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COVID-19 Rapid Communication

Practice recommendations for lung cancer radiotherapy during the COVID-19 pandemic: An ESTRO-ASTRO consensus statement [☆]

Matthias Guckenberger ^{a,*}, Claus Belka ^b, Andrea Bezjak ^c, Jeffrey Bradley ^d, Megan E. Daly ^e, Dirk DeRuyscher ^f, Rafal Dziadziuszko ^g, Corinne Faivre-Finn ^h, Michael Flentje ⁱ, Elizabeth Gore ^j, Kristin A. Higgins ^k, Puneeth Iyengar ^l, Brian D Kavanagh ^m, Sameera Kumar ⁿ, Cecile Le Pechoux ^o, Yolande Lievens ^p, Karin Lindberg ^q, Fiona McDonald ^r, Sara Ramella ^s, Ramesh Rengan ^t, Umberto Ricardi ^u, Andreas Rimner ^v, George B. Rodrigues ^w, Steven E. Schild ^x, Suresh Senan ^y, Charles B. Simone II ^z, Ben J. Slotman ^{aa}, Martin Stuschke ^{ab}, Greg Videtic ^{ac}, Joachim Widder ^{ad}, Sue S. Yom ^{ae}, David Palma ^w

^a Department of Radiation Oncology, University Hospital Zurich, University of Zurich, Switzerland; ^b Department of Radiation Oncology, LMU Klinikum, LMU Munich, Germany; ^c Department of Radiation Oncology, Princess Margaret Cancer Center, University of Toronto, Canada; ^d Department of Radiation Oncology, Winship Cancer Institute of Emory University, Atlanta; ^e Department of Radiation Oncology, University of California Davis Comprehensive Cancer Center, Sacramento, USA; ^f Department of Radiation Oncology (Maastricht Clinic), Maastricht University Medical Center*, GROW Research Institute, The Netherlands; ^g Dept. of Oncology and Radiotherapy, Medical University of Gdansk, Poland; ^h Division of Cancer Sciences, University of Manchester and The Christie NHS Foundation Trust, Manchester, UK; ⁱ Department of Radiation Oncology, University Hospital Würzburg, JMU Würzburg, Germany; ^j Department of Radiation Oncology, Medical College of Wisconsin and Zablocki VAMC, Milwaukee; ^k Department of Radiation Oncology, Winship Cancer Institute of Emory University, Atlanta; ^l Department of Radiation Oncology, UT Southwestern Medical Center, Dallas; ^m Department of Radiation Oncology, University of Colorado, Aurora; ⁿ Department of Radiation Oncology, Fox Chase Cancer Center, Philadelphia, USA; ^o Department of Radiation Oncology, Gustave Roussy Cancer Campus, Villejuif, France; ^p Department of Radiation Oncology, Ghent University Hospital and Ghent University, Belgium; ^q Department of Head, Neck, Lung and Skin Cancer, Theme Cancer, Karolinska University Hospital, Stockholm, Sweden; ^r Royal Marsden Hospital, London, UK; ^s Radiation Oncology, Campus Bio-Medico University of Rome, Italy; ^t Department of Radiation Oncology, University of Washington School of Medicine, Seattle, USA; ^u Department of Oncology, University of Turin, Italy; ^v Department of Radiation Oncology, Memorial Sloan Kettering Cancer Center, New York, USA; ^w Division of Radiation Oncology, Western University, London, Canada; ^x Department of Radiation Oncology, Mayo Clinic, Phoenix, USA; ^y Department of Radiation Oncology, Amsterdam UMC, The Netherlands; ^z Department of Radiation Oncology, New York Proton Center and Memorial Sloan Kettering Cancer Center, USA; ^{aa} Department of Radiation Oncology, Amsterdam UMC, The Netherlands; ^{ab} Department of Radiotherapy, University Duisburg-Essen, Germany; ^{ac} Department of Radiation Oncology, Cleveland Clinic Lerner College of Medicine of Case Western University, USA; ^{ad} Department of Radiation Oncology, Comprehensive Cancer Center, Medical University of Vienna, Austria; ^{ae} Department of Radiation Oncology, University of California San Francisco, USA

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ABSTRACT

Background: The COVID-19 pandemic has caused radiotherapy resource pressures and led to increased risks for lung cancer patients and healthcare staff. An international group of experts in lung cancer radiotherapy established this practice recommendation pertaining to whether and how to adapt radiotherapy for lung cancer in the COVID-19 pandemic.

Methods: For this ESTRO & ASTRO endorsed project, 32 experts in lung cancer radiotherapy contributed to a modified Delphi consensus process. We assessed potential adaptations of radiotherapy in two pandemic scenarios. The first, an early pandemic scenario of risk mitigation, is characterized by an altered risk–benefit ratio of radiotherapy for lung cancer patients due to their increased susceptibility for severe COVID-19 infection, and minimization of patient travelling and exposure of radiotherapy staff. The second, a later pandemic scenario, is characterized by reduced radiotherapy resources requiring patient triage. Six common lung cancer cases were assessed for both scenarios: peripherally located stage I NSCLC, locally advanced NSCLC, postoperative radiotherapy after resection of pN2 NSCLC, thoracic radiotherapy and prophylactic cranial irradiation for limited stage SCLC and palliative thoracic radiotherapy for stage IV NSCLC.

Results: In a risk-mitigation pandemic scenario, efforts should be made not to compromise the prognosis of lung cancer patients by departing from guideline-recommended radiotherapy practice. In that same scenario, postponement or interruption of radiotherapy treatment of COVID-19 positive patients is

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* Corresponding author at: Department of Radiation Oncology, University Hospital Zurich (USZ), University of Zurich (UZH), Rämistrasse 100, CH – 8091 Zurich, Switzerland.

E-mail address: Matthias.Guckenberger@usz.ch (M. Guckenberger).

generally recommended to avoid exposure of cancer patients and staff to an increased risk of COVID-19 infection. In a severe pandemic scenario characterized by reduced resources, if patients must be triaged, important factors for triage include potential for cure, relative benefit of radiation, life expectancy, and performance status. Case-specific consensus recommendations regarding multimodality treatment strategies and fractionation of radiotherapy are provided.

Conclusion: This joint ESTRO-ASTRO practice recommendation established pragmatic and balanced consensus recommendations in common clinical scenarios of radiotherapy for lung cancer in order to address the challenges of the COVID-19 pandemic.

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After the outbreak of the coronavirus SARS-CoV-2 (COVID-19) in Wuhan, China, in December 2019 [1], the disease rapidly became a global pandemic. Infection rates peaked and began to decline in some Asian countries by March 2020, but Europe and the US are now among the most affected regions [2]. Most COVID-19 infections are characterized by only mild symptoms of fever and cough; however, there is a high risk of severe pulmonary infection and death, in particular for the elderly and populations with comorbidities such as diabetes, hypertension and cardiopulmonary diseases [3,4]. Cancer patients have been reported to be at increased risk of mortality [5]. Therefore, many countries have implemented strategies to reduce the risk of spread, aiming to slow-down or “flatten” the infection rate of the coronavirus and to stay within the capacity of the healthcare services, especially intensive care units [6].

The pandemic mitigation strategies of most countries also apply to medical care in general and to oncology in particular, and include reduction of elective services, a focus on remote visits (e.g. telemedicine and video), and use of personal protective equipment. However, most health authorities maintain emergency services (e.g. for accidents) and services for diagnosis and treatment of severe diseases such as cancer. These dramatic developments related to COVID-19 are associated with challenges for the practice of radiation oncology [7,8], especially for radiotherapy of lung cancer patients, who represent one of the highest-risk groups, with high risks of death from both cancer and COVID-19 illness.

It may be challenging for radiation oncologists to continue to follow accepted practice guidelines, given these limitations, and delivering standard therapies may even become inappropriate. There are two potential scenarios that may unfold, with different radiation practice patterns [9].

In a *first (early) pandemic scenario*, sufficient resources are still available to deliver radiation or multimodality treatment. This is sometimes referred to as the “contingency standard of care” [10]. However, suppression strategies aiming to slow down the virus spread may also impact the practice of lung cancer radiotherapy due to: a) the need for suppression of the coronavirus and, therefore, the need to minimize the travel of patients [11] and exposure of our radiotherapy staff [12]; b) an altered risk–benefit ratio of radiotherapy for lung cancer patients due to their increased susceptibility for severe COVID-19 infection when repeatedly leaving their home and traveling to radiotherapy treatment and simultaneously being treated with thoracic radiotherapy. For example, a patient who contracts COVID-19 during a visit for radiation is at a high risk of morbidity and death due to that visit. In this scenario of the COVID-19 pandemic, standard-of-care practice of curative or palliative radiotherapy for lung cancer might require adaptations and lead to treatment recommendations that are outside current guidelines [13].

In a *second (later) pandemic scenario*, radiotherapy resources may not be available in sufficient quantity for treatment of all patients. A severe shortage of radiotherapy resources may result from sickness or home-quarantine of our department staffing. Service or repair of radiotherapy software and hardware might be

restricted or unavailable by radiotherapy vendors. These issues would require the allocation of resources and triage of patients [14,15], in addition to the potential need to make changes to lung cancer radiotherapy prescriptions. This phase is sometimes referred to as the “crisis standard of care” [10].

In this setting of the COVID-19 pandemic, hypofractionation is an attractive treatment option, one that is actively being discussed within the radiotherapy community on social media platforms such as Twitter and theMednet. However, the results of such *ad hoc* discussions do not address the needs of our radiotherapy community in an optimal way. Individual opinions may not be clinically appropriate and might expose cancer patients to potential harm from suboptimal radiotherapy practice. On the other end of the spectrum, adoption of appropriate hypofractionation might be low if that practice is outside of international guidelines and not endorsed by recognized experts and professional societies, yet such guidelines often take many months to develop.

In this practice recommendation, which is endorsed by the European Society for Radiotherapy and Oncology (ESTRO) and the American Society for Radiation Oncology (ASTRO), an international group of experts in lung cancer radiotherapy aims to rapidly provide guidance about the potential need to adapt the practice and fractionation of radiotherapy for lung cancer in the current COVID-19 pandemic.

Methods

On March 22nd, 32 experts in lung cancer radiotherapy were invited to participate in this project, 16 European and 16 US/Canadian experts. By March 24th, 97% had agreed, and a replacement was found for the single invitee who was unavailable, to keep the total at 32 with a balance between groups. All invited participants are co-authors of recent national and international lung cancer practice guidelines or principal investigators of lung cancer clinical trials. A modified Delphi process was used to establish consensus about whether and how to adapt radiotherapy for lung cancer in the COVID-19 pandemic [16]. Surveys were circulated to all individual participants using the online survey tool SurveyMonkey. All respondents agreed to participate in a rapid Delphi process, with 24 h to complete each round and successive rounds starting 24 h after the closure of the previous round.

Two scenarios of the COVID-19 pandemic were assessed, both of which were already occurring in some geographical regions:

- Early pandemic scenario 1 – risk mitigation: In this scenario, we asked if respondents would recommend changes to standard practice during the early phase, considering these challenges: The altered risk–benefit ratio of radiotherapy for lung cancer patients due to their increased susceptibility for severe COVID-19 infection, and minimization of patient traveling and exposure of our radiotherapy staff.
- Later pandemic scenario 2 – reduced radiotherapy resources: In this scenario, we asked respondents to consider how their above recommendations from scenario 1 would change if a lack

Table 1

The six lung cancer cases described, including the diagnosis and the presumed standard guideline-recommended therapy.

Case 1: Stage I NSCLC	New diagnosis of stage I, inoperable, peripherally located NSCLC Institutional standard fractionation of SBRT according to NCCN: 3–4 Fx total dose 45–54 Gy
Case 2: Stage III NSCLC	Locally advanced stage IIIA (bulky N2) NSCLC Standard fractionation of radiochemotherapy: 30–33 Fx over 6–6.5 weeks, total dose 60–66 Gy
Case 3: PORT NSCLC	Resected N2 (multi-station and extra nodal spread) NSCLC Standard fractionation of radiotherapy: 27 Fx over 5.5 weeks, total dose 54 Gy
Case 4: LS SCLC	SCLC, limited stage Standard fractionation of radiochemotherapy: 30 Fx over 3 weeks, BID, total dose 45 Gy, OR 33 Fx over 6.5 weeks, total dose 66 Gy
Case 5: PCI LS SCLC	PCI for SCLC limited stage after good response to radiochemotherapy Standard fractionation of radiotherapy: 10 Fx over 2 weeks, total dose 25 Gy
Case 6: palliative NSCLC	Palliative metastatic NSCLC with failure after first-line chemo-IO combination and symptoms due to mediastinal/hilar disease progression and severe cough and moderate dyspnea. Standard fractionation of radiotherapy: 10 Fx over 2 weeks, total dose 30 Gy

of radiotherapy resources prevented some patients at their centre from receiving radiation treatment.

Six common lung cancer cases were assessed for both pandemic scenarios (Table 1). For all six, we assumed a patient with average / standard characteristics for the lung cancer population. The standard treatment for each case was provided, consistent with guideline-recommended radiotherapy according to current versions of the National Comprehensive Cancer Network (NCCN), ESTRO, ASTRO and European Organization for Research and Treatment of Cancer (EORTC) guidelines.

The questions for the first round of the Delphi process are shown in Table 2. All responses were analyzed and consolidated by two investigators (MG and DAP). A threshold of $\geq 66\%$ for agreement or disagreement was required for each item to reach consensus and a threshold of $\geq 80\%$ for strong consensus. For questions voting on prioritizing the cases, the results of the vote are presented without necessarily achieving consensus. In the second and third rounds, participants received the results and summary of comments from prior rounds, and were asked to vote again on

items that had not reached $\geq 66\%$ agreement. New questions were constructed (by MG and DAP) in order to gain clarification or to raise issues noted in the comments from participants. Following the third round, any items still lacking consensus were not considered a recommendation, but some important issues raised by a large minority of respondents are reflected below.

Results

A total of three Delphi rounds were conducted. Surveys remained open for 24 h and response rates were 29/32 (March 23rd, round 1), 31/32 (March 25th, round 2) and 30/32 (March 27th, round 3).

Early phase of the COVID-19 pandemic: risk mitigation

Question: Would you recommend postponing the initiation of treatment by 4–6 weeks?

In the early phase of the COVID-19 pandemic, decisions on delay of treatment depended on the clinical case (Table 3). There

Table 2

Questions in the first round of the Delphi process.

<i>Early pandemic scenario 1 – risk mitigation</i>	
All cases	Do you recommend that physicians change their radiotherapy practice to address the challenges in this early phase of the COVID-19 pandemic? (i.e. risks due to multiple visits, susceptibility of lung cancer patients to COVID-19 morbidity/mortality)
All cases	Would you recommend postponing the initiation of treatment by 4–6 weeks?
All cases	Would you recommend hypofractionating beyond your usual fractionation?
Case 1–3	Would your answers to questions #2 and #3 above change if the tumor was mutation positive (EGFR or ALK) or PD-L1 positive (i.e. >50%)?
Case 2	Would you recommend induction therapy in this case?
All cases	If you recommended hypofractionation, what would be the maximum degree of hypofractionation you would propose to a patient in your clinical service? Specify the total dose, number of fractions, total treatment time, and provide any pertinent references if available.
All cases	If this patient was COVID-19 positive before starting treatment, would you postpone RT until the patient becomes asymptomatic and the test for COVID-19 negative?
All cases	If this patient became COVID-19 positive after starting treatment, would you recommend interrupting RT until the patient becomes asymptomatic and the test for COVID-19 negative?
Case 1	Case 1B: An operable patient with stage I NSCLC is referred to you by a thoracic surgeon because timely access to surgery is not available due to surgical capacity issues. Would you treat with SABR/SBRT?
Case 2	Would you recommend starting with induction chemotherapy to postpone the start of radiation?
<i>Later pandemic scenario 2 – reduced radiotherapy resources</i>	
All cases	How highly would you prioritize this patient's treatment compared to all other cancer patients in your centre?
All cases	If there was a critical shortage of RT capacity, would you recommend further hypofractionation beyond what you have described above?
All cases	If you answered yes to the question above, what would be the maximum degree of hypofractionation you would propose to a patient in your clinical service? Specify the total dose, number of fractions, total treatment time, and provide any pertinent references if available
All cases	In the setting of reduced RT capacity, if this patient was COVID-19 positive before the start of treatment, what would be the maximum duration to postpone the initiation of radiotherapy (in weeks)?
All cases	In the setting of reduced RT capacity, if this patient became COVID-19 positive after starting treatment, would you recommend interrupting RT until the patient becomes asymptomatic and the test for COVID-19 negative?
Overall	Please rank the six cases in order of priority, starting with the highest-priority case, in the setting of reduced resources
Overall	If you were to triage patients for treatment, in the setting of reduced RT resources, please provide up to 5 factors that you would use to decide who gets treatment, in order of importance

Table 3
Recommendations regarding postponement of treatment.

Case	Response
Case 1: stage I NSCLC	Yes: 43% No: 57%
Case 2: stage III NSCLC	Yes: 4% No: 96% (strong consensus)
Case 3: PORT NSCLC	Yes: 82% (strong consensus) No: 18%
Case 4: LS SCLC	Yes: 11% No: 89% (strong consensus)
Case 5: PCI SCLC	Yes: 70% (consensus) No: 30%
Case 6: Palliative NSCLC	Yes: 4% No: 96% (strong consensus)

was a strong consensus not to postpone curative treatment for case 2 (stage III NSCLC), case 4 (LS SCLC) and case 6 (palliative NSCLC). In contrast, there was a strong consensus to postpone treatment for case 3 (PORT NSCLC) and a consensus to postpone for case 5 (PCI SCLC).

For case 1 (stage I NSCLC), answers on postponement were balanced and we asked for factors influencing the decision whether or not to postpone. There was strong consensus that tumor growth rate (87%) should be used in the decision-making process and some support for these other factors (33–66%): patient preference, solid component vs GGO, patient performance status, T1 vs T2, current and future status of pandemic.

For case 5 (PCI SCLC) we asked about regular contrast-enhanced cranial MRI follow up as an alternative to PCI: this strategy was supported by 46% without reaching consensus.

Question: Would you recommend hypofractionating beyond your usual fractionation?

In the early phase of the COVID-19 pandemic, there was consensus not to universally change radiotherapy practice to more hypofractionated regimens (table 4). There was consensus or strong consensus not to change to more hypofractionated approaches in case 3 (PORT NSCLC), case 4 (LS SCLC) and case 5 (PCI SCLC). In contrast, there was strong consensus to change to more hypofractionation in case 6 (palliative NSCLC).

If a decision was made for hypofractionation beyond standard fractionations, there was strong consensus for using a single fraction SBRT of 30–34 Gy in case 1 (stage I NSCLC). In case 6 (palliative

NSCLC), palliative regimens in 5 fractions, 2 fractions and a 1 fraction all had similar support.

For case 2 (stage III NSCLC), we further differentiated fractionations based on whether the patient was treated with radiotherapy only, with sequential radiochemotherapy or concomitant radiochemotherapy. There was strong consensus that hypofractionated radiotherapy is appropriate in radiotherapy alone or sequential radiochemotherapy; however, there was consensus against hypofractionation in concomitant radiochemotherapy (Table 5). Various fractionations were considered as appropriate, with total doses between 50 Gy and 66 Gy delivered in 15–30 fractions.

Question: An operable patient with stage I NSCLC is referred to you by a thoracic surgeon because timely access to surgery is not available due to surgical capacity issues. Would you treat with SBRT?

Surgical capacities might become especially at risk because of the strong need for intensive care and ventilators in patients with severe COVID-19 infection. We therefore addressed a situation where an operable patient with stage I NSCLC is referred to radiation oncology by a thoracic surgeon because timely access to surgery is not available due to surgical capacity issues: it was asked whether treatment with SBRT would be offered. There was a 100% consensus to offer SBRT.

Question: Which multi-modality strategies would you consider as reasonable in order to address the challenges in this early phase of the COVID-19 pandemic?

This question was asked for the curative stage III NSCLC (case 2) only. It was explicitly described that the patient does not have any contraindications against the guideline recommended standard-of-care concomitant radiochemotherapy. Concurrent radiochemotherapy achieved strong consensus as the preferred treatment strategy. Radiotherapy alone, chemotherapy followed by radiotherapy and chemotherapy followed by radiochemotherapy were not considered as reasonable treatment strategies by >33% of participants.

We also asked if respondents would recommend against any standard concurrent chemotherapy agents (e.g. cisplatin-etoposide, cisplatin-vinka alkaloid, cisplatin-pemetrexed, carboplatin-paclitaxel, or carboplatin monotherapy), and there was no consensus to recommend against any of these. The carboplatin-paclitaxel regimen was chosen as a regimen of concern most often (by 37% of respondents), potentially due to risks of myelosuppression and/or pneumonitis.

Table 4
Fractionation recommendations.

Case	Standard fractionations	Response	Maximum degree of hypofractionation supported
Case 1: stage I NSCLC	SBRT: 45–54 Gy in 3 Fx, 48 Gy in 4 fractions	Yes: 50% No: 50%	30–34 in 1 Fx [17]: 90% support if choosing hypofractionation (strong consensus)
Case 2: stage III NSCLC	Radiochemotherapy: 60–66 Gy in 30–33 Fx over 6–6.5 weeks	Yes: 46% No: 54%	
Case 3: PORT NSCLC	PORT: 50–60 Gy over 5–6 weeks	Yes: 29% No: 71% (consensus)	
Case 4: LS SCLC	Radiochemotherapy: 60–66 Gy in 30–33 Fx over 6–6.5 weeks, or 45 Gy in 30 Fx over 3 weeks using BID fractions of 1.5 Gy	Yes: 33% No: 67% (consensus)	
Case 5: PCI SCLC	PCI: 25 Gy in 10 Fx over 2 weeks	Yes: 7% No: 93% (strong consensus)	
Case 6: Palliative NSCLC	30 Gy in 10 Fx over 2 weeks	Yes: 89% (strong consensus) No: 11%	Favored fractionations: 20 Gy in 5 Fx (30%) [18] 17 Gy in 2 Fx (37%) [19] 8–10 Gy in 1 Fx (33%) [20]

Table 5

Recommended hypofractionation regimens based on availability/use of concurrent and sequential radiochemotherapy, or radiotherapy alone.

Would you consider hypofractionated radiotherapy as appropriate?		
Case 2 stage III NSCLC	Response	Maximum degree of hypofractionation supported
Radiotherapy only	Yes: 97% (strong consensus) No: 3%	60 Gy in 15 Fx (33%) [21,22] 60 Gy in 20 Fx (27%) [23] 60–66 Gy in 24–30 Fx (2.2–2.75 Gy/day) (23%) [24] 55 Gy in 20 Fx (13%) [25] None (3%)
Sequential radiochemotherapy	Yes: 97% (strong consensus) No: 3%	60–66 Gy in 24–30 Fx (2.2–2.75 Gy/day) (27%) [24] 55 Gy in 20 Fx (27%) [25] 60 Gy in 15 Fx (23%) [21,22] 60 Gy in 20 Fx (20%) [23] None (3%)
Concomitant radiochemotherapy	Yes: 27% No: 73% (consensus)	See footnote*

*Although there was consensus not to recommend hypofractionation, the respondents supportive of hypofractionation ($n = 11$) were asked which fractionation(s) they would support, with multiple answers allowed. The favored options were 60–66 Gy in 22–30 Fx, given at 2.2–2.75 Gy/day, (75%) and 55 Gy in 20 Fx (63%).

Table 6

Recommendations on delay or interruption of treatment in COVID-19 positive patients.

Patient case	Time patient is diagnosed as COVID-19 positive	Postpone or interrupt RT?
Case 1: Stage I NSCLC	Start of Tx After start of Tx	Yes: 96% (Strong consensus) Yes: 54%
Case 2: Stage III NSCLC	Start of Tx After start of Tx	Yes: 100% (Strong consensus) Yes: 57%
Case 3: PORT NSCLC	Start of Tx After start of Tx	Yes: 96% (Strong consensus) Yes: 68% (Consensus)
Case 4: LS SCLC	Start of Tx After start of Tx	Yes: 89% (Strong consensus) Yes: 48%
Case 5: PCI SCLC	Start of Tx After start of Tx	Yes: 93% (Strong consensus) Yes: 67% (consensus)
Case 6: Palliative NSCLC	Start of Tx After start of Tx	Yes: 74% (Consensus) Yes: 78% (Consensus)

Question: Would your multi-modality treatment strategy change if the tumor was mutation positive (EGFR or ALK) or highly PD-L1 positive (i.e. > 50%)? (Cases 1–3)

There was strong consensus (96%) not to change the treatment strategy for case 1 (stage I NSCLC) and almost consensus (64%) for case 3 (PORT NSCLC).

For case 2 (stage III NSCLC), we asked about induction strategies to postpone the start of radiotherapy for the populations described in this question, although these are not yet evidence-based treatment options. There was limited support but no consensus to consider induction EGFR-targeting TKI for EGFR mutated NSCLC or induction ALK-targeting TKI for NSCLC with ALK rearrangement (38%); induction chemo-IO for cancers highly PD-L1 positive was not supported (17%).

For case 3 (PORT NSCLC) we asked about EGFR/ALK targeting TKIs and about immune-checkpoint inhibition (\pm chemotherapy) as options to postpone radiotherapy or as alternatives to radiotherapy (although these are not yet evidence-based treatment options): none of these strategies was supported by >25% of the participants.

Question: Handling of COVID-19 positive patients?

There was consensus in all cases to postpone initiation of radiotherapy until the patient becomes asymptomatic and the test for COVID-19 becomes negative (Table 6). When patients are diagnosed as COVID-19 positive during radiotherapy treatment, there was consensus to interrupt radiotherapy until the patient becomes asymptomatic and the test for COVID-19 is negative in cases 3, 5 and 6 whereas opinions were evenly split for the cases with curative radiotherapy at the time of primary diagnosis (cases 1, 2 and 4).

For case 2 (stage III NSCLC) and case 4 (LS SCLC) with longer radiotherapy treatments, the following factors were described as relevant in the decision-making process of whether or not to interrupt radiotherapy in patients diagnosed as COVID-19 positive: COVID-19 related symptoms, symptoms of lung cancer, and infection with COVID-19 near the end of treatment.

Later phase of the COVID-19 pandemic: lack of radiotherapy resources and need for patient triage

For the later phase of the COVID-19 pandemic with potentially reduced radiotherapy resources, we addressed the questions whether further hypofractionation or postponement of radiotherapy for COVID-19 positive patients would be considered as reasonable and how to prioritize and triage patients. Results are summarized in Table 7. For case 3 (PCI SCLC) there was strong consensus (83%) for regular contrast-enhanced cranial MRI follow up instead of PCI. Availability of MRI may, however, be limited during a pandemic situation.

Table 7

Recommendations regarding hypofractionation of treatment in the later phase of the COVID-19 pandemic characterized by a lack of radiotherapy resources.

Case	Maximum hypofractionation considered as appropriate (66% threshold)
Case 1: stage I NSCLC	30–34 Gy in 1 Fx
Case 2: stage III NSCLC	55–60 Gy in 20 Fx
Case 3: PORT NSCLC	Consensus against hypofractionation
Case 4: LS SCLC	40–45 Gy in 15 Fx
Case 5: PCI SCLC	Consensus against hypofractionation
Case 6: Palliative NSCLC	8–10 Gy in 1 Fx

Table 8
Prioritization of lung cancer patients and factor for triaging of patients.

Prioritization of lung cancer patients			Top 5 factors for triaging patients across all radiotherapy cases
Rank	Case*	Relative Priority Compared All Other Types Cancer Cases in Department**	
1.	Stage III NSCLC	Very high/high (71% consensus)	1. Potential for cure 2. Relative benefit of RT vs. other treatment options 3. Active COVID-19 infection (absence thereof) 4. Life expectancy 5. Performance Status
2.	LS-SCLC SCLC	Very high/high (78% consensus)	
3.	Stage I NSCLC	High/average (near consensus: 65%)	
4.	Palliative NSCLC	No consensus. Widely dispersed responses.	
5.	PORT NSCLC	Low/very low (68% consensus)	
6.	SCLC PCI	Low/very low (81% consensus)	

*The six cases were ranked, with 6 points given for a #1 ranking, 5 points for #2, etc, and the average number of points was determined. The average scores, in order of ranking as listed in the table, were 5.2, 4.9, 4.1, 3.0, 2.1 and 1.7, respectively.

**Respondents were asked to prioritize each case as very high, high, average, low, or very low, corresponding to quintiles of priority (e.g. very high = top 20%, very low = bottom 20%), compared to all types of cancers treated in their department. Adjacent categories were combined to determine consensus.

Regarding postponement or interruption of treatment for COVID-19 positive patients during scenario 2, since the consensus in Scenario 1 was to postpone and interrupt in all situations, it was concluded that treatment would be postponed/interrupted until the patient recovers and is COVID-19 negative in Scenario 2 as well, since it is a more extreme example.

Prioritization of cases and triage of patients

Table 8 shows the ranking of cases based on relative priority, their perceived priority relative to all other types of cancer cases, and the top 5 factors recommended in order to triage patients in a setting where not all patients can receive radiotherapy due to capacity shortages.

Discussion

This Delphi process was able to achieve consensus in many important aspects of lung cancer radiotherapy in the current COVID-19 pandemic. A total of 32 international experts in lung cancer radiotherapy completed 3 rounds of a consensus-building process and addressed six common lung cancer cases within the context of two different scenarios of the COVID-19 pandemic. Beyond detailed recommendations shown above, the following three take-home messages should be considered in lung cancer radiotherapy.

First, in a risk-mitigation pandemic scenario where radiotherapy resources remain available, efforts should be made to not compromise the prognosis of lung cancer patients by departing from guideline-recommended radiotherapy practice. Second, in that same scenario, postponement or interruption of radiotherapy treatment of COVID-19 positive patients should be considered to avoid exposure of cancer patients and staff to an increased risk of COVID-19 infection. Third, in a severe pandemic scenario characterized by reduced resources, if patients must be triaged, important factors included potential for cure, relative benefit of radiation, life expectancy, and performance status.

This joint ESTRO-ASTRO practice recommendation aims to provide rapid, pragmatic and balanced guidance in common clinical scenarios of radiotherapy for lung cancer. Practitioners must use their clinical judgement when considering how these consensus statements apply to their individual clinical practice. These consensus statements are not absolute clinical practice recommendations. Clinical decisions should take into account all clinical factors, and in some settings the consensus recommendations may not be appropriate. The decision-making process will be influenced by various stakeholders (governments, health care

authorities, hospital and university administration), will be restricted by logistical and financial aspects, will need to follow the appropriate legal frameworks, and will need to be put into political and cultural context. The ability to implement hypofractionation may depend on departmental resources available (e.g. physicist).

This ESTRO-ASTRO practice recommendation used methodologies that are established quality indicators for regular consensus and guideline processes [26]: the practice recommendation was officially endorsed by the ESTRO and ASTRO societies, a sufficiently large group of international experts in lung cancer radiotherapy contributed to this recommendation, the modified Delphi process started with open questions aiming to comprehensively collect the knowledge and opinions of all participants and consensus was established by follow-up rounds of feedback and voting. A systematic review was not part of the practice recommendation due to time constraints, and especially due to a lack of evidence for pandemic situations.

All co-authors therefore encourage practitioners to consider the results of this ESTRO-ASTRO practice recommendation on whether and how to adapt radiotherapy for lung cancer to the COVID-19 pandemic. Finally, we want to express our gratitude to all colleagues of all professions and disciplines who continue delivering optimal cancer care in serious situations such as now – take care of yourselves as well as your patients.

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References

- [1] Li Q et al. Early transmission dynamics in Wuhan, China, of novel coronavirus-infected pneumonia. *N Engl J Med* 2020.
- [2] Rosenbaum L. Facing Covid-19 in Italy – Ethics, Logistics, and Therapeutics on the Epidemic's Front Line. *N Engl J Med* 2020.
- [3] Guan W et al. Clinical Characteristics of Coronavirus Disease 2019 in China. *N Engl J Med* 2020.
- [4] Zhou F et al. Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. *The Lancet* 2020.
- [5] Xia Y, Jin R, Zhao J, Li W, Shen H. Risk of COVID-19 for cancer patients. *Lancet Oncol* 2020.
- [6] Ferguson N.M. et al. Impact of non-pharmaceutical interventions (NPIs) to reduce COVID-19 mortality and healthcare demand 2020:20.
- [7] Filippi AR, Russi E, Magrini SM, Corvò R. COVID-19 outbreak in northern Italy: first practical indications for radiotherapy departments. *Int J Radiat Oncol Biol Phys* 2020.
- [8] Krengli M, Ferrara E, Mastroloio F, Brambilla M, Ricardi U. Running a Radiation Oncology Department at the time of coronavirus: an Italian experience. *Adv Radiat Oncol* 2020.
- [9] Zhao Z, Bai H, Duan JC, Wang J. Individualized treatment recommendations for lung cancer patients at different stages of treatment during the outbreak of 2019 novel coronavirus disease epidemic. *Zhonghua Zhong Liu Za Zhi* 2020;42:E007.
- [10] Stroud C. Institute of Medicine (U.S.) & Forum on Medical and Public Health Preparedness for Catastrophic Events. Crisis standards of care: summary of a workshop series, National Academies Press: 2010.
- [11] Chinazzi M et al. The effect of travel restrictions on the spread of the 2019 novel coronavirus (COVID-19) outbreak. *Science* 2020. <https://doi.org/10.1126/science.aba9757>.
- [12] Lancet T. COVID-19: protecting health-care workers. *The Lancet* 2020;395:922.
- [13] Francesco C, Pettke A, Michele B, Fabio P, Helleday T. Managing COVID-19 in the oncology clinic and avoiding the distraction effect. *Ann Oncol* 2020; S0923753420363730. <https://doi.org/10.1016/j.annonc.2020.03.286>.
- [14] Christian MD. Triage *Crit Care Clin* 2019;35:575–89.
- [15] Emanuel EJ et al. Fair allocation of scarce medical resources in the time of Covid-19. *N Engl J Med* 2020.
- [16] Hsu C-C, Sandford BA. The Delphi Technique: Making Sense of Consensus. 12, 8.
- [17] Videtic GM et al. Long-term follow-up on NRG oncology RTOG 0915 (NCCTG N0927): A randomized phase 2 study comparing 2 stereotactic body radiation therapy schedules for medically inoperable patients with stage I peripheral non-small cell lung cancer. *Int J Radiat Oncol Biol Phys* 2019;103:1077–84.
- [18] Bezjak A et al. Randomized phase III trial of single versus fractionated thoracic radiation in the palliation of patients with lung cancer (NCIC CTG SC.15). *Int J Radiat Oncol* 2002;54:719–28.
- [19] Medical Research Council Lung Cancer Working Party et al. Randomized trial of palliative two-fraction versus more intensive 13-fraction radiotherapy for patients with inoperable non-small cell lung cancer and good performance status. *Clin Oncol* 1996;8:167–75.
- [20] Medical A. Research Council (MRC) randomised trial of palliative radiotherapy with two fractions or a single fraction in patients with inoperable non-small-cell lung cancer (NSCLC) and poor performance status. Medical Research Council Lung Cancer Working Party. *Br J Cancer* 1992;65:934–41.
- [21] Westover KD et al. Precision hypofractionated radiation therapy in poor performing patients with non-small cell lung cancer: phase 1 dose escalation trial. *Int J Radiat Oncol* 2015;93:72–81.
- [22] Iyengar P et al. A phase III randomized study of image guided conventional (60 Gy/30 fx) versus accelerated, hypofractionated (60 Gy/15 fx) radiation for poor performance status stage II and III NSCLC patients—an interim analysis. *Int J Radiat Oncol Biol Phys* 2016;96:E451.
- [23] Osti MF et al. Image guided hypofractionated 3-dimensional radiation therapy in patients with inoperable advanced stage non-small cell lung cancer. *Int J Radiat Oncol* 2013;85:e157–63.
- [24] Belderbos J et al. Randomised trial of sequential versus concurrent chemoradiotherapy in patients with inoperable non-small cell lung cancer (EORTC 08972–22973). *Eur J Cancer* 2007;43:114–21.
- [25] Maguire J et al. SOCCAR: a randomised phase II trial comparing sequential versus concurrent chemotherapy and radical hypofractionated radiotherapy in patients with inoperable stage III Non-Small Cell Lung Cancer and good performance status. *Eur J Cancer* 2014;50:2939–49.
- [26] Kötter T, Blozik E, Scherer M. Methods for the guideline-based development of quality indicators—a systematic review. *Implement Sci* 2012;7:21.