

Advances in Artificial Intelligence and Extended Reality for Enhanced Surgical Navigation in Thoracic Surgery

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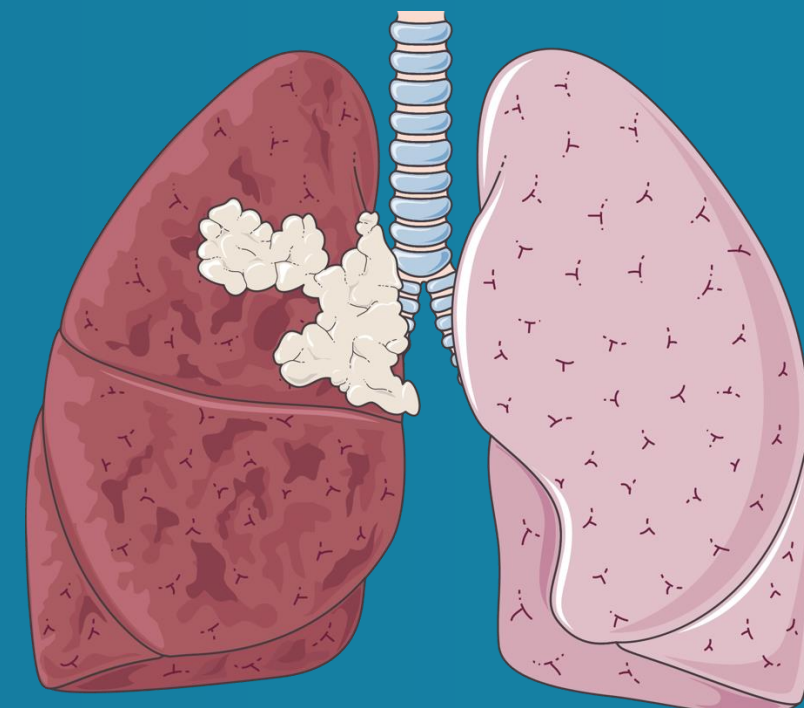
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Introduction and Rationale

Advancements in lung cancer screening using computed tomography (CT) has allowed for diagnosis at earlier stages¹

Significant precision is required for localizing lung tumors in relation to important structures, presenting challenges for **pre-operative planning and determining surgical plans**, especially in the era of lung-sparing surgery²

Augmented and virtual reality (AR/VR) and artificial intelligence (AI)-based segmentation techniques have been developed for preoperative imaging analysis and intraoperative guidance³

The scope of these technologies and safety profiles have not been well characterized in thoracic surgery

Objectives

This study aims to review **advances in AI, AR and VR** technologies for **preoperative planning** and **intraoperative guidance** for thoracic surgery

Methodology

Arksey and O'Malley methodological framework for scoping studies⁴

Search Strategy

Medline, EMBASE, and Web of Science searched from January 2010 to May 2024

Keyword search terms included: "thoracic surgery", "lung surgery" or "lung resection" and "artificial intelligence" or "augmented or virtual reality" or "machine learning"

Inclusion criteria:

- Use of AI, AR or VR technologies for surgical planning or intraoperative assistance in lung resections
- Original research articles published from January 2010 to May 2024
- Full-text available in English

Exclusion criteria:

- Non-elective lung resection procedures
- AI, AR/VR used for diagnostic clinical decision-making and/or post-operative monitoring
- Abstract or conference proceeding only

Methodology

Primary and Secondary Outcomes

- Changes to preoperative surgical plan
- Lesion or critical structure localization accuracy
- Surgical outcomes
 - Operating time
 - Intraoperative blood loss
 - Post-operative complications
 - Oncologic outcomes

- Qualitative user feedback towards technologies

Results – Study Screening and Selection

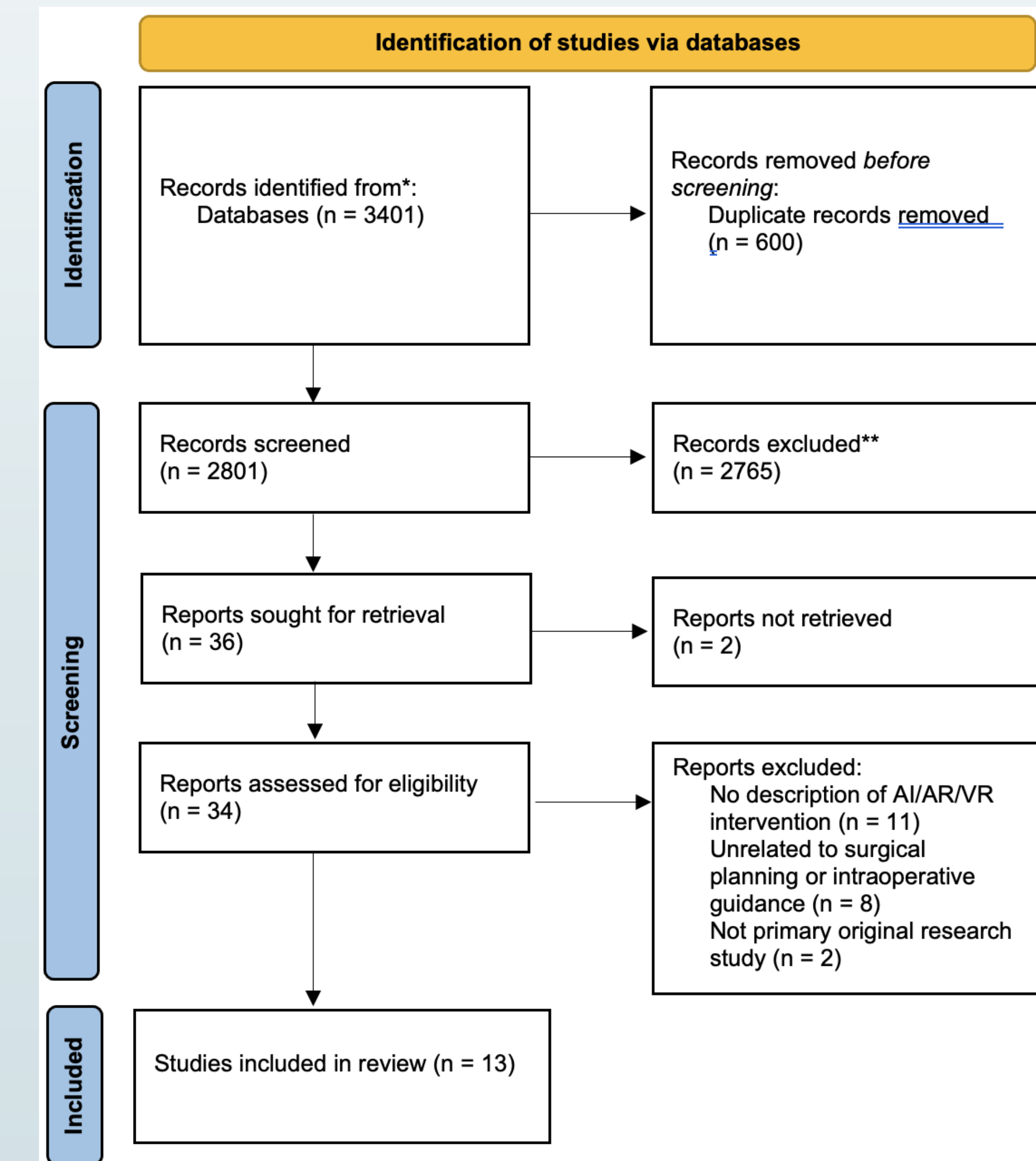


Figure 1. PRISMA flow diagram

Results – Study Demographics (n = 13)

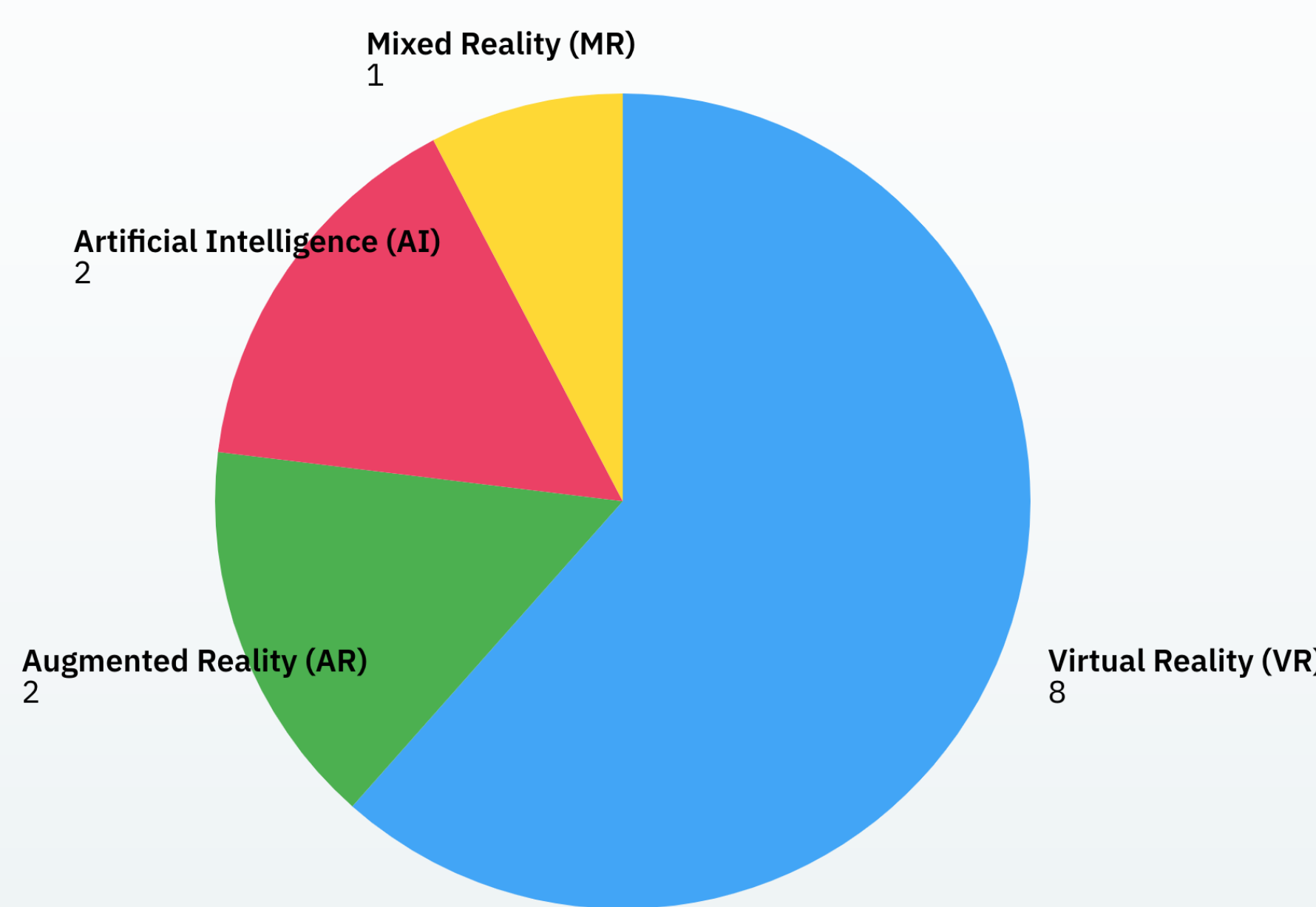


Figure 2. Types of technological platforms used for surgical enhancement

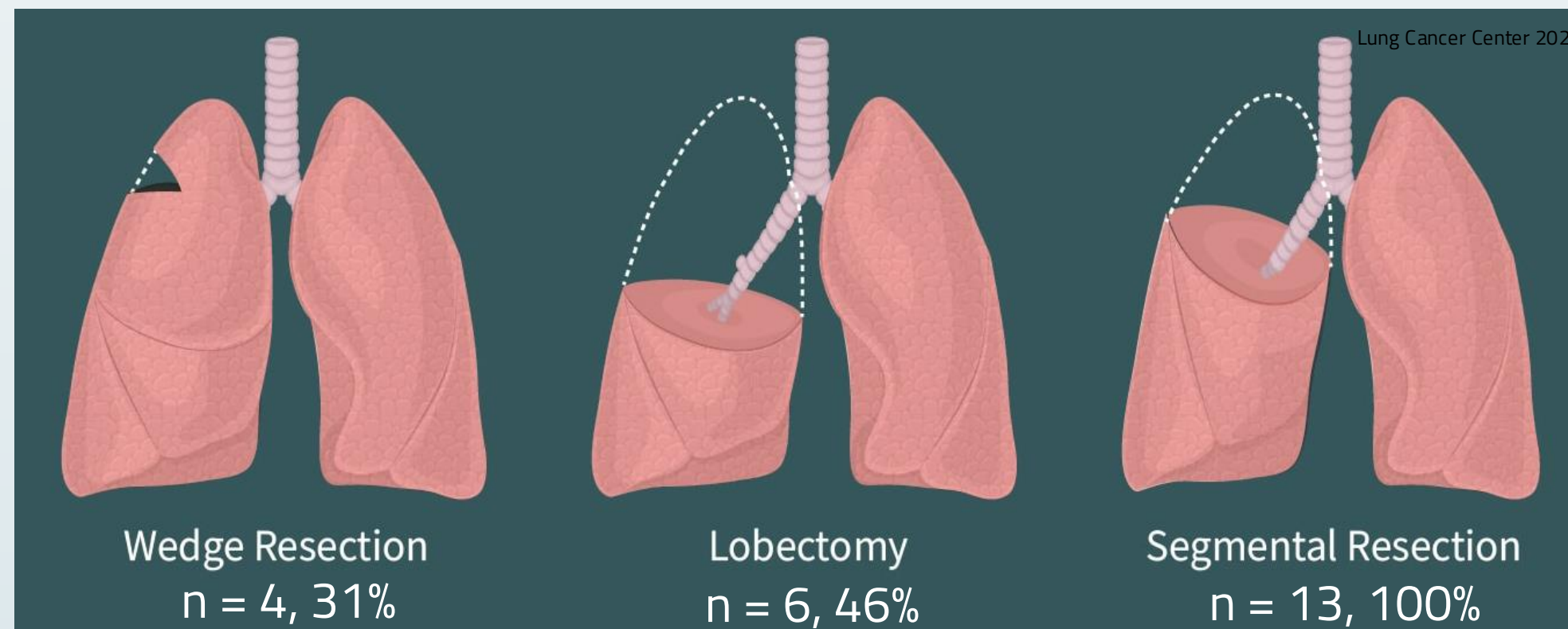


Figure 3. Distribution of lung resection types among included studies

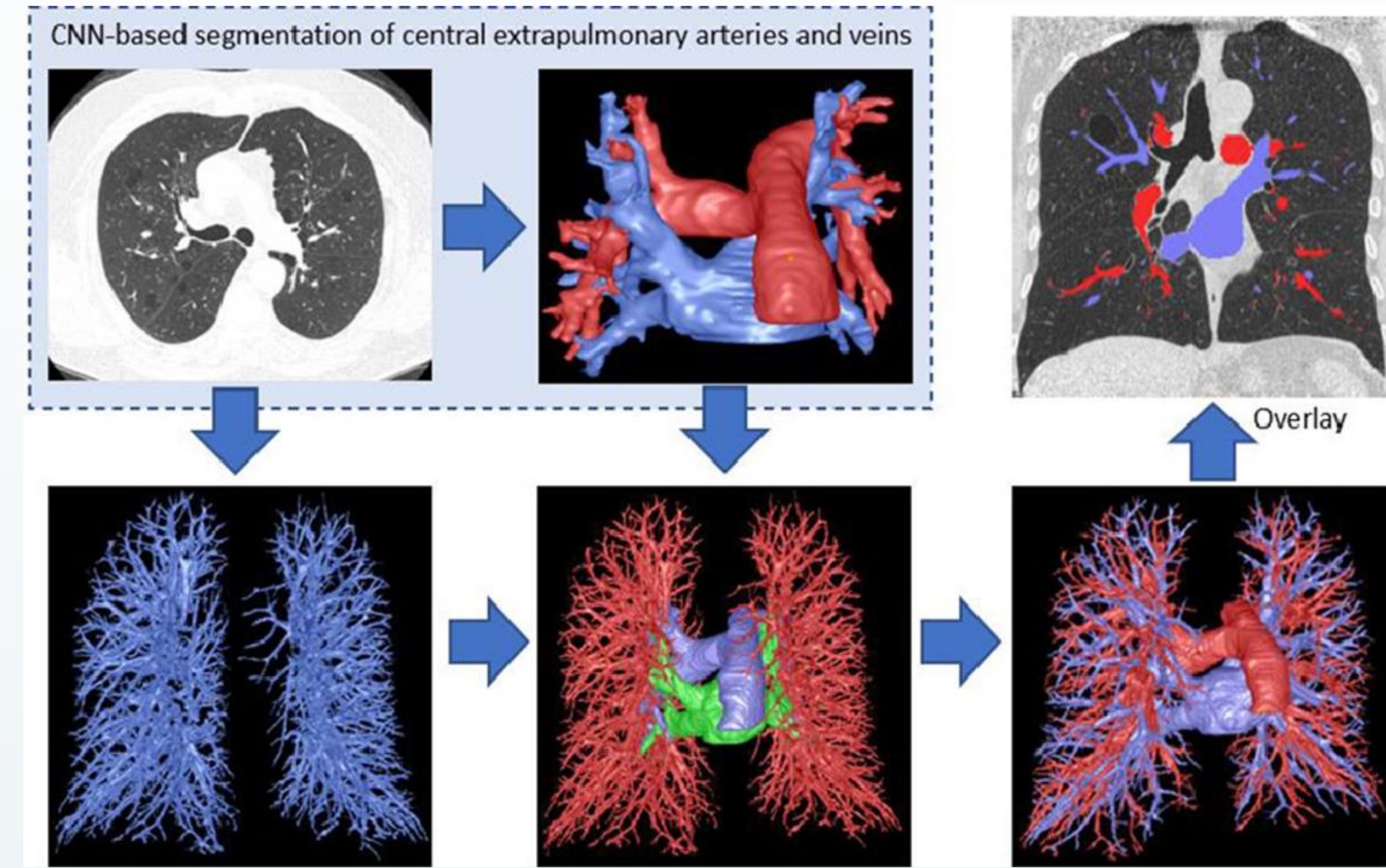
Results – Nodule and Structure Localization (n = 9)



Hisense Medical (VR) - **100% success**
Intraoperative localization of non-palpable nodules

HoloLens (AR)
With 3D printing model → **94% success**
AR alone → **70% successful** for localizing nodules

Results – Nodule and Structure Localization (n = 9)



Pu et al. 2022

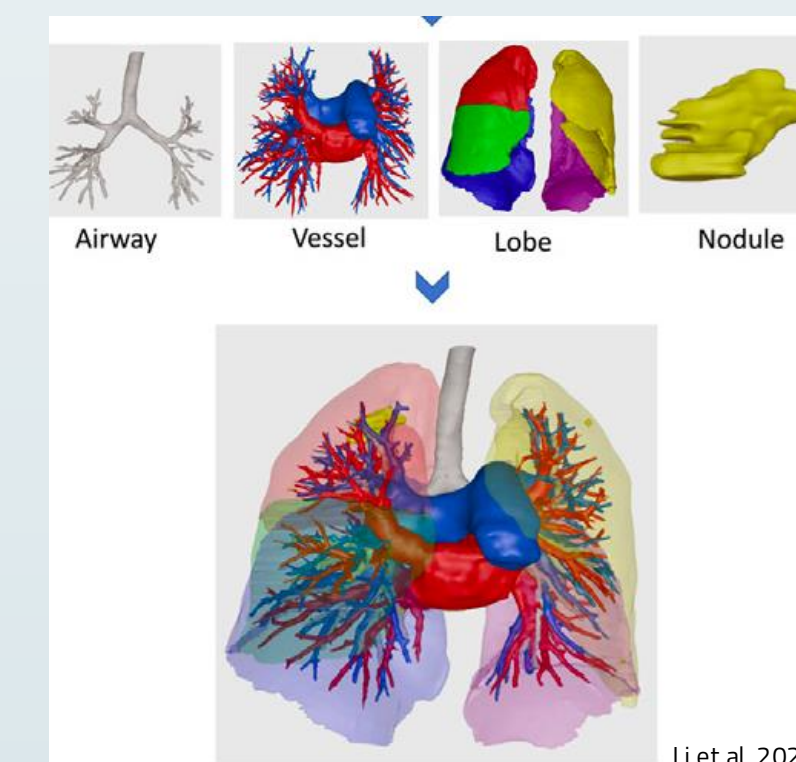
Deep learning segmentation achieved **70-80%** accuracy in pulmonary vascular recognition*

*Similar to performance of junior thoracic surgery attendings performing manual segmentation

AI modelling systems

High accuracy (93%- 100%) for identifying pulmonary segmental branches with:

- Improved **reconstruction times**
- Increased **model quality** scores



Li et al. 2022

Results – Modifications in Surgical Plan (n = 3)

Using the PulmoVR system, the surgical plan **would've been changed** in

40%-80% of surgical cases

Surgical plan adjustments included:

- Different target segment selection
- More lung-sparing segmentectomy
- Extended segmentectomy
- Lobectomy vs segmentectomy

Results – Surgeon Feedback Scores (n = 2)

PulmoVR (score out of 5)

4-5

Ease of use
Usefulness and efficiency

1-5

Future use in pre-op planning

HoloLens AR (score out of 100)



96-98

89-92*

*p = 0.001

Limitations

- Lack of comparator groups and consistent measures of performance, no direct comparison between technologies

- Inability to evaluate utility of platforms for specific lung resection procedures

- No formal risk of bias assessment conducted; likely high due to observational nature of included studies

Conclusions

The use of AI/AR/VR platforms in thoracic surgery has tremendous potential, however its applications and evidence for use remain **rudimentary at present**

Future randomized controlled trials with **standardized outcomes** and **feasibility data** are needed prior to widespread implementation and adoption

Acknowledgements and References

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