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Management of reirradiations: A clinical and technical overview based on a French survey

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ABSTRACT

Introduction: The reirradiation number increased due to systemic therapies and patient survival. Few guidelines regarding acceptable cumulative doses to organs at risk (OARs) and appropriate dose accumulation tools need, made reirradiation challenging. The survey objective was to present the French current technical and clinical practices in reirradiations.

Methods: A group of physician and physicists developed a survey gathering major issues of the topic. The questionnaire consisted in 4 parts: data collection, demographic, clinical and technical aspects. It was delivered through the SFRO and the SFPM. Data collection lasted 2 months and were gathered to compute statistical analysis.

Results: 48 institutions answered the survey. Difficulties about patient data collection were related to patient safety, administrative and technical limitations. Half of the institutions discussed reirradiation cases during a multidisciplinary meeting. It mainly aimed at discussing the indication and the new treatment total dose (92%). 79% of the respondents used various references but only 6% of them were specific to reirradiations. Patients with pain and clinical deficit were ranked as best inclusion criteria. 54.2% of the institutions considered OARs recovery, especially for spinal cord and brainstem. A commercial software was used for dose accumulation for 52% of respondents. Almost all institutions performed equivalent dose conversion (94%). A quarter of the institutions estimated not to have the appropriate equipment for reirradiation.

Conclusion: This survey showed the various approaches and tools used in reirradiation management. It highlighted issues in collecting data, and the guidelines necessity for safe practices, to increase clinicians confidence in retreating patients.

1. Introduction

Since more than a decade, local and systemic therapies allowed the patients to survive longer. Consequently, the occurrence risk of oligometastatic progression, local recurrence cancer or second primary tumor increased. Also, advanced techniques in radiation therapy, i.e., Intensity Modulated Radiotherapy (IMRT), Stereotactic Body radiation therapy (SBRT), tumor motion management and Image Guided Radiotherapy (IGRT) facilitated a repeat administration of radiotherapy to a previously exposed area, namely a reirradiation. Indeed, these techniques enabled sharp dose gradients making easier the OARs protection, and more accurate repositioning and targeting of the tumor [1,2]. Recently,

some practical guidance in reirradiation were proposed, based on consensus statements of expert's groups [3,4]. They confirmed that reirradiations could provide a clinical benefit in terms of local control or symptoms reduction, with acceptable toxicities.

However, reirradiation remains a challenge for the radiotherapy teams. Several issues in the process steps can be met, such as difficulties in collecting the patients' records, a lack of recommendations regarding the allowed cumulative maximum dose to 2 Gy biologically equivalent (EQD2) to OARs, the absence of appropriate tools for dose accumulation, etc. Reirradiations practice can therefore be felt as a burden by the institutions to ensure the treatment and patient safety.

To establish a picture of the French current practices in reirradiation

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management, a multidisciplinary team from the Lyrican (Lyon Recherche Innovation contre le CANcer) developed a questionnaire gathering the major issues of the topic.

2. Material and methods

A dedicated software Sphinx (Le sphinx, France) was used to propose a questionnaire on reirradiation management addressed to French radiation oncology departments (survey in [supplementary materials](#)). The questionnaire was divided into four parts: institutions' characteristics, previous treatment data collection procedure and reirradiation workflow, clinical and technical aspects for reirradiation management. It consisted in 174 items based on single answer or multiple-choice questions, and some questions required free sections to provide numerical data or specific details. The survey was designed to be completed in 20 min, in a confidential and anonymous way, preferably by a physician and a physicist. The term "reirradiation" was explicitly defined as an irradiation in a previously treated area (i.e., full or partial overlap with the previous irradiation area). The questionnaire was sent by e-mail using the Newsletter of two French scientific Societies, the Société Française de Radiothérapie Oncologique (SFRO) and the Société Française de Physique Médicale (SFFPM). Data collection lasted 2 months, from November 29, 2021, to January 31, 2022.

The answers were gathered to compute statistical analysis on reirradiation practices.

3. Results

3.1. Demographic data

Fifty-five respondents completed the questionnaire. Three respondents were excluded because coming from other countries, and for four institutions, answers were merged due to two different respondents from the same hospital. Finally, answers from forty-eight French institutions, continental and islander, were collected and analysed.

More than two-thirds of the respondents belonged to cancer centers and private institutions ($n = 17$ for each), and 20.8% and 8.3% of the respondents came from public hospitals and university hospitals respectively ([Table 1](#)). Also, 84% of the French cancer centers filled in the questionnaire. More than a half of the institutions (52%) had four linacs or more (min: 1; max: 11). More than a half of the respondents treated between 1000 and 2500 patients per year (min: 350; max: 6000) ([Table 1](#)). This survey benefited also from the experience of the three French Proton facilities.

3.2. Data collection and workflow

Awareness of the previous irradiation mainly came from the anamnesis (94%), and from the Electronic Patient Record (EPR) (84%). All institutions except one used the EPR to record the previous irradiation information. Other tools were also used: the record-and-verify systems

Table 1
Institutions demographic information.

Respondents	n	%	
	48	100	
Institution	Cancer center	17	35.4
	University Hospital	4	8.3
	Public Hospital	10	20.8
	Private hospitals	17	35.4
Number of treated patients per year	<1000	12	25.0
	1000–2500	25	52.1
	>2500	11	22.9
Number of linacs	median	4	NA
	min	1	NA
	max	11	NA

(R&V), the patient records and a specific form, for 69%, 34% and 12% of the institutions respectively.

When a patient was previously treated in another center, institutions asked unanimously the DICOM data of the prior irradiation (Computed Tomography images, plan, structure, dose). Half of them also asked the radiation therapy treatment summary. For sharing DICOM data of previous treatment, 60% of the institutions estimated to have a secure data transfer. Forty-one institutions reported and described the difficulties experienced during this data collection step: difficulties at the patient safety level, at the administrative level, and at the technical level ([Fig. 1](#)). The major reported difficulty was very old previous irradiation which was notified by 70.7% of the institutions.

For half of the institutions ($n = 24$), patient reirradiation cases were debated during a radiotherapy staff ($n = 16$), or a specific meeting such as multidisciplinary team meetings ($n = 7$), or a special reirradiations meeting ($n = 1$). These meetings mainly gathered physicians only (25%), or physicians and physicists (20.8%) ([Fig. 2](#)). Indication and new treatment total dose were the main discussed topics (92% each). For these institutions having a meeting, the previous treatment plan could be also reviewed, and the accumulation of the prior dose distributions could be performed (54% and 63% respectively). For 8 out of 24 institutions, the new treatment plan was validated in a collegial manner.

Regarding the retreatment plan and accumulated dose validation, 79% of respondents used guidelines from several sources which were scientific publications and reports from regional, national and/or international scientific societies. Recorad reports [[5,6](#)] were the most cited guidelines (62% of institutions which used guidelines). Three institutions indicated to refer to papers exclusively based on reirradiations experience [[3,4,7](#)].

3.3. Clinical aspects for reirradiation management

All the institutions managed reirradiation for at least two anatomical regions, and 85.4% of them for five and more anatomical regions ([Fig. 3](#)). The spine and head and neck were the most managed areas for reirradiation (89.6%), while only 62.5% for the abdomen ([Table 2](#)). The [Fig. 4](#) showed the distribution of the reirradiated patients number per year and per site ([Table 3](#), in [supplementary data](#), gives also the repartition of the respondents number per anatomical region and per annual reirradiated patients number). The two first indications for patient reirradiation were pain and neurological deficit. The median accepted minimal delay between two overlapping irradiations was 6 months (SD: 4.3 months; min: 0 month; max: 24 months).

Twenty-six institutions out of the 48 considered potential recovery between courses, for almost one organ at risk (OAR). Recovery was mostly applied on the spinal cord (85%) and the brainstem (58%) ([Fig. 5](#)). The trachea and main bronchus were the OARs the less mentioned for recovery (3 institutions). The predominant parameter for recovery consideration was the delay between two radiation courses (67%; $n = 29$ respondents). Six respondents indicated the recovery factor they used for the spinal cord: 50% at 2 years ($n = 3$), 50% at 1 year ($n = 2$), and 25% at 2 years ($n = 1$). The other quoted factors were the expected clinical outcome (14%), the tolerance at the first treatment (11%), the volume size (3%), the comorbidities (3%) and the invaded OAR (3%). Few answers were collected regarding the maximum accumulated EQD2 tolerated without recovery for different OARs ([Fig. 6](#)). The largest number of answers (between 22 and 27 respondents) was found for the central nervous system OARs (i.e., spinal cord, brainstem, chiasm and plexus).

3.4. Technical aspects for reirradiation management

A large part of the respondents (88%) thought that prerequisites were needed for reirradiation management, and a quarter of the institutions estimated not to have the appropriate equipment for this kind of treatment. Regarding the treatment machine or modality currently

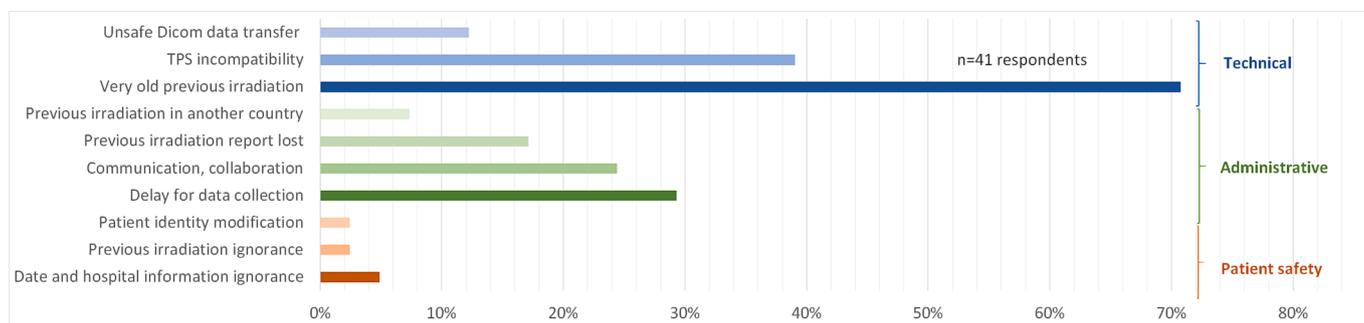


Fig. 1. Difficulties raised by the institutions during the previous irradiation data collection (based on open-ended questions).

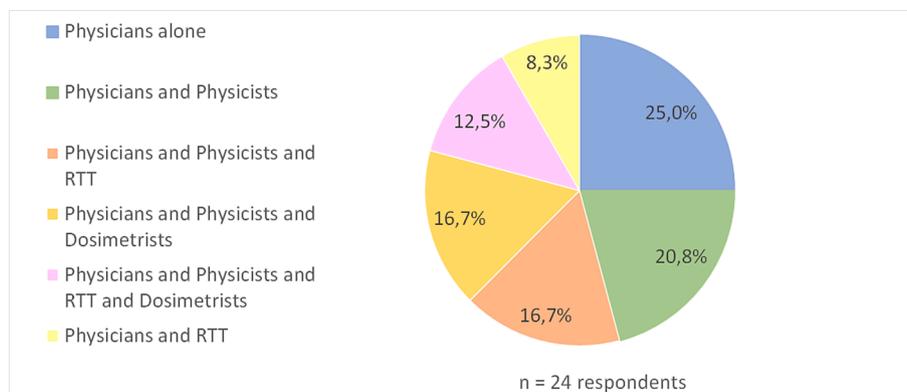


Fig. 2. Type of healthcare professionals participating to the radiotherapy meeting discussing about reirradiation cases (RTT = radiotherapist).

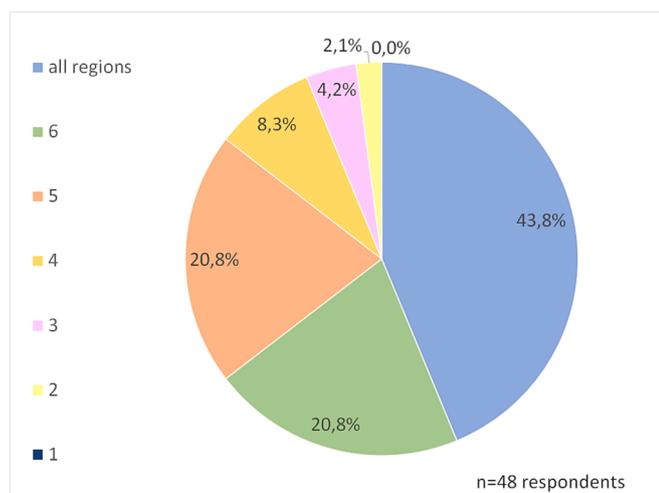


Fig. 3. Rate of anatomical regions number managed for reirradiation.

Table 2

Reirradiation management per anatomical region.

Percentage of centers managing reirradiation per site (%)							
Brain	Head and Neck	Thorax	Abdomen	Spine	Pelvis	Nodes	
87,5%	89,6%	81,3%	62,5%	89,6%	87,5%	87,5%	

used for reirradiation, linac-based Stereotactic RadioSurgery (SRS) and Stereotactic Body Radiation Therapy (SBRT) were the most quoted (66.7%), followed by conventional linac (58.3%), Cyberknife (31.3%), the protontherapy/Hadron Therapy (31.3%), the brachytherapy (20.8%) MRI linac (6.3%) and Gammaknife (4.2%) (Fig. 7). Thirteen

institutions occasionally referred patients to French protontherapy facilities.

Slightly more than a half of respondents (52.1%) accumulated the dose distribution from the different treatment plans using a commercial software. Among the quoted commercial software, four were Treatment Planning Systems (TPS) and three were specific additional software with dose accumulation tools. MIM was the most prevalent (32.0%), followed by Eclipse (28.0%), Raystation (24.0%), Artiview (20.0%), Mirada (4.0%), and Monaco (4.0%) (Fig. 8). For 45 institutions, physical dose was previously converted in EQD2 before summation.

Rigid and deformable registrations were performed commonly by 75% and 27% of the respondents respectively, and occasionally by 15% and 29% of the respondents respectively. Three institutions exclusively used deformable registration for dose accumulation for all their retreated patients. Twelve institutions indicated to have validated their deformable registration tool according to the AAPM TG 132 [8]. The prerequisites for reirradiation management, according to the respondents, were sorted in the Fig. 9. The major reported items were related to treatment delivery accuracy and patient repositioning.

4. Discussion

This survey provided an overview of the French current practices regarding reirradiations management with a response rate of 28% (48 out of the 174 French institutions). A response rate of about one third was expected, according to Cunningham study [9]. Despite two reminders from the national scientific societies (SFRO and SFPM) and individual personal invitation to several institutions, the response rate was slightly lower than expected, but of the same order of other recent surveys in the radiotherapy field (ranging from 13% to 28.5% in [10–12]). Similarly, two national surveillance studies were conducted in Japan [13,14] to evaluate and monitor the Japanese reirradiation practices. Unlike the Paradis et al. survey, which was only addressed to academic institutions [15], an equally repartition of the respondents

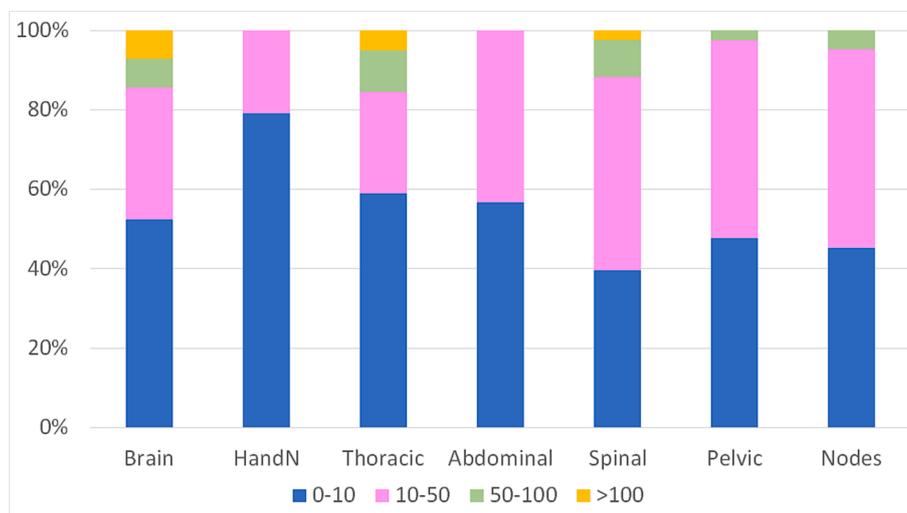


Fig. 4. Percentage of institution managing reirradiation per site and per patient number range.

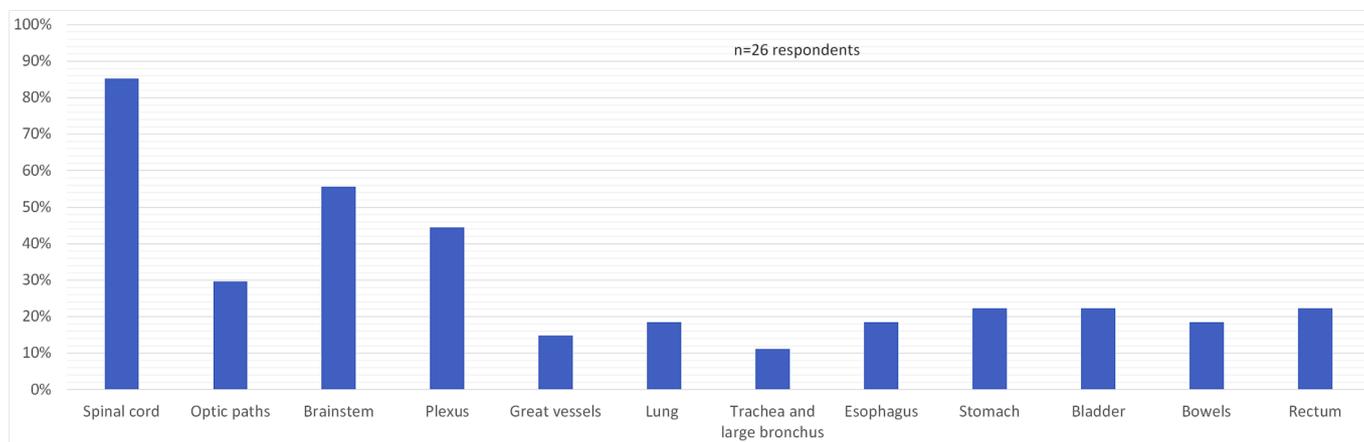


Fig. 5. Rate of the recovery use according to sites among the institutions considering recovery.

was obtained in terms of sector type; public, private and public-private institutions represented one third of the respondents each. All types of treatment delivery/facility were represented.

4.1. Organizational aspects

Available, complete and consistent data of the previous irradiation are crucial in reirradiation management. The patient’s records providing clinical, anatomical and dosimetric information, enable to estimate the overlap with the new treatment and which OARs are concerned by the reirradiation. Thus, they contribute to the decision-making regarding the new treatment total dose, the fractionation scheme, and the estimation of remaining allowable dose to the relevant OARs. They finally help the physicians to decide the re-treatment intent, i.e., curative or palliative intent.

Concerning the data collection, all the institutions asked for the previous treatment DICOM data in order to import them in their own TPS or in a complementary software. Only half of the respondents additionally asked for the previous radiation therapy treatment summary, but this latter is necessary to check, on one hand, the total delivered dose to the patient (in case of not complete treatment course), and on the other hand, the dose per fraction [16]. In case of dose per fraction > 2 Gy, either equivalent maximum dose received by the OARs has to be manually calculated using the linear-quadratic model, or the previous treatment physical dose map has to be biologically converted

by a complementary software.

The most reported difficulties encountered during the data collection were related to technical issues which were frequently no available DICOM data but « simple paper report » of very old previous treatment. Such poor data can lead to uncertainties in the previous treatment dose to OARs estimation, mainly due to errors from the field re-positioning (size, orientation, beam depth...), from the beam modeling (Cobalt, protons ...), and from unknown patient deformations. Another issue was the DICOM RT planning data transfer inability, between institutions or TPS, because of the TPS obsolescence or decommissioning, or incompatible formats [16]. A suggestion would be that TPS vendors guarantee compatibility of DICOM RT files provided by their software and inversely the ability of software to read DICOM RT files independently of their source. In any cases, it appeared crucial to record every plan report.

In France, the legal requirements to keep the medical records (paper, DICOM data, etc...) is 20 years and 40 years for cancer centers [17]. The Agence National de Sécurité de l’Information (ANSSI) and the Health ministry encourages to use secured mailing for patient data sharing. But currently, there is a large diversity of patient data transfer means (email, Wettransfer, Google Drive, constructor’s own sharing platforms, etc.). For best practice in the collection data, a common and secured platform could be developed and deployed nationally to allow inter-institutional data transfer.

The highlighted administrative issues were a slow collection of the previous treatment data and a lack of communication and collaboration

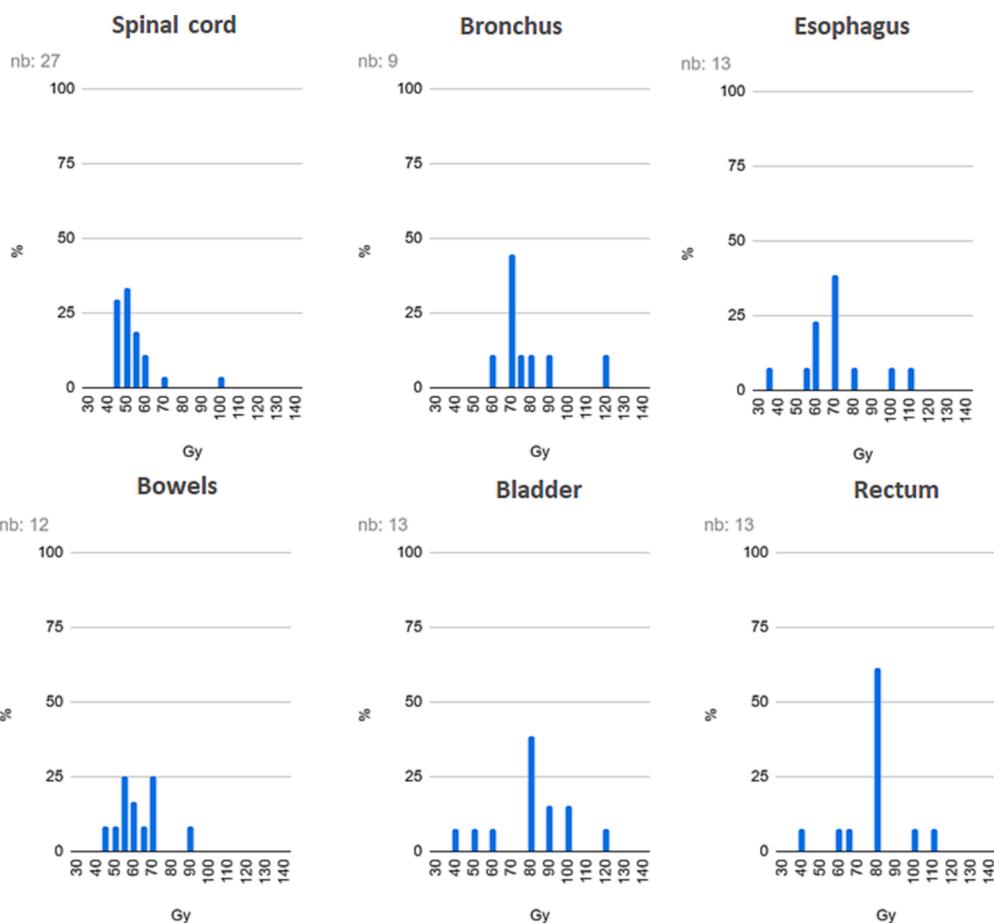


Fig. 6. Allowable cumulative EQD2 max for different OARs, without recovery. (nb: number of respondents).

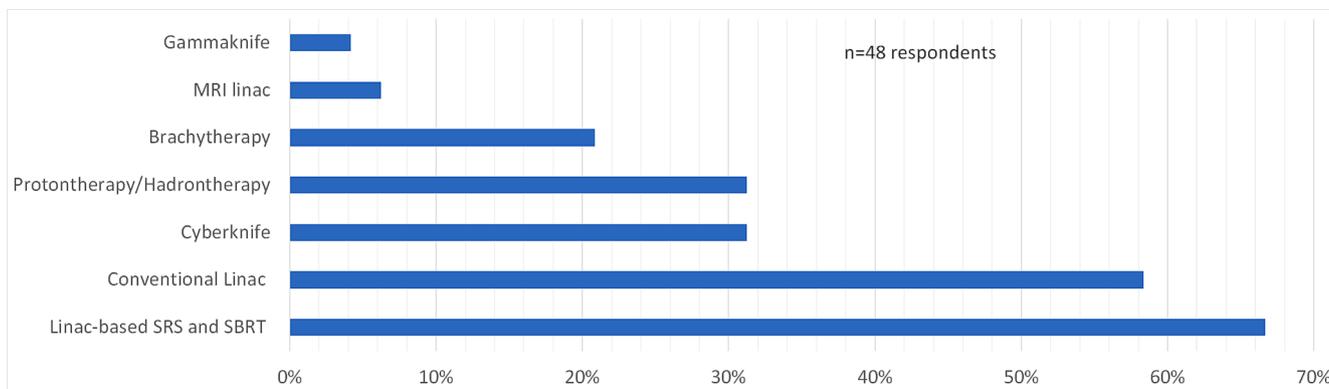


Fig. 7. Radiotherapy equipment and/or modalities currently used for reirradiations.

from outside institutions. A database of outside institution contacts and a procedure defining what are the mandatory data of the previous irradiation (DICOM data, radiation therapy treatment summary) and who handle it, could probably facilitate the record collection [18]. Three institutions also mentioned safety treatment issues such as previous irradiation ignorance or patient name change, which are the worst-scenario case in reirradiations.

Among the institutions discussing the reirradiation cases, all of them (except one) did it during the radiotherapy staff or a multidisciplinary team meeting. Frequent multidisciplinary meetings seem to be essential for safe reirradiation management. Indeed, it allows to share clinical experiences and to avoid omitting important facts in the technical and clinical reflections. For the academic institutions, these meetings can

offer to the residents the opportunity to be mentored by more experienced physicians, and/or, physicians with a specific organ expertise.

To ensure safe reirradiation treatment, Paradis et al and Price et al. suggested to implement a consistent process called « Special Medical Physics Consult Process for Reirradiation Patients» [15,18,19]. This latter can, for example, consists of a group of physicians and physicists, which duty is to define the institutional workflow, to establish procedures, to inform stakeholders, to gather publications on the topic and to regularly monitor the process [15,18].

4.2. Reirradiated areas and cumulative dose limits to OARs

This questionnaire confirmed that reirradiations was practiced by all

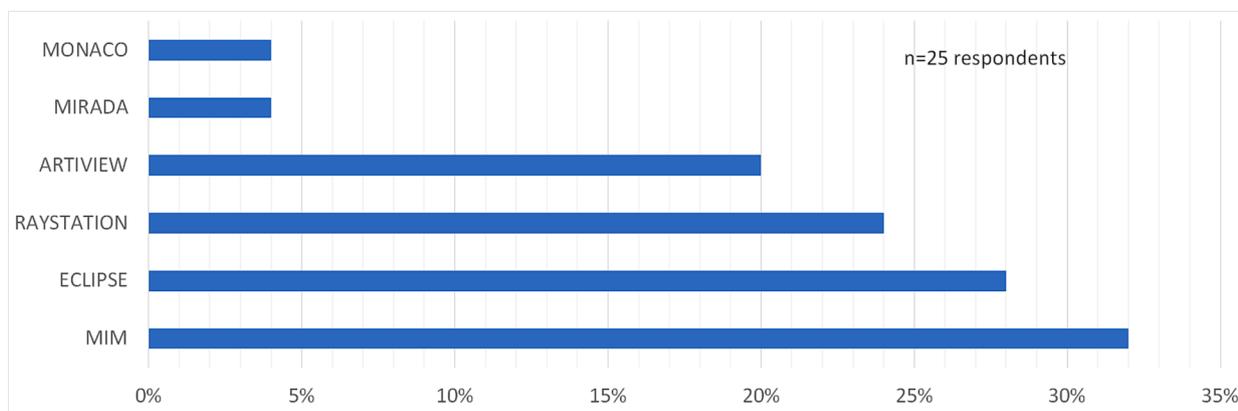


Fig. 8. Commercial software used for cumulative dose estimation (based on open-ended questions).

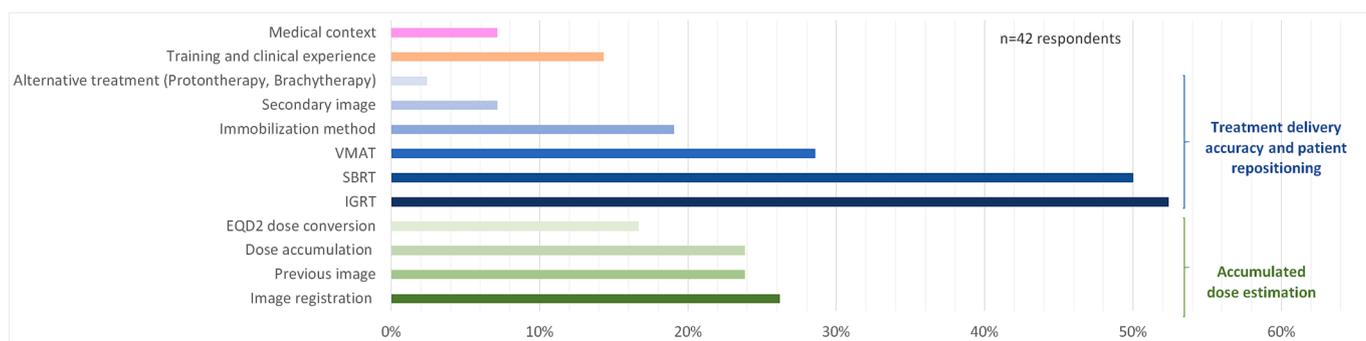


Fig. 9. Prerequisites for reirradiations management mentioned by the respondents (based on open-ended questions).

kind of institutions, as all respondents answered they managed re-treatments for at least two anatomical regions. The spine was one of most re-treated areas, with 50% of the institutions treating between 10 and 50 patients per year, and 11.6% of the institutions >50 patients per year. This can be explained by the fact that spinal metastases frequently occur inside or at the edge of the prior radiation fields (e.g., primary breast cancer including regional lymph nodes irradiation, and a few years later, T3 metastases occurrence), or that a spinal metastasis has to be reirradiated due to a pain response failure of the first conformal radiotherapy course [20–22].

For the head and neck area, the proportion of patients re-treated per year was lower (between 0 and 10 patients per year for 79% of the institutions). The local and/or regional recurrence rates for this pathology are up to 30% [23], and post-operative or exclusive reirradiation, with palliative or curative intent, is a feasible option.

On the contrary, reirradiations were less frequent in the abdominal region, probably due to the limited tolerance of OARs (stomach, duodenum, small bowels, and liver), but also to the lack of evidence regarding the local control and survival improvement after reirradiation [24].

Even if 54% of the institutions declared using a recovery factor, especially for spinal cord and brainstem, the methodology used was not clearly detailed. Also, a very few institutions provided, without tissue repair, the allowable maximal cumulative EQD2 they used for several OARs. The major clinical concern in re-treatment is the potential severe long-term normal tissue toxicity. Unfortunately, there are very few clinical studies and guidelines indicating what is permitted in this situation. By consequence, the physician’s clinical decision-making can be difficult. At the same time, the questionnaire showed that respondents largely referred to French guidelines for normal tissue tolerance in the primary situation, either from the literature [5,6,25], or from national or regional scientific societies. It may explain why most of the institutions

were conservative and didn’t exceed the maximum dose (Dmax) conventionally tolerated in a de novo irradiation context. This observation emphasizes the need of a multidisciplinary working group dedicated to clinical practice standardization in reirradiations.

However, some authors recently published new data from reviews, consensus and retrospective clinical studies, for spine, thoracic and pelvic areas [3,4,7,26].

4.2.1. Spinal cord

Regarding the time-dependent recovery, Nieder et al. [27] suggested the following rule: 25% after 6 months and 50% after 12 months. For reirradiation SBRT delivered in 1 to 5 fractions, Sahgal et al. proposed a spinal cord dose constraint, in terms of cumulative Dmax EQD2 ($\alpha/\beta = 2$) with a lower risk of radiation myelopathy (RM), inferior to 70 Gy [28]. In a retrospective Japanese study, where 123 patients received a prior conventional radiotherapy followed by a SBRT reirradiation (24 Gy in 2 fractions), 4 patients developed radiation myelopathy [29]. For these last patients, the median spinal cord cumulative Dmax EQD2 ($\alpha/\beta = 2$) was 68.3 Gy which was inferior to Sahgal et al recommendations. In Doi et al. study [26], two international series of patients which were reirradiated at the level of the spinal cord between 2007 and 2018, were merged to assess the spinal cord Dmax and D0.1 cc. They found a median cumulative spinal cord Dmax EQD2 of 80.7 Gy and a D0.1 cc EQD2 of 76.1 Gy and a high-risk score for 37,5% of the patients (delay between two overlapping irradiations > 6 months, no recovery factor applied, median clinical follow-up of 12 months). No radiation myelopathy was observed. But authors clearly specified that spinal cord damage could occur a long time after the reirradiation, and thus, the informed patient consent was mandatory. Other parameters impacting the spinal cord tolerance (other prior or concomitant therapies) still need to be explored. In our study, five institutions accepted maximum accumulated EQD2 superior or equal to 60 Gy, and inferior to 100 Gy. Through the

survey, it was also indicated that main indications for reirradiations were based on patient pain and neurological deficit. Nevertheless, the tumor local control should be taken into consideration too.

4.2.2. Bronchus, esophagus

Schroder et al. analysed the clinical and dosimetric data from a retrospective series of 42 patients who received two or more overlapping courses of radiotherapy [30]. They reported a median accumulated Dmax EQD2 ($\alpha/\beta = 3$) of 82 Gy (min 70.5; max: 187.3 Gy) and of 81 Gy (min 70.1; max: 103.7 Gy), on the bronchial tree and the esophagus respectively. For this cohort, acceptable toxicities were observed (except for one patient who had a fatal esophageal rupture probably due to a viral esophagitis). Then, Rulach et al. [4] developed an international expert consensus based on a Delphi process. Besides clinical and technical recommendations, they reported cumulative EQD2 dose constraints to the esophagus (Dmax point) of 75 Gy with an agreement of 86%. No consensus was reached for cumulative EQD2 dose constraints to proximal bronchial tree (Dmax point) of 80–105 Gy. The location of the treatment site seems also to take part in the toxicities, and especially for centrally located tumors caution must be followed [30,31]. In our study, three institutions accepted maximum accumulated EQD2 superior or equal to 80 Gy and inferior to 120 Gy for the bronchus, and three institutions accepted maximum accumulated EQD2 superior or equal to 70 Gy and inferior to 110 Gy for the esophagus.

4.2.3. Bowels

Regarding reirradiations in abdominal region, a lack of data on toxicity and cumulative dose received by OARs has to be noticed [24]. Institutions classically referred to guidelines for conventionally fractionated radiotherapy or for SBRT.

4.2.4. Bladder, rectum

In the retrospective study of Abusaris et al., fourteen patients had reirradiation in the pelvis area [32]. Considering a tissue repair and an $\alpha/\beta = 3$, they reported the following median cumulative EQD2 dose: 91 Gy for the rectum, 73 Gy for bowel and 79 Gy for the bladder. Unfortunately, the recovery factor and the acceptable maximum cumulative dose to OARs for this area is not consensual [3] and severe toxicities such as fistula were observed [33]. A recent retrospective study on prostate cancer relapse retreated with SBRT [34] provided safe EQD2 cumulative dose constraints ($\alpha/\beta = 3$) of $D_{30\%} < 57.90$ Gy for bladder, and $D_{30\%} < 66$ Gy and $V_{122.1 \text{ Gy}} < 5\%$ for rectum. For determining cumulative dose constraints, clinical experience from brachytherapy could be useful too [35].

The retrospective multicenter study of the French genito-urinary group (GETUG) on salvage SBRT for prostate cancer previously irradiated reported acceptable gastrointestinal and genitourinary toxicities, with a median physical dose received by 2% of the rectum and the bladder of 26.2 Gy and 23.4 Gy respectively (for the prior radiation therapy, the median total dose was 74 Gy in 37 fractions and for the SBRT reirradiation the median total dose was 36 Gy in 6 fractions) [36]. In our study, for the bladder, ten institutions allowed maximum accumulated EQD2 superior or equal to 80 Gy and inferior to 120 Gy. For the rectum, eight institutions accepted maximum accumulated EQD2 equal to 80 Gy, and two institutions, maximum accumulated EQD2 equal to 100 Gy and inferior to 110 Gy.

Two meaningful limitations are to be highlighted in all these cited retrospective studies: the patient cohort size is often small, and the patient follow up not enough long to assess late toxicities.

In the same way as dosimetric criteria were important in a reirradiation context, Beddock et al. stressed that the patient selection was essential in the entire clinical reflection [37].

4.3. Technical aspects

The patient reirradiation management strongly depends on the

available equipment in the institution and on the anatomical region to treat. A quarter of the institutions estimated not to have the appropriate techniques enabling safe retreatments. These last institutions treated a median of 850 patients per year, which could explain the supposed low proportion of reirradiated patients per year, and thus the difficulty to justify for expensive equipment (for example for additional software with accumulation dose tools).

In reirradiation situation with curative intent, it might be preferable to benefit from advanced radiotherapy techniques providing sharp dose gradients, tumor motion management and intra fraction motion monitoring [2,38]. Thus, a better OARs protection and a dose escalation to the tumor could be achieved. In our survey, the respondents used preferentially linac based SRS and SBRT to retreat patients. But they also mentioned using conventional linac for reirradiation; in that case, attention might be taken regarding the patient positioning accuracy (device and imaging frequency).

Dose accumulation tools bring a real added value in reirradiation management. Recent developments in TPS and third-party software allow a higher accuracy degree in data processing. Integration of linear quadratic model-based voxel by voxel dose conversion, rigid and deformable image registration and dose accumulation tools help to have an exhaustive and global analysis of the cumulative dose distribution. In a cohort of 21 patients retreated in the pelvic area, Nix et al. assessed the relevance of the linear quadratic model-based voxel by voxel dose conversion and of the deformable registration use [39]. They found that EQD2 dose accumulation was necessary not to miss potential OAR overdose and that deformable registration was clinically pertinent in 38% of patients due to anatomical changes. Deformable registration tools represent a great help in the reirradiation management, but they have to be carefully validated and used with caution [8,39,40]. Also, to face the diversity and the performance variability of the commercial software, an extensive training for all the users is strongly recommended.

Dose reporting is the last key point in the entire process of reirradiations. A common language regarding the methodology used and the relevant dosimetric parameters retained is clearly needed. Indeed, it will allow homogeneity in clinical studies and a better estimation of associated toxicity [4,28,41].

Some limitations of the study must be underlined. Some respondent's answers were detected as "potential error", probably due to a misunderstanding or an entry mistake. When possible, respondents were contacted for correction or additional information. Also, in the free sections, respondents' answers could be subject to interpretation. Nevertheless, the presented results reflected the current practices of reirradiations in France.

5. Conclusion

This survey dealing with the French current reirradiation management showed that these complex treatments were widely practiced, but with various organizational and technical approaches. This study highlighted that the respondents faced difficulties related to the previous treatment data collection, to the decision of cumulative EQD2 limits for specific OARs and sometimes to the lack of appropriate dose accumulation tools and treatment delivery techniques.

To guarantee the treatment and patient safety, a practice standardization could be thus considered, both, at the national level, and at a radiotherapy department level. A working group of physicians and physicists could especially produce French guidelines on an optimal process with peer review, the tolerated cumulative EQD2 to OARs (with or without recovery), a robust use of software allowing rigid and deformable registration for EQD2 accumulation and an accurate dose reporting. This could encourage to retreat selected patients who accept the toxicity risk and could legally secure physicians in the reirradiation practice.

An approach based on a specific anatomic region expertise might be

relevant too as clinical decisions and uncertainties from the technical part (e.g., organ deformation management between treatments) can differ according to the retreated region.

With all these resources, the institutions could then establish a reliable and customized process which will reinforce their confidence in retreating patients.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ejmp.2023.102582>.

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