Supplementary

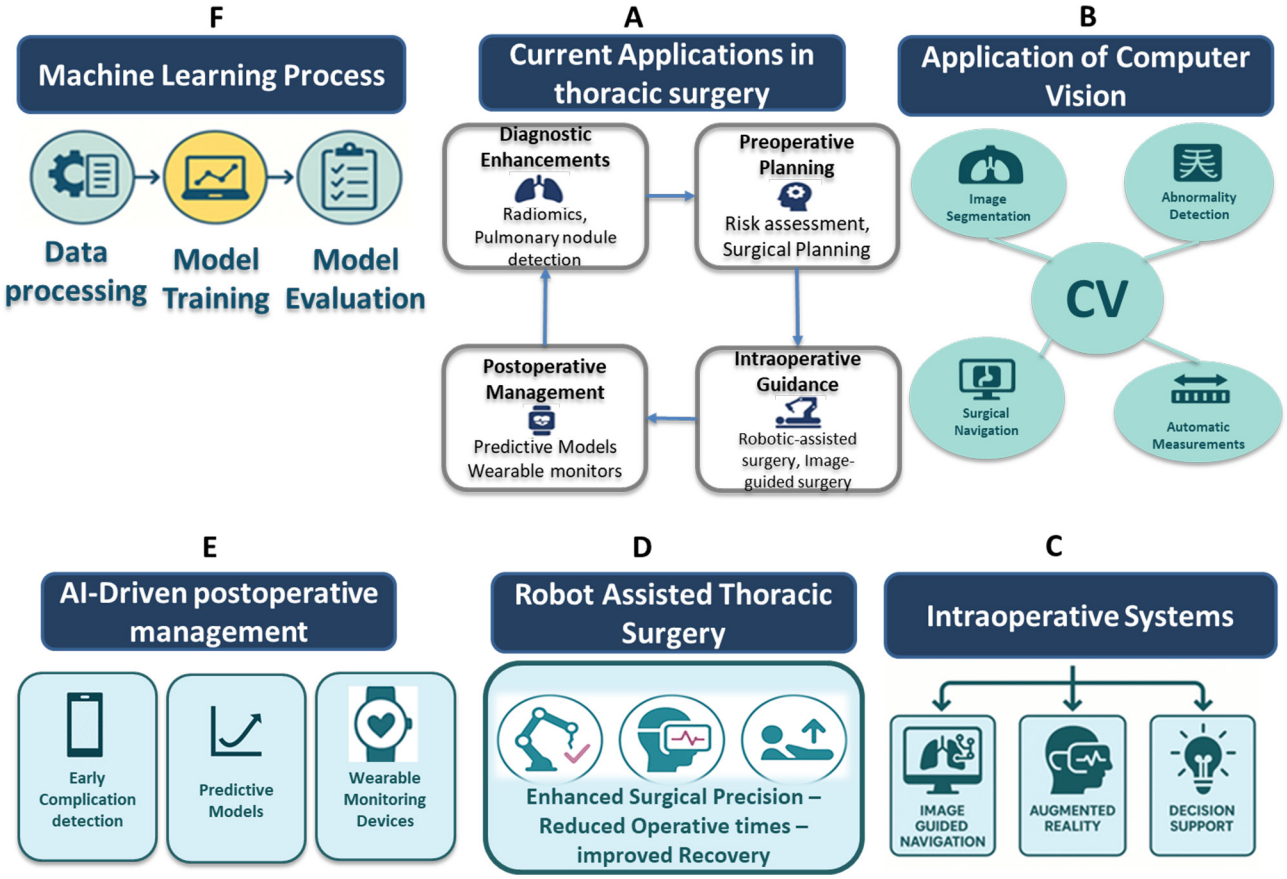

Figure S1 An overview of AI tools in thoracic surgery. (A) Current application of AI in thoracic surgery. (B) Applications of computer vision. (C) Intraoperative AI system. (D) Robotic-assisted thoracic surgery. (E) AI-driven postoperative management. (F) Machine learning process.

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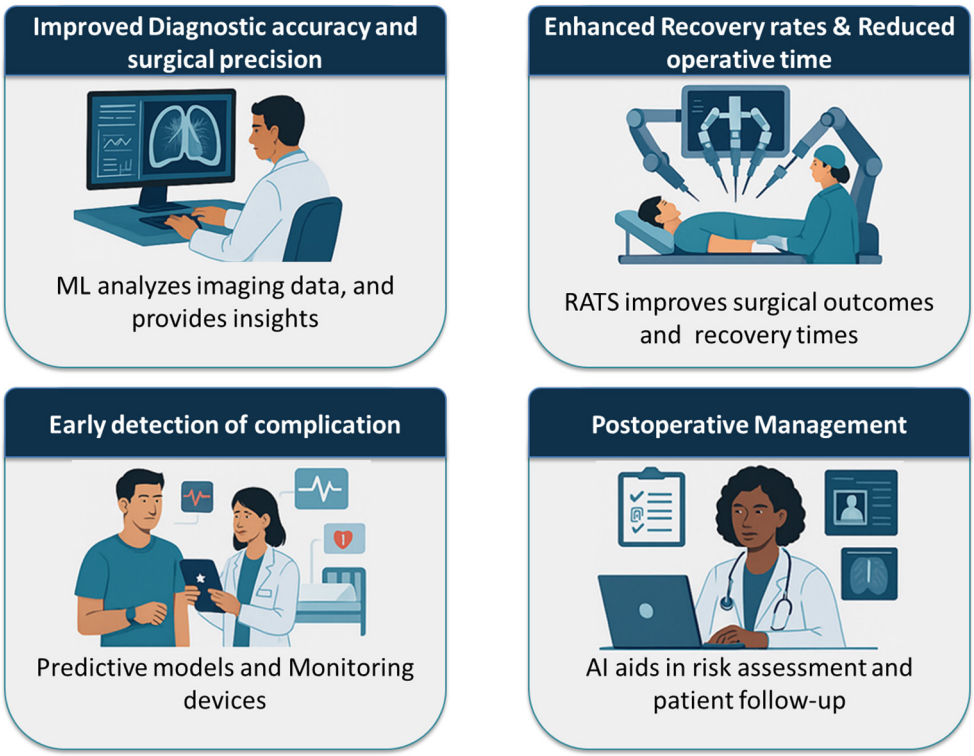

Figure S2 Visual summary of clinical benefits associated with AI integration in thoracic surgery.

Table S1 Comparative analysis of AI models

AI model	Application	Strengths	Limitations
CNN (ResNet, VGG)	Image classification, radiomics	High accuracy in image analysis	Requires large training datasets
RNN (LSTM)	Text analysis (medical records)	Good for sequential data	Prone to vanishing gradient problems
Decision Trees (XGBoost)	Risk prediction, decision support	Easy to interpret	May overfit without pruning

RNN, recurrent neural network; CNN, convolutional neural network; LSTM, long short-term memory; XGBoost, eXtreme Gradient Boosting; ResNet, residual network; VGG, Visual Geometry Group (network architecture).

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Table S2 AI tools and platforms in medicine and thoracic surgery

Tool/platform	Link	Advantages	Disadvantages
C2-Ai (Clinical AI)	C2-Ai	- Personalized preoperative risk assessment using global patient data	- Requires integration with hospital systems
		- Reduces complications and readmissions	- Dependent on data quality and completeness
		- Supports “prehabilitation” strategies	
Surgery Hero	Surgery Hero	- Provides tailored preoperative guidance on nutrition, exercise, and mental health	- May require patient engagement and adherence
		- Enhances patient readiness for surgery	- Limited to specific healthcare systems
Touch Surgery	Touch Surgery	- Mobile surgical training platform with simulations for over 200 procedures	- Not a substitute for hands-on surgical experience
		- Validated by multiple peer-reviewed studies	- May not cover all surgical specialties
		- Enhances surgical education and planning	
MONAI (Medical Open Network for AI)	MONAI	- Open-source framework for deep learning in healthcare imaging	- Requires programming knowledge
		- Facilitates development of AI models for image segmentation, classification, and more	- Geared towards researchers and developers
HoloSurgical ARAI™ System	HoloSurgical	- Augmented reality-assisted surgical navigation	- High implementation costs
		- Provides real-time 3D anatomical visualization	- Limited availability and adoption
		- Enhances precision in spine surgeries	
da Vinci Surgical System	Intuitive Surgical	- Robotic-assisted surgery with enhanced dexterity and 3D visualization	- High acquisition and maintenance costs
		- Reduces surgeon fatigue and improves precision	- Requires specialized training
ZEUS Robotic Surgical System	ZEUS System	- Enables minimally invasive microsurgery	- No longer in production
		- Offers tremor filtration and remote operation capabilities	- Superseded by newer robotic systems
PulmoVR	PulmoVR Study	- Virtual reality platform for personalized surgical planning in pulmonary segmentectomies	- Limited clinical validation
		- Enhances understanding of patient-specific anatomy	- Requires VR equipment
Advance Alert Monitor (AAM)	AAM Study	- Machine learning model predicting postoperative complications	- Dependent on real-time data availability
		- Provides early warnings for patient deterioration	- May require customization for different institutions
AI-Assisted Surgical Video Analysis	AI in Thoracic Surgery	- Utilizes convolutional neural networks for instrument and anatomical structure recognition	- Requires large annotated datasets
		- Aids in surgical training and intraoperative guidance	- Computationally intensive

VR, virtual reality; AI, artificial intelligence; MONAI, Medical Open Network for AI; ARAI™, Augmented Reality Artificial Intelligence; AAM, Advance Alert Monitor; CNN, convolutional neural network.

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Table S3 Summary of key studies involving implemented or validated AI models in thoracic surgery

No.	Study	Study type	AI tool/model	Application domain	Outcome metrics	Surgical phase
1	Peek *et al.*, 2024	Original study (n=8 procedures)	Stereo-endoscopic AI registration	Intraoperative AR guidance (VATS/RATS)	Registration error: 0.20 mm, reprojection error: 0.22 pixels	Intraoperative
2	Sadeghi *et al.*, 2024	Pilot study (n=5 patients)	PulmoVR + AI segmentation	Preoperative planning, AR navigation	Surgeon-reported spatial accuracy, setup time <15 s, no workflow interruptions	Preoperative & intraoperative
3	Zhong *et al.*, 2022	Original study	Deep learning model	Prediction of occult nodal metastasis in NSCLC using PET/CT	AUC: 0.87 (training), 0.84 (validation)	Diagnostic
4	Lazăr *et al.*, 2022	Review with technical data	AI-enhanced fluorescence imaging	Esophageal neoplasia diagnosis	Improved lesion detection; observer variability reduced	Diagnostic
5	Touch Surgery	Clinical validation study	AI simulation & skill assessment	Surgical education/ training	Objective performance metrics: economy of motion, time efficiency	Educational/ training

AI, artificial intelligence; AR, augmented reality; VATS, video-assisted thoracoscopic surgery; RATS, robot-assisted thoracoscopic surgery; NSCLC, non-small cell lung cancer; PET/CT, positron emission tomography/computed tomography; AUC, area under the curve.

Table S4 Overview of AI tools in thoracic surgery

AI tool/platform	Application	Advantages	Disadvantages	Link
C2-Ai (Clinical AI)	Risk prediction, preoperative planning	Personalized risk assessment, global data	Requires data integration, dependent on data quality	C2-Ai
Touch Surgery	Surgical training and planning	Interactive simulations, validated by studies	Not a substitute for hands-on training	Touch Surgery
HoloSurgical ARAI™ System	Augmented reality-assisted navigation	3D visualization, enhanced precision	High implementation costs	HoloSurgical
PulmoVR	Virtual reality for pulmonary surgery	Personalized anatomical understanding	Limited clinical validation	PulmoVR Study
Advance Alert Monitor (AAM)	Postoperative monitoring	Predicts complications, improves patient safety	Requires continuous data input	AAM Study

AI, artificial intelligence; ARAI™, Augmented Reality Artificial Intelligence; VR, virtual reality; AAM, Advance Alert Monitor.

Table S5 Comparison of AI performance in diagnostic imaging for thoracic surgery

AI application	Imaging modality	Sensitivity (%)	Specificity (%)	Reference
Pulmonary nodule detection (9)	CT (Radiomics)	86	84	Shi *et al.*, 2023
Lung cancer classification (12)	CT (deep residual network)	91.07	88.64	Nibali *et al.*, 2017
Lymph node metastasis prediction (11)	PET/CT	82	86	Li *et al.*, 2024

AI, artificial intelligence; CT, computed tomography; PET/CT, positron emission tomography/computed tomography.

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