



P1.129: Optimizing Intraoperative STAS Prediction in Stage IA Lung Adenocarcinoma : Composite Rule Integrating Frozen and CT Findings

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INTRODUCTION

Tumor Spread through air spaces (STAS)

- STAS is associated with recurrence in early-stage lung adenocarcinoma and may influence the extent of surgical resection
- Although intraoperative identification of STAS could potentially influence surgical decision-making, frozen-section assessment remains controversial because of limited sensitivity and variability related to specimen preparation and tumor characteristics

Aim of this study

- We hypothesized that frozen STAS should not be interpreted as an isolated diagnostic finding but rather within a clinical framework incorporating specimen adequacy, radiologic phenotype, and complementary frozen histologic features

METHODS

Design:

- Frozen section evaluation**
 - ✓ 1,819 patients with pathologic stage IA non-mucinous lung adenocarcinoma who underwent intraoperative frozen-section examination
 - ✓ Frozen slides were evaluated for STAS, micropapillary pattern (MP), histologic grade, and specimen evaluability – 1,257 evaluable cases
 - ✓ The diagnostic performance of frozen STAS was evaluated according to preoperative CT consistency (ground-glass opacity [GGO] versus solid tumors)
 - ✓ A CT-specific composite strategy integrating frozen STAS with MP or frozen histologic grade 3 (G3) was developed
- Outcome assessment**
 - ✓ Permanent STAS reported in the original pathology reports served as the reference standard
 - ✓ Recurrence-free survival (RFS) – 1,352 patients

DISCUSSION AND CONCLUSION

Actionable Take Away Message

- Frozen STAS should not be interpreted in isolation during intraoperative decision-making
- Both specimen preparation and CT phenotype influence the clinical utility of frozen STAS
- CT-specific composite strategies offer a practical framework for intraoperative STAS risk discussion

Future Direction for Research

- Intraoperative STAS assessment should evolve from a purely diagnostic tool toward a comprehensive risk-stratification strategy
- Integrating radiologic and pathologic information may facilitate more personalized surgical approaches in early-stage lung adenocarcinoma

REFERENCES & ACKNOWLEDGEMENTS

References

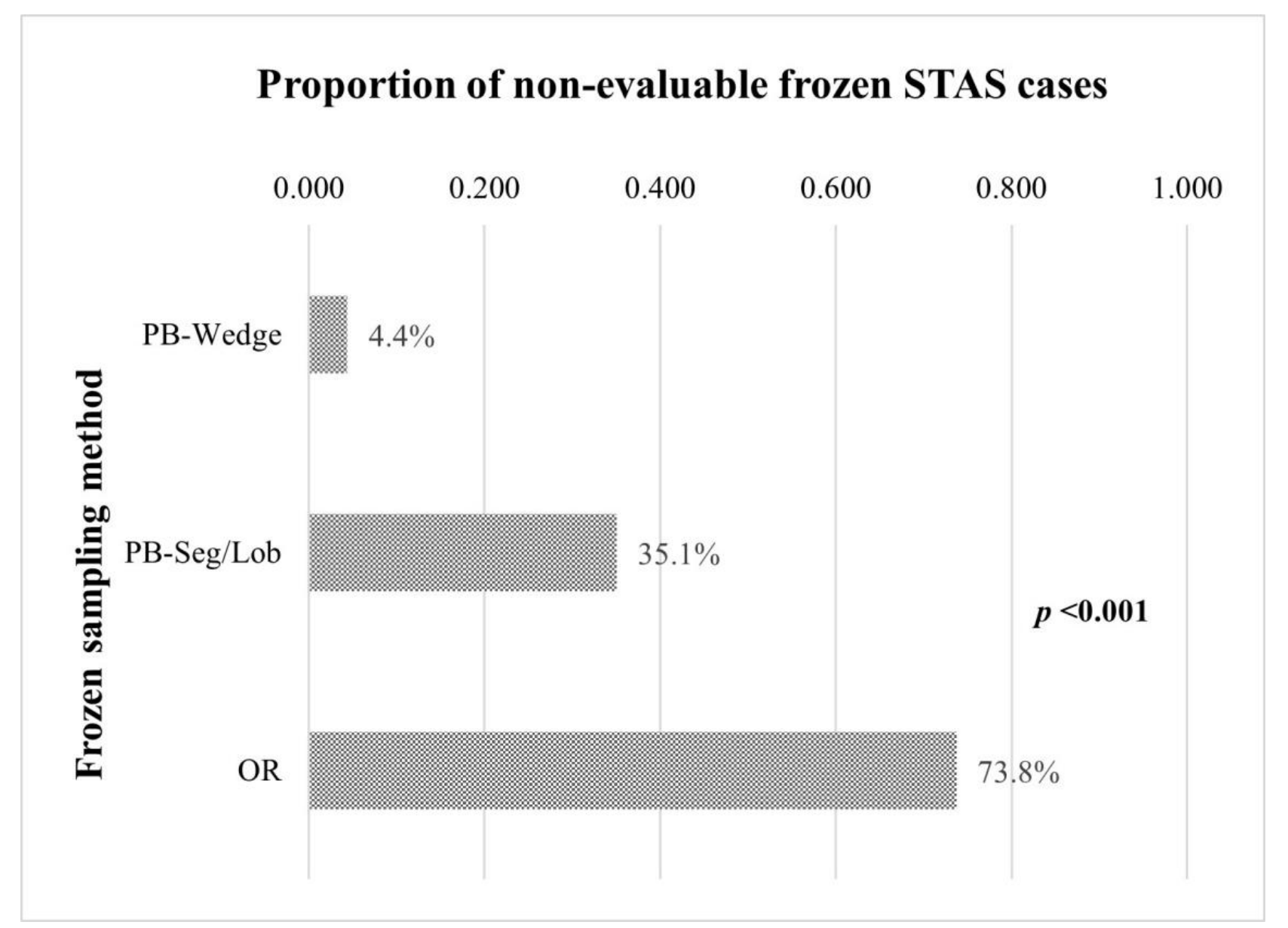
- Altorki N, Wang X, Kozono D, Watt C, Landrenau R, Wigle D, Port J, Jones DR, Conti M, Ashrafi AS, Liberman M, Yasufuku K, Yang S, Mitchell JD, Pass H, Keenan R, Bauer T, Miller D, Kohman LJ, Stinchcombe TE, Vokes E. Lobar or Sublobar Resection for Peripheral Stage IA Non-Small-Cell Lung Cancer. N Engl J Med. 2023 Feb 9;388(6):489-498.
- Kadota K, Kushida Y, Kagawa S, Ishikawa R, Ibuki E, Inoue K, Go T, Yokomise H, Ishii T, Kadowaki N, Haba R. Limited Resection Is Associated With a Higher Risk of Locoregional Recurrence than Lobectomy in Stage I Lung Adenocarcinoma With Tumor Spread Through Air Spaces. Am J Surg Pathol. 2019 Aug;43(8):1033-1041.
- Villalba JA, Shih AR, Sayo TMS, Kunitoki K, Hung YP, Ly A, Kem M, Hariri LP, Muniappan A, Gaissert HA, Colson YL, Lanuti MD, Mino-Kenudson M. Accuracy and Reproducibility of Intraoperative Assessment on Tumor Spread Through Air Spaces in Stage I Lung Adenocarcinomas. J Thorac Oncol. 2021 Apr;16(4):619-629.
- Zhou F, Villalba JA, Sayo TMS, Narula N, Pass H, Mino-Kenudson M, Moreira AL. Assessment of the feasibility of frozen sections for the detection of spread through air spaces (STAS) in pulmonary adenocarcinoma. Mod Pathol. 2022 Feb;35(2):210-217.
- Eguchi T, Matsuoka S, Iwaya M, Kobayashi S, Seshimoto M, Mishima S, Hara D, Kumeda H, Miura K, Hamanaka K, Uehara T, Shimizu K. Improving intraoperative diagnosis of spread through air spaces: A cryo-embedding-medium inflation method for frozen section analysis. JTCVS Tech. 2024 Mar 1;25:170-176.
- Ding Y, Zhao S, Liu X, Ren J, Li J, Zhang W, Xu M, Sun D. The value of frozen section diagnosis of tumor spread through air spaces in small-sized (≤ 2 cm) non-small cell lung cancer. World J Surg Oncol. 2023 Jul 3;21(1):195.

Artificial Intelligence (AI) Use Disclosure

ChatGPT (OpenAI, San Francisco, CA, USA) was used to assist with language editing and the refinement of the manuscript and poster text. All scientific content, data analysis, interpretation, and final decisions were performed and verified by the authors.

RESULTS

Figure 1. Proportion of non-evaluable frozen STAS cases according to frozen sampling method



Frozen sampling method (n=1819)					p-value
Pathology-based sampling		Operating-room sampling		Total	
STAS evaluability	Wedge resection	Segmentectomy or Lobectomy	Operating-room sampling	Total	
Evaluable	719 (95.6)	433 (64.9)	105 (26.3)	1257	
Non-evaluable	33 (4.4)	234 (35.1)	295 (73.8)	562	
Total	752	667	400	1819	<0.001

• Pathology-based(PB) sampling from wedge resection specimens showed the highest evaluability, whereas operating-room (OR) sampling showed the lowest evaluability ($p < 0.001$).

Table 1. Clinicopathologic characteristics of frozen STAS-evaluable cases according to CT consistency

Variable	Total (n=1257)	GGO (n=1054)	Solid (n=203)	p-value
Age (years), mean $\pm$ SD	62.9 $\pm$ 10.5	62.7 $\pm$ 10.5	63.7 $\pm$ 10.7	0.231
Sex				0.314
Male	535 (42.6)	442 (41.9)	93 (45.8)	
Female	722 (57.4)	612 (58.1)	110 (54.2)	
Invasive tumor size (cm) mean $\pm$ SD	1.1 $\pm$ 0.6	1.0 $\pm$ 0.6	1.6 $\pm$ 0.6	<0.001
Lymphatic invasion				<0.001
Absent	1157 (92.0)	996 (94.5)	161 (79.3)	
Present	100 (8.0)	58 (5.5)	42 (20.7)	
Vascular invasion				<0.001
Absent	1224 (97.4)	1041 (98.8)	183 (90.1)	
Present	33 (2.6)	13 (1.2)	20 (9.9)	
Perineural invasion				0.026†
Absent	1255 (99.8)	1054 (100.0)	201 (99.0)	
Present	2 (0.2)	0 (0.0)	2 (1.0)	
Histologic grade*				<0.001
G1	396 (31.8)	389 (37.0)	7 (3.6)	
G2	715 (57.3)	605 (57.6)	110 (55.8)	
G3	136 (10.9)	56 (5.3)	80 (40.6)	
Micropapillary pattern				<0.001
Absent	942 (74.9)	847 (80.4)	95 (46.8)	
Present	315 (25.1)	207 (19.6)	108 (53.2)	
Permanent STAS				<0.001
Absent	1023 (81.4)	922 (87.5)	101 (49.8)	
Present	234 (18.6)	132 (12.5)	102 (50.2)	
Frozen histologic grade				<0.001
G1	424 (33.7)	414 (39.3)	10 (4.9)	
G2	759 (60.4)	620 (58.8)	139 (68.5)	
G3	74 (5.9)	20 (1.9)	54 (26.6)	
Frozen micropapillary pattern				<0.001
Absent	1102 (87.7)	957 (90.8)	145 (71.4)	
Present	155 (12.3)	97 (9.2)	58 (28.6)	
Frozen STAS				<0.001
Absent	1028 (81.8)	910 (86.3)	118 (58.1)	
Present	229 (18.2)	144 (13.7)	85 (41.9)	

*Histologic grade data were available in 1247 patients.

†Fisher's exact test was used due to small expected cell counts.

Figure 2. Diagnostic performance of frozen STAS according to CT consistency

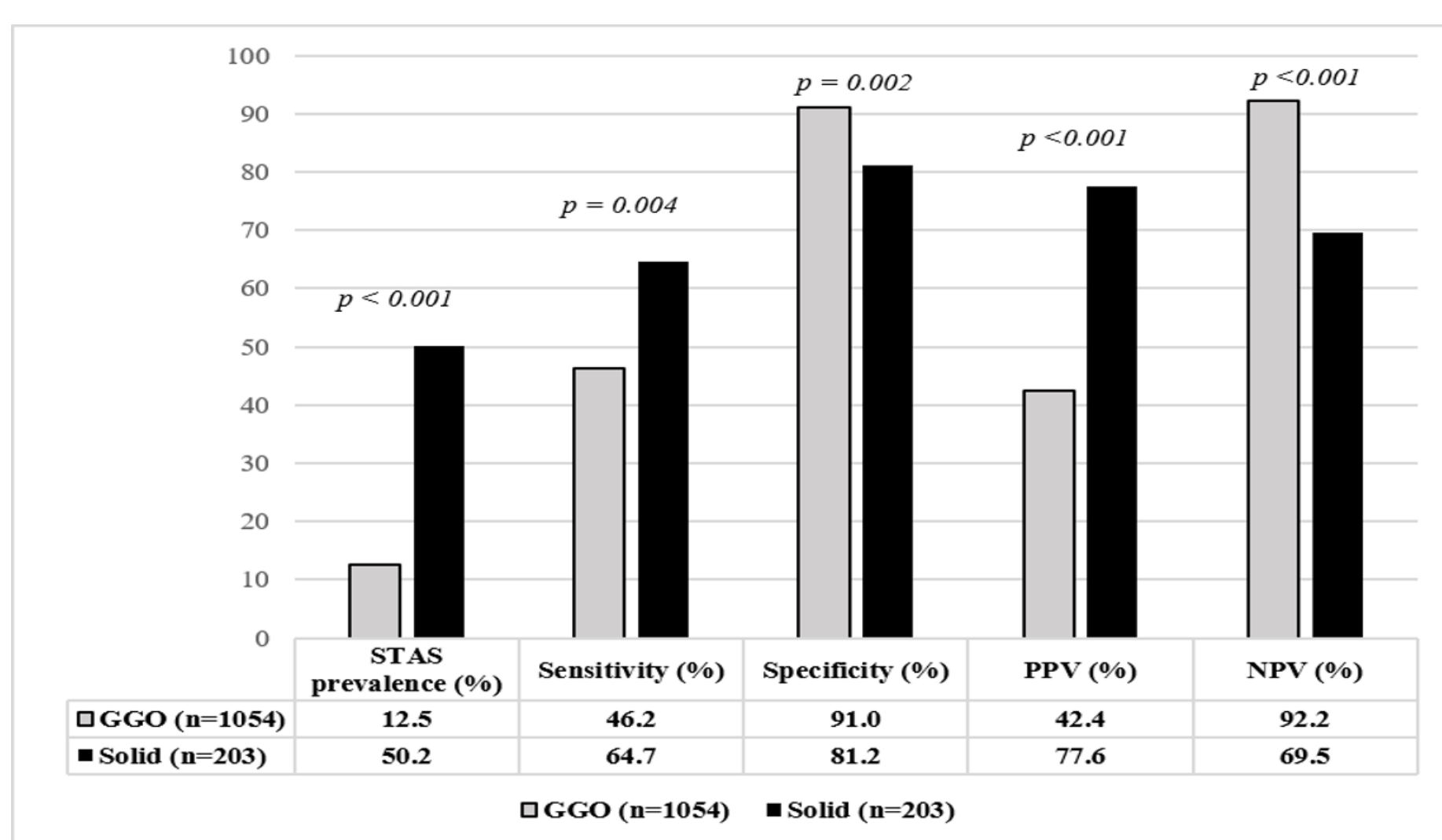
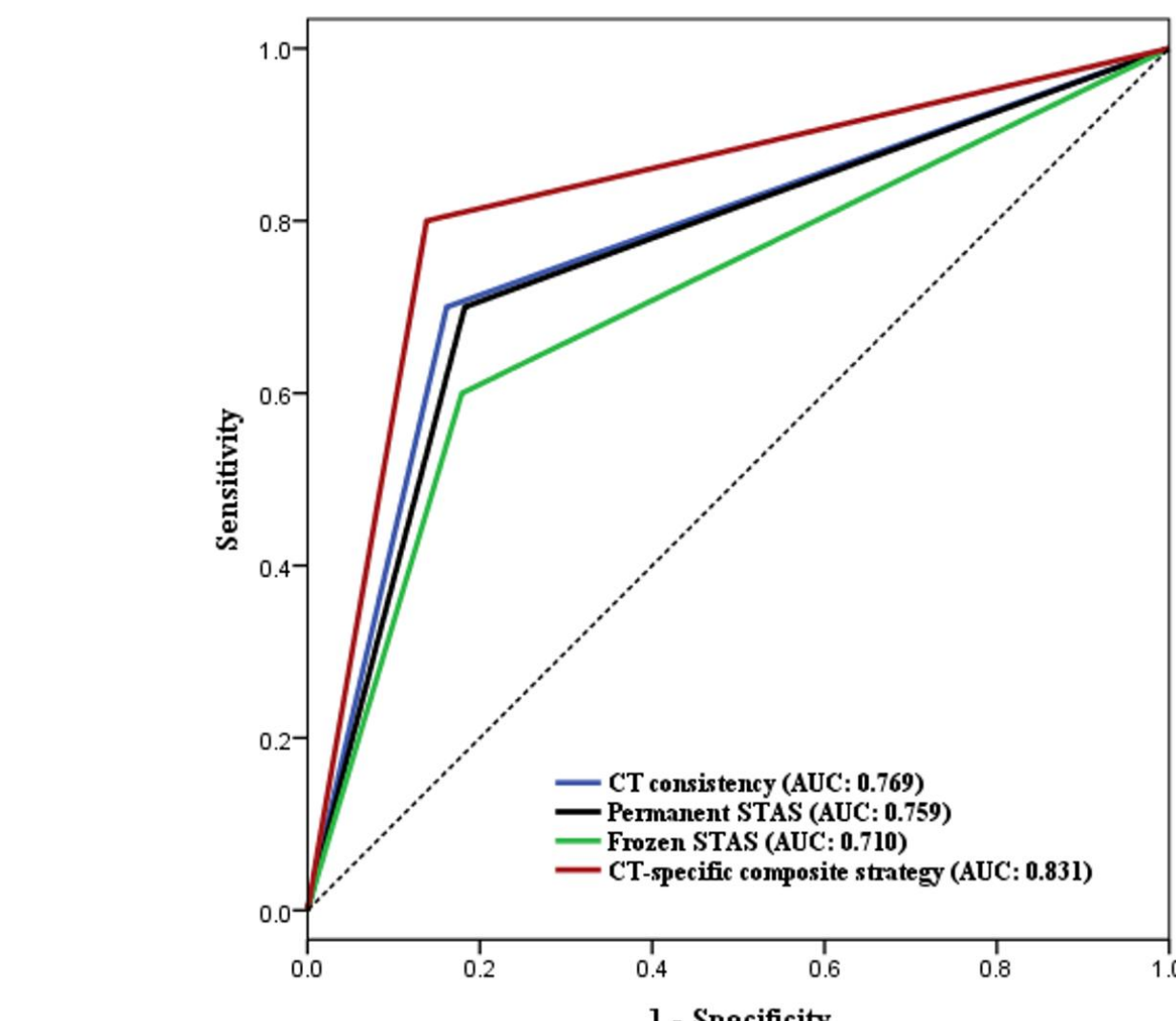


Table 2. CT consistency–stratified diagnostic performance of frozen STAS alone and subgroup-specific composite intraoperative strategies for predicting permanent STAS

	CT consistency GGO (n=1054)		Solid (n=203)	
	Frozen STAS alone	Frozen STAS AND (MP OR G3)	Frozen STAS alone	Frozen STAS OR MP OR G3
Sensitivity (%)	46.2	28.8	64.7	80.4
Specificity (%)	91.0	97.7	81.2	72.3
PPV (%)	42.4	64.4	77.6	74.5
NPV (%)	92.2	90.6	69.5	78.5
Accuracy (%)	85.4	89.1	72.9	76.4
Cohen's kappa	0.36	0.35	0.46	0.53
McNemar's p-value (vs. frozen STAS alone)	–	<0.001	–	<0.001

PPV, positive predictive value; NPV, negative predictive value.

Table 3. Univariable Cox regression analysis and discriminatory performance of intraoperative predictors for recurrence-free survival



Receiver operating characteristic curves comparing discrimination performance of CT consistency, permanent STAS, frozen STAS, and the CT-specific composite strategy for recurrence prediction.

Variable	HR (95% CI)	p-value	AUC (95% CI)
CT consistency (GGO vs. Solid)	11.035 (2.847–42.765)	0.001	0.769 (0.603–0.936)
Permanent STAS (Absent vs. Present)	10.425 (2.695–40.338)	0.001	0.759 (0.593–0.925)
Frozen STAS (Absent vs. Present)	7.451 (2.096–26.479)	0.002	0.710 (0.530–0.891)
CT-specific composite strategy (Negative vs. Positive)	24.615 (5.226–115.949)	<0.001	0.831 (0.687–0.975)

Figure 3. Proposed framework for intraoperative risk stratification according to CT consistency and frozen-section findings

