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“AI-powered implantable sleep apnea device can achieve better Apnea-Hypopnea Index (AHI) compared to CPAP device”

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Sleep is a fundamental aspect of global health, and addressing sleep-related issues such as Sleep apnea and insomnia etc. is crucial for overall well-being. As per reports, the global sleep economy is estimated to be worth $585 billion. In this regard, Capgemini has developed a solution for a first-of-its-kind AI-powered implantable sleep device. The solution integrates advanced monitoring and AI-driven therapy as it tracks breathing patterns, stimulates nerves to restore natural airflow, and securely transmits data to doctors via IoT and edge AI for therapy adjustments. Atul Kurani, VP, Global Health Medical Practice & IoT, Capgemini Engineering spoke to BioSpectrum about how technology can help to ease out the global burden associated with sleep disorders, and other health issues.

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What makes this AI-powered implantable device different from traditional sleep apnea treatments like CPAP, and why is it considered first-of-its-kind?

Unlike CPAP devices, which require a mask connected to a machine delivering continuous positive airway pressure in hospital or home care settings, Capgemini’s partnered solution is fully implantable, eliminating discomfort, noise, and portability issues. CPAP systems provide fixed or auto-adjusting air pressure but remain reactive, adapting only to airflow changes without considering real-time physiological variations like sleep stages and body positions which tend to influence airway collapse and the severity of sleep apnea. In contrast, the AI-powered implant dynamically adjusts stimulation based on sleep stage, breathing effort, and patient-specific patterns. Thus, an AI-powered implantable sleep apnea device has the potential to achieve a better Apnea-Hypopnea Index (AHI) compared to CPAP which is key measure of sleep apnea severity. This proactive approach enables personalized therapy, by predicting and preventing airway collapse rather than responding after an event occurs. By combining adaptive algorithms with implantable neurostimulation, the device offers a discreet, intelligent alternative to CPAP, improving comfort, compliance, and overall sleep quality.

How does the AI engine learn and adapt to each patient's breathing patterns over time, and what kind of improvements have you observed?

The AI engine continuously learns from each patient's nightly breathing patterns by analyzing data from implanted sensors and stimulation feedback. Initially, it establishes a baseline of respiratory rhythm and muscle response, then applies adaptive algorithms to predict apnea risk and severity and optimize stimulation timing and intensity based on sleep stage, body position and efforts. Over time, the system personalizes therapy by recognizing variations across sleep stages and body positions, reducing unnecessary stimulation while ensuring airway stability. Observed improvements include a significant reduction in Apnea-Hypopnea Index (AHI)which is a key metric used to diagnose and assess the severity of sleep apnea along with more consistent REM cycles, fewer awakenings, and enhanced patient comfort. This adaptive approach also improves compliance compared to CPAP, as therapy becomes proactive, precise, minimally intrusive, and multi parameter based, delivering better clinical outcomes and overall sleep quality.

What were the biggest engineering challenges in developing a device that can monitor, stimulate nerves, and deliver therapy in real time?

Developing an implantable device that monitors, stimulates nerves, and delivers therapy in real time does pose several engineering challenges. First, miniaturization is critical element, integrating sensors, stimulation leads, and a pulse generator into a compact, biocompatible form factor without compromising performance. Second, ensuring precise timing and synchronization between breathing detection and nerve stimulation requires robust signal processing with minimum latency. Power management is equally important, as the device must operate for years on a small battery while supporting adaptive algorithms. Additionally, achieving secure wireless connectivity for data transfer to mobile and cloud platforms demands advanced encryption and low-power communication protocols. Finally, designing an AI engine that learns patient-specific patterns while running efficiently on edge hardware is complex and requires deep understanding of the clinical domain. Sensor design is typically the client's IP and a key success factor, requiring expertise in biomedical engineering, material science, microelectronics, signal acquisition, and regulatory compliance to create sensors that accurately capture physiological signals for AI-driven therapy.

How do you see implantable, AI-driven devices shaping the future of personalized healthcare beyond sleep disorders?

Implantable, AI-driven devices represent a major leap toward truly personalized healthcare. Beyond sleep disorders, these systems can continuously monitor physiological signals, learn individual patterns, and deliver targeted interventions without external apparatus. For example, in cardiac care, AI-enabled implants could predict arrhythmias and adjust pacing dynamically, while in neurology, they could modulate nerve activity to manage chronic pain or epilepsy. In neurology, Deep Brain Stimulation (DBS) combined with AI can dynamically adjust stimulation for Parkinson's disease, epilepsy, and even treatment-resistant depression, learning patient-specific neural patterns to optimize therapy. Similarly, Spinal Cord Stimulation (SCS) for chronic pain is evolving into adaptive systems that predict pain episodes and modulate signals proactively. Mental health applications are emerging, where closed loop neurostimulators monitor brain activity and deliver targeted interventions for anxiety or mood disorders. These trends reflect a shift from static implants to intelligent, connected ecosystems integrating real-time analytics, cloud-based updates, and predictive algorithms. By continuously learning from physiological and behavioral data, AI-powered implants promise proactive, personalized care, reducing hospital visits, improving compliance, and transforming chronic disease management into a seamless, personalized patient centric experience.

Capgemini also works with pharma on AI for clinical trials and drug discovery—how does this sleep device fit into your larger healthcare innovation strategy?

Capgemini's Lifesciences innovation strategy spans the entire continuum—from drug discovery and clinical trials to smart connected care enabling precision medicine. Our work with pharma leverages AI tools for drug discovery, trial optimization, and predictive analytics, accelerating time-to-market of drugs. The AI-powered implantable sleep device fits into this vision by building intelligence in devices to the patient's bedside—and even inside the body. It exemplifies closed-loop, data-driven care, where real-time physiological insights feed into adaptive algorithms for personalized treatment. Combined with mobile platforms and cloud analytics, these devices create a connected ecosystem that complements digital twins and precision medicine initiatives. By integrating IT and OT, we enable proactive interventions, reduce hospital revisits and improve outcomes. In essence, this device is not an isolated innovation, it's a cornerstone in Capgemini's mission to transform healthcare into a predictive, personalized, and patient-centric experience.

With Capgemini's combined IT+OT capabilities, what new healthcare problems do you believe can now be solved that weren't previously possible?

With Capgemini's combined IT and OT capabilities, it becomes possible to integrate advanced analytics, IoT-enabled medical devices, and AI-driven automation with operational technologies, enabling real-time, closed-loop care systems. Implantable devices can stream physiological data securely through mobile platforms, which act as gateways for cloud connectivity. These mobile apps not only transfer data but also perform initial analytics, such as detecting anomalies, summarizing trends, and providing patient engagement before syncing with cloud-based predictive models. This convergence makes remote monitoring and adaptive therapy possible for chronic conditions like sleep apnea, cardiac arrhythmias, diabetes and neurodegenerative disorders. It also opens doors for digital twins of patients, enabling simulation-based treatment planning and personalized drug delivery.

Our combined IT+OT capabilities don't just transform connected care; they also enable breakthrough solutions like digital robotic surgical platforms. By integrating AI-driven analytics, IoT sensors, and automation into surgical platforms, we can deliver real-time decision support, predictive risk assessment, and precision control during complex procedures. For example, robotic-assisted knee or hip replacement systems leverage AI to analyze intraoperative imaging data, suggest the best choice of implants based on patient gait patterns and ligament tensions, enable adjustment of robotic instrument positioning dynamically, thus reducing chances of human error. Thus IT+OT synergy, with its smart connected intelligent ecosystem, will transform healthcare from reactive to proactive solutions, delivering precision medicine and improved patient outcomes.