

Intratumoral Injection of Hypertonic Glucose in Treating Refractory Pneumothorax Caused by Microwave Ablation: a Preliminary Study

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Abstract

Purpose The purpose of this technical report is to describe the technique of intratumoral injection of hypertonic glucose combined with low-negative pressure drainage to treat refractory pneumothorax (RP) after microwave ablation (MWA) of lung tumors.

Materials and Methods Between September 2016 and May 2018, four patients who developed RP after MWA of peripheral lung cancer were managed by a combined method, including intratumoral injection of hypertonic glucose and catheter drainage under low-negative pressure. Blood gas values were recorded and compared before the treatment and one-week posttreatment. All patients were followed up for at least one month to monitor the possible recurrence of pneumothorax by chest CT.

Results All patients were successfully treated. One patient received the intratumoral injection of hypertonic glucose twice, while the remaining three patients received a single injection. The technical success rate was 100%. Dyspnea related to RP was significantly relieved in all patients, and PaO₂ and SaO₂ values were higher than those measured

before treatment. No patient suffered a recurrence of pneumothorax during the follow-up.

Conclusion The combined method of intratumoral injection of hypertonic glucose and continuous catheter drainage under low-negative pressure might be an effective method to manage RP caused by MWA.

Keywords Refractory pneumothorax · Microwave ablation · Hypertonic glucose · Injection

Introduction

Refractory pneumothorax (RP) is defined as recurrent pneumothorax (unilateral pneumothorax occurring ≥ 2 times or bilateral pneumothorax occurring ≥ 3 times) or persistent pneumothorax (persistent air leakage after chest tube drainage > 7 days and lack of re-expansion on chest radiograph). RP caused by pulmonary microwave ablation (MWA) or radiofrequency ablation (RFA) is rare but difficult to manage, and patients with comorbidities, such as chronic obstructive pulmonary disease (COPD) and interstitial lung disease (ILD), are reported to have an increased incidence of RP [1]. Common management [2–4] includes surgery, bronchoscopy closure using fibrin glue or one-way endobronchial valves. However, these methods are complex and not always eligible to old patients. Injection of hypertonic glucose into pleural cavity through a catheter is an effective and simple method to manage RP [5], but causes great discomfort to patients due to excessive pleural aseptic inflammation. RP occurs when ablation area from

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MWA or RFA involves adjacent pleura, causing persistent air leak from the ablation tract [6]. Therefore, we propose that local injection of hypertonic glucose would seal the ablation tract and reduce the area of pleural aseptic inflammation. In this article, we present our initial experience of intratumoral injection of hypertonic glucose and continuous catheter drainage under low-negative pressure on four patients with RP caused by MWA.

Materials and Methods

Materials

Between September 2016 and May 2018, we performed 586 MWA procedures in our department and severe pneumothorax was observed in 29 of these patients. All these patients received oxygen inhalation (3 L/min), expectorant, antitussive therapy and continuous catheter (6 F) drainage under low-negative pressure which was successful to treat the pneumothorax within 7 days in all except 4 patients. In these 4 patients, the alternative technique of intratumoral injection of hypertonic glucose was performed (Table 1, Fig. 1).

Methods

The four patients subsequently received intratumoral injection of hypertonic glucose via a 22G Chiba needle under CT guidance. Briefly, the procedures included the following steps. First, the patient was placed in the same position as he/she was during ablation. A chest CT was performed to confirm the puncture site and detect the ablation tract which presented as low-density short tubular structure. Second, after local anesthesia with 4 mL 1% lidocaine, the Chiba needle was used for percutaneous puncture of ablated tumor along the direction of the prior microwave antenna route (Fig. 2). If the ablated tumor was apparently dislocated by severe pneumothorax and if the lesion was difficult to puncture, a 50-mL syringe was utilized to aspirate as much free air as possible from the pleural cavity by the catheter hub. After placement of needle in the ablated tumor, around twenty milliliters of 50% glucose was gradually injected. The volume of

glucose is based primarily on the size of the tumor. Then, continuous catheter drainage was done for three days under low-negative pressure ($-8 \sim -12$ cm H_2O). Negative pressure drainage and oxygen inhalation were then ceased, and a chest CT was performed. If pneumothorax still existed and air leak was detected by artificial aspiration, additional injection was required. If the lung fully re-expanded, the catheter would be removed. All patients were followed up for at least one month to monitor the possible recurrence of pneumothorax according to clinical symptoms.

Efficacy Criteria and Observation Indexes

Effective treatment is considered when the discomfort related to pneumothorax disappears with full lung expansion on the chest CT. Treatment failure is considered when air leaks persist after three injections. The values of PaO_2 , $PaCO_2$, SaO_2 were measured pre- and posttreatment without inhaling oxygen.

Results

The four patients with RP were all cured after the combined treatment (Fig. 3). One patient received the intratumoral injection of hypertonic glucose twice, while the remaining three patients received a single injection (Table 2). The technical success rate was 100%. All patients suffered short-duration mild chest pain after the procedure. According to the visual analogue scale (VAS), none of the patients scored more than 3, and no pain medicine was prescribed. One patient developed a fever ($38.7^\circ C$) following the hypertonic glucose injection and was treated with 325 mg paracetamol sustained-release tablets. Dyspnea related to RP was significantly relieved in all patients. PaO_2 and SaO_2 values increased significantly, and $PaCO_2$ values decreased (Table 3). No complications occurred, and no patient suffered a recurrence of pneumothorax during the follow-up.

Table 1 Clinical characteristics of the patients

	Gender	Age	Comorbidity	Pathological result
Case 1	Male	65	COPD	Primary adenocarcinoma
Case 2	Male	82	ILD	Metastasis
Case 3	Female	75	COPD	Primary squamous carcinoma
Case 4	Male	79	COPD	Primary adenocarcinoma

COPD chronic obstructive pulmonary disease, *ILD* interstitial lung disease

Fig. 1 A 79-year-old man with pulmonary adenocarcinoma in the right upper lung. **A** Prone CT images showed an irregular nodule (short arrow) with settings of severe emphysema (arrowheads). **B** A microwave ablation (MWA) antenna (long arrow) was punctured into the tumor

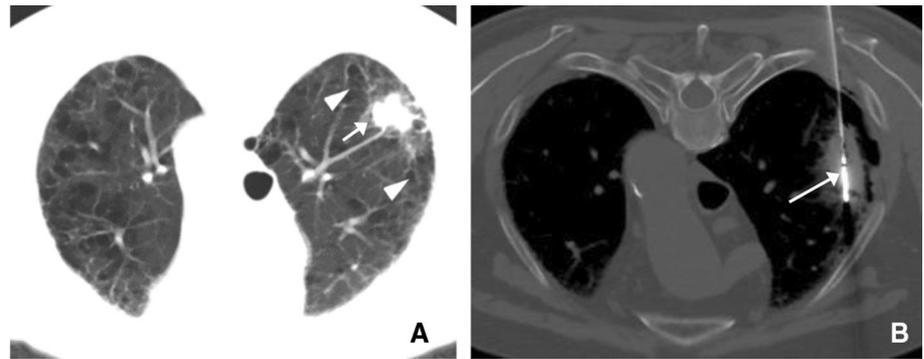


Fig. 2 The combined procedure. **A** The low-negative pressure drainage was performed by a 6F pigtail catheter (arrow). **B** Hypertonic glucose was manually injected by a 22G Chiba needle (arrowhead) which was punctured into the tumor

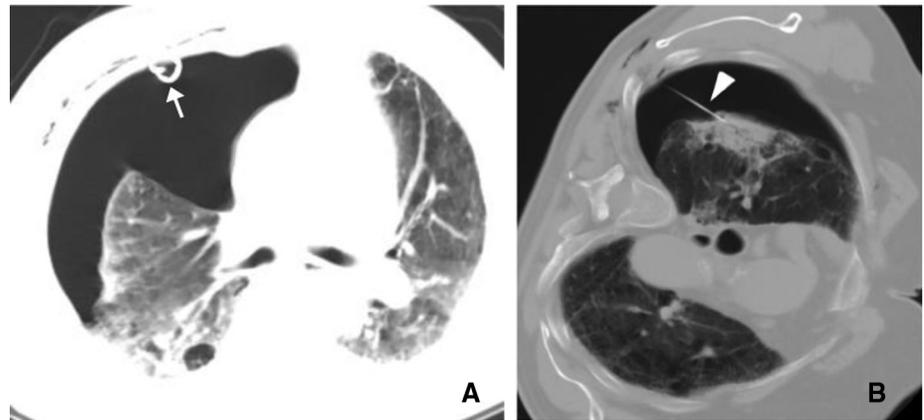


Fig. 3 Chest CT images during follow-up. **A** Three weeks after injection, pulmonary parenchyma expanded with a small amount of air (arrows) and cord-like adhesions (arrowheads) between the visceral and parietal pleura. **B** Pneumothorax was cured 1 month later

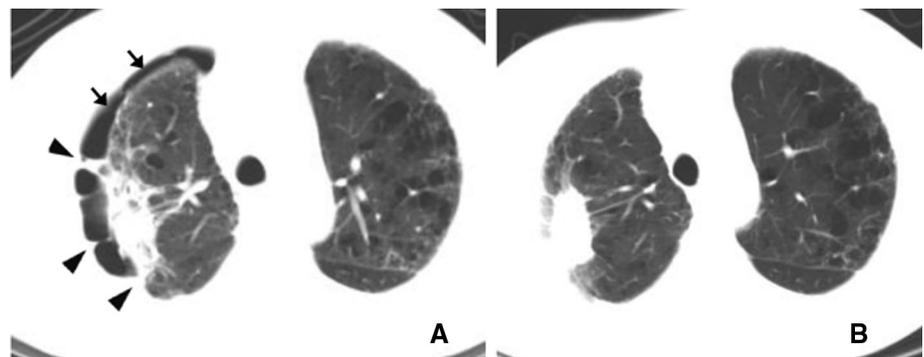


Table 2 Combined method data

	Amount of 50% hypertonic glucose (mL)	Negative pressure (cm H ₂ O)	Duration (day)
Case 1	20	- 8	3
Case 2	40	- 10	6
Case 3	30	- 10	3
Case 4	20	- 12	3

Discussion

Pneumothorax is the most common complication of pulmonary ablation, especially for patients with COPD or ILD [7]. Thoracic CT or chest radiograph is necessary to monitor pneumothorax after pulmonary ablation. Various

protocols have been described in the literature for managing pneumothorax [5, 8–15]. Thoracic drainage with a chest tube or a multipurpose catheter is needed if manual aspiration failed. Usually, it is quite effective to cure the pneumothorax soon; however, in some instances, the pneumothorax still exists after thoracic drainage for more

Table 3 Changes in blood gas analysis pre- and posttreatment

	PaO ₂ (mmHg)		PaCO ₂ (mmHg)		SaO ₂ (%)	
	Pretreatment	Posttreatment	Pretreatment	Posttreatment	Pretreatment	Posttreatment
Case 1	74	87	38	36	92	96
Case 2	69	73	39	37	91	95
Case 3	71	82	39	35	93	96
Case 4	75	94	38	36	94	99
Mean	72.3	84.0	38.5	36.0	92.5	96.5

than 7 days and re-expansion of the lung could not be achieved, which is diagnosed as RP. Continuous catheter drainage under low-negative pressure is now widely used to manage RP. The drainage can maintain pulmonary parenchyma re-expansion and facilitate attachment of the visceral and parietal pleura. However, the long-term placement of a chest tube or catheter causes much discomfort and inconvenience to the patients.

Hypertonic glucose can induce pleural aseptic inflammation and make two layers of pleura adhere together. Therefore, this agent is also frequently applied for pleural fixation and may facilitate early removal of the chest tube [16, 17]. However, injection through a catheter is non-targeted and commonly requires a relatively large amount of hypertonic glucose, leading to extensive aseptic inflammatory response and pleural fixation. This can result in great discomfort to patients. For patients who spontaneously develop RP, it may be a good method because of the unknown pleural fistula. For patients with RP after pulmonary MWA, the air leak from ablation tract is the main reason for the occurrence of pneumothorax [6, 18]. Theoretically, precise injection of hypertonic glucose would occlude the ablation tract and fill the adjacent alveolar cavities to close the potential fistulous tract by osmosis. In our study, four patients with RP caused by MWA were successfully treated using the combined procedure. After 1 month of follow-up, no recurrence of pneumothorax was detected.

This study is different in a number of ways from prior reported studies. First, RP was caused by MWA; thus, the site of the pleural fistula was relatively fixed and certain. Second, a 22G Chiba needle was used to puncture into the ablated tumor, followed by the injection of hypertonic glucose to occlude the ablation tract and to fill the adjacent alveolar cavities to block the potential fistula. This method can decrease the extent of pleural aseptic inflammation and thus reduce the discomfort to patients. However, there were limitations in our study. It was a retrospective study, and the sample size was very small and from a single center. For patients with high risk of occurrence of RP, including COPD, ILD and ablation area involving pleura, the possible role of immediate intratumoral injection of hypertonic

glucose after the removal of MWA antenna to prevent RP is being investigated.

Conclusion

The combined method of intratumoral injection of hypertonic glucose and continuous catheter drainage under low-negative pressure might be an effective method to treat RP caused by MWA. Further studies on larger sample size would help validate this result.

Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflicts of interest.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed Consent Informed consent was obtained from all individual participants included in the study.

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