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## TECHNICAL NOTE

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# Preoperative Computed Tomography-guided Hook-wire Localisation of Pulmonary Nodules

G Ho<sup>1</sup>, SHM Wong<sup>2</sup>, LC Cheng<sup>3</sup>

<sup>1</sup>Department of Radiology, Queen Mary Hospital; <sup>2</sup>Central Medical Diagnostic Centre; and <sup>3</sup>Department of Surgery, Queen Mary Hospital, Hong Kong

### ABSTRACT

*Percutaneous preoperative localisation of breast tumours using a hook-wire needle is a standard radiological practice. The use of a hook-wire in preoperative localisation of pulmonary nodules under computed tomography guidance has also been described in overseas publications. We describe herein our local experience with the use of a hook-wire needle that is primarily used in breast tumours in preoperative computed tomography-guided localisation of small pulmonary nodules, which would have otherwise been difficult to find at surgery.*

*Key Words:* Preoperative care; Solitary pulmonary nodule; Sutures; Tomography, X-ray computed

## 中文摘要

### 術前電腦斷層 (CT) 引導下鈎針定位肺內結節性病灶

何潔明、黃浩文、鄭力翔

使用鈎針作術前經皮定位乳腺腫瘤是一項常規的放射攝影定位法。外國文獻亦有關於術前CT引導下鈎針定位肺內結節性病灶的報導。術中要把肺內結節性病灶定位很難，本文報告把原用於定位乳腺腫瘤的技術，應用在術前CT引導下鈎針定位肺內結節性病灶。

### INTRODUCTION

The widespread use of computed tomography (CT) scans has resulted in the detection of many small pulmonary nodules of indeterminate significance.<sup>1</sup> Workup of these pulmonary nodules often involves interval CT scans, additional imaging such as positron emission tomography (PET) scans, CT-guided fine-needle aspiration cytology, and evaluation of serum tumour markers. When the nature of the pulmonary nodule remains indeterminate even after such workup, excisional biopsy may become necessary.<sup>2</sup> Despite advances in thoracoscopic surgical techniques,

pulmonary lesions that are small or too far from the pleura are difficult to locate for intra-operative resection. Use of hook-wire needles for preoperative localisation of pulmonary nodules is advantageous, because they can be precisely positioned under CT imaging guidance; the hook anchors the wire to the lung tissue and shortly thereafter the patient is transported to the operating theatre for excision of the target lesion.<sup>3</sup> Such preoperative hook-wire localisation has already been widely adopted to deal with breast lesions.

In this report, we describe our local experience using

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*Correspondence:* Dr Simon HM Wong, Central Medical Diagnostic Centre, 18/F Asia Standard Tower, 59-65 Queen's Road Central, Hong Kong.

Tel: (852) 2522 0108 ; Fax: (852) 2522 1324 ; Email: simonhwmwong@yahoo.com.hk

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X-Reidy Breast Lesion Localization Needle Sets (Cook Inc. William Cook Europe, Bjaeverskov, Denmark) for CT-guided percutaneous hook-wire placement to guide thoracoscopic resection of pulmonary nodules.

## METHODS

From June 2009 to October 2009, CT-guided percutaneous hook-wire localisation of five lung nodules was performed in four patients in Queen Mary Hospital, Hong Kong. All the pulmonary nodules were detected by CT, and had diameters ranging from 4 mm to 9 mm. They were considered too small for percutaneous fine-needle aspiration, in which the yield would very likely be non-diagnostic, and the procedure would be technically difficult as well.

The patients were referred for excisional biopsy of presumed lung disease. Preoperative CT-guided hook-wire localisation was requested, as the surgeon believed that the depth and size of the pulmonary nodule would preclude intra-operative visual and / or tactile detection. The optimal approach, position, site, depth, and angulation of needle entry were planned according to the location of each of the targeted pulmonary nodules as seen on the respective CT images.

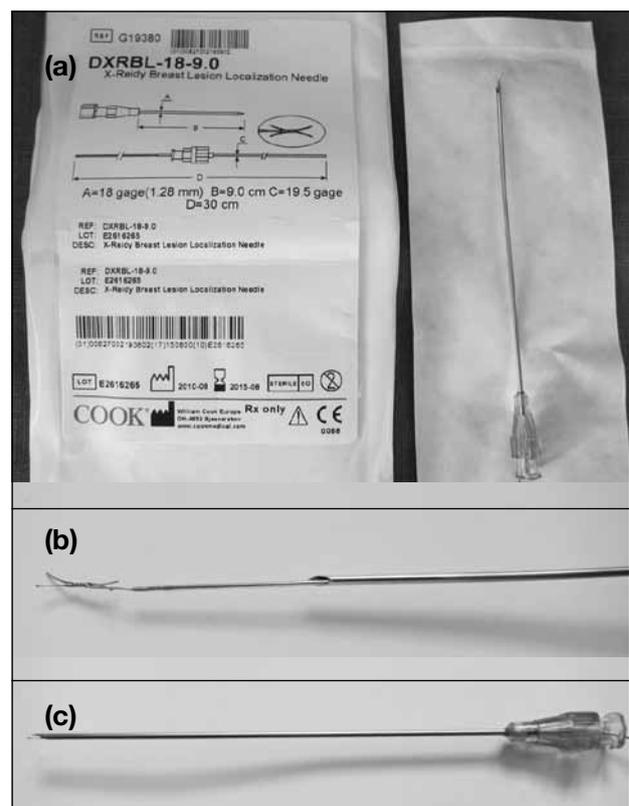
The procedures were performed using helical CT (General Electric Medical Systems; Milwaukee [WI], US) at 2.5 mm collimation. Each patient was placed on the CT table in a position that allowed the shortest possible direct hook-wire access to the targeted nodule and yet avoided vital intra-thoracic structures such as the heart and the great vessels. The X-Reidy Breast Lesion Localization Single Needle consists of an 18-gauge (1.29 mm) 9-cm long cannula with a bevel-tip needle, and a 30-cm long hook-wire with a 2-cm long stiff portion on the shaft, just proximal to the X-shaped hook (Figure 1). The X-shaped hook is designed for easy palpation during surgery.

Patients were initially scanned to locate the suspected lesion. The latitude and longitude of skin entry was denoted using the surface marker of the scanner. The depth and angle of needle insertion were calculated on the computer workstation. Skin was sterilised under aseptic technique. Local anaesthesia was administered to the cutaneous and subcutaneous tissues at the needle entry site. The cannula tip of the localisation needle was advanced at the required angulation towards the targeted nodule, stopping short of the pleural surface

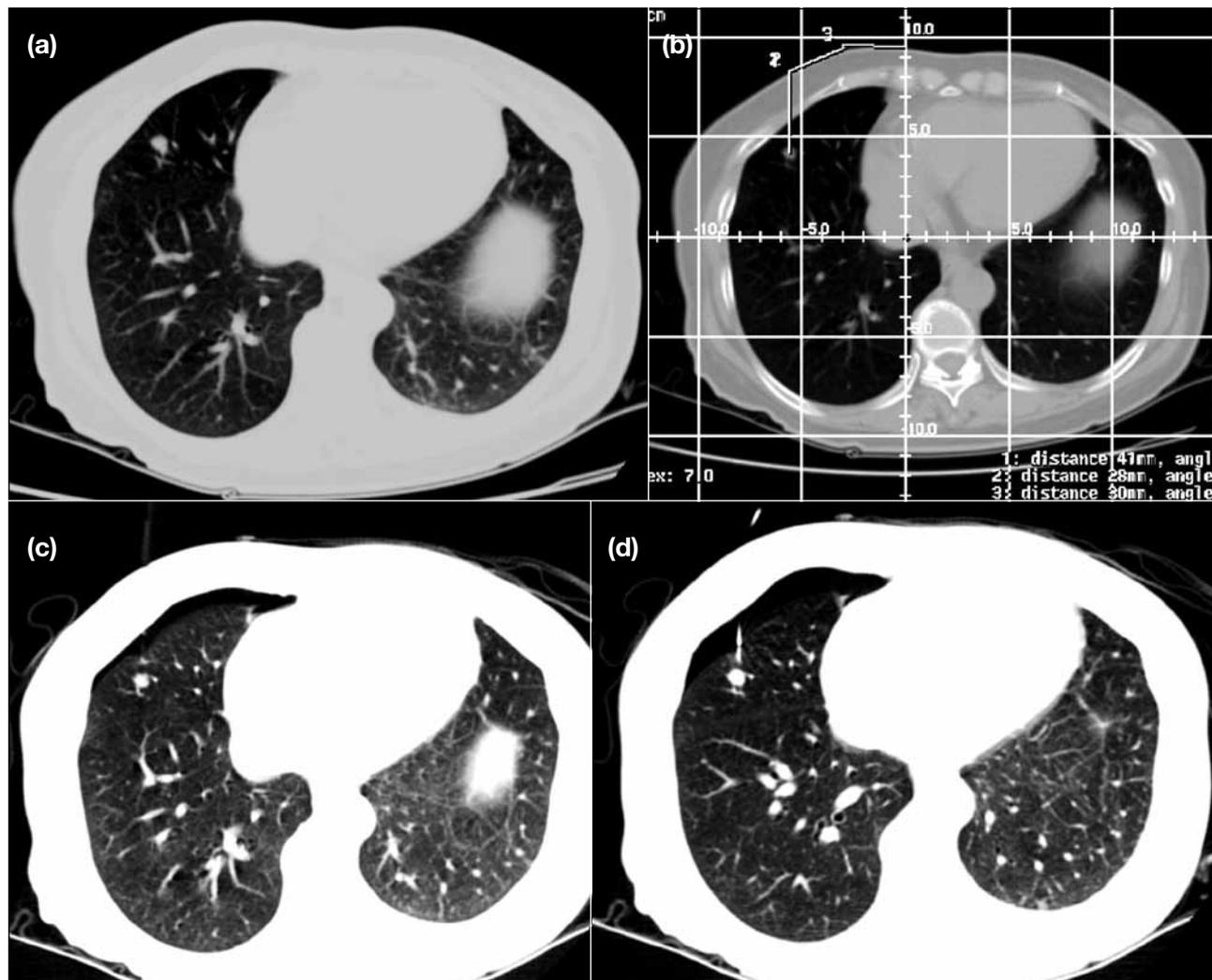
(to avoid pneumothorax and in case a second insertion was required). After confirmation of the appropriate route of needle entry by CT, the needle was further advanced to the calculated depth so as to reach the targeted nodule. Direct puncture of the nodule by the cannula was avoided (to preserve the pathological specimen). After optimal placement of the cannula tip as confirmed by CT, the hook-wire was deployed by slowly pulling back the cannula. Satisfactory placement of the ejected hook-wire in the lung was confirmed by CT; its location, depth, and angulation at the skin surface with respect to the nodule was measured on the CT and conveyed to the surgeon. The exposed part of the hook-wire was fixed with an alligator clip as a skin marker and secured. The patient was then transported to the operating theatre for immediate thoracoscopic resection. The subject's vital signs were closely monitored all along.

## RESULTS

Hook-wires were successfully placed in four patients with five targeted pulmonary nodules. None required



**Figure 1.** (a) The 18-gauge X-Reidy Breast Lesion Localization Needle. (b) X-shaped hook at the hook-wire tip and the 2-cm long stiff portion on the shaft. (c) The 9-cm long cannula with a bevel-tip needle.



**Figure 2.** Computed tomograms (a) showing a 9.6-mm nodule in right middle lobe; (b) during pre-hook-wire placement planning; (c) showing hook-wire needle insertion targeting the nodule in right middle lobe; small amount of right pneumothorax is noted; and (d) showing hook-wire deployed after withdrawal of the needle cannula.

**Table.** Size, preoperative diagnosis, and pathology of the pulmonary nodules.

Patient No.	Sex/age (years)	Size of pulmonary nodule (mm)	Preoperative diagnosis	Pathological result
1	M/65	4	Metastatic adenocarcinoma	Granulomatous inflammation
2	F/63	9.6	Carcinoid tumour with ectopic ACTH	Carcinoid tumour with tumorlets
3	M/54	8	Recurrent adenocarcinoma of lung or metastatic HCC	Mycobacterial infection
4	M/53	5 (two)	Metastatic HCC	One metastatic HCC One non-malignant

Abbreviations: ACTH = adrenocorticotrophic hormone; HCC = hepatocellular carcinoma.

a second puncture. Small pneumothoraces were encountered in three of the patients, and one patient suffered from a small amount of peri-focal parenchymal haemorrhage. The Table outlines the size of pulmonary nodules, preoperative diagnosis, and pathological results.

### Patient 1

A 65-year-old ex-chronic smoker with a treated rectal adenocarcinoma (in remission) was noted to have rising serum carcinoembryonic antigen levels. His PET-CT showed a 5-mm pulmonary nodule in the apical segment of the left lower lobe. Wedge resection of the lesion via hook-wire localisation was arranged, as a pulmonary metastasis was suspected. His CT showed a 4-mm nodule at the apical segment of the left lower lobe. The hook-wire was deployed 2 cm anterolateral to the nodule; the tip of the hook

was 7.9 cm deep to skin entry site. A minimal rim of pneumothorax was noted after the procedure. Pathology of resected lung showed granulomatous inflammation without evidence of malignancy.

**Patient 2**

A 63-year-old woman was diagnosed with adrenocorticotropic hormone (ACTH)-dependent Cushing’s disease by an endocrinologist. Initial CT showed a 6-mm nodule with surrounding scarring in the right middle lobe, with enlargement to 9.6 mm

noted on a subsequent CT two months later. Pituitary workup and an octreotide scan for ectopic ACTH were negative. The patient was referred for hook-wire localised nodule resection, for suspected carcinoid tumour with ectopic ACTH secretion.

The CT showed the hook-wire at a 0 degree angle insertion (Figure 2). The tip of the hook was touching ventral aspect of the pulmonary nodule in the right middle lobe, and was 5 cm from the skin entry site. Small pneumothorax was noted after the procedure.



**Figure 3.** (a) Post-hook-wire needle placement targeting the 8-mm nodule in right lower lobe. (b) Area of perifocal parenchymal haemorrhage after hook-wire was deployed.



**Figure 4.** (a) Two computed tomographic images showing a 5-mm nodule each in right upper lobe and right lower lobe, with pre-procedure planning for hook-wire localisation. (b) Hook-wire placement targeting the right lower lobe nodule.

Pathology revealed that the nodule was a carcinoid tumour with tumorlets.

### **Patient 3**

A 54-year-old man had a lobectomy for an adenocarcinoma in the upper lobe of the right lung and a history of hepatocellular carcinoma, for which he had had a partial hepatectomy. His follow-up CT showed a new 8-mm nodule in the apical segment of right lower lobe that was suspicious of a recurrence or a metastatic nodule. He was referred for hook-wire localisation to undergo right lower lobe wedge resection of the nodule.

The CT showed an 8-mm nodule in the apical segment of right lower lobe (Figure 3). With the patient lying prone, the hook-wire needle was deployed traversing the targeted nodule with the tip 1.3 cm deep to the lesion. A small amount of peri-focal parenchymal haemorrhage was encountered after the procedure. Pathology yielded granulomatous inflammation, consistent with mycobacterial infection.

### **Patient 4**

A 53-year-old man had a history of recurrent hepatocellular carcinoma with liver transplantation performed. His follow-up CT showed a 4-mm nodule in the right upper lobe and a 3-mm pulmonary nodule in the right lower lobe. He was referred for wedge resection of the nodules utilising CT-guided hook-wire localisation.

The CT showed a 5-mm nodule at the anterior segment of right upper lobe (Figure 4). Hook-wire placement was performed with the tip of the hook deployed 1.6 mm lateral to the lesion. Yet another hook-wire was inserted with its tip 5 mm caudal to another 5 mm of the nodule in the laterobasal segment of right lower lobe. A small pneumothorax was noted after the procedure. Pathologically, the 4-mm nodule in the right lower lobe was a metastatic hepatocellular carcinoma; the nodule detected in the right upper lobe was non-malignant.

## **DISCUSSION**

Preoperative wire localisation, initially described by Mack et al<sup>4</sup> and Plunkett et al,<sup>5</sup> involves placement of a wire with CT guidance in or adjacent to a pulmonary nodule. The wire provides a guide for the surgeon by targeting the lesion to be resected at video-assisted thoracic surgery.<sup>6</sup> Preoperative localisation is particularly useful when the pulmonary nodule is

deemed difficult to locate intra-operatively, because of its small size or distance from the pleura. The use of different hook-wire systems, often with purpose-built modifications, have been published.<sup>3,6,7</sup> Our experience using the hook-wire system primarily designed for breast lesions in CT-guided preoperative localisation of pulmonary nodules was encouraging. Its accuracy in facilitating the resection of pulmonary nodules was reflected by the positive pathological yield in all patients.

In two of the four patients, the pathology of the excised pulmonary nodules differed from what was postulated preoperatively. The latter nodules were regarded as indeterminate based on imaging and assumed to be neoplastic considering the patient's clinical history. After resection, their histopathology finally confirmed the presence of mycobacterial infection and granulomatous inflammation. Without a pathological diagnosis confirmed by surgical means, patient follow-up using serial radiological imaging would have delayed treatment. This would have been particularly disadvantageous for managing the patient with mycobacterial infection. Preoperative CT-guided hook-wire localisation thus has an important role in selected patients, for whom early pathological correlation of indeterminate pulmonary nodules might be critical for subsequent definitive management.

Suzuki et al<sup>8</sup> published a retrospective study on video-assisted thoracoscopic surgery for small indeterminate pulmonary nodules in 92 patients. According to that study, there was an absolute indication for preoperative marking when the distance to the nearest pleural surface was greater than 10 mm for nodules  $\leq 10$  mm in size, and a relative indication for such nodules located 5 to 10 mm from the nearest pleural surface. The absolute indication suggested by that study was generally accepted and adopted in our institution. Contraindications include suboptimal pulmonary function affecting suitability for wedge resection or lobectomy, bleeding tendency, and an unfavourably deep pulmonary location for hook-wire localisation.

Accurate placement of the cannula at its extra-pleural course is crucial to avoiding a second needle puncture, which could lead to more pneumothorax and render the procedure even more difficult, as this would alter the position of the target lesion.

Breakage of the hook-wire has been mentioned in the

literature. In Gossot et al's series,<sup>9</sup> one of the hooks broke shortly after its removal from the chest cavity. This highlighted the need for delicate handling of the equipment throughout to avoid intra-thoracic breaks. No such complication occurred in our series.

Small, asymptomatic pneumothoraces were encountered in three of our patients, whose conditions remained stable en-route to the operating suite. With reference to other studies, pneumothorax was not an uncommon complication. In all, about 50% of patients developed small-to-moderate pneumothoraces in series reported by Plunkett et al,<sup>5</sup> Shepard et al,<sup>10</sup> as well as Gossot et al.<sup>9</sup> Notably none of their patients had chest tubes inserted, and all of them tolerated the procedural pain well if given sufficient local anaesthesia and reassurance.

There was no dislodgement of the hook-wire during transport of the patients to the operating suite, though this was discussed in other publications.<sup>3,7</sup> In the series described by Dendo et al<sup>11</sup> and Shepard et al,<sup>10</sup> a few of the hook-wires slipped out resulting in unsuccessful placement, which was conceivable because the needle insertions were too shallow. Dendo et al<sup>11</sup> therefore modified their method for introducing the needle, to ensure insertion to a minimum depth of 1 cm from the pleural surface. Shepard et al<sup>10</sup> recommended anchoring the hook slightly deeper than the lesion so that any traction on the wire would pull the hook into the lesion and not away from it. This was particularly helpful if a pneumothorax was anticipated, since this could impose friction and traction forces on the hook-wire. As with other fine-needle biopsies of pulmonary nodules, there were reports of gas embolism in patients undergoing hook-wire localisation,<sup>12</sup> aspiration of air into the pulmonary veins (via the open lumen of the needle or along its tract) was the postulated mechanism, especially in association with a Valsalva manoeuvre, coughing, and mechanical ventilation. Use of a short trajectory for the hook-wire and avoiding sustained lung inflation was proposed as a means of reducing the likelihood of air embolism.<sup>12</sup> Moreover, no fatal complication ensued in our case series.

One of our patients underwent successful simultaneous double lesion localisation of pulmonary nodules on the same side. If the nodules had been located on opposite sides, simultaneous hook-wire localisation would have been much more risky, owing to more serious consequences from possible bilateral pneumothorax

and / or other complications.

The small number of patients in our report was a limitation. This prohibited in-depth analysis of the technique's efficacy and complications. In addition, we did not compare different types of hook-wire needle systems to discern possible drawbacks due to other hook-wire designs.

In summary, our local experience using the hook-wire needle that was primarily designed for breast lesions was safe and helpful for preoperative CT-guided localisation of pulmonary nodules. It facilitated thoracoscopic resection of indeterminate pulmonary nodules by providing intra-operative guidance to surgeons whenever tactile and visual detection appeared difficult.

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