ISPOR EU 2024

MT52

Shape-Sensing Robotic-Assisted Bronchoscopy: A Meta-Analysis of Diagnostic Performance and Safety

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INTRODUCTION

Lung cancer is the leading cause of cancer-related deaths worldwide for men and women.[1] The number of incidentally found pulmonary nodules is increasing due to updated screening recommendations and increased utilization of chest imaging.[2] There is an urgent need for minimally invasive biopsy techniques that can achieve high diagnostic results while maintaining a low safety risk.

OBJECTIVE

Shape-sensing robotic-assisted bronchoscopy (ssRAB) has potential to improve diagnostic accuracy and maximize yield, while ultimately shortening time to treatment and delivering better outcomes for patients. This single-arm meta-analysis investigated the diagnostic performance and safety of ssRAB.

METHODS

- A targeted search was conducted for papers published between January 2019 and December 2023.
- Studies were included if they reported outcomes of interest in adults undergoing lung biopsy with ssRAB.
- Studies were excluded if they reported data from cadaver or animal studies, were case reports, review articles, scientific letters, or abstracts.
- Articles were not restricted based on definition of diagnostic yield or use of adjunctive technologies.
- A meta-analysis was conducted using R software. Pooled diagnostic outcomes and complications were estimated using the Freeman-Tukey transformation. A random effects model was used in the presence of significant heterogeneity (I^2>50% or p<0.05).
- Systematic literature reviews of alternative biopsy modalities were reviewed for an indirect comparison of results.

RESULTS

- Search identified 16 publications reporting diagnostic and safety outcomes for ssRAB
- Data was available from 1931 patients and 2134 nodules
- Median nodule size ranged from 12 mm – 22 mm with most nodules located in the upper lobes.

Table 1. Lung Nodule Characteristics

Author Year	Nodules Biopsied	Median Nodule Size (mm)	Upper Lobe Location (%)	Bronchus Sign Present (%)
Abia-Trujillo 2023	192	12	50%	50%
Benn 2021	59	14	66%	46%
Brownlee 2023	503	21	50%	24%
Chambers 2022	79	20	57%	56%
Fielding 2018	29	14.8	69%	59%
Hammad Altaq 2023	42	12	69%	59%
Kalchiem-Dekel 2021	159	18	59%	63%
Low 2022	143	17	43%	40%
Meng 2023	52	21	65%	42%
Oberg 2022	120	22	53%	48%
Reisenauer 2022	30	17.5	60%	40%
Stryvoky 2023 [A]	269	18.4	58%	59%
Styrvoky 2022 [B]	209	19	60%	60%
Vu 2022	105	20	54%	25%
Xie 2022	30	16.9	67%	77%
Yu Lee-Mateus 2022	113	18	63%	NR

RESULTS CONT.

Single-arm Meta-Analysis of ssRAB

- Pooled diagnostic yield across all studies was 86% (95% CI; 84-88), (I^2=44%).
- Pooled sensitivity was 86% (95% CI; 82-89), (I^2=61%).
- The overall rate of pneumothorax across studies was 2.2% (95% CI; 1.5-2.9), (I^2=0%).
- The rate of pneumothorax requiring intervention was 1% (95% CI; 0.5-1.6), (I^2=0%).
- Bleeding events occurred in less than 0.01% of patients, (I^2=0%).

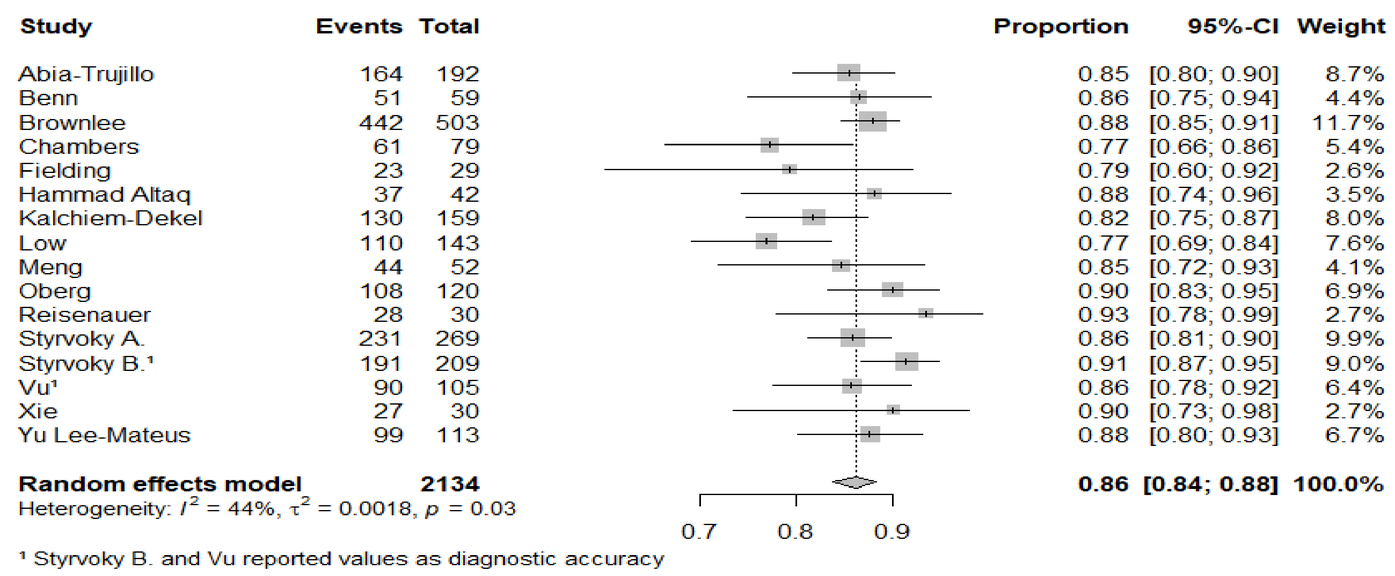
Indirect Comparison with CT-Guided Transthoracic Needle Biopsy (TTNA)

- A recent meta-analysis found TTNA had a pooled diagnostic accuracy between 85% and 90%, with average nodule sizes >30mm.[3]
- The same meta-analysis found a 23% to 28.9% rate of pneumothorax and a 17.3% to 20.1% rate of bleeding events.[3]

Indirect Comparison with Electromagnetic Navigation Bronchoscopy (ENB)

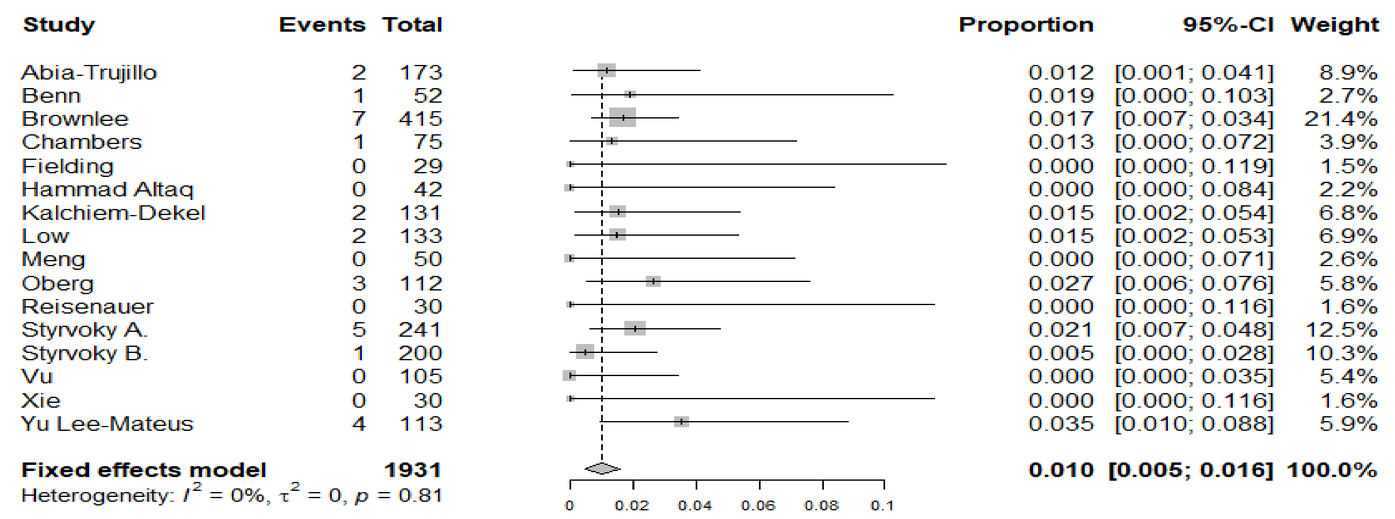
- A recent meta-analysis of ENB reported a pooled diagnostic yield of 70.3%, with average nodule sizes >20mm.[4]
- The same meta-analysis found complication rates of 3.4% for pneumothorax and 1.9% bleeding rate.[4]

Figure 1: Detailed Forest-plot for Diagnostic Yield



¹ Styrvoky B. and Vu reported values as diagnostic accuracy

Figure 2: Detailed Forest-plot for Pneumothorax Requiring Intervention



CONCLUSION

- ssRAB presents a safe and effective advancement in navigation bronchoscopy.
- The pooled results for ssRAB show a higher diagnostic yield than reported values for traditional bronchoscopic techniques and may be comparable to TTNA.
- These results also demonstrate significant benefit in terms of safety when compared to TTNA, and a comparable safety profile to ENB.

REFERENCES

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