Creation of an interface terminology of abdominal ultrasonography pathologies using a SNOMED CT to automate the process of ultrasound note creation.

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Abstract

Background: Ultrasound - one of the most common tests in diagnostic medicine and studies of abdominal organs are more than two thirds of all the ultrasound studies. Ultrasound findings include a description of pathologies found. Various information systems provide the ability to document the pathology found in the form of coded values. But due to the lack of uniform terminology different concepts are used to describe the same pathology. A lack of common principles of coding of health information leads to difficulties of interpretation and automatic processing of ultrasound findings, as well as the inability to ensure interoperability. **Objectives:** Creation of interface terminology of the pathologies found during abdominal ultrasonography using a SNOMED CT, followed by automation of the process of the creation of ultrasound note. **Methods:** Approach has been developed to design the interface terminology on the basis of international experience of SNOMED CT using. Approach includes five phases: domain analysis, determining level of detail for the concepts, determining selection criteria for concepts in given domain, creating subset of concepts, mapping from the subset to the set of terms already in use. Designed interface terminology of the pathologies was introduced in the hospital information system. On the basis of coded values, an automated process of forming the ultrasound note was built. **Results:** Interface terminology of the pathologies of the abdominal cavity have been created as the result, which included 93 pathologies, 80 of which were unambiguously mapped with SNOMED CT concepts. For the remaining 13 pathologies, post coordinated concepts were designed. The final interface terminology contains 82% more terms (from 51 to 93 terms) in comparison with the original. **Conclusions:** SNOMED CT has shown high efficiency in the encoding of specialized clinical terminology. The methodology used allowed us to extract the necessary terms for a given domain. We plan to continue our work to create various interface terminologies of pathologies based on SNOMED CT for other study methods.

Keywords

SNOMED CT, Subset, Post-coordinate, Interface terminology, Hospital information system.

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1 Introduction

To date, there is no standards accepted for classification and codification of medical terminology in the Russian health care. This leads to the fact that the various developers of medical information systems use different local vocabularies of medical terminology or no vocabularies at all.

The lack of terminological standards makes it impossible to exclude free, non-formal text entry of medical information, which makes it unsuitable for the automated analysis and interpretation, as well as for exchange between different medical information systems, thus preventing interoperability.

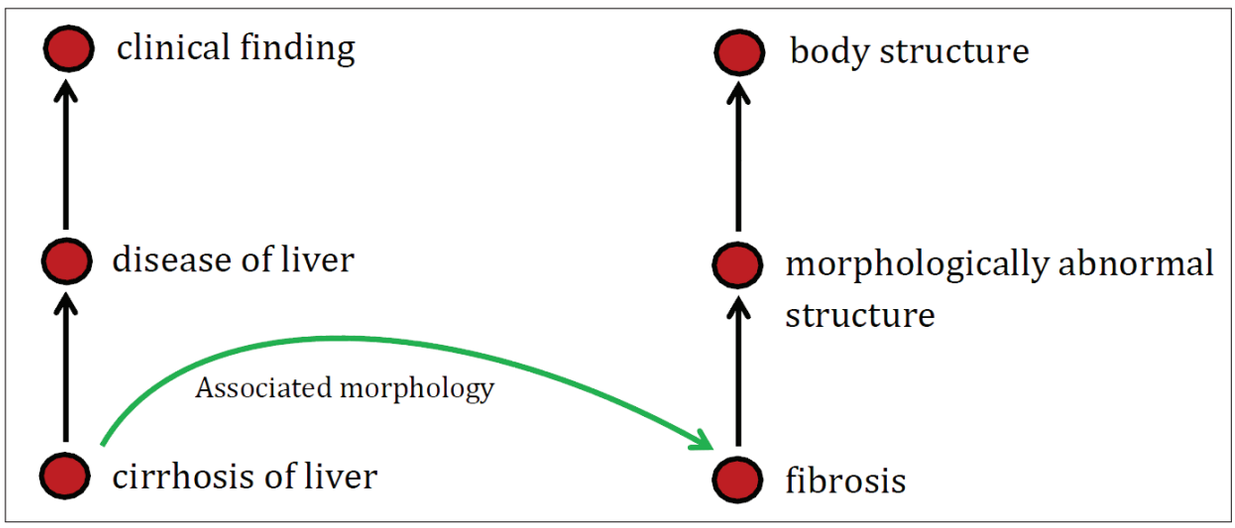

Figure 1: A graphical representation of a clinical findings concept's relationship to body structure hierarchy concept used for the selection of appropriate concepts.

Reference terminology SNOMED CT (Systematized Nomenclature of Medicine-Clinical Terms) is the most common terminology for coding clinical terms. This terminology is the most complete hierarchical database of medical terms (more than 300,000 unique concepts) and reference relationships between them (more than 1.3 million relationships) in the world.

Application of this standard will standardize and formalize the input and storage of medical information, allowing accumulation of information in the regional and global databases and providing great opportunities for the use of decision support systems, statistical and other data processing, as well as an opportunity to exchange medical information between medical information systems [1].

2 Methods

Approach has been developed to design the interface terminology [2, 3] on the basis of international experience of SNOMED CT using. Approach includes five phases: domain analysis, determining the level of detail for the concepts, determining selection criteria for concepts in given domain, creating subset of concepts, mapping from the subset to the set of terms already in use. Designed interface terminology of the pathologies was introduced in the hospital information system. On the basis of coded values automated process of forming the ultrasound note was built. In the following sections each of these phases is briefly described.

2.1 Domain analysis

The following hierarchies of SNOMED CT were chosen for analysis in this paper:

- Clinical finding. This hierarchy is central for this paper because it contains the diseases and conditions;
- Body structure. Main organs and structures that can be studied were selected from this hierarchy: the liver and biliary tract (common hepatic and cystic ducts, gall bladder), spleen, pancreas, kidneys and adrenal glands;
- Procedure. Methods of ultrasound diagnosis of each organ were taken from the hierarchy.

To narrow the number of terms for the analysis a set of concepts should be limited. The upper limit in the hierarchy of concepts has been established by specifying the starting point or node. The lower limit is set by specifying the level of detail. In our case, the hierarchy of nodes was as follows:

- disorder of liver;
- disorder of bile duct;
- disorder of spleen;
- disorder of pancreas;
- disorder of kidney;
- disorder of adrenal gland.

2.2 Determining the level of detail for the concepts

Determining the level of detail, or in other words, the determination of the degree of specialization of the concepts is an important part in terms of quantity and quality of information received. If you set very high level of detail, you can get a very wide range of pathologies of the abdominal cavity, many of which cannot be found using such a general method as ultrasound. If you set very low level of detail, you can receive too small set of pathologies, so many of the necessary concepts will not be presented.

Table 1: The result of comparing the two sets of pathologies.

Organ examined	The number of pathologies in the clinical set	Number of matched to SNOMED set	Number of unmatched to SNOMED set
Hepatobiliary system	21	20	1
Spleen	7	4	3
Pancreas	8	3	5
Kidneys and adrenals	15	11	4
Total	51	38	13

Having analyzed the hierarchy of pathologies of the abdominal cavity, we decided to set the level of detail of concepts equal 2, so elements of no further than the second-level of nesting for a specific concept of diseases of the abdominal cavity will be selected.

2.3 Determining selection criteria for concepts

Ultrasonography is a comprehensive method of diagnosis, and is used a lot in the hospitals and diagnostic centers to identify a wide range of diseases: inflammation, abnormalities of development, focal masses, degenerative changes, tumors, etc. However, this method is helpless in the diagnosis of genetic diseases, autoimmune diseases, fermentopathy, lesions caused by medications, and many others. Chosen organs branches of the "disease" hierarchy of the SNOMED CT nomenclature comprises all diseases of those organs and are not suitable for interface terminology because of redundancy of included concepts.

SNOMED CT has the relationships between concepts of different hierarchies, but they are intended to clarify the definitions of concepts and none of them would be suitable for encoding of non-definitional 'pragmatic' knowledge such as the set of clinically plausible findings some ultrasound method might generate. Therefore, the relationship between findings and the procedures (in our case, Ultrasonography) should be specifically set. Resulting set of such relationships can vary depending on many factors: the type of the equipment used, the technique used and skills of a doctor.

Ultrasonography allows fully evaluation of the morphology of the organs. Therefore, the presence of pathology's relation with the morphology had been chosen as the criterion for selection of appropriate concepts. And as we analyse the diseases of organs, then relation should be pointing to abnormal morphology. It should be noted that the morphology is a structural concept and therefore refers to the "body structure" hierarchy. The relationship between terms of different hierarchies are called horizontal, and the selection criteria is called an attribute. Such a scheme can be shown graphically (Figure 1).

Thus, "associated morphology" (associated morphology) attribute chosen as the selection criterion is a key factor in finding necessary concepts and organizing the structure and logic of the interface terminology of abdominal ultrasonography pathologies.

2.4 Creating subset of concepts.

Following concepts, criteria, attributes, relationships and values needed to build interface terminology [4] of abdominal ultrasonography pathologies based on the SNOMED CT were identified during the analysis and design of methodology:

- hierarchy nodes that contain concepts of pathologies of the abdominal cavity ("disease of liver", "disease of spleen", etc.);
- concept's relation to the hierarchy - the relationship "is a" (vertical relationship);
- attribute showing the relationship of the pathology hierarchy concepts ("associated morphology") to abnormal morphology hierarchy concepts (horizontal relationship);
- value of the pathology hierarchy - abnormal morphology hierarchy relationship attribute;

The application of this approach and using of the proposed selection criteria has resulted in construction of table of the abdominal cavity pathologies, as well as table of morphological pathology types and their relation to a particular type of morphology.

2.5 Mapping from the subset to the set of terms already in use.

Mapping [5] of the set of pathologies of the abdominal cavity for an ultrasonography specialist was carried out jointly with the head of the ultrasonography department of Moscow City Oncologic Hospital № 62.

Selected terms from the SNOMED CT were localized in Russian for the mapping. Localization was performed using detailed medical dictionaries and considering possible synonyms in English.

The comparison of clinical set of pathology, and derived from the SNOMED CT set of pathology was performed. Analysis of these sets for the presence of matching pathology items showed that the derived set does not contain a number of terms of the clinical set (Table 1). This

Table 2: The final results of construction of the interface terminology of ultrasonography pathologies.

Organ examined	Number of complete match	Number of post-coordinated match	Total number of concepts
Hepatobiliary system	38	1	39
Spleen	15	3	18
Pancreas	9	5	14
Kidneys and adrenals	18	4	22
Total	80	13	93

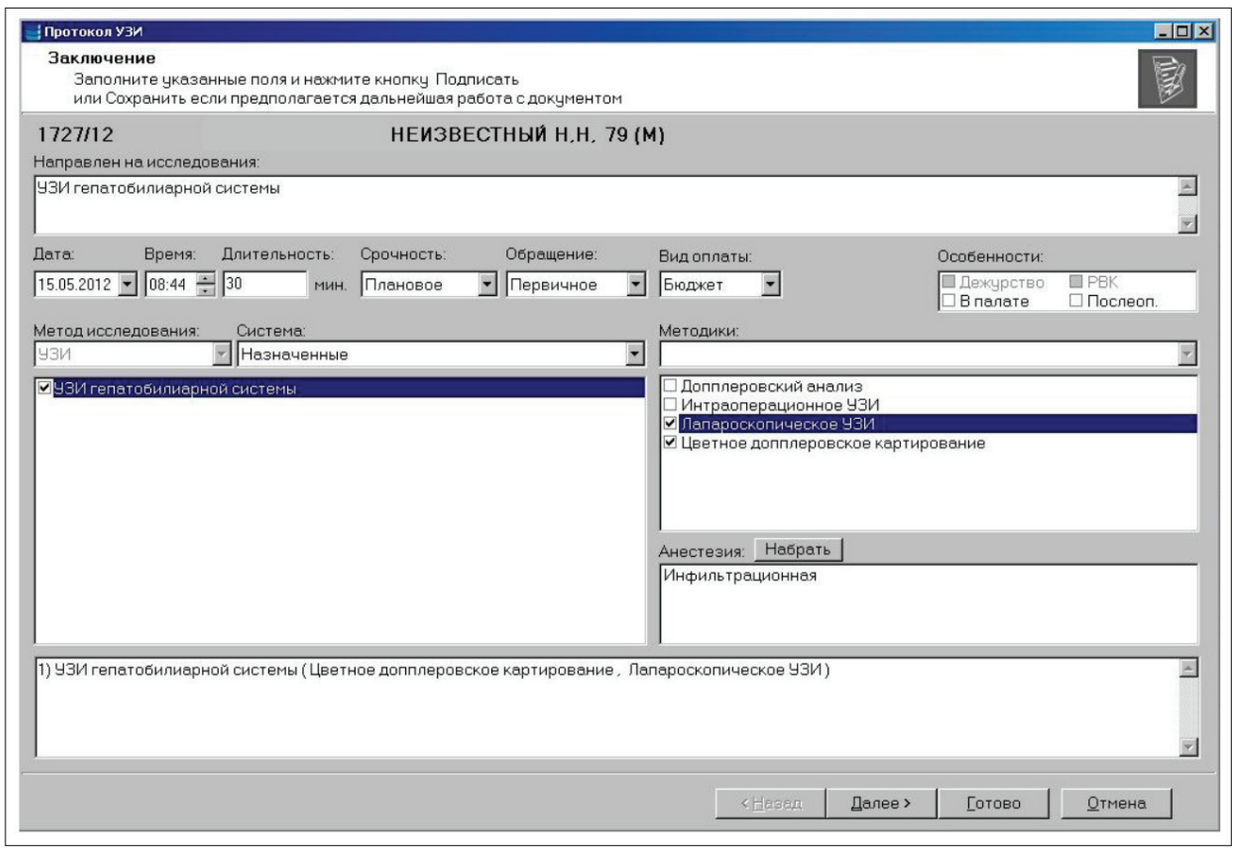

Figure 2: Description of the study performed.

can be explained by the specifics of ultrasound interpretation. Some ultrasonography results cannot be clearly described and therefore pathology cannot be clearly stated. None concepts for such specific terms were found in the SNOMED CT (e.g., a solid mass, a complex cyst).

One of the advantages of an interface terminology based on the SNOMED CT is the ability to include user-defined concepts, relations and conditions that do not exist in SNOMED CT into resulting subset. In this study such concepts constructed as post-coordinated concepts using concepts of SNOMED CT.

Eventually post-coordinated concepts were constructed for all unmapped pathology concepts (13 pathologies) which allowed us to obtain the final list of pathologies with 93 concepts.

Thus, all pathologies of the abdominal cavity were mapped. The total number of concepts is 93, which is by 82% more than the original clinical set of concepts. 80 concepts (86%) completely matched with the concepts of SNOMED CT, and for the remaining 13 (14%) post-coordinated concepts were constructed. The results of the analysis are presented in Table 2.

3 Implementation of interface terminology in the hospital information system

The implementation of the designed interface terminology was carried out on the basis of a specialized unit for ultrasonography specialist of hospital computerized information system (HIS) "Asclepius" deployed in one of Moscow hospitals (Moscow City Oncologic Hospital №

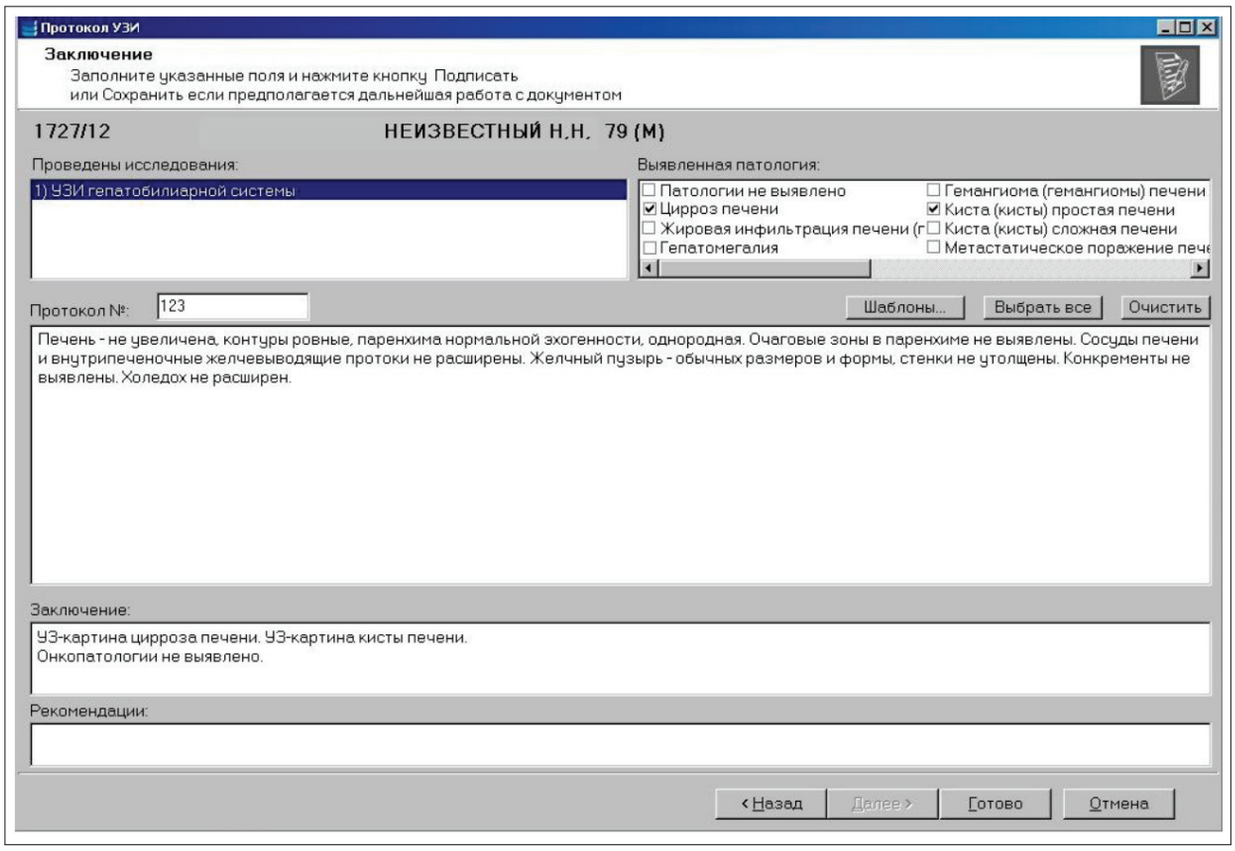

Figure 3: Automated construction of the conclusion of ultrasound study.

62).

Ultrasound - one of the most common tests in diagnostic medicine and studies of abdominal organs are more than two thirds of all the ultrasound studies. Ultrasound findings include a description of pathologies found. Various information systems provide the ability to document the pathology found in the form of coded values. But due to the lack of uniform terminology different concepts are used to describe the same pathology. A lack of common principles of coding of health information leads to difficulties of interpretation and automatic processing of ultrasound findings, as well as the inability to ensure interoperability.

Documentation of pathology found is a key point of the study. Therefore, quality control for the terminology used falls on the medical specialist performing the study. Considering that different clinicians use different terminology to describe the same medical concept, the interpretation of medical reports and automatic processing becomes more difficult. Therefore, coding of medical terms and automation of the construction of research reports are particularly important in the development of information technology in diagnostic medicine.

Functionality for constructing an automated ultrasound report was implemented in HIS "Asclepius", which includes two phases: the description of the study performed and making the conclusion of ultrasound study.

At the first stage medical specialist marks study performed, specifies the method of ultrasound (Doppler, color Doppler mapping, laparoscopic ultrasound, etc.), type of anesthesia (if done), and the date, time and duration of the study (see Figure 2).

At the second stage specialist marks pathology found (or indicates normal results) (see Figure 3). Built-in algorithm will lead to automated construction of the conclusion for the chosen pathology.

4 Results and discussion

Interface terminology of the ultrasonography pathologies of the abdominal cavity have been created as the result, which included 93 pathologies, 80 of which were unambiguously mapped with SNOMED CT concepts. In other words the efficiency of the SNOMED CT was 86%. For the remaining 13 pathologies post coordinated concepts were designed. Post-coordination was based on the concept model of SNOMED CT. The final interface terminology contains 82% more terms (from 51 to 93 terms) in comparison with the original.

Thus, a set of pathologies of the abdominal cavity is completely encoded in the codes of SNOMED CT international standard, allowing storing and sharing of encrypted clinical information between the various actors of health information space, and providing unambiguous information meaning for encoded values.

The developed algorithm for automated construction of the ultrasonography conclusion using SNOMED CT allows controlled using of the terminology, reducing medical errors, eliminating not-formalized medical information not suitable for interpretation and analysis.

Using of SNOMED CT as a standard for constructing medical terminology would allow the exchange of "understandable" information between different information systems, which is the basis to ensure their interoperability. This, in turn, is a key aspect in the further development and improvement of information technology in health care.

5 Conclusions

SNOMED CT has shown high efficiency in the encoding of specialized clinical terminology. The methodology used allowed us to extract the necessary terms for a given domain. We plan to continue our work to create various interface terminologies of pathologies based on SNOMED CT for other study methods.

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