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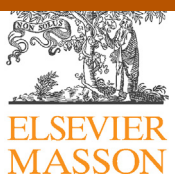

ORIGINAL ARTICLE / *Professional information*

Improvement of radiology requisition

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Medical history taking;
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Abstract
Purpose: Inadequate or incomplete information on radiology requisitions may have a substantial impact on the radiological process. This study aimed to evaluate the impact of standardization and computerization of radiology requisitions on the quality of provided data, satisfaction of hospital staff and access time.
Methods: The impact of requisition support was assessed at each step of the improvement process for inpatients: before (Step 1), after standardization (Step 2) and after computerization of radiology requisition (Step 3). The quality of information provided was assessed by proportion of missing data on MRI and CT requisitions. Satisfaction was assessed by an anonymous auto-questionnaire filled by ordering physicians, radiologists and radiology technicians. Access time was prospectively assessed.
Results: Standardization of radiology requisition resulted in a significant drop in proportion of missing data. Computerization of radiology requisition, based on the single standardized radiology requisition, further improved the quality of information reported on radiology requisitions. The median access time was significantly improved (from 5 to 3 days) for the largest provider of CT requisitions.
Conclusions: Standardization and computerization have a synergistic effect on the overall quality improvement. Moreover, the computerized provider order entry enables traceability of information, makes communication between radiologists and ordering physicians easier and improves examination planning.

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The quality of prescription is an important issue in the process of care, and this is more critical for imaging [1]. In this regard, several studies have evaluated the quality of information provided on radiology paper prescriptions and found rates of inadequate or incomplete prescriptions ranging from 2% to 29% [1–4]. Incorrect prescription has substantial impact on the radiological process, including errors in interpretation [5], potential complications for patients [6,7] and waste of time and money for the hospital [8]. A recent study has reported discrepant or incomplete clinical information in 62% of the paper prescriptions for CT scans by comparison with electronic information available to radiologists [9]. In addition, most of discrepancies had a substantial clinical impact. The final output of the radiologist is the report delivered to the relevant radiology stakeholder (referring physician, patient or administration) in a timely manner [10]. Some studies suggested that the radiology imaging completion might be improved by conformity of radiology requisitions along with quality and relevance of information provided [2]. One option to improve the quality of radiology requisition could be computerization [11]. One study has evaluated whether an appropriately designed computerized order entry system for radiology may be clinically accepted and influence ordering practices [12]. Another study showed that requests from a computerized radiology requisition system were more likely to contain pertinent clinical questions than more conventional paper-based requests [5].

A radiology requisition improvement project was conducted for MR imaging and CT examinations in our Institution, which is a tertiary care hospital. The project was led by the Department of Public Health. The heads of Radiology Departments were member of the steering committee. The multidisciplinary project team included representatives of each Radiology Department and representatives of the main ordering departments (Internal Medicine, Neurology and Abdominal Surgery). The diagnostic phase lead to six areas of improvement: two for ordering departments (quality and relevance of the prescription), two for radiology departments (times to obtain appointment and deliver report) and two regarding links between radiology departments and ordering departments (standardized radiology requisition and harmonized exchange process). Indeed, more than 10 different radiology requisition forms were available, and each radiology department has its own requisition form. Thus, a process of standardization and computerization of radiology requisition was conducted in our hospital.

The goal of this study was to evaluate the impact of standardization and computerization of radiology requisitions on the quality of information provided on radiology requisition, satisfaction of hospital staff and access time in radiology examinations.

Material and methods

Fig. 1 presents the three steps of the study and the sample size for each of the three metrics (quality of information, satisfaction, access time).

Diagnosis phase (2008)

The diagnosis phase was conducted between May 2008 and October 2008 and included a process analysis, an assessment of quality of data provided on radiology requisition and an assessment of access time, defined as the time between the requisition date and the date of appointment for imaging examination. Moreover, satisfaction on the all radiology process was assessed among the staff of the three radiology departments and among ordering physicians.

MR imaging or CT examination requisitions for diagnosis for inpatients were collected during three consecutive

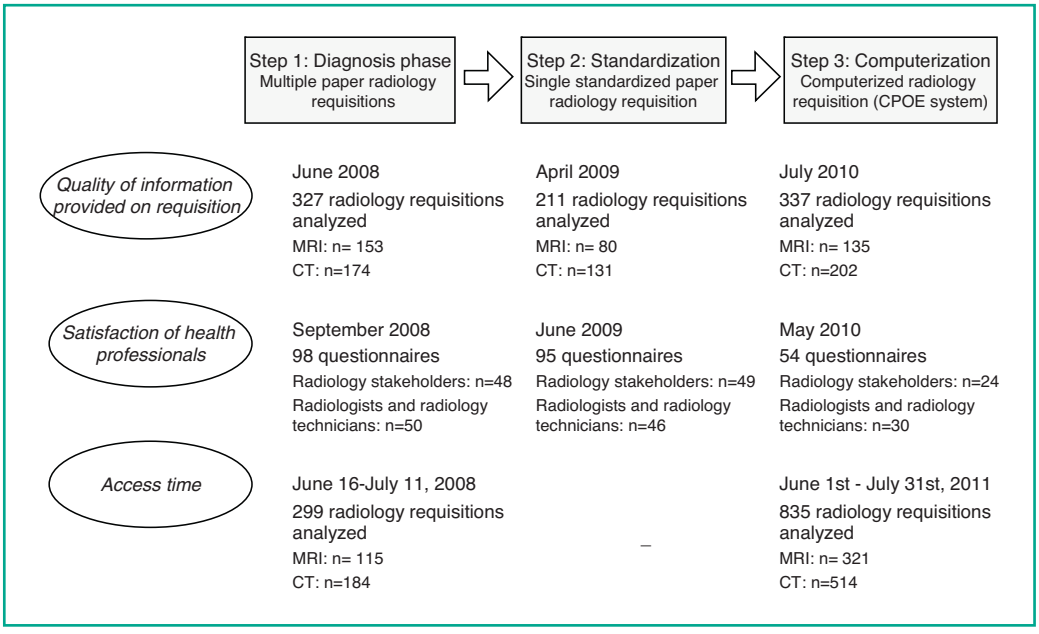

Figure 1. Study design.

weeks in June 2008. Requisitions made by the Emergency Department and Intensive Care Units were excluded from analysis, leading to 327 paper requisitions. Quality of data provided on requisitions was assessed by a single observer, using proportion of non-missing data. Quality of information was assessed in two dimensions: first, conformity using a score used in the French High Authority of Health (HAS) framework [13] (further referred to as mandatory data); secondly, clinical and administrative information useful to ensure patient safety and accurate completion of imaging examination (serum creatinine level and extension phone number of the referring physician; further referred to as secondary data). On one hand, serum creatinine level is required only for injected subset of imaging examinations that requires contrast material. On the other hand, it may be useful to have serum creatinine level for an examination that may actually require administration of contrast material, to avoid time-consuming postponing.

Satisfaction was assessed by a survey that was conducted among ordering physicians, radiologists and radiology technicians in September 2008 using an anonymous auto-questionnaire.

Access time for MR imaging or CT examination for inpatients were prospectively recorded for requisitions made between June 16th, 2008 and July 11th, 2008. Requisitions with missing date ($n = 27$) and cancelled requisitions ($n = 51$) were further excluded, leading to 299 requisitions that were actually analyzed.

Standardization of radiology requisitions (2009)

A working group including radiologists and radiology technicians from the three Radiology Departments was set up to elaborate a single standardized radiology requisition form for the entire hospital. The guidelines of the French Radiological Society and the results of the survey conducted among radiologists and radiology technicians were used to define the fields of the requisition form. Referring physicians reviewed the wording of the different fields. The following information were included on the standardized radiology requisition: radiology requisition date, ordering department, identity and phone number of the ordering physician, identity of the patient, date of birth of the patient, area to be explored, clinical history and aim of the imaging examination. The form was tested during 2 months in three clinical departments, and then generalized to the entire hospital on April 1st 2009.

To assess the impact of standardization of radiology requisition, after generalization of the standardized radiology requisition, the quality of data provided on radiology requisition and satisfaction of hospital staff were reassessed. For this phase, 211 MR Imaging or CT requisitions performed during three consecutive weeks for inpatients were analyzed (Fig. 1). Proportions of non-missing data were compared according to radiology requisition supports (multiple vs single standardized requisition) using χ^2 test. The satisfaction survey took place in June 2009.

Computerization of radiology requisitions (2009 and 2010)

The project of computerization of the standardized radiology requisition was conducted by a working group comprising organization and informatics engineers and the chief nurse officer of radiology departments. The computerized provider order entry (CPOE) system was based on the standardized radiology requisition, users' preferences, criteria used in the current HAS conformity score for radiology requisitions [13] and possible linkages with the hospital information system. The CPOE system was interfaced with the administrative database and the biological result database. Electronic interface allows automatic transmission of information from existing database into the CPOE, such as the last serum creatinine level. CPOE also routinely supplied a database including information required on quality indicators and delay indicators. CPOE was reachable via the intranet of the Institution. It was tested in two clinical departments and modified before implementation in each clinical department in February 2010.

To assess the impact of computerization of radiology requisition, the quality of data provided on radiology requisition, satisfaction of radiology staff and ordering physician and access time were reassessed (Fig. 1). For this phase, 337 MR imaging or CT requisitions performed during three consecutive weeks in July 2010 for inpatients were analyzed. Proportions of non-missing data were compared according to radiology requisition supports (single standardized vs computerized requisition) using the χ^2 or Fisher's exact tests. The satisfaction survey took place in May 2010. Access time was prospectively measured on requisitions for CT and MR imaging examinations made for inpatients between June 1st 2011 and July 31st 2011. Canceled examinations were excluded ($n = 85$), leading to 321 MR Imaging requisitions and 514 CT requisitions. Median time was compared according to the period (multiple paper radiology requisition forms vs computerized requisitions) using the Mann—Whitney two-sample statistic.

Results

Quality of data provided on radiology requisitions

Results regarding quality of data according to the support are presented in Table 1. During the diagnosis phase (i. e., when multiple forms for radiology requisitions existed), relatively high proportion of missing information was observed for mandatory data and also for secondary data, such as serum creatinine level. In 25% of radiology requisitions analyzed, the name of the ordering physician was missing. The specific anatomical region to explore was missing in 27%. The date of creation of radiology requisition was missing in 17%. Proportion of missing results for serum creatinine level varied according to the specific subgroup of patients. In this regard, this information was lacking in 23% for patient with impaired renal function and in 87% of patients older than 65 years. The extension phone number of the referring physician was missing in 17% of the requisitions.

Table 1 Proportion of filled data on radiology requisitions according to radiology requisition supports.

	Multiple radiology requisitions ($n = 327$) %	Standardized radiology requisition ($n = 211$) %	Computerized radiology requisition ($n = 337$) %
Mandatory data			
Date of radiology requisition	83	93[a]	100[b]
Referring department	93	94	100[c]
Name of ordering physician	75	88[a]	100[b]
Patient identification	99	99	100
Birth date of the patient	96	97	100[c]
Region to be explored	73	99[a]	100
Clinical history	98	97	100[c]
Aim (clinical question)	95	98	100[c]
Secondary data			
Serum creatinine level			
Patients > 65-year-old	13	28[a]	100[b]
Diabetic patients	34	54	100[c]
Patients with impaired renal function	77	67	100
Phone number of referring physician	83	89[a]	100[c]

[a] χ^2 test comparing proportions between multiple radiology requisitions and standardized requisitions with a P value < 0.05.
[b] χ^2 test comparing proportions between standardized requisitions and computerized requisitions with a P value < 0.05.
[c] Fisher's exact test comparing proportions between standardized requisitions and computerized requisitions with a P value < 0.05.

After generalization of the standardized radiology requisition, a substantial improvement was found for mandatory data. The greatest improvement was observed for the specific anatomical region to explore (73% vs 99%, $P < .05$). The name of ordering physician remained missing in more than 10% despite progress. Regarding secondary data, the proportion of missing value of serum creatinine level for patients older than 65 years decreased significantly but remained unreported in 72% of requisitions (54/75).

After computerization, no missing information was observed in the requisitions.

Satisfaction of hospital staff

During the diagnosis phase, 98 satisfaction questionnaires were collected (Fig. 1). For radiology stakeholders, the process of radiology requisition was considered satisfactory. The understanding of radiology requisition by radiologists was found satisfactory by 61% of referring physicians and delay for obtaining appointment was found satisfactory by 53% of referring physicians. The main causes for dissatisfaction involved emergency examinations, and time for obtaining appointment and final radiology reports. In particular, the lack of information on the processing of the requisition occasionally lead the referring physician to duplicate radiology requisitions. Radiologists and radiology technicians were globally not satisfied by radiology requisition process, especially regarding quality of information provided on radiology requisitions. Radiology technicians reported that the lack of information regarding patient condition prevented them to adapt examination process to the patients' need (such as perfusion or patient requiring isolation). Another major complaint of radiology teams was the cancellation of imaging examination due to the end of the hospitalization without notification to the radiology department.

After implementation of the single standardized requisition, the satisfaction survey was repeated and 95 questionnaires were collected. The single standardized requisition was found to be satisfactory by health professionals. It was seen as an improvement in patients care for 69% of those working in Clinical Departments and for 49% of those working in Radiology Departments. Ergonomics of the requisition was found satisfactory by 76% of the health professionals of Clinical Departments and 64% of those of Radiology Departments.

After implementation of CPOE, the satisfaction survey was repeated and 54 questionnaires were collected. Among Radiology Departments, 65% of the health professionals found an improvement in the quality of communication with ordering Clinical Departments. The clinical information provided on radiology requisitions was improved by the combination of standardization and computerization. In this regard, 83% of the health professionals of Radiology Departments found the clinical information pertinent and appropriate after implementation of CPOE compared to 25% in 2008 before the CPOE was available. Regarding information relative to patient preparation, the proportion of satisfied referring physicians dropped from 63% in 2008 to 48% in 2010. The proportion of satisfied referring physicians with access time rose from 53% in 2008 to 65% in 2010.

Access time

Results for the access time to radiology examination (i.e. the time between requisition and appointment) are presented in Table 2. For the entire hospital, the median time remained

stable between the diagnosis phase (i.e., when multiple paper requisition forms were used) and after generalization of the CPOE system. For all requisitions, the median access time for CT examination was 2 days for both periods and the median time for MR Imaging rose from 1 to 2 days. For the non-urgent CT requisition, the median access time decreased from 3 days ($q_1 = 1$; $q_3 = 5$) to 2 days ($q_1 = 1$; $q_3 = 4$).

For one Internal Medicine Department, the largest prescriber of CT scan, the median access time for CT examination dropped from 5 days ($q_1 = 2.5$; $q_3 = 5$) in 2008 to 3 days ($q_1 = 2$; $q_3 = 5$) in 2011 for all requisitions as well as for non-urgent requisitions ($P = 0.03$).

Discussion

Our study aimed to assess the potential impact of standardization and computerization of radiology requisition on the radiology process. The impact was assessed at each phase of the project using several outcomes that included the quality of data reported on radiology requisitions, satisfaction of hospital staff and delays in obtaining imaging examinations. We found that standardization of radiology requisition resulted in markedly improved quality of data necessary to ensure appropriateness of imaging examinations as evidenced by a significant drop in proportion of missing data to less than 4% for the majority of information.

Information relative to the ordering physician (i. e. physician's name or Department) and his phone extension number were still missing in more than 10% of the requisitions at the time a single standardized requisition form was available, and results regarding serum creatinin level remained insufficiently completed or were even missing in approximately 75% of the patients older than 65 years. A study found similar discrepancies between the printed requisition and the original handwritten requisition in 20% of the cases for the name of the ordering physician [14]. In the same study, phone extension number or pager number of ordering physician was also often incorrect or even missing. It is well admitted that inaccurate or incomplete information regarding the identity of ordering physician result in a waste of time for both radiologists and clinical physicians.

The quality of data provided on radiology requisitions was assessed at each step of the process by one single observer. Furthermore, with the exception of requisitions made by Emergency Department and Intensive Care Units, we analyzed all MR imaging or CT examination requisitions performed during three consecutive weeks for inpatients. We consider that this time frame was sufficient to sample the radiology requisition process of our Institution and draw valid conclusions with respect to the improvement due to CPOE.

Table 2 Access time for CT and MR Imaging examinations before and after standardized and computerized radiology requisitions.

All requisitions[a]	Multiple paper radiology requisition forms (year 2008)		Computerized radiology requisitions (year 2011)	
	CT ($n = 184$)	MRI ($n = 115$)	CT ($n = 514$)	MRI ($n = 321$)
Entire hospital				
Median (q_1; q_3)	2 (0; 5)	1 (1; 2)	2 (0; 4)	2 (1; 3)
Range	0—16	0—8	0—16	0—20
Internal medicine	$n = 28$	$n = 14$	$n = 108$	$n = 57$
Median (q_1; q_3)	5 (2.5; 5)	2 (2; 4)	3 (2; 5)	2 (1; 5)
Range	0—8	1—7	0—15	0—9
	Multiple paper radiology requisition forms (year 2008)		Computerized radiology requisitions (year 2011)	
Non urgent requisitions	CT ($n = 162$)	MRI ($n = 95$)	CT ($n = 372$)	MRI ($n = 218$)
Entire hospital				
Median (q_1; q_3)	3 (1; 5)	2 (1; 3)	2 (1; 4)	2[b] (1; 4)
Range	0-16	0-8	0-16	0-20
Internal medicine	$n = 25$	$n = 13$	$n = 104$	$n = 53$
Median (q_1; q_3)	5 (3; 5)	2 (2; 4)	3**(2; 5)	2 (1; 5)
Range	0—8	1—7	0—15	1—9

Note. All numbers are expressed in days.

[a] All requisitions for inpatients, except requisitions made by the Emergency Department and Intensive Care Units.

[b] P value for Mann—Whitney test < 0.05.

Computerization, based on a single standardized radiology requisition, has further improved the quality of information reported on requisitions. Completeness of information was achieved with CPOE, in particular for the ordering physician details and serum creatinine level for which the proportion of missing data remained unsatisfactory with the standardized requisition. CPOE enables traceability of information, makes communication easier between radiologists and ordering physicians and improves examination planning for Radiology Departments. First, it allows ordering physician to track the status of the radiology requisition at different steps of the process, including validation of the requisition by a radiologist, radiology examination scheduled, examination performed and availability of the final report. Second, the electronic interface implemented with the administrative database and the biological result database improves communication between radiologists and ordering physician. For instance, the electronic interface with biological result database enables the automatic transmission of the most recent result of serum creatinine level to radiologists that is updated every 15 min. Interface with administrative database allows Radiology Departments to better organize radiology examinations because pertinent information regarding the status of the patient is available for the radiology staff (i. e. in- or outpatient and exact patient location). When the demanding physician logs onto the CPOE, his phone number is automatically reported on the radiology requisition. The automatic transmission of information from existing database into the CPOE also avoids manual entry information, which is a well-established source of errors [9]. Overall, the COPE can improve communication between radiologists and ordering physicians and therefore, contribute to the reduction of perceptive and interpretative errors in radiology [15].

Regarding the CPOE system, further improvements are necessary, especially regarding the reporting of important clinical information, such as allergy, that is presumably underreported with the CPOE. One option might be to increase the number of compulsory fields, as we did for allergy past history (the allergy past history field became compulsory for final validation of the computerized requisition). However, compulsory field is not a guarantee that information is accurate and can make the tool cumbersome. Another option may be to modify the presentation of the field, using a binary answer, such as ''yes'' or ''no'', instead of a check box. We believe that this may help to reduce the risk for forgetting to fill it. Specific patient demographics (such as obesity) or infection is of importance for the radiology staff to adequately prepare the patient before imaging examination. An interface of CPOE with clinical and medical prescription database could provide the information without increasing time to fill in radiology requisition.

Some limitations may be raised with respect to our study. The first limitation relates to the assessment of access time. Indeed, the delay between the time of prescription and appointment for imaging examination was not assessed after generalization of the standardized requisition due to the relatively short period of time (4 months) between generalization of standardized paper requisition and first test of computerized requisition. Moreover, we cannot rule out the possibility that differences observed in access time between the two periods may be linked to unobserved factors (modification in radiology supply in the neighbourhood, increased demand for radiology examinations or change in the proportion of planned control imaging examinations). Furthermore, assessment of access times was conducted during 1 month in 2008 whereas it was conducted during 2 months in 2010, including a longer time of summer holidays during which hospital's activity decreases. Finally, the small number of requisitions included in analysis for internal medicine in 2008 led us to interpret these results with caution. Second, the quality of data was assessed on the basis of proportions of missing information whereas the accuracy of information provided to the radiologists was not assessed. Third, radiology reports were not studied, whereas according to Johnson et al., a radiology quality and safety program should include key process metrics for radiology, such as access time, waiting time and finalization time of reports [16]. Further studies are needed to also investigate finalization time of imaging reports.

Conclusion

Standardization and computerization have a synergistic effect on the overall quality improvement. Our results suggest that the CPOE enables traceability of information, makes communication between radiologists and ordering physicians easier, improves planning of radiology departments and shortens the process of radiology requisition. Electronic interface with biological result database enables automatic transmission of the most recent result of serum creatinine level to radiologists and improves the quality of care. Moreover, CPOE routinely supplies a database including information required for quality indicators, such as access time.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

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