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INTERVENTIONAL RADIOLOGY

TECHNICAL NOTE

Combined utility of one lung ventilation and artificial pneumothorax in thermal ablation of hepatic dome tumor: a technical note

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Radiofrequency ablation and microwave ablation are established treatment modalities for smaller (<3 cm) or isolated hepatic tumors. Transthoracic ablation of hepatic dome lesions is a well described technique. We report the use of one lung ventilation to facilitate the successful percutaneous transthoracic microwave ablation of a segment 8 hepatic dome lesion after induction of artificial pneumothorax. This involved the use of general anesthesia and insertion of a double lumen endotracheal tube to allow isolated ventilation of one lung, followed by creation of an artificial pneumothorax under computed tomography (CT) guidance. Complete ablation of the lesion was confirmed on CT liver at 1 and 7 months with no local recurrence. The combined techniques of one lung ventilation and artificial pneumothorax enabled a safe and accurate transthoracic targeting of the hepatic dome lesion.

Thermal ablation techniques such as radiofrequency ablation (RFA) and microwave ablation (MWA) are alternative treatment options for patients with small (<3 cm) or isolated lesions. Transthoracic ablation of lesions is safe and effective for treatment of hepatic dome lesions.

Current standard of practice in most centers is the administration of local anesthesia with moderate conscious sedation for percutaneous RFA or MWA. Thermal ablation under sedation is poorly tolerated in patients whose lesions are more than 3 cm in size or in the sub-diaphragmatic location, commonly requiring conversion to general anesthesia due to pain on ablation and/or need for controlled apnea to allow for accurate targeting of the lesion (1). Additionally, incomplete ablation of tumors is more common in procedures with sedation compared to general anesthesia (1).

Even under general anesthesia, hepatic dome lesion targeting is affected by the constant respiratory movements of the liver and diaphragm. We report the use of one-lung ventilation (OLV) to facilitate safe and successful transthoracic percutaneous computed tomography (CT)-guided MWA of a hepatic dome hepatocellular carcinoma (HCC) lesion after induction of artificial pneumothorax to avoid injury to the lung and visceral pleura.

Technique

Background history

The patient was a 66-year-old man who first underwent percutaneous MWA of a segment 8 HCC via transhepatic approach in April 2018, complicated by pneumothorax requiring chest tube insertion and a small residual tumor requiring repeat ablation in August 2018.

Liver CT performed in April 2019 showed a small recurrent tumor at the medial aspect of the previous ablation zone. In view of the prior difficult transhepatic approach (Fig. 1a), a transthoracic approach was planned under general anesthesia with OLV (Figs. 1b, 2a), allowing for the creation of an iatrogenic right-sided pneumothorax to facilitate a faster and safer transthoracic approach of the MWA probe.

Anesthesia

Consent for the procedure as well as general anesthesia were obtained. Unique risks of the insertion of a double lumen tube including increased risk of trauma to the airway were emphasized.

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Patient underwent general anesthesia with direct laryngoscopy used to place a size 35 F left-sided double lumen tube with positioning confirmed via video bronchoscopy. Two lung ventilation was resumed on completion of MWA. Neuromuscular blockade was reversed and the patient was extubated awake after completion of MWA.

Ablation procedure

With the right lung not ventilated and open to air, an artificial right pneumothorax was created via a lower anterior intercostal approach with a 21 G needle under CT guidance. A 6 F Skater pigtail catheter was inserted into the right pleural space. Approximately 200 mL of air was then injected into the right pleural cavity to isolate the lung away from the parietal pleura and the planned site of the transthoracic needle tract. A 15 cm 17 G PR XT Neuwave™ (Ethicon LLC) MWA antenna was then inserted via an intercostal approach under CT fluoroscopic guidance into the lesion (Fig. 2b). The absence of normal respiratory excursion of the liver enabled the faster and accurate placement of the antenna into the lesion on the first attempt. Segment 8 HCC lesion was subjected to 65 W of microwave power for 5 minutes. Tract thermoablation was also administered to minimize the risks of tumor seeding. The air in the pleural cavity was then aspirated and the 6 F drain was removed. A 4 phase CT scan done immediately postablation showed a good ablation zone with no immediate complications. Minimal residual right pneumothorax was noted (Fig. 3a). The whole procedure was completed in 55 minutes.

Postprocedure

A repeat CT scan of the liver one month postprocedure showed resolution of the right-sided pneumothorax with no residual enhancement within the ablation zone of the segment 8 HCC lesion. A further follow-up CT scan done 7 months post-procedure similarly showed no local recurrence (Fig. 3b). The patient remains disease free on clinical follow-up at 8 months.

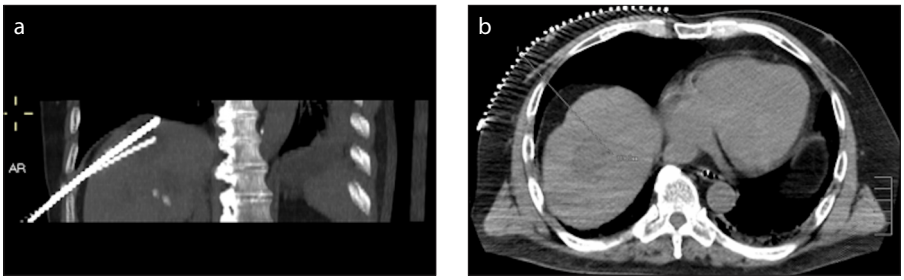

Figure 1. a, b. Intraprocedure CT image **(a)** shows an initially difficult transhepatic approach in 2018 complicated by pneumothorax and small residual tumor requiring repeat ablation. Image **(b)** shows the planning CT of the liver performed prior to ablation, with the *straight line* showing planned needle trajectory.

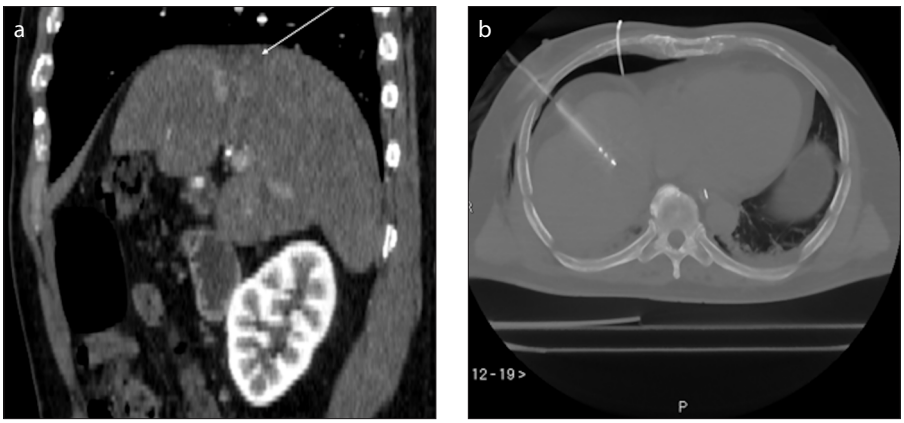

Figure 2. a, b. Sagittal view of planning CT of the liver **(a)** shows recurrent hepatocellular carcinoma at the margin of the prior ablation zone *(arrow)*. Intraoperative CT image **(b)** shows microwave ablation needle in situ as well as the skater drain in situ anteriorly.

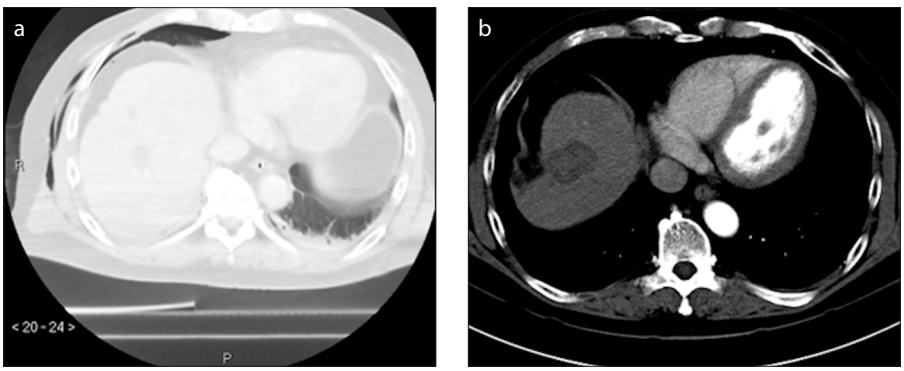

Figure 3. a, b. Liver CT image obtained immediately post-procedure **(a)** shows minimal residual pneumothorax. CT image **(b)** obtained 7 months post-procedure shows no evidence of local recurrence or residual tumor.

Main points

- The combined utility of one-lung ventilation and the induction of artificial pneumothorax can facilitate safe transthoracic percutaneous CT-guided microwave ablation of hepatocellular carcinoma lesions in the hepatic dome.
- One-lung ventilation allows for safe induction of pneumothorax in view of the reduction of respiratory/diaphragmatic movements.
- The absence of normal respiratory excursion of the liver with one lung ventilation also enabled faster and accurate placement of the antenna into the lesion on the first attempt.

Discussion

Previous papers have separately discussed the use of OLV or creation of artificial pneumothorax in their thermal ablation procedures (2, 3). This is the first reported utility of both OLV and artificial pneumothorax, to facilitate a successful transthoracic percutaneous CT-guided MWA of a hepatic dome HCC lesion.

A transthoracic route was attempted for direct approach to the lesion, in view of two previous unsuccessful transhepatic attempts. OLV allowed for safer induction of pneumothorax and accurate targeting of the lesion due to the reduction of respira-

tory movements of the liver/ diaphragmatic movements (4). In this case, ventilator breath hold was not performed as there was no significant movement of the right hemidiaphragm perceived by the operator hindering the microwave antenna placement under CT guidance. Temporary ventilator breath hold during probe placement would be useful if there is persistent significant diaphragmatic excursion.

Hepatic tract ablation was done to minimize the risks of bleeding and tumor seeding. Ablation of the pleura was avoided in view of the potential consequences of thermal ablation of the parietal pleura including chest pain, postoperative coughing and pleural reactions. However, we acknowledge the theoretical risk of tumor seeding in the parietal pleura or chest wall (5).

The use of induction of artificial pneumothorax to perform CT-guided RFA for sub-diaphragm HCC was previously described by Fujiwara et al. (6). Similarly, the small pneumothorax induced allowed a reduction in lung injury with occurrence in only 1 of 16 patients. Previously observed rates of pneumothorax requiring pleural drainage in cases of transpulmonary approach without the use of artificial pneumothorax or OLV were as high as 38%–71%. The use of OLV in our case provided the additional benefit of a reduction in respiratory movements (6).

Hypoxemia during OLV can occur secondary to several reasons including the reduction in functional residual capacity and oxygen stores. Additionally, the unventilated lung results in reduced area for gaseous exchange as well as a ventilation-perfusion mismatch, causing a temporary shunt. Intraoperatively, increasing positive end expiratory pressure of the ventilated lung can help to improve the functional residual capacity of the patient and increasing the fraction of inspired oxygen can also help minimize the fall in oxygen saturations on initiation of OLV (7).

Alternative techniques explored include the induction of hydrothorax which also helps reduce risk of thermal damage. However, this option is difficult with the use of CT guidance as it requires the patient to be in a semi-recumbent position (8).

In conclusion, we have presented a case of successful percutaneous transthoracic needle MWA for a hepatic dome lesion using OLV and induction of artificial pneumothorax. This approach may be considered as an alternative for hepatic dome lesions as it allows for safe and accurate targeting of such lesions. As this is a single case report, further studies looking at associated procedure times and complication rates with the use of OLV and artificial induction of pneumothorax for MWA should be carried out to investigate if the advantages we observed can be consistently replicated.

Conflict of interest disclosure

The authors declared no conflicts of interest.

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