Data integration in cardiac electrophysiology ablation toward achieving proper interoperability in health information systems

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Abstract:

INTRODUCTION: Providing information exchange and collaboration between isolated information systems (ISs) is essential in the healthcare environments. In this context, we aimed to develop a communication protocol to facilitate better interoperability among electrophysiology study (EPS)-related ISs in order to allow exchange unified reporting in EPS ablation.

MATERIALS AND METHODS: This study was an applied-descriptive research that was conducted in 2019. To determine the information content of agreed cardiac EPS Minimum Data Set (MDS) in Iran, the medical record of patients undergoing EPS ablation procedure in the Tehran Heart Center (THC) hospital was reviewed by a checklist. Then, an information model based on Health Level Seven, Clinical Document Architecture (HL7 CDA) standard framework for structural interoperability has been developed. In this framework, using NPEX online browser and MindMaple software, a set of terminology mapping rules was used for consistent transfer of data between various ISs.

RESULTS: The information content of each data field was introduced into the heading and body sections of HL7 CDA document using Systematized Nomenclature of Medicine – Clinical Terminology names and codes. Then, the ontology alignment was designed in the form of thesaurus mapping routes.

CONCLUSION: The sensitive, complex, and multidimensional nature of cardiovascular conditions requires special attention to the interoperability of ISs. Designing customized communication protocols plays an important role in improving the interoperability, and they are compatible with the needs of future Iranian health information exchange.

Keywords: Cardiac ablation, communication protocol, electrophysiology study, HL7 CDA, interoperability, terminology mapping

Introduction

Interoperability addresses the interconnection between information systems (ISs) to provide meaningful sharing of information.1 Indeed, interoperability is indispensable in healthcare ISs (HISs) allowing their collaboration through data exchange so that valuable information is available everywhere and at any time to support treatment and monitoring of inhabitants’ health.2 HISs have different architectures, standards, and technical infrastructures. HISs work independently and do not have a uniform data structure: each software product has its individual application programs, platform, contents, and formats.3 In this context, sharing health information is impeded, and consequently, heterogeneous HISs in each individual organization occur, leading to data redundancy and rework.4

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The need to exchange information between different HISs has emerged in recent years in Iran. The lack of interoperability and fragmentation of information are also some of the most important barriers to E-health acceptance in Iran government.\cite{5,6} Given that Iran has decided to implement electronic health record (EHR), an obstacle to the widespread adoption of EHR systems is the difficulty associated with capturing structured clinical information from health-care providers who desire to document clinical notes using “free text” natural language.\cite{7}

Designing a communication protocol is a key factor toward achieving interoperability. Two main components in communication protocols include syntactic (determining the structure and ordering of data bits of messages) and semantic (defining the semantics of data bits of messages) rules.\cite{8,9} In other words, homogeneous terminology and capturing structured data are a precondition to interoperability and exchanging health-care information.\cite{10} Consideration of the interoperability for creating an integrated network of systems is one of the most important requirements to achieve a comprehensive system of monitoring and controlling heart conditions.\cite{11} The complex, sensitive, and multidimensional nature of cardiovascular conditions requires the involvement of multidisciplinary teams from different organizations. In addition, it is vital to establish multilateral and network communications, sophisticated analytics, advanced multidimensional modeling of information, and create the maximum interoperability.\cite{8,12}

Heart diseases are a major contributor to disability and mortality in human societies. Arrhythmia is a cardiovascular disease and a common clinical problem. Currently, electrophysiology study (EPS) ablation is the first or second line for the treatment of various cardiac arrhythmias. This procedure has a remarkably high success rate and can enhance the patient’s quality of life to a large extent.\cite{13-17} Thus, it is necessary to standardize reporting and create exchange protocol of EPS ablation information. To tackle this issue, the present study proposes a communication protocol to drive interoperability among ISs involved in EPS ablation procedure.

Materials and Methods

This study was an applied-descriptive research that was conducted in 2019. The minimum data set (MDS) of cardiac electrophysiology interventions has already been designed using a combination of literature review and expert consensus approach.\cite{18} To determine the information content of developed MDS, the medical record of patients undergoing EPS ablation in the Tehran Heart Center (THC) was reviewed by a checklist. Then, the information content was coded using selected classification or nomenclature systems. For this purpose, printed coding systems and online terminology browser (e.g., SNOMED-CT) were used. After assigning codes, their validity and reliability were evaluated by two health information management specialists who had more than 5 years of work experience in disease coding units. Further, the external agreement method was used for re-coding the information content and comparing the primary codes with secondary codes.

In the next step, all scattered codes were mapped to integrated codes in the Systematized Nomenclature of Medicine–Clinical Terminology (SNOMED-CT) reference nomenclature system using Mind Maple software (Java software developer organization). This software is a graphic user interface to define ontologies that represent ideas, concepts, and objects in a graphical way.\cite{19}

Finally, integrated SNOMED-CT codes were structured into CDA standard framework in order to provide structural interoperability. The CDA form was proposed as an optimal and consistent structure for transferring information in comprehensive health information exchange infrastructure of Iran.\cite{20} Accordingly, all SNOMED-CT reference codes and terms were structured in the form of CDA body and title. Finally, the Extensive MarkUp Language (XML) rules were defined, and the final communication protocol was prepared.

Results

Defining the information content

The developed MDS of EPS ablation was divided into nonclinical and clinical data sections, 12 data classes and 61 data fields. The real information content was defined for each data element.

Coding the information content

The information content was coded using selected classification and nomenclature systems as follows: International Classification of Disease–tenth Revision (ICD-10) or its Clinical Modification version (ICD-10-CM), International Classification of Functioning, Disability and Health (ICF), Normalized Notations for Clinical Drug (RxNORM), Logical Observation Identifiers Names and Codes (LOINC), Ninth Revision, Clinical Modification (ICD-9-CM), Diagnostic and Statistical Manual of Mental Disorders (DSM), and Read Code Classification (RCC). The SNOMED-CT covered all these terms and codes.
Evaluating the validity and reliability of codes
The evaluation of validity and reliability of codes was done through external agreement showed that from two information categories, 14 information classes, 61 data fields, 65 preference codes, and 65 reference codes (SNOMED-CT), there were 55 similarities between the initial and secondary codes (code matching), three significant differences between the initial and secondary codes, and seven minor differences (decimal level) between the primary and secondary codes. All differences between the codes were ignored at decimal level. Thus, only significant differences were the basis for evaluating the final reliability between the primary and secondary codes. Table 1 reports these differences along with the results of their final reliability assessment.

Thesaurus mapping
The general paths of mapping from the preferred thesaurus onto the reference terminology include (1) mapping administrative information onto RCC; (2) mapping disease and problem situation to ICD-10 or ICD-10-CM; (3) mapping medication terms onto RxNORM; (4) health and welfare situation mapping to ICF; (5) mapping diagnostic, medical, and surgical procedures to ICD-9-CM; (6) mapping laboratory and evaluative measures onto LOINC; and (7) mapping mental situation to DSM codes. Finally, all preferred codes are mapped to the SNOMED-CT reference codes or names [Figure 1].

Tables 2 and 3 list the data sections, data classes, data fields and their content, data field format and values, preferred codes, and reference SNOMED-CT code.

SNOMED-CT has an excellent coverage of EPS MDS, and the result of the study showed that mapping was successful by defining all scattered codes into the SNOMED-CT unit code or term.

After normalizing the information content by integrating SNOMED-CT normal names and codes, they were structured in standard formats. The HL7 CDA standard was employed for standardization of the message structure [Table 4].

Discussion
In this study, we have presented an extension to a previously developed MDS of cardiac electrophysiology to allow for the exchange of EPS-related data among different ISs. The use of coordinated and agreed communication protocols can help overcome the challenge of data exchange between health ISs. However, there has been little progress in computerization of EPS-associated ISs. Determining data fields, normalizing their content, ontology mapping, defining field formats, and integrating the message template structure are fundamental steps toward effective interoperability.

The growing use of E-health technologies increases the attention to semantic interoperability. Semantic interoperability is related to unified, coordinated, consistent, unambiguous, and semantic harmonization of information for all systems and users. EHR semantic interoperability is urgently needed for systems to improve health-care quality. Semantic interoperability consists of metadata, value set defining, data format, data rules, and the terminology binding. Thesaurus mapping is a technical function for data integration through transformation of multiple terms into a unified term or code. Indeed, mapping can be used as a means for representing the ontology domain contributing to achievement of semantic interoperability. SNOMED-CT has been proposed as reference terminology for Iranian EHR (SEPASS project) interoperability. The use of this terminology will enhance the data quality criteria. The present study used the selected classifications or nomenclatures to normalize EPS ablation data; finally, all contents were integrated into the SNOMED-CT unique codes.

Syntactic interoperability means that the data collection and validation processes are integrated into consistent message frameworks. Reference models, XML-based CDA, reference model of classes and archetypes, distinct ontologies, terminology mapping, and use of reference archetypes for exchanging documents have been introduced as a component of the messaging standards for EHR in Iran.

The SNOMED-CT standard lexicon and HL7 CDA framework have been suggested for Iran’s E-Health. Accordingly, in this study, the content of data fields was integrated through preferred

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Table 1: Assessment of reliability codes

| Category       | Information class       | Data element            | Information (record) content             | Coding system | Primary code | Secondary code | Final evaluation |
|----------------|-------------------------|-------------------------|------------------------------------------|---------------|--------------|----------------|-----------------|
| Clinical       | Diagnostic/problems     | Final diagnosis         | Systolic heart failure stage D           | ICD10         | 152.9        | 150.0          | 150.0           |
| Clinical       | Heart conduction status | Ventricular tachycardia | Recurrent ventricular tachycardia         | ICD10         | 140.8        | 147.2          | 147.2           |
| Clinical       | Laboratory              | Diagnostic procedure    | Electronic Cardiogram (ECG)              | LOINC        | 34537-9      | 34534-8        | 34534-8         |

Figure 1: Triple mapping routes by MindMaple
classification or nomenclature systems for local purposes, followed by mapping into SNOMED-CT reference codes and names in order to achieve the macro levels of interoperability.

Slotwiner et al. developed a cardiac implantable electronic devices protocol and defined syntactic as well as semantic interoperability requirements including controlled vocabulary, specification of data element, agreement on data management framework, and structured reporting.[9] The cardiac electrophysiology experiment protocol for data sharing interoperability in the Quinn et al. study includes (1) use of standard templates, (2) codification of reporting, (3) proposal of a draft for Minimum Information about a Cardiac Electrophysiology Experiment, (4) content normalization through metadata, data dictionary, and classification, (5) synchronization of data flow models through mapping, and (6) adoption of message standards.[11] van der Velde et al. integrated data from remote monitoring systems into the hospital EHR system based on HL7/XML communication protocol.[33] The present study defined the information patterns for EPS ablation information exchange in CDA XML standard format.

Our study method had four major strengths. First of all, we derived the core data elements based on expert consensus through rigorous qualitative analysis. In addition, the data field format, content format, and preferred codes were determined for local uses. Second, we also mapped the data elements from different clinical terminologies to unique SNOMED-CT reference codes. The adoption of standard nomenclature such as

| Table 2: Nonclinical minimum data set description for information exchange of cardiac electrophysiology interventions |
|---------------------------------------------------------------|
| **Data classes/items**                                      | **Case sample** | **Response format** | **Vocab code** | **Preferred codes** | **References code** |
| Demographic                                                |                |                    |                |                    |                    |
| Name, Surname                                              | Entity name    | String             | RCC            | XaLva               | 371484003          |
| Father name                                                | Entity name    | String             | RCC            | XaLvs               | 371484008          |
| Physician name                                             | Entity name    | String             | RCC            | XaLvx               | 371484012          |
| Birthdate                                                  | yyyy/mm/dd     | Integer            | RCC            | 9155                | 184099003          |
| Age                                                        | 52 y           | Integer            | RCC            | X24Ai               | 28288005           |
| Place of birth                                             | Geographical location | String   | RCC            | XaG3t               | 315446000          |
| Gender                                                     | Female         | Binary             | RCC            | X768C               | 248152002          |
| Marital status                                             | Married        | Categorical        | RCC            | XEOoa               | 87915002           |
| Single                                                     |                |                    |                |                    |                    |
| Married                                                    |                |                    |                |                    |                    |
| Widow                                                      |                |                    |                |                    |                    |
| Other                                                      |                |                    |                |                    |                    |
| Education level                                            | Diploma        | Categorical        | RCC            | 13Z46               | 342341000000108    |
| Illiterate                                                 |                |                    |                |                    |                    |
| Under diploma                                              |                |                    |                |                    |                    |
| Diploma                                                    |                |                    |                |                    |                    |
| Bachelor                                                   |                |                    |                |                    |                    |
| Master of science or above                                 |                |                    |                |                    |                    |
| Unspecified                                                |                |                    |                |                    |                    |
| Identifier number                                          |                |                    |                |                    |                    |
| Medical Record Number                                      | xx-xx-xx       | Numerical           | RCC            | Xn73J               | 398225001          |
| National ID number                                         | XXX-XXXXXXX-X  | Numerical           | RCC            | XE2Hj               | 422549004          |
| Physician ID                                               | XX XXXX - XX   | Numerical           | RCC            | Xn21JE              | 118522005          |
| Insurance ID                                               | XXXX XXXX      | Numerical           | RCC            | XE2Hj               | 456281000000100    |
| Contact information                                        |                |                    |                |                    |                    |
| Postal code                                                | xxxxx-xxxxxxx  | Numerical           | RCC            | 9158                | 184102003          |
| Home address                                               | Province-city-street-alley-house no | String | RCC | XaDvP | 184097001 |
| Phone number                                               | (+98 xxx-xxx-xxxx) | Number     | RCC            | XaZ4q               | 824551000000105    |
| Patient disposition                                        |                |                    |                |                    |                    |
| Admission type                                             | Admission to community hospital | String | RCC | XaAmr | 305337004 |
| Admission date                                             | yyyy/mm/dd     | Integer            | RCC            | Xa0ck               | 399423000          |
| Discharge type                                             | Discharge by physician | String | RCC | XaAij | 306416004 |
| Discharge date                                             | yyyy/mm/dd     | Integer            | RCC            | Xa0ck               | 442684001          |
| Discharge status                                           | Discharge to home | String   | RCC            | XaApt               | 306689006          |

and classification, (5) synchronization of data flow models through mapping, and (6) adoption of message standards.[11] van der Velde et al. integrated data from remote monitoring systems into the hospital EHR system based on HL7/XML communication protocol.[33] The present study defined the information patterns for EPS ablation information exchange in CDA XML standard format.
Table 3: Clinical MDS description for the information exchange of cardiac electrophysiology interventions

| Data classes/items                          | Case sample          | Response format | Vocab code | Preferred codes | References code |
|---------------------------------------------|----------------------|-----------------|------------|-----------------|-----------------|
| Diagnostic/problems                         |                      |                 |            |                 |                 |
| Primary diagnosis                           | Functional heartburn | String          | ICD10      | R12             | 722876002       |
| Sign and symptom                            | Paroxysmal nocturnal | String          | ICD10      | R06.0           | 55442000       |
|                                              | dyspnea              |                 |            | R00.2           | 80313002       |
| Palpitations                                |                      |                 |            |                 |                 |
| Chief Compliant                             | Chest pain at rest   | String          | ICD10      | R07.3           | 9267009        |
| Final diagnosis                             | Systolic heart failure| String          | ICD10      | I50.0           | 120851000119104|
| Comorbidities                               | Diabetes mellitus type 1 | String | ICD10 | E10.6 | 46635009 |
| Past medical History                        |                      |                 |            |                 |                 |
| Non cardiovascular personal history          | Phx of diabetes mellitus type 1 | String | ICD10 | Z86.3 | 472970003 |
|                                              | Phx of urinary stone |                  |            | Z87.4           | 161548009      |
| Cardiovascular personal history             | Phx angina pectoris  | String          | ICD10      | Z86.7           | 161504004      |
| Cardiovascular Familial History             | No FHx of cardiovascular disease | String | RCC | 115451 | 160270001 |
| Non-Cardiovascular Familial History         | FHx of neoplasm of lung | String | ICD10 | Z80.1 | 297247000 |
| Personal history of cardiovascular procedures (Invasive or non- invasive) | No history of procedure | String | RCC | ZVu3S | 416128008 |
| Personal history of non-cardiovascular procedures (Invasive or non- invasive) | Extracorporeal Shock Wave Lithotripsy (ESWL) of the kidney | String | ICD9 CM | 98.51 | 24376003 |
| Personal history of drug treatment          | Tamsulosin           | String          | Rx NORM    | C0257343 | 372509005 |
|                                              | Insulin lispro       |                  |            | C0043031       | 372756006      |
| Social history                              | Social exclusion     | String          | ICD10CM    | Z60.4          | 105412007      |
| Physical Examination                        |                      |                 |            |                 |                 |
| Heart rate                                  | Normal heart rate    | Categorical     | RCC        | Xa7s1          | 76863003       |
| Blood pressure                              | Normal systolic blood pressure, 120-129 mm Hg | Categorical | RCC | Ua1FM | 2004005 |
|                                              | Maximum diastolic blood pressure, x >90 mm Hg |                  |            | XaF4R          | 314452008      |
| Heart murmur                                | Functional heart murmur | Binary | ICD10 | R01.0 | 59935001 |
| Yes                                           |                      |                 |            |                 |                 |
| Waist circumference                         | Measurement of waist circumference declined, <35 inch. | Categorical | RCC | Xa041 | 698484006 |
| <35 inches, 35-40 inches , >41 inches, Unknown |                      |                 |            |                 |                 |
| Lung (pulmonary) examination                | Superficial crackling rales | Categorical | ICD10 | R09.8 | 63642005 |
| Clear or normal, Rales, Decreased breath sounds or dullness, Rhonchi, Wheezing | Constant wheezing |                  |            | R06.2          | 86731100000104 |
| BMI level                                    | Body Mass Index 25-29 | Categorical     | ICD10      | E66.9          | 162863004      |
| <18.5 kg/m², 18.5-24.9 kg/m², 25-29.9 kg/m², >30 kg/m², Unknown |                      |                 |            |                 |                 |
| LAB test                                     | Complete Blood Count (CBC) | String | LOINC | 24317-0 | 26604007 |
| Routine tests name                          | Brain Natriuretic Peptide measurement (BNP) | String | LOINC | 30934-4 | 390917008 |
| Specialized tests name                      |                      |                 |            |                 |                 |
| Test date                                    | yyyy/mm/dd           | Integer         | RCC        | Xa0ck          | 804081000000104|
| Test result/interpretation                  | Primary hypercholesterolemia | String | ICD10 | E78.0 | 238076009 |
| Heart conduction status                     |                      |                 |            |                 |                 |

Contd...
Table 3: Contd...

| Data classes/items                  | Case sample                      | Response format | Vocab code | Preferred codes | References code |
|-------------------------------------|----------------------------------|-----------------|------------|-----------------|-----------------|
| Sinus node function                 | Normal sinus rhythm              | Categorical     | RCC        | X76Jd           | 647300000       |
| Normal sinus rhythm                 |                                 |                 |            |                 |                 |
| Sinus arrhythmia                    |                                 |                 |            |                 |                 |
| Sinus bradycardia                   |                                 |                 |            |                 |                 |
| Sinus arrest                        |                                 |                 |            |                 |                 |
| Sinus node dysfunction              |                                 |                 |            |                 |                 |
| Sick sinus syndrome                 |                                 |                 |            |                 |                 |
| Atrioventricular (AV) conduction    |                                 | Categorical     | ICD10      | I44.7           | 418341009       |
| Normal AV conduction                |                                 |                 |            |                 |                 |
| Short PR interval                   |                                 |                 |            |                 |                 |
| AV block                            |                                 |                 |            |                 |                 |
| AV abnormality following surgery    |                                 |                 |            |                 |                 |
| Congenital complete heart block     |                                 |                 |            |                 |                 |
| Isorhythmic dissociation            |                                 |                 |            |                 |                 |
| Paroxysmal AV block                 |                                 |                 |            |                 |                 |
| Pre-excitation (Delta wave)         |                                 |                 |            |                 |                 |
| Intraventricular (IV) conduction    | Bundle -Branch Block (BBB)      | Categorical     | ICD10      | I45.4           | 6374002         |
| Normal                              |                                 |                 |            |                 |                 |
| Left anterior/posterior fascicular block |                     |                 |            |                 |                 |
| Bundle -Branch Block (BBB)          |                                 |                 |            |                 |                 |
| Intraventricular conduction delay   |                                 |                 |            |                 |                 |
| IV conduction abnormality following surgery |             |                 |            |                 |                 |
| Supraventricular tachycardia (SVT)  | Supraventricular tachycardia with functional bundle branch block | Categorical | ICD10      | I47.1           | 233900001       |
| Normal                              |                                 |                 |            |                 |                 |
| Atrial tachycardia (AT)             |                                 |                 |            |                 |                 |
| Atrial fibrillation (AF)            |                                 |                 |            |                 |                 |
| Sinus tachycardia (ST)              |                                 |                 |            |                 |                 |
| Inappropriate ST                    |                                 |                 |            |                 |                 |
| Postural orthostatic tachycardia    |                                 |                 |            |                 |                 |
| AV node re-entry                    |                                 |                 |            |                 |                 |
| Junctional tachycardia              |                                 |                 |            |                 |                 |
| Ventricular tachycardia (VT)        | Recurrent ventricular tachycardia| Categorical     | ICD10      | I47.2           | 708124001       |
| Normal                              |                                 |                 |            |                 |                 |
| Recurrent                           |                                 |                 |            |                 |                 |
| Persistent                          |                                 |                 |            |                 |                 |
| Paroxysmal                          |                                 |                 |            |                 |                 |
| Incessant                           |                                 |                 |            |                 |                 |
| Ablation procedure                  | Stroke prophylaxis               | Categorical     | RCC        | XaINu           | 135875009       |
| Indication of catheter ablation     |                                 |                 |            |                 |                 |
| Symptoms reduction                  |                                 |                 |            |                 |                 |
| Desire for drug-free life style     |                                 |                 |            |                 |                 |
| Stroke prophylaxis                  |                                 |                 |            |                 |                 |
| Sudden death prophylaxis            |                                 |                 |            |                 |                 |
| Frequent ICD discharges              |                                 |                 |            |                 |                 |
| Other                               |                                 |                 |            |                 |                 |
| Sedation type                       | Induction of deep sedation       | Categorical     | RCC        | X70q9           | 426155000       |
| Minimal Sedation                    |                                 |                 |            |                 |                 |
| Moderate Sedation                   |                                 |                 |            |                 |                 |
| Deep sedation                       |                                 |                 |            |                 |                 |
| General Anesthesia                  |                                 |                 |            |                 |                 |
| Other                               |                                 |                 |            |                 |                 |

Contd...
Table 3: Contd...

| Data classes/items          | Case sample                  | Response format | Vocab code | Preferred codes | References code |
|-----------------------------|------------------------------|-----------------|------------|----------------|-----------------|
| Target of ablation          | Ablation of atrioventricular node | Categorical    | RCC        | 428663009       |                 |
| Pulmonary Vein Isolation    |                              |                 |            |                |                 |
| Surgical Ablation           |                              |                 |            |                |                 |
| Ablation of the atrioventricular node |                  |                 |            |                |                 |
| Ablation of Supraventricular tachycardia’s |                  |                 |            |                |                 |
| Ablation of Ventricular Tachycardia |                  |                 |            |                |                 |
| Other                       |                              |                 |            |                |                 |
| Source of energy            | Open irrigation radiofrequency ablation operation for arrhythmia | Categorical    | RCC        | X011d          | 233163003       |
| Non- irrigated Radiofrequency |                              |                 |            |                |                 |
| Radiofrequency with closed irrigation |                  |                 |            |                |                 |
| Radiofrequency with open irrigation |                  |                 |            |                |                 |
| Ultrasound ablation         |                              |                 |            |                |                 |
| Microwave ablation          |                              |                 |            |                |                 |
| Laser balloon               |                              |                 |            |                |                 |
| Cry thermal ablation        |                              |                 |            |                |                 |
| Duty‑cyded Radiofrequency energy |                  |                 |            |                |                 |
| Other                       |                              |                 |            |                |                 |
| Drug Prescription           | Di... | String | Rx | C0025854 | 387461009 |
| Current Prescription        | Drug allergy | Binary | ICD10 | Z88.8 | 416098002 |
| Allergy/adverse effects     |                              |                 |            |                |                 |
| Yes No                      |                              |                 |            |                |                 |
| Com... | Allergy to antibiotic | String | ICD10 | Z88.1 | 109991000119100 |
| Compliance assessment       | Drugs - partial non-compliance | Binary | ICD10CM | Z91.12 | 275928001 |
| Administration Route        | Oral form | Categorical | RCC | XalJ | 26643006 |
| I. Post procedure complication | No complication | Binary | RCC | X0006 | 88797001 |
| Minor complication          |                              |                 |            |                |                 |
| Yes No                      |                              |                 |            |                |                 |
| Major complication          | Complication associated with cardiac implant | Binary | ICD10 | T82.1 | 473036007 |
| Yes No                      |                              |                 |            |                |                 |
| Complication name           | Infective endocarditis as complication of ablation | String | ICD10 | T82.7 | 461416009 |

ESWL=Extracorporeal shock wave lithotripsy, CBC=Complete blood count, BNP=Brain natriuretic peptide, AV=Atrioventricular, IV=Intraventricular, BBB=Bundle branch block, SVT=Supraventricular tachycardia, AT=Atrial tachycardia, AF=Atrial fibrillation, ST=Sinus tachycardia, VT=Ventricular tachycardia, ICD-10=International Classification of Disease-Tenth Revision, PR=P wave Rate, BMI=Body mass index, LOINC=Logical Observation Identifiers Names and Codes

SNOMED-CT is suggested for the EHR as it captures clinical information at the level of details required by clinicians for the provision of care in most health-care disciplines and settings.[7] Furthermore, we leveraged HL7 CDA, functioning as a standard for the exchange of clinical documents, which should be readable by computers and humans. Finally, this study presented a practical model of real presentation of information exchange communication protocol for EPS ablation. Nevertheless, this work had a basic limitation due to the lack of comprehensive and systematic information exchange infrastructure in Iran’s health system; therefore, it was not possible to implement and evaluate the proposed protocol. Further research is suggested to improve the interoperability, hoping to implement a comprehensive and interoperable E-health system for Iran.

**Conclusion**

Interoperability leads to a common understanding and subsequently optimal use of information. Customized communication protocols are a way to achieve interoperability between health ISs. The complex and multidimensional aspects of cardiovascular diseases and their increasing prevalence in human societies have doubled the need for the use of interoperable information exchange infrastructures. Sharing the data of cardiac electrophysiology interventions (EPS ablation and device implantation) is categorized into two major classes including communication: (1) between implantable...
Table 4: HL7 CDA framework for information exchange of cardiac electrophysiology interventions

Document heading
- Doc title: Cardiac electrophysiology interventions information exchange
- Doc author: Physician
- Doc custodian: Tehran heart center
- Doc receiver: Iranian ministry of health (SEPASS project)
- Doc target: Interoperable EPS consistent reporting
- Doc date of creation: September 2, 2018
- Doc content standard: SNOMED-CT

Document body - administrative

Demographical information
- Patient name: Zohreh Jamshidi
- Sex: 248152002
- Age: 28288005
- Date of birth: October 01, 1964

Socioeconomically information
- Education level: 342341000000108
- Religion: 28010004
- Nationality/race: 297553001

Contact information
- Phone number: +98 912 xxxxx
- Postal code: 57896‑23511

Identification information
- Patient identifier (National ID): 011‑52148‑2
- Medical record number: 02‑29‑01
- Insurance ID: 44785233

Patient disposition
- Admission type: 305337004
- Admission date: August 21, 2018
- Discharge type: 306416004
- Discharge status: 306689006
- Discharge date: August 24, 2018

Document body - clinical

Diagnosis/problem
- Primary diagnosis: 722876002
- Final diagnosis: 120851000119104
- Chief compliant: 9267009
- Comorbidities: 46635009

Past medical history
- Cardiovascular personal history: 161504004
- Noncardiovascular personal history: 472970003, 161548009
- Cardiovascular familial history: 160270001
- Noncardiovascular familial history: 297247000
- Personal history of cardiovascular procedures: 416128008
- Personal history of noncardiovascular procedures: 24376003

Physical examination
- Heart rate: 76863003
- Blood pressure: 2004005, 314452008
- Heart murmur: 59935001
- Waist circumference: 698484006
- Lung (pulmonary) examination: 63642005, 867311000000104
- BMI level: 16286300

Laboratory test
- Routine tests name: 26604007
- Specialized tests name: 390917008
- Test date: August 23, 2018
- Test result/interpretation: 238076009

Heart conduction status
- Sinus node function: 64730000
- AV conduction: 418341009
- IV conduction: 6374002
- SVT: 23390001 VT: 708124001

Ablation procedure
- Indication of catheter ablation: 135875009
- Sedation type: 426155000T
- Target of ablation: 428663009
- Source of energy: 233163003

Prescription
- Current Rx: 387461009
- Allergy/adverse effects: 416098002
- Compliance assessment: 275928001
- Withdrawal cause: 224973000
- Administration route: 26643006

Complication
- Minor/major complication: 473036007
- Complication name: 461416009, 762667005

SNOMED-CT = Systematized Nomenclature of Medicine - clinical terminology,
AV = Atrioventricular, IV = Intraventricular, SVT = Supraventricular tachycardia,
VT = Ventricular tachycardia, EPS = Electrophysiology study, BMI = Body mass index

devices and ISs and (2) across various ISs. In addition, the design of communication protocols is categorized into two dimensions: information and technical protocols. In this study, we mapped EPS data elements to a coding system and HL7 CDA template. Further research is required to investigate the information and technical requirements for exchange of information between implanted intracardiac devices and ISs. The technical aspects of communication protocols also warrant further research.

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Conflicts of interest
There are no conflicts of interest.

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