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Dr. Ruchi Baraya
Specialist Radiologist (MD, FRCR, MMED), Mediclinic Airport Road Hospital, Abu Dhabi, UAE

Dr. Hazem Mahmoud Abdelmonem Hasish
Specialist Radiologist (MD, FRCR, MMED), Mediclinic Airport Road Hospital, Abu Dhabi, UAE

Corresponding Author:
Dr. Ruchi Baraya
Specialist Radiologist (MD, FRCR, MMED), Mediclinic Airport Road Hospital, Abu Dhabi, UAE

Future prospects for the radiology information system

Dr. Ruchi Baraya and Dr. Hazem Mahmoud Abdelmonem Hasish

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Abstract
CHIS and RIS functions are increasingly being merged as the growth of information systems in healthcare moves towards the process of integrating numerous systems into a single computer. In order to fully digitize and modernize the radiology facility, including the transition from film to paper, full electronic administration, and digital recordings, a Radiological Information System (RIS) was developed. By bringing together disparate systems, the RIS facilitates the development of a digital radiography hub where relevant data can be accessed at any time. The authors draw the conclusion that implementing RIS, HIS, and other information systems leads to automation, decreased potential for error, higher diagnostic and therapeutic quality, lower material costs, better efficiency, and time savings, among other benefits.

Keywords: Radiology, artificial intelligence, technology, customer service, EMR

Introduction

In the mid-1960s, the first computerized systems were developed to aid in the radiology reporting process [1], making radiology departments among the first in the healthcare system to incorporate electronic technologies into their clinical workflow. Early systems were data silos used for radiological management outside of the hospital. Keeping tabs on patients as they went through the process of imaging acquisition and having their reports interpreted required careful management of patient identity and ordering physician databases. PACS and the RIS (radiology information system) have been integrated into department workflow thanks to recent advances in radiology informatics, which have significantly boosted productivity. The increased departmental efficiency (more studies performed and interpreted), better customer service (through faster report turnaround time and ready availability of images for clinician review), and reduced costs have all resulted from the reduction in the number of steps within the standard workflow when using these systems compared to traditional film-and-paper-based systems. The primary benefits of such systems are their ability to store and make easily accessible vast amounts of data (including images, demographic and clinical information, billing and scheduling, and so on) and to streamline work-flow by doing away with unnecessary steps, allowing for more effective workflow management, and facilitating quick communication.

In the 1960s [1] the first RISs were created with the primary goal of increasing departmental and radiologist productivity in two key areas: report coding and delivery.

In the early to mid-1970s, as new server technologies became available, RISs like the Massachusetts General Hospital Utility Multi-Programming System were able to expand and become more reliable by including more complex programming and database applications. Departmental efforts to automate other functions, such as the implementation of structured reporting methods to improve reporting efficiency, the tracking of film jackets, and the delivery of reports via remote printing technology to dispersed areas for better results communication, benefited greatly from this cutting-edge technology.

In 1980, a consortium of academic and private hospitals came together to form the Radiology Information Systems Consortium (RISC), with the goal of creating a request for proposal for a better RIS and enlisting the help of commercial businesses to implement it. Digital Equipment Corporation was awarded the contract after submitting the winning proposal.

Through the middle of the 1980s, RISC worked with Digital Equipment Corporation and facilitated the growth of the DECrad users group, a nationwide organisation of DECrad's end-users dedicated to improving clinical workflow, IT infrastructure, and film management. The RISC evolved into the Society of Imaging Informatics in Medicine.

From the late 1990s through the early 2000s, when picture archiving and communication systems (PACS) technology became widely available and stable, radiology departments underwent yet another transformation, this time abandoning film in favour of digital imaging and a new digital workflow for diagnostic interpretation. In addition, the availability of digital dictation in the early 2000s made it possible to convert spoken words directly into text, speeding up the turnaround time of diagnostic reports once again.

Over the course of over 40 years, radiologists have worked to enhance workflow by implementing new information system technology. This process will continue to develop.

Methodology

With the use of a literature review, we were able to classify the most recent developments in RIS technology into eight distinct groups. It was determined that superior features were rarely offered by commercial RIS providers. Internal informatics teams at university medical centres were primarily responsible for developing this capabilities. Electronic medical record (EMR) aggregation, order entry decision assistance, enhanced workflow, clinical decision support, data mining, and customer service are the chosen categories to classify the functionality. The classifications we've used here are, admittedly, quite subjective. The categories tend to blend into one another, and the terminology isn't always clear. We think this is because the technology is so new and will only begin to take shape as it develops. It has been found that there are no universally accepted criteria for categorizing different kinds of health information technology in the existing radiology informatics literature (or, indeed, in the health informatics field at large). Our classification and naming schemes are based on current, widely accepted practices in the literature and are meant to be descriptive.

Discussion

EMR Aggregation

It is becoming increasingly apparent that enhanced access to the whole EMR to identify essential clinical information might alter diagnosis and, perhaps, improve patient care as radiologists and other doctors grow more reliant on information technology. Connecting various hospital information systems with unique sources of data for a given patient, such as PACS for diagnostic images, RIS for examination scheduling and diagnostic reporting, and general hospital information systems with other clinical data, is one of the many benefits of modern informatics systems. Sadly, radiologists are often given images to evaluate without any additional clinical data beyond what is supplied by the requesting clinician on the examination request. Sometimes these details, such as the patient's past, are sketchy and incomplete. This is not a brand-new issue, but the recent focus on patient-centered care, personalized medicine, and quality improvement suggests that it may soon be met with renewed calls for reform. Optimal modality and protocol selection, examination interpretation, and suggestions for subsequent patient management all benefit greatly from the inclusion of demographic and clinical data.

As the use of electronic medical records (EMRs) grows, more and more clinical data may be stored digitally [1-5]. Despite this, radiologists rarely make use of this data. The electronic medical record (EMR) is generally inaccessible to radiologists unless they utilize their own computers, software, and user names and passwords. In practice, this usually entails switching to a new computer, entering a new login, and retrieving, reviewing, and analyzing patient data by hand. To make matters worse, checking whether or not relevant information is available in an EMR typically requires the radiologist to visit to various sites, which can take several minutes and multiple clicks.

One study (in which the EMR was located on a remote workstation) showed that EMR usage in as high as 73% of examination interpretations with certain modalities, accounting for 21% of the diagnostic effort (defined as time spent on image analysis), despite the fact that this significantly impacted workflow [6]. Like many other academic medical facilities, we needed to create a custom application that would sync with our worklist and dictation software to instantly generate a summary of pertinent EMR data once an examination was initiated. There was a straightforward user interface on one of the side monitors of the workstation that displayed previous imaging results, clinical notes (such as surgical narratives, history and physicals, and discharge summaries), and laboratory and pathology data. Images could be retrieved and viewed (even if they belonged to different patients) without leaving the current examination, thanks to the system's integration with the PACS.

Presenting the huge and growing amount of data available on the EMR is a dynamic problem. Further simplification of processes may be possible with the addition of features like electronic medical record (EMR) indexing, structured searches, and automated searches. Using a programmed search system, Zalis and Harris [7] developed an EMR that facilitated inquiries of patients' medical records at the point-of-service. The system memorised complex searches in a structured format, narrowed down the EMR dataset to more relevant subsets, and then sent the results of the search to an external reader, such a web browser. A sample project that utilised a query designed for usage prior to interventional procedures demonstrated the system's value by yielding the same level of search satisfaction and accuracy as a manual EMR search while drastically cutting search time by a factor of 8. Additionally, automated queries can be performed at the time of order submission to identify potentially unnecessary duplicate examinations [7], and electronic medical record (EMR) searches can be performed to look for contraindications to specific procedures. Integration of clinical and radiographic data should be further refined in future research. Efforts are being made, for instance, to include pictures from RIS and other clinical imaging systems into the EMR, which should enhance the quality of patient care, save time, and boost the satisfaction of both doctors and patients through better communication and teamwork [8].

Clinical Decision Support at the time of ordering & Inspection

There are various points in the workflow chain, such as order input, image interpretation, and recommendation of future patient treatment, where integrated RIS-based decision support systems may improve patient management and optimise resource usage. In an effort to save healthcare expenditures in the United States, there is growing demand to restrict imaging use to situations where it has been shown to be effective [9]. However, the cost savings from proper medical imaging use extend well beyond the field of radiology; for instance, it has been demonstrated that the cost-effective use of CT in the emergency department reduces the number of needless surgeries [10]. Nonetheless, there are significant variances in ordering behaviour across clinicians [11]. Increased variety and complexity of imaging tests, along with a general lack of consensus on what constitutes acceptable care, have all contributed to the problem.

Beyond radiography, "just-in-time" therapies, or interventions provided at the point of care, have been proven to dramatically influence the safety and quality of patient management by lowering the occurrence of major medical mistakes [12]. In response, imaging decision assistance has been integrated into computerised order entry systems, which have shown high levels of clinician acceptability and reduced usage of low-yield exams [9, 13, 14]. Most rely on web-based software that presents potential tests in the form of drop-down selections associated with standardised diagnostic criteria (with varying levels of detail). At the time of order entry, appropriateness criteria, such as those published by the American College of Radiology [15], or direct evidence are presented. Examinations might be prioritised based on their usefulness and alternates offered [9, 11, 13, 14]. Furthermore, some systems have built-in data collecting features to monitor customer ordering habits and serve as an additional intervention channel [11, 14].

Quality can also be increased by the use of decision assistance throughout the picture interpretation process. Radiologist-specific image search engines (like Yottalook [16] and Goldminer [17] from the American Roentgen Ray Society), web-based diagnostic decision support systems in portal formats (like STATdx) [18], and biomedical literature databases are all examples of just-in-time learning tools (e.g., PubMed) [19]. There is also the possibility of using the evidence presented in the existing literature to build computational models that might aid in diagnosis and suggestion. For mammography, for instance, there are decision support systems wherein picture attributes and clinical data are entered as variables in a computer model, and a Bayesian network is then utilised to generate post-test probability for various diagnoses to aid in guiding subsequent therapy [20-22]. It is critical for usability and clinical acceptance that ancillary informatics tools be seamlessly integrated into the workflow, just as it is with other ancillary tools.

Critical Findings & Automated Reporting

Recent research suggests that communication difficulties are a substantial cause of total radiology mistakes [31], making effective communication of imaging data one of the most important components of radiology quality [30]. Accordingly, there is a growing regulatory emphasis on direct reporting of key discoveries with subsequent documenting of the communication [33, 34], and the medicolegal emphasis on correct and timely reporting of crucial findings [32] continues to grow. Direct synchronous connection with ordering doctors allows for two-way dialogue, instant response, and confirmation of message reception; nevertheless, it is also connected with a number of drawbacks, the most prominent of which is a substantial disruption to workflow. There are a number of methods that have been created to make this procedure more efficient [35–40]. The perfect answer will be tailored to the particulars of a given institution, but in general it will be one that works with preexisting infrastructure, sends messages at the point of care (i.e., just in time), gives users control over how and when those messages are sent, and automatically logs relevant information in the patient record. Asynchronous automated message transmission by e-mail or text page can be a highly effective option, but it cannot replace face-to-face conversation in life-or-death situations. Using a workflow management system, one group facilitated the immediate reporting and documentation of critical findings by nonradiologist staff within the department, while another developed an automated alert system for emergency department physicians that required an acknowledgment of receipt for documentation purposes [37]. Current and future informatics initiatives should provide answers to reduce disruptions, even if the dissemination of crucial results will likely remain a palpable component of normal workflow.

Technologist Feedback

When it comes to optimising productivity and quality in the radiology department, technologists have always been and continue to be an essential component. Despite evidence demonstrating the significance of ongoing quality analysis [44] and the publication of quality-control standards by the American Association of Physicists in Medicine [43, 45], the advent of digital radiography has been associated with a decline in quality control [43]. Informatics tools to aggregate, analyse, and present these data are scarce [46], despite the fact that most modern imaging acquisition or transmission machines have tools to collect valuable quality metrics (such as exposure data, repeat examinations, fluoroscopy time, and sonographic, thermal, and mechanical indexes). Additionally, input from the interpreting radiologists, a crucial quality-control indicator, is becoming increasingly constrained in the modern digital setting. Limited direct radiologist-technologist contacts have been caused by increased workflow demands and geographically remote image capture and interpretation [47].

In order to solve these issues, researchers have looked at a variety of informatics tools, typically adapting the ideas from this paper. In their departmental dashboard, Nagy et al. [48] included technologist-specific indicators such overall picture quality, the number of quality control issues provided by radiologists, and the examination repeat rate. According to the tenets of business analytics, these numbers were integrated into a comprehensive strategy for enhancing product quality (discussed later in this article).

Another team wrote some code to help with tech staff development, mentoring, and management [46]. They used a system that drew information from the CT reader to assess workflow and technician efficiency (e.g., number of examinations performed, repeat rate, and common reasons for repeat examinations). A computerised x-ray dashboard displayed the information for quick perusal. Not only did this team notice striking differences in individual performance (e.g., 80% of examinations were performed by 21% of the technologists) [46], but they also discovered that, by making certain systemic changes in workflow (e.g., positioning for scoliosis examinations), they could significantly decrease the rate of repeat examinations.

With the help of a web-based tool developed by Nagy et al. [48], radiologists could more easily document and provide feedback to technologists on individual cases, leading to the identification of systemic problems for root-cause analysis, an increase in technologists' receptivity to problems (and the ability to coach those technologists with a high number of issues), and a marked increase in the number of quality-control issues submitted (compared with prior paper-based methods). The installation also resulted in faster radiology turnaround times [47].

Data Mining

In the context of radiology informatics, the term "data mining" can refer to a number of different computer science subfields. The overarching objective is to get information from its original location and reformat it such that it may be used in some other context. Data mining is included in many of the ideas presented in this overview, including the implementation of digital dashboards. The approach has been used to improve measures for individual radiologist performance [55–58], radiological report optimization [59–60], technician quality control [46–47], and departmental quality metrics [48, 50–52]. Today, we'll look at how to get your hands on the final radiology text reports. Thanks to technological advancements in data gathering and storage, enormous data repositories are now available for research. The World Wide Web is only one example of a massive data source, making efficient data extraction techniques more and more crucial as time goes on. Our own product has been enhanced with several capabilities that should make it easier for the radiology community to use our product to increase real-time performance and further educational and scientific endeavours. Most of the stated report mining solutions are built around the idea of extracting data from a source (often the RIS, although other data sources like the hospital information systems and PACS might also be incorporated) and storing it in a separate database. Effective systems frequently include indexing techniques, such as creating a relational database with linked tables that each store distinct portions of data [61]. The database is the "back end," whereas the "front end" is the query client, which is often a web browser with a minimalistic graphical user interface. Boolean queries (AND, OR, NOT, etc.) improve the speed and accuracy of data retrieval. The results of a search can be shown as a list of relevant reports with a variety of presentation choices (such as by relevance or date) [61, 62].
It is possible to construct such systems [61] using a wide range of freeware and commercial software that may be adapted to meet the demands of individual programmes or entire organisations. The tremendous potential of these technologies is matched only by the need for stringent HIPAA compliance and comprehensive database security [61, 62]. Current research in areas such as natural language processing (the automated extraction of meaningful data from unstructured text reports), structured reporting, and radiology ontology (e.g., the RadLex lexicon) should increase the capabilities of report mining software and increase their use [62-66].

Customer Service

The health care industry is a service industry, making positive patient-provider relationships essential to long-term prosperity. Radiology in particular is service-oriented since it serves two main "customers"—patients and referring doctors. Concerns that the field is becoming ignored and commoditized in light of the ongoing digital revolution suggest that providing exceptional service is more vital than ever. Relationships with customers can benefit from informatics projects in a number of ways.
Radiologists and their patients may have better interactions if appointments can be made quickly and easily, patients are given clear instructions on how to prepare for exams and what to expect, results are made available as soon as possible, and patients are given room to make decisions about their care. Many of these goals may be met by utilising the growing number of web-based solutions that offer protected data storage, intuitive interfaces, information tailored to the user's current situation, and real-time interaction with healthcare professionals (e.g., online consultations) [38]. There is mounting evidence that patient participation in medical decision making improves outcomes [67-69], which is helping to fuel efforts like patient-centered care and the development of web-based communications systems [37].
Because medical imaging is so commonly used in clinical settings, it is imperative that the requirements of referring doctors be taken into account on a regular basis. Clinicians' access to RIS-based personnel tracking systems through the hospital intranet has been found to boost radiologist accessibility and reduce clinicians' time when looking for a certain radiologist [70]. In addition to reducing the turnaround time for results and the dependency on stationary computer terminals [37-39], automated reporting systems also provide for the tracking of message delivery and reception [29]. Risk-management features (e.g., electronic notices or reminders) and outcomes tracking [11] are two examples of the kind of enhancements made to computerised order entry systems with the referring provider in mind. Clarity, brevity, and clinical correlations are the three criteria most appreciated by both patients and clinicians, and ongoing work on structured reporting may increase physician satisfaction with these qualities [71]. Last but not least, steps are being taken in the field of informatics to meet the growing need for more thorough information management by expanding picture access, dissemination, and integration with the electronic medical record (EMR) [8, 11].

Conclusion

For more than 40 years, radiology departments have been technological pioneers, using cutting-edge ideas from other industries to advance patient care. Radiology departments have been under constant pressure to automate and improve their practices through the creative use of information technology, starting with early server and database improvements and evolving through newer technologies and workflows, such as remote image distribution and teleradiology. As one of the most technologically intensive fields of medicine, radiology might serve as an important laboratory for IT experts investigating how to enhance quality, efficiency, and patient care by providing better access to pertinent clinical data and novel software tools. When it comes to direct patient care interaction with computers, radiologists may spend more time than any other medical profession, making them ideal leaders in the movement to digitise medical information. We anticipate that radiology will continue to adapt to new technology, and we see a number of exciting openings for innovators who want to enhance the quality of treatment provided to patients across the healthcare system.

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