Review Article

The importance of standardized treatment planning and decision-making in radiation oncology for non-small-cell lung cancer—are current guidelines sufficiently strict for uniform target delineation?—a narrative literature review

Thomas Descamps, Luigi Moretti

Radiation Oncology Department, Institut Jules Bordet, Université Libre de Bruxelles, Brussels, Belgium

Contributions: (I) Conception and design: Both authors; (II) Administrative support: Both authors; (III) Provision of study materials or patients: Both authors; (IV) Collection and assembly of data: Both authors; (V) Data analysis and interpretation: Both authors; (VI) Manuscript writing: Both authors; (VII) Final approval of manuscript: Both authors.

Correspondence to: Thomas Descamps. Radiation Oncology Department, Institut Jules Bordet, Université Libre de Bruxelles, Rue Meylemeersch 90, 1070 Anderlecht, Brussels, Belgium. Email: thomas.descamps@bordet.be.

Background and Objective: Quality of treatment planning and delivery in radiation oncology is crucial. To tackle inter-operator variability (IOV), peer review quality assurance (PRQA) has been increasingly implemented over the past decades and has become part of standard clinical practice, through recommendations in multiple national and regional guidelines. In the context of the ongoing peer review ProCaLung (PROject on the CAncer of the LUNG) initiative in Belgium, an assessment of current peer review practice in radiation oncology is proposed here. The main aims are to identify the frequency of changes, which aspects of treatment planning they occur in and what clinical impact good PRQA has. Additionally, current target delineation guidelines are reviewed to evaluate their suitability for standardized nodal volume peer reviewing in locally advanced non-small-cell lung cancer (NSCLC).

Methods: A review of the published English literature was performed using the PubMed and Google Scholar databases within a specified timeframe (January 1, 2010–March 15, 2022). Publications must report the impact of peer review of one or multiple aspects of radiation oncology treatment planning. Current guidelines on peer review practice and treatment planning were obtained from the websites of respective societies.

Key Content and Findings: Rates of changes recommended during peer review vary between 3.3% and 26%, with major changes occurring in 0.7% to 8.6% of cases. Changes occur across all elements of treatment planning, but those in target volume delineation (TVD) are most prevalent. No direct evidence proves the enhancement of clinical outcomes after peer review in routine practice. However, good quality control leads to better clinical outcomes in clinical trials, which could indicate that peer review is beneficial. The ESTRO-ACROP (The European Society for Radiation Oncology, The Advisory Committee for Radiation Oncology Practice) guidelines on target volume definition and delineation for locally advanced NSCLC are the most recent and comprehensive guidelines currently available, but they allow for a large variability in nodal TVD. This should be avoided when performing a standardized peer review of these volumes.

Conclusions: PRQA in radiation oncology leads to frequent changes which have clinical impact. This supports the concept of a national peer review project aiming to standardize nodal treatment in NSCLC. However, current target delineation guidelines require adaptation before use in standardised peer review.

Keywords: Non-small-cell lung cancer (NSCLC); radiation oncology; radiation treatment planning; peer review quality assurance (PRQA); target volume definition and delineation

Received: 27 April 2022; Accepted: 23 August 2022; Published: 30 December 2022.

doi: 10.21037/pcm-22-17

View this article at: https://dx.doi.org/10.21037/pcm-22-17

Introduction

The quality of treatment planning and delivery in radiation oncology has long been a topic of discussion. Quality assurance (QA) processes in radiation oncology are deployed on many different levels of (clinical) practice. The four main pillars of good QA for external beam radiotherapy (EBRT), according to the International Atomic Energy Agency, are a comprehensive QA programme executed by a multidisciplinary radiotherapy team, QA for equipment, QA for treatment delivery and the execution of quality audits (1). These pillars are all very complex. For example, equipment QA includes many different steps. The entire process consists of initial specification, acceptance testing and clinical commissioning, quality control tests, training and documentation, end-to-end dose delivery validation and many more (1,2).

Addressing all of these processes at once would be a huge undertaking not fit for this publication, so it has been decided to limit this work to the study of peer review in the context of the upcoming project ProCaLung (PROject on the CAncer of the LUNG). This is an upcoming project that provides a centralized and standardized peer review for lung cancer radiation treatments in Belgium.

The implementation of peer review in routine clinical practice

The importance of good quality control and peer review mechanisms has often been stated and has been included in multiple national and/or local guidelines. One such example is the White Paper on peer review of the American Society for Radiation Oncology (ASTRO) published in 2013, as part of its series of 'White Papers on Patient Safety in RT' (3). This White Paper improved on the 2009 'Practice Guideline for Radiation Oncology' by the American College of Radiology (ACR), by providing a more comprehensive and practice-guiding overview of the current evidence on peer review in radiation oncology. Updates of the ACR guideline have been published as the 'ACR-ASTRO Practice Parameter for Radiation Oncology' (3,4). Other well-known guidelines that refer to peer review as part of standard clinical practice in radiation oncology include those published by the Canadian Partnership for Quality Radiotherapy, the Royal Australian and New Zealand College of Radiologists (RANZCR) and the Royal College of Radiologists (RCR) (5-8). In 1999, RANZCR published the first iteration of their Peer Review Audit Tool (PRAT) for radiation oncology. The PRAT has received subsequent updates in 2006, 2013 and 2019. The main aims of the PRAT are to allow departments to organize peer review processes, maintain a steady level of quality control and to identify which areas require improvement (9). The most recent revision in 2019 sought to improve the tool in certain key areas. These were the simplification of documentation requirements and a greater focus on radiation therapy management and plan review. Another important addition was the introduction of a 'major/minor changes recommended' system (10).

Peer review is able to identify inconsistencies with treatment guidelines across all elements of radiation oncology treatment planning. An analysis on the 10-year experience using PRAT, conducted between January 1999 and June 2009, reported that the large majority of deviations were due to errors in health records and documentation. It is important to note that target volume delineation (TVD) was not part of the peer review (11). However, Lefresne *et al.* reported on the peer review process of 1,247 cases and highlighted four main domains that had changes recommended. These were dose-related: inadequate target volume coverage, suboptimal prescription of dose or fractionation, errors in patient setup and overdosage of normal tissue (12). A similar analysis by Ballo *et al.* on 2,988 cases also indicates dose-related changes as frequent, but changes in target volumes were even more prevalent (respectively 28.3% and 69.1% of all changes). The exact nature of changes to the target volumes were not indicated (13).

Peer review initiatives in the Belgian radiotherapy community

In the context of the increasing relevance of peer review quality assurance (PRQA) in radiation oncology treatment planning, the Belgian College for Physicians in Radiation Oncology has organized a series of peer review initiatives with a focus on TVD. PROCARE (PROject on Cancer of the Rectum) was the first of these projects, organising a centralized peer review program for rectal cancer patients (14). The main objective was a reduction in diagnostic and treatment-related variability to improve outcomes in rectal cancer patients. The project reported a high level of agreement in clinical target volume (CTV) delineation from the start, most likely due to distribution of clear delineation guidelines from the start and the high level of anatomical boundary descriptions. Nevertheless, an improvement on CTV uniformity was found, which

was most pronounced in the first 10 cases of participating centres (14). PROCAB (PROject of CAncer of the Breast) aimed to improve the quality of breast cancer radiation treatment. To allow for uniform treatment, guidelines on delineation of the 6 regional lymph node levels were generated through expert consensus discussion and were subsequently published (15). Results of PROCAB have shown a learning curve for the delineation of regional lymph node levels between the first and both 20th and 50th patients recruited by centres, respectively (16).

The ProCaLung project

The current ProCaLung project is a national peer review initiative, which aims to standardize the target definition and delineation of mediastinal lymph nodes in locally advanced non-small-cell lung cancer (NSCLC). It is the third project organised by the Belgian College for Physicians in Radiation Oncology in a series of PRQA initiatives that aim to decrease the variability of care in Belgian radiotherapy departments. Mediastinal volumes in NSCLC have been chosen as the subject of this project for several reasons. Since NSCLC is a prevalent form of cancer, it should allow for a sufficient amount of inclusions during a limited time frame. The second reason is that guidelines for the treatment of locally advanced NSCLC have been changing up until recently (17). This increases the interest for a centralized peer review project, as it is possible that not all health care providers will have adapted their clinical practice according to these changes. A third major reason is that the project will allow for the evaluation of the current diagnostic workup quality in locally advanced NSCLC. This diagnostic process includes several different techniques, including computed tomography (CT), positron emission tomography (PET)-CT and biopsies through endobronchial ultrasound (EBUS), oesophageal ultrasound (EUS) or mediastinoscopy (18). Ultimately, it is the aim of the College to organize these centralized peer review projects for most of the primary tumour sites frequently treated by radiotherapy. A project on head and neck cancer is being organized simultaneously.

The current review will describe the rationale behind ProCaLung. Firstly, we will illustrate the current state of PRQA in radiation oncology, its importance and its impact on clinical outcomes. This will be done with an added focus on NSCLC where applicable. The second objective will be to assess whether current delineation guidelines for (locally advanced) NSCLC allow for standardized peer review and treatment planning when treating mediastinal volumes. We present the following article in accordance with the Narrative Review reporting checklist (available at https://pcm.amegroups.com/article/view/10.21037/pcm-22-17/rc).

Methods

The review of the literature used for this article was performed through several platforms. The main databases searched were PubMed and Google Scholar. Websites of (inter-)national and regional associations were consulted to acquire actual treatment and practice guidelines. Both free text and MeSH term search methods were used to perform the literature research. An overview of all different terms used can be found in *Table 1*, along with a brief overview of the entire search strategy.

The final search was conducted on the 15th of March 2022 and articles included had to be published from 2010 onwards, up until and including 2022. For guideline documents (target delineation, practice guidelines …), the most recent version available was used. Publications had to be written in English in order to be included. Non-English publications were excluded from literature review.

Articles were only included when their full-text was available online. Publications where only an abstract was available and conference proceedings were excluded from this review.

Original articles on current peer review practice in radiation treatment planning were included if they provided information of the impact of PRQA on one or more elements of radiation treatment planning. Review articles and commentaries were omitted from this review.

Only publications on peer review in EBRT were included, articles on brachytherapy for example were excluded from the current review.

The literature search was primarily conducted by TD, who conducted this initial search independently. Consequently, the selected publications were reviewed by LM and the selection was expanded where deemed necessary through consensus discussion. Finally, references of included articles were reviewed for any additional publications that could add value to the contents of this review.

Discussion

When assessing the need for thorough PRQA in radiation oncology treatment planning, several topics are crucial. The first topic discussed here will be whether PRQA leads

Table 1 The search strategy summary

Items	Specification
Date of search	The final and definitive search was conducted on the 15th of March 2022
Databases and other sources searched	PubMed (https://pubmed.ncbi.nlm.nih.gov/)
	Google Scholar (https://scholar.google.be/)
	Websites of national and regional associations (e.g., ASTRO, ESTRO, RANZCR, RCR, etc.)
Search terms used	MeSH terms used (PubMed): "Radiotherapy, Conformal" [MeSH]; "Quality Assurance, Health Care" [MeSH]; "Carcinoma, Non-Small-Cell Lung" [MeSH]; "Carcinoma, Non-Small-Cell Lung/anatomy and histology" [MeSH]; ("Radiotherapy, Conformal"[MeSH]) AND "Quality Assurance, Health Care"[MeSH]; (("Radiotherapy, Conformal"[MeSH]) AND "Quality Assurance, Health Care"[MeSH]) AND "Carcinoma, Non-Small-Cell Lung" [MeSH]; ("Radiotherapy, Conformal"[MeSH]) AND "Carcinoma, Non-Small-Cell Lung/anatomy and histology"[MeSH]; ("Carcinoma, Non-Small-Cell Lung"[MeSH]) AND "Quality Assurance, Health Care"[MeSH]
	Free text search terms used (PubMed and Google Scholar): peer review, target delineation, target volumes, dose coverage, microscopic tumour extension, pathology, biopsy
	Filters: English language, published in 2010 or later
Timeframe	Articles published from 2010 up until (and including) 2022 were considered for this review
	Regional guidelines: the most recent versions were reviewed, regardless of date of publication
Inclusion and exclusion criteria	Inclusion criteria: original articles, full-text availability online, language (English), articles on EBRT, impact of PRQA on ≥1 elements of treatment planning described
	Exclusion criteria: commentaries/response letters, conference reports, abstract, conference proceedings, language (non-English)
Selection process	The publications referred to in this article have been selected by TD independently. LM reviewed the article selection and has added publications where deemed necessary after discussion between TD and LM

ASTRO, American Society for Radiation Oncology; ESTRO, European Society for Radiation Oncology; RANZCR, Royal Australian and New Zealand College of Radiologists; RCR, Royal College of Radiologists; EBRT, external beam radiotherapy; PRQA, peer review quality assurance.

to a sufficient amount of changes in treatment plans in order to render it efficient. Second, we will try to identify which parts of treatment plans are changed most frequently and third, it should be assessed whether PRQA leads to an improvement in clinical outcomes.

Following the review of current PRQA practice in radiation oncology, we will try to assess whether current guidelines for locally advanced NSCLC allow for a standardized peer review project like ProCaLung.

Current peer review practice in radiation oncology QA

Rates of changes

Multiple health institutions worldwide have reported on their peer review activities. In 2017, Rouette *et al.* published the outcomes of peer review for all 14 cancer centres in Ontario. An analysis of 5,561 curative treatment plans was performed over a 3-month period. A change was recommended in just 184 cases (3.3%). Of these, 74 were deemed major (19). These numbers contrast with the results of another large analysis performed by Walburn *et al.* Out of a total of 1,271 cases, 326 (26%) received recommendations after early peer review, amounting to a total of 356 recommendations. 95 of these changes were deemed major, 129 moderate and 132 minor (20). Another large analysis on 7,645 treatment plans which analysed planning target volume (PTV) and organ at risk (OAR) volumes during PRQA reported a rate of change of 9.7% (750 cases). Of these 750 cases, 534 had changes recommended to the PTV and in 216 cases, OAR delineation was adjusted (21). These numbers seem to indicate that the yield of peer review is varies greatly between different institutions. Other reports seem to confirm this variability, with rates of changes varying between 5% and 23.3%. Rates of major changes varied between 0.7% and 8.6% (11-13,22-25).

Rates of change vary greatly between different reports. These rates could depend on the participating operators, the structure of peer review processes, techniques used …

Another factor that might play an important role, is the distribution of patients across different tumour subsites. In this context, head and neck treatment plans have been reported as the most frequently changed after peer review by some authors (13,21,25). However, not all agree, as some have reported other tumour subsites as the most frequently changed. Lefresne *et al.* stated that gastrointestinal, lung and lymphoma plans were most often changed (12), while Mitchell *et al.* reported significantly more changes in gastrointestinal plans, with a trend towards an increased number of recommendations in haematologic and genitourinary plans (22). Finally, Thaker *et al.* reported a greater rate of non-concordance to guidelines in lymphoma, brain and, to a lesser extent, gynaecologic tumour cases (23). In contrast, other reports have not been able to discover a significant correlation between tumour subsites and the amount of changes recommended (20,24).

Head and neck cancer is often discussed in the context of PRQA during routine clinical practice. In one instance, it has been decided to go as far as to add a supplementary clinical examination of the head and neck region in the peer review process. In 14% of patients, this examination lead to new findings. Further analysis of treatment plans (following a qualitative and a quantitative method separately) resulted in a recommendation of major changes in 35% of patients for the qualitative method, and major CTV changes in 30% following the quantitative method (26). Another analysis on 182 cases reported changes recommended in 46.7%, with 3.3% of all recommendations deemed major (27). Other publications on PRQA for head and neck cancer cases confirm these seemingly higher numbers, with rates of change at 14% to 42% Major changes occurred in 8.8% to 18.6% of treatment plans (28-30).

A report on PRQA for the treatment of haematological malignancies during weekly chart rounds in 158 patients resulted in changes to 16.5% of treatment plans (31). Peer review of palliative cases is less frequently included in routine practice. A recommended change rate of 2.1% might justify this decision or it could point out that PRQA is not always performed as diligently as is the case for curative treatments (32).

Areas of change

In the context of ProCaLung, the most important factor during the peer review process is TVD. However, and as stated before, in radiation oncology is able to identify deviations from standard practice in many different areas. These include medical records, documentation of diagnostic procedures, target definition and delineation, dose prescription and coverage and patient set-up (11-13). Here we will try to identify which aspects of treatment planning are most often changed during routine clinical practice.

In stereotactic body radiation therapy (SBRT) cases, delineation of the target volumes was reported to be the most commonly changed factor during chart rounds by two independent authors. Matuszak *et al.* reported on chart rounds during SBRT planning and found that 70 out of 140 (50%) changes were recommended to target volumes [gross tumour volume (GTV) and PTV]. The second most important reason for changes were changes to goals and priority levels for OAR, with 37 (26.4%) of recommendations (33). Fitzgerald *et al.* similarly reported target volumes to be most frequently changed (41.5% of recommendations). Changes to dose prescription (27.7%) and dosimetry (13.9%) were the other most important groups (34).

These reports seem to confirm that TVD is the most important subject of PRQA. However, since this concerns only SBRT cases, where the most important principle is the very precise delivery of high doses to the target lesion without compromising normal tissue. It seems logical that extra attention would go to the volume delineation and dose constraints, which is why it is important to look at reports outside of the scope of SBRT treatment.

In head and neck cancer treatment, the general consensus seems to agree with what was seen in the SBRT series. In these reports, changes to GTV, CTV and/or PTV are consistently described as the most frequently changed aspects of treatment plans during PRQA (27-30). This is confirmed in studies on haematological and palliative cases, which similarly indicate target volume changes as the most frequently occurring recommendations (31,32).

These data seem to confirm the hypothesis that TVD is one of the most important aspects when performing PRQA in radiation oncology. This statement is further supported by certain general reviews reporting on multiple anatomical tumour sites (19,22,25), but others found other factors to be more susceptible to changes, such as radiation therapy fields (20). However, it should be noted that a certain bias might exist. If delineation was deemed as most important from the onset of peer review projects, it is possible that more attention goes to this part of the PRQA process.

Peer review practice for lung cancer patients

Fewer reports exist on the application of peer review of radiation oncology plans in lung cancer specifically. Lo *et al.* (35) reported on their experience when peer

reviewing TVD in the preparation of SBRT treatments for NSCLC patients. For 40 cases, 472 contours (organs at risk and target volumes) were reviewed in the final analysis. Eighty percent of plans had at least 1 major change recommended to them. Individually, a major change was recommended for 107 (23%) of OAR contours, minor changes were recommended for 176 (37%) of contours and 32 (7%) of contours were reported missing. Out of 40 PTV's, 7 major changes and 17 minor changes occurred. When analysing the possible dosimetric impact of these deviations, it was found that 25 (5%) of delineated structures caused dosimetric violations when reapplying original plans to the modified structures. It is important to note that a certain learning curve was observed, with fewer plans requiring major changes in the further stages of the peer review intervention. However, this did not result in a reduction of the amount of dosimetric violations (35). In another publication on peer review for SBRT cases, it was shown that lung and liver treatment plans were less likely to receive changes after peer review. This was attributed to the fact that the number of these cases treated was clearly higher than in other sites (33). This finding seems to agree with the presence of a certain learning curve effect following peer review.

Additionally, a report on peer review during planning of the radical treatment of lung cancer (both small-cell and non-small-cell) has reviewed 122 cases over a 13-month period. Plan analysis included target volumes, OAR contours, dose prescriptions and dose-volume histograms (DVH's). Peer review lead to a change in 17% of treated volumes and 6% of all plans were adjusted after review of volumes and doses. In total, 27% of plans were changed in at least one aspect of planning. 3% of patients had a change of treatment aim (from curative to palliative) due to feasibility concerns during peer review (36).

An overview of all findings from the current literature can be found in *Table 2*, which displays an overview of the main topics discussed here for each publication included in the study: sample size, rates of changes, definition of the change 'labels' (major, minor, etc.) and the main areas in which changes were recommended during peer review (34).

The impact of QA on clinical outcomes in radiation oncology

The second major topic that needs to be discussed is whether PRQA in radiation oncology treatment planning lead to improvement in clinical outcomes for patients. Currently, there are no prospective, interventional trials investigating this subject. This is in large part due to the fact that randomization between a peer review and non-peer review arm is very hard to justify, since peer review is widely regarded as being beneficial. This is why we will need to look at secondary analyses from clinical trials, in which the coherence to study QA is assessed in relation to clinical outcomes of patients. In order to do this, some specific trials will be discussed, followed by a quick overview of published meta-analyses and systematic reviews.

In 2010, Peters *et al.* (37) published an analysis of protocol compliance during the TROG 02.02 trial, where the addition of tirapazamine to cisplatin-based chemoradiotherapy was tested for patients with locoregionally advanced squamous cell carcinoma of the head and neck region. During the trial, radiation oncology centres were required to submit diagnostic procedures and treatment plans to the Quality Assurance Review Centre (QARC), which performed a review of all radiation treatment plans in cooperation with radiation oncologists part of the Trial Management Committee (TMC). After post-treatment peer review, patients were divided into 4 cohorts, one of which included those patients with a treatment plan, non-compliant to the study protocol and predicted to have a major adverse impact on tumour control. These patients scored significantly worse for overall survival (OS), time to locoregional failure (TTLRF) and failure-free survival (FFS) when compared to patients who had protocol compliant plans from the onset. This difference remained significant following multivariable analysis (37).

Following the PROCLAIM trial, a similar radiation therapy quality assurance (RTQA) was performed. This trial compared concurrent pemetrexed-cisplatin with concurrent radiation therapy followed by consolidation pemetrexed versus etoposide-cisplatin with concurrent radiation therapy followed by a consolidation platinum doublet. Out of 554 patients, major RTQA violations were found in 40 of them (for a total of 42 violations), after completion of treatment. Major violations comprised violations in minimum PTV dose coverage, severe overdosing of tissue in- or outside of the PTV, violation of spinal cord dose constraints and violation of V20 lung dose constraints. Given the nature of these violations, it could be expected that these violations lead to important consequences. Increased local recurrences, lower survival and increased toxicity could have been caused by these non-compliant treatments. This is especially important since only about 20% of patient plans were reviewed prior to RT treatment in this trial. To analyse these possible adverse outcomes, patients were then stratified into 3 groups based on the amount of non-compliant plans submitted by their centre

Table 2 An overview of the analysed literature

Author	Sample size (n)	Rates of changes (amount of patient cases, unless otherwise specified)	Definition of changes (as defined in the original publication)	Areas of changes
Bayat BT *et al.*	2,597	Total: 137 (5%) changes	Not specified	Inadequate documentation/ record keeping (95%); treatment prescription (2%); other (3%)
Lefresne S *et al.*	1,247	A: 93%; B: 6%; C: 1%	A: "plan is adequate and does not require modification"; B: "plan is satisfactory to continue treatment but receives suggestions for potential changes that should be incorporated into similar plans in the future"; C: "plan is unsatisfactory and requires correction before the next fraction of radiation therapy is delivered"	Only assessed for grade C changes: inadequate target volume coverage (36%); suboptimal prescription of total dose or fractionation (27%); errors in patient setup (27%); overtreatment of normal tissues (9%); unknown (15%)
Ballo MT *et al.*	2,830	Total: 346 (12.2%)	Not specified	Dose changes (28.3%); target changes (69.1%); major treatment change (2.6%)
Rouette J *et al.*	5,561	Total: 184 (3.3%); major: 74 (1.3%); minor: 88 (1.6%); unknown: 22 (0.4%)	Major: "a change requiring repeat planning and/or having a foreseeable effect on treatment toxicity or cancer outcomes in the view of the peer-review physician"; minor: "a change that did not meet the criteria for a "major" change and did not lead to significant repeat treatment planning"	Target volume (58%); technique/ dosimetry (12.2%); organs at risk (10.1%); other (8.6%); unknown (11.1%)
Walburn T *et al.*	1,271	Total: 356 recommendations in 326 (26%) patients; major: 95 (27%); moderate: 129 (36%); minor: 132 (37%)	Major: "a ≥10-mm change (>2-mm change for SBRT) in target/OAR contour and/or field size, change in dose or fractionation, change in radiation technique or delay in treatment planning"; moderate: "a 5- to 10-mm change (1- to 2-mm for SBRT) in target/OAR contour/field size or a change in field orientation"; minor: "a ≤5-mm change (≤1-mm for SBRT) in target/OAR contour and/or field size"	Fields (38%); target contour (25%); dose or fractionation (17%)
Riegel AC *et al.*	7,645	Total: 750 (9.7%); PTV: 534 (7.0%); OAR: 216 (2.8%)	Changes in PTV and OAR volumes were assessed, no other factors were evaluated	PTV increase (57.9%), decrease (21.5%), both (2.8%), indeterminate (17.8%); OAR increase (47.2%), decrease (10.6%), both (0.9%), indeterminate (41.2%)
Mitchell JD *et al.*	442	Variation: 91 (20.6%); major deviation: 3 (0.7%)	Variation: "I would manage this case differently but the current management plan is reasonable"; major deviation: "I would manage this case differently. The current plan is not reasonable. I recommend changes to be made"	Target contours (9.96%); target dosimetry (3.2%); normal tissue dosimetry (2.9%); normal tissue contours (2.0%); workup and staging (2.0%); treatment intent and prescription (2.0%); position, immobilization and simulation (1.3%); motion assessment and management (1.3%)

Table 2 (*continued*)

Table 2 (*continued*)

Author	Sample size (n)	Rates of changes (amount of patient cases, unless otherwise specified)	Definition of changes (as defined in the original publication)	Areas of changes
Thaker NG *et al.*	104	Non-concordant: 18 (17%)	Non-concordant in respect to specified institutional guidelines	Inappropriate overall management plan [6]; inappropriate radiation management plan [14]; problems with technical aspects of the radiation plan [8]
Albert AA *et al.*	73	Any change: 17 (23.3%); major change: 6 (8.2%)	Any change: "Including both changes resulting in re-planning and those that did not result in re-planning"; major change: "Plan rejection. Plans requiring major modifications such as target volumes changes or dose fractionation changes resulting in re-planning"	"Half of these major changes were due to changes in target volumes and the other half were due to changes in dose necessitating re-plan." Total dose changed in 16.4%, dose per fraction in 6.8%
Qureshi BM *et al.*	116	Total: 26 (22.4%); major: 10 (8.6%); minor: 15 (12.9%); missing contour 1 (0.9%)	Not specified	Changes in CTV 19 (16.4%); treatment field 5 (4.3%); dose 2 (1.7%)
Cardenas CE *et al.*	85	Qualitative changes: major: 30 (35%); minor: 35 (41%). Quantitative changes: major: 23 (27%); minor: 36 (43%)	Qualitative: major: "if they were believed to clinically affect the likelihood of cure, adverse events, or locoregional control"; minor: "when the recommendations made were more elective or stylistic". Quantitative (based on DSC): major: "if any change in CTV level was classified as major, then the overall DSC change was labelled major"; minor: "if no changes in CTV levels were classified as major but at least 1 change was classified as minor, then the overall DSC was labelled as minor"	Only changes in CTV were assessed
Zairis S *et al.*	182	Total: 85 (46.7%); major: 6 (3.3%)	Major: "recommendations made to alter GTVs"	Change in contours 62 (34.1%); change in dose/fractionation 24 (13.2%); change in chemotherapy 7 (3.8%); additional imaging studies 2 (1.1%)
Amarasena I *et al.*	548	Total: 230 (42.0%); major: 102 (18.6%); minor: 128 (23.4%)	Major: "a change thought to be necessary by the second RO to at least 1 of the following: the GTVp and GTVn, the high-dose PTV, or the prescribed dose and fractionation"; minor: "changes to either the intermediate or low-dose PTV, dose to the OARs, or both"	Only for major changes. Changes to GTVp (22%); to GTVn (16.6%); to high-dose PTV (57.1%); to total dose or fractionation (3.4%).
Ramasamy S *et al.*	307	Total: 43 (14.0%); major: 27 (8.8%); minor: (5.2%)	Major: "an alteration to the GTV for the primary tumour/lymph node GTV and/or high-dose CTV and/or the prescribed dose or fractionation"; minor: "an alteration to the intermediate- or elective dose-CTV"	Changes in CTV 33 (77%); changes in GTV 4 (9.3%); no information available 4 (9.3%); change in dose fractionation 1 (2.3%); addition of bolus 1 (2.3%)

Table 2 (*continued*)

Table 2 (*continued*)

Author	Sample size (n)	Rates of changes (amount of patient cases, unless otherwise specified)	Definition of changes (as defined in the original publication)	Areas of changes
Fong C *et al.*	62	Total: 24 (39%); significant: 8 (13%); minor: 16 (26%)	Significant: "high risk of potential geographical miss or extensive unnecessary impact on critical organs at risk or normal tissues"; minor: "minor change, but original would have been acceptable (usually case-specific)"	Changes in GTV 8 (33.3%); in CTV 12 (50%); re-irradiation/at-risk tissue protection 3 (12.5%); non-head and neck clinician contourer 1 (4.2%)
Samuel R *et al.*	158	Total: 26 (16.5%)	Not specified	Change in CTV 23 (14.6%); in GTV 2 (1.3%); in PTV 2 (1.3%); in OAR 1 (0.6%); in dose/fractionation 1 (0.6%)
Thompson D *et al.*	1,413 (of which 139 were discussed in detail)	Total: 29 (2.1%); major: 22 (1.6%); minor: 7 (0.5%)	Major: "required significant replanning or had significant clinical implications"; minor: "did not require significant replanning"	Target volumes (37.9%); dose prescription (31.0%); technique and treatment setup (20.7%); dosimetry evaluation (10.3%)
Matuszak MM *et al.*	513	Total: 138 (26.8%)	Not specified	Definition of the GTV 42 (8.2%); goals or priority levels of OAR 37 (7.2%); changes to the PTV 28 (5.5%); changes to prescription 25 (4.9%); image registration (2.7% of those with defined registration)
Fitzgerald R *et al.*	285	Total: 53 (22.3%)	Not specified	Changes in contours, target and OAR (41.5%); dose prescription/fractionation (27.7%); management/intent (15.4%); dosimetry (13.9%); technique (1.5%)
Lo AC *et al.*	472 (contoured structures evaluated, not patient cases)	Total: 315 (67%); major: 107 (23%); minor: 176 (37%); missing: 32 (7%)	Major: "original contour unacceptable, as agreed upon by 2 reviewers"; minor: "original contour still acceptable"	Most frequently changed: skin, heart and proximal bronchial tree. Twenty-five structures with dosimetric violations, most often PTV, ribs, spinal canal and heart
Rooney KP *et al.*	122	Total: 33 (27%)	Not specified	Change in treatment volumes (17%); DVH violations (6%); change to either induction chemotherapy or palliative-intent (3%); dose prescription (1%)

PTV, planning target volume; OAR, organ at risk; SBRT, stereotactic body radiation therapy; CTV, clinical target volume; DSC, Dice similarity coefficient; GTV, gross tumour volume; GTVp, GTV primary; GTVn, GTV nodes; DVH, dose-volume histogram.

(0, 1 or ≥2). The cohort of 86 patients enrolled at centres submitting ≥2 non-compliant plans had significantly lower median progression-free survival (PFS) than patients treated at centres without major violations. Median OS was significantly lower in patients that were enrolled in centres with either 1 or ≥2 major violations. When performing multivariate analyses, only the median OS loss in patients treated at a centre including ≥2 non-compliant plans remained significant, but hazard ratio's (HR's) remained the same for all differences (38).

The RTOG 0617 trial compared standard-dose versus high-dose conformal radiotherapy combined with concurrent and consolidation chemotherapy based on carboplatin-paclitaxel, with or without cetuximab, in patients with locally advanced (stage IIIA or IIIB) NSCLC. The trial proved to be negative for the higher dose schedule, which evoked the question which factors were responsible for this. One factor that was analysed, was the possible influence of radiation therapy quality on OS and local failure rates, since treatment from the higher dose group was more often non-compliant with the study protocol. However, in contrast to the findings from the TROG 02.02 and PROCLAIM trials, poorer protocol compliance did not seem to explain the worse outcomes in this high dose radiotherapy group (39).

Insight on current data and the patient's perspective

Quality of the current data

Even though multiple publications on current peer review practice, its processes, its results and its clinical implications exist, several issues exist regarding the reporting on these data. The main issue is that peer review processes outside of clinical trials are currently not standardized, even though PRQA is recommended in multiple guidelines. Due to this lack of standardization, the reports and their data need to be analysed with caution and direct comparisons of different data are very difficult.

First off, many different approaches to the organisation of peer review exist in current clinical practice. The more traditional approach to peer review in routine clinical practice is the organization of (at least weekly) in-person chart rounds. However, more recently online formats (through videoconference) have also been proposed as an alternative, especially for networks that span large geographic areas (34). Furthermore, little is known about the ideal format for such meetings, be it online or in-person. Even though attendances, duration of meetings, the amount of cases presented, etc. are frequently reported, there is no data on what the ideal circumstances for peer review rounds are. Additionally, both documentation and reporting of PRQA in radiation oncology are not standardized. This is clearly illustrated in *Table 2*. Publications often report on certain degrees of changes (most often labelled major and minor changes), but these definitions vary greatly between reports. Finally, not all reports on PRQA in this context analyse the same steps in the treatment planning process, as is shown in *Table 2* (column 5).

It is important to keep in mind that other problems also exist when reviewing these data, such as lack of detailed information on treatment planning systems and treatment setups used, exact reasons why contours or dose prescriptions are changed, etc. Institutional guidelines upon which PRQA is based are often not reported, which decreases transparency and understanding of the reasoning for plan adaptations.

The patient's perspective

The data from the reports reviewed above provides clear arguments in favour of the beneficial effect of PRQA for patients treated in radiation oncology. The first and most important argument can be found in clinical trials, as it has been proven that adherence to trial protocols through QA can lead to better patient outcomes (37,38). While there is no randomized data reporting on the effect of PRQA on clinical outcomes in routine practice, the reviewed reports do show that organised peer review leads to changes and improvements in treatment plans (11-13). These arguments combined suggest that PRQA in daily clinical practice will indeed have a positive impact on the treatment of patients in radiation oncology.

Another important argument in favour of PRQA from the patient's point of view is the following: whilst it is a demanding process for health-care personnel, there is no added charge for the patient. The process does not rely on patient effort and compliance for its effectiveness. Finally, there is no real 'risk factor' for the patient when PRQA is performed during their treatment. When participating in peer review projects, the patient should not risk receiving a placebo, inferior or potentially more toxic treatment.

Current delineation guidelines for lymph node treatment in locally advanced NSCLC

What are the current delineation guidelines for nodal volumes in locally advanced NSCLC?

In radiation oncology, target volume definition and

delineation guidelines are often the result of a consensus discussion through an organisational committee. Such consensus guidelines also exist in the field of locally advanced NSCLC. They were published in 2018 by ESTRO-ACROP (The European Society for Radiation Oncology, The Advisory Committee for Radiation Oncology Practice) after expert consensus discussion and voting (17). In the context of this article, we will only discuss the sections covering the treatment of nodal volumes.

Target definition and delineation of the GTV should be based on adequate imaging and pathology. Where possible, this should include PET – CT staging and biopsies through EBUS, EUS or mediastinoscopy in addition to the diagnostic CT scan (17). The algorithm published by Peeters *et al.* is recommended for target definition when creating the GTV (17,40).

The delineation of the CTV of the lymph nodes can be done following one of two options. The first option follows the involved-field principle, where the whole pathologically affected lymph node station is included, with a margin of at least 5–8 mm around the GTV. The second option follows a geometric approach, where a geometric expansion of 5–8 mm around the GTV is used, in analogy to what is done for the primary tumour GTV. Elective nodal irradiation (ENI) is optional in two cases: inclusion of the hilum and/or neighbouring nodal stations and inclusion of uninvolved stations between areas involved in the disease. Other cases of ENI are not recommended (17).

The European Organisation for Research and Treatment of Cancer (EORTC) have also published guidelines [2017] on planning and delivery of radiation therapy in lung cancer. In these guidelines, it is recommended that a 5 mm extension of the GTV be used to create the CTV, with manual cropping to nearby organs and bony structures when necessary. This is justified by the fact that most studies in locally advanced lung cancer have used these 5 mm margins and that it is unclear which clinical impact adjustments of CTV sizes for histology or size of the lymph node truly make. Prospective trials on disease recurrence patterns would be needed in order to prove their clinical relevance and include them in guidelines (41).

Do these guidelines allow for a standardized and uniform peer review process of mediastinal nodal target delineation in locally advanced NSCLC?

It is clear that the ESTRO-ACROP guidelines offer a comprehensive and extensive proposition for the delineation of target volumes in NSCLC, through a meticulous analysis of the literature at the moment of their publication in 2018. However, these guidelines are very lenient when addressing the delineation of nodal CTV for (mediastinal) lymph nodes. Two different methods are allowed when extending the GTV volume into the CTV, which are the geometric expansion and the inclusion of whole involved lymph node stations. Additionally, the minimal margin around and involved lymph node is not strictly defined. Instead it is stated that 'at least 5–8 mm' are necessary. Finally, there is no complete prohibition for ENI (17).

These are all factors that could result in a large inter-operator variability (IOV) among treatment plans, even if radiation oncologists were to follow the guidelines perfectly. This is problematic since the aim of the ProCaLung project is to create a centralized, standardized and uniform PRQA platform for the target definition and delineation of mediastinal nodal volumes in patients with locally advanced NSCLC. The ESTRO-ACROP guidelines cannot be used in their original form for the project's protocol, since this would leave too much room for interpretation. It would prove impossible to draw conclusions from the assessment of IOV if both a 5 mm margin around an involved lymph node and ENI of adjacent lymph node stations are equally correct in the protocol.

This is why these guidelines were adapted for use in the ProCaLung protocol. An initial version of the ProCaLung guidelines was established after discussion with the ProCaLung team members and these were tested during a dummy-run performed prior to the start of the project. It was decided to use the ESTRO-ACROP guidelines as the foundation for the protocol, with two exceptions. For extension of the GTV into the CTV margins, only a 5 mm geometric extension was allowed. The second exception was that no ENI was allowed (42).

In the dummy run, the difference in IOV and conformity to guidelines was assessed during two phases. Nodal CTV delineation was performed on the same test patient case before and after introduction of the ProCaLung guidelines. This lead to an improvement in overall variability of mediastinal nodal TVD. However, it was clear that even with the adaptations to the ESTRO-ACROP guidelines, there was still room for interpretation. Firstly, in the dummy run, no atlas for crop-to structures was provided, which lead to the inclusion of certain blood vessels or a pericardiac recess in the CTV, etc. Secondly, it was found that it was unclear how small neighbouring nodes (SNNs) had to be handled. These are small (<10 mm) lymph nodes,

directly adjacent (<5 mm) to involved lymph nodes. Some participants included these in the GTV, others in the CTV and some in neither. One of the conclusions of the dummy run was that these issues had to be addressed and the ProCaLung protocol was adjusted accordingly, with the addition of a crop-to structure atlas and measures to include the SNN's in the CTV completely, but without any added margins (42).

The lessons learned from the dummy run have allowed us to create a standardized set of delineation guidelines, which give a uniform framework for the PRQA project that is currently ongoing. However, it has to be acknowledged that the 5 mm geometrical margin used in ProCaLung is not necessarily superior to an involved-field treatment (where the whole lymph node station is delineated). In order to assess which of the methods proposed by ESTRO-ACROP is preferable, an analysis of newer evidence (published after 2018) might be necessary. For example, the PET-plan trial might challenge the current ideas surrounding the delineation of nodal CTV in locally advanced NSCLC (43), but this is beyond the scope of this publication. Ideally, a randomized prospective study of 5 mm margins versus whole nodal station irradiation would be required to provide a definitive answer to this recurring question.

Conclusions

In conclusion, it is clear that PRQA has an important role in radiation therapy treatment planning. Non-compliance to protocol and deviations from guidelines are often discovered during PRQA in many steps of radiation therapy. All aspects of radiation treatment are susceptible to changes during peer review, from the intent of the treatment, to target selection and delineation to dosimetry. However, TVD appears to be the most frequently adjusted factor during peer review.

From secondary analyses on clinical trials in (radiation) oncology, it is clear that QA plays a very important role in the clinical outcomes of patients. Poor treatment QA and deviation from study protocols has been shown to influence these outcomes negatively, both regarding treatment toxicity and treatment success (OS, PFS …).

When looking at these conclusions, which are also applicable to NSCLC, we are convinced that there is a place for an alternative approach to PRQA in locally advanced NSCLC through projects such as ProCaLung. While current guidelines have to be adapted to allow for a strict and uniform standardization of peer review, this should not be a reason to discontinue our efforts to enforce quality radiation treatment for all NSCLC patients.

Acknowledgments

Funding: This work was supported in part by a grant from "L'Association Jules Bordet" and "The Belgian College for Physicians in Radiation Oncology" of the Federal Public Service Health, Food Chain Safety and Environment in Belgium.

Footnote

Provenance and Peer Review: This article was commissioned by the Guest Editors (Paul Van Houtte and Dirk Van Gestel) for the series "Quality Assurance in Radiotherapy" published in *Precision Cancer Medicine*. The article has undergone external peer review.

Reporting Checklist: The authors have completed the Narrative Review reporting checklist. Available at https://pcm.amegroups.com/article/view/10.21037/pcm-22-17/rc.

Conflicts of Interest: Both authors have completed the ICMJE uniform disclosure form (available at https://pcm.amegroups.com/article/view/10.21037/pcm-22-17/coif). The series "Quality Assurance in Radiotherapy" was commissioned by the editorial office without any funding or sponsorship. The authors have no other conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

References

1. Thwaites DI, Mijnheer BJ, Mills JA. Quality assurance

of external beam radiotherapy. In: Podgorsak EB. editor. Radiation Oncology Physics: A Handbook for Teachers and Students. 1st ed. Vienna: International Atomic Energy Agency, 2005.
2. Pawlicki T, Smith B, Hayman JA, et al. editors. Safety is no accident. A framework for quality radiation oncology care developed and sponsored by. 2nd ed. Arlington: American Society for Radiation Oncology, 2019.
3. Marks LB, Adams RD, Pawlicki T, et al. Enhancing the role of case-oriented peer review to improve quality and safety in radiation oncology: Executive summary. Pract Radiat Oncol 2013;3:149-56.
4. American College of Radiology. ACR-ASTRO practice parameter for radiation oncology. 2018. Available online: https://www.acr.org/Clinical-Resources/Practice-Parameters-and-Technical-Standards
5. Canadian Partnership for Quality Radiotherapy. Canadian Partnership for Quality Radiotherapy Quality Assurance Guidelines for Canadian Radiation Treatment Programs. 2019. Available online: https://www.cpqr.ca/
6. The Royal Australian and New Zealand College of Radiologists. Radiation Oncology Practice Standards Part A: Fundamentals. 2018. Available online: https://www.ranzcr.com/
7. The Royal Australian and New Zealand College of Radiologists. Radiation Oncology Practice Standards Part B: Guidelines. 2018. Available online: https://www.ranzcr.com/
8. The Royal College of Radiologists. Radiotherapy target volume definition and peer review RCR guidance. 2017. Available online: https://www.rcr.ac.uk/
9. The Royal Australian and New Zealand College of Radiologists. Peer review audit tool for radiation oncology. 2019. Available online: https://www.ranzcr.com/
10. Chin S, Or M, Ong WL, et al. Radiation oncology peer review in Australia and New Zealand. J Med Imaging Radiat Oncol 2022;66:258-66.
11. Taghavi Bayat B, Gill S, Siva S, et al. Ten-year results of quality assurance in radiotherapy chart round. BMC Health Serv Res 2013;13:148.
12. Lefresne S, Olivotto IA, Joe H, et al. Impact of quality assurance rounds in a Canadian radiation therapy department. Int J Radiat Oncol Biol Phys 2013;85:e117-21.
13. Ballo MT, Chronowski GM, Schlembach PJ, et al. Prospective peer review quality assurance for outpatient radiation therapy. Pract Radiat Oncol 2014;4:279-84.
14. Joye I, Lambrecht M, Jegou D, et al. Does a central review platform improve the quality of radiotherapy for rectal cancer? Results of a national quality assurance project. Radiother Oncol 2014;111:400-5.
15. Verhoeven K, Weltens C, Remouchamps V, et al. Vessel based delineation guidelines for the elective lymph node regions in breast cancer radiation therapy - PROCAB guidelines. Radiother Oncol 2015;114:11-6.
16. Kindts I, Vandermeulen A, Verhoeven K, et al. A Central Review Platform Improves the Quality of Regional Lymph Node Delineation for Breast Cancer Radiation Therapy. Int J Radiat Oncol Biol Phys 2016;96:E38-9.
17. Nestle U, De Ruysscher D, Ricardi U, et al. ESTRO ACROP guidelines for target volume definition in the treatment of locally advanced non-small cell lung cancer. Radiother Oncol 2018;127:1-5.
18. Postmus PE, Kerr KM, Oudkerk M, et al. Early and locally advanced non-small-cell lung cancer (NSCLC): ESMO Clinical Practice Guidelines for diagnosis, treatment and follow-up. Ann Oncol 2017;28:iv1-21.
19. Rouette J, Gutierrez E, O'Donnell J, et al. Directly Improving the Quality of Radiation Treatment Through Peer Review: A Cross-sectional Analysis of Cancer Centers Across a Provincial Cancer Program. Int J Radiat Oncol Biol Phys 2017;98:521-9.
20. Walburn T, Wang K, Sud S, et al. A Prospective Analysis of Radiation Oncologist Compliance With Early Peer Review Recommendations. Int J Radiat Oncol Biol Phys 2019;104:494-500.
21. Riegel AC, Vaccarelli M, Cox BW, et al. Impact of Multi-Institutional Prospective Peer Review on Target and Organ-at-Risk Delineation in Radiation Therapy. Pract Radiat Oncol 2019;9:e228-35.
22. Mitchell JD, Chesnut TJ, Eastham DV, et al. Detailed prospective peer review in a community radiation oncology clinic. Pract Radiat Oncol 2017;7:50-6.
23. Thaker NG, Sturdevant L, Jhingran A, et al. Assessing the Quality of a Radiation Oncology Case-Based, Peer-Review Program in an Integrated Academic and Community Cancer Center Network. J Oncol Pract 2016;12:e476-86.
24. Albert AA, Duggar WN, Bhandari RP, et al. Analysis of a real time group consensus peer review process in radiation oncology: an evaluation of effectiveness and feasibility. Radiat Oncol 2018;13:239.
25. Qureshi BM, Mansha MA, Karim MU, et al. Impact of Peer Review in the Radiation Treatment Planning Process: Experience of a Tertiary Care University Hospital in Pakistan. J Glob Oncol 2019;5:1-7.
26. Cardenas CE, Mohamed ASR, Tao R, et al. Prospective Qualitative and Quantitative Analysis of Real-Time

Peer Review Quality Assurance Rounds Incorporating Direct Physical Examination for Head and Neck Cancer Radiation Therapy. Int J Radiat Oncol Biol Phys 2017;98:532-40.
27. Zairis S, Margalit DN, Royce TJ, et al. Prospective analysis of radiation oncology image and plan-driven peer review for head and neck cancer. Head Neck 2017;39:1603-8.
28. Amarasena I, Herschtal A, D'Costa I, et al. Outcomes of Routine Intensity Modulated Radiation Therapy Quality Assurance in a Large Head and Neck Cancer Center. Int J Radiat Oncol Biol Phys 2017;98:541-6.
29. Ramasamy S, Murray LJ, Cardale K, et al. Quality Assurance Peer Review of Head and Neck Contours in a Large Cancer Centre via a Weekly Meeting Approach. Clin Oncol (R Coll Radiol) 2019;31:344-51.
30. Fong C, Sanghera P, Good J, et al. Implementing Head and Neck Contouring Peer Review without Pathway Delay: The On-demand Approach. Clin Oncol (R Coll Radiol) 2017;29:841-7.
31. Samuel R, Thomas E, Gilson D, et al. Quality Assurance Peer Review for Radiotherapy for Haematological Malignancies. Clin Oncol (R Coll Radiol) 2019;31:e1-8.
32. Thompson D, Cox K, Loudon J, et al. Outcomes of Peer Review for Radiotherapy Treatment Plans With Palliative Intent. J Oncol Pract 2018;14:e794-800.
33. Matuszak MM, Hadley SW, Feng M, et al. Enhancing safety and quality through preplanning peer review for patients undergoing stereotactic body radiation therapy. Pract Radiat Oncol 2016;6:e39-46.
34. Fitzgerald R, Pryor D, Aland T, et al. Quality and access - Early experience of implementing a virtual stereotactic chart round across a national network. J Med Imaging Radiat Oncol 2020;64:422-6.
35. Lo AC, Liu M, Chan E, 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.
36. Rooney KP, McAleese J, Crockett C, et al. The Impact of Colleague Peer Review on the Radiotherapy Treatment Planning Process in the Radical Treatment of Lung Cancer. Clin Oncol (R Coll Radiol) 2015;27:514-8.
37. Peters LJ, O'Sullivan B, Giralt J, et al. Critical impact of radiotherapy protocol compliance and quality in the treatment of advanced head and neck cancer: results from TROG 02.02. J Clin Oncol 2010;28:2996-3001.
38. Brade AM, Wenz F, Koppe F, et al. Radiation Therapy Quality Assurance (RTQA) of Concurrent Chemoradiation Therapy for Locally Advanced Non-Small Cell Lung Cancer in the PROCLAIM Phase 3 Trial. Int J Radiat Oncol Biol Phys 2018;101:927-34.
39. Bradley JD, Paulus R, Komaki R, 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.
40. Peeters ST, Dooms C, Van Baardwijk A, et al. 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.
41. De Ruysscher D, Faivre-Finn C, Moeller D, 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.
42. Charlier F, Descamps T, Lievens Y, et al. ProCaLung - Peer review in stage III, mediastinal node-positive, non-small-cell lung cancer: How to benchmark clinical practice of nodal target volume definition and delineation in Belgium☆. Radiother Oncol 2022;167:57-64.
43. Nestle U, Schimek-Jasch T, Kremp S, et al. Imaging-based target volume reduction in chemoradiotherapy for locally advanced non-small-cell lung cancer (PET-Plan): a multicentre, open-label, randomised, controlled trial. Lancet Oncol 2020;21:581-92.

doi: 10.21037/pcm-22-17
Cite this article as: Descamps T, Moretti L. The importance of standardized treatment planning and decision-making in radiation oncology for non-small-cell lung cancer—are current guidelines sufficiently strict for uniform target delineation?—a narrative literature review. Precis Cancer Med 2022;5:38.