A Proposal for Structured Diagnosis Reporting in Echocardiography, Using a DICOM Compliant Environment

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Abstract

Structured diagnosis of echocardiography is useful both for report generation and for indexing and retrieval of echocardiographic images, for the purpose of database generation. This paper presents a proposal for structured diagnosis reporting in echocardiography, dealing with both numerical and non-numerical findings. For each cardiac disease, an exhaustive description of the morphological, functional and homodynamic changes related to the various cardiac structures was attempted. A database of concepts, contexts and templates for echocardiographic diagnosis reporting was implemented. This database will be used for DICOM structured reporting generation and the implementation of structured reports databases.

1. Introduction

DICOM was introduced in echocardiography as a means to standardize storage and retrieval of digital images and image-related information. The implementation of networks, in cardiology departments, for DICOM echocardiographic files archiving on a server, directly from the echo laboratory, and for file retrieval, from peripheral stations in the cardiology wards, contributes to an easy and accurate patient final diagnosis.

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.

In a previous paper, we presented a structured reporting proposal for the diagnosis text field of the DICOM files [1, 2]. This was based on user-defined terms describing the echo findings concerning the different anatomical cardiac structures and, respectively, the echo diagnosis. The echocardiographist was able to create a user-defined dictionary of terms, adapted to his daily practice and with a progressive growth. A structured database of echocardiographic images was implemented and retrieval based on image diagnosis characteristics was possible

A change of our structuring methodology became necessary after the introduction of the DICOM rules for structuring the medical information. DICOM standard proposed solutions for defining structures of medical documents and for controlling their contents [3].

Under DICOM rules, every medical information is encoded as a concept. A number of concepts sharing the same semantic meaning form a context group. The context groups represent the information content of a DICOM report. Structuring this information is the job of a tree- like pattern called template.

DICOM supplement for echocardiography provided sets of concepts and context groups for numerical findings describing most of the cardiac structures, as well as templates for generating echocardiographic measurements reports [4].

In the actual stage, DICOM structuring proposals have at least two limitations. First, non-numerical information related to echocardiographic diagnosis was not structured [5]. Second, the cardiologist examining the DICOM echo images and using the numerical information offered by the DICOM report can perform an echocardiographic diagnosis, but this has to be finally written in still a free-text format, not using coded diagnosis concepts.

2. Aim of the study

Our goal was to develop a DICOM compliant echocardiography structured reporting method. Numerical and non-numerical findings were coded, an echocardiography dictionary of terms was proposed and context groups and templates were generated, in order to create the DICOM structured report.

We used a previously described software environment for coding, grouping and structuring the echocardiographic information [5].

The structured reporting methodology is of interest not only for clinical purposes, in order to generate the echocardiographic report in a structured manner, but also for teaching and research purposes, by means of the implementation of structured report databases, including images.

3. DICOM report structure

Templates specify the structure of a medical DICOM document. They define the items of information a report can contain and relationships between them (Figure 1). An item of information is a pair: concept name – value [6].

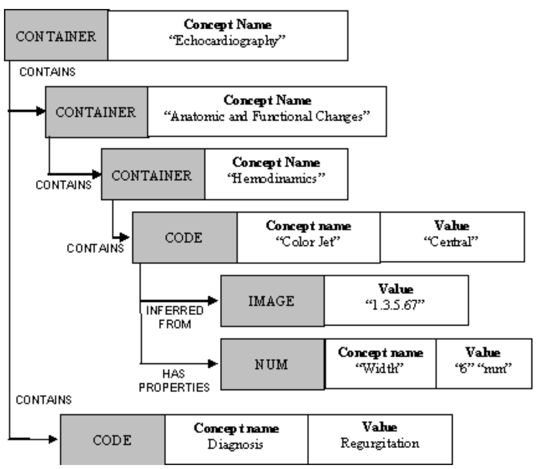


Figure 1. Example of a template structure

Concept names are always medical terms. Concepts can be used in different medical documents, in different semantic contexts. To overcome the ambiguity that can arise from such a situation, context groups were created [6]. They contain a number of concepts with similar semantic meaning.

A Template may specify another Template to be included by specifying "INCLUDE" in the Value Type field and the identifier of the included Template in the Concept Name field. All of the rows of the specified[3].

Another item we used is the parameter. A Template that is included by another Template may include parameters that are replaced by values defined in the invoking Template. Parameters may be used to specify coded concepts or Context Groups in the Concept Name, Condition, or Value Set Constraint fields of a Template [3].

The invoking Template may specify the value of the parameters in the included Template by name in the Value Set Constraint field of the INCLUDE row. The parameter in the included Template shall be replaced by the specified parameter value[3].

The parameter offers the opportunity to adapt a same general template (e.g. "echo measurements") to the specific needs (sets of concepts) of the various contexts environments represented by the different cardiac structures.

4. Methodology for report generation

Software tools were developed for coding concepts, contexts and templates, as well as for generating reports.

4.1. Concepts

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 the different cardiac diseases. This information was based on the analysis of information contained in several major echocardiography textbooks and articles. A database of coded concepts was created. For an easier retrieval of concepts, a hierarchical structure of concepts was created.

A large number of coded terms were included in a flexible ontology. . In such ontology, coded concepts are linked to each other by relationships: IS-A, HAS PROPERTIES, etc.[5]. Concepts have a unique meaning and a lot of descriptions to be used in different contexts.

In the process of concept selection, we tried to use terms from other dictionaries (LOINC, SNOWMED). The difficulty to adapt these terms to the specific needs of our echocardiography reporting methodology led us to the development of our own coding scheme (TUCNMR).

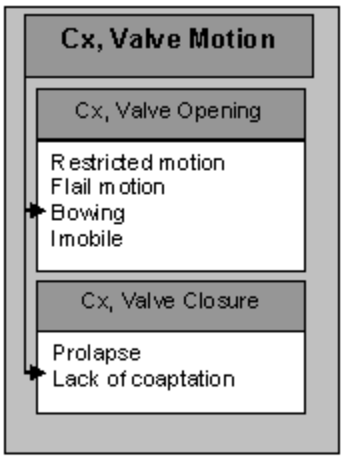
A previously created software environment allowed us to code new medical terms in a specified scheme. For each concept, a meaning and different descriptions were introduced.

In the process of concept dictionary generation, in order to cover the entire echocardiographic diagnosis terminology, we identified and structured, for each cardiac disease, the related morphological and functional changes. Tables, with a hierarchy of terms, were created. Then, every piece of information was coded in the form of concepts.

4.2. Context groups

Contexts were formed after comparing terminologies related to the various diseases and identification of similarities of semantic meaning. The concepts that form a context were semantically linked and could pertain to different coded dictionaries. Every concept that is part of a context has an associated description that must be used when it appears in the semantic context. Similar simple contexts used together may form a context group (Figure 2).

Figure 2. “Valve Motion” context group



To facilitate the use of concepts in different semantic situations, and to avoid ambiguities, we united similar concepts under a generic name.

To describe non- numeric characteristics, context groups like ‘Valve description’, ‘Ring description’, ‘Echo mass description’ were generated. For numeric findings, we used much of the context groups presented in the DICOM Supplement 72 [4].

Other types of context groups are those used in diagnosis description. For example, the context group “Mitral diagnosis” contains concepts like regurgitation, stenosis, and vegetation. For left ventricular diastolic function we used a context group containing the following concepts: impaired relaxation, pseudonormal, restrictive.

For attributing the normality value to a concept, we used the context ‘Normality Codes’, formed from the following concepts: normal, abnormal, abnormally high, abnormally low, normally undetermined.

The context ‘Trend’ contains the following concepts: increase, decrease, no response, biphasic response.

There are some very large context groups as ‘Left Ventricle’ which contains coded concepts referring to chamber dimensions, wall dimensions, velocities and mass.

4.3. Templates

After coding and sorting concepts and contexts, templates were created. Templates offer structural guidance in report construction. For every cardiac structure, a template was generated, containing the complete description of anatomic and functional changes. For every cardiac disease, diagnosis templates were also defined, including the information on the etiology, pathogeny and severity offered by the echo exam.

The complexity of such descriptions led to the generation of a multitude of successive templates inside other templates. The elementary ones refer to numeric findings (measurements) and non-numeric findings (echocardiographycally specific description of the pathology).

For numerical findings we used the EchoMeasurement described in DICOM Supplements [4, 7].

For non-numeric findings, EchoDescription is an elementary template. It contains a parameter called ‘Descriptor’ that can be instantiated with a large variety of context groups (e.g. ‘Valve opening’, ‘Cusps description’, ‘Cordage description’ etc).

The need of flexibility led to the effort of adapting some of the content items of templates (the pairs name-value, implicitly the context groups and concepts) to the various instances of usage.

In our structuring methodology, templates allow the reporting echocardiographist to follow the usual steps of cardiac structure description and of final echocardiographic examination diagnosis (Figure 3).

L	Relation with Parent	VT	Concept Name	Value set constraint
			EV (Anatomic and functional changes)	
>	CONTAINS	CT	EV (LV linear)	
>>	CONTAINS	INCLUDE	TID (EchoMeasurement)	$Measurement= Cx (LV linear)
>	CONTAINS	CT	EV (LV area)	
>>	CONTAINS	INCLUDE	TID (EchoMeasurement)	$Measurement= Cx (LV area)
>	CONTAINS	CT	EV (LV Volume)	
>>	CONTAINS	INCLUDE	TID (EchoMeasurement)	$Measurement= Cx (LV volume)
>	CONTAINS	CT	EV (Wall motion)	
>>	CONTAINS	INCLUDE	TID (Wall motion Analysis)	
>	CONTAINS	CT	EV (LV Geometry)	
>>	CONTAINS	INCLUDE	TID (EchoMeasurement)	$Measurement= Cx (LV Geometry)
>	CONTAINS	CT	EV (Hemodinamics)	
>>	CONTAINS	CT	EV (Inflow)	
>>>	HAS PROP	CT	EV (Mitral anterograde Flow)	
>>>>	CONTAINS	INCLUDE	TID (EchoMeasurement)	$Measurement= Cx (Mitral Anterograde Flow)
>>>	HAS PROP	CT	EV (Pulmonary Veins Flow)	
>>>>	CONTAINS	INCLUDE	TID (EchoMeasurement)	$Measurement= Cx (Echocardiography Pulmonary Veins)
		CT	EV (Diagnosis)	

>	CONTAINS	CODED	EV (LV Morphology)	Cx (LV Morphology)
>>	INFERRED FROM	CODED	EV (LV Mass)	Cx (Normality Codes)
>>	INFERRED FROM	CODED	EV (LV volume)	Cx (Normality Codes)
>>	INFERRED FROM	CODED	EV (LV Geometry)	Cx (Normality Codes)
>	CONTAINS	CT	EV (LV Function)	
>>	CONTAINS	CODED	EV (Global Systolic Function)	Cx (Normality Codes)
>>>	INFERRED FROM	CODED	EV (Longitudinal Systolic Function)	Cx (Normality Codes)
>>>>	INFERRED FROM	CODED	Cx (Longitudinal Systolic Function)	Cx (Normality Codes)
>>>	INFERRED FROM	CODED	EV (Radial Systolic Function)	Cx (Normality Codes)
>>>>	INFERRED FROM	CODED	Cx (Radial Systolic Function)	Cx (Normality Codes)
>	CONTAINS	CODED	EV (Global Diastolic Function)	Cx (Diastolic Pattern)
>	CONTAINS	CODED	EV (Regional Function)	Cx (Normality Codes)
>>	CONTAINS	INCLUDE	TID (Regional Function)	

Figure 3. Left Ventricle Template

4.4. Reports

Based on the templates created by the previously described methodology, we may generate reports covering a large diversity of cardiovascular pathology. Every report is created starting with a template specifying its structure. According to this structure, the physician has only to choose from a set of available options from the contexts. Report Editor Module is the software we created in order to generate the reports. The resulting reports are stored in a database and used afterwards for representation in different formats (DICOM, XML, text).

Every coded concept and its value are inferred from one or more specific images, which will appear encoded in the report. Images are stored in DICOM format using specifically developed software. Finally, an image database can be implemented.

An important task of our software environment is retrieving the information. There are two ways of retrieving. An easier one is by patient name, code etc. A more complex one is by selecting terms of interest from the templates of interest, a process similar to report generation. The user interrogating the report database can also retrieve the corresponding images from the images database.

5. Conclusions and future work

A structured diagnosis reporting methodology, in a DICOM environment, was implemented. It includes concepts, contexts and templates that cover the diagnosis of most of the cardiac pathology. Databases of echocardiographic reports, including related images, can be developed in the future, for teaching and research purposes.

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