Radiation Therapy for Lung Cancer

A Deeper Look at External Beam Radiation Planning Techniques

CARTA HEALTHCARE

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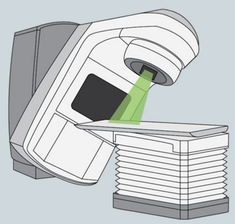
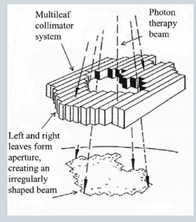
3D Conformal

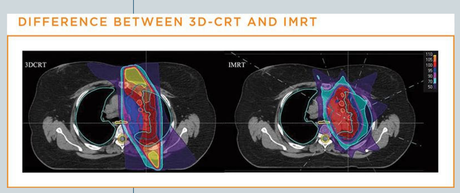
- 3-dimensional conformal radiation therapy (3D CRT) uses a computer to create a 3-dimensional picture of the tumor. Radiation is then directed in multiple X-ray beams at the unique shape and location of each tumor.
  - This allows doctors to give the highest possible dose of radiation to the tumor, while sparing the normal tissue as much as possible.
- 3D CRT decreases the treatment margins and minimizes the volume of normal tissue receiving a clinically significant radiation dose.
- Because 3D CRT allows for a high level of precision and accuracy in the delivery of radiation treatment, it may be recommended for addressing tumors that are shaped irregularly or that are positioned close to healthy/vital organs or tissue

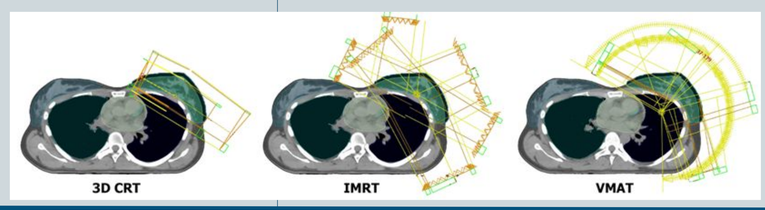
Code	Label	Definition
04	Conformal or 3-D conformal therapy	An external beam planning technique using multiple, fixed beams shaped to conform to a defined target volume. Should be clearly described as conformal or 3-D therapy in patient record.



Shape of the tumor







IMRT

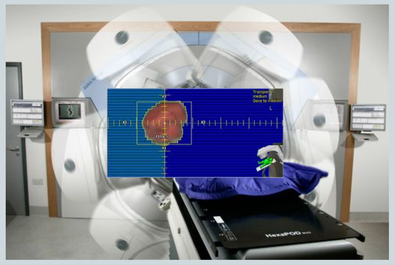
- Intensity-modulated radiation therapy (IMRT): IMRT is a type of conformal radiotherapy.
- IMRT or VMAT is believed to be more effective than 3D-CRT in target coverage, dose homogeneity, and reducing toxicity to normal organs
- IMRT uses coordinates of the tumor from the imaging to program a machine that can then deliver, from multiple angles, precisely shaped and higher doses of radiation to the tumor and lower doses to the surrounding normal, healthy tissue.
  - Because it is so precise, IMRT is an especially useful technique for use when a tumor is situated near a vital structure, such as the spine
- IMRT requires specialized equipment and highly trained personnel, and the planning and delivery of the therapy can be time-consuming and complex.
  - Some studies have shown that NPC patients receiving IMRT treatment can achieve local control and overall survival more than 90% and 80%, respectively
- IMRT has slightly better conformity and homogeneity with lower doses to normal tissue and MUs and treatment times compared to 3D-CRT. Lower MUs reduce the risk of secondary malignancies

Code	Label	Definition
05	Intensity modulated therapy	An external beam planning technique where the shape or energy of beams is optimized using software algorithms. Any external beam modality can be modulated but these generally refer to photon or proton beams. Intensity modulated therapy can be described as intensity modulated radiation therapy (IMRT), intensity modulated x-ray or proton therapy (IMXT/IMPT), volumetric arc therapy (VMAT) and other ways. If a treatment is described as IMRT with online re-optimization/re-planning, then it should be categorized as online re-optimization or re-planning

SBRT

- Stereotactic body radiation therapy (SBRT) is a technique that utilizes precisely targeted radiation to a tumor while minimizing radiation to adjacent normal tissue. This targeting allows treatment of small- or moderate-sized tumors in either a single or limited number of dose fractions
- Stereotactic body radiation therapy (SBRT): SBRT, also called stereotactic ablative radiotherapy (SABR), combines image-guided radiation therapy (IGRT) with even more advanced techniques to precisely deliver extremely high doses of radiation to the tumor while decreasing the dose to normal, healthy tissue nearby.
- Instead of giving small doses of radiation each day for several weeks, SBRT can be given in two to five treatments. When the treatment is delivered in only one session, it is referred to as stereotactic radiosurgery (SRS).
- In lung cancer, SBRT is most often used to treat early-stage NSCLC when the patient's health does not allow surgery or the patient does not want surgery. It can be used for tumors small in size (5 cm or less). It may also be used if an NSCLC patient has limited metastases

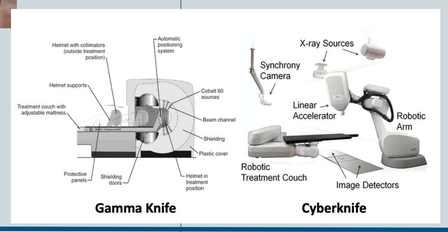
Code	Label	Definition
06	Stereotactic radiotherapy or radiosurgery, NOS	Treatment planning using stereotactic radiotherapy/radiosurgery techniques, but the treatment is not described as Cyberknife® or Gamma Knife®. These approaches are sometimes described as SBRT (stereotactic body radiation), SABR (stereotactic ablative radiation), SRS (stereotactic radiosurgery), or SRT (stereotactic radiotherapy). If the treatment is described as robotic radiotherapy (e.g. Cyberknife®) or Gamma Knife®, use stereotactic radiotherapy subcodes below. If a treatment is described as stereotactic radiotherapy or radiosurgery with online re-optimization/replanning, then it should be categorized as online re-optimization or re-planning.



Gamma Knife

- Gamma Knife radiosurgery (stereotactic radiosurgery) is a technology that uses radiation from 192 cobalt-60 radiation sources to deliver a single, large dose of radiation to a specific target in the lungs with surgical precision. The radiation reacts on a molecular level with the cancer cells and stops their reproduction, killing the cancer
  - After a treatment session, the tumor will shrink slowly over the next few weeks or months.
- The combination of Gamma Knife radiosurgery (GKRS) and systemic immunotherapy (IT) or targeted therapy (TT) is a novel treatment method for brain metastases (BMs) **in non-small cell lung cancer (NSCLC)**
  - There are no incisions, which means patients are unlikely to get an infection
  - The process is completed in two to five days and does not require a lengthy stay in the hospital, which also keeps costs down
  - The recovery period is very quick. Patients can return to their ordinary routines the following day if they wish.
  - No healthy tissues are touched or harmed

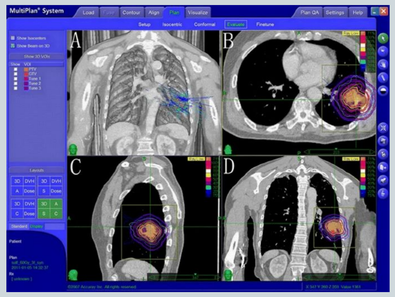
Code	Label	Definition
08	Stereotactic radiotherapy or radiosurgery, Gamma Knife®	Treatment planning using stereotactic radiotherapy/radiosurgery techniques which uses a Cobalt-60 gamma ray source and is specifically described as Gamma Knife®. This is most commonly used for treatments in the brain.



Cyberknife

- CyberKnife is a noninvasive way to treat lung cancer in 5 treatments or less. The CyberKnife robotic radiosurgery system incorporates Synchrony tracking technology adjusting for movement of the tumor that occurs during breathing.
- During treatment, the CyberKnife System's computer-controlled robot will move around your body to various locations from which it will deliver radiation. At each pre-defined position, it will stop to precisely deliver the dose while correlating your breathing motion with the tumor position.
- Cyberknife Radiation treatment is non-surgical and non-invasive offering good cancer control and significantly reduced incidence of common side effects such as shortness of breath, swallowing difficulties or a sore throat
- Treatments are typically completed in as little as 3 to 4 sessions across 1 to 2 weeks and most patients can continue normal activity throughout treatment

Code	Label	Definition
07	Stereotactic radiotherapy or radiosurgery, robotic.	Treatment planning using stereotactic radiotherapy/radiosurgery techniques which is specifically described as robotic (e.g. Cyberknife®).



Case Scenarios By Radiation Type

History of Present Illness: [redacted] 71-year-old male who had an abnormal CT lung screening. CT lung screening 8/21/23 showed a new suspicious 11 mm spiculated right upper lobe nodule. Other pulmonary nodules were stable. Mild prominent mediastinal nodes were unchanged. PET/CT on 9/22/23 showed FDG avid 11 mm right upper lobe pulmonary nodule, max SUV 4.75. No metastasis in the neck, chest, abdomen or pelvis. Focal activity at the base of the right trochanter medially was likely reactive. PFTs on 10/5/23 showed an FEV1 of 2.7 liters. Body CT on 10/16/23 showed slight interval enlargement of the nodule in the medial right upper lobe now 14 x 10 mm. EBUS on 10/16/23 showed the right upper lobe was positive for small cell carcinoma. The 11L, 4 L, 11 R nodes were negative. Brain MRI on 11/9/23 was negative. Patient saw Dr. Chen who discussed surgery followed by chemotherapy versus chemotherapy and radiation. The patient clearly favors chemotherapy and radiation over surgery. The patient has a ventral hernia and is scheduled for surgery on 12/1/23 but will delay this to begin treatment for his small cell lung cancer. He denies weight loss. Dr. Chen began concurrent Carbo/etoposide chemotherapy. Patient has a h/o smoking and had recently quit. He was seen in consult and began EBRT to the RUL nodule.

Region Treated:

Treatment Site	Energy	Dose/Fx (cGy)	#Fx	Dose Correction (cGy)	Total Dose (cGy)	Start Date	End Date	Elapsed Days
RUL Lung	6X	200	35 / 35	0	7,000	11/14/2023	1/5/2024	52
Technique:	3D CRT oblique fields using electronic compensators							
Total:					**7,000**	11/14/2023	1/5/2024	52

Response to Treatment: He tolerated radiation with complaint of mild fatigue relieved with rest. He complained of sore throat and sinus congestion and was started on 7 days of antibiotic by his PCP. He denied dysphagia. His weight remained stable at 224 lbs.

[redacted]

History of Present Illness: [redacted] 70-year-old female who presented with an abnormal screening CT. Lung CT screening 4/28/23 showed persistent central endobronchial and peribronchial nodularity in the right lower lobe. Numerous additional subsegmental endobronchial nodules were concerning for a more central partially obstructing lesion. PFT's on 6/6/23 showed a FEV1 of 1.89 liters. PET/CT 6/7/23 showed focal increased tracer uptake at the posterior right hilum. Elsewhere there was mild FDG tracer activity symmetrically in the hila and lower mediastinum; typical benign reactive lymph nodes. No abnormal FDG tracer uptake associated with the lungs, including the right infrahilar nodularity. No evidence of distant metastasis. EBUS on 6/14/23 showed the R4, station 7, R11 and right lower lobe were negative for malignancy. Brain MRI 7/31/23 was negative. Bronchoscopy with right lower lobe biopsy on 7/19/23 was positive for squamous cell carcinoma. Right lower/middle lobectomy on 8/26/23 showed 2.8 cm squamous cell carcinoma in the right lower lobe with positive margins. Station 7, R10, R11 (1/3 nodes), and 2/3 nodes in the right lower lobectomy specimen were positive (5 of 10 positive nodes). Tumor is 0.5 cm from the stapled bronchial margin and 0.1-0.2 cm from the raw hilar parenchyma margin. Pleura immediately inferior to the hilum were mildly roughened and palpably indurated.
Dr. Chen recommended 4 cycles of Carbo/Taxol. She had a severe Taxol reaction and was switched to Carbo/Gemzar for the remaining 3 cycles, completed on 11/21/23. She had a right hand tremor and a brain MRI on 11/17/23 was negative. She has a h/o smoking. She was seen in consult and began radiation to her right lung and mediastinum.

Region Treated:

Treatment Site	Energy	Dose/Fx (cGy)	#Fx	Dose Correction (cGy)	Total Dose (cGy)	Start Date	End Date	Elapsed Days
Mediastinum Lung	6X	180	33 / 33	0	**5,940**	12/12/2023	1/29/2024	48
Technique:	VMAT 2 Partial Arcs							
Total:					**5,940**	12/12/2023	1/29/2024	48

Response to Treatment: She tolerated radiation with c/o intermittent, shooting pain in left bicep, "8/10." She complained of worsening shortness of breath and nonproductive cough. A C-Xray on 1/22/24 showed a persistent moderate right pleural effusion and opacification of the right lung base, that was not significantly changed. Stable mediastinal shift to the right. She complained of palpitations and chest heaviness. She saw her PCP on 1/26/24 and was prescribed guaifenesin-

Diagnosis: C78.00 - H/o pT3 pN1b adenocarcinoma of the colon s/p colectomy in November 2020 followed by FOLFOX x 12. She had a liver metastasis and is s/p resection on 12/20/22. She now has a solitary right lower lobe lung metastasis.

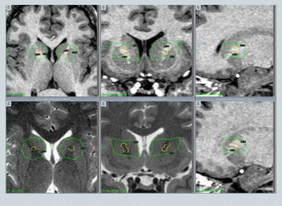
History of Present Illness: [redacted] a 67-year-old female who presented in 2020 with severe abdominal pain. CT A/P 11/24/20 showed a 2 cm mass in the mid transverse colon. CEA was 9.6. Exploratory lap with right hemicolectomy on 11/25/20 showed a 3.8 x 3.2 x 0.7 cm adenocarcinoma, moderately differentiated with invasion of muscularis into the pericolonic fat. Margins free. 2/44 nodes were positive. MSI stable. She received 12 cycles of FOLFOX from 1/20/21- 6/25/21. Signatera began rising and PET/CT on 10/29/22 showed a solitary right hepatic metastasis. MRI of the abdomen 11/12/22 showed persistent right hepatic mass. Partial hepatectomy on 12/13/22 was consistent with a 4.8 cm colon adenocarcinoma. KRAS G12 D mutation detected, HER2/neu negative by FISH. Tumor board recommendation was for observation if Signatera was negative. Body CT on 9/1/23 showed enlarging right lower lobe lung nodule now 7 x 5 mm, previously 5 mm. Right lower lung CT biopsy on 11/3/23 was positive for metastatic colon cancer. PET/CT on 11/30/23 showed mildly hypermetabolic pulmonary nodule in the right lower lobe. No evidence of other metastatic disease. Patient was discussed at tumor board and recommendation was for SBRT vs surgery vs palliative systemic therapy. The patient opted for SBRT. Signatera on 4/21/2023 was 0 and CEA was 10.9. Patient was seen in consult and began SBRT to RLL lung metastasis.

Region Treated:

Treatment Site	Energy	Dose/Fx (cGy)	#Fx	Dose Correction (cGy)	Total Dose (cGy)	Start Date	End Date	Elapsed Days
RLL Lung	6X-FFF	1,030	5 / 5	0	5,150	1/9/2024	1/24/2024	15
Technique:	VMAT 2 Partial Arcs							
Total:					**5,150**	1/9/2024	1/24/2024	15

Response to Treatment: She tolerated radiation without complaint.

Recommendation: She returns in follow up on 2/22/24.



Treatment planning for bilateral Gamma Knife Brain treatment, using axial, coronal, and sagittal images.
Gamma Knife Targeted with two 4-mm isocenters and the maximal radiation dose of 120 Gy.

Yellow lines define the dose distribution areas for 10 Gy 84 Gy and green lines define the dose distribution areas for 10 Gy

Primary Cancer	Treatment Site	Energy	# Fx	Total Dose (Gy)	Days to Complete Treatment
Non-Small Cell Lung Cancer	Brain	GammaKnife	1	15-20 Gy	1

	CyberKnife
Daily Dose	5-20 GY/ Fraction
Number of Treatments	3-5 Days
Accuracy (Tissue Margin)	1-5 Millimeters
Number of Radiation Beams	100-200+ Beams
Continous Correction for Breathing and Movement	Yes

STORE MANUAL Radiation Treatment Coding

Phase I-II-III Radiation Primary Treatment Volume
Code - Lung

Phase I-II-III Radiation to Draining Lymph Nodes
Code 02- Thoracic Lymph node region

Phase I-II-III Radiation Treatment Modality
Code 02- External beam, Photons

Phase I-II-III External Beam Radiation Planning Technique
Code Specific treatment used
3D, IMRT, SBRT, GammaKnife, CyberKnife

Phase I-II-III Dose per Fraction
Code dose in cGy for each fx

Phase I-II-III Number of Fractions
Code specific number of fractions
Can range from 1-35 fx

Phase I-II-III Total Dose
Code Total dose in cGy
The sum of total fx dose
Dose is dependent on treatment prescribed and tumor specifics