CLINICAL SCIENCE

RADIOLOGICAL REPORTS: A COMPARISON BETWEEN THE TRANSMISSION EFFICIENCY OF INFORMATION IN FREE TEXT AND IN STRUCTURED REPORTS

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INTRODUCTION: This work proposes to improve the transmission of information between requiring physicians and radiologists.
OBJECTIVES: Evaluate the implementation of a structured report (SR) in a university hospital.
METHODS: A model of a structured report for thyroid sonography was developed according to information gathered from radiologists and endocrinologists working in this field. The report was based on a web platform and installed as a part of a Radiological Information System (RIS) and a Hospital Information System (HIS). The time for the report generation under the two forms was evaluated over a four-month period, two months for each method. After this period, radiologists and requiring physicians were questioned about the two methods of reporting.
RESULTS: For free text, 98 sonograms were reported to have thyroids with nodules in an average time of 8.71 (+/-4.11) minutes, and 59 sonograms of thyroids without nodules were reported in an average time of 4.54 (+/- 3.97) minutes. For SR, 73 sonograms in an average time of 6.08 (+/-3.8) minutes for thyroids with nodules and 3.67 (+/-2.51) minutes for thyroids without nodules. Most of the radiologists (76.2%) preferred the SR, as originally created or with suggested changes. Among endocrinologists, 80% preferred the SR.
DISCUSSION: From the requiring physicians' perspective, the SR enabled standardization and improved information transmission. This information is valuable because physicians need reports prepared by radiologists.
CONCLUSIONS: The implementation of a SR in a university hospital, under an RIS/HIS system, was viable. Radiologists and endocrinologists preferred the SR when compared to free text, and both agreed that the former improved the transmission of information.

KEYWORDS: Computerized reports; Free text; Thyroid sonography.

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INTRODUCTION

The report of an imaging exam is a document in which the technique used, the findings and the diagnostic impressions should be included. The findings description must be registered in a concise, although complete, form and should be followed by the diagnostic possibilities that ideally, at least partially answer the questions that prompted the examination whenever possible. The methodology of writing a report relies on the professional experience of the radiologist, the physician in charge and his/her skills in

identifying findings – whether they are significant or not – and, after correlating them with clinical and laboratory data, defining one or more diagnostic possibilities. This process requires not only technical knowledge but also objectiveness and writing skills. The classic model of a radiology report, free text, usually does not present an explicit structure. During their medical residencies, radiologists learn only that the report should consist of two parts: a description and conclusions. Sometimes, the guidelines results in an extremely subjective report that very often does not answer the clinicians' questions or add significant information to the patient's management.[1] In addition, discrepant reports are common in routine cases, even when the same professional is responsible for the follow up. An effective report should not contain abbreviations or neologisms.[2] Another crucial point is how quickly the report is available to the requiring physicians, especially in emergency cases, where the relevant information should be transmitted immediately and personally to the ordering physician,[3] allowing for the eventual discussion of key points.[4] Currently, emails or text messages may also be used for this purpose in addition to the traditional paper reports.[5]

A report is qualified as structured when all of the relevant information and diagnostic impressions are included, following specific terms and descriptors previously defined, as well as a predefined design. Numerical values usually appear in specific cases, where the defined units are used. The structured report (SR) does not allow for an evasive or imprecise description, requiring the fulfillment of all fields, arguably yielding a more precise and efficient report, which impacts the patient's care. Another fundamental aspect of the SR is that it potentially enhances searching and comparison of information, improving clinical research and teaching activities.[6]

The potential rigidity and the limited descriptors, which could eventually prevent a complete description of more complex cases, are the main criticisms against SRs. Those who share this view argue that the complex variability found in an uncountable number of diseases may not be included in a predetermined structure, such as a SR.

Recent evidence points to a more widespread use of SRs among radiologists and requiring physicians.[7] The best example of this tendency is likely to be the BI-RADS (Breast Imaging Reporting and Data System) from the American College of Radiology, which has been accepted worldwide and is used in daily practice and research.[8]

The purposes of our study were to evaluate the impact of SRs on the transmission of information between requiring physicians and radiologists and to investigate the limiting factors and obstacles to the implementation of SRs in a school hospital.

MATERIALS AND METHODS

This prospective study was carried out at our institution's integrated division of Endocrinology and Radiology, after the approval of the Institutional Review Board. Informed consent was waived. Thyroid ultrasonography was the report chosen to be structured. A two-month period was chosen to evaluate both forms of reporting. During the first two months, free text (FT) was the only way to generate a thyroid US report in an RIS environment, and consecutive patients had their reports done under FT. After an explanation of how it works, the software for the SR was released on the RIS, again for two months, and radiologists were then unable to use FT. All patients examined in this period had their reports done using the SR form.

Thyroid ultrasonography was performed on the same equipment by radiology residents between their first and third year, for a total of 21 physicians. These were the executing physicians who evaluated the FT and the SR. The requiring physicians were endocrinologists working in the field of thyroid diseases and included ten physicians, third- and fourth-year residents and endocrinologists from the institution staff. All reports, both in FT and in the SR, were generated on the same computers, adjacent to the US rooms, using the same systems (RIS and HIS).

SR Software

The SR for the thyroid US was developed as a web-based form, using Borland Developer Studio 2006[9]on a Microsoft.NET platform [10]. To make it user friendly for radiologists, a methodology based on the XML standard ("eXtensible Markup Language") was used in association with a JavaScript language, called AJAX ("Asynchronous Javascript And XML"). Under the Radiological Information System (RIS), specializations to store the SR were created in the entity EXAM_RADIOLOGY (Figure 1):

a) EXAM_THYROID: storage of thyroid US SR.
b) EXAM_THYROID_NODULE: storage of nodules described in thyroid US SR.
c) EXAM_THYROID_ADENOPATHY: storage of the level of adenopathy in thyroid US SR.

To retain compatibility with the pre-existing RIS during the SR generation, a sheet containing the description of the acquired information was generated and recorded in the RIS, in such a way that other functions were not affected (Figure 1).

The types of information set to be included in the structured form for the thyroid US SR were as follows: equipment, dimensions and symmetry of thyroid lobes; isthmus description; parenchymal echogenicity; nodules,

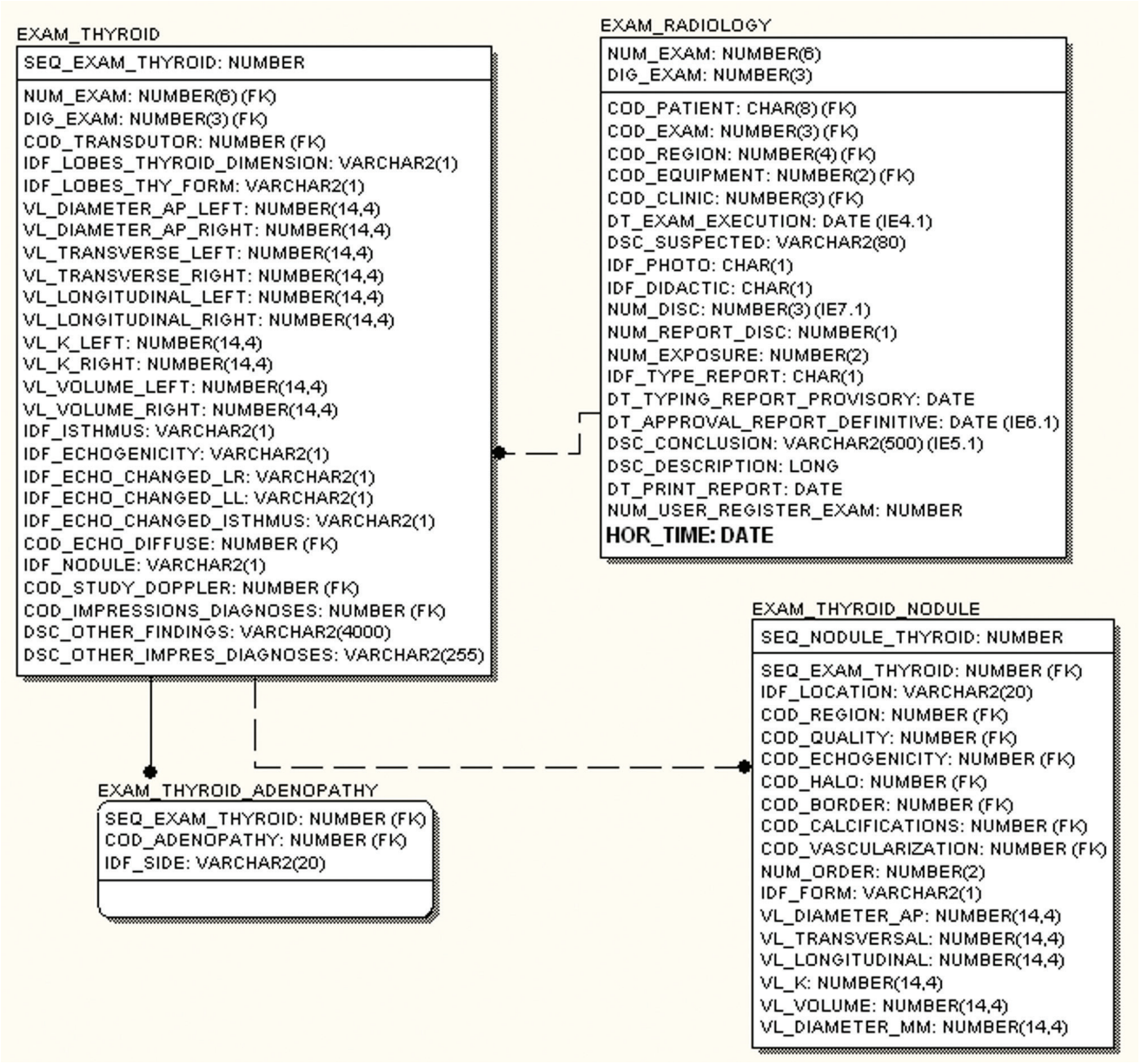

Figure 1 - This figure shows how the information of the SR was inserted in the RIS database

with fields for location, form, size, borders, echogenicity, calcifications, halo and vascularization at color-doppler (CD); levels and size of adenopathy; color-doppler findings; other findings not described and impressions. All of the information was standardized through the creation of a set of options for each domain. For example, in the description of the nodules (composed of a set of fields) found in the thyroid US SR, most of the information (fields) was composed of predefined descriptors written (configured) in the database instead of open fields. This provides flexibility because new descriptors may be added in a standardized way and existing descriptors may be modified, disabled or deleted (Figure 2). The diagnostic impression was created in a separate field and included the most common diagnoses observed in thyroid diseases. For both parts of the SR (description and conclusion), open fields were available for findings and conditions not previously inserted in the SR.

The study analysis was based on two criteria. The first was the time evaluation for SR generation as compared to free text. The second was the evaluation of the standardization and comparison between information transmission under free text and under the SR. The time for SR or FT report generation was measured by a clock inserted into the RIS, which was activated when the report field was opened and stopped when the radiologists finished the report. This was accomplished through the use of specific multiple-choice questionnaires for the requiring physicians and the radiologists. The radiologists were asked five questions that

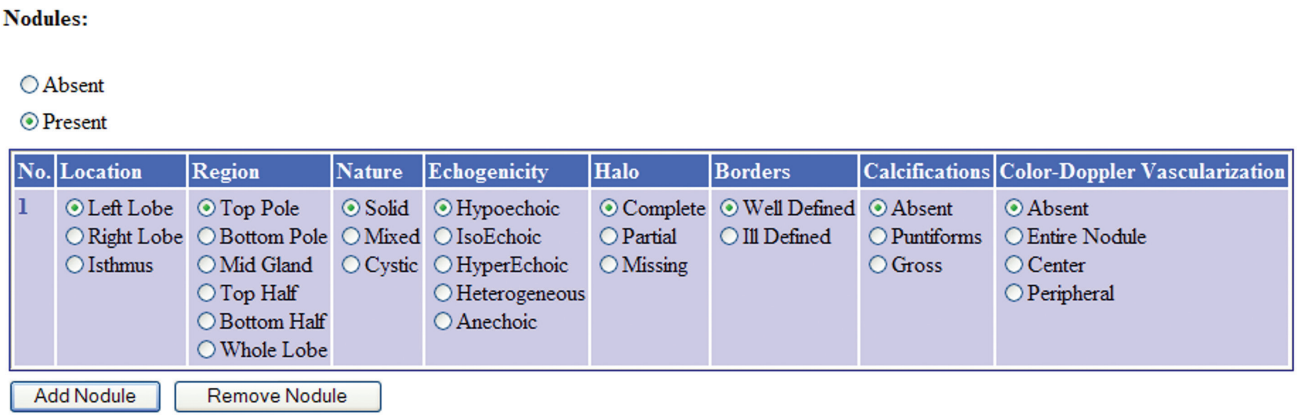

Figure 2 - The parameters and descriptors of thyroid nodules in the SR (information domains)

evaluated standardization, issuance of the report, coverage, preferences and problems in understanding the new software. At the end of the questionnaire, respondents were asked to make suggestions for improvement. The questionnaire for the requiring physicians included four multiple-choice questions regarding standardization, objectiveness, information transmission for both the SR and FT and preferences. They were also asked for suggestions.

Statistical Analysis

To compare the generation times for FT and the SR, a linear regression model with mixed effects (fixed and random) was used.[11] The software SAS® 9 with a PROC MIXED was used to perform the calculations.[12] This analysis compared the time to generate reports with and without isolated nodules and total times.

In this study, 257 consecutive thyroid examinations were inserted. One hundred were reported using the SR and 157 using free text.

RESULTS

Regarding the standardization of descriptors for the thyroid US findings (Table 1), the majority of radiologists (20/21=95.2%) agreed that a uniform terminology was reached for descriptors of thyroid US findings, although many (61.9%) described the terminology as only partial. One of the residents claimed not to be in a condition to evaluate the SR. None of the respondents disagreed with the statement that the SR allows for lexicon standardization.

Most of the executing physicians partially agreed (13/21 = 61.9%) that the SR made the report submission easier, and only one (1/21 = 4.76%) totally agreed. Six radiologists (6/21=28.57%) disagreed, arguing that the SR did not facilitate report generation, and one radiologist could not evaluate the SR.

Table 1 - Evaluation of lexicon standardization by radiologists

Executing physician standardization	Question 1 Does the sr standardize the lexicon?	
n=21	Frequency	%
A. Totally agree	7	33.33%
B. Partially agree	13	61.90%
C. Disagree	0	0.00%
D. Cannot evaluate	1	4.76%

Table 2 - SR facilitates report generation

Executing physician ease	Question 2 Does the SR facilitate your report creation?	
n=21	Frequency	%
A. Totally agree	1	4.76%
B. Partially agree	13	61.90%
C. Disagree	6	28.57%
D. Cannot evaluate	1	4.76%

As for SR coverage, most of the executing physicians (15/21 = 71.4%) said they were not able to insert some information, although this was reported sporadically for half of the respondants (7/21 = 33.33%) and very often for the other half (8/21 = 38.09%).

Although the majority of the executing physicians (16/21 = 76.19%) preferred the SR (Table 3), a significant number of them (14/21 = 66.67%) desired adjustments. A fraction of the executing physicians (5/21 = 23.81%) preferred the free text.

When asked if they had any problems understanding how the SR worked, the majority of the executing physicians (15/21 = 71.43%) said they had no problems at all, while some (6/21 = 28.57%) reported having had some sporadic problems.

In the open question, the main suggestion made by

Table 3 - Radiologists' (executing physicians) preferences

Executing physicians' preference	Question 3 Which form of report do you prefer?	
n=21	Frequency	%
A. Free text	5	23.81%
B. Free text with adjustments	0	0.00%
C. SR	2	9.52%
D. SR with adjustments	14	66.67%

radiologists was related to the possibility of mentioning and comparing previous exams to improve follow up.

All of the requiring physicians (10/10 = 100%) agreed that the SR allowed for a standardization of the descriptors of the thyroid US findings, although one third of the respondents (3/10 = 30%) said this happened only partially (Table 4).

Table 4 - Requiring physicians - Standardization

Requiring physicians standardization	Question 4: Does the SR allow for a standardization of the descriptors and of the whole thyroid US report?	
n=10	Frequency	%
A. Totally agree	7	70.00%
B. Partially agree	3	30.00%
C. Disagree	0	0.00%
D. Cannot evaluate	0	0.00%

Regarding the clarity of information and the objectiveness of the SR, more than half of the requiring physicians (6/10 = 60%) agreed that there was an improvement, although 30% said that it was only partial. Only one respondent (1/10 = 10%) disagreed, arguing that the SR did not improve objectiveness or clarity of information.

All of the requiring physicians said that the information transmission was better under the SR, but 40% reported that the improvement was only partial.

Most of the requiring physicians (8/10 = 80%) preferred the SR, although half asked for some adjustments. Only 20% of the endocrinologists preferred the free text report, also with adjustments. In the open question asking for suggestions, 7 out of the 8 physicians who answered it asked for some kind of scheme in which the nodules could be registered or drawn.

For the evaluation of time spent on the report, the data was grouped according to the form of generation, FT or SR, and a comparison was drawn using the whole number

Table 5 - Requiring physicians' preferences

Requiring physicians preferences	Question 5: Which model of reporting do you prefer?	
n=10	Frequency	%
A. Free text	0	0.00%
B. Free text with adjustments	2	20.00%
C. SR	4	40.00%
D. SR with adjustments	4	40.00%

Table 6 - Time (in minutes) for reporting

Report	Time	n	Mean (+/-SD)
SR	Total	100	5.43 (+/-3.65)
	Without Nodules	27	3.67 (+/-2.51)
	With Nodules	73	6.08 (+/-3.80)
Free Text	Total	157	7.14 (+/-4.53)
	Without Nodules	59	4.54 (+/-3.97)
	With Nodules	98	8.71 (+/-4.11)

of reports, separately considering reports with and without thyroid nodules. Thyroids with nodules were reported in 62.4% of the reports done by FT, while 73% were reported using the SR.

The difference in total time, including reports with and without nodules, was not significant (3.65 vs. 4.53), p=0.20. However, when only the reports of thyroids with nodules were considered, the difference was significant (6.08 vs. 8.71 minutes), $p< 0.01$.

DISCUSSION

Structured Reports (SR) are continuously gaining acceptance in radiology practice. However, structuring a report is not an easy task, considering the specificity of each exam and the unique information generated.[13,14] At university and school hospitals, this challenge must be faced because potential benefits are related to the patients and affect teaching and research activities. To change a classical model, such as free text, and introduce new concepts, such as a SR, one must be aware that obstacles will arise from intrinsic software problems. Therefore, the new solution must improve functionality and efficiency in order to be adopted.

Several reasons justify our choice of thyroid ultrasonography as the report to be structured. First, it is a very common exam, enabling a fast and thorough evaluation of a SR. Extensive reports are common in thyroid US due to the presence of parenchymal nodules, for which the description is often imprecise and controversial, making

comparisons in follow-up studies a very difficult task. In addition, in our institution, this is the examination with the largest number of complaints by the requiring physicians regarding standardization of the descriptions.

After discussing the issue, a consensus on descriptors as well as on what information should be included and how it should be displayed in the SR was reached based on literature research and the personal experiences of radiologists and endocrinologists.

During the implementation of the SR, we found problems related to software development as well as some intriguing aspects related to the physicians' perceptions of the SR. Regarding the executing physicians, the radiologists, it was clear that there were contrasting points of view: those who had periods of practice with the new software or who were familiar with the internet environment had different opinions from those who had not completed the training practice or who were not familiar with the internet and informatics. The former group encompassed the new tool as soon as they realized that it added functionality to their daily practice. The latter group was not excited about the new tool, sometimes even asking for the FT version. We believe this fact influenced their evaluation of the SR. It is important to stress that every radiologist was offered a training period, but due to their periodical rotation in several fields of radiology, some of them did not complete the full training. However, even those who were enthusiastic about the SR made suggestions for improving the software, such as a field for follow-up comparison.

Based on these observations, it is possible to make some inferences. It is clear that the implementation of a SR is a continuous process that will need adjustments in daily practice. The software should be as user friendly as possible, and full training periods must be offered to all users, with software experts available in the initial periods. A lack of training should be considered as a limiting factor for the development of structured reports.

When looking at the requiring physicians' perspective, it was observed that the SR enabled standardization and improved information transmission by allowing the use of precise and defined language. This is of great relevance because this group includes the physicians who received the information acquired using the imaging methods, making their answers about whether the SR improved information transmission so essential. In addition, the pronounced preference of the requiring physicians for the SR (80%) indicates that a clear and concise report is desirable. We believe such wide acceptance is related to the participation of endocrinologists in the creation of the SR.

A few reasons may explain the preference of 20% of the requiring physicians and 23.1% of the radiologists for the free text, the most important being the heterogeneous composition of both groups. As we have residents of all years among the requiring and executing physicians, it is understandable that the less experienced ones did not realize how many problems can arise from vague and imprecise reports. In addition, as research and teaching are not their functions, some also do not clearly see the potential benefits in these areas. For educational institutions, the widespread use of a SR would enhance mining operations and retrieval of data.[15,1] In addition, with the introduction of a standardized lexicon, it will be easier in the near future to use uniform terminology for radiological reports, such as that proposed by the RadLex initiative of the Radiological Society of North America.[6]

Regarding the time for report generation, there was no significant difference when taking into account all thyroid reports, with and without nodules. However, when we consider only the reports with nodules, the difference was significant, with the SR allowing reports to be generated more quickly. The description of nodules is time consuming for FT reports, and SR may accelerate this process as the terms are standardized.

One concern that radiologists have about the use of SRs is that it may result in an increase of the computer database, with all of the related costs. However, just the opposite actually occurs; because all information is codified in the SR and transformed into numeric fields, reports can be indexed, and the computational work to retrieve information can be reduced. On the other hand, information generated under free text does not allow for indexation, leading to excessive computational work. Other software-related problems were minor in this study and included sporadic interruptions in the software while it was running.

This study has some important limitations. First, it is a single-institution experience and reflects a particular environment. However, our institution uses the most innovative concepts of a modern imaging department, which should reflect what is found in most health tertiary centers. As discussed above, we could not provide adequate training for all of the physicians before starting to use the SR software, which may have influenced the evaluation by some executing physicians. Finally, the number of requiring physicians that evaluated the SR was low - only ten. This constitutes the universe of endocrinologists routinely involved in thyroid diseases. We did not include first- or second-year residents or interns, as their limited experience in the field would prevent a thorough evaluation. However, further studies including a larger number of requiring physicians could validate our results.

In conclusion, despite the problems related to the implementation and the adjustments suggested in the

software, the SR was preferred over FT, as it reduces the time required to generate reports, allows for lexicon standardization and, most importantly, improves information transmission between requiring physicians and radiologists.

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