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ORIGINAL PAPER

Preoperative CT-guided localization for pulmonary nodules: comparison between tailed coil and suture anchor localization

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Abstract

Introduction Both tailed coils and suture anchors are purpose-designed materials for preoperatively localizing pulmonary nodules (PNs). Their comparative clinical performance and safety profiles, however, have not been clearly established.

Aim To assess the comparative efficacy and safety of computed tomography (CT)-guided tailed coil and suture anchor placement for preoperative PN localization.

Materials and methods Patients who had undergone CT-guided PN localization followed by video-assisted thoracic surgery (VATS) resection between January 2025 and December 2025 were consecutively included in this retrospective analysis. Patients were categorized into tailed coil and suture anchor groups. Baseline characteristics and localization- and VATS-associated outcomes were collected and analyzed.

Results CT-guided localization was performed using tailed coils in 47 patients and suture anchors in 51 patients, with one PN localized per patient. The technical success rate was 100% in both cohorts. The mean time for localization was 20.1 (4.4) minutes in the tailed coil cohort and 21.2 (3.0) minutes in the suture anchor cohort (P = 0.16). Pneumothorax occurred in 21.3% of cases in the tailed coil cohort and 23.5% in the suture anchor cohort (P = 0.79). Pulmonary hemorrhage rates were 21.3% and 11.8%, respectively (P = 0.20). All patients successfully underwent VATS sublobar resection. Additional lobectomy following sublobar resection was required in 5 cases (10.6%) in the tailed coil cohort and 6 (11.8%) in the suture anchor cohort (P = 0.24).

Conclusions CT-guided tailed coil and suture anchor localization appear to offer comparable clinical efficacy and safety for preoperative PN localization.

Keywords

computed tomography, pulmonary nodule, localization, video-assisted thoracic surgery

Introduction Preoperative localization of pulmonary nodules (PNs) using computed tomography (CT) guidance is now widely adopted to improve the success of video-assisted thoracic surgery (VATS) wedge or segmental resections [1-3]. Historically, a variety of localization materials including hook-wires, microcoils, and liquid agents have been used for this purpose [4]. These materials, however, were not designed for the express purpose of PN localization, and each is associated with inherent limitations despite their clinical utility.

In recent years, several PN-specific localization devices have been developed to address the shortcomings of earlier techniques [5,6]. The suture anchor system represents an evolution of the hook-wire design and was specifically engineered for PN localization [5]. Although hook-wire placement is technically straightforward, its rigid metallic structure has been linked to a higher incidence of complications such as pneumothorax and patient discomfort [4]. The suture anchor retains the anchoring mechanism of the hook-wire while replacing the rigid wire with a flexible suture, thereby improving patient tolerance and potentially reducing procedure-related adverse events [5].

Microcoils are another commonly used localization material and have demonstrated lower complication rates compared with hook-wires [7]. Nevertheless, conventional microcoil localization has an important limitation: the entire coil may be deployed within the lung parenchyma, which can result in localization failure during surgery [8]. To mitigate this drawback, the tailed coil was developed as a dedicated PN localization device, incorporating an external tail that remains visible on the pleural surface [6]. Despite the increasing availability of these PN-specific materials, direct comparative studies evaluating their clinical effectiveness and safety remain scarce.

Aim The comparative efficacy and safety of CT-guided tailed coil and suture anchor placement as a means of preoperative PN localization were analyzed.

Materials and methods

Study design The study was approved by the Ethics Committee of The First Hospital of Zhangjiakou City (No. 2025-LW-33), with waiving of the need for written informed consent as the study was retrospective. Consecutive patients who had undergone CT-guided PN localization before VATS resection between January 2025 and December 2025 were included. Tailed coils were used for localization prior to June 2025, after which suture anchors were adopted as the standard localization material. Inclusion criteria were as follows: (a) PNs classified as Lung-RADS category 4; (b) PN diameter between 8 and 30 mm; and (c) patient age >18 and <80 years. The exclusion criteria were: (a) solid PNs >15 mm; (b) hilar nodules; and (c) contraindications to VATS or patient refusal of surgical treatment. Baseline characteristics, localization-associated outcomes, and VATS-associated outcomes were collected and compared between the tailed coil and suture anchor groups.

Localization materials The tailed coil system (Cherish Medical, Changzhou, China) consists of a circular metallic coil attached to a 20-50 mm metal tail. The circular component enables localization close to the PN, while the tail remains exposed on the pleural surface to facilitate intraoperative identification. The device is preloaded into a dedicated 20-G introducer needle.

The suture anchor system (Senscure, Ningbo, China) comprises a four-hook anchor connected to a 100–150 mm tri-colored suture. The anchor secures the device within the lung parenchyma near the PN, and the suture extends externally to mark the pleural surface. This system is also delivered using a matched 20-gauge introducer needle.

Computed tomography-guided localization of pulmonary nodules All procedures were conducted under local anesthesia and CT guidance by an interventional radiologist with more than 10 years' experience. The patients were positioned according to the target PN location, and the puncture trajectory was planned accordingly.

In the tailed coil cohort, the introducer needle was introduced into the lung parenchyma along the predetermined path. After positioning the tip of the needle approximately 10 mm from the target PN, the tailed coil was deployed using a pusher. The needle was then carefully withdrawn while ensuring that the coil tail was external to the pleura.

In the suture anchor group, the introducer needle was similarly advanced to within the lung parenchyma. After positioning the tip of the needle approximately 10 mm from the PN, the suture anchor was released. The needle was withdrawn smoothly, confirming that the tri-colored suture extended beyond the pleural surface.

Video-assisted thoracic surgery procedures VATS was performed within 3 hours following localization. Guided by the localization marker, sublobar wedge resection or segmentectomy was initially attempted. Segmentectomy was performed when wedge resection did not achieve adequate surgical margins. Resected specimens were submitted for intraoperative pathological examination. Systematic lymph node dissection was undertaken when invasive lung cancer was identified. Additional lobectomy was performed for invasive tumors larger > 2 cm or those having a solid-to-ground-glass ratio >50%.

Definitions The technical success of PN localization was based on several criteria: (a) clear visualization of the localization material during VATS; (b) no dislodgement of the localization device; and (c) confirmation of the target PN in the resected tissue. Localization time was defined as the time from the first to the final CT scans.

Statistical analyses Analyses were performed using SPSS 16.0. Continuous variables with normal and non-normal distributions are shown as mean (standard deviation) or median (interquartile range), respectively, and were compared using the t-test and Mann-Whitney U test. Categorical variables are presented as numbers and percentages, with comparisons performed using the χ^2 test. Multivariable logistic regression was conducted to identify predictors of localization-related complications. Variables with a P <0.1 in univariable analysis were incorporated in the multivariable model. A two-sided P <0.05 was deemed significant.

Results

Patients The study flowchart is provided in Figure 1. Ninety-eight patients were enrolled, of whom 47 had undergone CT-guided tailed coil localization (Figure 2) and 51 had undergone CT-guided suture anchor localization (Figure 3) for PNs. Each patient had a single PN localized. Baseline demographic and nodule-related features were comparable between the two cohorts (Table 1).

Localization-related outcomes Both localization techniques achieved a technical success rate of 100% (Table 2). The mean localization time was 20.1 (4.4) minutes in the tailed coil cohort and 21.2 (3.0) minutes in the suture anchor cohort, with a non-significant difference ($P = 0.16$). Pneumothorax was apparent in 21.3% of cases in the tailed coil cohort and 23.5% of cases in the suture anchor cohort ($P = 0.79$). Pulmonary hemorrhage was observed in 21.3% and 11.8% of cases in the tailed coil and suture anchor cohorts, respectively ($P = 0.20$). Importantly, none of these complications interfered with or delayed the subsequent VATS procedures.

Predictors of complications Univariable and multivariable logistic regression demonstrated that localization of PNs in the upper lobe was independently predictive of pneumothorax ($P = 0.03$; Table 3). Additionally, lower PN diameter ($P = 0.04$) and more extensive lesion depth ($P = 0.02$) were independently linked with an increased risk of pulmonary hemorrhage (Table 4).

Video-assisted thoracic surgery -related outcomes All patients successfully underwent VATS sublobar resection. Details of the surgical procedures are provided in Table 5. The sublobar resection types were comparable between the two cohorts (*P* = 0.05). Following intraoperative pathological assessment, additional lobectomy was required in 5 cases (10.6%) in the tailed coil cohort and 6 cases (11.8%) in the suture anchor cohort (*P* = 0.24). Final pathological diagnoses were also similar in these groups (*P* = 0.24).

Discussion An ideal pulmonary nodule localization device should meet achieve a secure anchor within the lung parenchyma near the target lesion and reliable intraoperative visualization during VATS. In recent years, localization devices specifically designed to satisfy these criteria such as the suture anchor and tailed coil have been introduced into clinical practice [6,9]. Prior evidence has shown that CT-guided suture anchor localization achieves higher success rates and fewer complications than traditional hook-wire techniques [10]. Similarly, Shan et al[6] reported that tailed coil localization significantly improved technical success compared with conventional microcoil placement (100% vs. 87.8%, *P* = 0.03).

Here, the efficacy and safety of CT-guided tailed coil and suture anchor localization were directly compared. Both techniques demonstrated excellent performance, achieving a 100% technical success rate. These rates were comparable to those (99.1%–100%) in previous studies regarding of suture anchor and tailed coil localization for PNs [6,9,11]. The four-pronged anchoring tip of the suture anchor provides stable fixation within the lung parenchyma. Zhou et al [9] found that suture anchor had a significantly lower dislodgement rate than hook-wire (0.0% vs. 4.8%, *P* = 0.03). Similarly, the coiled structure of the tailed coil offers similar anchoring capability. In addition, the tail-like external components of both devices extend beyond the pleural surface, facilitating easy intraoperative identification. These shared structural advantages likely account for the uniformly high localization success observed in both groups.

Localization time did not differ significantly between the two techniques, suggesting that procedural complexity and operator effort are comparable. Previous studies have indicated that both tailed coil and suture anchor localization require less time than conventional microcoil localization [6,11]. Traditional microcoils may be inadvertently deployed entirely within the lung parenchyma, increasing the risk of technical failure and necessitating additional manipulations, which prolong procedure time [6,11]. In contrast, the tail-like design of tailed coils and suture anchors simplifies deployment and reduces technical difficulty. This feature may also make these devices particularly suitable for operators with limited experience in PN localization.

Pneumothorax and pulmonary hemorrhage remain the most frequently reported complications associated with CT-guided PN localization [4,12,13]. In this study, the incidence of both complications was comparable between the tailed coil and suture anchor cohorts. Furthermore, the incident rates of pneumothorax (21.3% for tailed coil and 23.5% for suture anchor) and pulmonary hemorrhage (21.3% for tailed coil and 11.8% for suture anchor) were both comparable to those (16.1%–16.7% for pneumothorax and 11.9%–23.7% for pulmonary hemorrhage) in previous studies regarding of suture anchor and tailed coil localization for PNs [6,9]. Logistic regression indicated that the type of localization material was not an independent risk factor for either complication, indicating comparable safety profiles for the two techniques.

Upper-lobe PN location emerged as an independent predictor of pneumothorax. This finding may be explained by differences in respiratory mechanics, as the lower lung regions contribute more significantly to respiratory motion than the upper lobes [14,15]. Smaller nodule size and greater lesion depth were identified as predictors of pulmonary hemorrhage. Localization of small or deeply situated PNs often requires multiple needle adjustments or longer intrapulmonary needle paths, which may increase the likelihood of vascular injury. These observations are consistent with prior studies of CT-guided lung biopsy, which also identified smaller lesion size and greater depth as significant risk factors for pulmonary hemorrhage [16-18].

A previous meta-analysis found that suture anchor exhibited significantly lower rates of total complication (*P* = 0.01), pneumothorax (*P* = 0.003), and pulmonary hemorrhage (*P* = 0.004) than hook-wire for PN localization [10]. These findings may indicate that suture anchor has better safety than hook-wire. However, neither suture anchor nor tailed coil was superior to traditional microcoil in the aspect of PN localization-related safety [6,11]. This phenomenon may be attributed to that traditional microcoil localization is also a safe PN localization method [8].

Historically, detection of invasive lung cancer on intraoperative pathology mandated completion lobectomy following sublobar resection [8]. However, growing evidence suggests that sublobar resection may provide oncologic outcomes comparable to lobectomy for small

(≤2 cm), peripheral invasive lung cancers [19,20]. Here, only a small proportion of cases in either group required additional lobectomy, while the majority were adequately treated with sublobar resection alone. These findings underscore the role of accurate preoperative localization in facilitating precise surgical resection, avoiding unnecessary lobectomy, and preserving postoperative lung function.

The preoperative PN localization brings more benefit to patients with multiple PNs [12]. Gong et al [21] have found that suture anchor placement is a reliable and safe method for preoperative localization of multiple PNs. However, the tailed coil localization for multiple PNs has not been reported. This topic should be assessed in further clinical trials.

There are several study limitations. First, the study was retrospective, leading to potential selection bias, although the baseline features of the two cohorts were similar. Second, the two localization techniques were implemented at different times, which may further increase the risk of bias related to temporal factors. Finally, the investigation was undertaken at a single institution and had a relatively restricted sample size. Larger, prospective, multicenter trials are required for confirmation.

Conclusions In summary, the findings demonstrate that CT-guided tailed coil and suture anchor localization techniques provide comparable clinical effectiveness and safety for preoperative pulmonary nodule localization.

Article information

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Contribution statement CSZ conceived the concept of the study. WTZ and CSZ contributed to the design of the research. CH, JL, XXM, and JS were involved in data collection. JS analyzed the data. All authors edited and approved the final version of the manuscript.

AI statement Artificial intelligence was not used to write the article.

Conflict of interest None declared.

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Table 1 Patients' baseline data

	Tailed coil group, n = 47	Suture anchor group, n = 51	*P* value
Age, y	61.3 (10.2)	59.2 (10.4)	0.32
Gender	–	–	0.45
Male	15 (31.9%)	20 (29.2%)	–
Female	32 (68.1%)	31 (60.8%)	–
Smoking history	12 (25.5%)	11 (21.6%)	0.64
Malignancy history	2 (4.3%)	5 (9.8%)	0.44
PN diameter, mm	9.5 (3.6)	8.6 (3.5)	0.19
Nature of PN	–	–	0.37
Solid	8 (17.0%)	5 (9.8%)	–
Mixed GGN	21 (44.7%)	20 (39.2%)	–
Pure GGN	18 (38.3%)	26 (51.0%)	–
Lung sides	–	–	0.83
Left	22 (46.8%)	25 (49.0%)	–
Right	25 (53.2%)	26 (51.0%)	–
Lobe	–	–	0.30
Non-upper	20 (42.6%)	27 (52.9%)	–
Upper	27 (57.4%)	24 (47.1%)	–
PN depth, mm	9.8 (6.5 - 15.2)	9.2 (2.4 - 16.3)	0.57
Abbreviations: GGN, ground glass nodule; PN, pulmonary nodule			

Table 2 Localization-related outcomes			
	Tailed coil group, n = 47	Suture anchor group, n = 51	*P* value
Successful rate of PN localization	100%	100%	Not applicable
Localization time, min	20.1 (4.4)	21.2 (3.0)	0.16
Complications	–	–	–
Pneumothorax	10 (21.3%)	12 (23.5%)	0.79
Pulmonary hemorrhage	10 (21.3%)	6 (11.8%)	0.20
Abbreviations: PN, pulmonary nodule			

Table 3 Logistic analysis of pneumothorax			
Variables	Univariable analysis		
	Odds ratio	95% CI	*P* value
Age	1.001	0.956-1.049	0.96
Gender	–	–	–
Male	1	–	–
Female	0.964	0.359-2.589	0.94
Smoking history	0.667	0.201-2.217	0.51
Malignancy history	0.556	0.063-4.878	0.60
PN diameter	1.092	0.963-1.239	0.17

Nature of PN	1.013	0.517-1.984	0.97
Solid	1	–	–
Mixed GGN	3.375	0.385-29.556	0.27
Pure GGN	4.500	0.527-38.446	0.17
Lung sides	–	–	–
Left	1	–	–
Right	1.784	0.681-4.673	0.24
Lobe	–	–	–
Non-upper	1	–	–
Upper	3.124	1.103-8.847	0.03
PN depth	0.964	0.912-1.019	0.20
Localization time	0.970	0.855-1.101	0.64
Localization materials	–	–	–
Tailed coil	1	–	–
Suture anchor	1.138	0.439-2.950	0.79

Abbreviations: GGN, ground glass nodule; PN, pulmonary nodule

Table 4 Logistic analysis of pulmonary hemorrhage

Variables	Univariable analysis			Multivariable analysis		
	Odds ratio	95% CI	*P* value	Odds ratio	95% CI	*P* value

Age	1.018	0.963–1.076	0.54	–	–	–
Gender	–	–	–	–	–	–
Male	1	–	–	–	–	–
Female	1.269	0.402–4.003	0.68	–	–	–
Smoking history	1.105	0.319–3.829	0.88	–	–	–
Malignancy history	0.844	0.095–7.532	0.88	–	–	–
PN diameter	0.752	0.588–0.960	0.02	0.741	0.554–0.990	0.04
Nature of PN	–	–	–	–	–	–
Solid	1	v	–	–	–	–
Mixed GGN	0.463	0.094–2.278	0.34	–	–	–
Pure GGN	0.741	0.165–3.321	0.70	–	–	–
Lung sides	–	–	–	–	–	–
Left	1	–	–	1	–	–
Right	0.302	0.090–	0.05	0.424	0.113–	0.20

		1.016			1.585	
Lobe	–	–	–	–	–	–
Non–upper	1	–	–	1	–	–
Upper	0.356	0.113–1.116	0.08	0.427	0.122–1.494	0.18
PN depth	1.057	1.009–1.108	0.02	1.060	1.008–1.115	0.02
Localization time	1.089	0.941–1.260	0.25	–	–	–
Localization materials	–	–	–	–	–	–
Tailed coil	1	–	–	–	–	–
Suture anchor	0.493	0.164–1.484	0.21	–	–	–
Abbreviations: GGN, ground glass nodule; PN, pulmonary nodule						

Table 5 Video-assisted thoracic surgery outcomes

	Tailed coil group, n = 47	Suture anchor group, n = 51	*P* value
Types of sublobar resection	–	–	0.05
Wedge	40 (85.1%)	35 (68.6%)	–

Segmental	7 (14.9%)	16 (31.4%)	–
Additional lobectomy	5 (10.6%)	6 (11.8%)	0.86
Final diagnoses	–	–	0.24
Malignant	33 (70.2%)	30 (58.8%)	–
Benign	14 (29.8%)	21 (41.2%)	–

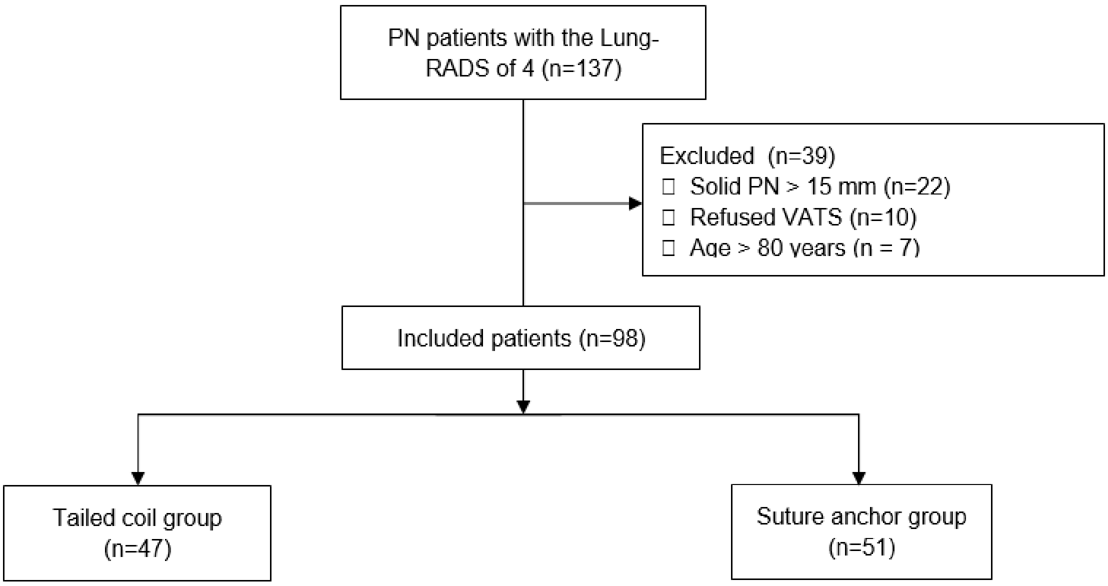

Figure 1 The flowchart of this study

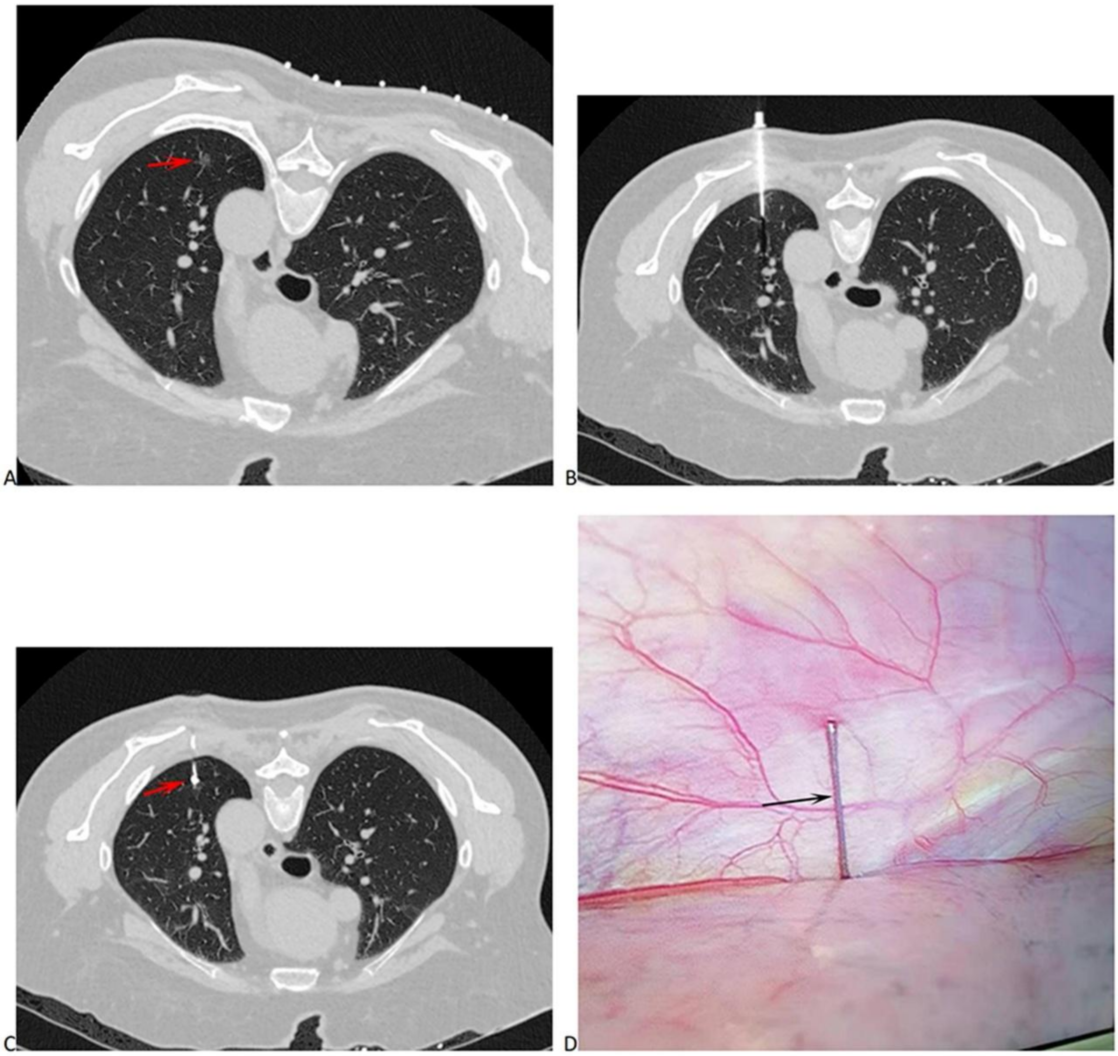

Figure 2 The preoperative computed tomography (CT)-guided tailed coil localization. **A** – Thoracic CT showed a pure GGN (arrow) at the left upper lobe; **B** – CT-guided needle puncture; **C** – Tailed coil (arrow) was placed for PN localization; **D** – Tailed coil (arrow) could be visualized during the video-assisted thoracic surgery procedure

Figure 3. The preoperative computed tomography (CT)-guided suture anchor localization. **A** – Thoracic CT showed a mixed GGN (arrow) at the right lower lobe; **B** – CT-guided needle

puncture; **C** – Suture anchor (arrow) was placed for PN localization; **D** – Suture anchor (arrow) could be visualized during the video-assisted thoracic surgery procedure

Short title: CT-guided TC vs. SA localization for PNs