From Scalpel to Algorithms in Lung Cancer Management: Precision Requires Wisdom—Beware Not Artificial Intelligence, but Natural Stupidity

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Luca Bertolaccini[1,2], Claudia Bardoni[1], Juliana Guarize[3], Lorenzo Spaggiari[1,2]

[1]Department of Thoracic Surgery, IEO, European Institute of Oncology IRCCS, 20141 Milan, Italy
[2]Department of Oncology and Hemato-Oncology, University of Milan, 20122 Milan, Italy
[3]Division of Interventional Pulmonology, IEO, European Institute of Oncology IRCCS, 20141 Milan, Italy

Introduction

Lung cancer management is undergoing a profound transformation, standing at the intersection of long-established surgical tradition and emerging technological innovation. Over the past two decades, thoracic surgery has witnessed profound changes, from the adoption of minimally invasive techniques to the integration of molecular diagnostics. Today, the convergence of precision medicine, artificial intelligence (AI), and robotic bronchoscopy is reshaping our field with unprecedented potential to deliver individualized, minimally invasive, and highly effective patient care. High-definition visualization and robotic dexterity promise a future where a wealth of real-time, patient-specific data informs surgical planning and execution. However, as with every disruptive innovation, this progress comes with a responsibility: to guard against the erosion of clinical judgment through cognitive biases, overreliance on automation, and professional complacency. The greatest threat is not the intelligence of our machines, but the natural stupidity of neglecting the critical thinking, vigilance, and ethical responsibility that define good surgical practice. This cautionary stance is not an argument against innovation, but a recognition that technological tools, no matter how advanced, remain subject to the same human vulnerabilities that have always shaped surgical decision-making. The transition from manual dexterity to algorithmic precision demands a deliberate balance, embracing new capabilities while safeguarding the surgical principles that have always underpinned patient safety and outcomes.

Precision Medicine and Artificial Intelligence-Enhanced Visualization

Molecular diagnostics, genomic profiling, and AI-assisted image reconstruction increasingly guide modern thoracic surgical planning. Preoperative assessments no longer rely solely on Computed Tomography (CT) or Positron Emission Tomography (PET) scans interpreted by human eyes; AI algorithms can now reconstruct three-dimensional models from multimodal imaging, enabling precise localization of lesions, assessment of their spatial relationship to vessels and bronchi, and prediction of nodal involvement.

In early-stage non-small cell lung cancer (NSCLC), the integration of genomic profiling into surgical planning has allowed the identification of subgroups who may benefit from neoadjuvant immunotherapy or targeted therapy. AI models, trained on large-scale imaging and pathology datasets, can detect radiomic patterns and subtle textural variations imperceptible to the human eye—features that may correlate with actionable molecular alterations or indicate aggressive tumour biology. Furthermore, AI-assisted visualization is increasingly being used intraoperatively to provide augmented reality overlays that map tumour margins in real time.

The value of artificial neural networks was demonstrated in refining lung cancer diagnosis and treatment paradigms, providing a blueprint for how machine learning could become a routine part of preoperative decision-making [1,2]. The fusion of AI-enhanced imaging, molecular insights, and robotic precision offers a vision of a surgical ecosystem where decisions are supported by comprehensive, patient-specific intelligence. Yet, these systems remain tools; they must be interpreted and applied by surgeons who understand both the power and the limits of the technology.

Artificial Intelligence in Clinical Decision Support: Promise and Pitfalls

AI models have achieved remarkable performance in detecting pulmonary nodules, predicting lymph node metastases, and estimating postoperative outcomes [3]. For example, convolutional neural networks have been shown to outperform radiologists in identifying subcentimeter nodules on low-dose CT, potentially enhancing lung cancer screening programs [4]. Predictive models integrating imaging, clinical, and biochemical data can estimate perioperative risks with higher accuracy than traditional scoring systems.

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Correspondence to: Luca Bertolaccini, Department of Thoracic Surgery, IEO, European Institute of Oncology IRCCS, 20141 Milan, Italy; Department of Oncology and Hemato-Oncology, University of Milan, 20122 Milan, Italy (e-mail: luca.bertolaccini@gmail.com).
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However, the translation of these tools into clinical reality is far from seamless. One well-recognized challenge is the phenomenon of "hallucinations", where AI systems produce confident but factually incorrect outputs [5]. In the surgical context, an overreliance on such outputs, especially when training datasets are biased or incomplete, can lead to inappropriate operative strategies or missed diagnoses. The lack of standardization in AI validation studies further complicates adoption, as performance metrics often fail to generalize beyond the development cohort.

Therefore, rigorous prospective validation, transparent reporting of training datasets, prospective multicenter validation, and structured integration into multidisciplinary decision-making pathways are essential before these systems can be safely embedded into daily thoracic surgical practice. The surgeon's role is to use AI as a decision-support tool, not as a substitute for human reasoning.

Automation Bias and the Risk of Deskilling

Automation bias—the human tendency to uncritically overtrust machine-generated recommendations—has been well documented in aviation, autonomous driving, and, increasingly, in clinical medicine [6]. In radiology, studies have shown that human vigilance declines when AI systems are available, with missed diagnoses in cases where the algorithm fails silently.

In thoracic surgery, such risks may emerge in intraoperative navigation or real-time decision support systems. If a surgeon relies excessively on AI guidance for localization or margin assessment, their ability to detect anomalies independently may degrade over time. This de-skilling effect is insidious: it is not the dramatic failure of technology, but the gradual erosion of the surgeon's ability to function effectively without it.

To counteract this, surgical training must continue to emphasize independent proficiency in core diagnostic and technical skills, even in an AI-rich environment. Simulation platforms incorporating AI assistance could be designed with variable "failure modes" to train surgeons to recognize when the system is wrong and to take corrective action.

Cognitive Bias: The Enduring Human Limitation

While much attention is given to AI errors, human cognitive biases remain an equally significant threat to surgical quality [7]. Overconfidence can lead surgeons to dismiss alternative diagnoses; anchoring can cause fixation on an initial assessment despite new contradictory evidence; confirmation bias may result in selective interpretation of data that supports pre-existing beliefs.

In thoracic oncology, these biases can manifest in subtle but impactful ways—for example, assuming that a small peripheral nodule in a lifelong nonsmoker is benign, or underestimating the aggressiveness of specific molecularly defined adenocarcinoma subtypes.

Robotic Bronchoscopy—Precision in Diagnostic Navigation

Robotic-assisted bronchoscopy, particularly utilizing the ION endoluminal system™, marks a paradigm shift in the diagnostic approach to peripheral pulmonary lesions [8]. The ION system's distinctive advantages—particularly its shape-sensing technology, superior navigation accuracy, and growing real-world adoption among interventional pulmonologists—project its future role in integrating diagnostic and potentially therapeutic bronchoscopic applications. Despite these encouraging outcomes, the effective adoption of robotic bronchoscopy mandates rigorous operator training, an adept understanding of pulmonary anatomy, and integration into multidisciplinary diagnostic workflows. Looking ahead, integration with AI-driven lesion characterization tools may allow robotic bronchoscopy not only to reach lesions with high precision, but also to provide intra-procedural assessments of malignancy probability.

Ethical and Governance Imperatives

The responsible integration of AI into thoracic surgery extends beyond technical performance. Ethical considerations include transparency in algorithm design, equitable access, and the prevention of bias that may exacerbate health disparities [9]. The European Union (EU) Artificial Intelligence Act and recent Food and Drug Administration (FDA) guidance on AI-based medical devices mandate explainability, continuous performance monitoring, robust post-market surveillance, and mechanisms to detect and mitigate algorithmic bias [10]. Equally critical is education. AI literacy should be incorporated into surgical training programs, ensuring that future surgeons understand the principles, limitations, and potential pitfalls of these systems.

The Surgeon as Guardian of Reason

Your contributions as surgeons are not defined solely by technical proficiency but by the wisdom to integrate technological advances with critical judgment, ethical responsibility, and patient-centered care. These works underscore a central truth: technology is only as effective as the judgment that governs its use.

Historically, every major innovation in surgery, from anaesthesia to thoracoscopy, has sparked concerns about skill erosion and overreliance on tools. In each case, those concerns proved valid when technology was adopted without adequate training, critical oversight, or respect for the fundamental principles of surgical care. AI represents a similar inflection point, but with the added complexity that its reasoning processes may be opaque even to its developers.

The progression from scalpel to algorithms should enrich, not replace, human expertise. Surgeons must remain stewards of patient care, validating technological outputs, recognizing when systems falter, and ensuring that human judgment remains sovereign. The actual danger lies not in AI,

but in natural stupidity: the complacency, bias, and erosion of critical thinking that no algorithm can correct.

As lung cancer management embraces the era of algorithms, let us do so with vigilance, humility, and unwavering commitment to the principles that have always defined our profession. As the guardians of both technical skill and ethical responsibility, thoracic surgeons are uniquely positioned to shape how AI is deployed in oncological care. The profession's challenge over the coming decade will be to lead this transformation without surrendering the essence of surgical craft—an equilibrium between technological empowerment and irreplaceable human insight. Wisdom must remain our most essential instrument—sharper than any scalpel, more discerning than any algorithm, and, above all, the one surgical tool that is and must remain unmistakably human.

Availability of Data and Materials

Not applicable.

Author Contributions

LB conceived the concept. CB, JG and LS outlined the editorial and contributed to discussion. LB drafted the manuscript. All authors contributed to the critical revision of the manuscript for important intellectual content. All authors read and approved the final manuscript. All authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

Not applicable.

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Conflict of Interest

Luca Bertolaccini is serving as one of the Editorial Board Members of this journal. We declare that Luca Bertolaccini had no involvement in the review of this article and has no access to information regarding its review. Other authors declare no conflict of interest.

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