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Radioguided video-assisted resection of non-palpable solitary pulmonary nodule/ground glass opacity: how to do it

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Background: Detection of subcentimeter solitary pulmonary nodules (SPN) and ground glass opacities (GGO) is increased but their small size may make them difficult to be reached by computerized tomography (CT) guided fine needle agobiopsy or transbronchial biopsy. Surgical resection provides the gold standard for obtaining a specimen for histopathologic diagnosis, and video-assisted thoracic surgery (VATS) allows in many cases a minimally invasive technique of resections. The limit of VATS techniques is the need of nodule localization. Often-digital palpation is all needed to identify the appropriate area of resection, but sometimes it may be very difficult to identify and remove small, deep, non-palpable lesions. The criteria for nodule marking are unclear and variety of localization methods have been developed and they are effective but burdened by significant failure rate and complications. To increase the efficacy of thoracoscopic localization/resection of small pulmonary nodules, we used the radioguided technique.

Methods: Under CT guidance, the nodule was identified and a needle was inserted to reach lesional or perilesional tissue. A solution of ^{99m}technetium (^{99m}Tc) macro-aggregates albumin diluted with iodized contrast medium was injected. After injection, CT was performed to confirm precise staining.

Results: At VATS, a gamma detector probe allowed localization of nodules in all patients. Resection was performed, and suture margins were checked with the probe to search for residual hyperabsorption. All specimens underwent frozen section. Frozen section revealed diagnosis in all cases.

Conclusions: Radioguided surgery is a cost-effective strategy for evaluating suspicious SPN/GGO with a success rate close to 100%, extremely low morbidity, and zero mortality. Radioguided VATS may be useful for preoperative localization of deep, small lung nodules that cannot be digitally localized or for GGO opacities that can be difficult to palpate even with the open technique.

Keywords: Lung cancer; video-assisted thoracic surgery (VATS); radioguided surgery

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Introduction

The results of the National Lung Screening Trial showing reduced lung cancer mortality with low-dose computerized tomography (CT) screening have led to the adoption of lung cancer screening with low-dose CT in many centers around the world (1). Accordingly, the detection of subcentimeter solitary pulmonary nodules (SPN) and ground glass opacities (GGO) is increased. Due to this fact, thoracic surgeons are often involved in decision making about small pulmonary nodules suspect for malignancy, their small size may make them difficult to be reached by CT guided fine needle agobiopsy or transbronchial biopsy (2). Surgical resection provides the gold standard for obtaining a specimen for histopathologic diagnosis, and video-assisted thoracic surgery (VATS) allows in many cases a minimally invasive technique of resections. The limit of VATS techniques is the need of nodule localization. Often-digital palpation is all needed to identify the appropriate area of resection, but sometimes it may be very difficult to identify and remove small, deep, non-palpable lesions or GGO areas.

Previous reports indicate that the criteria for nodule marking are unclear (3) and variety of localization methods have been developed ranging from thoracoscopic ultrasonography (4), percutaneous hook wires (5), contrast/dyes (6), and bronchoscopically placed localizers (7). These methods are generally effective but are burdened by significant failure rate and complications. To increase the efficacy of thoracoscopic localization/resection of small pulmonary nodules, we used the radioguided technique that was already described in a previous report (8).

Patients selection and workup

In our protocol, patients selected to undergo radioactive marking of the lesion before VATS were a maximum nodule diameter <15 mm, a distance from the nearest pleural surface of 20-40 mm, a GGO, and/or a posterior location of the SPN difficult to reach with the finger. The feasibility of percutaneous CT-guided injection of radiotracer and VATS wedge resection were evaluated, as the possibility of localization of the nodule with intraoperative gamma probe during the weekly meeting of the local multidisciplinary team.

Preoperative preparation

^{99m}Technetium (^{99m}Tc), a radionuclide with principal gamma photon emission energy of 140 keV, was used because of its half-life of about 6 hours and, as a consequence, a low patient-absorbed radiation dose. Moreover, it is a low-cost and easily available radionuclide. Depending on the time planned for the operation (the same morning or the next morning), 2-9 MBq corresponding to 0.10-0.12 mL of ^{99m}Tc macroaggregate albumin (MAA) was diluted with nonionic iodinated contrast medium. Then, 0.12-0.15 mL was injected into the lesion or in close proximity to it through a 22-gauge spinal needle. To prevent air embolism during the percutaneous localization, the syringe was withdrawn to check that no blood flowed in it before injecting the contrast medium. The patient then underwent surgery after a 3-19 hours interval from the ^{99m}Tc MAA localization of the nodules.

Equipment preference card

In the operating room, under thoracoscopic vision, a hand-held, 11-mm diameter collimated gamma probe connected to a gamma ray detector unit was used to detect ^{99m}Tc MAA radioactivity. The detector unit converted gamma ray emissions into audiovisual signals, proportional to the detected radioactivity. The biggest audiovisual signal matched with the area of the previously injected nodule.

Procedure

All thoracoscopic resections were performed under general anesthesia with selective intubation through a double-lumen tube to obtain ipsilateral lung collapse. Three incisions were made: one for a 10-mm 30° thoracoscope, one for an endoscopic grasper, and the third for alternating use of the gamma probe and the endostapler. Identification of the nodule was based on maximum intensities of both numeric and acoustic signals. After localization with the gamma probe, the area of the lung parenchyma with the maximum radioactive signal was grasped and elevated (*Figure 1*). The gamma probe was rotated to confirm the lesion's location from multiple angles using maximum signal intensity as a guide; signal intensity was both numeric and acoustic. This step helped determine the depth of the lesion in relation to the grasper (8). During resection, before firing the endostapler, the probe was used to guide the resection itself by verifying the absence of radioactivity just over and, above all, beyond the stapler line. Once the wedge resection was performed, the nodule was extracted from the pleural cavity into an endoscopic bag through the largest porthole to avoid tumor seeding to the chest wall. The presence of the nodule in the surgical specimen was immediately verified and was then sent for pathological examination. When lung cancer was preoperatively suspected and the diagnosis was confirmed by frozen section examination a VATS lobectomy was performed. In our experience, only minor complications that did not require any intervention were associated with the procedures (8).

Tips, tricks and pitfalls

Several studies have documented specific indications in which localization techniques should be employed. Suzuki and colleagues recommend that localization techniques be used when the nodules are <10 mm in size or >5 mm from the visceral pleural surface or both (10).

Figure 1 Radioguided video-assisted resection of a non-palpable solitary pulmonary nodule (9). After localization of the nodule with the gamma probe, the area of the lung parenchyma with the maximum radioactive signal was grasped and elevated. The probe was rotated to confirm the lesion's location using maximum signal intensity as a guide. During resection, before firing the endostapler, the probe was used to guide the resection itself by verifying the absence of radioactivity just over and, above all, beyond the stapler line. Once the wedge resection was performed, the nodule was extracted from the pleural cavity into an endoscopic bag and the real presence of nodule in the specimen was immediately verified. The absence of residual radioactivity in the surgical field was immediately verified.
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Nakashima developed three criteria: the nodule diameter ≤5 mm, the ratio of maximum diameter of nodule to minimum distance between pleural surface and inferior border of nodule ≤0.5, and the nodule is of low density on CT scan (11). Sancheti recommended that localization techniques should be used if two or more of the previous criteria are met (12). Saito determined that a linear function (depth =0.836× size −2.811) could differentiate between nodules requiring localization or not (13). The inherent advantages of the radioguided localization of nodules include the ability to perform the resections with routine thoracoscopic instruments. Of note, this method showed the ability to resect pure GGO lesions, difficult to identify and resect in VATS. The methodology presented requires a strict coordination between thoracic surgeon, radiologist, and the nuclear medicine physician (12). The utilization of multiple specialties does not add expense and complexity to the procedure.

However, surgeons at some institutions do perform their own interventional procedures, which could make the flow of steps much smoother (14). The marking of a nodule with the radiotracer is possible in any portion of the lung and does not interfere with the histological examination. Furthermore, the technique can increase the accuracy of the resection by verifying in real time the absence of radioactivity just above and below the stapler line.

The radioguided localization technique has some pitfalls. The first pitfall is the possibility of an outsized diffusion of the radiotracer inside the lung parenchyma, in case of bullous emphysema adjacent to the nodule. This can lead to a wider area of radioactivity, which reduces the precision of the resection. A second pitfall is the spillage of the radiotracer into the pleural space. This generally happens if the radiotracer is injected near the pleural surface of a major fissure, or, more frequently if a pneumothorax develops during injection. This increases the ground radioactivity, thus enabling the correct localization of the lesion, even if, part of the radiotracer was correctly injected within the nodule. In fact, we inject a solution that also contains a small amount of nonionic contrast material; thus, at the end of the procedure, we always verify by CT scan the presence of the solution within the lesion. A third limit could be the relatively short half-life of the radionuclide, which may lead to some difficulties in scheduling the injection procedure and the operation. The preoperative marking of the lesion must be followed by surgical resection, either immediately or within a few hours. Thus, in case of postponed operation, the radiotracer could have dissolved and no longer be detectable. Considering this, we used a modified solution with MAA assuring the stability of radiotracer in the lung for up to 18 hours without an increased hazard of radioactivity to the patient and the hospital personnel. Finally, the economic criticism (expensive method due to the required technology) has been overcome in recent years thanks to the widespread use of the sentinel lymph node technique in breast cancer surgery, which utilizes the same devices and is therefore now available in most centers (15).

Conclusions

Radioguided minimally invasive surgery may be useful for preoperative localization of deep, small lung nodules that cannot be digitally localized or for GGO opacities that can be difficult to palpate even with the open technique. Radioguided surgery avoids unnecessary thoracotomy in cases of benign lesions. Technological advances are usually thought to increase the costs of medical care. However, radioguided surgery is a cost-effective strategy for evaluating suspicious SPN/GGO with a success rate close to 100%, extremely low morbidity, and zero mortality.

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None.

Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

Ethical Statement: The study was approved by the University of Louisville IRB. Written informed consent was obtained from the patient. A copy of the written consent is available for review by the Editor-in-Chief of this journal.

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