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Critical Review

Radiation Therapy Department Reorganization during the Coronavirus Disease 2019 (COVID-19) Outbreak: Keys to Securing Staff and Patients During the First Weeks of the Crisis and Impact on Radiation Therapy Practice from a Single Institution Experience

Yazid Belkacemi, MD, PHD,[a,b,c,d,*] Gokoulakrichenane Loaganadane, MD,[a,b,d] Noémie Grellier, MD,[a,c] Gloria Fonteneau, RTT,[a] Gaël Zaoui, RTT,[a] Gabriele Coraggio, MD,[a,c] Asma Hadhri, MD,[a,c] Marie Adou, MD,[a] Jerôme Bendavid, MD,[a] Angela Boros, MD,[a] Sahar Ghith, MD,[a,c] Kamel Debbi, MD,[a,c] Pauline Cadot, PHD,[a] Adeline Bak, PHD,[a] Cindy Le Bret, PHD,[a] Wissal Hassani, MD,[a,c] Mathilde Mahé, MD,[a] Marie-Laure Hervé, PHD,[a] Laurianne Colson-Durand, MD,[a] Nhu Hanh TO, MD,[a,b,d] Deng Feng Luo, MD,[a,d] and Aziz Cherif, MD[a,b,c]

[a]Assistance Publique Hopitaux de Paris (APHP), Department of Radiation Oncology and Henri Mondor Breast Center, Henri Mondor University Hospital, Creteil, France; [b]Institut Mondor de Recherche Biomédicale (IMRB), Institut National de la Santé et de la Recherche Médicale (INSERM), U955 Team 21, and University Paris-Est Creteil (UPEC), Paris, France; [c]Association of Radiotherapy and Oncology of the Mediterranean Area (AROME), Paris, France; and [d]TransAtlantic Radiation Oncology Network (TRONE), Paris, France

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Abstract

Purpose: During the first weeks of the coronavirus disease 2019 (COVID-19) outbreak in France, it was necessary to clearly define organizational priorities in the radiation therapy (RT) departments. In this report, we focus on the urgent measures taken to reduce risk for both our staff and patients by reducing the number of patients receiving treatment.

Methods and Materials: We reviewed the fractionation schemes for all patients in our department, including those receiving treatment and those soon to start treatment. Our goals were to (1) decrease the number of patients coming daily to the hospital for RT, (2) adapt our human resources to continue patients' care in the department, and (3) help to cover understaffed COVID-19 sectors of the hospital.

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* Corresponding author: Yazid Belkacemi MD, PhD; E-mail: yazid.belkacemi@aphp.fr

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Results: We identified 50 patients who were receiving treatment (n = 6), were going to start radiation after CT scan simulation (n = 41), or for whom the CT scan was pending (n = 3). The majority were women (64%) treated for breast cancer (54%). RT was delayed for 22 (44%) patients. The majority were offered hormone therapy as "waiting therapy." Hypofractionation was considered in 21 (42%) patients mainly with breast cancer (18 of 21, 86%). The number of courses initially planned and replanned as a result of the COVID-19 outbreak during the period of March 15 to May 31, 2020, were 1383 and 683, respectively, which represented a reduction of 50% (including delayed sessions) that allowed our reorganization process.

Conclusions: To conserve resources during the pandemic, we successfully reduced the number of patients receiving treatment in a proactive fashion and adapted our organization to minimize the risk of COVID-19 contamination. Departments across the world may benefit from this same approach.

Introduction

The outbreak of coronavirus disease 2019 (COVID-19) has been identified as a public health emergency worldwide. Since December 2019, the oncology community has had to face an unprecedented situation for health care staff and patients. Many cancer patients, who frequently visit the hospital for treatment and disease surveillance, may be immunocompromised owing to their underlying malignancy or anticancer therapy, which may increase the risk of developing severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), the disease that causes COVID-19.[1] During the first weeks of the COVID-19 crisis, it was necessary to respond effectively to the constraints imposed by the ignorance of the virus, the increased risk of infection for staff and patients, and the lack of perspective regarding the organizational priorities for the departments and the hospital. Thus, to increase care and resource utilization during the COVID-19 pandemic, strategies had to be implemented to minimize interruption of cancer treatment, particularly in patients being treated with curative intent.[2] In this article, we share the urgent measures we have taken to organize the rotation of staff schedules in our department, and the changes in both treatment schedules and duration of radiation therapy (RT) we have enforced while following social distancing and hygiene practices widely recommended during the pandemic.[3]

Methods and Materials

Department reorganization

Staff reorganization methods

Our goal was to rotate therapists in our department on a weekly basis. To accomplish this, we reviewed all the fractionation schemes of the planned patients so that we could decrease the number of patients' daily visits to the hospital for RT.

During the first week of the crisis, all 12 therapists maintained their regular schedule. During the second week, we extended the treatment slots on one linear accelerator, putting 6 therapists on rotation for the week, to manage treatments and CT scan simulations, which were maintained to treat some of patients immediately.

For dosimetry and medical physics organization, we assigned 4 physicists and 2 dosimetrists. Pending the establishment of telework by our hospital administration, all these staff remained in the department during the first week to finalize the pending files and prepare recalculations of the hypofractionation of patients who were undergoing RT. After the second week, only 2 physicists and 1 dosimetrist per week worked in the hospitals. The other 2 physicists and the remaining dosimetrist worked from home using telework.[4]

For our staff, it was important to limit their exposure to COVID-19 very quickly by reducing their visits to the hospital. Thus, we put half of our doctors into telework in the second week. The doctors ensured that patients in remission who were using telemedicine for their visits had scheduled for follow-up appointments. Thus we drastically reduced the number of patients entering our department. However, all of our new patients' visits to the department were maintained, so that we could plan their treatments according to the degree of emergency and cancer prognosis.

After the second week, rotation of the medical staff rendered possible the deployment of our interns and residents to the emergency department and COVID-19 sectors as part-timers. Therefore, the organization of the medical resources in our department was systematically linked to their availability. We set up compensatory rest days for each of their on-call days and were careful to systematically release them in the weeks during which they were involved elsewhere. For planned patients, the weekly visit was ensured using telemedicine to limit the length of time patients were in the waiting room.

Organization for patient planning

We distinguished 3 situations:

1. Patients who had started their RT ("ongoing RT"; group 1). For this group the objective was to reduce

the number of fractions by changing the planned fractionation in progress for the same biological equivalent of the dose.
2. New patients for whom CT simulation was pending (group 2). For this group we selected the patients for whom the start of treatment could be postponed.
3. Patients who had just finished their CT scan simulation and were waiting to start treatment ("CT simulation performed"; group 3).

The CT scan planning and the start of the treatment depended on both the disease prognosis and the possibility of starting with hormone therapy (HT) in the waiting treatment period, which would postpone RT for several weeks. Figure 2 presents details of these groups.

Statistics

Pairwise comparisons between the number of radiation courses initially planned and replanned according to the COVID-19 outbreak were performed using a 2-tailed paired Student *t* test. The *P* value for statistical significance was set at .05 for sided comparisons. Statistical analyses were performed using the R software, version 3.5.1 (The R Foundation for Statistical Computing, Vienna, Austria).

Results

Staff and patient COVID-19 contaminations

After 1 month of staff rotation schedules and strict applications of the recommended prevention techniques,[3] 1 radiation oncologist out of 8 who presented minor symptoms of COVID-19 stayed home in self-quarantine for 14 days after showing these symptoms. None of the other 46 professionals working in our department had any COVID19 symptoms.

Treatment interruption for COVID-19 positivity

In the same period, among the 73 patients receiving treatment, only 3 presented COVID-19 symptoms during their treatment period; they tested positive by the COVID-19 positivity test performed in the hospital, and RT was subsequently stopped. RT interruption was 12 days for 1 case of breast cancer and 11 days for 1 case of esophageal cancer. After resolution of their symptoms, both patients resumed treatment at the end of the day. They entered the department via a separate entrance from the other patients. They were given masks to wear, and both therapists present at the time of the sessions wore full personal protective equipment and adopted the highest level of personal protection procedures. The third patient was receiving radiation for breast cancer and she developed SARS that required hospitalization in the ICU. At the time of this article, she has been hospitalized for 15 days and is stable per her medical inpatient team.

Patients' characteristics

On March 13, there were 68 patients receiving treatment on linear accelerators (Linacs) and 5 patients pending treatment with low x-ray energy (DARPAC) for skin cancer. After that date, our weekly chart rounds identified 50 patients, including 6 patients receiving treatment who were eligible for an intervention to either (1) delay their RT or (2) change fractionation of their RT that was either already in progress or was to be scheduled within the next few days. Table 1 shows the characteristics of the patients included. Median age was 70.5 years (36-94). The majority were women (64%) mainly treated for breast cancer (54%) and men treated for prostate cancer (26%). The majority of patients (68%) were planned for RT in the postoperative setting, whereas 32% were planned for definitive RT.

Delay of RT

Among the 50 patients included in our study, RT was delayed for 22 cases (44%). Most were prostate (56%) and low-risk breast cancer (39%) patients. The majority (19 of 22) were offered HT as a waiting therapy. Table 2 give the details about the delay of RT. The delay was <1, 2, and 3 months for 1, 11, and 10 patients, respectively. Twenty-one out of 50 patients (42%) had altered fractionation schedules. Table 3 presents the details of fractionation changes. In summary, the majority of hypofractionated schedules used for breast RT consisted of 45 Gy in 18 fractions or 40 Gy in 15 fractions $\pm$ 10 Gy, or 15 Gy in 2.5 Gy per fraction instead of 50 Gy in 25 fractions with a boost of 16 Gy in 8 fractions. Two patients had a modification of the RT duration without modification of the fraction. Among the 6 patients of group 1, the remaining dose was given with a more hypofractionated scheme in 5 cases, whereas for the remaining case with breast cancer the boost was omitted. In group 2, RT was delayed in all 3 cases and they were offered waiting HT. In group 3, RT was delayed for 20 patients, altered fractionation (hypofractionation) was proposed for 16 patients, and association of delayed RT and altered fractionation was offered to 4 patients.

The number of fractions initially planned in response to the COVID-19 outbreak during the period of March 15 to May 31, 2020, would have been 1383, but was reduced to 683 fractions; this represents a reduction of 50% and included the delaying of some sources. The difference was statistically significant (Fig 1). Figure 2 represents an overview of our program for patients who were eligible to undergo a specific intervention that allowed for the reduction of the number of courses and also a decrease in their exposure to the virus.

Table 1 Characteristics of patients included in the intervention cohort during the first month of the COVID-19 outbreak

Characteristics	N = 50	%
Age	Median	Range
	70.5	36-94
Sex		
Male	18	36%
Female	32	64%
Primary tumor		
Breast	27	54%
Prostate	13	26%
Palliative	3	6%
Hematologic	3	6%
Skin	3	6%
Sarcoma	1	2%
Modality of RT		
Definitive	16	32%
Postoperative	34	68%
Intervention		
Delayed RT*	22	44%
Altered fractionation	21	42%
Delayed RT and altered fractionation	5	10%
Modification of the RT course duration (without fractionation modification)	2	4%

Abbreviations: COVID-19 = coronavirus disease 2019; RT = radiation therapy.

* Hormonal therapy was initiated for 19 patients. One patient also had a modification of the RT duration.

Discussion

The unprecedented COVID-19 crisis surprised the world. It has changed the way in which our hospitals and our departments operate on a daily basis. The arrival of the pandemic in Europe, and most particularly in Italy, was with incredible force. Several parameters, such as (1) no one was prepared for such a surge of infected patients in the hospital during the initial period, (2) lack of knowledge of the virus, (3) fear of massive contamination of staff, (4) absence of specific recommendations, and (5) lack of data, had largely contributed to a significant heterogeneity of staff's and patients' organization and their priorities for RT initiation or continuation of treatment that had already begun.

Table 2 COVID-19 outbreak intervention for delaying radiation therapy

Delay in months	Number of patients (N = 22)	Primary tumor type	Number of patients
<1	1	Breast	1
2	11	Breast	3
		Prostate	6
		Skin	1
		Leukemia (CNS)	1
3	10	Breast	1
		Prostate	8
		Leukemia (TBI)	1
Median	2 m		

Abbreviations: CNS = central nervous system; COVID-19 = coronavirus disease 2019; TBI = total body irradiation.

The radiation oncology departments of the affected countries had to adapt quickly and immediately establish new ways of organizing, with a practical definition of priorities.[5] Thus, numerous recommendations and therapeutic options were developed to allow for the optimization of departmental organization and function to provide and continue to deliver optimal therapy to all patients with cancer.[6] One of the first articles published in March summarized discussions and described an "urgent online journal club" that provided some consensuses around themes of infection prevention, rationalization of workload, and working practices in the presence of infection. Finally, the authors proposed to proactively prepare their departments with training and personal protective equipment, and to consider their infection control procedures for a pandemic to be more critical than the risk of omitting RT.[7]

We were successful in rotating our health care personnel on an alternating weekly schedule, thanks to staff reorganizing patients onto one machine, working from home, and significantly reducing (by 50%) the number of treatments planned (Fig 1). This enabled us to have human resources available for the department if any staff were to fall ill, and also to facilitate staff working elsewhere in the hospital if they were needed.

To reduce the risk of COVID-19 infection in our patients, options such as delaying (44%) and shortening (42%) the RT course had been proposed. The decision was made according to the the timing of the CT simulation and its clinical context.

For patients in group 1, we either eliminated the breast boost or reduced the number of boost fractions with increased dose per fraction for the same biologic equivalence.[8,9] Indeed, in patients with favorable prognostic factors, omission of the boost to the tumor bed was reported as an option because it had minimal impact on local recurrence and no impact on survival.[10] This is particularly true for patients over the age of 70 years, which was the median value in our cohort. Early data from China suggests that cancer patients[1] and patients 65 years and older[11] had greater initial comorbidities, more severe symptoms, and were more likely to experience multiorgan involvement and death from COVID-19 compared with younger patients.

In group 2, which includes 3 elderly breast cancer patients for whom CT simulation was pending, primary HT was initiated for 2 to 3 months before starting the delayed RT. This was decided according to French[12] and

Table 3 COVID-19 outbreak intervention: Altered fractionation schedules

	Initial fractionation schedule	n	Modified fractionation schedule	n
Breast	WBRT: 50 Gy/25fr 5fr/wk + boost: 16 Gy/8 fr and RNI: 46Gy/23 fr	3	WBRT and RNI: 45 Gy/18 fr, 4 fr/wk + boost: 15 Gy/6 fr, 4 fr/wk	3
	WBRT: 50 Gy/25fr + boost: 10 Gy/4 fr and RNI: 46 Gy/23 fr	1	WBRT and RNI: 45 Gy in 18 fr, 4 fr/wk + boost: 15 Gy/6 fr, 4 fr/wk	1
	WBRT (reconstructed): 50.4 Gy/28fr + boost: 16 Gy/8 fr	4	WBRT: 50.4 Gy/28 fr + boost: 15 Gy/6 fr, 4fr/wk *Altered boost fractionation only*	1
			WBRT: 50.4 Gy/28 fr + boost: 12 Gy/ 4fr, 3 fr/wk *Altered boost fractionation only*	2
			WBRT: 50,4 Gy/28 fr + boost: 10 Gy/4 fr, 4 fr/wk	1
	WBRT: 50 Gy/25fr + boost: 16 Gy/8 fr	12	WBRT: 50 Gy/25 fr + boost: 15 Gy/6 fr, 4 fr/wk *Altered boost fractionation only*	1
			WBRT: 50 Gy/25 fr + boost: 1 2Gy/4 fr, 3 fr/wk *Altered boost fractionation only*	1
			WBRT: 45 Gy/18 fr, 4 fr/wk + boost: 15Gy in 6 fr, 4 fr/wk	5
			WBRT: 45 Gy/18 fr, 4 fr/wk + boost: 10 Gy in 4 fr, 4 fr/wk	3
			WBRT: 40 Gy/15 fr + boost: 10 Gy in 4 fr, 4 fr/wk	2
	WBRT: 50 Gy/25 fr + boost: 10Gy/ 4 fr	1	WBRT: 45 Gy/20 fr, 4 fr week + boost: 10 Gy/4 fr, 4 fr/wk	1
Skin	WBRT: 45 Gy/15 fractions, 3 fr/wk	2	30 Gy in 5 fr, 1 fr week, 6 Gy per 1 fr	1
			36 Gy/12 fr	1
Sarcoma	TB: 50Gy/25 fr + boost: 10Gy/5 fr,	1	TB: 50Gy in 20 fr, 4 fr/wk + boost: 10Gy/4 fr, 4fr/wk	1
High-grade Lymphoma	40Gy/20 fr, 5fr /wk	1	36Gy/12 fr, 4 fr/wk	1
Bone metastases	20Gy/5 fr, 5 fr/wk	1	20Gy/4 fr, 4 fr/wk	1

Abbreviations: COVID-19 = coronavirus disease 2019; WBRT = whole-breast radiation therapy; RNI = regional nodal irradiation; fr = fractions; TB = tumor bed.

international[13] networks that recommend adjuvant HT for patients over age 65 to 70 years with lower-risk stage I hormone receptor positive/HER2 negative cancers and DCIS; adjuvant endocrine therapy can be encouraged to defer/omit radiation without affecting overall survival. Indeed, when considering breast RT in patients aged >70 years with tumors <2 cm, the CALGB9343 trial showed an advantage of combined whole-breast irradiation plus tamoxifen over tamoxifen alone in terms of local control. However, this gain did not translate into an advantage for survival or breast preservation rate at 10 years.[14]

For the prostate cancer patients, data on primary HT during 2 to 6 months before RT initiation for unfavorable intermediate and high-risk patients are more robust in the literature.[15] Also, in the COVID-19 pandemic context, primary androgen deprivation therapy has been recommended for further deferral of RT as necessary.[16] In our cohort, 26% of the patients had prostate cancer. Among the 22 patients for whom RT was postponed by 2 to 3 months, 14 were treated by primary ADT for intermediate or high-risk prostate cancer (Table 2). None of these patients were seen in an adjuvant setting (where our procedure takes place now), according to the recent data from the TROG trial; this shows evidence that early salvage RT is preferred over adjuvant RT in all scenarios during a pandemic.[16,17]

In other tumor sites presented in Table 3, the patient with skin cancer already had surgery with minimal risk factors for local recurrence, whereas the 2 patients with leukemia were planned for total body irradiation and allogeneic bone marrow transplant (patient 1) and CNS irradiation (patient 2), delayed by 3 and 2 months, respectively.

For fractionation, among the 50 patients, 21 (42%) were replanned with hypofractionation schedules. Moderate fractionation is already considered in many countries to be

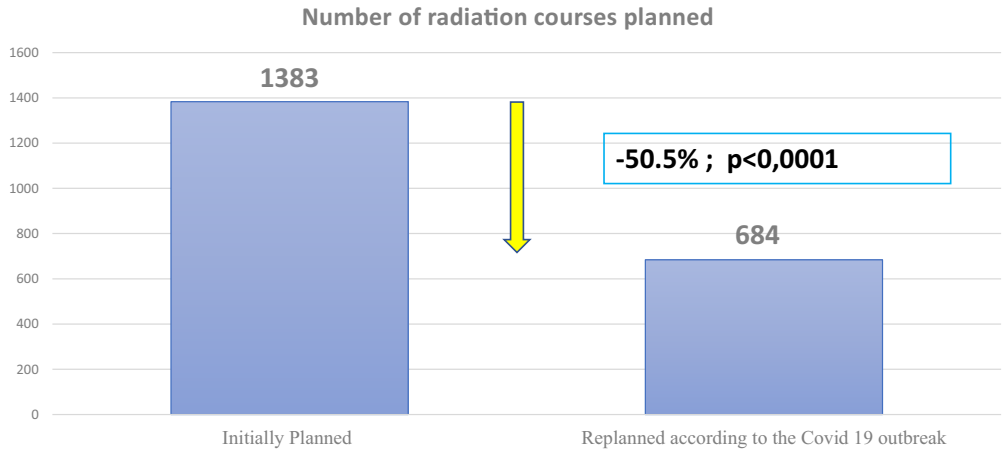

Figure 1 Number of radiation courses initially planned and replanned according to the coronavirus disease 2019 outbreak.

the standard for patients who meet inclusion criteria in published trials, such as no nodal irradiation, no chemotherapy, and no large breasts.[18,19] Owing to our lack of robust data from studies with sufficient follow-up using severe or moderate hypofractionation in patients with nodal RT indications,[20,21] we decided to use mainly 45 Gy in 18 fractions rather than 40 Gy in 15 fractions. Indeed, in our department the first has been routinely used for elderly patients and when 4 fractions per week are required. This schedule is reported elsewhere as safe to use in a large cohort outside of the COVID-19 context.[21] However, even if hypofractionation schedules are advocated by recent recommendations during the COVID-19 crisis,[13] they should be used with high caution in patients with regional node RT, as lung damage caused by COVID 19 infection may be worsened by prior or ongoing lung radiation-exposure.[22]

For all previously planned additional boosts, we also decided to change fractionation. The scheme of the 10 Gy boost in 4 fractions was mainly planned. Patients who had to start their boost during the COVID-19 period had 12 Gy in 3 fractions, instead of 16 Gy in 8 fractions as planned initially. This scheme has been suggested by Coles et al.[13]

For the other tumor sites, we postponed all prostate cancer without a need to alter fractionation, given the

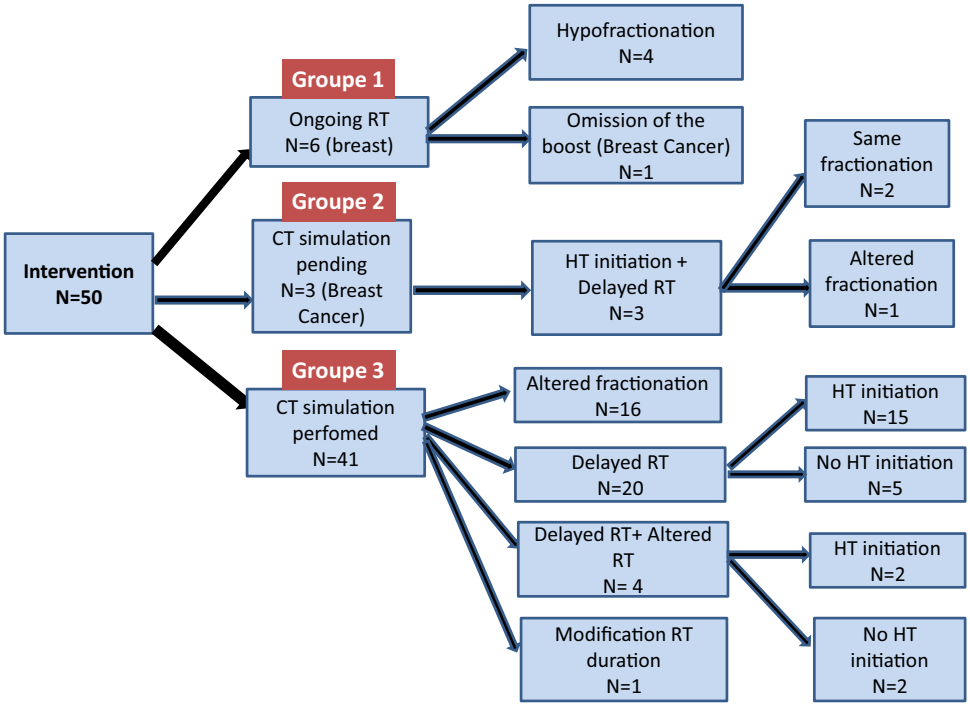

Figure 2 Overview of patients' management in the interventional cohort. *Abbreviations:* HT = hormone therapy; RT = radiation therapy.

slow tumor growth in this type of cancer. In one elderly patient with skin cancer who was scheduled for adjuvant RT, the 45 Gy was changed to 30 Gy in 5 fractions once per week, as planned in our ongoing phase 3 trial, IMPACTE-01, comparing these 2 schemes. For the last 2 patients with high-grade lymphoma and sarcoma, hypofractionated schedules were planned according to the biologic equivalent dose, to reduce the number of fractions.[8]

Conclusions

There are 2 main priorities for radiation oncology departments of the countries affected by the COVID-19 pandemic. The first is to quickly adapt a new way of organizing to minimize staff exposure. The second is to minimize patient exposure. In this article we showed the importance of (1) early, clear procedures for protection and for rotating the medical staff and therapist schedules to ensure treatment continuation for patients who had already started RT, and (2) delaying treatment for those whom the benefit/risk, regarding COVID-19 infection, is not in favor of immediately starting RT. Departments across the world may benefit from this same approach.

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