Advances in Radiation Oncology (2016) 1, 136-140

advances in radiation oncology

www.advancesradonc.org

Teaching Case

Reexpansion of atelectasis caused by use of continuous positive airway pressure (CPAP) before radiation therapy (RT)

Sarit Appel MD [a], Noam Weizman BSc [a], Tima Davidson MD [b], Damien Urban MD [c], Yaacov Richard Lawrence MD [a], Zvi Symon MD [a], Jeffrey Goldstein MD [a,*]

[a] *Department of Radiation Oncology, Sheba Medical Center, Tel Hashomer, an affiliate of the Sackler School of Medicine, Tel Aviv University, Tel Aviv Israel*
[b] *Department of Nuclear Medicine, Sheba Medical Center, Tel Hashomer, an affiliate of the Sackler School of Medicine, Tel Aviv University, Tel Aviv Israel*
[c] *Department of Internal Medicine, Sheba Medical Center, Tel Hashomer, an affiliate of the Sackler School of Medicine, Tel Aviv University, Tel Aviv Israel*

Received 3 November 2015; received in revised form 14 March 2016; accepted 16 March 2016

Abstract

Introduction: Although radiation therapy (RT) is an effective treatment for malignant atelectasis, its accurate delivery is challenging because of difficulty differentiating between tumor and atelectatic lung. Furthermore, reexpansion of lung during treatment repositions tumor and normal structures necessitating replanning to ensure treatment accuracy. Facilitating lung reexpansion before initiation of RT may improve RT treatment accuracy, spare normal tissue, and reduce obstructive symptoms. We report a case of reexpansion of right upper lobe (RUL) atelectasis caused by use of continuous positive airway pressure (CPAP) before RT.

Case report: A 52-year-old woman presented with dyspnea and cough. Imaging studies showed an RUL mass with atelectasis. Bronchoscopy showed extrinsic compression of the RUL and middle lobe bronchi. Biopsy showed small cell lung cancer. Staging with positron emission tomography-computed tomography (CT) and contrast enhanced CT of brain showed no other disease. Following 4 cycles of platinum-based chemotherapy, CT imaging showed a decrease in tumor volume, but persistent RUL atelectasis. She agreed to participate in an institutional study to evaluate the use of CPAP to reduce respiratory motion and immobilize tumors during RT. During CPAP training, she complained of vertigo, headache, and weakness and refused simulation. The next day she reported less dyspnea and completed training and CT simulation without difficulty. CT simulation with CPAP showed reexpansion of the RUL. Lung volume increased from 2170 to 3767 mL (74 %). Gross tumor volume, clinical volume, and planning volume decreased 46%, 45%, and 38%, respectively. Mean lung dose and mean heart dose decreased 20% and 51%, respectively.

Sources of support: Supported by unrestricted grants from the LeRoy Schecter Foundation and Parasol Foundation.
Conflicts of interest: United States and international patent applications have been submitted by Z.V. and J.G.
Clinical Trial Registration: NCT02319980 at ClinicalTrials.Gov PRS.

* Corresponding author. Department of Radiation Oncology, Sheba Medical Center, Tel Hashomer, Israel
E-mail address: jgoldstein@Sheba.health.gov.il (J. Goldstein)

http://dx.doi.org/10.1016/j.adro.2016.03.002

CPAP was used daily for 1 hour before and during treatment. Cone beam CT scans showed that the RUL remained inflated throughout treatment.
Conclusion: This is the first reported use of CPAP for reexpansion of atelectasis before RT planning and treatment. Reexpansion of atelectasis improved RT planning, decreased dose to uninvolved lung, and removed the need for replanning. Further study of CPAP as an initial intervention to improve RT delivery in patients with malignant atelectasis is warranted.

Introduction

Atelectasis from endobronchial obstruction or external bronchial compression may cause respiratory distress and obstructive pneumonia.[1,2] Rapid initiation of treatment is important to open the obstruction and relieve symptoms. Endobronchial lesions respond well to treatment with invasive bronchoscopic techniques such as laser ablation, cryotherapy, and stent placement and, if treated early, patients will often experience rapid lung reexpansion.[3,4]

When atelectasis is from external bronchial compression or if invasive bronchoscopic techniques are unavailable, obstructing tumors are often treated with radiation therapy (RT). Accurate placement of radiation fields is challenging because of difficulty in differentiating between tumor and atelectatic lung on computed tomography (CT) images alone.[5] In addition, lung reexpansion during the course of treatment may shift the location of the tumor and normal structures away from their original positions. Replanning of the radiation fields to account for changing organ position resulting from lung reexpansion is essential to ensure treatment accuracy. We hypothesized that facilitating lung reexpansion before initiation of RT would improve treatment accuracy and reduce the need for replanning radiation treatments.

We report the occurrence of reexpansion of right upper lobe (RUL) atelectasis in a patient with small cell lung cancer caused by use of continuous positive airway pressure (CPAP) during RT treatment planning.

Case presentation

A 52-year-old woman with a 60 pack-year history of smoking and a history of ischemic heart disease presented

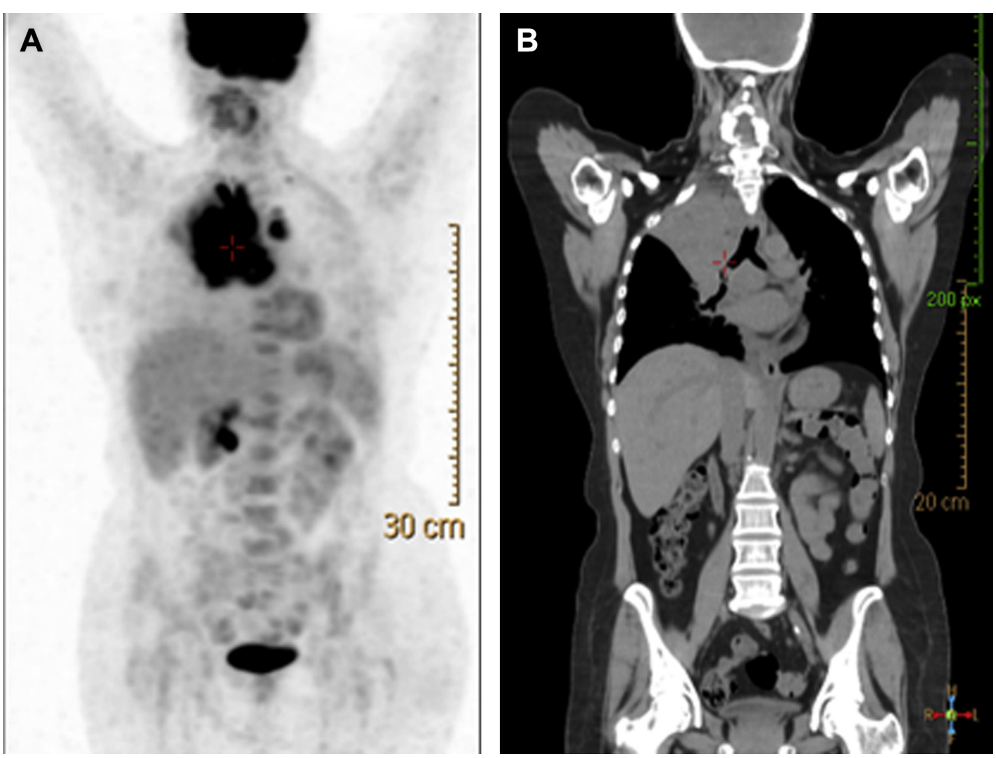

Figure 1 (A, B) Diagnostic positron emission tomography computed tomography scan before initiation of chemotherapy.

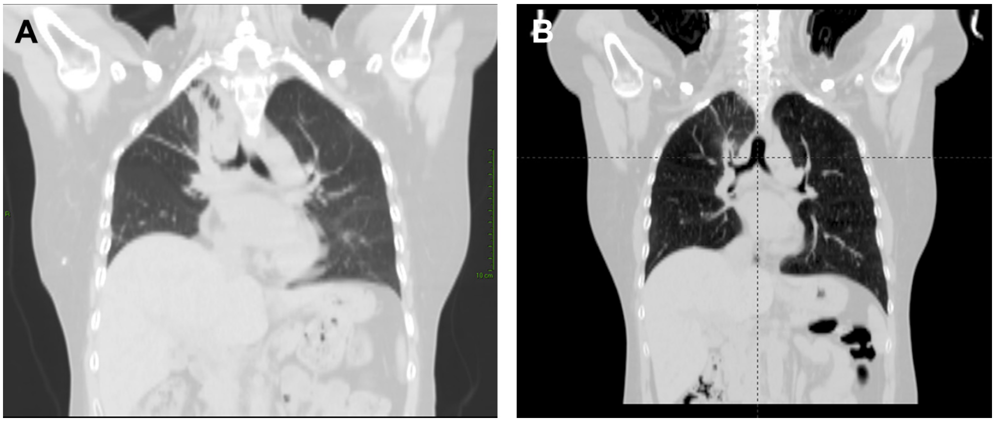

Figure 2 (A) Planning computed tomography (CT) scan without continuous positive airway pressure (CPAP). (B) Planning CT scan with CPAP.

complaining of sweating, coughing, and shortness of breath. Chest x- ray and CT scans showed an RUL mass, atelectasis, mediastinal widening, and a right-sided pleural effusion. Positron emission tomography (PET)-CT scan (Fig 1A,B) showed disease limited to the thorax. Contrast enhanced CT of the brain was normal. Bronchoscopy showed extrinsic compression and infiltration of the RUL and the right middle lobe bronchi. Bronchoscopic biopsy showed small cell lung cancer. Thoracentesis showed no malignant cells in pleural fluid. Systemic treatment was initiated with cis-platinum and etoposide. She developed acute renal failure after 2 cycles. After recovery, 2 cycles of carbo-platinum and etoposide were given.

The patient was referred for outpatient RT. She complained of persistent cough and dyspnea on exertion. She continued to smoke. Physical examination showed a thin woman in no respiratory distress. Vital signs were normal. Breath sounds were absent in the right upper and midchest. The liver and spleen were not palpable. The extremities were without edema. The prescribed dose was 60 Gy specified as 95% dose to 95% of the planning target volume. The initial planning CT (Fig 2A) showed partial reduction in the RUL mass and persistent RUL atelectasis. The total lung volume was 2170 mL. Mean lung dose (MLD), V5, and V20 were 20.5 Gy, 51.8%, and 34.8%, respectively. The patient was offered participation on an Institutional Ethics Committee–approved trial to evaluate CPAP for improving RT delivery by reducing respiratory motion. Resolution of atelectasis was not an indication for participation. After obtaining informed consent, CPAP training began within the RT department before CT simulation by administering CPAP for 1 hour at 15 cm H_2O.[6] After 30 minutes, she complained of vertigo, headache, and weakness and refused further training or CT simulation. The next day, she reported less dyspnea. She returned in 1 week and completed CPAP training and CT simulation without difficulty. CT simulation with CPAP (Fig 2B) showed reexpansion of the RUL. Table 1 shows that with use of CPAP total lung volume increased 74% to 3,767 mL, GTV, CTV and planning target volume decreased 46%, 45%, and 38%, respectively. Figure 3 shows a dose-volume histogram comparing dose with tumor and normal structures with and without CPAP. MLD and mean heart dose decreased 20% and 51%, respectively.

CPAP was used daily with the same technique as used during simulation: for 1 hour before and during treatment. Figure 4 shows a cone beam CT image from day 11 demonstrating that the RUL remained inflated throughout treatment.

After the 11th treatment, the patient began complaining of headaches, weakness, and confusion. A magnetic resonance imaging scan of the brain suggested leptomeningeal disease. Chest RT was discontinued, and RT to the cranial contents were started. She died 8 weeks posttreatment.

Table 1 Size of planning structures and dose to normal organs with and without CPAP

Parameters	FB	CPAP	Δ	%
GTV (mL)	388	209	−179	−46
CTV (mL)	605	331	−275	−45
PTV (mL)	902	560	−342	−38
Lung volume (mL)	2170	3767	1597	+74
Mean lung dose (Gy)	20.5	16.3	−4	−20
V5 (%)	51.8	43.9	−8	−15
V20 (%)	34.8	27.4	−7	−21
Heart volume (mL)	510	515	5	+1
Mean heart dose (Gy)	16.4	8.0	−8	−51
V10 (%)	37.7	21.0	−17	−44
V20 (%)	28.3	10.6	−18	−62
V30 (%)	21.5	7.1	−14	−67
Mean spine dose (Gy)	18.5	12.7	−6	−31
Mean esophagus dose (Gy)	37.7	31.1	−7	−17

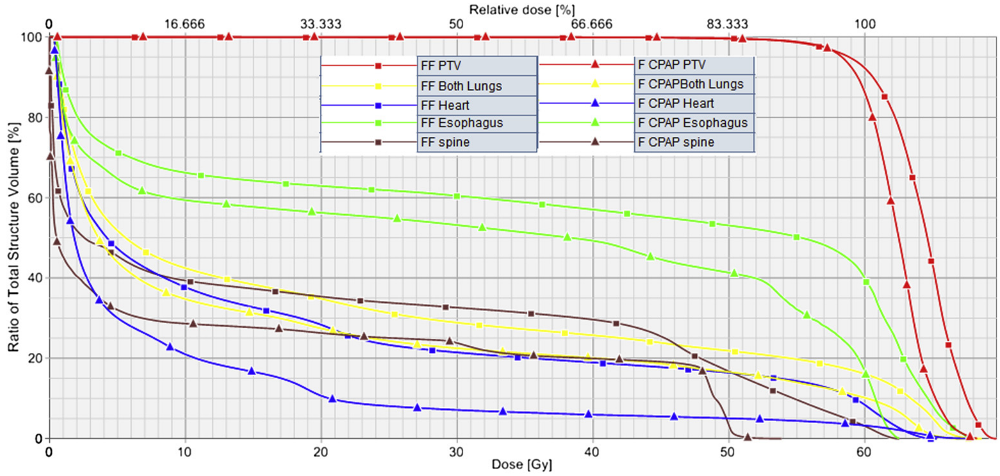

Figure 3 Dose volume histogram showing doses with and without continuous positive airway pressure.

Discussion

To the best of our knowledge, this is the first reported case describing use of CPAP for reexpansion of obstructive atelectasis from malignancy before RT. CPAP has been long used as a treatment for sleep apnea and more recently as a prophylactic therapy and treatment for postoperative atelectasis.[7] In this case, the intent of CPAP was to reduce respiratory motion and preserve normal lung function. Reexpansion of the RUL atelectasis was an unexpected benefit that persisted throughout the course of RT.

When atelectasis is present, functional imaging studies such as PET-CT provide improved discrimination between collapsed lung and tumor and are useful for planning RT.[8] However, use of PET-CT in treatment planning is often limited because studies obtained before developing atelectasis may not provide an accurate representation of the tumor location once atelectasis occurs. Scans obtained when atelectasis is present may lose usefulness as the atelectatic lung reexpands. Furthermore, there may be insufficient time to obtain PET-CT imaging before initiating RT in patients who present with rapid onset of symptoms.[5]

Recently, our group reported reduced tumor motion and expanded lung volumes in patients who received stereotactic body RT with CPAP.[6] The improvements observed in this case were largely consistent with our earlier findings, which showed an increase in total lung volume and decrease in dose to the lung and heart.[6] Although CPAP had no effect on GTV in our earlier study, in this case report, GTV was reduced by 46% because of reexpansion of the lung and improved identification of tumor for contouring.[6] The decreases in lung V5, V20, and MLD with CPAP were less than expected because some of the reexpanded lung was irradiated. The decrease in heart dose was substantial because depression of the diaphragm repositioned the heart out of the path of the radiation beam.

Reexpansion of atelectasis with chemotherapy alone is uncommon and lung reexpansion often occurs only after RT is added to the therapeutic plan.[9] In this case, the reduction in tumor volume from the first 4 cycles of chemotherapy contributed to the rapid lung reexpansion and resolution of atelectasis caused by the use of CPAP. Because this patient received no additional chemotherapy

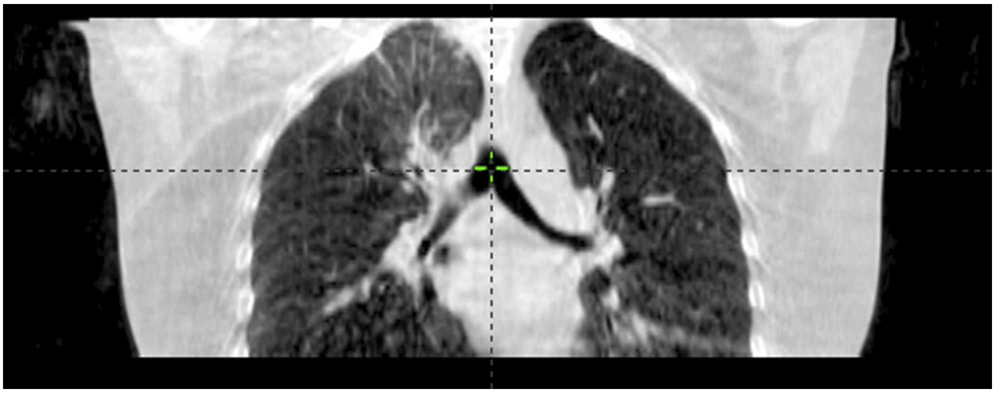

Figure 4 Cone beam computed tomography scan showing persistent lung expansion during course of treatment.

between simulations, the vertigo, headaches, and weakness the patient described during the first use of CPAP may have been caused by lung reexpansion. However, use of CPAP may also have caused a transient early occurrence of symptoms from the leptomeningeal disease that presented soon after starting RT. However, the absence of symptom recurrence during subsequent CPAP use suggests that these initial symptoms were due to lung reexpansion rather than leptomeningeal tumor.

Because a 4-dimensional scan was not obtained during the initial simulation, we were unable to fully assess the reduction in respiratory motion caused by use of CPAP. A 4-dimensional scan was obtained during the simulation with CPAP and showed negligible tumor motion and was not used for planning. Because our experience with CPAP is limited, we are unable to offer guidelines for selection of patients with atelectasis most likely to benefit from treatment with CPAP. Also, we do not know if longer duration or repeated use of CPAP may prove to be effective in patients who are refractory to initial use of CPAP treatment. The use of CPAP to facilitate reexpansion of atelectasis does not replace other available therapeutic options. Instead, CPAP is an additional therapeutic option to consider that may facilitate lung reexpansion before initiation of RT. Further study is suggested to better define appropriate patient selection and optimize the use of this technique.

Conclusion

The use of CPAP caused reexpansion of atelectasis resulting from malignant bronchial obstruction. Lung reexpansion improved treatment planning by allowing for better identification and targeting of the obstructing lesion, sparing of normal lung tissue from radiation exposure, and reducing the need for replanning treatment. Further study to assess the use of CPAP for reexpansion of atelectasis resulting from malignant bronchial obstruction is indicated.

References

1. Vaaler AK, Forrester JM, Lesar M, et al. Obstructive atelectasis in patients with small cell lung cancer. Incidence and response to treatment. *Chest*. 1997;111:115-120.
2. Christian E, Adamietz IA, Willich N, et al. Radiotherapy in oncological emergencies—final results of a patterns of care study in Germany, Austria and Switzerland. *Acta Oncol*. 2008;47:81-89.
3. Canak V, Zaric B, Milovancev A, et al. Combination of interventional pulmonology techniques (Nd:YAG laser resection and brachytherapy) with external beam radiotherapy in the treatment of lung cancer patients with Karnofsky Index < or =50. *J BUON*. 2006;11:447-456.
4. Zhikai Z, Lizhi N, Liang Z, et al. Treatment of central type lung cancer by combined cryotherapy: Experiences of 47 patients. *Cryobiology*. 2013;67:225-229.
5. Bradley J, Thorstad WL, Mutic S, et al. Impact of FDG-PET on radiation therapy volume delineation in non-small-cell lung cancer. *Int J Radiat Oncol Biol Phys*. 2004;59:78-86.
6. Goldstein JD, Lawrence YR, Appel S, et al. Continuous positive airway pressure for motion management in stereotactic body radiation therapy to the lung: A controlled pilot study. *Int J Radiat Oncol Biol Phys*. 2015;93:391-399.
7. Ferreyra GP, Baussano I, Squadrone V, et al. Continuous positive airway pressure for treatment of respiratory complications after abdominal surgery: A systematic review and meta-analysis. *Ann Surg*. 2008;247:617-626.
8. Nestle U, Walter K, Schmidt S, et al. 18F-deoxyglucose positron emission tomography (FDG-PET) for the planning of radiotherapy in lung cancer: High impact in patients with atelectasis. *Int J Radiat Oncol Biol Phys*. 1999;44:593-597.
9. Higginson DS, Chen RC, Morris DE, et al. Predicting the need for palliative thoracic radiation after first-line chemotherapy for advanced nonsmall cell lung carcinoma. *Cancer*. 2012;118:2744-2751.