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Radiotherapy based management during Covid-19 pandemic – A systematic review of presented consensus and guidelines

Zahra Siavashpour a,*, Neda Goharpey b, Mosayyeb Mobasheri c

a Radiotherapy Oncology Department, Shohada-e Tajrish Educational Hospital, Shahid Beheshti University of Medical Sciences, Tehran, Iran
b Radiotherapy Oncology Department, Shohada-e Tajrish Educational Hospital, Tehran, Iran
c Medical Physics Department, Tarbiat Modares University, Tehran, Iran

ARTICLE INFO

Keywords:
Radiotherapy
COVID-19
Oncology
Pandemic

ABSTRACT

Treatment management of cancer patients in the radiation oncology departments during the current COVID-19 pandemic is challenging. A systematic review of published consensus/guidelines on the role of radiotherapy prioritization, suggested treatment protocols, and set up management was undertaken based on the PRISMA protocol and through PubMed/PMC, Scopus, Google Scholar, Web of Science databases until 01/20/2021. One hundred and sixty-eight publications or regional consensus were included. Summary of recommendations contained: (1) using hypo-fractionated (Hypo-F) regimens for therapeutic/palliative indications, (2) delaying radiotherapy for several weeks or until pandemic over, (3) omitting radiotherapy by replacement of alternative therapies or active surveillance, (4) applying safer patients’ setup and preparation protocols, (5) developing telemedicine/telehealth service. To conclude, it is essential to carefully weigh the risk of exposure to COVID-19 infection and the benefit of treating cancer patients during the pandemic. Trying to have a global guideline facing this or any other probable crisis is crucial for health care service.

1. Introduction

The outbreak of coronavirus 2 (COVID-19) is a severe acute respiratory syndrome caused by severe acute respiratory syndrome-related coronavirus-2 (SARS-CoV-2). The virus has impacted ordinary everyday life and medical approaches worldwide since about December 2019. Meanwhile, vulnerable patients such as cancerous ones are at substantial risk and need meticulous care to reduce and avoid all the possibilities of contracting the infection. Since the spread of COVID-19 is a severe and long-lasting catastrophe, termination or delay of treatment may jeopardize patient care and health. The radiation oncology centers are endeavoring to present guidelines on coping with this crisis.

There were two severe acute respiratory syndrome-related coronavirus (SARS-CoV) and middle east respiratory syndrome-related coronavirus (MERS-CoV) in the 2002 and 2012 outbreak before this current pandemic, respectively (Saber Soltani et al., 2020; Hosseiny et al., 2020). However, the SARS outbreak has been controlled, with no human infection reported since 2003, but MERS’ small epidemics continue to be notified (Hosseiny et al., 2020). World health organization indicated the initial diagnostic symptoms of this public health emergency as fever and flu-like symptoms and/or breathing difficulty with pulmonary ground-glass opacity (GGO) appearance in the computed tomography (CT) images (Novel Corona Virus Update [Online], 2021).

This rapidly expanding pandemic has impacted all daily life areas, especially the clinical routines of other life-threatening diseases such as cancer and its care in radiotherapy departments. Before the pandemic era, the radiotherapy area was categorized based on the risk of radiation exposure and contamination to controlled and uncontrolled areas (Radiation Protection in the Design of Radiothe and rapy Facilities, 2006). However, this pandemic adds other categorization based on the risk of viral infection. Many recommendations were presented by categorizing the treatment department area, room cleaning, sanitization, or disinfection protocols, staff preparation such as having a different level of protective clothing, protocols on setting treatment appointment time for the suspicious or high-risk patients, and urgent event handling (Wei et al., 2020; Starling et al., 1992).

Immunosuppression in cancer patients makes them more fragile during this crisis, and their treatment has been faced with a severe challenge. As the pandemic becomes more widespread, the population concurrently challenged by cancer and corona will increase across the world undoubtedly (Uzzo et al., 2021). Some recent multi-central
studies find no meaningful associations between the COVID-19 mortality with any cancer type and anticancer therapies. In contrast, the other cohort or review ones conclude a higher prevalence and morbidity risk of COVID-19 in the cancer population. Some cohort studies reported a higher fatality rate than the other COVID-19 infected patients (Garasino et al., 2020; Zhang et al., 2020; Kuderer et al., 2020; Lee et al., 2020a; Poortmans et al., 2020; Chakraborty and Pandey, 2020).

Therefore, many departmental consensuses, original articles, rapid reviews, case/case series-reports, editorials, and national and international guidelines were presented in the last months addressing this compromised clinical condition.

Before the outbreak of this pandemic, numerous institutes and healthcare centers applied telehealth services (Parashar et al., 2020; Wright et al., 2020). Developing this service has been highlighted, and it plays an essential role in decreasing unnecessary hospital admission, specifically in the spread of the COVID-19 era (Zhao et al., 2020). This service can be used for online patient’s visit and consultation, online image or lab data review (e.g., to minimize the CD handling), online/offline treatment evaluation/verification, and online patient’s follow-up using real-time two-way video/audio communication mostly for the cases with low and intermediated priority (Parashar et al., 2020).

However, telemedicine is not a possible option for patients who need radiotherapy as a therapeutic/palliative treatment method. Therefore, radiotherapy (RT) resources and departments have been tried to adjust management protocols to make an optimal decision on delivering the best care to all cancer patients with radiotherapy indications (Slotman et al., 2020).

Rapid recommendations were presented by global resources such as the American Society for Radiation Oncology (ASTRO), European Society for Radiotherapy and Oncology (ESTRO), National Health Service (NHS), Cancer Core Europe (CCE), Royal College of Radiologists (RCR), European Society for Medical Oncology (ESMO), etc. on the patients and staff care and prioritizing the patient’s treatment strategies. The foundation of these guidelines has been based on safety, avoidance (RT omission when there is a severe risk of infection and its related morbidity), rescheduling (deferring/delaying RT), and shortening (using hypo-fractionated RT (Hypo-F RT) schedule) (Slotman et al., 2020; Gundavda and Gundavda, 2020). However, these rapid publications of consensus can also be confusing, especially when there is not a gathered and organized schema.

Despite the improvements of cancer care and radiotherapy facilities and knowledge, there are still many limitations in the radiotherapy departments’ infrastructure that do not let them obey some of these recommendations. Therefore, to propose practical solutions, it is necessary to consider the facilities, technologies, and substructures of medical and radiotherapy centers in all countries. For categorizing the recommendations, it is essential to pay attention not only to the prioritizing of patient’s cancer stage but also the national-specific RT departments practices, their reimbursement system of healthcare, scientific and experimental preparation of the treatment team, and the impact of national legislations undertaken during the crisis (Achard et al., 2020; Kochbati et al., 2020).

This study aimed to overview the presented guidelines of radiotherapy national/international organizations or individual departments’ consensus during this pandemic regarding patient care. This would lead to having a compact and comprehensive radiotherapy database of recommendations for any ongoing crisis that will threaten the healthcare system. Also, any radiotherapy department can choose one of these consensuses that match his facilities and knowledge.

2. Materials and methods

2.1. Searching strategy

To perform this review searching strategy for systematic review was followed, and Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) chart was designed (Moher et al., 2009, 2015).

Searching was performed through the English language literature using the PubMed/PMC, Scopus, Google Scholar, Web of Science databases up to 01/20/2021.

Using Medical Subject Headings (MeSH), the following search terms were selected for coronavirus: coronavirus, SARS-CoV-2, COVID-19, COVID19, 2019-nCoV, SARS2. The search terms chosen for radiation therapy were: ‘radiation, radiotherapy, brachytherapy, teletherapy, and intraoperative radiation therapy’. These terms were combined using the logical operator of ‘AND’ and ‘OR’ properly to give all relevant publications containing coronavirus in the radiation therapy field. In the Scopus database, the search was through title, abstract, and keywords. In the Pubmed/PMC, it was through the title and abstract. Through title and keyword in Google Scholar, it was through topics and titles in the Web of Science. For Web of Science and Google Scholar, the search results were restricted from 2019 to 2021. Finally, obtained search results were exported, and duplicated records were omitted after merging into EndNote™ (Clarivate Analytics, version X7) reference management software. Then, two of the researchers reviewed the results and removed irrelevant records by inspecting titles independently.

2.2. Inclusion and exclusion criteria

Articles were qualified for inclusion if they contained guidelines, consensus, or recommendations on radiotherapy standards of care for cancer patients during the COVID-19 pandemic. Single or multi-departmental consensus for the treatment of each patient’s cancer type was included. Also, international radiotherapy guidelines and review articles that addressed radiotherapy and COVID-19 issue were considered. Published international/national consensus for applying different patient’s preparation strategies in radiotherapy departments during the current pandemic also included. The proposed approach for delaying, continuing as pre-pandemic protocols, or deferring the RT techniques/fractionation for each discussed cancer type were addressed. Dedicated priority to choose one of these mentioned approaches confronted with each cancer patient considering his disease stage, age, performance status, and risk of infection was extracted from the published studies. To an article be excluded, both authors had to agree or consult with the third to decide if the literature was not relevant or have some unclear aspect or bias or not containing practical recommendations involving radiotherapy practice during coronavirus crisis. Moreover, publications that addressed all cancer treatment strategies, except radiotherapy, such as surgery, chemotherapy, and hormonotherapy, were excluded. The published studies in journals without peer-reviewing proceedings and the articles that just including reports of case studies or case series were also excluded.

2.3. Study screening and data collection process

A protocol was designed for data extraction following the purpose of this review by three of the authors. Besides, every independently extracted data was discussed later by two of the authors. Conflicts were resolved by referring to the third researcher. Tables and figures were designed by two authors and review by the third one, finally.

Published data were considered and presented in this review, and therefore no approval of a research ethics committee was sought.

3. Results

Eventually, considering the explained search, extraction strategy, and inclusion/exclusion criteria yielded 168 involved publications deemed eligible. PRISMA flowchart summarizing the results of the literature search and study selection is illustrated in Fig. 1.

Lots of published recommendations exist to guide radio-oncology teams during the COVID-19 crisis. Recommendations support implementing standard/hypo-fractionation radiotherapy regimens, considering omission of radiotherapy for some cases with a high risk of coronavirus...
infection, and implementing alternatives to the previous patient’s preparation/fixation techniques. Moreover, there was consensus to delay radiotherapy/chemoradiation therapy for those with lesser priority, such as the elderly or fragile case. All of the included recommendations, guidelines, and consensuses are presented in Tables 1–4.

Figs. 2 and 3 illustrate the distribution of selected papers versus the cancer type and the distribution of included documents concerning the countries that presented them, respectively. As shown, the number of guidelines and consensus is almost related to the frequency of cancer type with radiotherapy indication as one of the treatment strategies. For instance, breast, gynecological, and prostate cancer include more than 32% of all diagnosed cancer type. About 23% of all cancer patients who need to receive radiotherapy also have one of these three malignancies around the world (Joiner et al., 2019).

4. Discussion

Numerous recommendations were consistently published to guide radiation oncologists in the era of the COVID-19 crisis. In the beginning, the radiotherapy of some cases was postponed; however, the pandemic has been taking an unexpectedly long time. Therefore, patient selection and prioritization protocols proposed alternative treatments and modification of delivery techniques (Chakraborty and Pandey, 2020). Making proper treatment comments require weighing the risk of infection exposure and the benefit of treatment in a careful manner. A comprehensive review was done to extract the essential recommendations and consensus for radiotherapy during the current pandemic. Fig. 1 summarized the results of the review based on the PRISMA protocol.

Fig. 2 indicates the distribution of papers versus the considered disease site in the coronavirus outbreak. As illustrated, the published recommendations’ rate matches the frequency of the most common cancer type worldwide. As presented in this figure, about 24% of the recommendations were related to the radiotherapy of breast and prostate malignancies. However, based on a recent meta-analysis, most death rates between COVID-19 infected cancer patients were associated with hematological malignancies followed by lung. The higher degree of immunosuppression utilized in treating patients with hematological malignancies was known as the reason for this significant death rate (Venkatesulu et al., 2020). Previous studies did not indicate any apparent connection between any anticancer treatment modality and the chance of COVID-19 mortality, while the higher intubation and fatality rate of cancer patients was reported (Garassino et al., 2020; Venkatesulu et al., 2020).

Fig. 3 shows the distribution of papers versus countries where released guidelines and determines treatment priorities for cancer patients during the coronavirus era. The countries extracted based on the publication’s author affiliation or the propounded departments. About 29% of these included articles came from the USA and UK based on this figure. Lots of the proposed radiotherapy guidelines are dependent on the existence of advanced radiotherapy facilities and techniques. Despite worldwide improvements in financial safety and service coverage, some significant gaps remain, particularly for the most vulnerable countries and nations such as the Asian and African countries. Many centers, even in developed countries, do not have MV/MeV radiotherapy facilities, based on the IAEA Directory of Radiotherapy Centers (DIRAC) database (I. A. E. A. (IAEA), 2021). Therefore, many centers cannot technically apply some of these recommendations, such as hypo-fractionated and short-course radiotherapy techniques.

According to Fig. 3, developing countries published less guidance to face this scope. They rarely addressed their consensus, which may be due to fewer radiotherapy centers/high-tech equipment comparing to the developed ones. Eventually, some of these prescribed consensuses or even international recommendations do not fit the facilities, equipment, and staff knowledge across the whole RT centers. Considering the availability of dedicated high-tech equipment and human resources and tailoring COVID-19 pandemic management strategies to the regional context was not only recommended but also seemed mandatory (Kochbati et al., 2020).
| Cancer type | Hold/Omit irradiation | Delay of radiation if required | Continue irradiation/Treatment |
|-------------|-----------------------|-------------------------------|--------------------------------|
| Re-irradiation for patients with recurrent GBM | - age ≥ 65 yrs: Hypo-F RT | - age < 65 yrs (KPS ≥ 70): standard fractionation (Noticewala et al., 2020a) | GBM: fractionation type depends on KPS (Combs et al., 2020) |
| Asymptomatic meningioma | | | |
| Low-grade glioma | | | |
| Craniopharyngioma | | | |
| Trigeminal Neurinoma | | | |
| Schwannomas | | | |
| GBM: Age > 60 yrs – methylated | | | |
| Asymptomatic meningioma, Asymptomatic AVM Asymptomatic schwannoma | | | |
| Low-grade glioma | | | |
| Low-grade glioma (as much as possible) | | | |
| Grade II meningiomas | | | |
| Recurrent meningiomas | | | |
| Schwannomas | | | |
| Pituitary adenomas | | | |
| Craniopharyngiomas | | | |
| CNS | | | |
| Grade II ependymoma | | | |
| GBM: Age > 65 yrs (esp. in poor PS) | | | |
| Anaplastic oligodendroglioma (up to 4-6 month) | | | |
| Low-grade glioma asymptomatic meningioma G1–2 | | | |

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Table 1 (continued)

| Cancer type                              | Hold/Omit irradiation                | Delay of radiation if required                        | Continue irradiation/ Treatment |
|------------------------------------------|--------------------------------------|-------------------------------------------------------|---------------------------------|
| GBM: Elderly with poor KPS/unmethylated  |                                      | - Grade 1, Grade 2, and Grade 3 meningiomas           | - Meningioma: (Hypo-F RT)       |
|                                          |                                      | - Schwannomas                                         |                                 |
|                                          |                                      | - Low-grade gliomas                                    |                                 |
|                                          |                                      | - GBM: Elderly with poor KPS/methylated:              |                                 |
|                                          |                                      | 34 Gy /10 frs or 5 Gy weekly × 6 weeks                     |                                 |
|                                          |                                      | - Low-grade gliomas                                    |                                 |
|                                          |                                      | - Hypo-F RT                                           |                                 |
|                                          |                                      | Grade 1, Grade 2: 25 Gy / 5 frs                        |                                 |
|                                          |                                      | Grade 3: 45 Gy in 15 fractions                         |                                 |
|                                          |                                      | - Schwannomas: frameless SRS/ Hypo-F RT (25 Gy / 5 frs) |                                 |
|                                          |                                      | - GBM:                                               |                                 |
|                                          |                                      | Elderly with poor KPS/methylated: 34 Gy /10 frs or 5 Gy weekly × 6 weeks |                                 |
| Asymptomatic meningioma grade I-II       |                                      |                                      |                                 |
| Asymptomatic AVM                         |                                      | - Grade 3 glioma (anaplastic oligodendrogioma) for 4–6 months | Non-co-deleted (anaplastic astrocytoma) |
|                                          |                                      | - Low-grade gliomas                                    | Hypo-F RT: 40 Gy/15 frs or 30 Gy/6 frs (Hinduja et al., 2020) |
| Adjuvant RT:                             |                                      | - SRS for asymptomatic AVM by few months               |                                 |
| -Meningioma (benign and atypical)        |                                      | - Adjuvant RT for primary spinal tumors in minimally symptomatic patients or patients with stable neuro-deficits |                                 |
| -Pituitary adenoma, schwannoma, and low-grade glioma |                                      | - Low-grade astrocytoma and 1p/19q co-deleted tumors |                                 |
| Multiple brain metastases                |                                      | - Hypo-F RT for poor PS and age> 70 yrs (40 Gy /15 frs or 34 Gy /10 frs) |                                 |
|                                          |                                      | - For medulloblastoma: craniospinal RT (4–6 weeks after surgery) with a possible start of the posterior fossa boost (IMRT or VMAT) (Stepanovi´c and Nikitovi´c, 2020) |                                 |
|                                          |                                      | - Standard RT for younger fit patients with GBM (60 Gy / 30 frs) or Hypo-F RT with 60 Gy / 20 frs (SIB) |                                 |
| Head and Neck                            |                                      | - Standard RT for younger fit patients with GBM (60 Gy / 30 frs) or Hypo-F RT with 60 Gy / 20 frs (SIB) |                                 |
|                                          |                                      | - Hypo-F RT: 40 Gy/15 frs or 30 Gy/6 frs (Hinduja et al., 2020) |                                 |
|                                          |                                      | - Low grade: RT after 3 months                        |                                 |
|                                          |                                      | - Radical: Do not defer until a rationale alternative (Simcock et al., 2020) |                                 |
|                                          |                                      | - Definitive RT: SIB techniques (standard or accelerated) (De Felice et al., 2020) |                                 |
|                                          |                                      | - Radical RT and High-risk postop cases (Wright et al., 2020) |                                 |
|                                          |                                      | - COVID-19+ patients (until recovery)                   |                                 |
|                                          |                                      | - COVID-19+ patients till recovery                     |                                 |
|                                          |                                      | - Delay but not more than 4.6 weeks:                  |                                 |
|                                          |                                      | - Oropharyngeal (T2N + M0)                            |                                 |
|                                          |                                      | - Laryngeal tumor (T3N1M0)                            |                                 |
|                                          |                                      | - Laryngeal glottic (T1bN0M0)                         |                                 |
| Cancer type | Hold/Omit irradiation | Delay of radiation if required | Continue irradiation/Treatment |
|-------------|-----------------------|--------------------------------|-------------------------------|
| Metastatic hypopharyngeal (T4N1M1) | Continue the standard fractionation scheme (Starling et al., 1992) | High priority: | |
| Oral cavity (pT2pN2aM0) | Palliative RT | | |
| | Adjuvant RT (lower/intermediate risk of recurrence) | | |
| | | | |
| | Palliative RT | | |
| | Adjuvant RT: R0 resection and minor risk factor | Post-op RT in patients with salivary gland tumors until 12 weeks after surgery | |
| | | | |
| | Adjuvant RT: R0 resection and minor risk factor | Post-op RT in patients with salivary gland tumors until 12 weeks after surgery | |
| | | | |
| | Post-op RT in patients with salivary gland tumors until 12 weeks after surgery | | |

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| Cancer type | Hold/Omit irradiation | Delay of radiation if required | Continue irradiation/ Treatment |
|-------------|-----------------------|-------------------------------|--------------------------------|
| Breast      |                       |                               | - High priority for treatment: radical RT for HNSCC and adjuvant RT for HNSCC with involved margin / High-growth mass and who undergoing curative radical (chemo) RT  
- Lower priority: adjuvant RT for HNSCC with minor risk factors  
- Limited and selected cases of OSCC, T4a laryngeal SCC, and advanced sinonasal malignancy: cCRT or RT  
- Radical RT in less aggressive cancers (definitive RT or adjuvant RT in rapid proliferating cancers with residue after surgery)  
- Adjuvant RT incomplete resection patients and palliative RT (lowest priority) (Salari et al., 2020)  
- Oropharynx/ larynx: CRT/RT for curative intent  
- Oropharynx (Early stage): RT preferred to surgery  
- Oropharynx (Locally advanced): cCRT  
- Locoregional advanced hypopharyngeal: cCRT (fit patients)  
- Nasopharynx (stage II-IV): NACT followed by CRT (IMRT)  
- Early glottic cancer: RT  
- Oral cavity (early resectable) and high-risk factors such as margin positivity and perinodal extension: cCRT (definite overall survival benefit)  
- Nasopharynx (stage III): RT (Talapatra et al., 2020)  
- Head-and-neck: RT as the main treatment (Carvalho et al., 2020)  
- Hypo-F CRT for head and cancer (68–70 Gy/34–35 frs; 60–66 Gy/30 frs; 55 Gy/20 frs): 65 Gy/30 frs rather than standard fractionation 70 Gy/35 frs  
- Locally advanced laryngeal cancer: 67.2 Gy/28 frs  
- Hypo-F RT alone: 60 Gy/25frs (T1-T3 N0- N2c HPV+ and T1-T2 N0 HPV-)  
- Oropharyngeal patients: 60 Gy/30 frs  
- Hypo-F accelerated RT: 64 Gy/25 frs  
- Locally advanced disease: IMRT (55 Gy/20 frs) (Vreugdenhil et al., 2020)  

Age > 70 yrs:  
- Completely excised (margin ≥ 1 mm)  
- Low-risk invasive disease (pT1/pN0, grades I-II, LV1 negative, ER+, HER2-, without extensive intra-ductal component)  
- Age > 55 yrs:  
- DCIS < 2.5 cm, grades I-II, and margin ≥ 1 mm  
- Adjuvant: replace alternatives (prioritize by age and other comorbidities)  

DCIS (Koch et al., 2020)  

Inflammatory BC or mastectomy  

Node+: TNBC or HER2+ disease  

Post-mastectomy with four or more nodes+  

Residual node + disease after NAC  

PMRT with 1-3 tumor + nodes  

Node+: TNBC or HER2+ (BCT) Positive margin after BCT for invasive BC with no alternative  

Age < 40 yrs:  
- BCT, node-negative with > 1 additional high-risk features (LV1+, PNI+)  
- ER- DCIS with a positive margin after surgery  

Adjuvant: prioritize by age and other comorbidities (Samiee et al., 2020)  

Bleeding  

Painful inoperable local-regional disease  

Symptomatic metastatic disease  

Progression of disease during neoadjuvant chemotherapy (Dietz et al., 2020; Breast cancer in the COVID-19 era [Online], 2021; Luther and Agrawal, 2020)  

Post-mastectomy  

Nodal irradiation  

After immediate reconstruction: Hypo-F RT  

Boost: Hypo-F RT or integrated with whole-breast irradiation

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Table 1 (continued)

| Cancer type | Hold/Omit irradiation | Delay of radiation if required | Continue irradiation/ Treatment |
|-------------|-----------------------|-------------------------------|---------------------------------|
| ER+ PR+, HER2 negative, Ki67 < 10% | Whole breast and node irradiation: - 26 Gy / 5 frs and 29 Gy at the tumor bed with an integrated boost dose of 5.8 Gy (IMRT, VMAT, IGRT) Partial irradiation of the breast: - Intra-operatively (30 Gy / 5 frs or 27.5 Gy /10 frs twice daily on the tumor bed with negative margin) Pre-op irradiation: - 40.5 Gy / 15 frs (54 Gy concomitant boost delivered 3.6 Gy daily) Elderly patients without indication for surgery: - Weekly 6.5 Gy for five weeks for a total of 32.5 Gy (a boost of two 6.5 Gy frs) (Pardoa et al., 2020) | | |
| Low or medium grade DCIS including non-palpable tumors, size < 25 mm with free margins | Breast/chest wall and nodal (moderate Hypo-F RT) (Coles et al., 2020) | | |
| Age ≤ 65 yrs (or younger with relevant co-morbidities) | Node negative tumors without boost RT (28–30 Gy in once weekly fr over five weeks or 26 Gy in 5 daily frs over one week) | | |
| An invasive tumor (up to 30 mm) Grade I-II, ER+, HER2- and node- (endocrine therapy) DCIS Boost RT (unless age ≤ 40 yrs, or over 40 yrs with significant risk factors for local relapse) Nodal RT: - Post-menopausal women for T1, ER+, HER2- G 1-2 tumors with 1-2 macro-metastases | | | |
| Boost RT (unless for age ≤ 60 yrs, high-grade tumors, inadequate margins) | | | |
| Age ≥ 65 yrs: Invasive breast cancer < 30 mm Clear margins Grade 1-2, ER+, HER2- Node- (planned for endocrine therapy) Low-risk DCIS or active surveillance/ carcinomas (Combs et al., 2020) CALGB/PRIME II | | | |
| ER+DCIS | | | |
| | | | |
| Post Mastectomy: T 1-2 N1 | Post-mastectomy and/or regional node(RT with moderate Hypo-F RT (42.5 Gy/16 frs or 40 Gy/15 frs) (Achard et al., 2020) | | |
| Early-stage Low-risk elderly breast cancer Boost in selected patients Nodal irradiation in selected patients Elderly patients with low risk of relapse (except for moderately or extremely Hypo-F RT) | Early breast cancer (Low-risk): Postop RT by six months | | |
| | Up to 3 months from diagnosis to treatment (Montesi et al., 2020a) | | |
| Elderly patients (underwent adjuvant endocrine therapy) | Moderately or extremely Hypo-F RT regimens (Vordermark, 2020a) | | |
| Hormone-sensitive stage I and II | Early-stage breast cancer (Slotman et al., 2020) Early cases (in situ neoplasia, small invasive carcinomas, luminal tumors): up to 2 months after the surgery Patients underwent chemotherapy before RT: up to 8 weeks | | |
| Adjuvant RT: age ≥ 65 yrs, with T1/T2N0 luminal tumors (endocrine therapy) | Moderate Hypo-F RT FAST: Once weekly fractions over five weeks (28–30 Gy) FAST-Forward: five daily fractions over one week (26 Gy) (Lancet et al., 2020) Normal fraction: young women (50–66 Gy) Hypo-F RT protocol: elderly women (42–53 2 Gy /15–19 frs) (Amaoui et al., 2020) | | |
| | Early cases (in situ neoplasia, small invasive carcinomas, luminal tumors): - IORT or accelerated partial breast RT (if available) | | |

(continued on next page)
| Cancer type | Hold/Omit irradiation | Delay of radiation if required | Continue irradiation/ Treatment |
|-------------|-----------------------|-------------------------------|---------------------------------|

**Breast conservation**

- DCIS
- Invasive disease

- Low risk (esp. older patients)
  - Age $>$ 65 yrs, ER +, HER2-

- Post-mastectomy T1-2 N1 (LN + breast cancer) (Marcus and Mahajan, 2020)
  - DCIS, RH +

- Adjuvant: Age $<$ 65 yrs (receiving hormonal therapy)
  - DCIS age $>$ 65 yrs (low-risk criteria) (Ismael et al., 2020)

**Negative axilla**

- Age $>$ 65 years (younger with comorbidities)
  - Breast cancer $<$ 3 cm with clear margins + grade 1/2 + ER + and HER2 - node- planned for endocrine therapy

- Omit boost or shift to Hypo-F RT (except in patients $<$ 40 years age and whom with a high risk of local recurrence)

- Omit nodal RT for Postmenopausal women with T1, grade 1-2, ER +, HER2 - tumor with 1-2 macro metastases requiring WBRT following BCS and sentinel node biopsy

- Boost: age $>$ 50 yrs with HR + and/or small HER2 + RT in which survival is not affected:
  - $>$ 65 yrs with an early stage, HR +, HER2 -, node-, grade I-II
  - After excision of a low-to-intermediate grade ER + DCIS.

If the boost is necessary:

- Postop RT: for several weeks or even months

- Adjunctive RT: up to 3 months after surgery

- Delay of definitive radiotherapy for good-risk tumors

**Boost RT in selected patients**

- Certain non-invasive carcinomas with good prognostic factors (Age $>$ 40 yrs, tumors $<$ 2.5 cm, low and intermediate grade, and sufficient surgical margins $>$ 2 mm)
  - Age $>$ 65 yrs (or with comorbidities) with invasive BC with good prognostic factors (grade 1-2, hormone-positive, tumors $<$ 3 cm, Node -, HER2 -)

- Boost for patients $>$ 40 yrs without risk factors (LVI, high grade, hormone-negative, and positive surgical margins)

- Whole breast +/- LN: Hypo-F RT (5frs) (Starling et al., 1992)

- Emergency periop breast RT: 26 Gy / 5 frs +/- Boost (SIB:6 GY / 5 frs or Sequential 10 Gy / 2 frs)

- Complete response tumor: 26 Gy / 5 frs Boost (SIB:6 GY / 5 frs totally 35 Gy / 5frs or sequential 10 Gy / 2 frs)

- Negative axilla: Not or 26 Gy / 5 frs to levels 1-4 if node-positive at presentation before primary systemic therapy

- Postop RT: for several weeks or even months

- Adjunctive RT (26 Gy in 5 daily fractions over 1 week or 28–30 Gy in 1 weekly fraction over 5 weeks):
  - Others who recognized to need whole or partial breast or chest wall: (Manoj Gowda et al., 2020)

- Neoadjuvant RT (40 Gy in 10 fractions then 30 Gy in 5 fractions over 1 week):
  - Invasive breast cancer with no systemic therapy option
  - Completion of all neoadjuvant therapy and triple-negative breast cancer
  - Loco-regional cancer progression/poor response despite the use of all available neoadjuvant therapies

- Adjuvant RT (26 Gy in 5 daily fractions over 1 week or 28–30 Gy in 1 weekly fraction over 5 weeks):
  - For postmenopausal patients $>$ 65 yrs with stage I or II and hormone-dependent breast cancer (Ng et al., 2020a)

- Hypo-F RT for adjuvant treatment (Ng et al., 2020a)

- HR +, HER2 - (Adjuvant setting): 42.6 Gy / 16 frs or 40 Gy / 15 frs (Hypo-F RT) (Raghavan et al., 2020)

- Adjuvant local RT in early-stage breast cancer: 26 Gy / 5 frs over 1 week is non-inferior to 40 Gy / 15 frs over 3 weeks for (UK FAST-forward trial) (Upadhyay and Shankar, 2020)

- Hypo-F RT for adjuvant treatment (Ng et al., 2020a)

- Adjuvant RT for high-risk BC:

- Low-risk disease

- In-situ carcinoma (CIS) by 3-6 months

- For postmenopausal patients $>$ 65 yrs with stage I or II and hormone-dependent breast cancer

- Stages T3 or N-positive

(continued on next page)
| Cancer type | Hold/Omit irradiation | Delay of radiation if required | Continue irradiation/ Treatment |
|-------------|-----------------------|-------------------------------|--------------------------------|
| Invasive breast cancers (node-negative): post-op, patients aged ≥ 65 yrs with HR+ tumors | | | |
| | | | |
| Abandon RT: | Postpone RT up to 20 weeks after the completion of surgical or systemic treatment: | | |
| | - Patients > 65 yrs, tumors up to 30 mm, N0, ER+, HER2, G 1-2, margins ≥ 2 mm, DCIS, especially with ER+, patients on hormone therapy. | | |
| | -Tumor T1, T2, N0 hormone-sensitive, HER2, > 40 yrs, patients on hormone therapy, unfavorable prognostic factors (close margins, G3) | | |
| Good risk DCIS: Low/intermediate grade, < 2.5 cm, margin >3 mm | DCIS: up to 12 weeks | EBC: Young premenopausal women | |
| EBC: | EBC post BCS: delay RT without chemotherapy up to 20 weeks | Locally advanced breast cancer | |
| | Good risk DCIS: ER/PR+ , EBC/DCIS | Boost dose for EBC: | |
| | ER + disease with N1a nodes (1-3 nodes)/ Node negative TNBC/Pathological N0 post-NACT / LVI | - Hypo-F RT | |
| Adjuvant RT (DCIS): low-risk cases (age ≥ 50 yrs with no necrosis, low grade, small tumor size, at least 2 mm margins) | | - Hypo-F RT | |
| | | -SIB or concomitant boost (daily or weekly) | |
| | | -5.2 Gy single fraction after ultra-Hypo-F RT | |
| | | Inflammatory breast cancer/Residual nodal disease after NACT/N2 disease (4 or more nodes)/Recurrent disease/Node positive TNBC/Extensive LVI (Hinduja et al., 2020) | |
| | | Adjuvant RT (DCIS): higher-risk cases (Hypo-F RT) | |
| | | -APBI:40 Gy/10fx, 38.5 Gy/10 fs twice a day over 5-8 days | |
| | | -FAST FORWARD regimen for WBI: 26 Gy / 5 daily frs | |
| | | Node negative invasive cancer: | |
| | | -Low-risk patients aged 40-64 yrs (maximum tumor size 3 cm, ER+) | |
| | | -APBI: 30 Gy / 5 fs daily (IMRT) or 40 Gy / 10 fs daily (3D CRT) | |
| | | WBE: 40 Gy / 15 fs (standard Hypo-F or FAST FORWARD regimen) | |
| Cancer type                     | Hold/Omit irradiation | Delay of radiation if required | Continue irradiation/ Treatment                                                                 |
|--------------------------------|-----------------------|--------------------------------|--------------------------------------------------------------------------------------------------|
| Lung                           |                       |                                |                                                                                                                                                         |
| SCLC-Extensive                 |                       |                                |                                                                                                                                                         |
| Early-stage (non-biopsied, slow growth, advanced age, or comorbidities) |                       |                                | Oligometastatic patients                                                                                                                                |
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| Cancer type   | Hold/Omit irradiation                                      | Delay of radiation if required | Continue irradiation/ Treatment                                                                 |
|--------------|-----------------------------------------------------------|--------------------------------|---------------------------------------------------------------------------------------------------|
| SCLC         | Consolidation RT or PCI in patients with SCLC and extensive disease. PCI in patients with SCLC with limited disease (Starling et al., 1992) |                                 |                                                                                                   |
|               | **NSCLC**: stage I-II NSCLC (SBRT) stage II               |                                 |                                                                                                   |
|               | (node positive) - III NSCLC, stage IV NSCLC               |                                 |                                                                                                   |
|               | SCLC: limited-stage (stage I-III), extensive-stage (stage III-IV) |                                 |                                                                                                   |
|               | Palliative RT (Rathod et al., 2020)                       |                                 |                                                                                                   |
|               | NSCLC (curative treatment: SABR)                          |                                 |                                                                                                   |
|               | Stage I-II patients (1-3 frs):                            |                                 |                                                                                                   |
|               | - 30–34 Gy /1 fr for tumors < 2 cm and ≥ 1 cm from the chest wall |                                 |                                                                                                   |
|               | - 48–54 Gy / 3 frs over one week for peripheral lesions    |                                 |                                                                                                   |
|               | - Mild Hypo-F RT (45–60 Gy / 4-8 frs) for central and ultra-central lesions |                                 |                                                                                                   |
|               | Stage II-III patients:                                   |                                 |                                                                                                   |
|               | - 55 Gy / 20 fs                                          |                                 |                                                                                                   |
|               | Stage III inoperable:                                    |                                 |                                                                                                   |
|               | - Accelerated Hypo-F RT (45 Gy /15 frs)                   |                                 |                                                                                                   |
|               | Stage I-II SCLC (3-5 frs) in peripheral lesions:          |                                 |                                                                                                   |
|               | - 60 Gy / 3 frs                                          |                                 |                                                                                                   |
|               | - 48 Gy / 4 frs                                          |                                 |                                                                                                   |
|               | - 50 Gy / 5 frs                                          |                                 |                                                                                                   |
|               | Limited-stage SCLC:                                      |                                 |                                                                                                   |
|               | - Early or upfront cCRT (thoracic RT / 15 days: 45 Gy / 30 twice daily 1.5 Gy fs) are comparable to the twice-daily regimen: 40–42 Gy /15 daily frs or 50–55 Gy / 20–25 daily frs |                                 |                                                                                                   |
|               | Stage III NSCLC (accelerated fractionation ((55 Gy / 20 frs)/ IMRT/VMAT) |                                 |                                                                                                   |
|               | Early-stage SCLC: SABR for T 1-2 N0M0                    |                                 |                                                                                                   |
|               | Limited-Stage (LS) SCLC (good PS): 40 Gy / 15 frs         |                                 |                                                                                                   |
|               | (Faivre-Finn et al., 2020)                               |                                 |                                                                                                   |
|               | Curative-intent RT (reduction of the fraction)           |                                 |                                                                                                   |
|               | Early-stage NSCLC:                                       |                                 |                                                                                                   |
|               | 1. single-fraction SABR: 30–34 Gy for tumors < 2 cm, > 1 cm from the chest wall |                                 |                                                                                                   |
|               | Non-surgical treatment (esp. elderly patients with locoregionally advanced tumors or oligometastatic disease) (Vordermark, 2020c) |                                 |                                                                                                   |
|               | SCLC: -CRT followed by PCI for limited-stage disease     |                                 |                                                                                                   |
|               | -Chemotherapy followed by RT and PCI for extensive-stage disease |                                 |                                                                                                   |
|               | RT alone if chemotherapy is challenging. Peripheral stage I/IA NSCLC (SBRT) |                                 |                                                                                                   |
|               | Stage IIB/II NSCLC: sequential radiation and chemotherapy |                                 |                                                                                                   |
|               | RT: definitive treatment, pre-op treatment, and postop RT, extra-capsular extension or |                                 |                                                                                                   |

(continued on next page)
### Table 1 (continued)

| Cancer type                      | Hold/Omit irradiation                  | Delay of radiation if required                                                                 | Continue irradiation/Treatment                                                                 |
|----------------------------------|----------------------------------------|-------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------|
|                                   |                                        | positive margins, gross residual disease (Parashar et al., 2020)                                |                                                                                                 |
|                                   |                                        | Peripheral early-stage NSCLC (T1-T2): Single-Fraction SBRT (34 Gy / 1 fr vs. 48 Gy / 4 frs)      |                                                                                                 |
|                                   |                                        | Central Lung Tumors: Multi-fraction SBRT (Sylvia et al., 2020)                                  |                                                                                                 |
|                                   |                                        | Treating lung cancer with SBRT in 1–5 frs (Upadhyay and Shankar, 2020)                          |                                                                                                 |
|                                   |                                        | NSCLC: -CRT for stage III - Palliative or ablative radiotherapy (SBRT): compression of airways or bleeding |                                                                                                 |
|                                   |                                        | SCLC: - CRT for limited-stage - Palliative or ablative radiotherapy (SBRT) (Omeroglu Simsek, 2020) |                                                                                                 |
|                                   |                                        | Thoracic consolidation radiotherapy                                                             |                                                                                                 |
|                                   |                                        | extensive stage                                                                                |                                                                                                 |
|                                   |                                        | SBRT (reduced from 8 frs to 5 or 3) and palliative RT in single or 2 frs (8–10 Gy or 17 Gy, respectively). |                                                                                                 |
|                                   |                                        | Extensive-stage SCLC: PCI                                                                      |                                                                                                 |
|                                   |                                        | Postpone initiation of treatment by 4 weeks:                                                   |                                                                                                 |
|                                   |                                        | - Post-Operative Radiotherapy (PORT)                                                          |                                                                                                 |
|                                   |                                        | NSCLC - Prophylactic Cranial Irradiation (PCI)                                                 |                                                                                                 |
|                                   |                                        | SCLC - Hypo-F RT regimens (Bakhribah et al., 2020)                                            |                                                                                                 |
|                                   |                                        | - Stage I NSCLC: 45–54 Gy / 3 frs or 48–50 Gy / 4 or 5 frs or 30–34 Gy / 1 fr in select patients (SBRT/ablation) |                                                                                                 |
|                                   |                                        | - Locally advanced NSCLC (stage III): 60 Gy / 24 frs or 55 Gy / 20 frs or up to 60 Gy / 15 frs (Hypo-F RT schedule) |                                                                                                 |
|                                   |                                        | Extensive SCLC (PCI or palliative intent)                                                      |                                                                                                 |
|                                   |                                        | SCLC, Extensive:                                                                               |                                                                                                 |
|                                   |                                        | - PCI                                                                                                                                               |                                                                                                 |
|                                   |                                        | NSCLC, T1/2N0M0, medically inoperable; peripheral:                                               |                                                                                                 |
|                                   |                                        | - SBRT 30–34 Gy /single fr (T1 N0M0)                                                           |                                                                                                 |
|                                   |                                        | - 54 Gy / 3 frs in 1.5 weeks (Eligibility includes T1, 2 (<5 cm), T3 < 5 cm, chest wall involvement positive, no mediastinal or bronchial tree invasion) |                                                                                                 |
|                                   |                                        | - 48 Gy / 4 frs daily RT NSCLC, T1/N0M0, medically inoperable, central:                       |                                                                                                 |
|                                   |                                        | - 60 Gy / 8 daily frs                                                                          |                                                                                                 |
|                                   |                                        | - 70 Gy / 10 daily frs                                                                          |                                                                                                 |
|                                   |                                        | - 50 Gy / 5 daily frs                                                                           |                                                                                                 |
|                                   |                                        | Stage III, Locally advanced NSCLC:                                                              |                                                                                                 |
|                                   |                                        | - 55 Gy / 20 frs with concurrent sequential chemotherapy                                         |                                                                                                 |
|                                   |                                        | - 60 Gy / 15-20 frs                                                                            |                                                                                                 |
|                                   |                                        | NSCLC, advanced - inoperable, large for Palliative RT: 8–10 Gy / 1-2 frs                       |                                                                                                 |
|                                   |                                        | SCLC, localized: 40-42 Gy /15 daily frs (Hinduja et al., 2020)                                 |                                                                                                 |
|                                   |                                        | Curative treatment for stage III NSCLC: Hypo-F in cCRT strategy (60–66 Gy / 22–30 frs and 50 Gy / 20 frs) |                                                                                                 |
|                                   |                                        | Inoperable stage II-III NSCLC                                                                  |                                                                                                 |
|                                   |                                        | Limited stage SCLC:                                                                            |                                                                                                 |
|                                   |                                        | Palliative NSCLC (spinal cord compression or SVCO)                                              |                                                                                                 |
|                                   |                                        | Early-stage NSCLC: SABR:30–34 Gy /1 fr to 48–54 Gy / 3 frs                                    |                                                                                                 |
|                                   |                                        | Central tumors: Hypo-F RT (50–60 Gy /15 frs)                                                   |                                                                                                 |
|                                   |                                        | Inoperable early-stage NSCLC and operable NSCLC: SBRT                                         |                                                                                                 |
|                                   |                                        | Stage II NSCLC: definitive RT (Stepanović and Nikitović, 2020)                                 |                                                                                                 |

(continued on next page)
### Table 1 (continued)

| Cancer type | Hold/Omit irradiation | Delay of radiation if required | Continue irradiation/ Treatment |
|-------------|-----------------------|-------------------------------|---------------------------------|
| Adjuvant RT (pathological N2 or R1 post-op): after chemotherapy or 3 months after surgery | Early-stage disease: SBRT for tumors <2.0 cm (a single fraction of 30 – 34 Gy) | | |
| | Adjuvant Hypo-F RT: 50 – 60 Gy /25–30 frs | | |
| | Locally advanced disease (clinical stage III): cCRT (mild Hypo-F:50 Gy /20frs) | | |
| | SCLC extensive disease: 45 Gy/15 frs or 30 Gy /10 frs | | |
| | SCLC limited disease: SBRT (Arrieta et al., 2020) | | |
| Patients with known SARS-CoV-2 or active COVID-19: for a few weeks until resolving symptoms and subsiding inflammation | Lung cancer: IMRT and proton beam therapy (Iiwang et al., 2020) | | |
| Delay RT for 1–2 months: sequential CRT instead of cCRT | Lung RT (palliative): 30-39 cGy / 10–13 frs (Elkhousy et al., 2020) | | |
| | SBRT or SABR for early-stage (<5 cm) node-negative NSCLC: –50-70 Gy/5-10 frs for central tumors | | |
| | -A single fraction of 24-4 Gy for peripheral tumors < 2 cm | | |
| | Locally advanced lung cancer (stage III NSCLC): Hypo-F RT (55 Gy/20 frs) (Dingemans et al., 2020) | | |
| Delay SBRT for small, slow-growing tumors | Lung cancer: IMRT and proton beam therapy (Iiwang et al., 2020) | | |
| Postponing SBRT in indolent tumors | No Postpone RT start | | |
| NSCLC and SCLC: Interruption for suspected or confirmed case of COVID-19 within 15 days | Limited disease: no changes | | |
| | Extensive disease: PCI and thorax consolidation | | |
| | No Postpone RT start (Carvalho et al., 2020) | | |
| High priority: | -SCLC limited disease stage I/II and III: cCRT | | |
| | -Inoperable NSCLC Stage III: cCRT (Concomitant or sequential) | | |
| | -Inoperable stage II to III: RT (contraindications for C) | | |
| Extensive stage SCLC: MRI active surveillance instead of PCI (after C) | -SCLC limited disease stage II/III and SCLC limited disease: cCRT | | |
| | - SVCO or significant hemoptysis, spinal cord compression, or any threatening lesion: RT | | |
| | Medium priority: | | |
| | -Stage I: SABR or SBRT | | |
| | -Limited SCLC: PCI (after C) (Passaro et al., 2020) | | |
| | Stage I NSCLC (SBRT): | | |
| | -Safe Zone: 30-34 Gy/1 fr; 54 Gy / 3 frs | | |
| | -Peripheral Lesions: 48 Gy /4 frs | | |
| | -Central Tumor: 50- 60 Gy / 5 frs vs. 60 Gy /8 frs | | |
| | Stage III NSCLC: | | |
| | - CRT: 60-66 Gy /30-33 frs | | |
| | Stage III NSCLC (RT Alone/sequential): | | |
| | - 55 Gy / 20 frs; 45 Gy / 15 frs | | |
| | LS-SCLC: | | |
| | - CRT 60-66 Gy /30-33 frs over 6- 6.5 weeks, or 45 Gy /30 frs over 3 weeks (twice a day: 1.5 Gy) | | |
| | PCE: 25 Gy /10 frs (Counago et al., 2020) | | |
| | Definitive: CRT (OSCC and OAC) if not Hypo-F RT (50 Gy/16 frs for tumors > 5 cm or 55 Gy /10 frs for tumors > 10 cm) | | |
| | Neoadjuvant: Hypo-F CRT (40 Gy / 15 frs) | | |
| | Palliative (8 Gy / 1 fr or 20 Gy / 5 frs) (Jones et al., 2020a) | | |
| | Neoadjuvant therapy plus surgery vs. surgery vs. dCRT (Combs et al., 2020) | | |
| | Curative-intent esophageal cancer (Wright et al., 2020) | | |
| | Locally advanced (T2N + or T3+N/any) operable esophageal carcinoma | | |
| | Neoadjuvant CRT (41 Gy / 23 frs or 40 Gy /15 frs) | | |
| | Inoperable esophageal cancer: dCRT (50 Gy / 25 frs) | | |

(continued on next page)
| Cancer type                  | Hold/Omit irradiation | Delay of radiation if required | Continue irradiation/ Treatment                                                                                                                                 |
|-----------------------------|-----------------------|--------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Definitive RT: Hypo-F RT (50 Gy / 16 or 20 frs) |                                      |                                |  |
| Palliative RT (6-8 Gy / 1 fr for pain or bleeding, or 20 Gy /5 frs for dysphagia) (Tchelebi et al., 2020) |                                      |                                |  |
| If surgery or cCRT is challenging (RT alone) Pre-op RT just in case of availability of surgery in a few weeks |                                      |                                | Definitive RT Post-op RT (Parashar et al., 2020) Gastroesophageal junction (Montesi et al., 2020a)                                               |
| Priority level 1: Rapidly proliferating tumors currently being treated with radical RT with curative intent |                                      |                                | Priority level 2: Urgent palliative RT (malignant spinal cord compression: 8 Gy / 1 fr or 20 Gy / 5 frs) Priority level 3: - Radical RT for less aggressive tumors - Postop RT (determined residual disease after surgery in tumors with aggressive biology) Priority level 4: Palliative RT (alleviation of symptoms) Priority level 5: Adjuvant RT (Jones and Crosby, 2021) |
| Priority level 5: Adjuvant chemotherapy or CRT (Vordermark, 2020a) |                                      |                                |  |
| Resectable/ Unresectable (Marcus and Mahajan, 2020) |                                      |                                | Adjuvant CRT: up to 12 weeks                                                                                                                                                                     |
| Palliative: alternatives to RT |                                      |                                |  |
| Locally advanced (TanyNanyM0): - Neoadjuvant CRT - Adjuvant (Postoperative radiation) |                                      |                                |  |
| Adjuvant curative RT (Kochbati et al., 2020) |                                      |                                | Postpone RT up to 3 months in indolent disease (Carvalho et al., 2020)                                                                                                                                   |
| Operable and resected cases: RT may be avoided |                                      |                                |  |
| Stomach: No neoadjuvant or adjuvant RT |                                      |                                | Palliative RT (6-8 Gy / 1 fr) (Tchelebi et al., 2020) Perioperative: neoadjuvant chemotherapy/ CRT, adjuvant chemotherapy /CRT Preoperative RT to delay surgery Postoperative RT (Parashar et al., 2020) Non-surgical approach for non-urgen gastrointestinal cancer (Vordermark, 2020a) |
| Gastrointestinal: within 3 months Stomach: up to 3 months (Carvalho et al., 2020) |                                      |                                |  |
| Unresectable (Marcus and Mahajan, 2020) |                                      |                                |  |
| Unresectable/locally advanced: - Neoadjuvant radiation therapy: SBRT (30-33 Gy / 5 frs) without SBRT, 25 Gy / 5 frs, or 30 Gy in 10 frs - Unresectable/locally advanced: - Radiation therapy (SBRT/ single fraction (8-10 Gy) for palliation) (Tchelebi et al., 2020) Pancreatic cancer receiving dCRT (Hypo-F RT/ CRT wherever feasible) Borderline resectable / resectable patients in lack of surgery (neo-adjuvant Hypo-F RT 25-35 Gy / 5 frs or CRT: 36 Gy / 15 frs) LAPC: Hypo-F CRT (45 Gy / 15 frs) or RT (25-35 Gy / 5 frs) Palliative RT (8 Gy / 1 fr) (Mukherjee and Jones, 2021) |                                |  |
| Palliative: alternative non-RT procedure |                                      |                                |  |

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### Table 1 (continued)

| Cancer type | Hold/Omit irradiation | Delay of radiation if required | Continue irradiation/ Treatment |
|-------------|-----------------------|---------------------------------|--------------------------------|
| CRT: prevent local recurrence (adjuvant) / decrease local progression (locally advanced) | Unresected pancreatic adenocarcinomas: short-course SBRT (30-45 Gy / 3 frs or 25-45 Gy / 5 frs) | Resectable preoperative CRT: 36 Gy / 2.4 Gy frs | Resected pancreatic adenocarcinoma RT (tumor bed, surgical anastomoses, and adjacent lymph node) (Parashar et al., 2020) | Locally advanced and borderline resectable: Multi-fraction SBRT (Sylvia et al., 2020) |
| - Hypo-F RT: 45 Gy/15 frs (cCRT) | - Hypo-F RT: 25-35 Gy /5 frs (Hinduja et al., 2020) | In case of the direct invasion of the bowel and stomach | Borderline pancreatic cancers: SBRT (Talapatra et al., 2020) | Neoadjuvant SBRT (Carvalho et al., 2020) |
| Early-stage HCC, Following resection, Intermediate stage HCC, Locally advanced HCC with vascular invasion (TACE/Y90 or SBRT) | - Liver metastases: Chemotherapy then resection or RFA or SBRT (Tchelebi et al., 2020) | Palliative (Kochbati et al., 2020) | Operable cholangiocarcinoma | Curative-intent gallbladder/bile duct cancer (Wright et al., 2020) |
| BCLC 0 or BCLC A: SBRT and proton beam therapy | BCLC B: RT (e.g., SBRT, proton beam therapy, or systemic RT BCLC C: -RT (45 Gy / 15 frs) -Patients with hepatocellular carcinoma and portal vein thrombosis: SBRT (Barry et al., 2020) | Inoperable cholangiocarcinomas: Induction chemotherapy then RT (Tchelebi et al., 2020) | RT for local control and at tumor bed (high-risk diseases, e.g., T4) | Preoperative (+/- concomitant chemotherapy) or postoperative RT (Parashar et al., 2020) |
| BCLC D: RT (e.g., SBRT, proton beam therapy, or systemic RT BCLC C: -RT (45 Gy / 15 frs) -Patients with hepatocellular carcinoma and portal vein thrombosis: SBRT (Barry et al., 2020) | Curative-intent rectal cancer (Wright et al., 2020) | Stage I disease: | Locally advanced (T2N+ or T 3-4 /Nany) operable rectal: | Neoadjuvant treatment: Short-course RT (Achard et al., 2020) |
| -Neoadjuvant radiation (long-course CRT / short-course RT: 5 Gy / 5 frs) | - Inoperable: definitive RT | -Adjuvant (low risk of local failure) | - Preference: RT alone (52 Gy / 20 frs or 25 Gy / 5 frs) over long-course CRT (Tchelebi et al., 2020) | RT/CRT (Combs et al., 2020) |
| Elective priority treatments (Montesi et al., 2020a) | Short-course preoperative RT (Starling et al., 1992) | Rectal | Locally advanced (short-course RT: (25 Gy / 5 frs) T3N0-2 / T4 (Lancia et al., 2020) | Early and Intermediate Rectal Cancer: - SCRT/ CRT - T1/T2N0: Hypo-F RT (25 Gy/5 frs) and delay Locally Advanced Rectal Cancer: Non-margin threatening disease: SCRT instead of lCRT In Threatening or involving the margin or pelvic sidewall: | (continued on next page) |
Table 1 (continued)

| Cancer type                          | Hold/Omit irradiation                  | Delay of radiation if required | Continue irradiation/ Treatment |
|--------------------------------------|----------------------------------------|-------------------------------|--------------------------------------|
| Colorectal cancer (not elective)     | Post Op RT and palliative RT (if pain controlled) | Post Op RT and palliative RT (if pain controlled) | Early / intermediate risk (Muirhead et al., 2021) |
|                                      |                                        | T3 and M1: a short course of pelvic RT (25 Gy / 5 frs) + surgery (one-week interval) | Conventional fractionation for postop rectal cancer (tumor bed plus boost) |
|                                      |                                        | Unresectable: RT alone        |                                       |
|                                      |                                        | Protons (Parashar et al., 2020) |                                       |
|                                      |                                        | Long-course CRT (surgery: after 12 weeks) (Vordermark, 2020a) | Intermediate risk: SCRT where needed |
|                                      |                                        | Locally advanced: SCRT followed by chemotherapy |                                       |
| Early-stage: Post-op RT              | Low-risk cases                         | Adjuvant RT in T4, margin positivity, N2 disease |                                       |
|                                      |                                        | High-risk cases: LCRT (Lewis and Talapatra, 2020) |                                       |
|                                      |                                        | T 1-2 N+ / T3N ± (with > 2 mm MRF-D): SCRT (25 Gy / 5 frs) |                                       |
|                                      |                                        | T3N ± (with ≤ 2 mm MRF-D) / T4 disease: LCRT (45–50.4 Gy / 25–28 frs) |                                       |
|                                      |                                        | Unresectable: Brachytherapy with a dose of 10–20 Gy / 2–4 frs upon SCRT (Siavashpour et al., 2020) |                                       |
|                                      |                                        | LCRT for threatening margins converted to SCRT: 25 Gy / 5 daily frs (Hinduja et al., 2020) |                                       |
|                                      |                                        | Possible neoadjuvant SCRT: 25 Gy / 5 frs followed (within 1 week) by surgery (unless T4b or extension into the anal canal) (Elkhoubi et al., 2020) |                                       |
|                                      |                                        | Locally advanced rectal cancer: - SCRT (25 Gy / 5 frs) followed by delayed surgery (5–13 weeks) |                                       |
|                                      |                                        | In the case of involved circumferential margin or clinical T4 disease: - LCRT (50.4–54 Gy / 28–30 frs) (De Felice and Petrucciani, 2020a) |                                       |
|                                      |                                        | Neoadjuvant SCRT: 25 Gy / 5 frs (Talapatra et al., 2020) |                                       |
|                                      |                                        | Neoadjuvant RT: 5 Gy / 5 frs (followed by C between RT and surgery) (Carvalho et al., 2020) |                                       |
|                                      |                                        | Curative-intent anal cancer (Wright et al., 2020) |                                       |
|                                      |                                        | Local or locally advanced (TanyNanyM0) All non-metastatic cases (CRT) (Tchelebi et al., 2020) |                                       |
|                                      |                                        | Elective priority treatments (Montesi et al., 2020a) |                                       |
|                                      |                                        | dCRT: current standard of care Elderly patients (poor PS): less intensive treatment schedule: - Hypo-F RT 30 Gy /15 frs (cCRT) (O’Cathail et al., 2020) |                                       |
|                                      |                                        | Standard radical CRT (Hypo-F RT: (30 Gy /15 frs or 30 Gy /10 frs) (Muirhead et al., 2021) |                                       |
|                                      |                                        | Standard treatment: cCRT Low-risk / high-risk elective nodal PTV T 1-2 lesions with residual disease, T 3-4 lesions, or N1 lesions Protons (Parashar et al., 2020) |                                       |
|                                      |                                        | Non-metastatic cases: a) cCRT: standard fractionation schedules b) No cCRT: moderate Hypo-F RT (50 Gy/20 frs) (Talapatra et al., 2020) |                                       |

(continued on next page)
| Cancer type                     | Hold/Omit irradiation | Delay of radiation if required | Continue irradiation/Treatment |
|--------------------------------|-----------------------|-------------------------------|--------------------------------|
| **Renal Cell Carcinoma (RCC)** |                       |                               | Where RT is the main treatment: No changes/no postpone RT (Carvalho et al., 2020) |
|                                |                       |                               | Unresectable: 26 Gy / 1 frs or 14 Gy / 3 frs |
|                                |                       |                               | Poor surgical candidates: 25 Gy / 1 frs |
|                                |                       |                               | Medically inoperable: 24-48 Gy / 4 frs or 21-48 Gy / 3 frs (Parashar et al., 2020) |
|                                |                       |                               | Primary RCC in unresectable or comorbid patients: single-fraction SBRT (Sylvia et al., 2020) |
|                                |                       |                               | Curative-intent bladder cancer (Wright et al., 2020) |
|                                |                       |                               | Muscle invasive (CRT) (reduction of fractionation) |
|                                |                       |                               | Muscle invasive, N0 – Bladder only (reduction of fractionation) (Simcock et al., 2020) |
|                                |                       |                               | Radical RT (shorten treatment schedule: 55 Gy /20 frs) |
|                                |                       |                               | Palliative RT: |
|                                |                       |                               | - Improvement of local symptoms (21 Gy / 3 frs) |
|                                |                       |                               | - Good local control (36 Gy / 6 frs) |
|                                |                       |                               | - Bleeding or local symptom control (8-10 Gy / 1 fr) (Birtle et al., 2021) |
|                                |                       |                               | Unresected bladder cancers (Whole bladder +/− pelvic nodes): |
|                                |                       |                               | - Conventional or accelerated Hypo-F RT +/− boost (55 Gy / 20 frs) or SIB to gross sites) (Parashar et al., 2020) |
|                                |                       |                               | No changes of RT: Hypo-F RT for bladder |
|                                |                       |                               | No Postpone RT start |
|                                |                       |                               | No interruption if the patient is a suspected or confirmed case of COVID-19 (Carvalho et al., 2020) |
| **Bladder**                    |                       |                               | If an alternative exists (Prioritize by age and other comorbidities) (Samies et al., 2020) |
|                                |                       |                               | Low and favorable intermediate-risk (primary setting if not detrimental) |
|                                |                       |                               | Low risk (using ADT, active surveillance, or hormonal deprivation) (Combs et al., 2020) |
|                                |                       |                               | Intermediate and high risk: delay of radical treatment by neo-adjuvant hormonal therapy strategies. |
|                                |                       |                               | All other curative-intent prostate cancers |
| **Genitourinary**              |                       |                               | High-risk: RT plus androgen deprivation (No shift towards increased use of extreme Hypo-F RT) (Achard et al., 2020) |
|                                |                       |                               | Early salvage RT over adjuvant RT after radical |
|                                |                       |                               | Shorter RT regimen (60 Gy / 20 frs or even 5-6 frs in total) (Lancia et al., 2020) |
|                                |                       |                               | Curative-intent high-grade prostate cancer (Wright et al., 2020) |
|                                |                       |                               | Reduction of fractionation: Intermediate/high risk, Prostate only |
| **Prostate**                   |                       |                               | Unfavorable intermediate/high/very high risk, Postop |
|                                |                       |                               | High risk or M1 |
|                                |                       |                               | Low/intermediate risk |
|                                |                       |                               | Post-prostatectomy, Fossa only (Simcock et al., 2020) |
|                                |                       |                               | Low, favorable intermediate risk (Marcus and Mahajan, 2020) |
|                                |                       |                               | Very low-/ low/favorable intermediate-risk disease |
|                                |                       |                               | Unfavorable intermediate-/high-/very high risk |
|                                |                       |                               | Post-prostatectomy |
|                                |                       |                               | Clinical node-positive |
|                                |                       |                               | Oligometastatic |
|                                |                       |                               | Low volume M1 (Zaorsky et al., 2020) |
|                                |                       |                               | Oligometastatic HSPC |

(continued on next page)
Table 1 (continued)

| Cancer type | Hold/Omit irradiation | Delay of radiation if required | Continue irradiation/ Treatment |
|-------------|-----------------------|-------------------------------|---------------------------------|
| Localized low-risk (very low-, low- and favorable-intermediate-risk) | Localized high-risk (unfavorable-intermediate-risk, high-risk, and very high-risk) | Advanced (clinical nodal involvement, BCR post-primary treatment, metastatic disease): - Early salvage RT over adjuvant RT - Node-positive prostate without metastases: ADT and Hypo-F RT | Oligometastatic HSPC |
| Oligometastatic HSPC | - Painful bone metastases or bone metastases at high risk of fracture (weight-bearing bone): short-course palliative RT (Kokorovic et al., 2020) | Localized high-risk and very high-risk diseases with positive ganglions: (neoadjuvant androgen deprivation therapy) (Ismael et al., 2020) | Low/very low risk |
| Low/very low risk | Intermediate-risk (No rush to initiate any prostate RT) | High priority: symptomatic palliative /radical high-risk/prostate bed | Receiving neo-adjuvant hormonal therapy and not commenced RT |
| Low risk: kept on surveillance, no urgency in therapy | Low priority: radical low/intermediate-risk prostate (Alonzi et al., 2021) | Low, Intermediate, and High-Risk Prostate Cancer: - Moderate Hypo-F RT: 60 Gy / 20 frs, 70 2 Gy / 26 frs, or 70 Gy / 28 frs - Conventional fractionation: 66.6 - 90 Gy / 37 – 45 frs | Very Low Risk -Low Risk and Intermediate Risk: - 78 Gy/39 frs (Conventional Fractionation) - 60 Gy/20 frs or 70 Gy/28 frs (Moderate Hypo-F RT) |
| Very low/low risk | Moderate Hypo-F RT (Griffiths et al., 2021) | Ultra-Hypo-F RT in low/low-intermediate risk: 36.25 Gy/5 frs or 60 Gy/20 frs | Unfavorable intermediate-risk and High-risk: Very high risk: Neoadjuvant RT (preferably Hypo-F and without fiducial marker or rectal spacer insertion) (Obek et al., 2020) |
| Brachytherapy | Unfavorable intermediate risk: 36.25-40 Gy / 5 frs or 60 Gy/20 frs | Post-prostatectomy/salvage: 52.5 Gy/20 frs (Caicedo-Martínez et al., 2020) | Multiple neoplasms: Multiple neoplasms: Hypo-F RT |
| Multiple neoplasms: | -Postop RT for 2 weeks / Prostate cancer under ADT for 2 weeks | Ultra-Hypo-F RT in low/low-intermediate risk: 36.25 Gy/5 frs (Griffiths et al., 2021) | Extreme Hypo-F: 36 Gy / 6 frs for elderly, frail, or metastatic patients (Martell et al., 2020) |
| -Omit RT in low and favorable intermediate-risk and for oligometastatic prostate cancer | -Delay RT for low/intermediate-risk prostate disease | Extremely Hypo-F: 36 Gy/6 frs for elderly, frail, or metastatic patients (Martell et al., 2020) | Unfavorable Intermediate risk/High/very high risk: N=:
| Prostate: Delay RT for very low, low, and favorable intermediate-risk disease | N=:
| Very low/low risk | Favorable Intermediate risk | Unfavorable Intermediate risk/High/very high risk: N=:
| -Modest Hypo-F RT: 60 Gy/20 frs | -Ultra Hypo-F: 42.7 Gy/7 frs every other day or 36 Gy/6 frs (6 weeks) | -Adjuvant RT: Standard (33-35 frs) / Hypo-F RT (60 Gy/20 frs) in high-risk features |

(continued on next page)
| Cancer type                     | Hold/Omit irradiation                  | Delay of radiation if required                                                                 | Continue irradiation/ Treatment                                                                 |
|--------------------------------|---------------------------------------|------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------|
| Oligometastatic: SABR (1 or 3 frs) | Radical treatment: up to 6 months if the patient receiving hormonal therapy | Possible Hypo-F: 60 Gy / 20 frs (IMRT) (Elkhously et al., 2020)                                         | Low volume M1: 5 or 6 frs (Ilinduja et al., 2020)                                             |
| Low volume M1: 5 or 6 frs (Hinduja et al., 2020) | Low-risk and favorable intermediate-risk; unfavorable intermediate-risk; high-risk, very high-risk, and N + patients: 5 /20 frs | Adjuvant/salvage RT: 20 frs                                                                      | Oligometastatic + low volume metastatic disease: 3–5 frs RT (Talapatra et al., 2020)            |
| Very low-risk                  | Low-risk and favorable intermediate-risk |                                                                                                  |                                                                                                |
| Low or intermediate-risk in hormone therapy, and high risk with only one risk factor: RT after 3 months | Postpone RT start: Interruption for a suspected or confirmed case of COVID-19 within 15 days     |                                                                                                  | Vad Hype-F (Carvalho et al., 2020)                                                              |
| Elderly with favorable tumors  | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
| Testicular                     | Seminoma, stage I (Simcock et al., 2020) |                                                                                                  |                                                                                                |
| Cervical                       | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
| Gynecological                  |                                        |                                                                                                |                                                                                                |
| Cervical                       |                                        |                                                                                                |                                                                                                |
| Up to 8–12 weeks:              | - Inoperable cases or refuse surgery (Stage IA1, IA2) |                                                                                                  |                                                                                                |
|                                | - Postoperative (Stage IA1-IB2) with indication for adjuvant RT |                                                                                                  |                                                                                                |
|                                | - Postoperative cases with positive pelvic (or PA nodes), surgical margins, or parametria (CRT) |                                                                                                  |                                                                                                |
|                                | - Metastatic disease with annoyance oral pain or minimum bleeding (palliative RT) |                                                                                                  |                                                                                                |
| Adjuvant therapy: 12 weeks for adjuvant RT and 8 weeks for adjuvant CRT | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
| Elderly with favorable tumors  | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
| Very low-risk                  | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
| Low or intermediate-risk in hormone therapy, and high risk with only one risk factor: RT after 3 months | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
| Elderly with favorable tumors  | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
| Very low-risk                  | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
| Low or intermediate-risk in hormone therapy, and high risk with only one risk factor: RT after 3 months | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
| Elderly with favorable tumors  | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
| Very low-risk                  | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
| Low or intermediate-risk in hormone therapy, and high risk with only one risk factor: RT after 3 months | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
| Elderly with favorable tumors  | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
| Very low-risk                  | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
| Low or intermediate-risk in hormone therapy, and high risk with only one risk factor: RT after 3 months | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
| Elderly with favorable tumors  | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
| Very low-risk                  | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
| Low or intermediate-risk in hormone therapy, and high risk with only one risk factor: RT after 3 months | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
| Elderly with favorable tumors  | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
| Very low-risk                  | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
| Low or intermediate-risk in hormone therapy, and high risk with only one risk factor: RT after 3 months | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
| Elderly with favorable tumors  | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
| Very low-risk                  | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
| Low or intermediate-risk in hormone therapy, and high risk with only one risk factor: RT after 3 months | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
| Elderly with favorable tumors  | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
| Very low-risk                  | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
| Low or intermediate-risk in hormone therapy, and high risk with only one risk factor: RT after 3 months | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
| Elderly with favorable tumors  | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
| Very low-risk                  | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
| Low or intermediate-risk in hormone therapy, and high risk with only one risk factor: RT after 3 months | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
| Elderly with favorable tumors  | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
| Very low-risk                  | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
| Low or intermediate-risk in hormone therapy, and high risk with only one risk factor: RT after 3 months | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
| Elderly with favorable tumors  | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
| Very low-risk                  | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
| Low or intermediate-risk in hormone therapy, and high risk with only one risk factor: RT after 3 months | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
| Elderly with favorable tumors  | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
| Very low-risk                  | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
| Low or intermediate-risk in hormone therapy, and high risk with only one risk factor: RT after 3 months | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
| Elderly with favorable tumors  | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
| Very low-risk                  | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
| Low or intermediate-risk in hormone therapy, and high risk with only one risk factor: RT after 3 months | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
| Elderly with favorable tumors  | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
| Very low-risk                  | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
| Low or intermediate-risk in hormone therapy, and high risk with only one risk factor: RT after 3 months | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
| Elderly with favorable tumors  | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
| Very low-risk                  | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
| Low or intermediate-risk in hormone therapy, and high risk with only one risk factor: RT after 3 months | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
| Elderly with favorable tumors  | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
| Very low-risk                  | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
| Low or intermediate-risk in hormone therapy, and high risk with only one risk factor: RT after 3 months | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
| Elderly with favorable tumors  | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
| Very low-risk                  | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
| Low or intermediate-risk in hormone therapy, and high risk with only one risk factor: RT after 3 months | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
| Elderly with favorable tumors  | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
| Very low-risk                  | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
| Low or intermediate-risk in hormone therapy, and high risk with only one risk factor: RT after 3 months | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
| Elderly with favorable tumors  | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
| Very low-risk                  | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
| Low or intermediate-risk in hormone therapy, and high risk with only one risk factor: RT after 3 months | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
| Elderly with favorable tumors  | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
| Very low-risk                  | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
| Low or intermediate-risk in hormone therapy, and high risk with only one risk factor: RT after 3 months | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
| Elderly with favorable tumors  | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
| Very low-risk                  | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
| Low or intermediate-risk in hormone therapy, and high risk with only one risk factor: RT after 3 months | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
| Elderly with favorable tumors  | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
| Very low-risk                  | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
| Low or intermediate-risk in hormone therapy, and high risk with only one risk factor: RT after 3 months | Postoperative cervical cancer (up to 8 weeks) |                                                                                                  |                                                                                                |
Table 1 (continued)

| Cancer type | Hold/Omit irradiation | Delay of radiation if required | Continue irradiation/ Treatment |
|-------------|-----------------------|-------------------------------|---------------------------------|
| Patients with suspected or confirmed COVID-19 (until COVID-19 is cured) | | | In the case of RT is the primary treatment for patients with minimal risk of COVID-19 |
| Adjuvant RT: postponed within 12 weeks after surgery | | | Emergency cases (Wang et al., 2020) |
| Stages IB, IIA-IIIC, and early IVA (cRT): | | | Stages IB3, IIA2-IIIC2, and early IVA (cCRT): |
| − 50.4 Gy / 28 frs (bulkier or node-positive) | | | − 50.4 Gy / 28 frs (bulkier or node-positive) |
| with 3DCRT | | | with 3DCRT |
| − 45 Gy / 25 frs with SBRT to gross nodes | | | − 45 Gy / 25 frs with SBRT to gross nodes |
| − 5 5-6 2.5 Gy / 25 frs with IMRT | | | − 5 5-6 2.5 Gy / 25 frs with IMRT |
| − RT boost (18 Gy / 10 frs) in the absence of brachytherapy | | | − RT boost (18 Gy / 10 frs) in the absence of brachytherapy |
| Stages IA1, IA2, IB1, IB2, IIA1 (cRT for high-risk patients): | | | Stages IA1, IA2, IB1, IB2, IIA1 (cRT for high-risk patients): |
| 45 Gy / 25 frs with IMRT; if resource constraints, 3DCRT | | | 45 Gy / 25 frs with IMRT; if resource constraints, 3DCRT |
| IVA (frank bladder or rectal infiltration) or IVB (palliative RT): 8 Gy / 1 fr or 20 Gy / 5 frs | | | IVA (frank bladder or rectal infiltration) or IVB (palliative RT): 8 Gy / 1 fr or 20 Gy / 5 frs |
| Stage II or III cervix with a radical/curative intent: Radical CRT (Talapatra et al., 2020) | | | Stage II or III cervix with a radical/curative intent: Radical CRT (Talapatra et al., 2020) |
| Uterine cervix: RT as the main treatment | | | Uterine cervix: RT as the main treatment |
| Adjuvant if an alternative exists (prioritize by age and other comorbidities of the patient) (Samiee et al., 2020) | | | Adjuvant if an alternative exists (prioritize by age and other comorbidities of the patient) (Samiee et al., 2020) |
| Inoperable endometrial cancer | | | Inoperable endometrial cancer |
| Postop endometrial cancer (Wright et al., 2020) | | | Postop endometrial cancer (Wright et al., 2020) |
| Adjuvant RT: up to 3 months from surgery | | | Adjuvant RT: up to 3 months from surgery |
| (unless there is a residual disease, positive resection margins, or aggressive histological subtype) | | | (unless there is a residual disease, positive resection margins, or aggressive histological subtype) |
| Locally advanced and high-risk groups (Hypo-F RT) (Guidance for radiotherapy for gynaecological cancer and COVID-19 [Online], 2021) | | | Locally advanced and high-risk groups (Hypo-F RT) (Guidance for radiotherapy for gynaecological cancer and COVID-19 [Online], 2021) |
| Microscopic disease: 45 - 50 Gy / 25 frs | | | Microscopic disease: 45 - 50 Gy / 25 frs |
| Gross residue in postop cases (add boost: a total dose of 60 - 70 Gy) | | | Gross residue in postop cases (add boost: a total dose of 60 - 70 Gy) |
| Neoadjuvant RT: 45 - 50 Gy (Parashar et al., 2020) | | | Neoadjuvant RT: 45 - 50 Gy (Parashar et al., 2020) |
| Postop stage I A, grade I-II endometrioid carcinoma with higher risk features (age > 60 yrs, LVSI) | | | Patients with extreme vaginal bleeding |
| Inoperable endometrioid carcinoma candidates for hormone therapy | | | Inoperable patients with non-endometrioid histology (not candidates for systemic therapy) |
| Postop stage III-A: chemotherapy alone (±/− RT after chemo) | | | Recurrent vaginal cuff disease (Elledge et al., 2020) |
| Postop stage I A, grade III or stage IB, grade II-I, and low-risk stage II endometrioid carcinoma | | | The higher dose of 50.4 Gy instead of 45 Gy instead of a brachytherapy boost (Dewan et al., 2021) |
| Postop stage IB, grade III, and stage II endometrioid carcinoma | | | Surgical stage III and IV a: Adjuvant RT/ In case of pelvic RT: Hypo-F |
| Postop patients with grade I histology with positive nodes (Stage IIIIC) | | | Pelvic recurrence: Hypo-F RT (Lee et al., 2020) |
| Postop stage IA-IV non-endometrioid histology | | | Stages IB Gr 3, Stage II (RT 8-12 weeks post-op): 45 Gy / 25 frs (IMRT preferred) |
| In case of COVID + after 1-2 fr, further sessions may be postponed until 10-14 days after recovery from infection | | | Stage IIA-IIIC (RT 6-8 weeks post-op): 45 Gy / 25 frs (IMRT preferred) |
| (continued on next page) | | | Stage IVB (palliative): 8 Gy / 1 fr or 20 Gy / 5 frs (Hinduja et al., 2020) |
| | | | High priority: |
| | | | -High-risk patients: Post-op RT ± C |
| | | | -Symptomatic unresectable primary tumor (not a candidate for surgery): RT |

*Z. Siavashpour et al.*
Table 1 (continued)

| Cancer type | Hold/Omit irradiation | Delay of radiation if required | Continue irradiation/ Treatment |
|-------------|-----------------------|-------------------------------|--------------------------------|
| **Ovarian** | Isolated locoregional relapse in patients with former surgery and chemotherapy | Postpone RT start (3 months) | Medium priority: 
- Intermediate-high risk: Brachytherapy 
- Isolated vaginal relapse after surgery: RT (curative intent) 
Low priority: 
- Asymptomatic vaginal/pelvic recurrence: RT (Colombo et al., 2020) |
| **Vulvar** | Interruption for a suspected or confirmed case of COVID-19 within 15 days (Carvalho et al., 2020) | Postop vulvar cancer | Bleeding or extremely painful disease in metastatic patients (not candidates for surgical or systemic therapies) (Elledge et al., 2020) 
Curative intent RT: 
- Radical RT for patients not appropriate for surgery (using IMRT for reduction of skin toxicity) 
- Adjuvant RT 
- Palliative RT: a single fraction to control symptoms until re-treatment is feasible (Guidance for radiotherapy for gynaecological cancer and COVID-19 [Online], 2021) |
| Postop stage IB-II (close margins not candidates for margin re-excision or possibly with + LVS, tumor size ≥4 cm) | Postop patients with close/positive margins or involved nodes with no gross residual disease | | Postop patients with ≥ 1 positive lymph node 
Intact stage III/IVA disease 
Intact recurrent inguinal or pelvic disease (not candidates for surgery) (Elledge et al., 2020) |
| **Sarcoma** | Interruption for a suspected or confirmed case of COVID-19 | Adjuvant and Neoadjuvant: if alternative exist (Prioritize by age and other comorbidities) (Samiee et al., 2020) | Severe pain 
Uncontrolled bleeding (Wright et al., 2020) 
Neoadjuvant and adjuvant: Hypo-F RT (Starling et al., 1992) |
| Delay Postop RT for: | Soft tissue sarcoma: 
- Preop RT for non-complex tumors not close to critical structures (few patients): Hypo-F RT using 25 Gy /5 frs 
- Postop RT: Hypo-F RT (40 – 45 Gy / 15 – 20 frs and 36 Gy / 6 once-weekly frs not for younger patients) | Neoadjuvant/Adjuvant/Definitive RT | |
| - Soft tissue sarcoma | Bone sarcoma: Ewing’s sarcoma: Surgery (1st local therapy) / definitive RT (curative treatment) 
- Non-malignant locally aggressive condition 
Low-grade tumors, including chordoma (slow-growing indolent tumors): delay for a couple of months | | |
| - Fibromatosis | Ewing’s sarcoma: Surgery (1st local therapy) / definitive RT (curative treatment) 
- Postop RT based on resection histology 
- Definitive RT if surgery is not feasible/suitable | Non-Ewing’s bone sarcomas (osteosarcoma, chordosarcoma, chordoma) 
High-grade tumors: urgent RT | |
| - Ewing’s sarcoma: postop RT for | (continued on next page) | | |
| Cancer type | Hold/Omit irradiation | Delay of radiation if required | Continue irradiation/ Treatment |
|-------------|-----------------------|-------------------------------|----------------------------------|
| Locally advanced high-grade tumors including osteosarcoma: definitive RT with shorter fraction schedules (Seddon and Zaidi, 2021) | | | |
| Soft-Tissue Sarcomas (NCC recommendations): | | | |
| Postop RT doses: RT (50 Gy) + RT boost (Negative margins: 10 - 16 Gy) Microscopically positive margins: 16-18 Gy Gross residual disease: 20-26 Gy Using SBRT as a preop regimen (e.g., 35 Gy / 5 frs) for sarcomas (Parashar et al., 2020) | | | |
| Preop RT or chemotherapy: - High-risk surgery cases (e.g., retroperitoneal sarcoma) Adjuvant RT for soft tissue sarcoma: - Operable grade II-III soft tissue sarcoma (not to defer surgery) (Vordermark, 2020a) | | | |
| Soft tissue sarcoma: - Protracted RT regimens (25 Gy / 5 frs) if the disease is not close to critical structures Hypo-F RT: 40-45 Gy / 15-20 frs and 36 Gy / 6 frs once weekly (except in young patients due to increased late RT related toxicities) (Hinduja et al., 2020) | | | |
| Pediatric | | | |
| All optional or unnecessary radiation cases | | | |
| All cases where chemo or other interventions to delay initiation of RT Chemo-sensitive tumors: e.g., rhabdomyosarcoma and Ewing sarcoma, medulloblastoma, ependymoma, and germ cell tumors presenting with metastases | | | |
| Active surveillance for grade I-II primary CNS Low-grade gliomas and craniopharyngiomas after primary biopsy or debulking surgery | | | |
| Highly proliferative tumors: rhabdomyosarcoma, Ewing sarcoma, medulloblastoma, germ cell tumors, and ATRT | | | |
| Poor prognostic tumors and palliative care | | | |
| Medulloblastoma/embryonal CNS tumors, RMS, Ewing Sarcoma, chemo-sensitive NRSTS, intracranial germ cell tumors, neuroblastoma, ependymoma | | | |
| Priority 1: Radical RT (any delay or interruption of RT decreases cure) - Medulloblastoma - Embryonal CNS tumors/ pineoblastoma - RMS/ Ewings - definitive treatment/ incomplete resection - Intracranial Germ Cell tumors - Ependymoma G2/G3 - Nasopharynx/ Head and neck - Total body irradiation - Retinoblastoma - ATRT | | | |
| Priority 2: Urgent palliative RT (save the loss of function/ life) - Cord compression - Bleeding, hemorrhage - Pontine/ spinal diffuse midline or high-grade glioma | | | |
| Priority 3: Adjuvant RT (aggressive tumors or with recognized residue) RMS/ Ewings-complete resection - Wilms' tumor - Neuroblastoma - Chordoma/ Chondrosarcoma - Bone tumors - NRSTS - Hodgkin Lymphoma - Salivary gland tumors/ Adenoid cystic carcinoma - Esthesioneuroblastoma - High grade/ diffuse midline glioma other than pontine or spinal - Metastatic RMS/ Ewings - Meningioma G3/ anaplastic - Pineal parenchymal tumors | | | |

(continued on next page)
| Cancer type | Hold/Omit irradiation | Delay of radiation if required | Continue irradiation/ Treatment |
|-------------|------------------------|-------------------------------|--------------------------------|
| **Priority 4: Palliative RT (control of symptoms to enhance the quality of life)** | - Symptomatic metastatic sites | - Symptomatic local recurrence / re-irradiation | |
| - Symptomatic local recurrence | | | |
| **Priority 5: Radical RT** | - Benign / gradually proliferative tumors | | |
| - Optic pathway | - Low-grade glioma | - Desmoid-type fibromatosis | |
| - Pituitary Adenoma | - Meningioma- G1/G2 | - Myxopapillary Ependymoma (Mandeville, 2021) | |
| CNS tumors including medulloblastoma, grade II-III ependymoma, embryonal CNS tumors, intracranial germ cell tumors, atypical teratoid/ rhabdoid. Total body irradiation, retinoblastoma, nasopharynx, and head and neck malignancies (Hinduja et al., 2020) | Considering Hypo-F where RT is required: Wilms tumor Low-grade glioma Palliative cases with urgent symptoms (Sullivan et al., 2020) | Pediatric tumors: No changes and no delay of RT (Carvalho et al., 2020) | |
| **HL: if RT not available** | Individualize interruption for a suspected or confirmed case of COVID-19 | | |
| **Lymphoma and hematological malignancies** | When there is no/little expected adverse effect: | | |
| - for asymptomatic localized low-grade lymphomas; | - for localized nodular lymphocyte-predominant HL | - for whom develop COVID-19 infection before commencing RT | |
| - for localized nodular lymphocyte-predominant HL if completely excised | | | |
| - in consolidation RT for diffuse large B-cell lymphoma/ aggressive NHL for those who have completed a full chemotherapy course with complete remission. | | | |
| **For ≥ 60 yrs:** | | Using alternative Hypo-F RT when RT cannot be omitted or delayed to maintain high cure/ palliation rates without excessive toxicity (e.g., For patients with symptomatic sites of disease and localized aggressive NHL, primary RT alone, and NK-/T-cell lymphoma) (Yahalom et al., 2020; Di Ciaccio et al., 2020) | |
| - for the palliative purpose where alternative treatment is available | - for localized nodular lymphocyte-predominant HL if completely excised | | |
| - for localized low-grade lymphomas if completely excised | - in consolidation RT for diffuse large B-cell lymphoma/ aggressive NHL for those who have completed a full chemotherapy course with complete remission. | | |
| **In a minority of cases, if alternative treatment options were available** | When there is no/little expected adverse effect: | | |
| - for asymptomatic localized low-grade lymphomas; | - for localized nodular lymphocyte-predominant HL | - for whom develop COVID-19 infection before commencing RT | |
| - for localized nodular lymphocyte-predominant HL if completely excised | | | |
| - in consolidation RT for diffuse large B-cell lymphoma/ aggressive NHL for those who have completed a full chemotherapy course with complete remission. | | | |
| **Skin** | Primary and resected skin cancers (if not use short courses and limit radiation to the mucosa) | | |
| Primary tumors < 2 cm: 30 Gy / 5 frs over 2 weeks | | | |
| Primary tumors > 2 cm: 45-55 Gy over 3 to 4 weeks, 10-2 Gy in 3 frs weekly | | | |
| | | | (continued on next page)
### Table 1 (continued)

| Cancer type                  | Hold/Omit irradiation | Delay of radiation if required | Continue irradiation/ Treatment |
|------------------------------|-----------------------|--------------------------------|--------------------------------|
| **Resected SCC/BCC:**       | - 50 Gy / 4 weeks (2.5 Gy / fr) |                                |                                |
|                             | - 44 Gy / 10 frs in 4 days a week |                                |                                |
| **Melanoma**                |                       |                                |                                |
| Definitive cases:           | 35 Gy / 5 frs over a week for < 3 cm² |                                |                                |
| Postop: 30 Gy / 5 frs twice a week or every other day (Parashar et al., 2020) |                                |                                |
| **CM:**                     |                       |                                |                                |
| - Patients with ≥ T2 disease for three months with negative biopsy margins |                                |                                |
| - T0-T1 disease for three months if no macroscopic residue is detected at biopsy |                                |                                |
| BCC: up to 3 months except for extremely symptomatic patients |                                |                                |
| **cSCC:**                   |                       |                                |                                |
| - T1-T2a disease for 2-3 month except for prompt growth or symptomatic/ immunosuppressed patients (prioritize patients with ≥ T2b disease) |                                |                                |
| **MCC:**                    |                       |                                |                                |
| - Around one month for patients with favorable T1b disease High-risk patients: COVID-19 infection, elderly, and/or weak patients (Baumann et al., 2020) |                                |                                |
| **Non-melanoma skin tumors (Slotman et al., 2020)** |                        |                                |                                |
| Adjuvant RT for BCC (with limited benefit) |                        |                                |                                |
| Definitive RT including incompletely excised |                        |                                |                                |
| Melanoma (involved high-risk nodal basins) NMSC |                        |                                |                                |
| BCC (definitive and postop) incomplete excised |                        |                                |                                |
| Adjuvant RT (benefit limited) for patients with closely excised cSCC <1 mm or with minor risk factors (lower/intermediate risk of recurrence) |                        |                                |                                |
| cSCC, MCC, and rare skin pathologies incompletely excised: for 2-3 months |                        |                                |                                |
| Melanoma: LM, LMM, and melanoma in situ within 2-3 months |                        |                                |                                |
| **MMS: SCC, MCC, and rare skin pathologies incompletely excised in 2-3 months** |                        |                                |                                |
| Suspend all treatment forms until the pandemic is over (Hinduja et al., 2020) |                        |                                |                                |
| Rare indications of Melanoma (e.g., lentigomaligna, lentigo malignant melanoma, and melanoma in situ) should be deferred for 2-3 months |                        |                                |                                |
| Radical RT for advanced SCC: COVID-19 positive patients: based on patient’s and lesion’s characteristics (site and size) |                        |                                |                                |
| Adjuvant RT for advanced SCC: COVID-19 positive patients |                        |                                |                                |
| Radical RT for advanced BCC: (both COVID-19 negative and positive patients): Multidisciplinary discussion based on the lesion size and location (priority for face lesion) |                        |                                |                                |
| Adjuvant RT for advanced BCC: COVID-19 positive patients |                        |                                |                                |
| In palliative case (e.g., bleeding or fungating skin nodules): Hypo-F RT (1-4 frs for 8-20 Gy) (Nahm et al., 2021) |                        |                                |                                |
| Radical RT for advanced SCC: COVID-19 negative patients: No delay, especially for a large lesion or palliative setting or facial lesion |                        |                                |                                |
| COVID-19 positive patients: Hypo-F RT (based on patient’s and lesion’s characteristics) |                        |                                |                                |
| Dedicated COVID-19 positive RT pathways |                        |                                |                                |
| Adjuvant RT for advanced SCC: COVID-19 negative and positive patients: Choice is based on patient’s (age, comorbidities) and lesion’s characteristics (location and size) |                        |                                |                                |
| Radical RT for advanced BCC: (both COVID-19 negative and positive patients): Multidisciplinary discussion based on the lesion size and location (priority for face lesion): Hypo-F RT |                        |                                |                                |
| Adjuvant RT for advanced BCC (COVID-19 negative patients): Choice based on patient’s (continued on next page) |                        |                                |                                |
| Cancer type | Hold/Omit irradiation | Delay of radiation if required | Continue irradiation/ Treatment |
|-------------|-----------------------|--------------------------------|---------------------------------|
| Skin: not treating | (Carvalho et al., 2020) | prognosis, age, comorbidities, and the location (priority for face lesion) (Tagliaferri et al., 2020) | |
| Bone metastasis | | Cord compression, superior vena cava obstruction, life-threatening bleeding: Do not defer until a reasonable alternative (Radical treatment) (Samiee et al., 2020) | |
| Multiple brain metastasis | | Cord compression, Symptomatic brain metastases or brain metastases >5 mm, Malignant airways obstruction, SVCO, Severe pain from primary, Heterotopic bone (Wright et al., 2020) | |
| Painful spine metastasis, Spinal cord compression or spine metastases with the epidural disease, Brain metastases <5 mm, Patients with stable or minimum symptomatic oligo-metastatic disease | | Brain metastases (SRS for good PS/SRS of resection cavity for postop) (Combs et al., 2020) | |
| Painful metastasis, uncomplicated, other systemic options | | Painful metastases without impending structural/neurologic compromise | |
| Oligometastatic (e.g., prostate cancer) | | Esophageal bleeding/ dysphagia | |
| Postoperative radiotherapy (for pathologic fracture) | | PGM, poor KPS | |
| CNS metastasis from NSCLC needing WBRT | | Head & Neck | |
| Prostate cancer patients, breast cancer patients, benign CNS tumor (up to 3 months from diagnosis to treatment) | | Palliative non-emergent indications (Slotman et al., 2020) | |
| Palliative intent in asymptomatic or oligosymptomatic patients | | In cases of spinal cord compression, metastatic bone pain irreversible to other treatments or micro-vascular bleeding: single fraction (Starling et al., 1992) | |
| Spinal cord compression, SVCO, or bleeding in confirmed cases of COVID-19 (Ismael et al., 2020) | | Spinal cord compression, SVCO, or bleeding in confirmed cases of COVID-19 (Ismael et al., 2020) | |
| Symptomatic brain metastases: 20 Gy / 4 - 5 frs | | Symptomatic brain metastases: 20 Gy / 4 - 5 frs | |
| For COVID-19 patient: Palliative RT for a highly symptomatic patient (life expectancy >3-6 months) and without any other therapeutic alternative (Amaoui et al., 2020) | | Very algic bone metastases refractory to analgesics: 8 Gy / 1 fr (Amaoui et al., 2020) | |
| Urgent cases: pain due to bone metastases, cord compression, SVCO, and tumor bleeding: 5-8 Gy/1 fr (single fraction) Hypo-F RT and single fraction palliative RT (Upadhyay and Shankar, 2020) | | Urgent cases: pain due to bone metastases, cord compression, SVCO, and tumor bleeding: 5-8 Gy/1 fr (single fraction) Hypo-F RT and single fraction palliative RT (Upadhyay and Shankar, 2020) | |

(continued on next page)
### Table 1 (continued)

| Cancer type | Hold/Omit irradiation | Delay of radiation if required | Continue irradiation/Treatment |
|-------------|------------------------|-------------------------------|--------------------------------|
| Postop for a pathological fracture | Treatment is limited to function- or life-threatening situations (e.g., spinal cord compression) The shortest possible course (e.g., single-fraction treatment for bone pain [Weisel et al., 2020]) Palliative RT: spinal cord compression, uncontrolled bleeding from fungating tumors, and intractable pain [Ng et al., 2020a] RT for emergencies (spinal cord compression, symptomatic brain metastases) [Ismaili and El Majjaoui, 2020] Palliative RT, e.g., in painful bone metastases a single 8 Gy / fr [Mahmoodzadeh et al., 2020] Palliative treatment of bleeding/fungating inoperable breast mass, spinal cord compression, and symptomatic brain metastases [Ighazawy et al., 2020] Single or two weekly fractions for palliative thoracic RT [Bakhribah et al., 2020] - Single-fraction for bone metastases and spinal cord compression: 8-24 Gy / 1 fr - Airway obstruction: 17 Gy / 2 frs [Singh et al., 2020] Bone Mets, fracture/spinal compression, SVCO: 8 Gy / 1 fr [Kochbati et al., 2020] Stage IVB of cervical cancer: RT for cord compression/Brain metastasis [Dewan et al., 2021] BCLC C: Palliative RT in a single 8 Gy fr for symptomatic disease (local or metastatic) [Barry et al., 2020] Brain metastases: - For solitary/limited brain met with good DS-GPA: 8 Gy-F RT: 30–35 Gy / 5–6 frs - For multiple brain metastases/whole-brain: Hypo-F RT (20 Gy / 5 frs) Spinal cord compression: Hypo-F RT (8 Gy / single fr or 20 Gy / 5 frs) [Balakrishnan et al., 2020] Palliative/temporary control of vulvar cancer: - Long course: 30 Gy / 10 frs - Short course: 16 Gy / 4 frs or 20 Gy / 5 frs (symptomatic patients) [Garganese et al., 2020] Palliative treatment of head and neck malignancies (Short fractionation schedules): 25 Gy / 5 frs, 20 Gy / 5 frs, 30 Gy / 6 frs, IMRT over 2 weeks, or Single 8 Gy fr [Hinduja et al., 2020] Brain metastases: - For metastases <10 cc: single fraction treatment - SRS (replace neurosurgical options) - Postop: SRS to the cavity 5 Gy / fr for 7 frs - If life expectancy >3 months: 4 Gy / fr for 5 frs to the whole brain Spinal cord compression: 8 Gy in a single fraction Tumor bleeding: - 20 Gy / 5 frs given daily - Single fraction of 8 Gy SVCO: - 20 Gy / 5 daily frs - 8-10 Gy in a single fraction Painful bone metastases: 8 Gy single fraction [Hinduja et al., 2020] Symptomatic metastases (pain, obstruction, or bleeding) palliative short course Hypo-F RT: 8 Gy / 10 Gy or SBRT [Arrieta et al., 2020] (continued on next page) |
### Table 1 (continued)

| Cancer type | Hold/Omit irradiation | Delay of radiation if required | Continue irradiation/ Treatment |
|-------------|------------------------|---------------------------------|---------------------------------|
| Cord compression or bony metastases: 20 Gy/5 frs or 8-10 Gy/1 fr or 30 Gy/10 frs for good prognosis  
Breast palliation: 6 Gy for 5 to 6 weeks  
Brain metastases: where appropriate: SRS; all others: 20 Gy/5 frs or 12 Gy/2frs (daily) (Chan et al., 2020)  
Hypo-F RT:  
- Bone metastasis: 6-8 cGy/1 fr; 15 Gy/3 frs; 20 Gy/5 frs to a small radiation field  
- Brain metastasis: 20 Gy/5frs (Elkholy et al., 2020)  
Palliative RT for melanoma:  
COVID-19 negative patients (No delay)  
COVID-19 positive patients: In case of pain or dedicated COVID-19 positive RT pathways (Tagliaferri et al., 2020)  
Brain metastases from lung cancer (whole brain RT)  
Short course Hypo-F RT: 20 Gy/5 frs; 30 Gy/10 frs (patients with better survival outcomes); 12 Gy/2 frs (once a week) in patients with poor PS  
Hypo-F boost of 10 - 15 Gy after WBRT  
Single fraction SRS as an alternative to surgery (oligo-metastases and controlled extracranial disease) (Mumudii et al., 2020)  
Malignant spinal cord compression: 8 Gy/1 fr (Cameron, 2020)  
Brain metastases: 20 Gy/5 frs  
Cord compression: 8 Gy/1 fr  
Tumor bleeding: 14.8 Gy / 4 twice daily frs; 20 Gy/5 daily frs  
SVCO: 17 Gy/2 weekly frs; 20 Gy/5 daily frs  
Bone metastases: 8 Gy/1 daily fr (Yerramilli et al., 2020a)  
The omission of whole-brain radiation: multiple brain metastases and limited life-expectancy (<3-6 months)  
Single-fraction palliative RT for bone metastases/metastatic spinal cord compression (Gupta et al., 2020a)  
High priority: Spinal cord compression with potential neurological recovery  
Moderate priority: Palliation of symptoms like hemoptysis in lung cancer (Talapatra et al., 2020)  
Selected palliative treatments (Carvalho et al., 2020)  
High priority: Spinal cord compression, brain metastases, other critical metastatic lesions  
Low priority: Palliative RT for asymptomatic recurrence not amenable to surgery (Colombo et al., 2020)  
Pain or bony lesion: 8 Gy / 1 fr; Bleeding: 10 Gy / 1 fr; 20 Gy /5frs (If single fraction not possible, Hypo-F RT)  
Multiple brain metastases: 20 Gy / 5 frs (in the favorable subgroup)  
MSCC: 8 Gy / 1 fr (Cowgill et al., 2020)  
Symptomatic bone metastases: 8 Gy/1 fr (Kwek et al., 2021)  

**Benign Disease**

- Keloid, heterotopic Ossification, Actinic Keratosis
- Benign Disease, Pituitary Adenoma, Fibromatosis Other: Actinic Keratosis, Recurrent/Refractory Fasciitis, other rare benign (Simcock et al., 2020)
- Benign tumors (schwannomas and asymptomatic meningiomas) (Starling et al., 1992)
- Non-malignant indications (Slotman et al., 2020)
- Benign tumors: RT after 3 months (Carvalho et al., 2020)
4.1. General prioritization of radiotherapy during COVID-19 pandemic

Table 1 and 2 summarizes the prioritization strategies of common cancer types to mitigate the demand of EBRT and brachytherapy during this crisis retrospectively. Some authors categorized the priority scale in three levels of omission, delayed, and continuing the irradiation. Using the short-course irradiation or hypo-fractionated radiotherapy (Hypo-F RT) over normal fractionation is the most frequent and preferred standard of care for radiotherapy during the pandemic.

Recommendations support the utility of active surveillance in low-risk tumors, which permitted to defer the treatment based on the disease biology and pathology, for several months or until an expected fall or management of COVID-19 pandemic. Taking into account that deferred therapy should not lead to detrimental impacts on treatment consequences. Moreover, it suggested avoiding radiotherapy for patients with poor prognostic tumors in early-stages (e.g., Hodgkin’s Lymphoma) and low-risk (e.g., postoperative radiotherapy for thymoma) disease. It was recommended to omit the treatment of palliative setting as long as the patient symptom can be under control by adopting alternative approaches, elderly patients with severe health circumstances, benign disease (e.g., keloids), and boost whenever possible (Wright et al., 2020; Simco et al., 2020; Wallis et al., 2020). These approaches have been summarized in Table 1.

Based on the suggested prioritizations (Table 1), radiation treatment should maintain and continue according to the pre-pandemic schedule for patients undergoing therapy unless the COVID-19 virus infects them. The treatment should sustain for urgent issues, where there is no alternative modality to radiation therapy and those with symptomatic cases, malignancies in locally advanced stages (e.g., breast, lung, cervix locally advanced cancers) should treat as the standard of care. Emergency cases (known as the urgent category) such as superior vena cava syndrome (SVCO), uncontrollable pain or bleeding, occlusion, and spinal cord compression are recommended for radiotherapy continuation with high priority (Ismail, 2020b; Cruz et al., 2020).

Table 3 summarized the department’s consensus for radiotherapy candidates during pandemic and indications of the feasible Hypo-F RT and short-course treatment regimens. Extending the use of an evidence-based Hypo-F RT schedule or simultaneous integrated boost (SIB) (e.g., for prostate, breast, and head and neck cases) and short-course radiation therapy (e.g., for rectal cancer) were recommended frequently. There are also other classifications based on (1) the urgent/critical and non-urgent/non-critical treatment indication, (2) high-risk/ high-grade pathological malignancy stages, (3) degree of cancer cell proliferation, (4) the feasibility of treatment options during the pandemic, and (5) patient’s performance status (Wright et al., 2020; Combs et al., 2020; Simco et al., 2020; Montesi et al., 2020b).

4.2. Comprehensive cancer-based radiotherapy guidelines during the COVID-19 pandemic

Presented consensuses and recommendations of Tables 1–3 can be summarized based on the cancer type as follow:

4.2.1. Central nervous system (CNS)

In glioblastoma multiform (GBM) cases, age and karnofsky performance status (KPS) of patients introduced as the determining factors in choosing radiotherapy schedule and fractionation (e.g. KPS ≥ 70: 60 Gy / 30 frs, KPS < 70 or elderly: 40 Gy / 15 frs, KPS < 50: 34 Gy / 10 frs or 25 Gy / 5 frs) (Noticewala et al., 2020a). Continuing treatment was generally recommended for high-grade glioma cases with not poor KPS. For example, Hypo-F RT can be considered where there is not any probability of compromising outcome (e.g., for patients with brain metastases or O6- methylguanine DNA methyltransferase (MGMT) promoter- unmethylated glioblastoma) based on the EMRO recommenda- tion to reduce hospital visits (Weller and Preusser, 2020). Stereotactic radiosurgery (SRS) was suggested for solitary or limited brain metastases (up to four lesions with less than 4 cm maximum size) with good KPS patients. SRS with 15–24 Gy can be prescribed based on the maximum lesion size. Whole-brain radiotherapy (WBRT) is still introduced as the standard of care for more or/and larger brain metastatic lesions (Tables 1–3) (Di Franco et al., 2020).

4.2.2. Head and neck

For head and neck cancer patients, all indications for continuing the combined chemo-RT must be preserved following the acceptable delay time between diagnosis and RT (i.e., ≤ 4 weeks) or between surgery and RT (i.e., 6–8 weeks) (Belkacemi et al., 2020b). Radiotherapy omission was allowed just for benign or low-risk slow-growing lesions (Table 1). Delaying radiotherapy is also permitted not more than 4–6 weeks for COVID-19 positive cases or in cases such as melanomas, as indicated in Table 1 in detail. RT fractionation must be optimized using Hypo-F RT, simultaneous integrated boost (SIB), accelerated RT scheduling (6 frs / week), or SBRT techniques. Strong agreement was reported following ASTRO-ESTRO consensus to shift from the standard approach (2–2.4 Gy / fr) to the Hypo-F regimen (2.21–3.2 Gy / fr) or Ultra-Hypo-F...
### Table 2
Summary of international guidelines or national multi-cancer recommendation for brachytherapy prioritization during COVID-19 pandemic.

| Cancer type                          | Hold BT and choose another treatment option | Delay BT until the end of the pandemic | Continue BT during the pandemic |
|--------------------------------------|-------------------------------------------|---------------------------------------|-------------------------------|
| **Brain** (For primary or metastases/adjuvant cases): | - Avoid BT until pandemic solves | - SRS/SRT for glioma or metastatic cases ([Mohindra et al., 2020](#)) | Oral tongue (pT1-T2, N0) high risk of local recurrence: | - Avoid BT until pandemic solves | - SRS/SRT for glioma or metastatic cases ([Mohindra et al., 2020](#)) | - Continue BT during the pandemic |
| Definitive/boost oral cavity/oropharynx, boost nasopharynx or any re-irradiation: | - Avoid BT until pandemic solves | - For COVID-19+ patients, continue EBRT rather than BT boost ([Mohindra et al., 2020](#)) | | | | |
| **Head and neck**                   | Switch interstitial BT to EBRT             |                                       |                               | Low-risk cases: | Postpone interstitial BT for up to 16–20 weeks for ER + invasive cases or 12 weeks for DCIS ([Mohindra et al., 2020](#)) | Early-stage: | - Neoadjuvant endocrine therapy due to delay of surgeries during the crisis; | - Early-stage: | - Deem BT as an equivalent option to EBRT | - BT for APBI with a single-entry intra-cavity or multi-catheter interstitial technique after surgery | Very Low-, Low- and Intermediate Risk: | - HDR-IBT 27 Gy/2fr Monotherapy | - HDR-IBT boost 15 Gy/1 fr ([Murakami et al., 2020](#)) |
| Breast                               | Accelerated partial breast irradiation (Exclusive): | Accelerated partial breast irradiation (Exclusive): | Very Low-, Low- and Intermediate Risk: | - Postpone (8–12 weeks) | - Opt for EBRT according to local facilities ([Chargari et al., 2020](#)) | - Postpone (8–12 weeks) | - HDR-IBT boost 15 Gy/1 fr ([Murakami et al., 2020](#)) | - For palliative and post-transplant stenosis: | - Avoid BT until the pandemic solves ([Mohindra et al., 2020](#)) | - Palliative and re-irradiation: | - Avoid BT until the pandemic solves ([Mohindra et al., 2020](#)) | Palliation with symptoms: | - Continue BT () | (continued on next page)
| Cancer type                        | Hold BT and choose another treatment option                                                                 | Delay BT until the end of the pandemic                                                                 | Continue BT during the pandemic                          |
|-----------------------------------|---------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|----------------------------------------------------------|
| Palliative unresectable malignant biliary obstruction or hepatocellular carcinoma cases (not for the transplant) and metastatic lesions: | - Avert BT until pandemic solves (Mohindra et al., 2020)                                                  | Preoperative or definitive postpone brachytherapy until pandemic solves (HypoF RT) (Mohindra et al., 2020) | After SCRT:                                               |
| For COVID-19+ patients:           | - Hypo-F-EBRT rather than BT boost                                                                             |                                                                                                          | ● For Unresectable, Medically inoperable, or Frail elderly cases: 10-20 Gy in 2-4 frs (Siavashpour et al., 2020) |
| Rectal                            |                                                                                                               |                                                                                                          |                                                          |
| Anal                              | - Switch interstitial BT to EBRT                                                                               |                                                                                                          |                                                          |
|                                   | - Switch to IORT if facilities are available (Barthwal et al., 2020)                                          |                                                                                                          |                                                          |
| Genitourinary Prostate            |                                                                                                               |                                                                                                          |                                                          |
| Prostate                          |                                                                                                               |                                                                                                          |                                                          |
| Low-risk prostate (Exclusive):     | - Delay BT for at least 3–6 months                                                                             |                                                                                                          |                                                          |
| Low-risk prostate cancer (Exclusive): | - Postpone (8–12 weeks)                                                                                    |                                                                                                          |                                                          |
| Intermediate and high-risk prostate: | - Postpone (8–12 weeks)                                                                                    |                                                                                                          |                                                          |
| Brachytherapy should be avoided as far as possible |                                                                                                               |                                                                                                          |                                                          |
| Temporarily defer certain specialized procedures (HDR-BT) (Kwek et al., 2021) |                                                                                                               |                                                                                                          |                                                          |
| Positive COVID-19 patients:       | - Postpone up to 10–14 days                                                                                   |                                                                                                          |                                                          |
|                                   | - Increase dose by 5 Gy / week deferent (consider OAR constraints)                                             |                                                                                                          |                                                          |
| Gynecological Cervix              |                                                                                                               |                                                                                                          |                                                          |
| When that is not feasible EBRT boost should be considered. |                                                                                                               |                                                                                                          |                                                          |

(continued on next page)
### Table 2 (continued)

| Cancer type                  | Hold BT and choose another treatment option | Delay BT until the end of the pandemic | Continue BT during the pandemic |
|------------------------------|--------------------------------------------|--------------------------------------|---------------------------------|
|                              |                                             | 9 Gy × 2 frs weekly (in patients with low volume disease post-RT and in whom inferior local control) (Kumar and Dey, 2020) | For centers with single brachytherapy operating: |
|                              |                                             | Stages IB3, IIA2-IIIC2, and early IVA: Intracavitary HDR brachytherapy 3 frs | Reduced number of fractions: 24 Gy/3 frs or 28 Gy/4 frs |
|                              |                                             | Stages IA1, IA2, IB1, IB2, IIA1: Vault brachytherapy 12 Gy/2 frs (Hinduja et al., 2020) | HDR ICBT: 7 Gy/4 frs at 1 week apart or 2 frs per day separated by a 6 h interval |
|                              |                                             | For patients >70 yrs, significant comorbidities, small tumors, or responding well to RT: | For patients >70 yrs, significant comorbidities, small tumors, or responding well to RT: |
|                              |                                             | - Shortened schedule (9 Gy /2 frs at 1 week apart) | - Standard treatment (preferably three frs) |
|                              |                                             | - Brachytherapy for cervical cancer (stage IB1, IIIB) (ElMajjaoui et al., 2020) | - Standard treatment (preferably three frs) |
|                              |                                             | Advanced cervical cancer: temporarily defer interstitial brachytherapy (Kwek et al., 2021) | Advanced cervical cancer: temporarily defer interstitial brachytherapy (Kwek et al., 2021) |
|                              |                                             | - Postpone BT but no more than 12 weeks after surgery (Williams et al., 2020) | - Postpone BT but no more than 12 weeks after surgery (Williams et al., 2020) |
|                              |                                             | Inoperable definitive positive COVID-19 symptomatic patients: | Inoperable definitive positive COVID-19 symptomatic patients: |
|                              |                                             | - Hold on RT for 10-14 days | - Hold on RT for 10-14 days |
|                              |                                             | - Start BT after recovery (Mohindra et al., 2020) | - Start BT after recovery (Mohindra et al., 2020) |
|                              |                                             | High-risk cases: | High-risk cases: |
|                              |                                             | - Postpone boost (8-12 weeks) | - Postpone boost (8-12 weeks) |
|                              |                                             | - Opt EBRT according to local facilities (Chargari et al., 2020) | - Opt EBRT according to local facilities (Chargari et al., 2020) |
|                              |                                             | Interstitial BT for definitive COVID-19+ cases: | Interstitial BT for definitive COVID-19+ cases: |
|                              |                                             | - Delay treatment up to 10-14 days after recovery | - Delay treatment up to 10-14 days after recovery |
|                              |                                             | - Increase BT dose by 5 Gy / week deferent (Mohindra et al., 2020) | - Increase BT dose by 5 Gy / week deferent (Mohindra et al., 2020) |
|                              |                                             | Intermediate risk endometrial cancer | Intermediate risk endometrial cancer |
|                              |                                             | (Exclusive): Postpone (8-12 weeks) or opt for surveillance (Chargari et al., 2020) | (Exclusive): Postpone (8-12 weeks) or opt for surveillance (Chargari et al., 2020) |
|                              |                                             | Postop vaginal cuff cases: | Postop vaginal cuff cases: |
|                              |                                             | - Postpone BT up to 8-9 weeks after surgery | - Postpone BT up to 8-9 weeks after surgery |
|                              |                                             | - COVID-19+ patients: postpone BT until pandemic solves | - COVID-19+ patients: postpone BT until pandemic solves |
|                              |                                             | Early-stage intermediate risk: | Early-stage intermediate risk: |
|                              |                                             | - Postpone BT up to 6 months based on patient comorbidities | - Postpone BT up to 6 months based on patient comorbidities |
|                              |                                             | – 7 Gy (to 0.5 cm depth) in 3 frs allowing 14 days inter-fraction interval | – 7 Gy (to 0.5 cm depth) in 3 frs allowing 14 days inter-fraction interval |
|                              |                                             | Stage II: | Stage II: |
|                              |                                             | - Postpone by 1–2 months | - Postpone by 1–2 months |
|                              |                                             | - Postpone at least 24 days for COVID-19 positive cases (ElMajjaoui et al., 2020) | - Postpone at least 24 days for COVID-19 positive cases (ElMajjaoui et al., 2020) |
|                              |                                             | Stages IB Gr 3, stage II G1 and G2 with no high-risk features, stage IIIA-IIIC Vault brachytherapy (Hinduja et al., 2020) | Stages IB Gr 3, stage II G1 and G2 with no high-risk features, stage IIIA-IIIC Vault brachytherapy (Hinduja et al., 2020) |
|                              |                                             | For patients with significant comorbidities: for 6 months | For patients with significant comorbidities: for 6 months |
|                              |                                             | Intermediate-risk endometrial cancer: | Intermediate-risk endometrial cancer: |
|                              |                                             | Delaying VVB up to 12 weeks | Delaying VVB up to 12 weeks |
|                              |                                             | Stage II endometrial cancers: | Stage II endometrial cancers: |
|                              |                                             | Adjuvant VVB (exclusively: if invasion < 50 % of the myometrium, G1 and 2 or after RT: if invasion > 50 % of the myometrium, G3): postpone brachytherapy by 1-2 months | Adjuvant VVB (exclusively: if invasion < 50 % of the myometrium, G1 and 2 or after RT: if invasion > 50 % of the myometrium, G3): postpone brachytherapy by 1-2 months |
|                              |                                             | COVID-19 positive patient: postpone treatment (at least 24 days) | COVID-19 positive patient: postpone treatment (at least 24 days) |
|                              |                                             | Stage I: | Stage I: |
|                              |                                             | - Postpone BT up to 1–6 months for patients with significant comorbidities | - Postpone BT up to 1–6 months for patients with significant comorbidities |
|                              |                                             | Patients who should start VVB: 7 Gy/3 frs (depth of 0.5 cm) with an interval spacing of 14 days between the fractions | Patients who should start VVB: 7 Gy/3 frs (depth of 0.5 cm) with an interval spacing of 14 days between the fractions |
|                              |                                             | High-risk patients (received adjuvant RT): Omitting VVB | High-risk patients (received adjuvant RT): Omitting VVB |
|                              |                                             | Stages IA Gr I-Gr III and IB Gr I-II: Vault brachytherapy if positive margins, suboptimal surgery | Stages IA Gr I-Gr III and IB Gr I-II: Vault brachytherapy if positive margins, suboptimal surgery |
|                              |                                             | Stages IB Gr 3, stage II G1 and G2 with no high-risk features, stage IIIA-IIIC Vault brachytherapy (Hinduja et al., 2020) | Stages IB Gr 3, stage II G1 and G2 with no high-risk features, stage IIIA-IIIC Vault brachytherapy (Hinduja et al., 2020) |
|                              |                                             | For patients with significant comorbidities: for 6 months | For patients with significant comorbidities: for 6 months |
|                              |                                             | Intermediate-risk endometrial cancer: | Intermediate-risk endometrial cancer: |
|                              |                                             | Delaying VVB up to 12 weeks | Delaying VVB up to 12 weeks |
|                              |                                             | Stage II endometrial cancer with poor prognostic factors (if invasion > 50 % of the myometrium, G3), and for stage I high-risk endometrial cancer: | Stage II endometrial cancer with poor prognostic factors (if invasion > 50 % of the myometrium, G3), and for stage I high-risk endometrial cancer: |
|                              |                                             | Adjuvant RT and brachytherapy (ElMajjaoui et al., 2020) | Adjuvant RT and brachytherapy (ElMajjaoui et al., 2020) |
|                              |                                             | Advanced stage (ElMajjaoui et al., 2020) | Advanced stage (ElMajjaoui et al., 2020) |
|                              |                                             | Early vaginal cancer (stage I, < 5 mm of invasion) with significant comorbidities: postpone brachytherapy by 1-2 months | Early vaginal cancer (stage I, < 5 mm of invasion) with significant comorbidities: postpone brachytherapy by 1-2 months |
|                              |                                             | Upper and lower vagina (Hinduja et al., 2020) | Upper and lower vagina (Hinduja et al., 2020) |
|                              |                                             | For advanced stage: | For advanced stage: |
|                              |                                             | CRT followed by vaginal brachytherapy (7 Gy/3frs) | CRT followed by vaginal brachytherapy (7 Gy/3frs) |

(continued on next page)
4.2.3. Breast

Based on a previous review, the RT of breast cancer in cases with locally advanced and inflammatory, residual positive lymph node (N2), recurrent, triple-negative node-positive, and extensive lymph vascular invasion categorized with high priority indication (Zaniboni et al., 2020). The most frequent thresholds for age and maximum tumor size were 65 years old and 2.5–3 cm, respectively. Standard Hypo-F RT (i.e., 40 Gy / 15 frs), the routine schedule for breast irradiation, is the most highlighted treatment. However, when BT is feasible, applying HDR accelerated partial breast irradiation (APBI) or LDR interstitial brachytherapy (LDR) technique using a single applicator or needle entry was proposed for early-stage disease. It allowed a maximum delay of 12 weeks for patients’ RT of ductal carcinoma in situ (DCIS) cases with high RT indication (e.g., ER-negative with positive surgical margin).

4.2.4. Lung

Almost all related kinds of literature recommended continuing RT for non-small cell lung cancer (NSCLC), limited-stage of small cell lung cancer (LS-SCLC), or palliative setting (Table 1) during the pandemic. However, they proposed to hold off RT for the extensive-stage (ES-SCLC). Delaying the prophylactic cranial irradiation (PCI) of SCLC with both limited and extensive disease was highly recommended in the COVID-19 pandemic setting (Madan et al., 2020). The stereotactic body radiotherapy (SBRT) technique with a limited fraction number is the ideal RT option during the pandemic era. For instance, the fractionation suggested for the peripheral and central tumors of NSCLC was 54 Gy / 3 frs and 50 Gy / 5 frs, respectively. Besides, for limited-stage and extensive SCLC stage, 40 Gy / 15 frs and 25 Gy / 5 frs for radical and consolidation radiotherapy, and 25 Gy / 10 frs for PCI, respectively (Rathod et al., 2020).

4.2.5. Gastrointestinal

Continuing CRT or neoadjuvant RT for esophageal cancer treatment using the Hypo-F RT regimen was frequently recommended (e.g., 50 Gy / 4 frs) for palliative cases, during the breakdowns and shortage of RT capacities. However, in these cases, concomitant chemotherapy was restricted to the RT regimen with a prescribed dose of less than 2.4 Gy / fr (Thomson et al., 2020). It is recommended to continue brachytherapy of oral tongue cases with high local recurrence probability and SCC of the lip, oral mucosa, and nasal region. Switching to EBRT is preferred for COVID-19 positive cases, also patients and caregivers with a higher risk of infection (Table 2).

Table 2 (continued)

| Cancer type          | Hold BT and choose another treatment option | Delay BT until the end of the pandemic | Continue BT during the pandemic |
|----------------------|--------------------------------------------|---------------------------------------|---------------------------------|
| Vulvar               | Volva: radical, adjuvant and palliative (Hinduja et al., 2020) | low priority and only be carried out when operation theatre capacity allows it (Barthwal et al., 2020) | Postpone BT boost until pandemic solves. For COVID-19+ patients during RT, continue EBRT rather than brachytherapy boost (Mohindra et al., 2020) |
| Sarcoma              | Prevent non-melanoma skin cancers: | Soft-tissue sarcomas: | Soft-tissue sarcomas: |<br>- BT alone (HDR instead of LDR with iridium-192 wires) rather than 60–66 Gy / 1–8–2 Gy / fr<br>- adjuvant EBRT ()<br>- BT can be employed in specialized centers, especially for rhabdomyosarcoma (Barthwal et al., 2020) |
| Pediatrics           | Pediatrics indication: To be discussed on an individual basis (Chargari et al., 2020) | | |<br>- Use BT with fewer fractions, especially in inoperable patients () |
| Skin                 | Basal cell carcinoma (Exclusive): | Basal cell carcinoma: | Basal cell carcinoma: |<br>- Postpone according to functional risk<br>- Until it is suitable for the institute (Barthwal et al., 2020)<br>- Do not postpone (Chargari et al., 2020) |
| Keloids (Exclusive)  | Hypo-F RT can be delivered in a twice-daily frs<br>- Switch interstitial BT to EBRT<br>- Switch to IORT if facilities are available (Barthwal et al., 2020)<br>- Omit BT and consider options (Chargari et al., 2020) | BT should be avoided and replaced by Hypo-F EBRT (Barthwal et al., 2020) | Continue (Mohindra et al., 2020;) |
| Uveal Melanoma       | BT should be avoided and replaced by Hypo-F EBRT (Barthwal et al., 2020) | | |<br>- Delay BT until end of pandemic<br>- Continue BT during the pandemic |
| Palliative           | | | |<br>- Do not postpone (Chargari et al., 2020) |

RT: radiotherapy, BT: brachytherapy, EBRT: external beam radiotherapy, HDR: high-dose-rate, LDR: low-dose-rate, SCC: squamous cell carcinoma, PPE: personal protective equipment, IORT, intra-operative radiotherapy, Hypo-F RT: hypo-fractionated RT, ISBT: interstitial brachytherapy, VVB: Vaginal vault brachytherapy.
34

/ 16 frs for tumors up to 5 cm, 55 Gy / 10 frs for tumors up to 10 cm in length, and 40 Gy/15 frs for neoadjuvant Hypo-F dCRT (Jones et al., 2020a). Surgery can be postponed up to 3 months for these cases (Belkacemi et al., 2020b). Tumor length was defined as a restricting factor for dose per radiotherapy fraction (Tables 1 and 3).

SBRT (e.g., 24–60 Gy /1–5 frs), proton therapy, or systemic RT was suggested for the liver malignancies based on the cancer stage (Atitken et al., 2020). For locally advanced pancreatic cancer continuing with Hypo-F RT with/without SBRT technique is recommended for both unresected (single fraction SBRT (8–10 Gy) for palliation) and resected cases (SBRT: 30–33 Gy / 5 frs and without SBRT: 25 Gy / 5 frs, or 30 Gy /10 frs) (Tchelebi et al., 2020). For operable cholangiocarcinoma, surgery can be the option of cancer management. Avoiding BT was suggested for patients with esophageal- and cholangial-carcinoma until the pandemic and the risk of virus transmission reduces.

For locally advanced rectal cancer (LARC), delaying radiotherapy is not recommended to decrease the recurrence rate and increase anal sphincter preservation probability (Siavashpour et al., 2020). However, neoadjuvant short-course radiation therapy (SCRT) (i.e., 25 Gy in 5 frs) with postponed surgery (up to three months) for the intermediate-to-high-risk patients can be an optimum choice based on the recommendations of the pandemic setting to decrease the frequency and duration of the patients’ exposure. However, distance from the mesorectal fascia (MRF-D) is considered a restricting factor for SCRT selection. Long-course chemoradiotherapy (LCCRT) (i.e., 45–54 Gy in 25–30 frs) was suggested for patients with MRF-D ≤ 2 mm to safely delay the surgery and improve the chance of clinical response. Adjuvant RT can be omitted or postponed for early-stage and low-risk cases (Madan et al., 2020). Delaying or omitting rectal BT is recommended for all patients except for unresectable lesions, frail elderly, or medically inoperable ones (Siavashpour et al., 2020; Mohindra et al., 2020). It was suggested to continue the anal cancer radiotherapy by Hypo-F RT regimen (i.e., 30 Gy / 10–15 frs) or following the standard treatment. However, switching from BT to EBRT or IORT was suggested in these cases (Tables 1–3).

4.2.6. Genitourinary

Delaying or omitting surgery for muscle-invasive bladder cancer (MIBC) patients and choosing treatment options like RT and chemotherapy may be suboptimal. However, in the COVID-19 pandemic, this delay has been avoidable due to operating room closure and saturation of ICU beds (Sarkis et al., 2020). Therefore, some recommendations were proposed for treating these patients using RT even by curative or palliative indication. Hypo-F RT was the dominant suggested regimen by, for example, 55 Gy / 20 frs and 21 Gy / 3 frs for curative and palliative purposes, respectively (Table 1). SIB technique can also be applied for the unresected cases. It’s better to continue RT, but with a Hypo-F regimen (e.g., 24 Gy / 1–4 frs) for unresectable or medically inoperable renal cell carcinoma (RCC) cases.

In prostate cancer, EBRT omission and active surveillance (AS) were recommended for very low-, low-, and intermediate-to-low-risk cases during the pandemic. 3–6 months delaying radiotherapy and using AS, ADT, or hormonal deprivation can be chosen for low risk, intermediate-to-high, high-risk, or localized prostate cancer in a post-operation setting. It is recommended to continue radiotherapy for high-risk and advanced cases with curative intent. The Hypo-F RT regimen is highly preferred (Tables 1 and 3). This irradiation regimen (e.g., 36 Gy / 6 frs) is also suggested for oligometastatic disease (Belkacemi et al., 2020b). Radiotherapy omission or short-course palliative also preferred shortening the BT fractionation of intermediate- and high-risk prostate cancer (e.g., 15 in one fraction) or ultimately shifting to the EBRT to reduce the risk of patient exposure to the infection is proposed during the pandemic.

4.2.7. Gynecological

In gynecological cancer, adjuvant treatment after surgery with curative intent has a high-priority for radiotherapy (Uwins et al., 2020). For example, not postponing EBRT or BT was highly suggested for locally advanced cervical cancer (Tables 1 and 2). In invasive uterine cervix carcinoma, it was proven to have lower tumor control and higher recurrence risk when the overall treatment time (OTT) exceed more than seven weeks, especially for squamous cell carcinoma (SCC) (Mohammadi, 2019; Siavashpour, 2016). Tanderup et al. suggested an additional 5 Gy dose to the high-risk CTV (CTVHR) to compensate for the local control loss if the OTT increases from one week to more than seven weeks (Tanderup et al., 2016). Therefore, the proposed consensus tried to align these principles and keep the OTT less as possible, even by hypo-fractionated brachytherapy (Table 3). Continuing EBRT in advanced stages or palliative situation of endometrial, ovarian, and vulvar cancer was also recommended during this crisis. Postponing BT for intermediate-risk gynecological malignancies except for cervical cancer or COVID-19 positive patients is also proposed (Table 2).

4.2.8. Sarcoma

Preoperative RT of soft tissue sarcoma (STS) is not generally accepted due to the higher risk of wound complications after radiotherapy. However, there are also some benefits for this neoadjuvant RT, such as the lower risk of tumor cell seeding during operation, lesser organs at risk exposure during radiotherapy. In the pandemic, two more benefits of decreasing the OTT and the risk of exposure to virus infection were added to this neoadjuvant treatment, especially for large border-line resectable sarcomas using the Hypo-F regimen (e.g., 28 Gy / 8 frs or 25 Gy / 5 frs) (Spalek and Rutkowski, 2020). SBRT is a good treatment option for these patients with unresectable or lung metastases from sarcoma. Preoperative RT for Ewing’s sarcoma cases can be an option where surgery is not feasible or suitable (Gulia et al., 2020). In specialized and dedicated centers, HDR-BT can be employed for soft tissue cases such as rhabdomyosarcoma.

4.2.9. Pediatric

The oncologists recommend following the standard treatment for pediatrics as long as the radiotherapy has the most efficient clinical consequence (Janssens et al., 2020). Radiotherapy omission was just recommended for low-grade cases or where the palliative care is intended based on the pediatric part of Tables 1 and 2. Five priority levels were defined for continuing radiotherapy of pediatrics, dedicating higher RT priority to the medulloblastoma, high-grade ependymoma, retinoblastoma cases, and lower priority to the low-grade glioma and meningioma cases (Table 1). Continuing the brachytherapy of pediatric patients has also been emphasized in the pandemic period (Table 2).

4.2.10. Lymphoma

For aggressive disease, T-Cell and high-grade lymphomas, or for symptomatic patients continuing radiotherapy should be selected. However, RT was recommended for even early-stage Hodgkin lymphoma (HL) (Vordermark, 2020b). Radiotherapy can be ignored in old patients with low-grade lymphomas or when good results were obtained after surgery or chemotherapy (Table 1).

4.2.11. Skin

Definitive RT of melanoma, unresectable SCC and basal cell carcinoma (BCC), and rare cases of Merkel cell carcinoma (MCC) were suggested during the pandemic (Table 1). However, adjuvant RT’s omission can be chosen for BCC, melanoma, and SCC with low relapse risk and when the limited benefit is expected. Delaying radiotherapy up to 3 months was proposed for non-prompt growing disease or rare skin pathologies, which were incompletely excised.

4.2.12. Palliative

Radiotherapy omission and switching to the supportive care accomplished with medical therapies were proposed for patients with short life expectancy (days to few weeks) during the coronavirus pandemic setting. These patients are usually in critical conditions that need supportive immobilization or even getting help from palliative sedation to reach
| Cancer type | Country | Radical EBRT technique | Palliative EBRT Indication of EBRT during the pandemic | Suggested EBRT technique during the pandemic |
|------------|---------|------------------------|----------------------------------------------------|---------------------------------------------|
| CNS        | USA     | ✓ 60 Gy / 30 frs       | Not recurrent cases                                 | a) KPS ≥ 70: 60 Gy / 30 frs                |
|            |         |                        |                                                    | b) KPS < 70 or elderly: 40 Gy / 15 frs      |
|            |         |                        |                                                    | c) KPS < 50: 34 Gy / 10 frs or 25 Gy / 5 frs |
|            |         |                        |                                                    | 40 Gy in 15 frs OR 25 Gy in 5 frs           |
|            | Canada  | ✓ 60 Gy / 30 frs       |                                                    | dCRT should be limited to SIB techniques in the standard (5 fractions per week) or accelerated schedule (6 fractions per week) |
|            | Italy   | ✓ Almost a sequential technique |                                                    |                                             |
|            | Canada  | ✓ HPV+T1-T3N0-N2c (TNM-7), HPV+T1-T2N0 HNSCCs, and select stage III HNSCCs | 60 Gy / 25 frs (5 weeks; 24 Gy / frs) |                                             |
|            | India, USA | ✓ 1.8–2 Gy / fr | Hypo-F RT: 55 Gy / 20 frs |                                             |
|            | UK      | ✓ 35 frs regimens      |                                                    | 20 frs regimen                            |

**Head and neck**

| Cancer type | Country | Radical EBRT technique | Palliative EBRT Indication of EBRT during the pandemic | Suggested EBRT technique during the pandemic |
|-------------|---------|------------------------|----------------------------------------------------|---------------------------------------------|
| USA         | Kang et al., 2020 | ✓ | Treatment guidelines for curable patients | Treatment guidelines for curable patients |
|             |         |                        | - Nasopharynx: a) T1N0 | - Nasopharynx: a) RT alone (69.96 Gy/33 frs or 70 Gy/35 frs) |
|             |         |                        | b) All other M0 patients | b) CRT (69.96 Gy/33 frs or 70 Gy/35 frs) |
|             |         |                        | - Nasal cavity and paranasal sinuses (T1-T4) | - Nasal cavity and paranasal sinuses: Adjuvant RT (60–66 Gy/30–33 frs) + CC |
|             |         |                        | - Oral cavity (T1-T4) | In the absence of surgery: |
|             |         |                        | - Oropharynx and unknown primary | Definitive CRT: 70 Gy/35 frs + CC |
|             |         |                        | a) p16-positive | a) Oral cavity: Definitive CRT: 70 Gy / 35 frs + CC (proton therapy if feasible) |
|             |         |                        | a1) T1N0-T2N0 | a1) T1N0-T2N0: Definitive RT (69.96 Gy/33 frs or 70 Gy/35 frs) |
|             |         |                        | a2) Any T3, T4, or N+ | a2) Any T3, T4, or N+: Adjuvant RT (60–66 Gy/30–33 frs) + CC |
|             |         |                        | b) p16-negative | In the absence of surgery: |
|             |         |                        | b1) T1N0-T2N0 | b1) T1N0-T2N0: Definitive RT (70 Gy/35 frs) |
|             |         |                        | b2) Any T3, T4, or N+ | Consider proton therapy if feasible. |
|             |         |                        | - Larynx | - Larynx: |
|             |         |                        | a) T1N0 glottic larynx | a) T1N0 glottic larynx: Definitive RT (69.96 Gy/33 frs or 70 Gy/35 frs) |
|             |         |                        | a2, b2) Any T3, T4, or N+ | a2, b2) Any T3, T4, or N+: Definitive CRT (70 Gy/35 frs) + CC |
|             |         |                        | b) T2N0 glottic larynx | b) T2N0 glottic larynx: |
|             |         |                        | c) T1-T2N0 supraglottic or subglottic larynx | - Larynx: |
|             |         |                        | d) T3, T4, or N + glottic larynx; all other larynx | d) T3, T4, or N + glottic larynx; all other larynx: |
|             |         |                        | - Hypopharynx | - Hypopharynx: |
|             |         |                        | a) T1N0-T2N0 | a) T1N0-T2N0: |
|             |         |                        | b) Any T3, T4, or N+ | b) Any T3, T4, or N+: |

**Treatment guidelines where LRC is important**

a) Definitive RT (63 Gy / 28 frs)  
b) Definitive RT (65.25 Gy / 29 frs)  
c) Definitive RT (70 Gy / 35 frs or 69.96 Gy / 33 frs)  
d) Definitive CRT (70 Gy / 35 frs) + CC  

(continued on next page)
| Cancer type | Country | Radical | Palliative | Pre-pandemic EBRT technique | Indication of EBRT during the pandemic | Suggested EBRT technique during the pandemic |
|-------------|---------|---------|------------|-----------------------------|----------------------------------------|-----------------------------------------------|
| Breast      | Canada (Al-Rashdan et al., 2020) | ✓       |           | Hypo-F RT (42.5 Gy / 16 frs) | All referred                           | - APBI (27 Gy / 5 frs) for suitable (40 % of referred) |
|             | France (Belkacemi et al., 2020a) | ✓       |           | 50 Gy / 25 frs with 16 Gy / 8 frs boost | (50 Gy / 25 frs) or 40 Gy / 15 frs or 42.4 Gy / 16 frs for WBI | - 45 Gy / 18 frs |
|             | Canada (Koch et al., 2020) | ✓       |           | Standard fractionation (50 Gy / 25 frs) | (50 Gy / 25 frs) for BBI and 40 Gy / 15 frs or 42.4 Gy / 16 frs for WBI | - 40 Gy / 15 frs or 15 Gy / 6 frs |
| Breast      | Iran (Samiee et al., 2020) | ✓       |           | 50 Gy / 25 frs or 40 Gy / 15 frs | All referred                           | - 15 Gy / 3 frs |
|             | Italy, Portugal, Belgium, Australia, Switzerland, Poland (Thureau et al., 2020) | ✓       |           | Standard fractionation (50 Gy / 25 frs) or moderate Hypo-F RT (40 Gy / 15 frs) | All referring                           | - 12 Gy / 3 frs |
| USA (Dietz et al., 2020) | ✓       |           |           | All breast/chest wall and nodal RT | All referring                           | - Hypo-F RT |

**Table 3 (continued)**

- Recurrent HNC in need of re-irradiation: Treatment guidelines where LRC is important
- Recurrent HNC in need of re-irradiation:
  a) Conventionally fractionated RT (60–66 Gy/30-33 frs)
  b) Conventionally fractionated RT (70 Gy/35 frs)
  c) Quad Shot (3.7 Gy/frs twice daily × 2 consecutive days = 1 cycle; may repeat cycle every 3–4 weeks for up to 4 total cycles)
- Severe restrictions or limitations in radiation oncology operations
  - Larynx:
    a) T1N0 glottic larynx
    b) T1-T2N0 glottic
    c) Larynx
  - Oropharynx:
    a) T1-T2N0-N1 oropharynx
    b) p16+ T1N1-T2N2b or T3N0-T3N2b with ≤10-pack-y smoking history
    c) Locally advanced HNC (oral cavity, oropharynx, hypopharynx)
  a) T1N0-T4N3 SCC
  b) T1-T4N2-N3 SCC
  c) T3-T4N0 or any N + SCC

a) Postop patients
b) No surgery; >2 y from RT or good KPS
c) No surgery and rapid recurrence from first course
| Cancer type          | Country                                      | Radical EBRT technique | Palliative EBRT technique | Indication of EBRT during the pandemic                                                                 | Suggested EBRT technique during the pandemic |
|---------------------|----------------------------------------------|------------------------|---------------------------|------------------------------------------------------------------------------------------------------|---------------------------------------------|
|                     | Spain, UK (Pardoa et al., 2020)              | ✓                      | Hypo-F RT                 | c) boost should be reserved for patients with the greatest absolute benefit (e.g., positive margins, age ≤ 40) Adjuvant irradiation a) Hypo-F RT (boost with Hypo-F RT or even integrated with whole-breast irradiation (complete the treatment in 15 frs)). b) Eligible for ultra-short schedules b) Ultra-short schedules (5-7 frs) c) A 26 Gy / 5 frs (daily) and 29 Gy at the tumor bed with an integrated boost dose of 5-8 Gy d) 5 frs x 6 Gy for a 30 Gy dose or 35 Gy in 3.75 Gy / fr (twice daily) on the tumor bed with a negative margin. (Brachytherapy can also be an alternative) | d) Partial breast irradiation (for eligible ones) |
|                     | UK, Netherland, Italy, Australia, Israel, Spain, Denmark, France, Nederland, Brazil (Coles et al., 2020) UK (Higgins et al., 2020) France (Beddok et al., 2020) Slovenia (Orazem and Ratosa, 2020)                        | ✓                      | Hypo-F RT                 | Neoadjuvant irradiation a) All the case with delayed surgery a) Patients that require RT with node negative tumors (not require a boost) b) Selected cases b) Patients that require RT breast/chest wall and nodal a) Any breast cancer (first choice) b) 26 Gy / 2.6 Gy / fr and concomitant 29-30 Gy boost in 5-7.5 Gy / frs at the tumor bed. Elderly cases Hypo-F RT: - weekly 6.5 Gy dose delivered for five weeks for a total of 32.5 Gy Elderly cases - A boost of two 6.5 Gy / fr can be - 5.5 Gy / fr will be delivered up to a total dose of 27.5 Gy if axillary nodes are to be included. a) 28-30 Gy / 5 frs (1 fr / week) or 26 Gy / 5 daily frs | Hypo-F RT: 26 Gy / 5 frs Hypo-F RT: 40 Gy / 15 frs Hypo-F RT: 26 Gy / 5 frs |
|                     | Switzerland (Achard et al., 2020)            | ✓                      | Normo-fractionation and Hypo-F RT | Increase of Hypo-F RT n (from 65% to over 80%) - Moderate Hypo-F RT (42.5 Gy / 16 frs or 40 Gy / 15 frs) for majority of stages - Hypo-F RT (26 Gy / 10 frs daily or 26 Gy / 5 frs once-weekly) | Normo-fractionation or moderate Hypo-F RT |
|                     | Zambia, USA (Lombe et al., 2020)             | ✓                      | 50 Gy / 25 frs             | a) Breast Chest wall b) Breast supraclavicular + chest wall All eligible patients adopting the Fast-Forward | a) Breast Chest wall b) Breast supraclavicular + chest wall All eligible patients adopting the Fast-Forward |
|                     | Belgium (Machiels et al., 2020)              | ✓                      | 40 Gy / 15 frs             | Ultra-Hypo-F RT: 26 Gy / 5 frs + A single boost dose of 6 Gy was delivered using an IMRT technique for deeply seated tumors and a single electron field for superficial tumors | Ultra-Hypo-F RT: 26 Gy / 5 frs |
|                     | Canada (Patrick et al., 2020)                | ✓                      | 40 Gy / 15 frs             | Hypo-F RT: 26 Gy / 5 frs | Hypo-F RT: 26 Gy / 5 frs (continued on next page) |

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| Cancer type | Country | Radical EBRT technique | Palliative EBRT technique | Indication of EBRT during the pandemic | Suggested EBRT technique during the pandemic |
|-------------|---------|------------------------|--------------------------|----------------------------------------|--------------------------------------------|
| Egypt, Morocco, Saudi Arabia, USA, Jordan (Elghazawy et al., 2020) | ✓ | 50 Gy / 25 frs | | c) WBRT +/- regional lymph nodes | a) 30 Gy / 5 frs, daily 28.5 Gy / 5 frs, daily 38 Gy / 10 frs, twice a day b) 20 Gy once c) Hypo-F RT: 40.05 Gy / 15 frs, daily, 3DCRT - Extreme Hypo-F RT (node-negative, without boost) 28.5 Gy / 5 frs, weekly or 26 Gy / 5 frs, daily d) 40.05 Gy / 15 frs, daily, 3DCRT 43.5 Gy / 15 frs, daily, 3DCRT |
| USA (Ling et al., 2020) | ✓ | 40 Gy / 15 frs | | a) Partial breast | a) 30 Gy / 5 frs b) 26 Gy / 5 frs c) 30 Gy / 5 frs every 2nd day or IMRT technique |
| | | | | b) Whole breast | b) UK FAST: 28.5 Gy / 5 frs each once a week |
| Poland (Lacko et al., 2020) | ✓ | 50 Gy / 25 frs | | c) WB + RNI | c) SIB: 40 Gy / 15 frs per breast (3.66 Gy + 3.2 Gy per boost (total dose of 48 Gy)) - SIB: 42.56 Gy / 16 frs per breast + 3 Gy per boost (total dose of 48 Gy) |
| | | | | d) WBI + RNI | d) 40 Gy / 15 frs |
| Lung | USA (Wu et al., 2020) | ✓ ✓ | | a) NSCLS 1,2,3) 18 Gy / 3frs, 12 Gy / 4frs, or 10 Gy / 5frs 4) 60-70 Gy / 30-35 frs 5) 54-60 Gy / 27-30frs for margin-positive 50-54 Gy / 25-30 frs for margin negative | b) SCLC: 1) 45 Gy in twice-daily 1.5Gy or 66-70 Gy / 33-35frs 2) 25 Gy / 10frs 20 Gy / 5frs 3) Ultra-central T 1-2 N0 4) Locally advanced NSCLC 5) Postoperative radiation for NSCLC 5) 50 Gy / 25 frs |
| | | | | 1) Peripheral T 1-2 N0 2) Central T 1-2 N0 3) Ultra-central T 1-2 N0 4) 55 Gy / 20 frs or 45-60 Gy / 15 frs | a) NSCLS |
| | | | | 1) 34 Gy / 1 fr 2) 50 Gy / 5 frs 3) 60 Gy / 8 frs 4) MRI surveillance 5) Palliative lung RT | b) SCLC: 1) Limited-stage SCLC (thoracic RT) 2) Limited-stage SCLC (prophylactic cranial RT) 3) Extensive-stage SCLC (thoracic RT) 4) Extensive-stage SCLC (prophylactic cranial RT) 5) Palliative lung RT |
| | | | | 1) 45 Gy / 30 twice-daily frs 2) 25 Gy / 10 frs vs. MRI surveillance 3) MRI surveillance 4) MRI surveillance 5) 20 Gy / 5 frs, 17 Gy / 2frs or 10 Gy / 1 fr | a) NSCLC: 1) peripheral a) NSCLC: 1) SBRT: 54 Gy / 3 frs b) central 2) SBRT: 50 Gy / 5 frs 3) concurrent CRT 3) concurrent CRT |
| | Canada (Rathod et al., 2020) | ✓ | 60 Gy / 30 frs or 66 Gy / 33 frs | | continued on next page |

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| Cancer type       | Country                              | Radical Indication of EBRT during the pandemic | Palliative Suggested EBRT technique during the pandemic |
|-------------------|--------------------------------------|-----------------------------------------------|-------------------------------------------------------|
|                   |                                      | 4) sequential CTRT 4) 40 Gy / 15 frs or 50 Gy | 4) 40 Gy / 15 frs or 50 Gy |
|                   |                                      | b) SCLC: 45 Gy / 30 frs or 66 Gy / 33 frs | b) SCLC: 45 Gy / 30 frs or 66 Gy / 33 frs |
|                   |                                      | PCI: 25 Gy / 10 frs 4) 25 Gy / 10 frs        | PCI: 25 Gy / 10 frs 4) 25 Gy / 10 frs |
|                   | USA (Kumar et al., 2020) ✓           | When concurrent chemotherapy is not necessary | Hypo-F IMRT (with SIB were needed): |
|                   |                                      | a) NSCLC: 1) SABR IN 1-3 frs for stages I-II | a) NSCLC: 1) SABR IN 1-3 frs for stages I-II |
|                   |                                      | 2) 30-34 Gy / 1 fr for tumors < 2 cm and ≥ 1 cm from the chest wall | 2) 30-34 Gy / 1 fr for tumors < 2 cm and ≥ 1 cm from the chest wall |
|                   |                                      | 3) 48-54 Gy / 3 frs for peripheral lesions | Extensive stage: 2) Early stage: 40-42 Gy / 15 frs daily or 50-55 / 20-25 frs daily |
|                   |                                      | 4) 45 – 60 Gy / 4-8 frs for central and ultra-central lesions | 4) Extensive stage: 30 Gy / 10 frs |
|                   |                                      | 5) 55 Gy / 20 frs for stage II-III | 5) Extensive stage: 30 Gy / 10 frs |
|                   |                                      | 6) 45 Gy / 15 frs for poor performance patients | 6) Extensive stage: 30 Gy / 10 frs |
|                   |                                      | b) PCI - 25 Gy / 10 frs | c) PCI - 25 Gy / 10 frs |
|                   | USA, France, China, Spain, the UK (Liao et al., 2020) ✓ | When concurrent chemotherapy is not necessary | Hypo-F IMRT (with SIB were needed): |
|                   |                                      | a) NSCLC: 1) SABR IN 1-3 frs for stages I-II | a) NSCLC: 1) SABR IN 1-3 frs for stages I-II |
|                   |                                      | 2) 30-34 Gy / 1 fr for tumors < 2 cm and ≥ 1 cm from the chest wall | 2) 30-34 Gy / 1 fr for tumors < 2 cm and ≥ 1 cm from the chest wall |
|                   |                                      | 3) 48-54 Gy / 3 frs for peripheral lesions | Extensive stage: 2) Early stage: 40-42 Gy / 15 frs daily or 50-55 / 20-25 frs daily |
|                   |                                      | 4) 45 – 60 Gy / 4-8 frs for central and ultra-central lesions | 4) Extensive stage: 30 Gy / 10 frs |
|                   |                                      | 5) 55 Gy / 20 frs for stage II-III | 5) Extensive stage: 30 Gy / 10 frs |
|                   |                                      | 6) 45 Gy / 15 frs for poor performance patients | 6) Extensive stage: 30 Gy / 10 frs |
|                   |                                      | b) SCLC: 1) SABR IN 3-5 frs, 60 Gy / 3 frs, 48 Gy / 4 frs or | Extensive stage: 2) Early stage: 40-42 Gy / 15 frs daily or 50-55 / 20-25 frs daily |
|                   | Canada (Kidane et al., 2020) ✓       | Early-stage: For the limited stage standard of care is concurrent chemoradiation with 45 Gy / 30 frs twice daily | Extensive stage: 3) Extensive stage: 30 Gy / 10 frs |
|                   |                                      | a) Early-stage (T1-T2N0M0) NSCLC (non-central tumors) | Extensive stage: 3) Extensive stage: 30 Gy / 10 frs |
|                   |                                      | b) Pulmonary oligometastases (central tumors) | Extensive stage: 3) Extensive stage: 30 Gy / 10 frs |
|                   | USA (Ng et al., 2020b) ✓             | Peripheral early-stage NSCLC                    | Extensive stage: 3) Extensive stage: 30 Gy / 10 frs |
|                   |                                      | - dCRT as the most appropriate curative option for both OSCC and OAC | Extensive stage: 3) Extensive stage: 30 Gy / 10 frs |
|                   |                                      | - High-risk patients for readmission, such as those with high-grade dysphagia, may not be appropriate for dCRT | Extensive stage: 3) Extensive stage: 30 Gy / 10 frs |
|                   | UK (Jones et al., 2020a) ✓ ✓         | dCRT: 2 Gy / fr                                | dCRT: 2 Gy / fr |
|                   |                                      | - Where dCRT is unavailable or inappropriate, consider Hypo-F-dRT | - Where dCRT is unavailable or inappropriate, consider Hypo-F-dRT |
| Gastrointestinal Esoophageal |                                      | Early-stage                                     | Early-stage |
| Brazil (Riechelmann et al., 2020) ✓ |                                      | 1) cT2-T4 and/or clinically lymph-node positive (cN+) SCC cases | 1) Neoadjuvant chemoradiation with reduced dose (41-4 Gy) |
|                   |                                      | 2) Patients with obstructive symptoms or hemorrhage | 2) Patients with obstructive symptoms or hemorrhage |
|                   |                                      | a) Operable patients                            | a) Operable patients |

(continued on next page)
| Cancer type | Country | Radical | Palliative | Pre-pandemic EBRT technique | Indication of EBRT during the pandemic | Suggested EBRT technique during the pandemic |
|-------------|---------|---------|------------|----------------------------|----------------------------------------|---------------------------------------------|
| Lymphoma    | USA     | ✓       |            | Conventional- or Hypo-F RT | Where surgery is unlikely to be available for the resectable and borderline disease | Single-fraction SBRT: 25 Gy Hypo-F RT: 25–35 Gy/5 frs (RT alone) or 36 Gy/15 frs CRT with concurrent capcitabine SABR: 24–60 Gy/1–5 frs radiofrequency ablation or stereotactic RT |
| Pancreatic   | UK      | ✓       | ✓          | Standard techniques       | Localized BCLC stage A                  | SCRT                                        |
|             | USA     | ✓       |            | SCRT                       | Locally advanced pancreatic cancer      | SCRT                                        |
|             | Brazil  | ✓       |            | SCRT (neoadjuvant)         | Locally advanced                       | SCRT                                        |
| Liver       | India   | ✓ ✓     |            | SCRT                       | Locally advanced                        | SCRT                                        |
|             | Italy   | ✓       |            | SCRT                       | Locally advanced                        | SCRT                                        |
|             | USA     | ✓       |            | SCRT                       | Locally advanced                        | SCRT                                        |
|             | France  | ✓       |            | SCRT                       | Locally advanced                        | SCRT                                        |
|             | Switzerland | ✓ |            | SCRT                       | Locally advanced                        | SCRT                                        |
|             | Brazil  | ✓       |            | SCRT                       | Locally advanced                        | SCRT                                        |
|             | USA     | ✓       |            | SCRT                       | Locally advanced                        | SCRT                                        |
| Rectal      | USA     | ✓       |            | SCRT                       | Locally advanced                        | SCRT                                        |
|             | Brazil  | ✓       |            | SCRT                       | Radiotherapy                            | SCRT                                        |
|             | USA     | ✓       |            | SCRT                       | Locally advanced                        | SCRT                                        |
|             | Italy   | ✓       |            | SCRT                       | Locally advanced                        | SCRT                                        |
|             | The USA, UK | ✓ |            | SCRT                       | Locally advanced                        | SCRT                                        |
| Genitourinary | Iran    | ✓       |            | Standard techniques       | Radiation of the whole pelvis is not intended | Ultra-Hypo-F RT (1-6 frs) or Moderate Hypo-F RT (5-20 frs) |
| Prostate    | Singapore | ✓ |            | Standard techniques       | Localized prostate cancer               | Salvage (20 frs) - SBRT - Abbreviated radiotherapy - A single 19 Gy /1 fr HDR brachytherapy CHHiP: 60 Gy / 20 frs over four weeks or 57 Gy / 19 frs over 3.8 weeks (Dearnaley et al., 2016) (continued on next page) |

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Table 3 (continued)

| Cancer type | Country | Radical | Palliative | Pre-pandemic EBRT technique | Indication of EBRT during the pandemic | Suggested EBRT technique during the pandemic |
|-------------|---------|---------|------------|-----------------------------|----------------------------------------|---------------------------------------------|
|             |         |         |            |                             | - UIR, HR, and VHR prostate cancer patients for whom RT should begin NADT | Hypo-F RT                                      |
|             |         |         |            |                             | - High-risk features post-RP (early salvage RT) |                                             |
|             | Canada  | ✓       | ✓          |                             | 74 Gy / 37 frs                           | High risk                                    |
|             | (Kokorovic et al., 2020) |         |            |                             | 60 Gy / 30 frs                           | 60 Gy / 20 frs                                |
|             | Zambia, USA (Lombe et al., 2020) | ✓       | ✓          |                             | All risk groups of localized prostate cancer | - SBRT with Ultra Hypo-F RT in 5-7 frs |
|             | Canada (Patrick et al., 2020) | ✓       | ✓          |                             | All but for the patients that may need elective radiotherapy to the paraaortic drainage, or if significant downstaging is necessary, like for the cases with FIGO stage IIIB-IVA. |                                             |
|             | USA (Ling et al., 2020) | ✓       | ✓          |                             | EBRT: 50 Gy / 25 frs                      |                                               |
|             | Zambia, USA (Lombe et al., 2020) | ✓       | ✓          |                             | EBRT: 50 Gy / 25 frs                      |                                               |
|             | Morocco (Ismailli, 2020a) | ✓       | ✓          |                             | Brachytherapy: 7 Gy / 4 frs               |                                               |
|             | UK, Canada (Mendez et al., 2020) | ✓       | ✓          |                             | EBRT: 50 Gy / 25 frs                      |                                               |
|             | France (Belkacemi et al., 2020a) | ✓       | ✓          |                             | Preoperative Soft tissue sarcoma: 50 Gy / 25 frs |                                               |
|             | Poland (Spalek and Rutkowski, 2020) | ✓       | ✓          |                             | Preoperative Soft tissue sarcoma: 50 Gy / 25 frs |                                               |
|             | France (Belkacemi et al., 2020a) | ✓       | ✓          |                             | High-grade: 40 Gy / 20 frs                |                                               |
|             | UK (Rembielak et al., 2020) | ✓       | ✓          |                             | a) 35 Gy / 5 frs                          | cSCC, MCC, and rare skin pathologies for which definitive RT should be considered |
|             | France (Belkacemi et al., 2020a) | ✓       | ✓          |                             | b) 45 Gy / 10 frs                         |                                               |
|             |                  |         |            |                             | c) 55 Gy / 20 frs                         |                                               |
|             | Australia (Veness, 2020) | ✓       | ✓          |                             | Non-Melanoma (NMSC):                      |                                               |
|             |                  |         |            |                             | 1) BCC                                   |                                               |
|             |                  |         |            |                             | 2a) 30-45 Gy / 5-15 frs 1-4 frs           |                                               |
|             |                  |         |            |                             | 1b) 30-45 Gy / 5-15 frs 1-4 frs           |                                               |
|             |                  |         |            |                             | 1c) 45-50 Gy / 15-20 frs 5-6 frs          |                                               |
|             |                  |         |            |                             | 2) SCC                                   |                                               |
|             |                  |         |            |                             | 2a) 30-45 Gy / 5-15 frs 1-4 frs           |                                               |
|             |                  |         |            |                             | 2b) 30-45 Gy / 5-15 frs 1-4 frs           |                                               |
|             |                  |         |            |                             | 2c) 45-50 Gy / 15-20 frs 1-4 frs          |                                               |
| Cancer type | Country | Radical | Palliative | Pre-pandemic EBRT technique | Indication of EBRT during the pandemic | Suggested EBRT technique during the pandemic |
|------------|---------|---------|------------|-----------------------------|--------------------------------------|----------------------------------|
|            |         |         |            |                             |                                       | 70–80 years                        |
|            |         |         |            |                             |                                       | ECOG 0/1:                         |
|            |         |         |            |                             |                                       | 1a)                               |
|            |         |         |            |                             |                                       | 30–40 Gy / 5–10 frs               |
|            |         |         |            |                             |                                       | 1b) no RT                         |
|            |         |         |            |                             |                                       | 30–40 Gy / 5–10 frs               |
|            |         |         |            |                             |                                       | 1c)                               |
|            |         |         |            |                             |                                       | 40–45 Gy / 10–15 frs              |
|            |         |         |            |                             |                                       | 1a)                               |
|            |         |         |            |                             |                                       | 15–18 Gy / single frs             |
|            |         |         |            |                             |                                       | 1b)                               |
|            |         |         |            |                             |                                       | 15–18 Gy / single frs             |
|            |         |         |            |                             |                                       | 2c)                               |
|            |         |         |            |                             |                                       | 15–18 Gy / single frs             |
|            |         |         |            |                             |                                       | 2d) no RT                         |
|            |         |         |            |                             |                                       | 40–45 Gy / 5–10 frs               |
|            |         |         |            |                             |                                       | Italy (van der Linden et al., 2020) |
|            |         |         |            |                             |                                       | ✓                                |
|            |         |         |            |                             |                                       | SFRT or MFRT                      |
|            |         |         |            |                             |                                       | If Unavoidable                     |
|            |         |         |            |                             |                                       | FR: bone metastasis                |
|            |         |         |            |                             |                                       | - SFRT: almost all                 |
|            |         |         |            |                             |                                       | - MFRT: adjuvant case or           |
|            |         |         |            |                             |                                       | highly suspicious for fracture     |
|            |         |         |            |                             |                                       | USA (Verramilli et al., 2020)      |
|            |         |         |            |                             |                                       | ✓                                |
|            |         |         |            |                             |                                       | c) 10 Gy / 1 fr or 3.7 Gy /        |
|            |         |         |            |                             |                                       | 4 frs twice daily                  |
|            |         |         |            |                             |                                       | c) Tumor bleeding                  |
|            |         |         |            |                             |                                       | d) 8.5 Gy / 2 weekly fractions     |
|            |         |         |            |                             |                                       | or 4 Gy / 5 daily fractions        |
|            |         |         |            |                             |                                       | d) SVCO or airway obstruction      |
|            |         |         |            |                             |                                       | a) Tumor bleeding                  |
|            |         |         |            |                             |                                       | b) Other Palliative RT regimen     |
|            |         |         |            |                             |                                       | Canada (Hahn et al., 2020)         |
|            |         |         |            |                             |                                       | ✓                                |
|            |         |         |            |                             |                                       | a) Brain: 20 Gy / 5 frs            |
|            |         |         |            |                             |                                       | b) Spinal cord and bone            |
|            |         |         |            |                             |                                       | met.: 8 Gy / 1 fr                  |
|            |         |         |            |                             |                                       | c) 3.7 Gy / 4 twice daily fractions|
|            |         |         |            |                             |                                       | or 4 Gy / 5 daily fractions        |
|            |         |         |            |                             |                                       | d) 8.5 Gy / 2 weekly fractions     |
|            |         |         |            |                             |                                       | or 4 Gy / 5 daily fractions        |
|            |         |         |            |                             |                                       | a) 8 Gy / 1 fr                     |
|            |         |         |            |                             |                                       | b) 8 Gy in 0-7-21 (3 days)         |
|            |         |         |            |                             |                                       | regimen (ensuring the final fraction |
|            |         |         |            |                             |                                       | is off-cord and brainstem)         |
|            |         |         |            |                             |                                       | Iran (Aghili et al., 2020)          |
|            |         |         |            |                             |                                       | ✓                                |
|            |         |         |            |                             |                                       | a) Brain: 20 Gy / 1 fr             |
|            |         |         |            |                             |                                       | b) Spinal cord and bone met.: 8 Gy |
|            |         |         |            |                             |                                       | / 1 fr                            |
|            |         |         |            |                             |                                       | c) 3.7 Gy / 4 twice daily fractions|
|            |         |         |            |                             |                                       | or 4 Gy / 5 daily fractions        |
| Palliative |         |         |            |                             |                                       | Canada (Rathod et al., 2020)       |
|            |         |         |            |                             |                                       | ✓                                |
|            |         |         |            |                             |                                       | 20 Gy / 5 frs                      |
|            |         |         |            |                             |                                       | a) Stage IV NSCLC                   |
|            |         |         |            |                             |                                       | b) Extensive stage (III-IV) SCLC   |
|            |         |         |            |                             |                                       | 8 Gy / 1 fr                        |
|            |         |         |            |                             |                                       | - 24 Gy / 3 frs (D0-D7-D0-D21)     |
|            |         |         |            |                             |                                       | - 25 Gy / 5 frs                    |
|            |         |         |            |                             |                                       | - QUAD SHOT technique:             |
|            |         |         |            |                             |                                       | 3.7 Gy bid given over two          |
|            |         |         |            |                             |                                       | consecutive days, a total           |
|            |         |         |            |                             |                                       | dose of 14.8 Gy per cycle, each     |
|            |         |         |            |                             |                                       | cycle every four weeks             |
|            |         |         |            |                             |                                       | USA (Chaves et al., 2020)          |
|            |         |         |            |                             |                                       | ✓                                |
|            |         |         |            |                             |                                       | Locally advanced HNSCC             |
|            |         |         |            |                             |                                       | Italy, Switzerland (                |
|            |         |         |            |                             |                                       | Banna et al., 2020)               |
|            |         |         |            |                             |                                       | ✓                                |
|            |         |         |            |                             |                                       | Lung                              |
|            |         |         |            |                             |                                       | - 8-10 Gy / 1 fr                   |
|            |         |         |            |                             |                                       | - 17 Gy / 2 frs                    |
|            |         |         |            |                             |                                       | a) Brain                           |
|            |         |         |            |                             |                                       | - SRS: 1-3 frs                     |
|            |         |         |            |                             |                                       | USA, France, China, Spain, the UK  |
|            |         |         |            |                             |                                       | (Liao et al., 2020)               |
|            |         |         |            |                             |                                       | ✓                                |
|            |         |         |            |                             |                                       | a) Brain                           |
|            |         |         |            |                             |                                       | b) Lung (stage IV)                 |
|            |         |         |            |                             |                                       | - patients with spinal cord        |
|            |         |         |            |                             |                                       | compression, - superior vena cava   |
|            |         |         |            |                             |                                       | syndrome - bleeding identified by   |
|            |         |         |            |                             |                                       | a specialist                        |
|            |         |         |            |                             |                                       | Argentina (Ismael et al., 2020)    |
|            |         |         |            |                             |                                       | ✓                                |
|            |         |         |            |                             |                                       | 20 Gy/5 frs                        |
|            |         |         |            |                             |                                       | a) Breast                          |
|            |         |         |            |                             |                                       | b) 8 Gy / 1 fr                     |
|            |         |         |            |                             |                                       | 10 Gy / 2 frs four weeks apart     |
|            |         |         |            |                             |                                       | c) 20 Gy / 5 frs                   |
|            |         |         |            |                             |                                       | Zambia, USA (Lombe et al., 2020)   |
|            |         |         |            |                             |                                       | ✓                                |
|            |         |         |            |                             |                                       | 41.25/15 frs                       |
|            |         |         |            |                             |                                       | b) Cervix EBRT Stage IVA (VVF, RVF) |
|            |         |         |            |                             |                                       | 30 Gy / 10 frs                     |
|            |         |         |            |                             |                                       | c) Head and Neck                   |
43

stable positioning during treatment, which requires a higher number of caregivers with a higher risk of infection (Hinduja et al., 2020). For the other cases, prioritization was performed to ease patient selection for palliative RT. As mentioned, patients with neurological or airway compromise or tumor bleeding belong to the highest priority (Tables 1 and 2). Using Hypo-F RT with a short number of fractions reaches desirable outcomes for patients requiring palliation for oncologic emergencies without compromising care. For example, 20 Gy / 5 frs for brain metastasis (urgent indications), 8 Gy / 1 fr for spinal cord compression and bone metastasis, 14.8 Gy / 4 frs twice daily or 20 Gy / 5 frs tumor bleeding, and 17 Gy / 2 weekly fractions of 20 Gy / 5 daily fractions for SVC or airway obstruction (Table 3) (Yerramilli et al., 2020a). Using SBRT or frameless SRS was also suggested for these patients where these radiotherapy techniques are feasible. Avoiding palliative BT was proposed to minimize coronavirus infection risk (Barthwal et al., 2020).

4.2.13. Benign

For the benign disease, delay of radiotherapy was proposed. BT has reasonable local control for keloid cases. However, during the pandemic setting, the risk-benefit analysis leads to BT omission and switching to EBRT, such as treatment with the electron beam.
4.3. Patient’s preparation guidelines for radiotherapy during COVID-19 pandemic

Selecting the best techniques to reduce the organs at risk (OARs) doses of each patient relies highly on the center’s available equipment, staff’s experience, patient’s anatomy, and disease site. However, another aspect added to the previous criteria by selecting the best technique for patient positioning and monitoring the simulation and RT delivery during the pandemic. By considering all these aspects and patient benefits, the radiotherapy can be performed by some delivery techniques for better patient management and positioning. Table 4 summarized some of these techniques recently addressed by radiotherapy professionals in the pre/post-pandemic era.

For instance, in breast cancer, RT delivery techniques such as deep inspiration breath-hold (DIBH) can be performed voluntarily, with moderate or active breathing control/coordinator (ABC) equipment. ABC’s utility is clinically necessary to control the dose of lung and heart (for left breast cases). It is also applied for gastrointestinal, thoracic, or pediatric patients if using abdominal compression or free-breathing leads to severe and unacceptable toxicity without reaching the normal tissue safety objectives (Wright et al., 2020). CBCT or prone positioning can also be used, mostly in case of reducing the delivered dose of lung and heart, and suggested as an alternative to reduce the infection risk during the pandemic situation by the majority of departments based on Table 4 (Desai et al., 2019; Joseph et al., 2017). However, daily CBCT can prolong treatment time and increase staff and exposure risk in other points of view. Therefore, it is also recommended to pay attention to this note-getting weekly CBCT or even the use of orthogonal films (Parashar et al., 2020).

It can be more useful to apply BBD (Belly Board device) for pelvic malignancies whenever the small bowel dose could be a restrictive factor for target dose escalation in clinical routine (Estabrook et al., 2016). For lung cancer, the supine position is superior to prone orientation by mitigating the target margins (Guy et al., 2020). Nevertheless, using spirometry analysis for respiratory gating of lung cancers was also abandoned and replaced by 4D scanners usage to high-risk components management; it avoids the risk of contamination spread from breathing filters and droplet precautions (Table 4) (Beddok et al., 2020).

It was also suggested to apply a chin rest for a slit lamp exam or chin strap, rather than the bite block during the proton therapy of uveal malignancies by the Particle Therapy Co-Operative Group (PTCOG). It can decrease the salivary fluid and maintain the positioning and reproducibility accuracy in parallel to care about the cleaning condition (Mishra et al., 2020). However, it is more time consuming to use prone positioning than routines supine or acquire daily CBCT rather than using ABC for each case. However, getting daily CBCT of patients can help detect COVID-19 cases caused lung infection in asymptomatic or mildly symptomatic (Table 4) (Sepulcri et al., 2020). It is essential to distinguish between radiation-related pneumonitis and ground-glass opacity from pulmonary symptoms of COVID-19 on chest CT images of patients undergoing chest radiotherapy (Shaveridian et al., 2020).

Eventually, besides choosing the best alternative procedures, shortening treatment time is dramatically crucial to alleviate droplet transmission risk among patients during the pandemic.

Upper airway procedures should be performed using personal protective equipment (PPE) such as wearing an N95 facemask, eye shield, and gloves based on the American Academy of Otolaryngology recommendation. On the other hand, all head and neck cancer cases need a thermoplastic mask during the simulation and treatment steps. Some of these cases also require a tongue blade, individualized mouth prosthesis, or bite blocks. Using these additional setup helpers caused controversy by having PPEs during the RT steps. Therefore, the centers suggested their novel approaches for making and forming the masks and tongue depressors facing this challenge during the pandemic (Yanagihara et al., 2020; Portuluri et al., 2020).

4.4. General consideration in radiotherapy during COVID-19 pandemic

For patients with an indication of definitive CRT (dCRT), robust processes should be obeyed to ensure that their radiotherapy can uninterruptedly continue their treatment even with approved COVID-19 infection (Table 1) (Clinical guide for the management of cancer-patient during the coronavirus pandemic [Online], 2021). Patients with spinal cord compression, bleeding, or SVCO syndrome are such cases to follow the routines.

It was suggested to dedicate a treatment machine to these cases or treating them at the end of the day by obeying post-treatment cleaning protocols (Jones et al., 2020a). It was suggested to postpone RT for head and neck, lung, gynecological cancer cases for a few weeks until resolving symptoms and subsiding inflammation. Using prone positioning instead of the supine one with the DIBH technique was also a reported consensus for COVID-19 positive breast cancer cases (Beddok et al., 2020). Switching to EBRT (with standard or hypo-fractionated regimen) was proposed as an alternative for continuing the treatment of COVID-19 positive cancer patients with BT indication such as GYN or rectal cases (Mohindra et al., 2020).

Hypofractionation is the most reported consensus of RT departments during the COVID-19 pandemic to minimize the risk of cancer patients’ contagion without reducing their treatments’ effectiveness (Tables 1 and 3) (Larrea et al., 2020). However, there are some doubts about the long-term results and toxicity of the proposed treatment schedule during this pandemic crisis due to the absence of long-term randomized trials in some suggested regimens. Using SCRT for rectal cancer can be named an example, especially for those who suffered from low rectal tumors and bulky ones with a close or positive circumferential residual margin (Romesser et al., 2020). Definitive Hypo-F RT of inoperable esophageal cancer patients is another example of debate due to the increasing probability of late toxicities (Tchelebi et al., 2020; Jones et al., 2019). However, the centers accept these risks and mandate Hypo-F short-course radiotherapy to reduce patient infection likelihood with the coronavirus in the pandemic setting (Romesser et al., 2020). However, in some cases, de-escalation of treatment intensity, such as advanced head and neck cancers, is not as curable as standard care. Consequently, these patients should be discussed and informed about the risk and benefit of choosing Hypo-F and standard fractionated regimens, their frequency of hospital visits, the potential of immunosuppression, and the risk of exposure to coronavirus infection (Iqbal et al., 2020).

Furthermore, based on Table 1 and the previous published papers data, there has been a significant omission or reduction and less intensive prescribing of RT strategies for elderly patients during the pandemic (Koch et al., 2020; Zaniboni et al., 2020). Reducing hospital admission frequency and following the isolation procedures was highly recommended for fragile and low-performance patients. Based on the recent adaptive recommendations for the older cancer patients, some similar protocols such as breast cancer Hypo-F RT or IORT and avoiding boost for the early stages, rectal cancer SCRT, single-fraction RT for palliative purposes, SRS technique for early non-small cell lung cancer (NSCLC), or central nervous system (CNS) metastases (Battisti et al., 2020). However, RT omission can be justified for frail or older patients due to the reported comorbidity and poor outcome of age and COVID-19 infection (Meattini et al., 2020).

The relationship between previous suggested OARs dose constraints and the risk of mortality and morbidity was also addressed during the COVID-19 emergency of cancer patients (Kabarriti et al., 2020).
Table 4
Summary of national consensus for applying different patient’s preparation strategies of radiotherapy departments during COVID-19 pandemic.

| Cancer                      | Country                        | Routine EBRT/BT Technique | EBRT/BT Technique during the pandemic                                                                 |
|-----------------------------|--------------------------------|---------------------------|-------------------------------------------------------------------------------------------------------|
| **External beam radiotherapy** |                               |                           |                                                                                                       |
| Breast                      | USA (Eghbavzy et al., 2020)   | SRS with mask-based       | - Mask-on policy by fitting the thermoplastic mask to the patient after wearing a personal protective mask and cutting the end of a tongue depressor - to use an open-faced thermoplastic mask and place a nonnick barrier between it and a surgical mask The patient was asked to wear one surgical mask (or a second mask if the patient has tracheostomy) during the positioning steps. The thermoplastic mask was used after the setup confirmation. - All treatment was done by VMAT technique and image guidance. |
| Prostate                    | USA (Barnett et al., 2020)    | SRS with frame-based      |                                                                                                       |
| Lymphoma                    | USA (Wright et al., 2020)     | ABC (DIBH)                |                                                                                                       |
| Thoracic                    | USA (Wright et al., 2020)     | ABC (DIBH)                |                                                                                                       |
| Sarcoma                     | USA (Williams et al., 2020)   | ABC (DIBH)                |                                                                                                       |
| Pediatric                   | USA (Kumar et al., 2020)      | ABC (DIBH)                |                                                                                                       |
| Lung                        | USA (Williams et al., 2020)   | CBCT                      |                                                                                                       |
| Gastrointestinal            | USA, China, Spain, the UK (Liao et al., 2020) | CBCT                     | - Free-breathing or abdominal compression - ADCT - ABC with a new single-use mouthpiece and filter kit must be used per treatment per patient - IMRT/VMAT to meet dose objectives - Daily image guidance using CBCT to help assess the development of infiltrates in asymptomatic patients |
| Head and neck               | Italy (Alterio et al., 2020)  | SRS with mask-based       | A visually monitored voluntary breath-hold technique - ABC with a new single-use mouthpiece and filter kit must be used per treatment per patient. (in a case with cardiac mean dose >4 Gy or lung V20 > 40 %) - IMRT/VMAT to meet dose objectives CBCT with a prompt review of the lung windows is recommended - 4D scanner imaging and daily CBCT-based positioning - 4DCT compression abdominal holding techniques - Free-breathing or abdominal compression - ADCT - ABC with a new single-use mouthpiece and filter kit must be used per treatment per patient - IMRT/VMAT to meet dose objectives - Daily image guidance using CBCT to help assess the development of infiltrates in asymptomatic patients |
| USA (Yousef et al., 2020)   | SRS with mask-based treatment |                           |                                                                                                       |
| France (Beddok et al., 2020) | SRS with mask-based treatment |                           |                                                                                                       |
| Slovenia (Orozem and Ratsa, 2020) | SRS with mask-based treatment |                           |                                                                                                       |
| Egypt, Morocco, Saudi Arabia, USA, Jordan (Egypt, Morocco, Saudi Arabia, USA, Jordan (| SRS with mask-based treatment |                           |                                                                                                       |
| **Breast, prostate, gynecologic** |                               |                           |                                                                                                       |
| USA (Elghazawy et al., 2020) | SRS with mask-based treatment |                           |                                                                                                       |
| USA (Parashar et al., 2020) | SRS with mask-based treatment |                           |                                                                                                       |
| USA (Williams et al., 2020) | SRS with mask-based treatment |                           |                                                                                                       |
Table 4 (continued)

| Cancer                        | Country       | Routine EBRT/BT Technique | EBRT/BT Technique during the pandemic |
|-------------------------------|---------------|---------------------------|--------------------------------------|
| Breast, prostate, gynecologic, head and neck, skin | Iran ()       | General anesthesia for implantsations | for two treatment fractions |
|                               | USA (Mohindra et al., 2020) | General anesthesia for implantsations | 2) Outpatient strategy: have a pre-BT MRI and incorporated it with CT performed at CT-based planning for CT-based planning with subsequent MR fusion |
|                               | India (Barthwal et al., 2020; Kumar and Dey, 2020) | Vaginal cuff gold seeds placement for postoperative vaginal cuff BT | 3) Using a mit sleeve placed at first implant time for CT-based planning |
| All cases with BT indication  |                            |                           | 4) Using ‘cognitive fusion’ and contouring on a CT with the applicator in place referring to a pre-BT MRI |
|                               |                            |                           | - Give priority to local or spinal anesthesia for applicator insertion |

ABC (OIBH): active breathing control/coordinator (deep inspiration breath-hold), PTCOG: particle therapy co-operative group, IMRT: intensity-modulated radiotherapy, VMAT: volumetric modulated arc therapy, CBCT: cone-beam computed tomography, LA-NSCLC: locally advanced non-small cell lung cancer, IGBT: image-guided brachytherapy, APBI: accelerated partial breast irradiation, BT: brachytherapy, GYN: gynecological, SRS: stereotactic radiosurgery.

As mentioned previously, choosing shorter fractionation schedules for palliation and cure is critical to adapt to the regional health system. This technique necessarily needs the use of advanced RT skills and high-tech equipment for imaging, planning, immobilization, and treatment delivery to avoid the increasing of normal tissue toxicity; it also mandates to maintain the equivalent benefit as in conventionally fractionated radiotherapy (Kochbati et al., 2020).

Therefore, there is still a long way to reach optimum cancer treatment all over the world. It is necessary to renew some emergency national/international protocols parallel to different aspects of RT developments. Overall survival and disease-free survival of various cancer stages have been updating through the newly published references influenced by the improvements in screening culture, follow-ups, and the mentioned treatment progresses. Hence, it should be frequently renewed the patient prioritizing to receive RT according to anticipated outcomes.

The COVID-19 pandemic challenged healthcare resources by creating an extraordinary struggle. The oncology community has been suddenly required to protect a group of cancer patients. They are assumed to be susceptible to a potentially fatal infection without threatening cancer treatments. Risk-to-benefit ratios should be considered dealing with quarantine line, outbreaks, lockdowns situations, and cancer treatment priorities (Poortmans et al., 2020). At the early of the pandemic, every cancerous patient was assumed to be at higher risk of mortality from COVID-19. This assumption originated from the rapid primary publications, which caused abandonment or delay of some anticancer treatments, particularly for those who were the candidate to receive systemic treatments (Poortmans et al., 2020). Some multi-center studies find no meaningful associations between the COVID-19 mortality with any cancer type and anticancer therapies such as their current radiotherapy, cytotoxic chemotherapy, hormone therapy, or targeted therapy. On the other hand, some recommended treatment protocols or RT fractionation for which the phase III trials were not done or ongoing (Simcock et al., 2020).

In conclusion, it should be acknowledged that a recent meta-analysis shows cancer patients have higher mortality, although some studies did not show a strong link (Garassino et al., 2020; Zhang et al., 2020). Therefore, it is imperative to reconsider and rethink suggested cancer care protocols during the COVID-19 outbreak. It should be discussed to consider the oncological care, individualized risk factor assessment to choose the pre-pandemic standard approach and avoiding definitive and effective treatment strategies or switching to the new therapeutic options based on the pandemic situations.

Role of the funding source

There was no funding source for this study.

Data statement

The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

CRediT authorship contribution statement

Zahra Siavashpour: Conceptualization, Data curation, Writing - original draft, Supervision. Neda Goharpey: Data curation, Writing - review & editing. Mosayyeb Mobasher: Data curation, Resources.

Declaration of Competing Interest

The authors declare that there is no conflict of interest.
Acknowledgments

The authors would like to thank physicians, medical physicists, radiotherapy technicians, and all the nursing team of Shohada-e Tajrish educational hospital, for staying on the front line during this crisis. The authors would like to acknowledge and express their gratitude to numerous radio-oncologist colleagues for their valuable contributions to distribute this survey. We are also grateful to all physicians and caregivers worldwide who are doing their best to treat cancer patients during the COVID-19 pandemic.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.critrevonc.2021.103402.

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Zahra Siavashpour. Ph.D. of Medical Radiation Engineering, Shahid Beheshti University, Tehran, Iran. Assistant professor of Shahid Beheshti University of Medical Sciences, Tehran, Iran, since 2018-present. Ten years of experience as a medical physicist in radiotherapy and brachytherapy departments and five years of health physician officer experience. Three years of experience in eye plaque brachytherapy. Have been elected member of the National Elite Foundation of Iran, 2018-Present. ORCID ID: https://orcid.org/0000-0003-4-061109X

Zed Babajou: Master of Science, medical physics, Tarbiat Modares University, Tehran, Iran. The medical physicist of the radiation oncology department of Shohada-e-Tajrish hospital, Since September 2016 until the present. Responsible for developing and maintaining quality assurance (QA) and quality control (QC) programs of radiation therapy modalities; also preparing and validating computerized treatment plans (both 3D CRT and advanced techniques) and calculations of patient dose.

Mosayyeb Masbaher: Ph.D. of medical physics, Tarbiat Modares University, Tehran, Iran.