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Development of a methodology for structured reporting of information in echocardiography

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Abstract

In order to conduct research relying on ultrasound images, it is necessary to access a large number of relevant cases represented by images and their interpretation. DICOM standard defines the structured reporting information object. Templates are tree-like structures which offer structural guidance in report construction.

Aims: Laying the foundations of a structured reporting methodology in echocardiography, through the generation of a consistent set of DICOM templates.

Material and methods: We developed an information system with the ability of managing echocardiographic images and structured reports. In order to perform a complete description of the cardiac structures, we used 1900 coded concepts organized into 344 contexts by their semantic meaning in a variety of cardiac diseases.

Results: We developed 30 templates, with up to 10 nesting levels. The list of templates has a pyramid-like architecture. Two templates are used for reporting every measurement and description: "EchoMeasurement" and "EchoDescription". Intermediate level templates specify how to report the features of echoDoppler findings: "Spectral Curve", "Color Jet", "Intracardiac mass". Templates for every cardiovascular structure include the previous ones. "Echocardiography Procedure Report" includes all other templates. The templates were tested in reporting echo features of 100 patients by analyzing 500 DICOM images.

Conclusions: The benefits of these templates has been proven during the testing process, through the quality of the echocardiography report, the ability to argue and to link every diagnostic feature to a defining image and by opening up opportunities for education, research. In the future, our template-based reporting methodology might be extended to other imaging modalities.

Keywords: echocardiography, medical imaging, data reporting, databases, standardization

Introduction

In order to conduct research and education relying on digital ultrasound images it is necessary to access a large number of relevant cases represented by images and their interpretation. Therefore, searching and retrieval of images based on anatomic and diagnostic features is a baseline requirement [1].

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Imaging report is the final product linking the imaging doctor to clinicians. The imaging studies contain sometimes hundred of images [2]. The physician identifies the essential images and presents them in a friendly way to the clinician, embedded in the report and linked to the relevant semantic information [2].

Until recently, imaging reports were organized as a free text, making unfeasible their semantic processing and the retrieval of images based on anatomic and diagnostic features. Narrative reports do not always address key clinical questions; they may contain ambiguous terms, even clinical errors. Structured reporting offers many advantages, but perhaps the most important one is the possibility of building databases with standardized reports [1].

The DICOM (Digital Imaging and Communication in Medicine) standard was introduced in echocardiography

as a method to standardize storage and retrieval of digital images and image-related information. DICOM Standard defines structured reporting as a consistent representation modality of the semantic data that can be extracted from medical images and proposed solutions for structuring medical reports and controlling the terminology [3]. Every medical term is encoded as a concept and a context group consists of a number of concepts sharing the same semantic meaning [3]. Templates specify the structure of a medical DICOM structured document. They define the items of information a report can contain and the relationships between them and the relationships specify the semantic connections between content items. Reports are edited by instantiating the rows of templates with data extracted from medical images [4,5].

The aim of our paper is to lay the foundations of a structured reporting methodology in echocardiography, through the generation of a consistent set of templates, using the coded concepts of a previously developed ontology and the DICOM Standard rules [5]. We started from the templates specified in the DICOM Supplement 72 [6]. The echocardiography procedure report template presented there is limited to reporting a list of organized measurements, regardless of the whole body of echocardiographic description together with its internal logic [4].

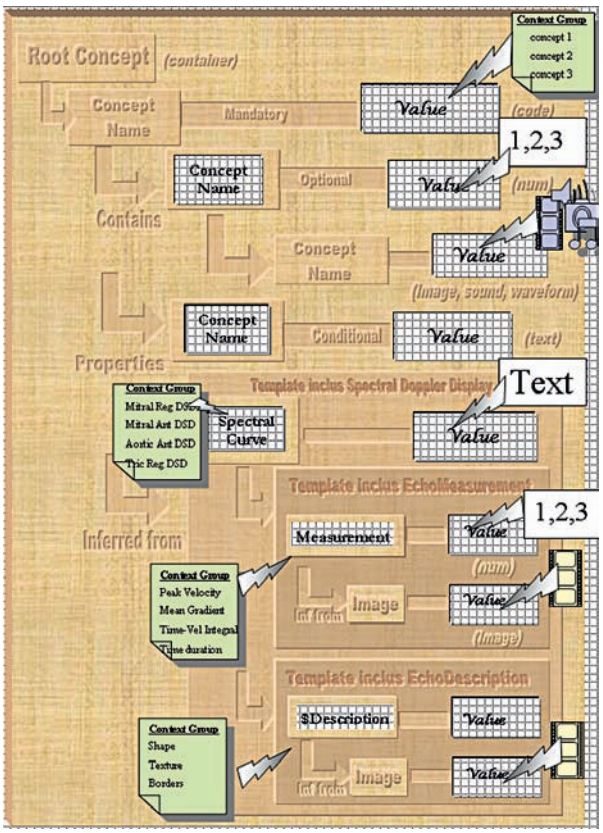


Fig 1. The content items (name-value pairs), relationships between rows and all template constraints are carved in the body of the wooden template. The lists of concepts (context groups) are attached to the template.

Material and methods

We developed an integrated information system with the ability of managing both echocardiographic DICOM images and structured reports. The system contains multiple servers and clients with functions in images processing and report editing. A suite of software tools was also developed for coding concepts, contexts and templates, as well as for generating reports [4,5].

The medical domain structuring module comprises the ontologic editor and also the context and template editor which manages DICOM primitives: coded concepts, context groups and templates. They are stored in different databases. Report templates are patterns of structured document content that suggest or constrain concept names, value types, value sets, and/or relationship types for a particular kind of report [4].

There are three types of rows within a template: content item, included template and reference [5,7]. A content item row will be instantiated in the report as a name-value pair [7]. Templates contain a set of constrains (conditions of presence, parameters etc.) on the values of their rows, involving a continuous evaluation of the report structure during editing [5]. For better understanding of the virtual templates, we undertook the analogy with a wooden template, where the concepts, nesting levels, relationships and presence rules are carved on the surface of templates and values are filled in special boxes, cut in the piece of wood. The lists of concepts to choose from are attached on the template surface (fig 1).

Regarding the appearance within a report, template rows have a requirement type, required by the interpreter software tool [5]. This requirement may be mandatory, user optional or conditional. The latter means that a row will appear within the report if a previous row have a certain value. This is accomplished through presence conditions written in a special field. The most difficult task in introducing template rows is the specification of conditions, because it requires being familiar with the syntax defined by us, according to DICOM standard.

Often we use the same template to report different features (e.g. measurements, simple descriptions or even more complex descriptions, like a spectral Doppler Wave or a Colour Doppler jet). In order to achieve this, we keep

the same basic template structure, but we need to vary same content items (concept names or values) each time the template is included in a larger one, with a different purpose. These variable content items are specified within the template, through a parameter. The values the parameter take (concepts, context groups) are specified when we include the basic template. These values may be conditioned by previous rows. The condition is written in a special field.

The final report is template-based and follows the TID (template ID) "Echocardiography Procedure Report" template tree-like structure. In other words, the physician generating the report has to search and select template's rows that will be instantiated and populated with values. As the user proceeds through report editing, the interpreter software evaluates its input and updates the structure, in order to satisfy the constraints imposed by the template.

Results

After a thorough consultation of the echographical literature, coded concepts were defined in order to perform a complete, attempted exhaustive, description of the anatomical and functional changes of the different cardiac structures, in a variety of cardiac diseases. These coded concepts were included into an ontological structure. Context groups were formed after comparing terminologies related to the various diseases and identification of similarities of semantic meaning.

After coding and sorting concepts and contexts, templates were created, respecting DICOM Structured Reporting rules. For every cardiac structure, a template was generated, containing the complete description of anatomic and functional changes and the information on the aetiology, pathogeny and severity of diseases, offered by the echo-Doppler examination. A total number of 30 templates were thus generated. The echographical terms used (about 1900) were taken from a previously developed ontology. They were organized into 344 contextual groups and then included in templates. Templates are extremely complex, with up to 10 nesting levels, including numerous other templates, a large number of parameters and presence conditions.

The list of templates has a pyramid-like architecture:

- At the base level, there are two templates used for guiding the reporting of every measurement and description: TID "EchoMeasurement" and TID "EchoDescription". Within each measurement or description reporting process, we include the examination conditions (image mode and view), anatomic target sites and degrees of normality of the specific finding. The ability to use our unique echocardiographic template in a large variety of clinical reporting instances is allowed by the existence of predefined parameters. TID "EchoDescription" contains two basic parameters (specified by $ sign, in the DICOM standard): 1. "$ Items" parameter specify the description item ("shape", "texture", "borders") that will be reported and takes values into different context groups, according to the structure that we want to describe (e.g. bidimensional echographic structure, TM curve, spectral Doppler curves or color flow jets). 2. "$ Descriptor" parameter will also receive values from multiple context groups during the reporting process, corresponding to the description item previously chosen (e.g. CID "Shape Description", CID "Texture Description" etc).

These basic templates are included in larger templates.

- Intermediate level templates specify how to report the features of echo-Doppler findings: TID "Spectral Doppler Display Description", TID "Description Color Jet", TID "Intracardiac mass". Their use, in a variety of reporting instances, is driven through the allocation of different values to their parameters: "*$DopplerCuve"* will be instantiated by specific spectral curves (e.g. "anterograde Doppler Mitral Curve") and *"$DopplerWave"* by the specific wave of the spectral curve (e.g. "A wave" or "E wave"). To those spectral waves, we apply the same set of measurements (peak velocity, time-velocity integral, time interval, gathered in the context group) and the same descriptions (shape, texture, borders etc) through the inclusion of the basic templates "EchoMeasurement" and "EchoDescription".
- On the upper level, we developed templates guiding the reporting of cardiac structures echocardiographic assessment: TID"Cardiac Valves", TID"Ventricular Function", TID"Left ventricule", TID"Right ventricular", TID"Atrial Chamber", TID"Aortic Artery" and TID"Pulmonary Artery". All these templates include the intermediate level templates concerning echo-Doppler findings, whose parameters will be instantiated in a specific manner. We developed unique templates for similar cardiovascular structures: e.g. TID"Cardiac Valves" will be used for all four heart valves and TID"Ventricular Function" for describing both left and right ventricular function.

Templates on this level have a unitary structure. Each template contains two major sections: in the section "Anatomical and functional changes", echocardiographic data are presented as they result from direct examination; in the second section, "Diagnosis", we present the conclusions emerging from the correlation of various numerical or non numerical features reported in the previous section. Conclusions of the 'Diagnosis' section are

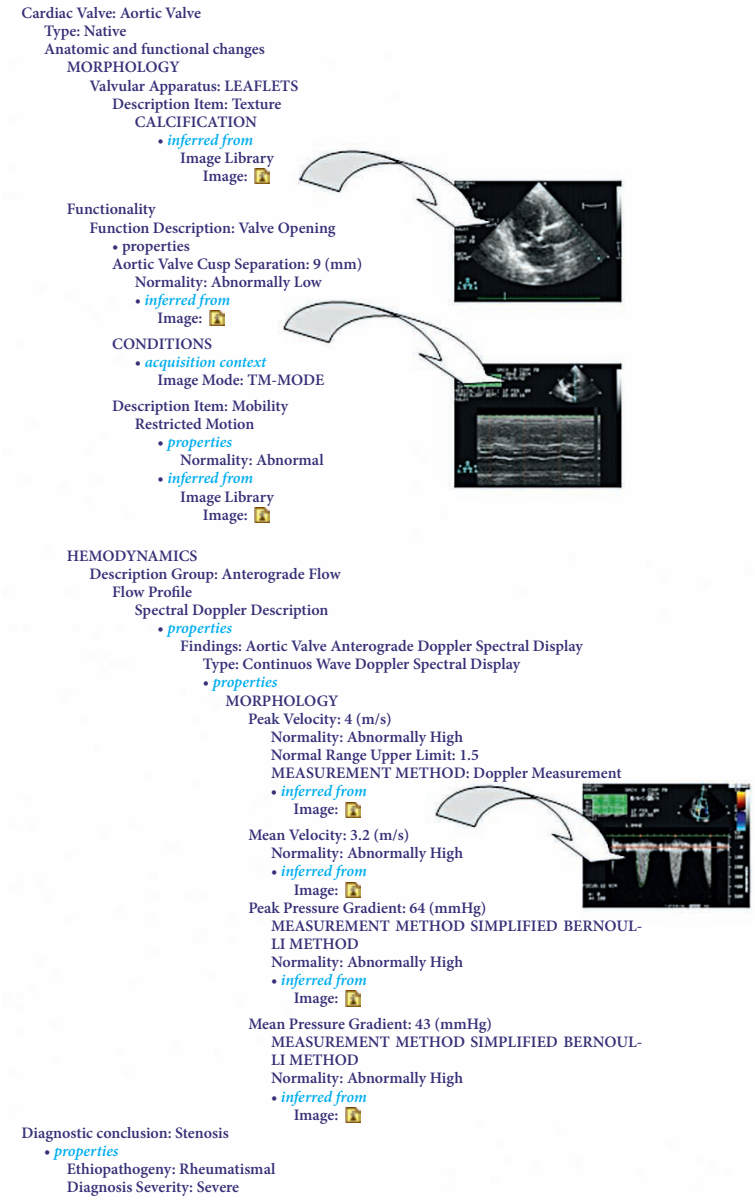


Fig 2. The report is based on the „Echocardiography Procedure Report" template and contains the EchoDoppler examination of a patient with severe aortic stenosis.

related by the INFERRED FROM relationship (defined in the DICOM Standard) to the echocardiographical data that led to their formulation.

- At the top of the pyramid is the TID "Echocardiography Procedure Report" template, developed through the inclusion within its rows of the previous level templates corresponding to individual cardiac structures. Using the TID "Ecocardiography Procedure Report", we generate the report starting from a series of DICOM images previously stored in the database (fig 2).

The "Echocardiography Procedure Report" template which includes the complete set of templates previously described, was extensively tested in the reporting process of echocardiographic features of 100 patients from Medical Clinic no I Cluj-Napoca. Their series of echocardiographic images covered the whole spectrum of cardiovascular pathology. We analyzed 500 DICOM images and we generated 150 echocardiographic reports that were included in the database. On this database we performed more than 200 complex queries. All these testing processes led us to rearrange the structure of templates generating a lot of versions until reaching the final one, in order to fulfill the requirements for completeness and flexibility of the reporting methodology. The next step in the implementation process was testing the reporting methodology during echocardiografic examination (real time conditions) proving its feasibility in daily clinical practice.

Discussions

DICOM Standard offers, within Supplement 72 [6], a set of echocardiographic measurements for every cardiac structure. Each measurement is reported using "Measurement" template, particularized for echocardiography within DICOM Supplement 72, as "EchoMeasurement" template [6,7]. Descriptions, which form a large volume of information within the echocardiographic examination, are not covered by DICOM rules [4]. Therefore, one of the original contributions of this paper is the organization in a structured form of the description information from the echocardiographic domain. Following the same baseline principles as for DICOM "EchoMeasurement" template, we developed a template for echo-Doppler description reporting. Afterwards, both numeric and descriptive information were organized into templates specific for cardiac structures [5].

In order to develop an original reporting methodology at the same time flexible and exhaustive, following echocardiographic logic, we required our own ontology. Therefore, after a thorough consultation of the echographical literature, we generated an extensive echocar-

diographic ontology, where we took a number of concepts from DICOM Supplement 72 [6], but the large majority of terms are original, generated by our group. The structure of the templates was updated during a testing process of the reporting methodology, which included reports editing on a large variety of clinical cases and complex querying. The editing process tested both the easiness of filling in the reports and their completeness, emerging from the possibility to describe the most diverse and rare echocardiographic findings. The multiple querying processes tested the educational and research value of the proposed methodology through its efficacy in solving complex questions.

Conclusion

The benefits of the set of templates developed has been proven during testing process, through the quality of the diagnostic echocardiography report, compatible with the highest clinical standards, the ability to argue and to link every diagnostic feature to a defining image, the ability to manage the large number of images from the imaging department, as well as by opening up opportunities for education and research. In the future, our template-based reporting methodology might be extended to other imaging modalities (angiography, CT, RMN) increasing the power of databases for managing both image and image-related information. It will increase also their performance in solving very complex queries as tools for research, education and daily clinical practice.

Conflict of interest: none

References

1. Reiner BI. The challenges, opportunities, and imperative of structured reporting in medical imaging. J Digit Imaging 2009; 22: 562-568.
2. Langlotz CP. Automatic structuring of radiology reports: Harbinger of a second information revolution in radiology. Radiology 2002; 224: 5-7.
3. DICOM working group. Digital imaging and communications in medicine (DICOM) standard, Supplement 53: DICOM Content Mapping Resources. Rosslyn, Va: NEMA, 2003. http://medical.nema.org/dicom/2003.html.
4. Homorodean C, Olinic D, Nedevschi S, Olinic N. Templates Implementation for Structured DICOM diagnosis reporting in echocardiography. Computers in cardiology 2005; 32: 379-382.
5. Olinic D, Homorodean C, Nedevschi S, et al. A proposal for structured diagnosis reporting in echocardiography, using a DICOM compliant environment. Computers in Cardiology 2004; 31: 601-604.
6. DICOM working group. Digital imaging and communications in medicine (DICOM) standard, Supplement 72: Echocardiography Procedure Reports. Rosslyn, Va: NEMA, 2003. http://medical.nema.org.
7. DICOM working group. Digital imaging and communications in medicine (DICOM) standard, Supplement 23: Structured Reporting Storage SOP Classes, Rosslyn, Va: NEMA, 2000. http://medical.nema.org.