Evolutionary and Revolutionary Roles of Artificial Intelligence in Medicine

Adewole O. Olufemi

In less than a decade, artificial intelligence (AI) has moved from proof-of-concept tools in computer science laboratories to agenda-setting themes in global medical discourse. In 2025, I was involved in three major international scientific gatherings in Amsterdam, Copenhagen, and London, where deep learning, clinical AI, and the ethical responsibilities of emerging technologies and innovations in lung health were discussed with unusual candor and urgency. The conversations at these meetings amongst others, reflected a pivotal question now facing the medical community: *Is AI an evolutionary technology that incrementally improves what we already do, or is it a revolutionary force that is fundamentally restructuring how we discover, diagnose, test, and deliver interventions?* Reality suggests both forces are unfolding simultaneously. The challenge is to harness AI's revolutionary potential while continuing the evolutionary work of building safe, equitable, and trustworthy medical systems.

Medicine today is advancing along two intertwined trajectories. On one hand is the gradual evolution of established practices—refinements in imaging, diagnostics, therapeutics, and clinical workflow. On the other is the profound revolution driven by AI, molecular biomarkers, and biotechnology. These shifts extend across pulmonology, thoracic surgery, cardiology, neurology, oncology, infectious diseases, and population. In fact no single speciality in medicine and dentistry is left behind. In cardiology, machine-learning interpretation of echocardiography and ECG has enhanced the early detection of silent cardiomyopathies and arrhythmia syndromes. In neurology, AI applied to MRI, EEG, speech cadence, and gait metrics now augments the detection of Parkinsonism, early Alzheimer's disease, and epileptic networks. Across disciplines, clinical medicine is transitioning from symptom-driven categorisation to data-driven precision.

Respiratory medicine illustrates this dual movement particularly clearly. For decades, the field progressed through evolutionary improvements, more refined spirometry, sensitive gas transfer measurements, high-resolution CT imaging, improved ventilatory strategies, and incremental development of inhaled therapies and antifibrotics. These enhancements strengthened clinical practice without altering its conceptual structure. In recent years, however, steady progress has merged with revolutionary technologies in digital diagnostics, molecular biomarker profiling, advanced radiomics, and biologically engineered therapies. Pulmonologists, internists, and physician-educators now work within a landscape where traditional principles coexist with tools that fundamentally challenge how we conceptualise lung disease.

One of the clearest illustrations of this evolution-to-revolution continuum is seen in interstitial lung diseases (ILDs). Historically, ILDs were defined through clinical history, HRCT pattern recognition, lung biopsy, and physiological assessment. But the incorporation of biomarkers such as KL-6 (Krebs von den Lungen-6) and SP-D (surfactant protein-D) has added layers of biological depth that imaging alone cannot provide. KL-6, produced by regenerating type II pneumocytes, rises in conditions marked by epithelial injury and fibroproliferative activity. Elevated KL-6 correlates with disease severity, radiographic extent of fibrosis, and survival outcomes. SP-D increases in settings of alveolar inflammation, impaired epithelial integrity, or acute exacerbation. In combination, KL-6 and SP-D help distinguish inflammatory from fibrotic phenotypes, identify high-risk patients, assess treatment response, and potentially reduce reliance on invasive biopsy. Far from being peripheral, ILD biomarkers are stepping into the core of disease monitoring and risk stratification.

AI further amplifies this transition by exposing patterns beyond the visual or cognitive reach of human observers. In ILDs, deep-learning models can detect ultra-early fibrotic changes before they are perceptible on HRCT, quantify the spatial distribution of fibrosis, measure vascular pruning, integrate hundreds of radiomic features, and predict trajectories months before physiological decline occurs. These tools shift diagnosis from a static snapshot to a dynamic, computationally enriched interpretation of disease biology. AI can also classify ILDs into mechanistic subtypes, identify progression-prone phenogroups, and integrate biomarker panels with imaging to generate multidimensional digital phenotypes.

In obstructive lung disease, AI models analyse flow-volume loops, integrate wearable-derived respiratory signals, assess environmental exposures, and forecast exacerbations. In asthma, AI-guided biologic selection systems are emerging, synthesising eosinophils, FeNO, clinical markers, genomics, and environmental triggers. For COPD, AI quantifies

emphysema subtypes, small-airway disease, mucous plugging burden, and air-trapping heterogeneity, providing more granular phenotyping than traditional GOLD criteria.

AI also expands global lung health. Automated chest X-ray interpretation systems for tuberculosis are now capable of detecting disease in high-burden settings where radiologists are scarce. AI-enhanced lung ultrasound tools support diagnosis of pneumonia, ARDS, and pleural diseases including in emergency, remote, or resource-limited contexts.

Therapeutics are evolving in parallel. Traditional drug development for respiratory disease, long constrained by slow pipelines and limited targets is being transformed by AI-driven discovery. Machine-learning models map protein–protein interactions, screen millions of compounds in silico, predict drug–target dynamics, and reveal repurposing opportunities for pulmonary fibrosis, pulmonary hypertension, cystic fibrosis, and lung cancer. AI enables researchers to simulate disease behaviour under therapeutic conditions, reducing time and cost.

This revolution extends into thoracic surgery. Video-assisted thoracoscopic surgery represented an evolutionary improvement: smaller incisions, less pain, and faster recovery while preserving the anatomical principles of open thoracotomy. Robotic-assisted thoracic surgery (RATS), however, is fundamentally transformative. With wristed instruments, 3D magnified vision, tremor elimination, and augmented-reality overlays, the robotic platform expands surgical capacity. Surgeons can perform complex segmentectomies, sleeve resections, lymphadenectomies, and thymectomies with unprecedented accuracy. AI adds further layers: real-time anatomy segmentation, tumour-margin detection, vascular-structure prediction, and intraoperative complication forecasting. The future operating room is an intelligent, AI-integrated environment.

These scientific and technological accelerations require profound change in medical education. The traditional curriculum anchored in anatomy, physiology, pathology, and bedside apprenticeship though highly essential is no longer sufficient. Clinicians must understand the fundamentals of AI: how models learn, where bias is introduced, what constitutes algorithmic drift, and how to interpret probabilistic outputs. Pulmonologists must be fluent in radiomics, ILD biomarkers, genomic signatures, and digital phenotyping. Thoracic surgeons must master robotic platforms, virtual simulation, and AI-augmented navigation. Internists and primary care physicians must learn how to integrate algorithmic predictions with bedside reasoning.

For residents and medical students, this era presents remarkable opportunity. Training now requires fluency in digital diagnostics, biomarker interpretation, precision-medicine frameworks, and critical appraisal of algorithmic outputs. Learners must understand not only the biological meaning of KL-6, SP-D, NT-proBNP, high-sensitivity troponin, or neurofilament light chain, but also how AI models integrate such variables, where errors arise, and how to communicate uncertainty to patients. Humanistic competence becomes even more important in an AI-rich environment: compassion, contextual intelligence, and communication cannot be automated.

Alongside opportunity, the revolution carries serious ethical responsibilities. AI can amplify inequities if trained on biased or non-representative data. Automated radiography systems may underperform on certain ethnicities if training datasets lacked diversity. Algorithms may misclassify or overdiagnose when applied outside their developmental context. Regulatory structures struggle to keep pace with self-updating models whose behaviour evolves after deployment. Data privacy, informed consent, algorithmic transparency, and accountability become central to clinical integrity. These are not peripheral concerns, they are the conditions upon which trust in AI-enabled medicine depends.

Across disciplines, one theme emerges: the boundaries of what clinicians can perceive, diagnose, and treat are expanding. AI increases sensitivity and precision; biomarkers illuminate disease biology; robotics enhances surgical dexterity; genomics and cellular therapies move medicine toward disease modification and not merely disease management. But these advancements must be balanced with safety, equity, and evidence-based implementation.

Medicine stands at a moment of extraordinary potential. Evolutionary improvements continue to refine clinical practice, while revolutionary technologies invite a reimagining of disease classification, therapeutic strategy, and clinical reasoning. The challenge for physicians, surgeons, internists, educators, and trainees is not simply to adapt, but to provide stewardship and ensuring that innovation elevates patient care and preserves the humanity at the core of our profession. If guided wisely, the union of evolution and revolution will define a new era of medicine grounded in precision, equity, responsibility, and compassion.

Adewole O. Olufemi, MD,
Heart Lung Innovation, Division of Respiratory Medicine, Department of Medicine, St Pauls Hospital, University of British Columbia, Vancouver.
Department of Medicine, Obafemi Awolowo University, Ile Ife, Nigeria

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