Radiotherapy and Oncology 127 (2018) 1–5

Contents lists available at ScienceDirect

Radiotherapy and Oncology

journal homepage: www.thegreenjournal.com

ESTRO ACROP guideline

ESTRO ACROP guidelines for target volume definition in the treatment of locally advanced non-small cell lung cancer

Ursula Nestle [a,b,*], Dirk De Ruysscher [c,d], Umberto Ricardi [e], Xavier Geets [f], Jose Belderbos [g], Christoph Pöttgen [h], Rafal Dziadiuszko [i], Stephanie Peeters [c], Yolande Lievens [j], Coen Hurkmans [k], Ben Slotman [l], Sara Ramella [m], Corinne Faivre-Finn [n], Fiona McDonald [o], Farkhad Manapov [p], Paul Martin Putora [q,r], Cécile LePéchoux [s], Paul Van Houtte [t]

[a] Department of Radiation Oncology, Kliniken Maria Hilf, Moenchengladbach; [b] Department of Radiation Oncology, University Hospital Freiburg, Germany; [c] Maastricht University Medical Center, Department of Radiation Oncology (Maastro clinic), GROW School for Oncology and Developmental Biology, The Netherlands; [d] KU Leuven, Radiation Oncology, Belgium; [e] Department of Oncology, University of Turin, Italy; [f] Department of Radiation Oncology, Cliniques universitaires Saint-Luc, MIRO – IREC Lab, UCL, Belgium; [g] Department of Radiation Oncology, The Netherlands Cancer Institute, Amsterdam, The Netherlands; [h] Department of Radiation Oncology, West German Tumor Centre, University of Duisburg-Essen Medical School, Germany; [i] Department of Oncology and Radiotherapy, Medical University of Gdańsk, Poland; [j] Department of Radiation Oncology, Ghent University Hospital, Belgium; [k] Catharina Hospital, Department of Radiation Oncology, Eindhoven; [l] Department of Radiation Oncology, VU University Medical Center, Amsterdam, The Netherlands; [m] Department of Radiation Oncology, Campus Bio-Medico University, Rome, Italy; [n] University of Manchester & The Christie NHS Foundation Trust, Manchester; [o] Department of Radiotherapy, The Royal Marsden NHS Foundation Trust, London, UK; [p] Department of Radiation Oncology, University Hospital, LMU Munich, Germany; [q] Department of Radiation Oncology, Kantonsspital St. Gallen; [r] Medical Faculty, University of Bern, Switzerland; [s] Department of Radiation Oncology, Gustave Roussy Cancer Campus, Villejuif, France; [t] Department Radiation Oncology, Institut Bordet, Université Libre Bruxelles, Belgium

ARTICLE INFO

Article history:
Received 16 February 2018
Received in revised form 22 February 2018
Accepted 22 February 2018
Available online 28 March 2018

Keyword:
NSCLC
Target volumes
Radiotherapy

ABSTRACT

Radiotherapy (RT) plays a major role in the curative treatment of locally advanced non-small cell lung cancer (NSCLC). Therefore, the ACROP committee was asked by the ESTRO to provide recommendations on target volume delineation for standard clinical scenarios in definitive (chemo)radiotherapy (RT) and adjuvant RT for locally advanced NSCLC. The guidelines given here are a result of the evaluation of a structured questionnaire followed by a consensus discussion, voting and writing procedure within the committee. Hence, we provide advice for methods and time-points of diagnostics and imaging before the start of treatment planning and for the mandatory and optional imaging to be used for planning itself. Concerning target volumes, recommendations are given for GTV delineation of primary tumour and lymph nodes followed by issues related to the delineation of CTVs for definitive and adjuvant radiotherapy. In the context of PTV delineation, recommendations about the management of geometric uncertainties and target motion are given. We further provide our opinions on normal tissue delineation and organisational and responsibility questions in the process of target volume delineation. This guideline intends to contribute to the standardisation and optimisation of the process of RT treatment planning for clinical practice and prospective studies.

Radiotherapy (RT) plays a major role in the curative treatment of locally advanced disease, which represent approximately one third of patients diagnosed with non-small cell lung cancer (NSCLC) [1,2]. It therefore accounts for a high workload in most RT departments worldwide and is predicted to further increase in the years to come [3,4]. The ACROP committee provides recommendations for target volume (TV) delineation for standard clinical scenarios in definitive (chemo)RT and adjuvant RT for locally advanced non-small cell lung cancer (NSCLC).

Methodology

All recommendations in this manuscript are the result of the evaluation of a structured questionnaire followed by a consensus discussion and voting procedure within the committee. This resulted in a categorisation of recommendations in four categories: Mandatory (M), Recommended (R), Optional (O) or Discouraged (D). This procedure was followed by a writing process including referencing of relevant published literature, a final discussion and review by committee members.

* Corresponding author at: Kliniken Maria Hilf GmbH, Viersener Str., 41063 Mönchengladbach, Germany.
E-mail address: ursula.nestle@mariahilf.de (U. Nestle).

https://doi.org/10.1016/j.radonc.2018.02.023
0167-8140/

Recommendations

Diagnostics/imaging

In preparation of TV delineation for curative-intent RT or chemo-RT in patients with NSCLC, a diagnostic CT scan with intravenous (IV) iodine contrast (unless contra-indicated) and a diagnostic whole body FDG-PET-CT are considered mandatory (M). The FDG-PET-CT scan should be performed within 3 weeks before start of treatment [5] (R) since PET-CT information may otherwise be outdated with increasing time to treatment [6–8]. In case of sequential chemotherapy followed by definitive RT, it is mandatory to perform FDG-PET-CT scan before induction chemotherapy and repeat a chest CT with IV iodine contrast (unless contra-indicated) after chemotherapy prior to the start of RT (M).

For the diagnosis of nodal involvement, beyond imaging, additional tests should be considered. In case of radiologically enlarged lymph nodes (short axis $\geq$ 1 cm on the CT scan) [9] or lymph nodes with increased focal FDG uptake on FDG-PET-CT, biopsy (histology, cytology) is recommended, if it has impact on TV definition (R). The appropriate method for biopsy of mediastinal lymph nodes is based on their location and options include endobronchial ultrasound (EBUS), oesophageal ultrasound (EUS) or mediastinoscopy; in case of supraclavicular nodes ultrasound-guided biopsy may be used (O).

A diagnostic MRI scan of the chest or sub-regions of interest is optional and should be considered in cases with chest wall infiltration, superior sulcus tumours [10] or para-spinal tumours [11] (O).

Planning-CT scan

At the time of planning, a CT scan in treatment position is mandatory (M) and should include IV iodine contrast (unless contra-indicated) to help delineation of the primary tumour and lymph node TV and the OARs (R). Planning CT scans should have a matrix of typically 512 $\times$ 512 voxels on the axial plane, a slice thickness of 2–3 mm and a longitudinal scan range covering at least from the cricoid to the mid abdomen to ensure the inclusion of the full thoracic cavity (M).

An assessment of respiratory motion on a respiratory-correlated 4D-CT scan is recommended (R). The reconstructed 8 to 10 equally distributed temporal phases of the 4D-CT are used for motion quantification purposes. To facilitate RT treatment planning, several image reconstruction techniques can be used (O) to generate a 3D data set to be used for dose calculation that incorporates the patient's specific tumour motion such as the Maximum Intensity Projection (MIP) which is applicable to more peripherally located primary tumours and displays the highest density value pixels throughout the respiratory cycle, the Mid-Ventilation (MidV) scan which corresponds to the CT scan phase closest to the time-weighted mean tumour position, or Mid-Position (MidP) technique where the tumour is represented at its exact time-weighted mean position.

An active breathing coordinator (ABC) system, e.g. with audio-visual feedback, may optionally be used to further regularize the breathing frequency and amplitude and reduce reconstruction artefacts in the 4D data set [12] (O). A 3D CT can be omitted if the Mid-Ventilation or Mid-Position CT derived from the 4D-CT is primarily used for TV and OAR delineation.

Additional imaging for RT planning

A specific planning-PET-CT scan is recommended and should be done preferably in planning position (R). A planning MRI in treatment position is optional for specific tumour indications (O). Additional imaging should only be matched with the planning-CT in the treatment planning system, if acquired in planning position (M). Before the start of delineation, the quality of the co-registration should be checked under the responsibility of the radiation oncologist and/or physicist. To avoid incorrect contouring due to wrong co-registration, additional imaging datasets not acquired in planning position should not be co-registered in the TPS but viewed side by side for selection of pathologic structures (R).

A 4D PET-CT in treatment position is optional [13] (O). It may improve sensitivity of nodal identification and provide additional valuable information to help distinguish between tumour extent and adjacent tissues (atelectasis, diaphragm). It may therefore in selected cases help to avoid geographic misses and furthermore improve consistency in the delineation between observers [13,14].

Gross tumour volume (GTV)

GTV delineation on the planning-CT is mandatory (M). The GTV of the primary tumour and GTV of the lymph node(s) should be drawn separately, if anatomically distinguishable (R). The pre-set lung window setting (W = 1600 and L = −600) should be used to delineate tumours surrounded by lung tissue while the mediastinum pre-set window setting (W = 400 and L = 20) should be used to delineate lymph nodes and primary tumours invading the mediastinum or chest wall (R) [9]. Delineation of the GTV based on both recent CT and FDG-PET information is recommended (R). Regions of atelectasis visible on the CT image beyond the edge of the increased FDG uptake may be excluded from the GTV (O) [5].

GTV of the primary tumour post induction chemotherapy should be based on current CT imaging, however pre-chemotherapy imaging (including PET-CT) should be considered (R). GTV of the lymph nodes should include all involved lymph nodes or lymph node stations based on pre-chemotherapy clinical, pathological and imaging information, even if a node has completely disappeared in imaging (M).

Lymph nodes which are proven malignant by biopsy or considered pathological on PET (focal accumulation above blood pool) are delineated as GTV [15]. With respect to the inter-observer variation of reporting FDG-positive mediastinal nodes, in case of diagnostic uncertainty, a node should rather be included than excluded in the GTV [16,17]. Lymph nodes that are FDG-PET-positive and EBUS/EUS-negative should be included in the GTV as the false negative rates of EBUS/EUS are high (Fig. 1) [16]. PET positive nodes may only be omitted, if there is clear non-malignant biopsy explanation for the FDG positivity [16,18] or if a mediastinoscopy has been performed showing no malignant cells in the lymph node. When delineating nodal stations, the TNM Atlas 8th edition should be used as a basis for lymph node region definition (R), ideally using three-dimensionally illustrated anatomical atlases [19].

Clinical target volume (CTV)

CTV of the primary tumour should be created by expansion from the GTV by e.g. 5–8 mm [20] and should be manually edited accounting for surrounding anatomy, e.g. natural barriers such as bones or heart [21,22] (M).

CTV of the lymph nodes should be created (M) and there are two options:

Option 1 (lymph node stations): inclusion of the whole pathologically affected lymph node station (Fig. 2) including at least a 5–8 mm margin around the GTV. This option has been used in large multicentre trials without unacceptable out-field mediastinal recurrence rates [23].

Option 2 (geometric expansion): geometric expansion of nodal GTV to CTV in analogy to the primary tumour (5–8 mm). This

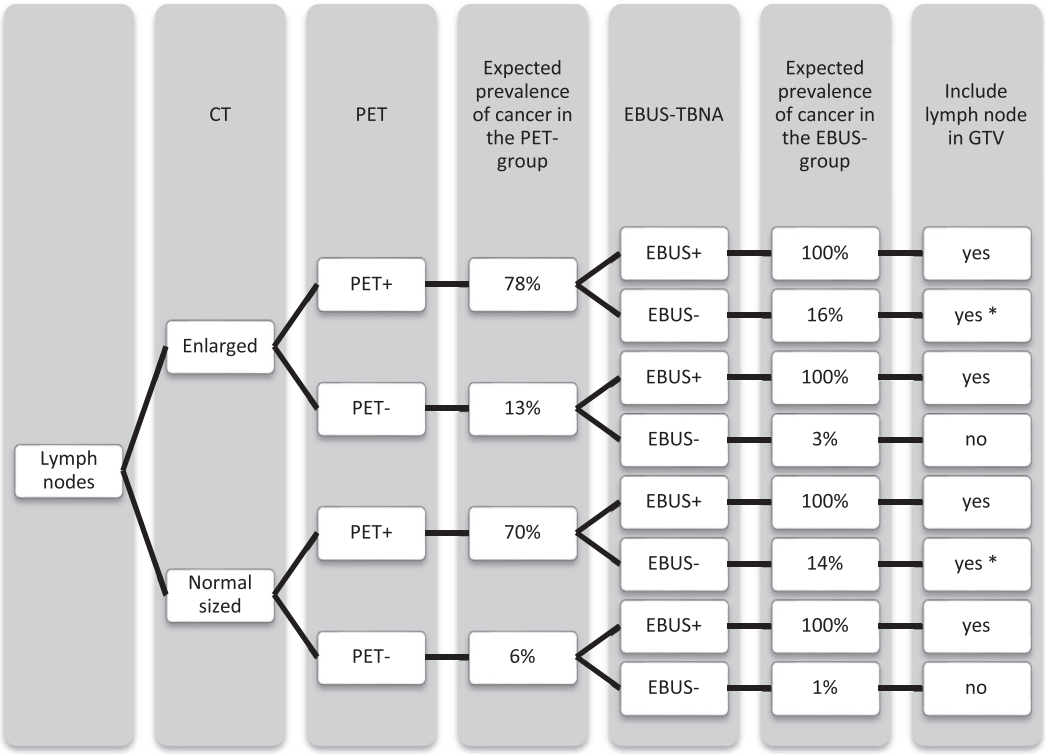

Fig. 1. Proposition of algorithm determining when to include lymph nodes in GTV based on expected prevalence of cancer based on CT, PET and E(B)US in literature, from Peeters [16]. * with the exception of symmetrical FDG-PET positive LN with a non-malignant diagnosis (anthracosis, silicosis, granulomatous disease ...) after adequate full EBUS-mapping.

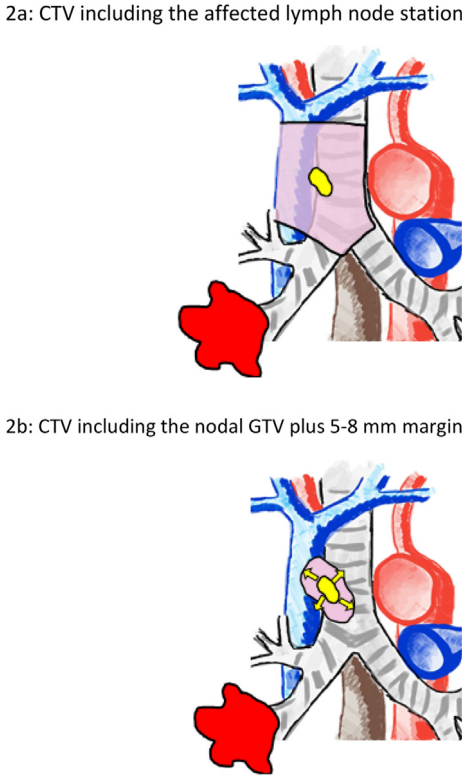

Fig. 2. Illustration of the two options for the definition of nodal CTV as recommended here.

margin may be tailored according to the size of lymph nodes or histology of the primary tumour [20,22] but care should be taken with respect to neighbouring normal organs (e.g. oesophagus) in order to not increase toxicity.

Beyond this, elective inclusion of the hilum and/or neighbouring nodal lymph node stations can be considered (O). Inclusion of uninvolved areas between involved stations (especially the hilum) is optional (O). Further inclusion of elective lymph nodes in the CTV is not recommended (D).

When post-operative RT (PORT) is indicated in locally advanced NSCLC, the CTV consists of the resected involved anatomical mediastinal lymph node regions, the bronchial stump, the ipsilateral hilum and nodal stations 4 and 7 [24]. All other recommendations given here apply to PORT in analogy.

Planning target volume (PTV)

A margin should be applied around the CTV to create the PTV to account for the geometric uncertainties (M) according to current ICRU recommendations. Sources of uncertainties include delineation errors [25], the inter- and intra-fraction patient (setup), tumour (baseline shift) and tumour motion-related errors (see below). Residual positioning errors depend on the department specific positioning and image guidance policy. These should ideally be quantified in each individual RT department for the relevant treatment settings (R). Manual editing of the PTV should not be performed (D).

For the specific motion-related uncertainties, different policies can be chosen:

1. Delineation of an internal target volume (ITV): it includes all CTV positions during the breathing cycle as per ICRU 62. ITV can be generated either by adding all CTVs from the different breathing phases of the 4DCT (manual delineation on each

separate CT phase or deformation of the CTV contour from one breathing phase to the others) [26], or by contouring the CTV on a MIP CT.

2. Application of the mid-ventilation or mid-position approaches with the tumour motion derived from the 4DCT then being integrated as a random error into the van Herk statistical PTV margin [27]:
   (a) a mid-ventilation CT approach: the single CT scan closest to the time-averaged position over the breathing cycle is selected from the 4D-CT data set [28–30].
   (b) a mid-position CT is generated from deformable registration and corresponds to the mean position of the anatomy along the respiratory cycle.
3. Application of respiratory-synchronised techniques, such as gating or tracking, with use of system-specific PTV margins according to departmental definition.

As the motion pattern may differ between the primary tumour and the involved lymph nodes, individualised anisotropic PTV margins should be defined (R) [31].

Organs at risk

For planning of conventionally fractionated or moderately hypo-fractionated RT for locally advanced NSCLC, the mandatory organs at risk to be contoured are: the lungs (both lungs separately and together, both excluding the GTV), the whole heart (optionally also cardiac sub-structures), the oesophagus (from cricoid to oesophageal-gastric junction) and the spinal canal (as a PRV safety surrogate for the spinal cord) (M). Optionally, other structures may be contoured: lungs minus PTV for optimisation purposes, brachial plexus if superior sulcus tumour and if the GTV is adjacent to or abuts the upper thoracic inlet (O). The trachea, proximal bronchial tree, great vessels and chest wall do not need to be defined for conventionally fractionated or moderately hypo-fractionated RT. The delineation of normal tissues should preferably be done using published atlases [32,33] (R).

Re-planning

Adaptive re-planning during the course of irradiation is advised on an individual basis (O) in case CBCT or other information reveals a tumour baseline shift or intrathoracic anatomical changes (e.g. atelectasis, pleural effusion) that have an anticipated significant influence on the dose distribution at any time point [34].

Organisation/responsibilities

It is recommended to develop departmental instructions for delineation (R). For physicians and RT treatment therapists (RTTs) during training, the supervision of delineations by an experienced colleague is mandatory (M). Additionally, hands-on training in an experienced centre or by participation in teaching courses may be helpful (O). All delineation steps for tumour volumes (GTVs, CTVs etc.) should be supervised by radiation oncologists (M) according to local practice, OARs may be contoured by RTTs (O). Final approval of all contours before planning must be performed by a radiation oncologist (M). An additional review by other radiation oncologists is highly recommended because inter-observer variation in the delineation is one of the main uncertainties in RT treatment planning of lung cancer [35] (R). A rigorous peer reviewed quality assurance process at the departmental level and beyond has been advocated to decrease variability in TV delineation in daily practice (R) [36]. In addition, the use of automated training and delineation tools are expected to improve contouring consistency, provided they have been submitted to a validation process before introduction into daily practice [37].

Conflict of interest statement

The authors declare that they have no competing interests.

None of the authors has any financial and personal relationships with other people or organisations that could inappropriately influence (bias) of this work.

References

[1] Glatzer M, Elicin O, Ramella S, Nestle U, Putora PM. Radio(chemo)therapy in locally advanced nonsmall cell lung cancer. Eur Respir Rev 2016;25:65–70.
[2] Borras JM, Barton M, Grau C, Corral J, Verhoeven R, Lemmens V, et al. The impact of cancer incidence and stage on optimal utilization of radiotherapy: methodology of a population based analysis by the ESTRO-HERO project. Radiother Oncol 2015;116:45–50.
[3] Borras JM, Lievens Y, Barton M, Corral J, Ferlay J, Bray F, et al. How many new cancer patients in Europe will require radiotherapy by 2025? An ESTRO-HERO analysis. Radiother Oncol 2016;119:5–11.
[4] Atun R, Jaffray DA, Barton MB, Bray F, Baumann M, Vikram B, et al. Expanding global access to radiotherapy. Lancet Oncol 2015;16:1153–86.
[5] Konert T, Vogel W, MacManus MP, Nestle U, Belderbos J, Grégoire V, et al. PET/CT imaging for target volume delineation in curative intent radiotherapy of non-small cell lung cancer: IAEA consensus report 2014. Radiother Oncol 2015;116:27–34.
[6] Everitt SJ, Ball DL, Hicks RJ, Callahan J, Plumridge N, Collins M, et al. Differential 18F-FDG and 18F-FLT uptake on serial PET/CT imaging before and during definitive chemoradiation for non–small cell lung cancer. J Nucl Med 2014;55:1069–74.
[7] Geiger GA, Kim MB, Xanthopoulos EP, Pryma DA, Grover S, Plastaras JP, et al. Stage migration in planning PET/CT scans in patients due to receive radiotherapy for non–small-cell lung cancer. Clin Lung Cancer 2014;15:79–85.
[8] Booth K, Hanna GG, McGonigle N, McManus KG, McGuigan J, O'Sullivan J, et al. The mediastinal staging accuracy of 18F-Fluorodeoxyglycose Positron Emission Tomography/Computed Tomography in non-small cell lung cancer with variable time intervals to surgery. Ulster Med J 2013;82:75.
[9] De Ruysscher D, Faivre-Finn C, Moeller D, Nestle U, Hurkmans CW, Le Pechoux C, et al. European Organization for Research and Treatment of Cancer (EORTC) recommendations for planning and delivery of high-dose, high precision radiotherapy for lung cancer. Radiother Oncol 2017;124:1–10.
[10] Wielpütz M, Kauczor H-U. MRI of the lung: state of the art. Diagn Interv Radiol 2012;18:344.
[11] Sommer G, Stieltjes B. Magnetic resonance imaging for staging of non-small-cell lung cancer—technical advances and unmet needs. J Thor Dis 2015;1098:7.
[12] Goossens S, Senny F, Lee JA, Janssens G, Geets X. Assessment of tumor motion reproducibility with audio-visual coaching through successive 4D CT sessions. J Appl Clin Med Phys 2014;15.
[13] Chirindel A, Adebahr S, Schuster D, Schimek-Jasch T, Schanne DH, Nemer U, et al. Impact of 4D–18 FDG-PET/CT imaging on target volume delineation in SBRT patients with central versus peripheral lung tumors. Multi-reader comparative study. Radiother Oncol 2015;115:335–41.
[14] Sindoni A, Minutoli F, Pontoriero A, Iatì G, Baldari S, Pergolizzi S. Usefulness of four dimensional (4D) PET/CT imaging in the evaluation of thoracic lesions and in radiotherapy planning: Review of the literature. Lung Cancer 2016;96:78–86.
[15] Schaefer A, Vermandel M, Baillet C, Dewalle-Vignion A, Modzelewski R, Vera P, et al. Impact of consensus contours from multiple PET segmentation methods on the accuracy of functional volume delineation. Eur J Nucl Med Mol Imaging 2016;43:911–24.
[16] Peeters ST, Dooms C, Van Baardwijk A, Dingemans A-MC, Martinussen H, Vansteenkiste J, Decaluwé H, De Leyn P, Yserbyt J, Nackaerts K. Selective mediastinal node irradiation in non-small cell lung cancer in the IMRT/VMAT era: How to use E (B) US-NA information in addition to PET–CT for delineation? Radiother Oncol 2016;120:273–8.
[17] Nestle U, Rischke HC, Eschmann SM, Holl G, Tosch M, Miederer M, et al. Improved inter-observer agreement of an expert review panel in an oncology treatment trial–Insights from a structured interventional process. Eur J Cancer 2015;51:2525–33.
[18] Steinfort DP, Siva S, Leong TL, Rose M, Herath D, Antippa P, et al. Systematic endobronchial ultrasound-guided mediastinal staging versus positron emission tomography for comprehensive mediastinal staging in NSCLC before radical radiotherapy of non-small cell lung cancer: a pilot study. Medicine 2016;95.
[19] Lynch R, Pitson G, Ball D, Claude L, Sarrut D. Computed tomographic atlas for the new international lymph node map for lung cancer: a radiation oncologist perspective. Pract Radiat Oncol 2013;3:54–66.
[20] Giraud P, Antoine M, Larrouy A, Milleron B, Callard P, De Rycke Y, et al. Evaluation of microscopic tumor extension in non-small-cell lung cancer for three-dimensional conformal radiotherapy planning. Int J Radiat Oncol Biol Phys 2000;48:1015–24.

[21] Van Diessen JN, Chen C, Van Den Heuvel MM, Belderbos JS, Sonke J-J. Differential analysis of local and regional failure in locally advanced non-small cell lung cancer patients treated with concurrent chemoradiotherapy. Radiother Oncol 2016;118:447–52.
[22] Yuan S, Meng X, Yu J, Mu D, Chao KS, Zhang J, et al. Determining optimal clinical target volume margins on the basis of microscopic extracapsular extension of metastatic nodes in patients with non-small-cell lung cancer. Int J Radiat Oncol Biol Phys 2007;67:727–34.
[23] Bradley JD, Paulus R, Komaki R, Masters G, Blumenschein G, Schild S, et al. Standard-dose versus high-dose conformal radiotherapy with concurrent and consolidation carboplatin plus paclitaxel with or without cetuximab for patients with stage IIIA or IIIB non-small-cell lung cancer (RTOG 0617): a randomised, two-by-two factorial phase 3 study. Lancet Oncol 2015;16:187–99.
[24] Le Péchoux C. Role of postoperative radiotherapy in resected non-small cell lung cancer: a reassessment based on new data. Oncologist 2011;16:672–81.
[25] Peulen H, Belderbos J, Guckenberger M, Hope A, Grills I, van Herk M, et al. Target delineation variability and corresponding margins of peripheral early stage NSCLC treated with stereotactic body radiotherapy. Radiother Oncol 2015;114:361–6.
[26] Janssens G, Jacques L, de Xivry JO, Geets X, Macq B. Diffeomorphic registration of images with variable contrast enhancement. Int J Biomed Imaging 2011;2011:3.
[27] van Herk M, Remeijer P, Rasch C, Lebesque JV. The probability of correct target dosage: dose-population histograms for deriving treatment margins in radiotherapy. Int J Radiat Oncol Biol Phys 2000;47:1121–35.
[28] Wanet M, Sterpin E, Janssens G, Delor A, Lee JA, Geets X. Validation of the mid-position strategy for lung tumors in helical TomoTherapy. Radiother Oncol 2014;110:529–37.
[29] Wolthaus JW, Schneider C, Sonke J-J, van Herk M, Belderbos JS, Rossi MM, et al. Mid-ventilation CT scan construction from four-dimensional respiration-correlated CT scans for radiotherapy planning of lung cancer patients. Int J Radiat Oncol Biol Phys 2006;65:1560–71.
[30] Wolthaus J, Sonke JJ, Van Herk M, Damen E. Reconstruction of a time-averaged midposition CT scan for radiotherapy planning of lung cancer patients using deformable registration. Med Phys 2008;35:3998–4011.
[31] Schmidt ML, Hoffmann L, Knap MM, Rasmussen TR, Folkersen BH, Toftegaard J, et al. Cardiac and respiration induced motion of mediastinal lymph node targets in lung cancer patients throughout the radiotherapy treatment course. Radiother Oncol 2016;121:52–8.
[32] Feng M, Moran JM, Koelling T, Chughtai A, Chan JL, Freedman L, et al. Development and validation of a heart atlas to study cardiac exposure to radiation following treatment for breast cancer. Int J Radiat Oncol Biol Phys 2011;79:10–8.
[33] Kong FM, Ritter T, Quint DJ, Senan S, Gaspar LE, Komaki RU, et al. Consideration of dose limits for organs at risk of thoracic radiotherapy: atlas for lung, proximal bronchial tree, esophagus, spinal cord, ribs, and brachial plexus. Int J Radiat Oncol Biol Phys 2011;81:1442–57.
[34] Sonke J-J, Belderbos J. Adaptive radiotherapy for lung cancer. Semin Radiat Oncol 2010:94–106.
[35] Vinod SK, Jameson MG, Min M, Holloway LC. Uncertainties in volume delineation in radiation oncology: A systematic review and recommendations for future studies. Radiother Oncol 2016;121:169–79.
[36] Rasch C, Belderbos J, van Giersbergen A, De Kok I, Laura T, Boer M, et al. The influence of a multi-disciplinary meeting for quality assurance on target delineation in radiotherapy treatment preparation. Int J Radiat Oncol Biol Phys 2009;75:S452–3.
[37] Lo AC, Liu M, Chan E, Lund C, Truong PT, Loewen S, et al. The impact of peer review of volume delineation in stereotactic body radiation therapy planning for primary lung cancer: a multicenter quality assurance study. J Thorac Oncol 2014;9:527–33.