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Title page

Systematic screening of COVID-19 disease based on chest CT and RT-PCR for cancer patients undergoing radiotherapy in a coronavirus French hotspot.

Running title

Covid-19 screening in radiotherapy

Authors

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Conception and design: RS, ED

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Key words:

COVID-19, SARS-CoV-2, cancer, radiotherapy, screening

1 **ABSTRACT**

2 **Background**

3 Cancer patients are presumed to be more vulnerable to COVID-19. We evaluated a screening
4 strategy combining chest computed-tomography (CT) and reverse transcription polymerase
5 chain reaction (RT-PCR) for patients treated with radiotherapy (RT) in our cancer center
6 located in a COVID-19 French hotspot during the first wave of the pandemic.

7 **Methods**

8 Chest CT images were proposed during the radiotherapy CT simulation. Images were reviewed
9 by an expert radiologist according to the CO-RADS classification. Nasal swabs with RT PCR
10 assay were initially proposed in case of suspicious imaging or clinical context and were
11 eventually integrated into the systematic screening. A dedicated radiotherapy workflow was
12 proposed for COVID-19 patients to limit the risk of contamination.

13 **Results**

14 From March 18, 2020 to May 1, 2020, 480 patients were screened by chest CT, with 313
15 patients having both chest CT and RT-PCR (65%). Cumulative incidence of COVID-19
16 was 5.4%, 95%CI [3.6, 7.8] (26 patients out of 480). Diagnosis of COVID-19 was made before
17 RT for 22 patients (84.6%) and during RT for 4 patients (15.3%). Chest CT directly aided the
18 diagnosis of 7 cases for whom the initial RT-PCR was negative or not feasible; out of a total of
19 480 patients (1.5%) and 517 chest CT acquisition. Four patients with COVID-19 at the time of
20 the chest CT screening had a false negative CT. Sensitivity and specificity of chest CT screening
21 in patients with both RT-PCR and chest CT testing were estimated to be 0.82, 95% CI [0.60,
22 0.95] and 0.98, 95% CI [0.96, 0.99] respectively.

23 Adaptation of the radiotherapy treatment was made for all the patients with seven postponed
24 treatments (median=5 days, IQR [1.5, 14.8]).

25 **Conclusion**

26 The benefit of systematic use of chest CT screening during CT simulation for patients
27 undergoing radiotherapy during the COVID-19 pandemic seemed limited.

28

29 **TEXT**

30 **INTRODUCTION**

31 The standard laboratory test to diagnose coronavirus disease 2019 (COVID-19) consists of
32 reverse transcription polymerase chain reaction (RT-PCR) to detect SARS-CoV-2 ribonucleic
33 acids (RNAs) extracted from nasopharyngeal samples. However, even though testing is very
34 specific, false negative cases have been reported as the sensitivity of the test can be affected by
35 the sample collection method and the timing of the sampling with respect to the course of the
36 disease and the onset of symptoms (1). Since chest Computed-Tomography (CT) has shown to
37 be valuable for COVID-19 diagnosis with characteristic image findings (2), some authors have
38 initially suggested a pivotal role of chest CT for diagnosis and screening to alleviate the
39 shortage of RT-PCR kits which characterized the beginning of the pandemic, and the number
40 of false negative patients with nasopharyngeal and oropharyngeal swabs (3–5).

41 Management of cancer patients during this health crisis has been particularly challenging with
42 many uncertainties regarding the risk of severity of COVID-19 for patients undergoing anti-
43 cancer treatment and affected by COVID-19 (6–11). For patients undergoing radiation therapy,
44 chest screening can be performed without modifying the patient workflow, as the treatment
45 planning requires a CT simulation for each patient. Therefore, screening based on chest CT and
46 RT-PCR was implemented to control and mitigate the risk of COVID-19 spreading within our
47 radiation oncology department, located in a coronavirus hotspot. This study aimed to assess the
48 feasibility of this COVID-19 screening procedure and to evaluate the performance of chest CT
49 as a screening tool in our radiotherapy department in the context of limited availability of RT-
50 PCR tests at the time of the first France lockdown.

51

52 **METHODS AND MATERIAL**

53 **Study Design and screening strategy**

54 Between March 18, 2020 and May 10, 2020, a screening strategy for COVID-19 based on a
55 chest CT acquisition was proposed to all patients undergoing a CT simulation when feasible by
56 our radiation therapy department. We performed a unicenter retrospective observational study
57 including all patients with cancer (solid tumors or hematological malignancies) who underwent
58 a chest CT screening during CT simulation. The use of RT-PCR in this screening strategy
59 evolved over time, according to the availability of testing resources. Nasopharyngeal swabs for
60 RT-PCR testing were firstly limited to symptomatic patients and asymptomatic patients with
61 suspicious chest CT images. In early April, RT-PCR testing was extended to all the patients
62 undergoing chemoradiotherapy. As of April 20, 2020, systematic COVID-19 RT-PCRs were
63 performed before the first RT session since large implementation of virus testing in local
64 laboratories were available. Patients could also have benefited from RT-PCR screening before
65 the start of radiotherapy in our center, i.e. before surgery, or chemotherapy, or in the context of
66 an ongoing observational study conducted in our center.

67 Clinical symptoms and temperature were collected upon arrival at the front desk of our
68 department.

69 Data regarding COVID-19 diagnosis, clinical presentation, treatment and clinical outcome
70 including impact on cancer management were retrieved up to the date of the statistical analysis
71 on June 17, 2020.

72 A written consent was obtained for all the patients screened by chest CT. This retrospective
73 study was approved by the institutional review board and conducted in accordance with ethical
74 standards and with the 1964 Helsinki declaration and its later amendments.

75 **CT Examination and imaging Evaluation**

76 Breath-hold chest CT scans were obtained using a 16-row multi-detector scanner (Siemens
77 Sensation 16, Erlangen, Germany) with the following parameters: 120 kVp, 150 mA, 1.7
78 collimation and 1.5:1 pitch. Images were reconstructed with a reconstruction matrix of
79 512X512, a slice thickness of 1mm, and a BI57 (lung parenchyma) kernel (Siemens
80 Healthineers). The width and level of the pulmonary window were set as 1500/-500. Free-
81 breathing acquisition could have been carried out for some patients with deterioration of health
82 conditions. Chest acquisition was not carried out when CT simulation was obtained in feet first
83 orientation (i.e. lower limbs irradiation) to avoid additional repositioning.

84 All chest CT images were analyzed by an 8-year experienced radiologist without access to
85 clinical or laboratory findings, within 48h of image acquisition. COVID-19 associated CT
86 imaging features were described in accordance with ACR recommendations, (12), and included
87 ground glass opacity, consolidation, interlobular septal thickening or “crazy paving”,
88 subpleural line, lymph node enlargement, pleural effusion, and pericardial effusion (13). The
89 COVID-19 Reporting and Data System (CO-RADS) classification was used to assess the
90 pulmonary involvement and to stratify the level of suspicion of COVID-19 disease (2). CO-
91 RADS provides a level of suspicion for pulmonary involvement of COVID-19 based on the
92 features seen on a non-enhanced chest CT. The level of suspicion increases from very low (CO-
93 RADS 1) to very high (CO-RADS 5). Two additional categories respectively encode a
94 technically insufficient examination (CO-RADS 0) and RT-PCR-proven SARS-CoV-2
95 infection at the time of examination (CO-RADS 6). In this study, CO-RADS scores of 4 and 5
96 were considered as suspicious of COVID-19 disease.

97 A RT-PCR screening was performed for all the patients with concerning images prior to
98 commencing radiotherapy treatment, and could be repeated in case of a negative COVID-19
99 results, depending on the presence of symptoms and the level of suspicion, after a

100 multidisciplinary evaluation with infectious disease specialists. Three radiation oncologists
101 ensured prospectively that chest CT screening and RT-PCR results were analyzed within 48h.

102 **COVID-19 RT-PCR testing**

103 SARS-CoV-2 diagnostic testing by RT-PCR was mostly conducted in our center from March
104 23 (Supplementary text), but could have been performed in an outside laboratory depending on
105 the patient's preference (11).

106 **Definitions**

107 Confirmed COVID-19 cases were defined as patients with positive RT-PCR results. Clinically
108 positive COVID-19 cases were defined as patients with suspicious symptoms and chest CT
109 images but negative RT-PCR.

110 A direct benefit of chest CT screening was defined by the diagnosis of confirmed or clinically
111 positive COVID-19, in patients who were not known to be actually or recently infected, or who
112 were not specifically tested for COVID-19 (RT-PCR and/or diagnostic chest CT) due to acute
113 symptoms, and for whom a concomitant RT-PCR testing was not feasible or considered as false
114 negative.

115 **Statistical analyses**

116 Clinically positive COVID-19 cases were considered as a gold standard to assess the
117 performance of RT-PCR testing, and chest CT for the diagnosis of COVID-19. Accuracy of
118 chest CT screening for the diagnosis of COVID-19 was estimated using data of patients having
119 both RT-PCR testing and chest CT. This limited bias linked to the risk of overestimation of
120 patients considered negative by scan, and who had not been confirmed by PCR. Results of
121 sensitivity and specificity of chest CT at the time of RT screening are presented.

122 The analysis of RT-PCR accuracy for the diagnosis of COVID-19 included all the serial RT-
123 PCR results available in this cohort.

124 Analyses were performed using R software version 3.6.0 (<https://www.r-project.org/>) (14).
125 Comparisons of demographic variables and clinical variables between patient groups were
126 performed using Fisher test for categorical variables and Wilcoxon signed-rank test or Kruskal-
127 Wallis test for continuous variables in Table 1 and Table S5. Sensitivity, specificity, negative
128 and positive predictive value of chest CT and RT-PCR with exact binomial confidence interval
129 were computed using the epiR R package version 2.42. No imputation was made for missing
130 values.

131

132 **RESULTS**

133 **Patients and feasibility of the screening**

134 From March 18, to May 10, 508 cancer patients underwent a CT simulation in our radiotherapy
135 department. A chest acquisition was feasible for 480 of them (94.5%). They accounted for a
136 total of 517 chest CT acquisitions, and a breath-old acquisition was obtained for 455 patients
137 (94.8%) (flowchart in **Figure 1**). Median age was 62 years (interquartile range IQR [50, 70])
138 (patient characteristics are detailed in **Table 1**).

139 The median volume computed tomography dose index (CTDIvol) related to chest CTs was
140 8.08 mGy, IQR [6.24, 11.12], with a median dose-length product (DLP) of 291.25, IQR
141 [209.93, 388.78] (**Table S1**). To note, a breath-hold chest acquisition was performed as part of
142 the pre-therapeutic CT simulation without any additional dose delivery required for 37 patients
143 (7.3%) who were planned to be treated using deep inspiration breath hold (DIBH) technique.

144 313 patients (65.2%) had both RT-PCR and screening chest CT at the time of CT simulation.

145 A total of 470 RT-PCR tests for COVID-19 were available for the 313 patients, including 305

146 patients (97.4%) with a RT-PCR testing performed less than 7 days before the CT simulation
147 or after the CT simulation (n=462samples). 311 out of 470 samples (66.1%) were realized
148 before the onset of radiotherapy (**Supplementary Figure S1, Table S2**). The percentage of
149 positive tests in our cohort was 5.1 %.

150 **COVID-19 screening results**

151 Clinical symptoms compatible with viral pneumonitis at the time of the simulation CT were
152 reported in 41 out of 467 patients for whom clinical data were available (8.5%), without
153 significant difference according to the screening procedure ($p = 0.08$) (Table 1).

154 Half of the patients with chest CT images performed at the time of the simulation CT (246
155 patients out of 480, 51.3%) presented lung abnormalities compatible with non-specific lesions
156 compatible with infection lesions (CO-RADS ≥ 2). (**Table 1**). 24 patients who underwent pre-
157 treatment screening (5.0%) presented a COVID-19 infection (PCR-confirmed or clinically-
158 positive for COVID-19) before the start of the RT. However, 4 patients had false negative chest
159 CT, leading to a delayed diagnosis of COVID-19 after the start of RT for 2 patients.

160 Sensitivity and specificity of screening chest-CT using the CO-RADS score ≥ 4 for diagnosis
161 of COVID-19 were 0.82, 95% CI [0.60, 0.95] and 0.98 (95% CI [0.96, 0.99]) respectively, with
162 positive and negative predictive value of 0.75 (95% CI [0.53, 0.90]) and 0.99 (95% CI [0.96,
163 1.00]) (**Table 2A** and **Table S3**).

164 To note, two other patients developed a COVID-19 infection after the start of radiotherapy,
165 leading to a total of 26 COVID-19 patients during this period, with a cumulative incidence of
166 5.4% (95%CI [3.6, 7.8]) (**Figure 2**).

167 The details of RT-PCR tests carried out in COVID-19 patients are summarized in **Table 2B**
168 and **Table S3**. Considering the false negative PCR results, the estimated sensitivity of
169 nasopharyngeal samples in this cohort was 0.69 (95% CI [0.51, 0.83]) (**Table 2B**).

170 20 COVID-19 patients (76.7%) experienced symptoms related to the infection (**Table 3**).
171 Although 11 COVID-19 patients detected by chest CT screening were asymptomatic at the time
172 of the screening , it was estimated that chest CT screening played a central role in the diagnosis
173 of only 7 out of the 480 screened patients (1.5%) (**Table 3** and **Table S4**). Among these 7
174 patients, 5 patients with initially negative RT-PCR results presented suspicious chest CT images
175 (CO-RADS ≥ 4) on screening, prompting repeated nasopharyngeal swabs that finally confirmed
176 the carriage of SARS-CoV 2. One patient refused the nasopharyngeal sample due to palliative
177 status and health condition deterioration, while another patient had a negative RT-PCR test,
178 however both had suspicious images and compatible symptoms (**Table 3**). They were
179 considered clinically positive COVID-19 patients and managed the same way as RT-PCR
180 positive patients.

181 Diagnosis of COVID-19 allowed treatment adaptation for all the COVID-19 patients (**Table**
182 **S5**). Radiotherapy was postponed for 7 patients (26%) with a median delay of 5 days (IQR
183 [1.50, 14.75]) and discontinued due to COVID-19 infection diagnosed during radiotherapy in
184 3 patients, but could be resumed within ≤ 2 days of discontinuation for all of them. 19 patients
185 (73%) were treated on a dedicated accelerator.

186

187 **DISCUSSION**

188 In this study, we reported the results of an active screening combining chest-CT and RT-PCR
189 of patients undergoing radiotherapy in a tertiary cancer center in Ile-de-France at the peak of
190 the first wave of the COVID-19 pandemic.

191 While several authors have shown that chest CT may have higher sensibility than RT-PCR for
192 COVID-19 diagnosis (15), its role for mass screening was highly debated due to radiation
193 exposure and a possible low predictive value due to low specificity (16), and guidelines did not
194 recommend chest CT as a screening tool in the overall population (17). However, the downside
195 of such exams appeared to be low for cancer patients undergoing radiotherapy and could have
196 seemed to be interesting when access to RT-PCR tests were limited (18). CT simulation is
197 needed in radiotherapy for treatment planning, and while free-breathing images are usually
198 performed, breath-hold chest acquisition can be easily added without modifying the patient
199 workflow. Moreover, the radiation exposure might be considered as negligible in regards to
200 radiotherapy, even for extra-thoracic treatments. Indeed, it has been shown that 0.05%-0.7% of
201 the prescribed dose is still delivered at 30 cm from the irradiated field. Namely, a pelvic
202 treatment of 45 Gy may deliver around 25-315 mGy to the chest, which is equivalent to 3-40
203 chest CT (19).

204 Although we confirmed a good sensitivity and reasonable specificity of chest CT for the
205 diagnosis of COVID-19, the direct benefit of chest CT screening seemed limited in our study.
206 Indeed, most cases detected by chest CT screening reported a history of symptoms or close
207 contact with COVID-19 positive persons, and most of them could be detected by serial RT-
208 PCR.

209 We acknowledge that this study had some limitations. Firstly, the screening procedure, and in
210 particular the use of PCR, has evolved over time, depending on the availability of this test,

211 bringing some heterogeneity in the management of patients. However, screening results of all
212 the patients were discussed prospectively by the same team, which helped to ensure
213 homogeneous decisions regarding access to RT-PCR tests. Secondly, the number of COVID-
214 19 patients detected in our cohort was relatively low, which might have brought uncertainties
215 in the estimation of chest CT performance, therefore results should be interpreted with caution.
216 This study was carried out in the context of the pandemic peak of COVID-19 in France and
217 since the impact of a screening procedure is dependent on disease prevalence, these results may
218 only be representative of situations where the prevalence of COVID-19 is similar. Moreover,
219 this study was performed at the beginning of the pandemic, when the availability of RT-PCR
220 testing was limited. Finally, although early detection of COVID-19 is important in this
221 population, several weeks of daily sessions remains the rule for most curative treatments, also
222 justifying the need for on-treatment screening. Nowadays, other approaches relying for instance
223 on weekly repeated use of RT-PCR, or rapid antigenic testing, may allow regular screening
224 before and during treatment. Similarly, vaccination against COVID-19, which is currently
225 being evaluated, could be a solution for controlling the spread of COVID-19 (20).

226

227 **CONCLUSION**

228 The COVID-19 pandemic is likely the greatest public health crisis in decades. While it is still
229 unclear how long it could last, with countries facing a third wave, the need for high-level care
230 in oncology remains a priority for patients with cancer. Although systematic strategies of
231 screening are needed to limit disease transmission while allowing continuity of treatment, the
232 benefit of systematic use of chest CT screening during CT simulation for patients undergoing
233 radiotherapy during the COVID-19 pandemic seemed limited.

234

235 **REFERENCES**

- 236 1. Zou L, Ruan F, Huang M, *et al.* SARS-CoV-2 Viral Load in Upper Respiratory Specimens of
237 Infected Patients. *N. Engl. J. Med.* 2020;382:1177–1179.
- 238 2. Prokop M, van Everdingen W, van Rees Vellinga T, *et al.* CO-RADS - A categorical CT
239 assessment scheme for patients with suspected COVID-19: definition and evaluation. *Radiology.*
240 2020:201473.
- 241 3. Wang W, Xu Y, Gao R, *et al.* Detection of SARS-CoV-2 in Different Types of Clinical Specimens.
242 *JAMA.* 2020.
- 243 4. Yang, Yang Y, Yang M, *et al.* Evaluating the accuracy of different respiratory specimens in the
244 laboratory diagnosis and monitoring the viral shedding of 2019-nCoV infections.
- 245 5. Ai T, Yang Z, Hou H, *et al.* Correlation of Chest CT and RT-PCR Testing in Coronavirus Disease
246 2019 (COVID-19) in China: A Report of 1014 Cases. *Radiology.* 2020:200642.
- 247 6. Liang W, Guan W, Chen R, *et al.* Cancer patients in SARS-CoV-2 infection: a nationwide analysis
248 in China. *Lancet Oncol.* 2020;21:335–337.
- 249 7. Miyashita H, Mikami T, Chopra N, *et al.* Do patients with cancer have a poorer prognosis of
250 COVID-19? An experience in New York City. *Ann. Oncol.* 2020.
- 251 8. Lee LYW, Cazier JB, Starkey T, *et al.* COVID-19 mortality in patients with cancer on
252 chemotherapy or other anticancer treatments: a prospective cohort study. *Lancet.* 2020;395:1919–
253 1926.
- 254 9. Assaad S, Avrillon V, Fournier M-L, *et al.* High mortality rate in cancer patients with symptoms of
255 COVID-19 with or without detectable SARS-COV-2 on RT-PCR. *Eur. J. Cancer.* 2020.
- 256 10. Moujaess E, Kourie HR, Ghosn M. Cancer patients and research during COVID-19 pandemic: A
257 systematic review of current evidence. *Crit. Rev. Oncol. Hematol.* 2020;150:102972.
- 258 11. Albiges L, Foulon S, Bayle A, *et al.* Determinants of the outcomes of patients with cancer infected
259 with SARS-CoV-2: results from the Gustave Roussy cohort. *Nature Cancer.* 2020.
- 260 12. Simpson S, Kay FU, Abbara S, *et al.* Radiological Society of North America Expert Consensus
261 Statement on Reporting Chest CT Findings Related to COVID-19. Endorsed by the Society of
262 Thoracic Radiology, the American College of Radiology, and RSNA. *Radiology: Cardiothoracic*
263 *Imaging.* 2020;2:e200152.
- 264 13. Hansell DM, Bankier AA, MacMahon H, *et al.* Fleischner Society: Glossary of Terms for
265 Thoracic Imaging. *Radiology.* 2008;246:697–722.
- 266 14. R Core Team. R: A Language and Environment for Statistical Computing. 2017. Available on
267 <https://www.R-project.org/>
- 268 15. Herpe G, Lederlin M, Naudin M, *et al.* Efficacy of Chest CT for COVID-19 Pneumonia in France.
269 *Radiology.* 2020:202568.
- 270 16. Kim H, Hong H, Yoon SH. Diagnostic Performance of CT and Reverse Transcriptase-Polymerase
271 Chain Reaction for Coronavirus Disease 2019: A Meta-Analysis. *Radiology.* 2020:201343.
- 272 17. American College of Radiology. ACR Recommendations for the use of Chest Radiography and
273 Computed Tomography (CT) for Suspected COVID-19 Infection. Available on:

274 [https://www.acr.org/Advocacy-and-Economics/ACR-Position-Statements/Recommendations-for-](https://www.acr.org/Advocacy-and-Economics/ACR-Position-Statements/Recommendations-for-Chest-Radiography-and-CT-for-Suspected-COVID19-Infection#:~:text=The%20Centers%20for%20Disease%20Control,19%20on%20CXR%20or%20CT.)
275 [Chest-Radiography-and-CT-for-Suspected-COVID19-](https://www.acr.org/Advocacy-and-Economics/ACR-Position-Statements/Recommendations-for-Chest-Radiography-and-CT-for-Suspected-COVID19-Infection#:~:text=The%20Centers%20for%20Disease%20Control,19%20on%20CXR%20or%20CT.)
276 [Infection#:~:text=The%20Centers%20for%20Disease%20Control,19%20on%20CXR%20or%20CT.](https://www.acr.org/Advocacy-and-Economics/ACR-Position-Statements/Recommendations-for-Chest-Radiography-and-CT-for-Suspected-COVID19-Infection#:~:text=The%20Centers%20for%20Disease%20Control,19%20on%20CXR%20or%20CT.)

277 18. Sun R, Ammari S, Bockel S, *et al.* Optimization of Patient Management During the COVID-19
278 Pandemic: Chest CT Scan and PCR as Gatekeepers of the Radiation Therapy Workflow. *Front. Oncol.*
279 2020;10:556334.

280 19. Benadjaoud MA, Bezin J, Veres A, *et al.* A multi-plane source model for out-of-field head scatter
281 dose calculations in external beam photon therapy. *Phys. Med. Biol.* 2012;57:7725–7739.

282 20. Ribas A, Sengupta R, Locke T, *et al.* Priority COVID-19 Vaccination for Patients with Cancer
283 while Vaccine Supply Is Limited. *Cancer Discov.* 2020.

284

285

286 **FIGURE CAPTIONS**

287

288

289 **Figure 1.** Flowchart of patients according to the screening procedure.

290 *: false negative RT-PCR. Red: false negative chest CT.

291

292

293 **Figure 2.** Epidemic curve of COVID-19 in the radiotherapy department.

508 patients

No chest CT screening:
28 pts
• No consent: 10 pts
• Other: 18 pts

Screened population: 480 pts

Chest CT only

167 pts (34.8%)

Chest CT and PCR

313 pts (65.2%)

Chest CT first

266 pts (55.4%)

PCR first

47 pts (9.8%)

Diagnosis of COVID-19:

Before RT: n=1*
• No symptoms during the screening but appearance of symptoms secondary
• Screening CT CORADS 4-5: n=1

Before RT: n=15
Symptoms during the screening: n=8/15
• Screening CT CORADS 4-5: n=**13/15**
• 3 pt had false negative PCR initially
• 1 pt had no positive PCR*

Estimated time of infection before the CT simulation but diagnosis during RT: n=2
• Past history of symptoms or contact: n=2/2
• Screening CT CORADS 4-5: n=**0/2**

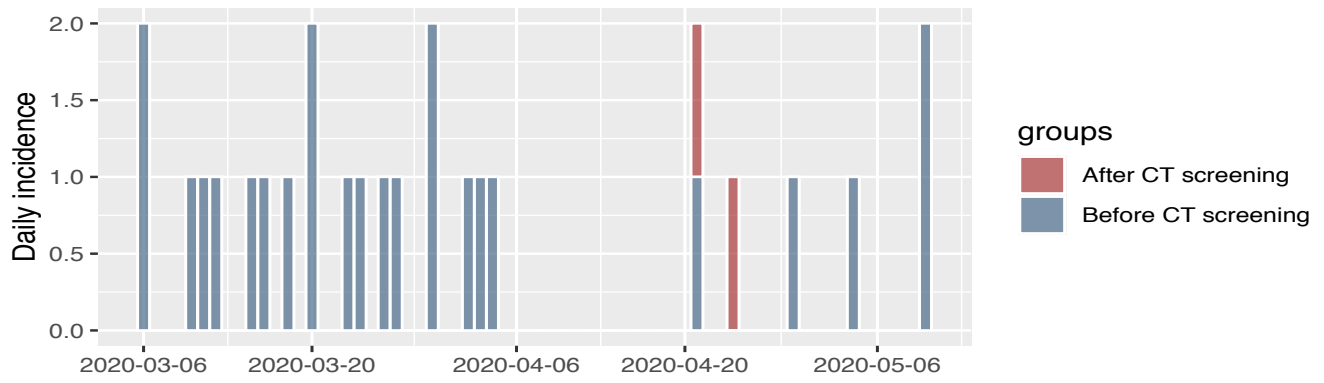
Before RT: n=6
• Symptoms during the screening: n=1/6
• Positive PCR at the time of CT simulation: n=5
• Screening CT CORADS 4-5: n=5/5
• 1 pt had false negative PCR initially
• PCR turned negative at the time of CT simulation: n=1 (Screening CT CORADS 2)

COVID-19 developed during RT: n=2
• Initial screening CT negative
• Symptoms during RT, diagnostic CT CORADS 4, but negative PCR: n=1*
• Systematic on-treatment PCR positive, no symptoms: n = 1 (no diagnostic CT performed)

1 COVID-19 patient
(No PCR test performed due to deterioration of health condition)

19 COVID-19 patients
(including 2 PCR-negative pts)
4 pts with normal CT had positive PCR

6 COVID-19 patients
Including 1 patient with a PCR that turned negative at the time of CT simulation



Date of COVID-19 diagnosis	March 18 - March 31	April 1 - April 19	April 20 - May 11
Number of patients	16 patients	3 patients	7 patients

TABLE 1. Patients characteristics

	level	Overall	CT and PCR	CT only	p
N		480	313	167	
CT simulation (%)	Yes	480 (100.0)	313 (100.0)	167 (100.0)	1.000
	No (already on treatment)	0 (0.0)	0 (0.0)	0 (0.0)	
Age, y (median [IQR])		62.00 [50.00, 70.00]	62.00 [50.00, 70.00]	62.00 [50.00, 70.50]	0.942
(%)	<15	21 (4.4)	11 (3.5)	10 (6.0)	0.218
	15 - 44	72 (15.0)	46 (14.7)	26 (15.6)	
	45 - 64	203 (42.3)	143 (45.7)	60 (35.9)	
	65 - 74	129 (26.9)	77 (24.6)	52 (31.1)	
	≥75	55 (11.5)	36 (11.5)	19 (11.4)	
Sex (%)	Female	228 (47.5)	157 (50.2)	71 (42.5)	0.133
	Male	252 (52.5)	156 (49.8)	96 (57.5)	
Tumor type (%)	Brain tumor	20 (4.2)	10 (3.2)	10 (6.0)	0.010
	Breast cancer	68 (14.2)	46 (14.7)	22 (13.2)	
	Endocrine cancer	18 (3.8)	8 (2.6)	10 (6.0)	
	GI cancer	43 (9.0)	34 (10.9)	9 (5.4)	
	Gynecologic cancer	40 (8.3)	33 (10.5)	7 (4.2)	
	Head and neck cancer	67 (14.0)	50 (16.0)	17 (10.2)	
	Hematologic cancer	21 (4.4)	13 (4.2)	8 (4.8)	
	Lung carcinoma	78 (16.2)	46 (14.7)	32 (19.2)	
	Pediatric cancer	29 (6.0)	14 (4.5)	15 (9.0)	
	Sarcoma	29 (6.0)	18 (5.8)	11 (6.6)	
	Skin cancer	16 (3.3)	12 (3.8)	4 (2.4)	
	Urologic cancer	51 (10.6)	29 (9.3)	22 (13.2)	
Type of radiation therapy (%)	Brachytherapy (BT)	18 (3.8)	17 (5.4)	1 (0.6)	0.016
	External Radiotherapy (RT)	462 (96.2)	296 (94.6)	166 (99.4)	
N of hospitalization days for BT (median [IQR])		3.00 [3.00, 4.00]	3.00 [3.00, 4.00]	7.00 [7.00, 7.00]	0.080
N of patients RT sessions (median [IQR])		11.00 [5.00, 24.00]	10.00 [5.00, 20.00]	15.00 [5.00, 25.00]	0.374
Symptoms at the time of inclusion (%)	No	426 (88.8)	275 (87.9)	151 (90.4)	0.077
	Yes	41 (8.5)	32 (10.2)	9 (5.4)	
	NA	13 (2.7)	6 (1.9)	7 (4.2)	
N of chest CT by pt (%)	1	447 (93.1)	289 (92.3)	158 (94.6)	0.746
	2	30 (6.2)	21 (6.7)	9 (5.4)	
	3	2 (0.4)	2 (0.6)	0 (0.0)	
	4	1 (0.2)	1 (0.3)	0 (0.0)	
CO-RADS score (%)	1	234 (48.8)	139 (44.4)	95 (56.9)	<0.001
	2	201 (41.9)	132 (42.2)	69 (41.3)	
	3	20 (4.2)	18 (5.8)	2 (1.2)	
	4	15 (3.1)	14 (4.5)	1 (0.6)	
	5	10 (2.1)	10 (3.2)	0 (0.0)	
N of RT-PCR by pt (%)	None	167 (34.8)	0 (0.0)	167 (100.0)	<0.001
	1	207 (43.1)	207 (66.1)	0 (0.0)	
	2	68 (14.2)	68 (21.7)	0 (0.0)	
	3	27 (5.6)	27 (8.6)	0 (0.0)	
	4	10 (2.1)	10 (3.2)	0 (0.0)	
	6	1 (0.2)	1 (0.3)	0 (0.0)	
COVID (%)	RT-PCR or clinically positive	26 (5.4)	25 (8.0)	1 (0.6)	0.001

Abbreviations. Y: years RT: radiotherapy, BT: brachytherapy, pt: patient, N: number, GI: gastro-intestinal, RT-PCR: reverse transcription polymerase chain reaction, CO-RADS: COVID-19 Reporting and Data System classification.

Tables 2A. Contingency table of chest CT screening CO-RADS score according to COVID-19 status for patients with both chest-CT and RT-PCR available at the time of the COVID-19 diagnosis. The highest CO-RADS score for each patient were kept in case of multiple chest

	COVID-19 +	COVID-19 -		COVID-19 +	COVID-19 -	Total	
CO-RADS 5	10 (100)	0 (0)	CT.	CO-RADS 4-5	18	6	24
CO-RADS 4	8 (57.1)	6 (42.9)		CO-RADS 1-3	4	285	289
CO-RADS 3	0 (0)	18 (100)		Total	22	291	313
CO-RADS 2	0 (0)	132 (100)					
CO-RADS 1	4 (2.9)	135 (97.1)					

Chest CT CORADS 4-5	Estimate	95% confidence interval
Sensitivity	0.82	(0.60, 0.95)
Specificity	0.98	(0.96, 0.99)
Positive predictive value	0.75	(0.53, 0.90)
Negative predictive value	0.99	(0.96, 1.00)

	COVID-19 +	COVID-19 -	Total
RT-PCR+	24	0	24
RT-PCR -	11	435	446
Total	35	435	470

Tables 2B. Contingency tables of RT-PCR results according to COVID-19 status.

RT-PCR	Estimate	95% confidence interval
Sensitivity	0.69	(0.51, 0.83)
Specificity	1.00	(0.99, 1.00)
Positive predictive value	1.00	(0.86, 1.00)
Negative predictive value	0.98	(0.96, 0.99)

Abbreviation: RT-PCR: reverse transcription polymerase chain reaction

TABLE 3: Times and way of COVID-19 diagnosis according to the presence of symptoms at the onset of the disease

	Chest CT screening	No symptoms (n)	Actual or past history of symptoms (n)	Total (n)	Chest CT screening direct benefit (n)
Screening detected (RT-PCR or chest CT)	CORADS 1-3	3 patients including two with false negative chest CT: (no false negative PCR) -1 had a first positive RT-PCR one week before CT simulation, but at the time of the chest CT screening, both RT-PCR and CT were negative	2 patients including one with false negative chest CT: - 1 had initial false negative RT-PCR however repeated tests motivated by a history of symptoms enabled patient diagnosis - 1 developed COVID-19 during RT (systematic RT-PCR performed before concomitant chemotherapy, one month after the start of RT. No diagnostic chest CT was performed at the time of the diagnosis).	5 (19.2%)	0
	CORADS 4-5	3 (no false negative PCR)	8 patients: - 4 had initial false negative RT-PCR but repeated tests enabled diagnosis - 1 had no positive RT-PCR (one test performed) - 1 refused the PCR test	11 (42.3%)	6 (23.1%)
	Total	6 (23.1%)	10 (38.5%)	16 (61.5%)	
COVID-19 infection Known before RT management	CORADS 1-3	0	1 false negative chest CT	1 (3.8%)	0
	CORADS 4-5	0	7 patients: - 1 had a past infection of RT PCR-confirmed COVID-19 one month before CT simulation. Two negative RT-PCR allowed planification of RT, however suspicious images on chest CT screening led to request a third RT-PCR which was positive)	7 (26.9%)	1 (3.8%)
	Total		8 (30.8%)	8 (30.8%)	
Revealed by symptoms, n (%)	CORADS 1-3	0	1 patient had negative chest CT screening: -symptoms of COVID-19 infection occurred during RT, 1 month after, with positive diagnostic chest CT. PCR was negative, but patient was considered clinically positive.	1 (3.8%)	0*
	CORADS 4-5	0	1 patient, no false negative RT-PCR	1 (3.8%)	0
	Total	0	2 (7.7%)	2 (7.7%)	
TOTAL		6 (23.1%)	20 (76.9%)	26 (100%)	7 (26.9%)

*A diagnostic chest CT allowed the diagnosis, despite a negative RT-PCR