5 Template-Based Structured Reporting

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5.1 Introduction

The radiological report is a fundamental step of radiologists' professional activity, by which the results and interpretation of a radiological procedure are formally documented in relation to the patient's history and clinical query [1]. Therefore, radiological reports should be prepared following criteria of completeness, clarity, and methodological rigor as prerequisites for an optimal communication with colleagues and patients.

Traditionally, radiological reports have been written using a narrative style based on free text language. Narrative reporting is deeply rooted in radiology history, as it is a simple and technically straightforward reporting method that does not require any complex IT infrastructure and grants unlimited freedom of expression to the reporting radiologist. However, too much content and style variability may involve the risk of composing unclear, incomplete, and/or inaccurate reports, thereby hindering its communicative effectiveness and overall clinical usefulness. Furthermore, advancements in medical knowledge and the growing availability of state-of-the-art technological equipment in radiology departments have broadened the spectrum of clinical indications to imaging (with particular reference to multidetector CT and MRI), opening up the opportunity to quickly obtain vast amounts of information that must be effectively summarized in radiological reports. In parallel, the development of validated recommendations and guidelines for the diagnostic and therapeutic management of several diseases calls for a more standardized reporting approach, taking into account all required information for a correct categorization of each individual patient's condition [2–4].

Structured reporting (SR) has the potential to overcome the limitations of narrative reporting, owing to its being based on a predefined digital "structure" that can be selected and at least partially modified at the user's discretion. From a practical viewpoint, standardized models (so-called templates) can be used for reporting that are user-selected based on the clinical setting and contain predefined types of information, such as alphanumeric data, free text, key images, movies, web links, and so on [5–8] (Fig. 5.1).

Major scientific societies have undertaken initiatives aimed to promote a widespread dissemination of radiological template-based SR, including the creation of standardized templates by RSNA, the joint RSNA/ESR initiative to translate RSNA templates into European languages, and the ESR paper on SR [9–14]. Unfortunately, so far such efforts have been faced with significant hurdles. A survey launched by the Imaging Informatics Chapter of the Italian Society of Medical and Interventional Radiology (SIRM) has shown that although most SIRM radiologist members

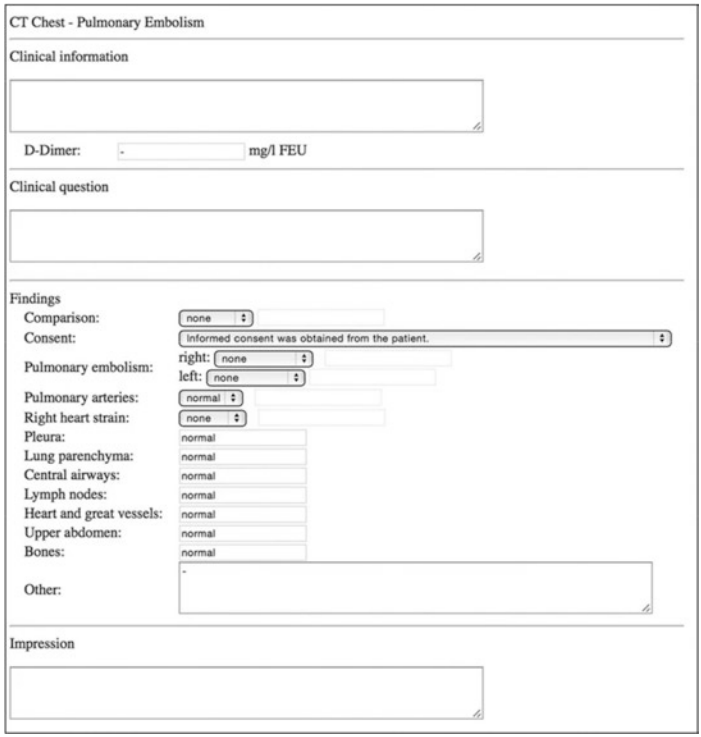

Fig. 5.1 Example of SR template for chest CT examinations performed in patients with suspected pulmonary embolism. Reproduced from [23] under a Creative Commons Attribution 4.0 International license (CC BY 4.0, http://creativecommons.org/licenses/by/4.0/)

were interested in SR and open to the possibility of using it, they were concerned that its adoption in their real working life could lead to semantic (i.e., definition, standardization, and validation of templates), technical (SR implementation and integration with existing RIS/PACS platforms), and professional issues (perception of the radiologist's professional role by other specialists and patients) [4].

In this chapter, the main pros and cons of template-based radiological SR versus narrative reporting will be discussed. Some hints will also be provided for a successful implementation of template-based SR in radiology practice.

5.2 Advantages of Template-Based SR over Narrative Reporting

The main strengths of template-based SR over narrative reporting include the following:

- *Standardized structure and terminology*. Standardized terminology is pivotal for adherence to diagnostic and/or therapeutic recommendations and enrolment in clinical trials [15], reduces the ambiguity that may arise from nonconventional language, and enables faster and more effective communication with other radiologists and nonradiologists [16–20]. Moreover, lexicon standardization and data categorization can favor trainees' learning [21, 22], aid reimbursement policies, and ease data mining and the creation of large multicenter databases (also called "big data") driving biomedical research, the development of guidelines, quality assurance processes, and epidemiological statistics [7, 23–25] (Fig. 5.2). Moreover, specific templates can be used that have been developed from evidence-based recommendations [20, 24]. Well-known examples of classification systems that naturally lend themselves to SR integration are the Reporting and Data Systems of the American College of Radiology; those include, e.g.,

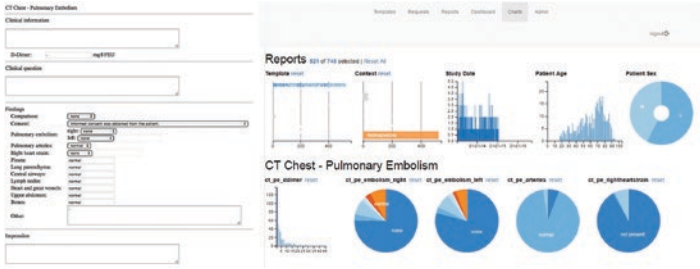

Fig. 5.2 Dashboard of summary results of all SR reports created with the SR template shown in Fig. 5.1, including patient's age and gender, D-dimer level, location of emboli, and signs of right heart failure. Reproduced from [23] under a Creative Commons Attribution 4.0 International license (CC BY 4.0, http://creativecommons.org/licenses/by/4.0/)

BI-RADS for breast imaging, LI-RADS for CT and MR imaging of hepatocellular carcinoma, LUNG-RADS for CT screening of lung cancer, or CAD-RADS for CT coronary angiography [25].

- *Key images and data-rich reports*. Template-based SR allows producing reports with a virtually unlimited information density ("data-rich") relatively quickly. In particular, the possibility to link images or other data to the report makes for clearer, more reproducible and easier-to-use reports, either for nonradiologists or other radiologists who may need to reassess a patient's case or report a follow-up examination of the same patient. For instance, it is possible to link key images or other data elements within a template-based SR that show the main findings of an imaging examination, resulting in improved communication [7, 8, 11, 19].
- *Better communication and greater clinical impact*. Various studies have shown that both radiologists and nonradiologists tend to prefer template-based SR to narrative reporting thanks to its greater effectiveness and clarity [17, 18, 26–32]. Such qualities can be especially appreciated in specific tasks of

higher complexity, owing to the greater ease of finding all necessary information for patient management. One of the areas that could benefit most from these characteristics is oncological imaging, due to the need to perform a systematic, accurate, and reproducible comparison of imaging findings at precise time frames of a patient's radiological history based on validated methods for treatment response assessment (e.g., RECIST criteria) [19, 29, 33–35]. In a British multicenter study encompassing 21 centers and 1283 cancer staging reports, Patel et al. showed that compared to 48.7% of narrative reports, 87.3% of SRs contained all required staging information, yielding a 78% improvement in staging completeness at all centers and for all cancer types [35] (Fig. 5.3). Template-based SR has also been shown to be more effective than unstructured reporting for determining tumor resectability, such as in the case of pancreatic adenocarcinoma [36] or rectal cancer [37].

- *Error reduction*. Template-based SR can help reduce the rate of diagnostic errors owing to its ordered structure, allowing radiologists to focus their attention on relevant findings and systematically review the report at the end of the reporting process [19, 24]. In a retrospective analysis of 3000 spine MRI examinations, SR would have revealed 68.6% of extraspinal collateral findings compared to 7.2% actually highlighted by narrative reporting [38]. In a review of 644 radiological reports, Hawkins et al. showed that, compared to narrative reporting, SR enabled a statistically significant reduction of nongrammatical errors (26% vs. 33%, $p = 0.024$), omission errors (i.e., capable of modifying the meaning of a sentence: 1.2% vs. 3.5%, $p = 0.0175$), and commission errors (i.e., due to typos contradicting the report findings or conclusions: 0.8% vs. 3.9%, $p = 0.0007$) [39]. Furthermore, compared to narrative reporting, SR was associated with a greater recall rate of patients with critical findings (i.e., requiring diagnostic or therapeutic intervention: 82.7% vs. 65.1%, $p < 0.001$), implying that the greater communicative efficacy of template-based SR can also have a positive effect in preventing clinical management errors [40].

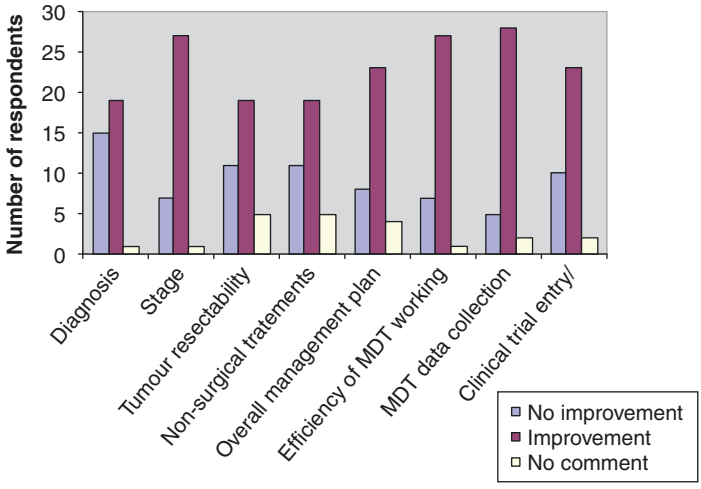

Fig. 5.3 Perceived performance improvement of template-based radiological SR compared to narrative reporting for the diagnostic workup of cancer patients by oncology multidisciplinary team (MDT) end-users, as assessed by Patel et al. [35]. Adapted from [37] under a Creative Commons Attribution Noncommercial license (CC BY-NC 4.0, https://creativecommons.org/licenses/by-nc/4.0/)

5.3 Potential Limitations of Template-Based SR

It has been observed that the adoption of template-based SR can be hampered by several factors, including the following:

- *Resistance to change*. Some radiologists believe that template-based SR is too rigid and may therefore limit their freedom of expression. According to this opinion, template-based SR could involve the risk of worse communication (due to the inability to express useful details for an accurate diagnosis) and reduced consideration of the radiologist's profession compared to other specialists, as it would be seen by nonradiologists as more of a laboratory report than a clinical consultation between colleagues [4, 10, 19, 41]. As a matter of fact, nonra-

diologists tend to accept template-based SR more than narrative reporting because of its greater clarity and completeness and actually consider it as a useful tool to interact more with radiologists by stimulating mutual understanding and trust [42]. Besides, SR templates can be user-modified under specific circumstances. A dedicated section of template-based SR that leaves full freedom to the operator is represented by the conclusions of the report, where the radiologist summarizes the results of his diagnostic reasoning and offers an interpretation based on the scientific and professional skills pertaining to his/her specialty [10].

- The radiologists' *learning curve* during the transition from narrative reporting to template-based SR might lead to longer turnaround times that could negatively impact workflow and overall productivity. A gradual transition from narrative reporting to SR should be preferred over an abrupt one, prioritizing simpler templates and/or some already validated by scientific societies and institutions. In addition, the learning curve issue would not be due to any intrinsic limitation of template-based SR itself, but rather to a problem of adaptation to change involving individual radiologists to different degrees (i.e., some radiologists would be slower and others faster than average, resulting in a partial compensation effect) [19, 41].
- *Reduced concentration on images* due to the radiologist keeping his/her eyes more focused on the SR template than on images. This argument is supported by psycho-perceptive considerations on the basis that we as humans are accustomed from birth to elaborating visual stimuli and communicating using verbal language. Hence, distracting the radiologist from images could compromise the mental process leading from image observation to diagnosis, involving a higher likelihood of errors, longer reporting times, and reduced productivity [19, 41, 43].
- *Oversimplification*, which might make template-based SR less suitable than narrative reporting for communicating more sub-

tle details or complex information, especially in atypical and/or more difficult cases [4, 19, 44, 45]. However, SR templates usually include free text fields to cater to any additional data that cannot be embedded in default template fields. The user can also create new templates or adopt more advanced technological solutions allowing for greater template flexibility while maintaining the SR architecture.

- Additional limitations of template-based SR may be related to the presence of unnecessary details (such as in negative templates or simpler cases, compromising the fluency and understability of the report), improper use (possibly causing more errors, e.g., retaining the predefined sentence "no gallbladder stones" in post-cholecystectomy patients), and failure to report collateral findings, as radiologists may focus exclusively on the key features of the disease condition(s) related to the template of their choice, paying scarce attention to unexpected findings [10, 19]. Narrative reporting is not immune to those same issues, which depend on poorer radiologist's attention due, e.g., to tiredness or lack of time. Yet, the hierarchical architecture of template-based SR (including incidental findings and conclusions) should offer an additional safety margin over narrative reporting, in that the various template items can systematically be checked at the end of reporting, thus minimizing the risk of inaccuracies or missing findings.

5.4 Clues for the Implementation of Template-Based Radiological SR

A prerequisite for a successful adoption of template-based SR in radiology is that radiologists do not see it as a potential danger to their professional reputation, but leverage its strengths to improve the quality of their work and prioritize it over mere quantity, lead the transition from narrative reporting to SR, and increase the consideration of their professional role among nonradiologists

and patients [46]. A positive attitude toward SR should spur the creation of templates based on validated recommendations and multispecialty involvement of radiologists and nonradiologists [9]. Template-based SRs can also be produced based on existing clinical decision support systems (CDS) that apply validated diagnostic and/or therapeutic pathways to provide recommendations for the diagnosis and subsequent patient management, starting from clinical data and imaging findings [3, 19, 24].

The adoption of template-based SR should begin with a pilot experimentation among most enthusiastic radiologists as a first step to gain familiarity with it and gradually spread the process to the entire workplace. Simpler, more flexible and easily standardizable templates should be preferred in this start-up phase over more complex ones [9, 47], and subspecialty radiological and clinical societies should disseminate up-to-date SR templates for free usage by the medical community [9, 11] (Fig. 5.4). At every facility, SR performance should be regularly audited by radiologists and other specialists to test its effectiveness and fix any potential issues.

The availability of state-of-the-art technology is essential to integrate template-based SR into existing RIS/PACS systems, supporting seamless connection with the identification codes of templates, voice recognition devices, and direct data transfer from DICOM images into the report [4, 23]. Further requirements to fully tap the potential of template-based SR include the option to add links to key images, measurements, and advanced processing data directly into the report (e.g., findings of CAD systems or quantitative biomarkers) [9, 19], and the interoperability with other IT systems (including those handling dematerialized clinical request and informed consent, electronic medical record, radiation dose and contrast medium monitoring, etc.), possibly harnessing the power of cutting-edge artificial intelligence algorithms [48].

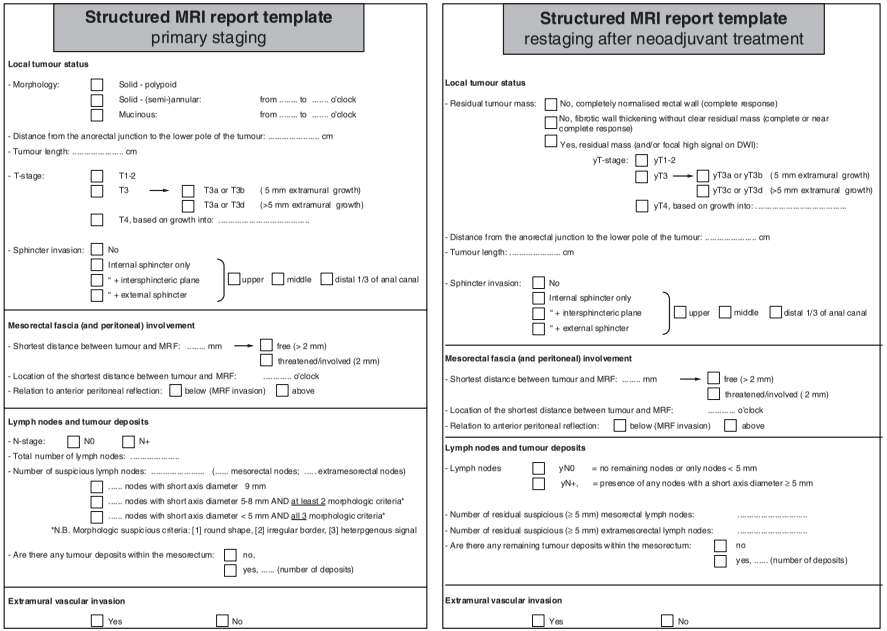

Fig. 5.4 SR templates for MRI-based primary staging (left) and post-neoadjuvant treatment restaging of rectal cancer (right) devised by the 2016 ESGAR consensus meeting. Reproduced from [15] under a Creative Commons Attribution 4.0 International license (CC BY 4.0, http://creativecommons.org/licenses/by/4.0/)

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