. A constellation of syndromes that often overlap and carry devastating consequences. These conditions are associated with longer admissions, functional deterioration, institutionalisation and increased mortality. Yet despite their prevalence, we remain remarkably limited in how we observe the ageing brain. Recent work by Campbell et al. has highlighted that resting-state EEG features may not directly predict cognitive performance in older adults, but instead moderate the relationship between aging and memory decline, underscoring the importance of how, when and in whom brain activity is measured [1].

Neurological assessment in older adults is often challenging; witnesses are absent, recall is unreliable and symptoms fluctuate. Diagnostic tests such as electroencephalography (EEG) are rarely available outside specialist centres. The irony is that we continuously monitor nearly every other organ (heart rate, oxygen saturation, blood pressure) but not the brain. For syndromes characterised by fluctuation rather than fixed deficit, including delirium, non-convulsive seizures and post-operative encephalopathy, episodic EEG risks missing the very phenomena that confer vulnerability.

Scalp EEG remains the gold standard for assessing neuronal activity and is used to investigate seizures, sleep disorders and encephalopathy. In frail patients, however, its use is constrained by practical barriers. Equipment is bulky, application requires specialist expertise and prolonged monitoring is often poorly tolerated. Even in intensive care settings, continuous EEG monitoring is uncommon and typically reactive, requested only after seizures are suspected. This approach leaves many neurological events unseen. Routine brain monitoring could instead offer new parameters for prognosis, reveal subclinical seizure activity and inform more timely clinical decision-making.

A new generation of devices may soon make this possible. In-ear EEG records neural activity from discreet electrodes placed in or around the ear canal. These devices are small, wireless and comfortable enough to be worn for hours or days. They can be inserted without specialist training, overcoming one of the major barriers to conventional EEG use in general wards or community settings. Their comfort and simplicity mean they could be used in frail or cognitively impaired patients who would otherwise be unable to tolerate scalp electrodes.

EEG's most established role is in epilepsy. Seizures are more common in older adults than in any other age group, yet they are frequently underdiagnosed. Longer-term EEG recording increases diagnostic yield, but traditional systems

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make this difficult outside specialist centres. Recent studies have shown that ear-EEG can reliably detect focal-onset seizures with performance comparable to conventional recordings [2]. Musaeus and colleagues demonstrated that long-term ear-EEG monitoring in patients with dementia was feasible, supporting its use in cognitively impaired populations [3].

Delirium remains one of the most common yet least understood syndromes affecting older adults. It occurs in up to one in three hospitalised patients and is associated with high mortality [4]. EEG studies have consistently shown that delirium is characterised by slowing of background rhythms and loss of alpha power, changes that correlate with severity and clinical outcomes [5,6]. These abnormalities may precede overt clinical recognition, suggesting a physiological window during which vulnerability is present before bedside diagnosis. Yet such studies have largely been confined to research settings, limited by cumbersome equipment and specialist staffing. Although no study has yet validated in-ear EEG specifically for delirium detection, its feasibility in dementia and seizure monitoring suggests a plausible role. Early work exploring simplified EEG systems for delirium detection in older surgical patients further highlights the potential of scalable neuromonitoring approaches outside specialist neurophysiology laboratories (add reference: DOI: 10.1093/eurjcn/zvaf128). If future work confirms that in-ear EEG can capture early spectral slowing or loss of connectivity, it could enable real-time delirium monitoring in routine care.

Beyond the general ward, in-ear EEG may also have applications in intensive and emergency care. Continuous EEG monitoring in the intensive care unit is labour-intensive and limited to a small number of centres. In-ear EEG could extend neuromonitoring to a wider patient population, providing ongoing information about cortical activity during sedation, coma or recovery. Continuous brain monitoring may reveal prognostic patterns analogous to cardiac telemetry. Similarly, after head injury, prolonged EEG recording could reshape our understanding of secondary brain injury. Current protocols often rely on nurse-observed seizures, informed by studies from the 1990s, contributing to widespread prophylactic antiepileptic use. While such treatment may benefit some patients, it can also exacerbate delirium and cognitive decline, particularly in older adults.

For all its promise, in-ear EEG is not without limitations. Recording from a small number of electrodes, typically one to three per ear, restricts spatial coverage compared with a full 19-channel scalp EEG. This limits localisation of activity and detection of focal pathology. Signals may also be influenced by ear canal anatomy, skin integrity and hearing-aid use, while the surrounding bone attenuates higher-frequency signals. As a result, in-ear EEG is better suited to detecting broad changes in cortical rhythms than subtle regional discharges. Interpretation may therefore depend on algorithms specifically designed for this geometry rather than direct comparison with standard EEG. Cost, validation and integration into clinical workflows remain additional barriers and devices must demonstrate meaningful impact on patient-centred outcomes before widespread adoption.

Despite these challenges, the principle underlying in-ear EEG is compelling. For frail or cognitively impaired patients, it may represent the only practical means of recording brain activity longitudinally. In this context, in-ear EEG aligns with emerging evidence that brain signals may be most informative when used to characterise trajectories and vulnerability rather than static diagnoses [1]. In practice, in-ear EEG could shift neuromonitoring from the laboratory to the bedside, from reactive investigation to proactive care, allowing us to study delirium and other fluctuating syndromes as they unfold rather than after they resolve.

In-ear EEG represents more than a technical innovation. It reflects a philosophical shift from studying the brain in controlled environments to listening to it in real life. The technology is imperfect, but so too is our current approach. If we wait for a perfect solution, we risk perpetuating a system in which the brains of our most vulnerable patients remain largely unobserved. The challenge now is not whether we can record from the ear, but whether we are ready to listen.

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