CT Perfusion Imaging to Assess Treatment Response in Lung Cancer

Friedrich D. Knollmann, MD, PhD

Goals of tumor imaging

- Detect a tumor
- Determine tumor type
- Stage tumor spread
- Plan treatment
- Determine response to treatment
- Restage
- Detect tumor recurrence or metastatic disease

Overview

- Why another tool to determine treatment response?
- Challenges to CT perfusion imaging in lung cancer
- Solutions

Response evaluation criteria in solid tumors (RECIST)

- Devised for the clinical evaluation of cancer therapeutics
- Originally focused on clinical trials (phase II and III)
- Adopted by many investigators, cooperative groups, industry, and government authorities
- Used as a surrogate for overall survival
- Many oncologists use RECIST guidelines for clinical decision making
- ACR: Values lies not in a report, but in meaningful and actionable information that improves care

Response Evaluation Criteria in Solid Tumors (RECIST) Guidelines

J Natl Cancer Inst 2000 92:205-16

- Complete response (CR) – disappearance of all target lesions
- Partial response (PR) – 30% decrease in the sum of the longest diameter of target lesions
- Progressive disease (PD) – 20% increase in the sum of the longest diameter of target lesions
- Stable disease (SD) – small changes that do not meet above criteria

Response to anti neo angiogenic treatment

Pre: 15 mm
Post: 12 mm
3/15=20%, SD
Survival in Stage III/IV lung cancer by treatment response, according to RECIST, in 100 patients.

Clinical lung cancer, in press

CT Perfusion series of lung cancer

Color coded perfusion map

Reproducibility of perfusion measurements, from two repeated scans

1. Scan – 87 ml/100g/min
2. Scan – 89 ml/100g/min

Tumor perfusion response to chemotherapy: Blood flow

Pre: 218 ml/100g/min Post: 120 ml/100g/min

CTP to assess treatment response in lung cancer: early results

• Significant decrease in NSCLC blood flow after sorafenib and erlotinib, correlates with size response in 23 patients Lind, Eur Radiol 2010 20:2890-8
• Bevacizumab reduces NSCLC perfusion, and responders after 3 cycles had a concurrent decrease in perfusion after one cycle. Tacelli, Eur Radiol 2013 23:2127-36
Challenges in CTP imaging for assessing treatment response in lung cancer

- Dual blood supply of lung cancer (Milne, Am J Roentgenol 1967)
- Respiratory motion
- Anatomic coverage, determined by tumor size
- Temporal resolution
- Radiation dose
- Non-standardized technique/analysis
- Conflicting requirements (Miles, Guidelines, Eur Radiol 2012 22:1430-41)

Tumor blood flow (BF) estimates for different input algorithms (RSNA 2012)

- Blood flow estimates with dual input algorithm higher than with either systemic or pulmonary artery input algorithm
- Systemic algorithm not different from pulmonary artery input algorithm

Comparison of tumor blood flow estimates with different blood supply assumptions

Distribution of pulmonary blood supply fraction (PSF, in % of total tumor blood flow)

Role of respiratory motion

Before motion correction

After motion correction

CTP: Motion correction
UCD CTP protocol

- GE VCT 64 row, 4 cm detector
- Volume shuttle mode, 8 cm z-axis coverage
- Inspiratory breath hold, oxygen priming
- 100 kVp, 85 mAs, 30% ASIR, 0.4 s rotation, DLP 600 mGycm
- 30 cc contrast, 4 cc/s
- Interscan delay 1.6 s (min), 50 s
- 5 mm slices
- Dual input perfusion algorithm (AW Perfusion 4D), BF, BV, MTT
- Motion correction (DEMONS)

CTP to assess treatment response in lung cancer: Conclusions

- CTP is an attractive biomarker in lung cancer
- Directly assesses the mechanism of antiangiogenic treatment
- Challenges include dual blood supply, motion, radiation
dose, temporal and spatial resolution, anatomic
coverage, nonstandardized analysis
- For a valid analysis, use dual artery input algorithm,
motion correction, iterative reconstruction, and wide
anatomic coverage (large detector, volume shuttle
mode)