

Case Report

Navigated Percutaneous Lung Ablation under High-Frequency Jet Ventilation of a Metastasis from a Wilms' Tumour: A Paediatric Case Report

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Keywords

Wilms' tumour · Microwave · Ablation · High-frequency jet ventilation · Lung · Metastasis

Abstract

This is a case report of microwave energy being used to ablate an inoperable metastasis of a Wilms' tumour in a 6-year-old boy using state-of-the-art navigated computed tomography targeting and high-frequency jet ventilation to reduce organ displacement and the potential risk of procedure-related pneumothorax. After the ablation, the young boy had high-dose chemotherapy followed by an autologous stem cell transplantation with rapid reduction of three recurrent right-sided lung metastases.

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Introduction

Thermal ablation of lung tumours is more frequently used as a primary mode of treatment in adults, its efficacy having been proven in several studies [1, 2]. The benefit of this technique is that it is less invasive and spares healthy lung tissue, reducing the overall complication rate and costs and allowing for repeated treatments. The use of ablative lung pro-

cedures in a paediatric setting has been reported, but there are only a few publications on this subject. In previous studies, radiofrequency energy has been used [3].

Microwave energy has several advantages over radiofrequency, such as its speed, no reliance on tissue conductivity, which can be a problem in the air-filled lungs, and the absence of tissue charring which reduces the effect of radiofrequency energy.

Targeting of lung tumours is dependent on non-ultrasound modalities as most lung tumours are impossible to visualize behind air-filled alveoli. Computed tomography is the primary choice but has some negative characteristics, mainly the use of radiation. This can, however, be reduced by using state-of-the-art computer-assisted navigation, making antenna insertion exact and quick, and without the need for fluoroscopy. Accuracy in this setting requires the targeted organ to be immobilized, since the real-time feedback of the tumour location is not monitored. High-frequency jet ventilation has previously been shown to be very effective in reducing ventilation-caused organ displacement in the abdomen, and as it causes minimal lung movement, it is a prerequisite for accurate lung targeting with the reported technique [4]. Further, there is minimal positive airway pressure during anaesthesia, and since the ventilation technique is used throughout the procedure, the risk of pneumothorax is probably reduced.

Lastly, immunological benefits of ablative procedures have been reported in animal studies, where ablated tissue has been argued to cause an in situ tumour immunization, an effect that is not seen when the tumour or the ablated tissue is removed. This effect has not been commonly reported in humans but may play a role with new generations of immunoregulatory drugs being available, unlocking tumour inhibition of humoral defence mechanisms [5].

Case Report

A 6-year-old boy with a Wilms' tumour in the right kidney had 1 year previously been resected for the primary tumour which at the time of diagnosis had spread with a tumour thrombus in the inferior caval vein and lung metastases. Successful chemoradiation therapy was given. After 6 months, recurrence was diagnosed in the lungs with multiple metastases in the right lung and a solitary metastasis in the left lung. Chemotherapy was initiated with a good primary response followed by an open resection of the right lung. At a postoperative scan, a 15-mm metastasis in the inferior lobe of the left lung was seen. A second resection was not possible due to reduced lung capacity after the first resection. Because of the rapid growth of the tumour and absence of other metastases, an ablative procedure was planned.

The ablation was performed under total intravenous anaesthesia using propofol and remifentanyl in continuous infusions. Muscle relaxation was achieved by incremental doses of rocuronium. Single-jet high-frequency jet ventilation (Monsoon III, Acutronic, Hirzel, Switzerland) with a driving pressure of 1.1 bar and a frequency 220/min was used to decrease lung displacement and to reduce the potential risk of postoperative pneumothorax.

For tumour targeting, a native computed tomography scan of the lungs was made. The tumour was readily visible and easily targeted using a commercial system, CAS-One (CAScination AG, Bern, Switzerland), which uses infrared cameras to optically track reflective spheres glued on to the skin and reflectors attached to an aiming device locked on the target coordinates; thus, the depth of antenna insertion is suggested and a 2D and 3D representation of the target and path is shown after the antenna has been inserted through the aiming guide. A control scan was made, the antenna was advanced 3 mm, and a 2-min ablation at

80 W was performed using the Acculis MTA 2.45-GHz microwave generator (Angiodynamics, USA) with a standard 1.8-mm, 14-cm antenna (fig. 1). The whole procedure took 43 min. After 2 h of observation, the patient was returned to the paediatric hospital. A new scan on the following day showed a complete ablation, and he did not experience any discomfort from the procedure.

The ablative procedure was followed by high-intensity chemotherapy (200 mg/m² melphalan; Alkeran) and autologous stem cell transplantation, which was performed after 1 week.

The patient took 1 month to recover from this serious treatment, and after 2 months, a follow-up scan showed good resolution of the ablated scar in the left lung. Three small residual tumours in the right lung had complete response.

Discussion

The presented case is, to our knowledge, the first presentation of microwave ablation of a lung tumour in a child and highlights three aspects of ablative treatment of lung tumours: (1) the use of microwave energy to treat lung tumours; (2) the use of targeting technology to potentially reduce radiation and increase precision, and (3) the use of high-frequency jet ventilation to reduce organ displacement and the potential risk for postoperative pneumothorax.

Traditionally, radiofrequency energy has been used to treat soft-tissue tumours, but in recent years, microwave energy has been suggested to be more favourable [1, 2], as heating is quicker and not dependent on direct tissue conductivity; moreover, it enables larger ablations, is less affected by cooling effects of nearby vessels (heat-sink effect) and, with later generations of hardware, produces near-spherical ablation zones.

Targeting pulmonary tumours with computed tomography fluoroscopy is a well-established technique, and with each generation of scanners, the radiation dose decreases. A further reduction can be achieved if a non-fluoroscopic technique is used [6]. This is especially important in the treatment of children, where the lifetime risk of tumour induction can be expected to be higher.

High-frequency jet ventilation is an old technique of maintaining blood oxygenation where normal ventilation is restricted for anatomical or surgical reasons. In recent years, it has had a revival due to its minimal effect on organ displacement in the percutaneous treatment of liver, kidney, pancreas and lung lesions. We speculate that it also has positive effects regarding the risk of postoperative pneumothorax after lung ablations, since the mean airway pressure needed to maintain adequate gas exchange remains lower under high-frequency jet ventilation than with conventional tidal volume lung ventilation, an argument that needs further investigation [7]. We have, however, not had any pneumothoraxes in the 6 adult patients we have managed in this way.

The immunological effects of ablative treatments are probably the most intriguing aspects, as there might be a superiority of ablative treatment over resective treatment. Animal studies have shown some promising results [8], but it is clear that this issue has not been clinically proven yet.

In conclusion, a paediatric patient with an inoperable lung metastasis from a Wilms' tumour was successfully treated with percutaneous navigated microwave ablation under high-frequency jet ventilation. The case demonstrates the clinical applicability of new-generation targeting technologies, energy sources and a new application of an old ventilation technique.

Statement of Ethics

The patient's parents have reviewed and approved the publication of this case report.

Disclosure Statement

On behalf of all authors, the corresponding author states that there are no conflicts of interest.

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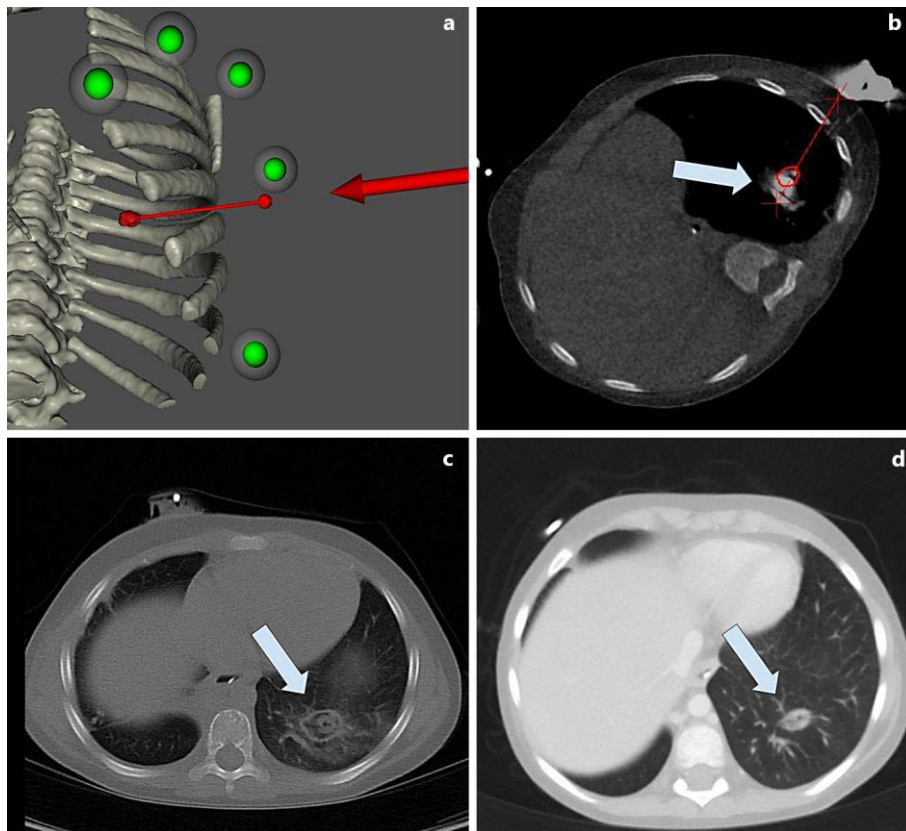


Fig. 1. **a** Interventional planning image with tumour and planned antenna insertion path rendered in red. Green reflective skin markers are glued onto the skin. **b** Fused image with preinterventional image and image with antenna in place. The tumour as well as the planned path (solid red line) and the actual path (dotted red line) are rendered in red. The dark band on the antenna represents the centre of ablation. The bulky artefact outside the skin is the aiming device that locks the planned path of the antenna. **c** Ablated zone 1 day after ablation. **d** Ablated zone 2 months after treatment.