Robotic Brachytherapy Techniques for Lung Cancer

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Introduction

Early stage non-small cell lung cancer (NSCLC) is best treated by definitive surgical resection. Lobectomy is traditionally recommended for even small peripheral tumors as wedge resections have an increased risk of recurrence.[1] Various degrees of surgical resection in combination with external, intraluminal and interstitial radiation for palliative treatment have evolved over the last few decades. The use of limited resection with concurrent radiation techniques has shown promising results in a subset of NSCLC patients with limited cardiopulmonary reserve who would not have tolerated complete resection.[2]

Expanded indications for the application of brachytherapy in patients with early stage lung cancer require improved methods of localized resection and tailored delivery of implantable radiation therapy. Surgical robotics offers enhanced visualization and facilitated intracorporeal dexterity over traditional video-assisted thoracoscopic instruments. We hypothesized that robotic seed placement when performed in conjunction with a minimally invasive resection might allow for localized treatment with the potential for more accurate and therefore higher directed dosing to potentially limit excessive collateral damage to healthy tissue.

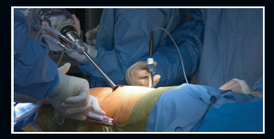
Methods

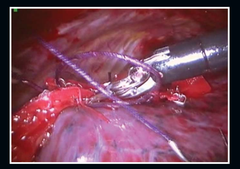
Using the da Vinci Surgical System and our previously reported technique developed in animal models [3], two patients aged 81 and 78 underwent robotic brachytherapy seed placement. Patients presented with clinical T1N0 stage IA NSCLC of the peripheral left lung in the setting of multiple medical comorbidities including reduced exercise performance, severe interstitial lung disease, previous contralateral lobectomy and cardiac dysfunction. Lesions were confirmed with FNA biopsy and metastases were ruled out with PET/CT scanning.

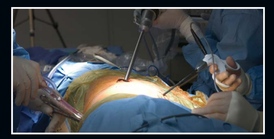
A thoracoscopic wedge resection was performed with serial applications of a Ethicon EndoGIA stapler. Resection edges were butressed with bovine pericardium. Robotic intracorporeal suturing of I-125 radiation seeds was performed. Source strength averaged 0.6mCi per seed and was designed to give a dose of 14,400 cGy at 1 cm from the plane of the implant delivered over nine months [5 half-lives]. Radiation seeds were sutured in place using either a spiral or longitudinal geometric configuration.

Left: Seeds are part of the Rigid Absorbable Permanent Implant Device (RAPID Strand™; Amersham Health) product line that consists of welded titanium capsules containing I-125 absorbed onto a silver rod and spaced 1cm apart on a polyglactin 910 suture.

Right: CT guided needle biopsy of a lung mass in patient 1 is shown. Both patients suffered from extensive medical comorbidities and T1N0 Stage IA NSCLC of the left lung.

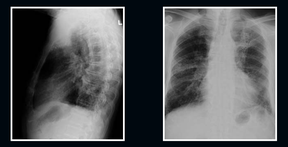






Left: Port placement and video-assisted wedge resection are shown in each of the two patients. Middle: Robot is positioned posterior to the patient, aligning the robotic arms to use the same incisions as the thoracoscopic resection. Right: Robotic arms are shown suturing brachytherapy seeds to the buttressed stapled line in a spiral fashion.

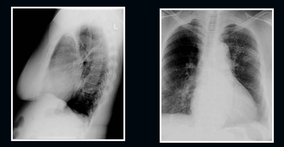
Patient 1: Spiral Technique of Seed Placement



Top: PA and lateral chest xrays demonstrate spiral seed stability at 6 month follow-up.

Left: Strands of spiral seeds can be seen around the staple line on chest xray.

Patient 2: Longitudinal Technique of Seed Placement



Top: Positional stability of longitudinal technique is confirmed in these two xrays performed 6 months post-operatively.

Left: Longitudinal strands of seeds encircle the resection margin.

Results

Patients underwent uncomplicated wedge resections of their primary tumor with surgical margins negative for carcinoma. Anesthesia time averaged 239 minutes and total surgical time averaged 162 minutes. In the first patient, a total of 20 seeds were placed in a spiral technique at a depth of 1.0 cm in two separate strands. The second patient had a total of 17 seeds in two strands placed longitudinally around the resection line at a distance of approximately 1.0 cm. There were no complications and post-operative courses were uneventful. CT scanning on both patients 6 months post-procedure demonstrated seed position stability and lack of tumor recurrence.

Conclusion

The goal of therapy for patients with lung cancer who have significant risk factors and/or poor performance status is two-fold: 1. Complete resection of the primary lesion through a minimally invasive approach. 2. Delivery of radiation that would achieve the highest tumoricidal dose with the least collateral damage to the surrounding lung parenchyma. The intracorporeal dexterity of the robotic system allows accurate and specific configurations of seed placement, limiting excessive collateral damage to healthy tissue.

Clinical Implications

Robotic surgical techniques now offer the ability to deliver precise brachytherapy through a minimally invasive surgical approach for selected patients with limited pulmonary reserve and significant comorbidities. Tailored application of brachytherapy in specific geometric patterns is now part of the treatment armentarium for high risk lung cancer patients. The use of robotic technology is now part of the evolution in the treatment of lung cancer at our institution.

Bibliography

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