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A code orange for traffic-light-protocols as a communication mechanism in IGRT

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A R T I C L E I N F O

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A B S T R A C T

Introduction: Traffic-light protocols (TLPs) use color codes to standardize image registration and improve interdisciplinary communication in IGRT. Generally, green indicates no relevant anatomical changes, orange signals changes requiring follow-up but does not compromise the current fraction, and red flags unacceptable changes. This study examines the communication aspect, specifically the reporting accuracy for locally advanced non-small-cell lung cancer (LA-NSCLC), and identifies barriers to reporting.

Materials & Methods: We conducted a retrospective study on 1997 CBCTs from 74 LA-NSCLC patients. Each scan was in retrospect assessed blinded using the tailored TLP by an IGRT-RTT and subsequently by a second RTT for a subset of fractions. The assessment included both CBCTs from current clinical practice (TLP_{2023}) and from the TLP implementation period (TLP_{2019}). Accuracy of image registration was not evaluated. Reporting barriers were identified through focus group discussions with RTTs.

Results: During TLP_{2023}, 22 of the 63 (35%) patients received at least one code orange during therapy, with 2 of them having a systematic code orange, totaling 43 (2%) fractions with at least one code orange. The IGRT-RTT assigned code orange or red in 59 (94%) patients, 38 (60%) of which had systematic codes orange. In total, the IGRT-RTT reported 684 (40%) fractions with code orange and 13 with code red. During TLP_{2019}, similar numbers are observed. In the subset reviewed by two IGRT-RTTs, reports matched in 77% of cases. Various factors contribute to a low reporting rate, originating both during the decision-making process such as lack of online reporting tools and within offline processes such as divergent feedback expectations.

Conclusion: While our TLP has successfully promoted the widespread adoption of CBCT-based RTT-led IGRT, it has not succeeded in establishing interdisciplinary communication. Our study reveals significant underreporting of flagged LA-NSCLC fractions in clinical practice using a TLP. This underreporting stems from multifactorial origins.

Introduction

Radiation therapist-led (RTT) image-guided radiotherapy (IGRT) utilizing on-board cone-beam CT imaging (CBCT) is the standard-of-care strategy for daily position verification in modern radiotherapy [1–5]. CBCT-based position verification ensures accurate dose delivery to the target while minimizing dose to organs-at-risk (OAR) combined with well-considered PTV margins [6]. Next to position verification, IGRT provides insight into the internal anatomical changes [7]. Given that only couch displacements are possible with IGRT, addressing these alterations is challenging [8]. Therefore, IGRT is evolving towards image-guided adaptive radiotherapy (ART) [9–13]. Identifying anatomical alterations that may lead to deteriorated dose distributions falls under the scope of the RTTs, under the supervision of radiation oncologists (RO). This delegated task requires minimal interpretation differences between RTTs when it comes to communication towards ROs and aims for time-efficient decision-making. Traffic Light Protocols (TLPs) not only facilitate this through standardized image-registration, they also provide a framework for communication by defining actions with color codes based on predefined geometric parameters[7,14,15]. Generally, a code green indicates that no parameters have been exceeded, orange often involves offline communication towards ROs, while red signifies online

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decision required by the RO and Medical Physicist Expert (MPE) [7]. Variations on these TLPs include action-linked color codes, where orange, for example, could signify pleural fluid extraction [16]. The presented color definition can be further expanded with additional color codes representing other predefined actions, such as dose calculation on CBCT by the medical physics assistant/expert (MPE/A) to provide the RO with additional information before initiating a repeated CT scan.

Such flagging system is particularly useful in the treatment of indications with expected anatomical changes such as locally advanced non-small-cell lung cancer (LA-NSCLC). Changes in lung density or tumor shifts can lead to dose deteriorations while these patients benefit from regular plan-adaptations[7,9,17].

TLPs have been gradually implemented in our institute since 2016–2019, coming along with increasing use of CBCT-based IGRT. Given a recent institutional desire for increased adaptive treatments, it is necessary for our TLPs to function as a robust communication system between RTTs and ROs to ensure that each fraction is correctly flagged. In lung cancer, as our focus of interest, a proper identification and reporting of intra-thoracic changes ensures timely intervention through, for instance, a CBCT-based dose calculation or in severe anatomical alterations, a repeated planning-CT.

The objective of this retrospective study is to evaluate the interdisciplinary communication aspect of TLPs in terms of reporting accuracy through blinded review, to examine reporting trends by comparing reporting accuracy during the implementation phase with current clinical use, and to identify barriers in TLP-reporting. Our focus of interest is specifically oriented toward the TLP of LA-NSCLC as an example.

Materials and methods

Patient, treatment and department characteristics

For the first time, we have analyzed the reporting accuracy during the TLP implementation phase (TLP_{2019}), and current clinical practice (TLP_{2023}). For TLP_{2019}, consecutively treated LA-NSCLC stage III patients between April 2019 to July 2019 (n = 11 patients, 289 fractions) were included. This arbitrary timeframe was selected to assess reporting during the initial phase of TLPs in their current form. For TLP_{2023}, consecutively treated patients between August 2022 to August 2023 (n = 63 patients, 1708 fractions) were included. The selected patients were treated with a conventional radiochemotherapy regimen: 17–24 fractions of 2.75 Gy/fraction for sequential schedules and 30–33 fractions of 2 Gy/fraction for concurrent schedules.

Patients underwent 4DCT-simulation on CT Somatom Definition Edge/Drive (Siemens AG, Munich, Germany). Target volumes involving the primary tumor and lymph nodes were delineated on the mean intensity projection (MeanIP) of the 4DCT based on international guidelines [18,19]. IMRT planning was performed in Eclipse™ (Varian, a Siemens Healthineers Company; Palo Alto, CA, USA). Patients were primarily treated on Halcyon™. All patients underwent daily position verification via CBCT.

A rotating team of RTTs (34 during TLP_{2019}, 41 during TLP_{2023}, 66 % retention rate) are in charge of daily position verification under the offline supervision of two staff respiratory ROs. Annually, 10–12 RO-residents are tasked with offline monitoring of IGRT tasks, first-fraction IGRT evaluation and are also called to evaluate online imaging when deemed necessary by the RTT. In addition, residents and supervisors have weekly rounds of image review where per patient a random CBCT is reviewed. Tri-monthly, residents rotate through care programs as part of their training to become specialist-ROs.

Traffic Light protocol (TLP)

- IGRT procedure

The TLP starts with CBCT-acquisition. CBCT parameters are template-based with 125 kV, 300 mAs and a slice thickness of 2 mm covering the entire thorax. CBCT scans are acquired during free breathing.

- *Image-registration*

Daily image guidance follows a four-step TLP as indicated in Fig. 1:

- *Communication*

Steps 2 through 4 involve color-coded criteria. Code green in our TLPs indicates criteria within tolerance, code orange indicates criteria requiring offline communication with the RO, and red indicates criteria outside tolerance where radiation should not proceed before online assistance from a RO and MPE. Both orange and red codes are reported in the delegated digital offline task system (CarePath) of the oncology information system (OIS). Tasks (offline image review for orange or red code) are directed to the responsible ROs, allowing the responsible RO to provide optional feedback that can be read online upon opening the patient the next day, or offline via the Offline Review platform in the OIS. A written form is used to report interfraction motion.

- Implementation

The TLP was introduced in its current version in 2019 based on available literature at the time to facilitate increased CBCT-adoption [7]. An initial draft was further discussed through institutional multidisciplinary meetings. The implementation of the TLP for LA-NSCLC was not isolated but proceeded alongside a phased implementation of TLPs for various other indications.

- Training

Education has been majorly focused on the standardization of IGRT. Both interactive and case presentations were held during breaks. Since 2019, we utilize offline workstations where an online IGRT-environment is simulated. Early-career RTTs routinely utilize these offline workstations, providing them with the opportunity for one-on-one teaching moments led by one of the four educator-RTTs, allowing practice of TLP usage. Additionally, since 2021, IGRT e-learnings have been integrated, which RTTs are required to complete annually [20].

Peer review of TLP-utilization in clinic

A quantitative comparison is conducted between the retrospectively reported codes in the clinic and a blinded peer review by an experienced IGRT-RTT (DC) interpreting the TLP in a strict sense. The peer review was performed by evaluating all 1997 CBCTs in the Varian Offline Review platform. On this platform, it is not visible whether a particular code was assigned, assuring a blinded process. After peer review, all imaging codes were collected via CarePath to compare clinical usage with peer review. Additionally, the interpretation time of the IGRT-assessment process in the clinic was collected as an indicator for the efficiency in the decision-making process. To assess interobserver variability, a second blinded evaluation was performed by another experienced IGRT-RTT (RDH) who reviewed 5 randomly selected patients (136 fractions). Both IGRT-RTTs are RTT trainers in the department with national and international experience in IGRT education and have contributed to the development of TLPs for various indications, including the exemplary one utilized in this study.

Identifying TLP-reporting barriers

Based on the quantitative results, reporting barriers were prospectively discussed with RTTs through focus groups. A total of 35 out of 41 RTTs from the department expressed interest in participating in these

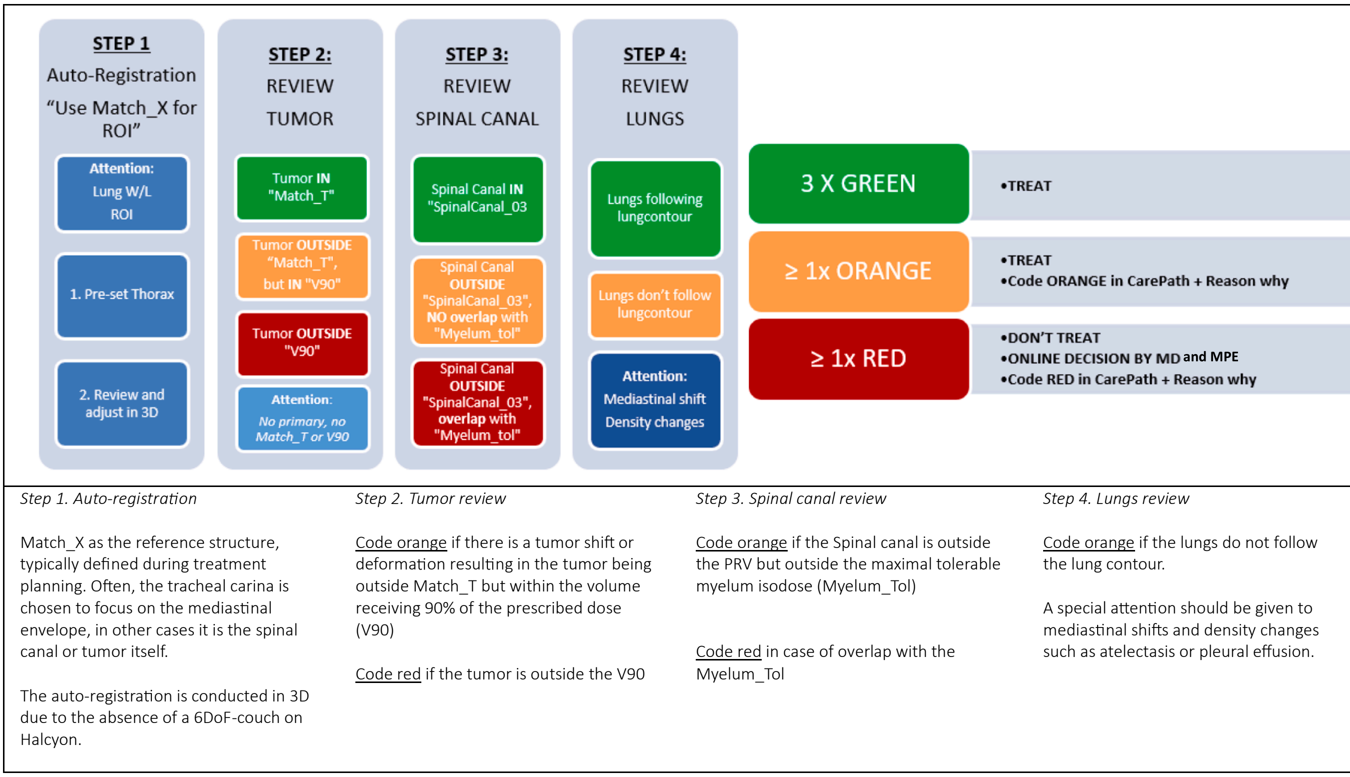

Fig. 1. The Traffic Light Protocol (TLP), clinically in use since April 2019.

focus groups. The pre-condition to participate was that they have been working in the department for at least three months.

Three focus groups were conducted in a meeting room, each with a maximum of 12 RTTs. Time was allocated for 60 to 75 min. The focus groups were moderated by the IGRT-RTT (DC), with support from two quality managers. A semi-structured discussion protocol, based on hypotheses, was prepared as guidance (see appendix I). Additionally, an anonymous MS Forms survey was used to allow RTTs to provide their opinions in writing (see appendix I). This MS Forms survey was also utilized to quantify responses to certain believed sensitive questions. A total of 23 out of 35 respondents completed the limited survey.

The focus group discussion began with a brief history of the use of TLPs. An overview was provided on how images are assessed in similar academic centers (*see acknowledgments*). The purpose of the focus group was then explained, emphasizing the intention to dive deeper into the reporting behavior of CBCT images. For simplification purposes, it was communicated that it concerns the interpretation of all TLPs. All TLPs in the department are similarly structured and follow the same reporting procedures. It was emphasized that the discussion was confidential. All conversations were non-verbatim transcribed. The information from the first transcribed focus group discussion was then cross-checked in the next focus group.

Ultimately, all transcribed focus group discussions were thematically analyzed (DC) based on the steps described by Clarke et al.[21], utilizing an inductive approach to coding; aligning with the pre-defined focus group guideline document. The coding was written in a cohesive story following a final group discussion (DC, JV, RDH, PB, ML, WC) to formulate a response regarding the barriers and how these barriers may have arisen.

Results

Peer review of TLP-utilization in clinic

In total, 1997 CBCT-scans have been evaluated in respect to the communication objective of the TLP.

During TLP_{2019}, it was observed that 36 % of patients in the clinic were assigned an orange/red code at least once throughout their course, compared to 91 % of patients in blinded retrospective review (Table 1). Similar figures were observed in TLP_{2023}, with 35 % in the clinic and 94 % in peer review.

For TLP_{2019}, 18 % of cases were reported to have a systematic

Table 1
Reported codes were compared between TLP_{2019} and TLP_{2023}; all fractions were retrospectively evaluated by the IGRT-RTT in comparison to the reported code of the RTT in Clinic.

	TLP_{2019}		TLP_{2023}	
Total Fractions	289		1708	
Total Patients	11 *(1 patient with ad-hoc ART)*		63 *(2 patients with ad-hoc ART)*	
	RTT in Clinic	**IGRT-RTT (DC)**	**RTT in Clinic**	**IGRT-RTT (DC)**
Total patients with minimum 1 reported code	4 (36 %)	10 (91 %)	22 (35 %)	59 (94 %)
Total patients with systematic error *(3 consecutive codes)*	2 (18 %)	8 (72 %)	2 (3 %)	38 (60 %)
Total fractions with Code Orange	12 (4 %)	102 (36 %)	43 (2 %)	684 (40 %)
Total fractions with Code Red	0	1	0	13 *(3 patients)*
Code Orange*				
Tumor	4 (1 %)	36 (12 %)	15 (0,9%)	149 (9 %)
Spinal Canal	6 (2 %)	41 (14 %)	8 (0,5%)	247 (14 %)
Lungs	2 (0,7%)	73 (25 %)	13 (0,8%)	537 (31 %)
Code Red*				
Tumor	0	0	0	8
Spinal Canal	0	1	0	5

*See Fig. 1 *for the written TLP, multiple reasons per fraction are possible* deviation in the clinic, while 72 % were identified in review. In TLP_{2023}, there is a decrease observed, with only 3 % of patients reported to have a systematic deviation. However, review assessments suggest this figure to be 60 %.

The majority of reported codes in both clinic and review are predominantly code orange. There is a significant reporting difference both in TLP_{2019} and TLP_{2023}. The most substantial difference lies in the code orange for lung criteria. In the clinic, this was reported in 0.7 % of all fractions, whereas the IGRT-RTT reported this for 25 % of fractions. Similar figures were observed in TLP_{2023}, with 0.8 % of all fractions reported as orange for lung criteria versus 31 % for IGRT-RTT reporting.

No red codes were reported in the clinic. However, the IGRT-RTT reported one fraction as a red code from TLP_{2019}, and 13 fractions were reported as red codes in TLP_{2023}.

Remarkable interpretation time differences between TLP_{2019} and TLP_{2023} are not observed (Table 2, Fig. 2). There may be a slight acceleration in interpretation time in TLP_{2023} or it could be attributed to faster software processing. The slower interpretation times in cases of fractions that should have been reported code orange/red suggest the possibility that within these fractions assistance from the on-call RO was asked. However, we do not observe a significant time difference between the factions reported as code orange/red and those that should have been reported as such. In 90 % of fractions, the image interpretation is made within five minutes.

In 77 % of the fractions from the randomly selected patients, both IGRT-RTTs reported the same code. IGRT-RTT (RDH) classified 18 fractions of a single patient as a red code, whereas IGRT-RTT (DC) classified them as an orange code (Table 3). The origin of this discrepancy lies in a patient where atelectasis occurred in the proximity of the tumor, making it difficult to distinguish between tumor and atelectasis. In the other discrepancies, IGRT-RTT (DC) defined the fractions as green, whereas IGRT-RTT (RDH) assigned an orange code to fractions where the lung contour deviated. IGRT-RTT (DC) assessed this as a code green since the contour deviation was too far longitudinal from the region of interest.

Identifying TLP-reporting barriers

Thematic analysis identified five themes and accompanying subthemes for underreporting. The barriers originating from the decision-making moment are referred to as 'online barriers', whereas those defined within offline processes are termed 'offline barriers' (Table 4).

Online barriers

- CBCT-based decision making

During the decision-making process, the image quality of both Halcyon and TrueBeam CBCTs is indicated to complicate the decision

Table 2
Time comparison between TLP_{2019} and TLP_{2023}.

	TLP_{2019}	TLP_{2023}
Total Fractions	289	1708
Total Patients	11	63
Interpretation Time		
Green in clinic *(mean ± SD;* max*)*	0:02:45 *(±0:01:37; 0:10:14)*	0:02:14 *(±0:01:07; 0:18:35)*
Fractions with reported orange/red *(mean ± SD;* max*)*	0:04:23 *(±0:02:27; 0:10:02)*	0:04:04 *(±0:02:42; 0:15:23)*
Fractions with unreported orange/red *(mean ± SD;* max*)*	0:03:42 *(±0:02:00; 0:09:49)*	0:03:08 *(±0:02:13; 0:24:33)*
Interpretation time > 5 min.	8 %	6 %
Interpretation time > 10 min.	1 %	1 %

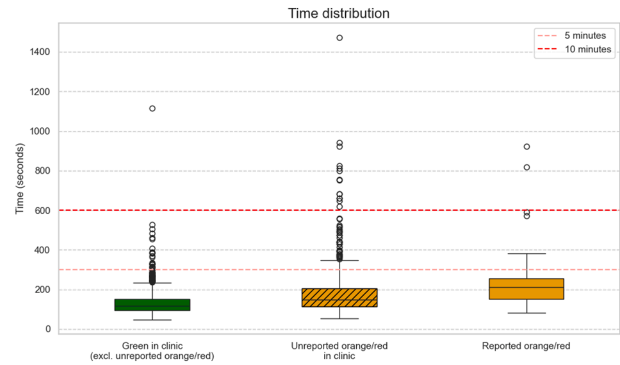

Fig. 2. Time distribution across 'green' fractions in clinic (unreported fractions with orange/red excluded), unreported orange/red fractions in clinic and reported orange/red fractions in clinic. The distribution comes from TLP_{2023}.

Table 3
Interobservervariability between two IGRT-RTTs.

	Random selection of patients (August'22 – August'23)	
Total Fractions	136	136
Total Patients	5	5
	IGRT-RTT (DC)	**IGRT-RTT (RDH)**
Total patients with minimum 1 reported code	5 (100 %)	5 (100 %)
Total patients with systematic error *(3 consecutive codes)*	3 (60 %)	4 (80 %)
Total fractions with Code Orange	39 (29 %)	36 (26 %)
Total fractions with Code Red	0 (0 %)	18 (13 %)
Identical reported decisions ***(no matter color code)***	77 %	

Table 4
Themes and subthemes as root causes for reporting barriers.

	Themes	Subthemes
Online Barriers	1. CBCT-based decision-making	i. Image quality ii. Image perception
	2. Protocol knowledge	i. RTT ii. Resident
Offline Barriers	3. Reporting opportunities	iii. Offline software
	4. Interdisciplinary communication and feedback mechanisms	i. RTT – clinical staff communication ii. RTT – RTT communication
	5. Departmental organization	i. Continuity of residents ii. Continuity of RTT-staff

between code green and code orange in cases of inferior contrast resolution. RTTs mention cases where the tumor is surrounded by atelectasis or pleural effusion and cases with severe breathing-induced artifacts. Additionally, the RTTs indicate that because of this, interpretation differences may arise. Due to a lack of consensus between the operating RTTs no code is reported.

> *"(…) Sometimes it happens that my colleague says the tumor is shifted. Then, when I look, I don't know. It could be an inferior registration or it could actually be a tumor shift (…). So I say one thing, and my colleague says another, well, then I don't enter a code in the system."*

This perception extends further to the residents. RTTs feel that residents focus on different aspects during online assistance with complex registrations. They indicate that residents are focused on target and that there are variations in interpretation among residents.

"If I call the doctor one day, they'll say 'just continue for today.' The next day, I call the on-call doctor, and this one looks beyond the PTV and says we're not matching well."

RTTs ask themselves during the focus groups whether each fraction should be reported. They mention that they presume based on anatomy whether or not the fraction leads to deteriorated dosimetric consequences. In addition, they deduce based on the limited amount of repeated planning-CTs that patients get treated well.

"Do we really need to report every fraction? We rarely perform repeated CT-simulations?"

- Protocol knowledge

While the RTTs are generally satisfied with the clarity of TLPs (mean: 7.4/10) (Fig. 3), the majority admit that they do not always use them during registration (Fig. 4). RTTs elaborate that not every TLP has clear thresholds and associated actions which prevent from reporting. Regarding the lung protocol, they indicate satisfaction with the thresholds but note a lack of associated actions. Furthermore, knowledge concerning the applicability of the TLP is a factor influencing protocol adherence.

The adherence of residents to the protocol is illustrated in the previous example, where RTTs mention that residents make decisions while seemingly ignoring the TLP. RTTs indicate that residents have little understanding of what the TLP exactly entails, therefore creating a feeling of reluctance to report within RTTs as they are in the assumption that they will not receive tailored feedback. It must be emphasized that this could be situational and resident-dependent. It could be a feeling within the RTTs or an actual awareness-problem of the TLP within the RO-residents.

- Reporting opportunities

There is no option to report a code on the online registration screen. RTTs indicate that clicking through different tabs prevents taking the time to register the code. They emphasize the cumbersome time-consuming process.

Offline barriers

- Interdisciplinary communication and feedback mechanisms

Within this theme of RTT-resident communication, RTTs expressed the most concern. They indicate that they have a feeling that a code does not initiate dialogue but rather remains one-way-communication. This does not incentivize offline reporting but rather encourages them to call the on-call resident in cases on the borderline of acceptability or difficulties interpreting for improving dialogue.

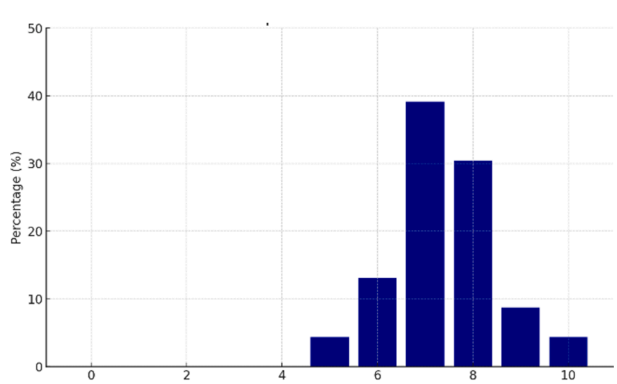

Fig. 3. How well-defined are the TLPs?

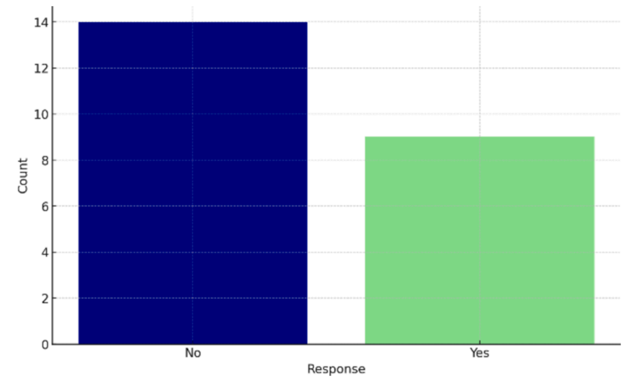

Fig. 4. Do you use the TLPs during the registration?

"Why do I have to enter a code orange for every fraction? Nothing happens when I enter it one day. The next day, I check and see that it's reviewed. What do we know then? Do we still need to report it further? Or is it then good for the rest of the treatment?"

Furthermore, there is a lack of RTT communication among the rotating team, partly due to the lack of continuous flow of written feedback (tools) about the patients between the RTTs.

"You don't know if a code orange was reported yesterday (…) and if so, that makes you say, okay, it must be fine for today (…)"

- Departmental organization

In cases of difficulties or uncertainties, the on-call resident is contacted. However, this resident may not belong to the same care program and has other tasks while being on-call, leading to a lack of continuity in follow-up. RTTs frequently reiterate the argument of receiving feedback faster in this manner, but they seem not always to be aware that the codes should be formally reviewed by the care-program resident. This contributes to attention tunneling, where RTTs focus on immediate concerns without recognizing the broader reporting structure.

"If I see that resident X is on call, then I won't call, I'll just do the matching (…) – Do you then enter a code in the system (Interviewer)? – No, not always because you're so focused on doing the matching as quickly as possible, and afterwards you don't think about it anymore."
"I would rather call someone so I'm certain that I treat well (…) even if it is code orange. In situations like this, I don't add a code orange in the system."

RTTs face continuity challenges in treatment units due to heavy workloads and shift flexibility, along with specialized expertise requirements. This hinders the transfer of information since currently there is no easily accessible dialogue-driven feedback system for RTTs to check whether a code was given in the past few days.

RTTs also indicate that working with two RTTs, as is common, there is barely time left to report a code. They prioritize patient care to help patients from the couch as quickly as possible or to greet patients at the welcome desk instead of entering the code.

The barriers are also reflected in Fig. 5, where participants were asked whether they can confidently say that they always report a code.

Discussion

In this TLP study, incorporating a blinded peer evaluation of a total of 1997 fractions from 74 LA-NSCLC patients, we observe a very low TLP reporting accuracy. In retrospective evaluation, the limited reporting

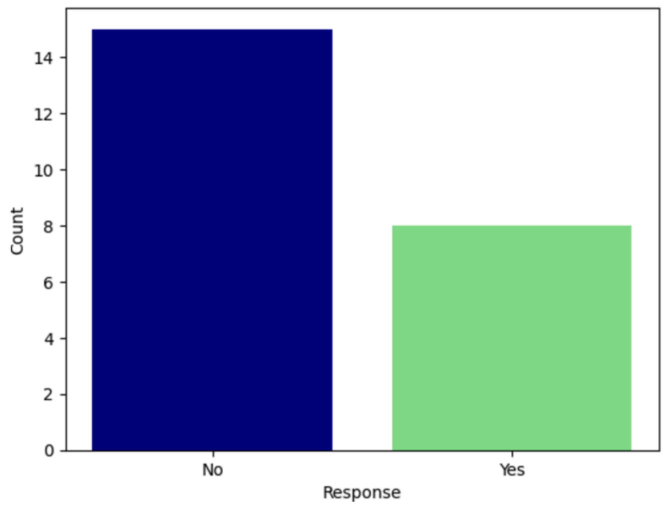

Fig. 5. I am comfortable to say I always report a code when necessary?

accuracy was present during TLP_{2019}, as well as in TLP_{2023}, warranting attention to the TLP as a communication mechanism. Various factors contribute to this low reporting rate, originating both during the decision-making process and within offline processes such as institutional organization and interdisciplinary communication loops.

Given the diverse definitions of the various TLPs for LA-NSCLC across institutions, a one-to-one comparison with similar research is not straightforward. Kwint et al. (2014) flagged 72 % of patients with intra-thoracic changes (ITACs) in weekly CBCTs[7], whereas in our dataset with daily CBCTs, 35–36 % have been flagged once. Through peer review it was detected that this figure should have been 91–94 %. It must be noted that we include positional misalignments visible through spinal canal deviation, which likely explains the higher percentage in comparison with Kwint et al. When the institution of Kwint et al started taking daily CBCTs, the reporting rate with the same TLP was 49 % for all fractions [22]. Blinded review in our study flagged 36–40 % of fractions, similar to that of Sousa et al (43 %)[23]. It is important to notice that our decision-making for tumor-flagging is less strict via V90, while some TLPs make use of the PTV. In 25–31 % of our sample, lung anatomy changes were present; which is in line with Hattu et al (24 %) where they similarly specifically defined *changes of lung anatomy* in the TLP [14]. In a follow-up study on Kwint et al by Buijs et al on the evolution of TLPs towards using action-oriented protocols for criteria out of tolerance, accuracy rates of flagging fractions of 99 % were observed in bladder and prostate treatments, attributed to over 10 years of reporting experience within their group of RTTs [24].

In our institution, we have variable RTT and resident-teams due to the department being an academic training center. While there is a 66 % retention rate over 5 years among RTTs, the majority of RTTs entering our department have no background in radiotherapy but are nurses. Belgium faces a severe shortage of trained medical imaging technologists [25], which may reflect in CBCT-based decision-making, contributing to larger interpretation differences among RTTs. However, decision-making seems not to be the primary factor, as RTTs generally express satisfaction with the clarity of TLPs. Moreover, significant investment is made in standardization of image registration through offline stations, e-learning, presentations, mentorship, etc. Knowledge of the protocol may have slightly diminished throughout the years, but not to an important extent, considering we don't notice a substantial reporting fatigue (Table 1; 4 % of all fractions reported in 2019 vs. 2 % in 2023). Within protocol knowledge, there seems to be a form of attention tunneling, given the very low reporting of lung alterations compared to the reporting of target or spinal canal deviations (Table 1). This could be because the evaluation is highly target-oriented or because the importance of proximal lung alterations on a dosimetric level is not well understood by members of the team.

A main contributing barrier is attributed to the lack of online reporting opportunities through the OBI-software and feedback expectations. While improving the OBI graphical user interface with a mandatory classification system could enhance reporting accuracy, such changes alone will not address the divergent feedback expectations, potentially leading to a continued underreporting in cases to be labeled as code orange. RTTs desire feedback/a response after reporting. However, based on the protocol, this has never been a requirement. The RO-resident is allowed to review/verify/reject the CBCT without further explanation. Due to the absence of written feedback in this regard, the RTTs feel being in a one-way communication process, resulting in less willingness to report a code. Additionally, they indicate that communication from the supervising RO does not trickle down, and it appears nothing is done with the images even when they report code orange. However, the RTT interpretation of the TLP framework deviates from its initial intention on several aspects. First, a code orange does not indicate an action in the form of a plan-adaptation has to be performed. Secondly, every reported fraction gets reviewed and discussed in backoffice. Having the feeling that *nothing gets done with it* implies indeed that this information does not trickle down. Third, also the number of reports can influence the decision for subsequent actions such as a plan adaptation by the supervisor, which is currently missed in ad-hoc reporting.. These concerns highlight the need to adjust the current departmental feedback processes, evolving from a one-way communication model to an integrated two-way feedback system with a bidirectional flow of information. Based on the results of this study, these changes could strengthen RTT-driven decision-making. An alternative non-ICT based solution could be involving the treating RTTs in the weekly ad-hoc CBCT reviews. Moreover, assigning dedicated IGRT-RTTs, instead of rotating on-call residents, for assistance in online decision-making could improve continuity in IGRT follow-up [26]. This would enhance the sense of continuity among RTTs and ensure accurate code reporting after decisions are made. Continuous investment in planning knowledge for our RTT group is crucial to ensure that it is understood that not every code orange will lead to plan adaptations, but reporting does prompt attention from the responsible ROs and MPEs.

One can question whether every fraction needs to be flagged. The clinical-evaluation strategy of weekly CBCT evaluation between the RO-resident and RO-supervisors demonstrates that patients are treated well, attributed to the standardization of image registration through the TLP. Moreover, our patient data demonstrate clinical endpoints in line with standard-of-care outcome [27,28]. The existing TLP may be too stringent, but without CBCT-based dose calculations, this cannot be objectively reported. In a future study, we therefore aim to further analyze this statement through CBCT-based dose calculations [12].

The study is considered robust due to its extensive data-collection. There are not particularly many studies quantifying reporting accuracy outside of the mentioned ones. These studies mainly originate from Dutch research [7,24], where there is considerable experience with these protocols among RTTs. In addition, the organization of RTTs in the Netherlands is different. First, nurses are not practicing the role of RTT in the Netherlands. Second, RTTs involvement in IGRT as an official mandate is very rare in Belgium, lacking a bridge person between the professions. Also for this study, we could not analyze the results with a large IGRT-RTT team. Additionally, the aim of this research was to map out the barriers from an RTT-perspective, but we did not explore how to improve them during the focus group discussions.

To conclude, we want to point out that TLPs appear very useful and they did facilitate an RTT-led daily CBCT-approach in our institution. However, they do not cover the full expectations as a communication framework for handling deviations (orange/red). If this aspect is overlooked, TLPs may not be effective in certain institutions where various circumstances come together, including periodic staff turnovers and the lack of online reporting possibilities. Implementing TLPs in practice for improving interdisciplinary communication, without taking the institutional context into account is therefore not advisable. From our department's perspective, we recognize the need for an alternative communication method beyond the task-based system. Clear expectations regarding feedback-loops should be communicated to all groups. Transparency is essential for discussions and actions occurring in the back-office between ROs and MPEs. Additionally, there seems to be a need for an (IGRT-)RTT liaison within this regard. The question remains if a higher reporting accuracy is necessary, considering institutional treatment outcomes are in line with expectations for this indication. Supportive (automated) CBCT-based dose calculations could serve as an alternative flagging system for the geometrically-driven TLP.

Conclusion

In this study, we demonstrate a large underreporting of flagged LA-NSCLC fractions in clinical practice based on an established TLP. While our TLP has successfully promoted the widespread adoption of CBCT-based RTT-led IGRT, it has not succeeded in enhancing interdisciplinary communication raising awareness to find an alternative interdisciplinary communication solution.

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.tipsro.2024.100286.

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