Templates Implementation for Structured DICOM Diagnosis Reporting in Echocardiography

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Abstract

We previously reported the development of a DICOM structured diagnosis application allowing efficient storage and retrieval of echocardiographic information. Reports are generated for every patient and every type of information is stored into a complex database. For such a structure to be efficiently use in the echocardiography laboratory, we extended EchoSection template with a description section including a EchoDescription template allowing generation of echocardiographic reports for every cardiac structure. This was possible by using parameters and by developing a simple programming language for specifying complex relationships between different rows of the template.

We are currently generating reports for a large variety of cardiac diseases and storing them into a DICOM image database.

1. Introduction

Digital storage and review is now the state of the art in echocardiography, and practitioners are urged to move quickly to an all digital solution in their laboratories (1) . DICOM is a set of rules to specify how images and other data should be exchanged between compliant pieces of equipment. Individual image files are stored with information on the patient, the purpose and technique of examination, interpretation of the image and the pixel data themselves. (1, 2)

Information Objects are defined in DICOM standard as an abstraction of a real information entity (e.g., Patient, Study, CT Image, Structured Report, etc.) which is acted upon by one or more DICOM Commands. Composite Information Object Classes provide a structured framework for expressing the communication requirements of images where image data and related data needs to be closely associated (3). Recent work of DICOM has focused on non-imaging data elements (patient demographics, study information, image/procedural findings) that can be associated with an image or image set (1). The Structured Reporting SOP Classes allow users to link text and other data to particular images and/or waveforms and to store the coordinates of findings so that users can see exactly what is being described in a report. In addition, users can label, index and retrieve clinically relevant information using codes. The structured Reporting SOP classes fully support conventional free text reports and provide the capability to record structured information that enhances the precision, clarity and value of clinical documents.

DICOM Standard has defined structured reporting as a coherent representation modality of the data that can be extracted from medical images. Coded concepts and report templates represent the primitives of this reporting method. Reports are generated through the instantiation of corresponding template rows with data extracted from medical images or supplied by the referring physician. (4) Echocardiographic reports are generated for every patient and every type of information (text, sound, image) is stored into a complex database. In order to generate reports, tree like structures (templates) were developed. Within such a structure, every row may be instantiated with a specific coded medical term (concept), a group of concepts (context) or another template. By attributing values to template`s rows, a report is generated.

Physicians and sonographers interact with computers to acquire, transmit, analyze and interpret echocardiography studies. Final reports can be generated at the same time as study review, and images can be included in the final report (1).

DICOM supplement 72 standardizes terms for adult echocardiographic measurements and calculations that can be transmitted as part of a DICOM message (5). Non numeric characteristics are not included in the supplement and the Echocardiography Procedure Report template gives a limited characterization of echocadiographic examination.

Our goal was to implement the DICOM structured reporting concept for echocardiography in a software environment used in clinically daily practice.

We previously developed an image database using Information Entities defined by DICOM such as Patient

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IE, Study IE, Series IE and Image IE. Medical information extracted from the echocardiographic images was presented in a primitive structured format using compulsory keys, attributes and specifiers (6). Our present work focused on the structuration of echocardiographic information according to the rules developed in DICOM standard, using coded concepts and templates as a basis in generating echocardiographic reports (7, 8).

2. Methods

In the present work we tried to extend some of the context groups proposed by DICOM Supplement 72, to define description (non numeric) terms as coded concepts and group them into context groups. Our structuring method used the templates proposed by the DICOM document but we extended them in order to include description sections. The templates were also extended in order to be more flexible and comprehensible. We developed templates describing valvular pathology, LV and RV function, atrium morphology and function, pericardium, aorta and the veins (cavae and pulmoary veins).

3. Results

For the efficient use in the echocardiography laboratory, templates should be easy to use, comprehensive and flexible. This is achieved by template inclusion and usage of parameters. Parameters may be used to specify coded concepts or Context Groups in the Concept Name, Condition, or Value Set Constraint fields of the Template (7). Echocardiography procedure report template includes EchoSection template which is a generic section heading for any of the examined anatomical structures (5). EchoSection template uses $SectionSubject parameter. At its inclusion in the parental template $SectionSubject parameter is instantiated with a coded concept designating anatomical structure : Cardiac valves, Left ventricle, Vena cava etc. We extended this template by a description section, therefore we need to create coded concepts and context groups (Fig. 1) and to develop templates for non numeric descriptions (EchoDescription, Fig. 2) similar to the template EchoMeasurement used to specify numeric variables and presented in the DICOM Supplement 72. These templates are included in EchoSection template.

Measurements and descriptions within a section appear as groups (ex. measurements grouped by image mode : TM mode, 2D mode etc.) . Descriptions are grouped under heading like Morphology, Mobility and Hemodinamics. The included templates contain parameters that are replaced by values defined in the invoking template.

EchoDescription template include three parameters : $Descriptor, $TargetSite, $TargetSiteMod.

- The parameter $Descriptor is replaced with coded values from different context groups : Cx Valve morphology (Fig. 1), Cx Valve mobility.

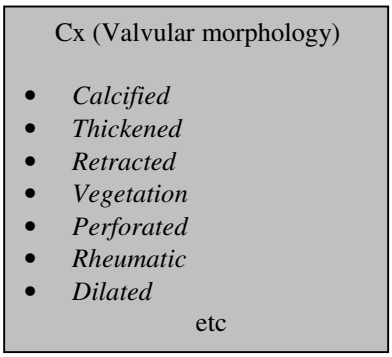

Figure 1: “Valvular morphology” context group

- The specific anatomical location of the description is defined using another parameter: $TargetSite. It takes its contextual values from context groups like Cx Valvular apparatus (leaflet, cordages, annulus, papilary muscles)

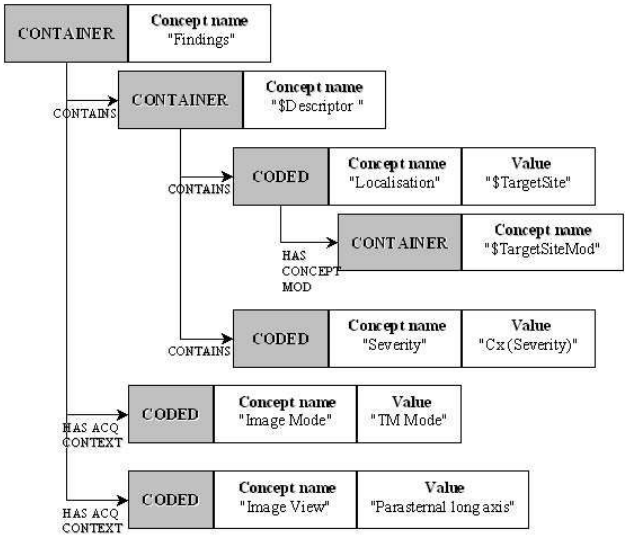

Figure 2: “Echo Description” template

- $TargetSiteMod takes its value from context groups as Cx MitralLeaflet (anterior, posterior) achieving a detailed location of the described structure (ex : calcified- leaflet- anterior) . The template row containing this parameter is linked by its parental row by the relationship : HAS CONCEPT MODIFIER. Thus we used the post- coordination in

generating complete concept names.

The description is INFERRED FROM an image which is referred by its UID (unique identifier). The characteristic is quantified into mild, moderate and severe by a relationship HAS PROPERTIES. Image mode and image view are also specified and are linked to their parental rows by the relationship HAS ACQUISITION CONTEXT .

The extended EchoSection template allows generation of SR for every cardiac valves, ventricles, atrium, pericardium, veins, aorta and pulmonary artery. Anatomic and functional changes (e.g. morphology, mobility of the valvular apparatus) are described in the description section succeeded by the Measurement group which contains hemodinamics measurement. $Measurement parameter, included in the EchoMeasurement template, may have values from context groups as : Cx Echocardiography Mitral Valve, CxEchocardiography Aortic Valve , CxEchocardiography Tricuspid Valve. The final section is a conclusion on the valvular function (normal, stenotic, regurgitation).

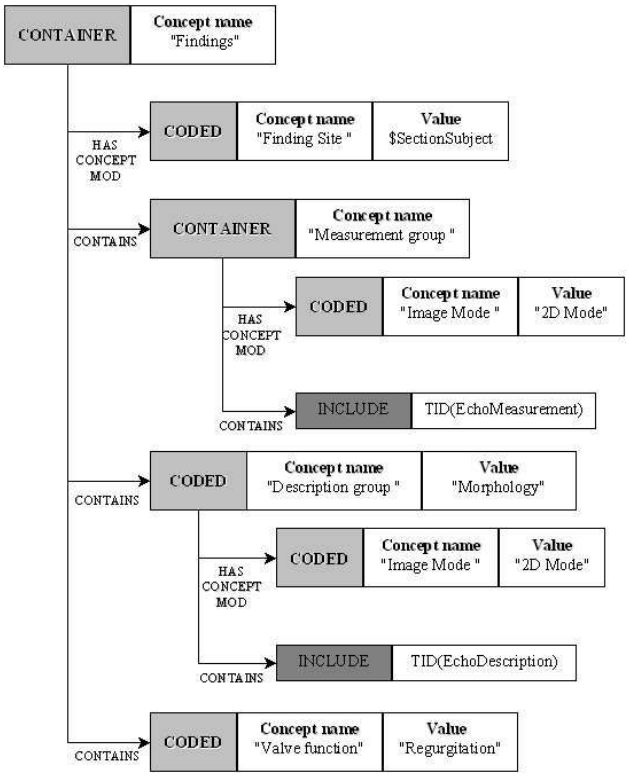

Figure 3: Extended "EchoSection" template

A single template characterizing left ventricular function (systolic, diastolic, global and regional) was also developed and it was reported in one of our previous papers. It is developed as a template different from the EchoSection template because this one was not considered appropriate for the complexity of LV echocardiographic examination. This was possible by using included templates with parameters and by developing a simple programming language for specifying complex relationships between different rows of the template.

4. Discussion

DICOM was introduced in echocardiography as a mean to standardize storage and retrieval of digital images and image-related information (9). We previously created a specific application able to use DICOM defined Composite instance Information Objects in developing a complex echocardiographic database. We used information entities defined by DICOM standard within these Composite Information Objects (3) :

- **Patient IE** which defines the characteristics of a patient who is the subject of one or more medical studies which produce medical images.
- **Study IE** defines the characteristics of a medical study performed on a patient. A study is a collection of one or more series of medical images, presentation states, **SR documents,** overlays and/or curves which are logically related for the purpose of diagnosing a patient. Each study is associated with exactly one patient. A study may include Composite SOP Instances that are created by a single modality, multiple modalities or by multiple devices of the same modality.
- **Series IE** defines the Attributes which are used to group Composite SOP Instances into distinct logical sets. Each series is associated with exactly one Study.
- **Image IE :** The Image IE defines the Attributes that describe the pixel data of an image.
- **Structured reporting IE :** The SR Document IE defines the Attributes that describe the content of an SR Document. These include semantic context as well as Attributes related to document completion, verification and other characteristics. An SR Document SOP Instance is related to a single Series within a single Study.

The disadvantage of our previous database was a poor structured medical information : we used items like compulsory key, attributes and specifiers. stored in dedicated dictionaries but not as coded concepts and context groups. DICOM files include a field for the description of the echocardiographic characteristics related to the digital images. The cardiologist is interested in structuring the diagnosis information, both for generating a final DICOM echocardiographic report and for the implementation of DICOM echocardiographic

images databases, for clinical and teaching purposes (9).

Recent work of DICOM has focused on non-imaging data elements (patient demographics, study information, image/procedural findings) that can be associated with an image or image set (1). Some rules governing Structured reporting are described in DICOM standard and in supplements (5, 8). Recently we developed a specific application that allows to code echocardiographic concepts, to group them into context groups and construct templates which finally will lead to structured report generation (9). We used the context groups and templates described in the DICOM supplement 72 and we extended them in order to be able to report description sections and also to achieve a more comprehensive format. In a previous paper we reported a specific LV template appropriate for the complexity of ventricular echocardiografic examination (9). We are able now to generate in our software environment reports for every type of echocardiographic pathology. Such a database is useful not only in daily clinical practice but also for teaching purposes. It includes powerful methods of retrieval specific images and their linked structured echocardiographic information.

The report editor module implements three different methods for locating medical reports (4). The first method uses patient name or identifier as interrogation key (4). A more complicated method takes as input parameters concept name – coded value pairs and returns the reports that contain such pairs (4). The last retrieval method we propose locates medical reports that satisfy a specified content structure (4). The user has to specify the interest data and also its structure, following the same steps as in the process of report editing. What results in the process of retrieval is a set of reports that satisfy the imposed constraints, but also the attached data to reports – images, waveforms. In the light of this, we could interpret the retrieval method based on content structure as a way of finding images that are defining for some specified concepts.

5. Conclusion

The paper presents complete structured echocardiographic information in adult patient and its implementation in a DICOM compatible software environment. A complex database with powerful tools of retrieval of medical information was generated. Our future work will focus on implementation of this database in daily clinical practice and its population with a large number of echocardiographic images in order to serve its teaching purposes.

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