MEDINFO 2013
C.U. Lehmann et al. (Eds.)

doi:10.3233/978-1-61499-289-9-244

Early Experiences from a Guideline-based Computerized Clinical Decision Support for Stroke Prevention in Atrial Fibrillation

Rong Chen MD PhD [a,b], Carlos Valladares MD [c], Iago Corbal [b,d], Nadim Anani [a], Sabine Koch PhD [a]

[a] *Health Informatics Centre, LIME, Karolinska Institutet, Sweden*
[b] *Cambio Healthcare Systems, Sweden*
[c] *Cardiology Department, Linköping University Hospital, Sweden*
[d] *Institute of Biomedical Research of A Coruña (INIBIC), Spain*

Abstract

Atrial fibrillation (AF) affects 1-2% of the population. Twenty percent of all strokes are caused by AF. In this study, we represented the clinical knowledge in the European Society of Cardiology guideline using Guideline Definition Language (GDL), a format that binds openEHR archetypes, rule languages, and reference terminologies together. The computerized guidelines are applied to electronic health record (EHR) data retrospectively in order to identify possible gaps between current clinical practice and optimal care recommended by the evidence-based guidelines. Treatment compliance is checked in two patient groups: one received treatment from a cardiologist who is responsible for AF treatment in the region (n=514) and the other was a much larger patient group from the whole region (n=8130). The compliance checking shows the cardiologist group has substantially higher percentage of compliant treatment compared with that of the general population group. Based on this important finding, we are now implementing at-point-of-care clinical decision support reusing the same computerized guideline knowledge in GDL format in order to increase the guideline adherence of the treatment.

Keywords:

Clinical Decision Support Systems, Computerized Guidelines, Electronic Health Record, openEHR Archetypes, Guideline Definition Language, Atrial Fibrillation, Stroke.

Introduction

Atrial fibrillation (AF) affects 1-2% of the population. Twenty percent of all strokes are caused by AF and strokes caused by AF are more severe than strokes caused by other reasons [1]. CHA2DS2-VASc is a risk assessment scheme for predicting stroke risks in AF patients and the acronym stands for cardiac failure, hypertension, age ≥75 (doubled), diabetes, stroke (doubled),vascular disease, age 65–74 ,and sex category (i.e. female) [2]. The European Society of Cardiology (ESC) has published a series of guidelines for the management of atrial fibrillation. The latest version comprises the full version published in 2010 [3] and an update published in 2012[4]. In this update, CHA2DS2-VASc is recommended as a means of assessing stroke risks in non-valvular AF. Based on the CHA2DS2-VASc of the patient, a recommendation about antithrombotic therapy is given. Such recommendations are the highest class of recommendations with the strongest evidence in evidence-based guidelines.

Östergötland County is a county in southeast Sweden with roughly 400 thousand inhabitants. The healthcare is documented by the County Council of Östergötland through a single regional electronic health record (EHR) system, Cambio COSMIC, covering both a university hospital and primary care centres in the region. In other words, the patient record is always accessible anywhere in the region regardless of whether the patient meets a specialist at the university hospital or a primary care doctor at one of the primary care centres since it is the same EHR system they are using. One of the authors (CV) is the responsible cardiologist for atrial fibrillation in the region. He follows the relevant clinical guidelines published by ESC and tries to disseminate this knowledge to his colleagues (both general practitioners and non-cardiology specialists) through written practical instructions in Swedish language and workshops. However, CV observes a gap between clinical practice and guideline recommendations and acknowledges the undertreatment of AF patients in the region. Exact figures about guideline non-compliance as well as effective means to disseminate guideline knowledge are, however, lacking.

The aim of this study is to find a way to represent clinical knowledge related to stroke prevention in AF in a formal way in order to quantify the clinical gaps of the current practice in terms of non-compliance to the published guidelines. Furthermore, we aim to apply the computerized guidelines at the point of care as clinical decision support (CDS) to reduce non-compliant treatment. The ultimate clinical goal is to increase efficacy of stroke prevention in AF thus reducing stroke incidents in the region.

Methods

The source of the clinical knowledge was the ESC guidelines for the management of atrial fibrillation published in 2010 [3] and the focused update published in 2012 [4]. CV provided necessary clinical guidance in this work by identifying relevant parts of the guideline and interpreting the narrative text in the document.

The openEHR Clinical Knowledge Manager [5] was browsed and searched for archetypes necessary for representing the guidelines. A number of guidelines based on the knowledge from the guideline document were authored by RC and IC in GDL by using a GUI-based user-friendly guideline authoring

tool. The guidelines were simulated in an interactive way to get a first iteration of verification. They were continuously modified until sufficient quality was achieved. Necessary terminology bindings required for matching drug names and diagnostic codes were identified and verified by CV.

The study is a retrospective (two-armed) cohort study. Two AF patient groups were used for compliance checking in this study. The first AF group consisted of 514 patients; all treated by a cardiologist specialist (CV) and registered in the quality register AURICULA**.** The second group comprised all AF patients registered in the regional EHR (identified by relevant ICD10 codes for AF) during 2011 and consisted of 8130 patients. The second group includes the first patient group. Patient data from both patient groups were anonymised. For each group, demographic information, diagnosis list, and medication list were retrieved in order to perform compliance checking. Due to time constraints, patient data of CV's patient group in the quality register were used instead of those in the EHR. Since the patient data were originated from the regional EHR system, they should be identical to the data in the quality register. Also worthy to note is that the general population patient group is a superset of the CV's patient group. These patient data were then transformed into the openEHR Reference Model format to facilitate compliance checking. In the CDS Workbench, a software tool for applying GDL guidelines on the EHR data, the compliance checking was finally performed. Different compliance figures were obtained and analysed in our study.

In order to validate the correctness of the computerized guideline knowledge in the GDL guidelines, one hundred patient cases are randomly extracted from the regional AF patient group registered in EHR in 2011 and saved as spreadsheet in CSV format. CV then used Microsoft Excel to manually review each of the patient case, and gave a CHA2DS2-VASc score and a recommended treatment based on his knowledge of the ESC guidelines.

A stroke prevention CDS prototype application is developed and is scheduled to be first tested with a small group of clinicians. If clinically verified and accepted, the CDS application will be rolled out on the regional level.

Results

In order to represent guideline knowledge in rules, relevant archetypes and terminology resources need to authored and mapped.

Clinical Archetypes

Three archetypes defined and maintained by the openEHR Foundation can be reused in this study without any changes. These reused archetypes are:

1. openEHR-EHR-EVALUATION.problem-diagnosis.v1
2. openEHR-EHR-INSTRUCTION.medication.v1
3. openEHR-EHR-ITEM_TREE.medication.v1

Three new archetypes created by this study are as follows:

1. openEHR-EHR-OBSERVATION.chadsvas_score.v1 (Figure1).
   This archetype is used to record all the sub-components as well as the total score of CHA2DS2-VASc. It used both for recording calculated CHA2DS2-VASc score and as input to compliance checking rules.
2. openEHR-EHR-OBSERVATION.basic_demographic.v1
   Note that the use of EHR Observation for demographic information is due to limited support of demographic archetypes in the tooling. Patients' age and gender are represented in this archetype.
3. openEHR-EHR-EVALUATION.compliance_checking.v1
   This archetype records the result of compliance checking.

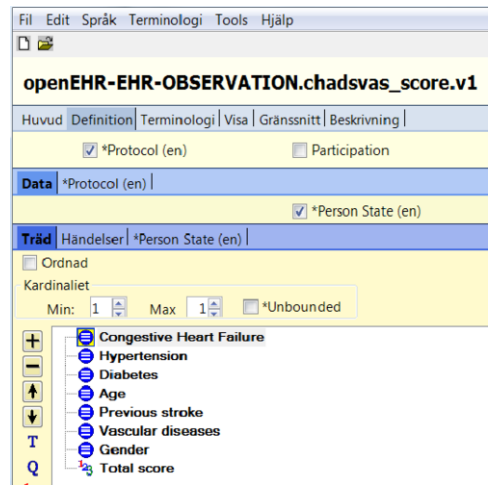

Figure 1 – The archetype for recording CHA2DS2-VASc

Terminologies

ATC Codes for Drugs

ATC codes are used to codify generic names of drugs in Sweden. The ATC codes for the drugs mentioned by the guidelines as potential stroke prevention treatment are listed as follows:

- Warfarin (B01AA03)
- Dabigatron (B01AE07)
- Rivaroxaban (B01AX06)
- Apixaban (B01A)
- Acetylsalicylic acid (B01AC06)
- Clopidogrel (B01AC04)

ICD10 Code for Detecting AF

A list of ICD10 codes are used to detect AF diagnosis in the EHR.

- I48 (with all its subcodes)

ICD10 Codes for Relevant Diagnoses

These codes are responsible for detecting relevant diagnoses in the EHR. They are organized in groups as in CHA2DS2-VASc score. For practical reason, some diagnoses are not included, e.g. thrombo-embolism.

- Congestive heart failure/LV dysfunction: I50
- Hypertension: I10, I11, I12, I13, I15
- Diabetes mellitus: E10, E11, E12, E13, E14
- Stroke / TIA / thrombo-embolism: I63, I69.3, G45.9

- Vascular disease: I21, I22, I24.9, I25.0, I25.1, I25.2, I25.9, Z95.1, I73.9, I70

GDL Guidelines

Four guidelines have been authored to capture the clinical knowledge from the ESC guideline. Each guideline represents the knowledge for a single clinical decision. Different guidelines can be chained together to aid complex decision making. The guidelines have been authored in GDL-editor using the archetypes and terminology resources mentioned above.

CHA2DS2-VASc calculation guideline

This guideline checks patient's demographic information and diagnosis list from the EHR, sets each sub-component in the CHA2DS2-VASc archetype, and derives a total score as the output (Figure 2). The validity of the CHA2DS2-VASc calculation guideline is checked by comparing the result from the GDL-based calculation with that done by the cardiologist (CV). There were 4 cases that the results differ. Three of them were due to miscalculation by CV (clinically insignificant since all of these patients should have received anti-coagulants anyway), the other one were due to a diagnostic code that was not initially included in the GDL guideline. After amending the guidelines, the difference is reduced to 3 out of 100 patient cases.

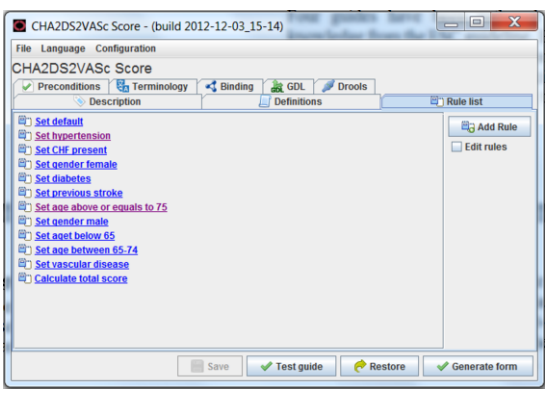

Figure 2 - CHA2DS2-VASc calculation guideline

Stroke risks guideline

This guideline gives estimated stroke risks based on the provided CHA2DS2-VASc score. This information is potentially useful to both the patient and the clinician.

Stroke prevention compliance checking guideline

This guideline takes CHA2DS2-VASc score and a medication list as the input and determines if the given treatment is compliant with the recommendations from ESC guidelines. The same guideline is used for both retrospective compliance checking and at-point-of-care CDS. Figure 3 illustrates the rule that checks the compliance of medication treatment when the CHA2DS2-VASc score equals to 1. Note that both the term "Antiplatelet" and "Oral anticoagulant" in the rule are only interface terms, which can be bound to reference terminology like ATC or SNOMED CT.

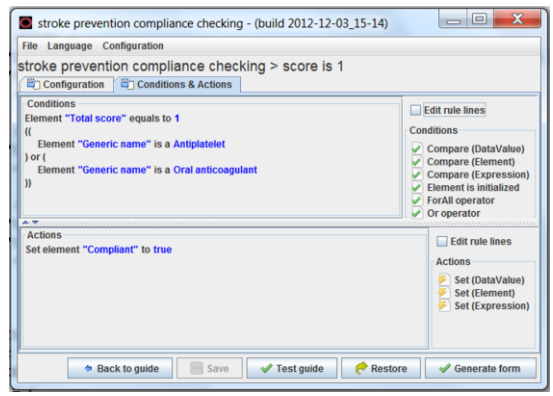

Figure 3 – Compliance checking rule when CHA2DS2-VASc score equals to 1

Stroke prevention treatment recommendation guideline

This guideline takes as input CHA2DS2-VASc score and suggests an optimal treatment based on the ESC guidelines' recommendations.

Stroke Prevention Treatment Compliance Checking

The compliance checking is based on ESC guidelines published in 2010. The percentages of compliant treatment in each patient group are presented in Table 1.

Table 1- Summary of compliance checking of stroke prevention treatment

Patient Group	Total Num. of Patients	Compliant treatment in %
Cardiologist-treated group	514	90.66
AF patients in whole region	8130	62.57

Discussion

The result of the compliance checking indicated there is a clear difference between the compliance of the treatments in the cardiologist and the general patient groups. The patient group treated by the AF-responsible cardiologist displayed nearly 30% higher compliance compared with the general patient group whose treatments are mainly provided by non-cardiologists in the region. Some further work has revealed that both cardiology departments in the region have 10-20% higher guideline compliance compared with the average.

A question could be raised here is what caused such low compliance in the patient group treated by non-cardiologists? Is it justified by clinical contraindications, e.g. more bleeding risks or terminal illness in the general patient group than the cardiologist patient group? Is the non-compliance perhaps caused by lacking of the latest clinical knowledge or the ability to detect non-compliant treatment at the point of care? Some non-compliant treatment can be justified by clinical contraindication and patient refusal, so the compliance rate could be underestimated [6].

In order to provide optimal treatment based on the guidelines, a CDS prototype for stroke prevention has been designed and implemented inside Cambio COSMIC, the primary EHR sys-

tem of Östergötland. The CDS prototype is driven by the same GDL guidelines used for retrospective compliance checking and is fully integrated with the rest of the EHR. It detects and warns the clinicians about any non-compliant stroke prevention treatment in AF patients and suggests an optimal treatment recommended by the ESC guidelines.

From the informatics perspective, GDL guidelines built on top of archetypes, reference terminology, and rules seem to be expressive enough to represent stroke prevention knowledge in the ESC guidelines. It seems feasible to use the same GDL guidelines for both retrospective compliance checking and providing clinical decision support at point of care. Whether the guideline-based CDS can improve the efficacy of stroke prevention in AF remains to be studied.

Conclusions

Clinical gaps in terms of non-compliant stroke prevention in AF can be detected and measured in a regional EHR using computerized ESC guidelines knowledge in GDL format. Further study is planned to investigate the efficacy of at-point-of-care CDS based on the same GDL guidelines on the regional level.

Competing interests

RC and IC are employed / contracted by Cambio Healthcare Systems to work on the design and implementation of the Guideline Definition Language and the CDSS reported in this study. CV is employed by the County of Östergötland during the course of the study.

References

[1] Lip GY, Tse HF, Lane DA. Atrial fibrillation. Lancet. 2012 Feb 18;379(9816):648-61.

[2] Lip GY, Nieuwlaat R, Pisters R, Lane DA, Crijns HJ. Refining clinical risk stratification for predicting stroke and thromboembolism in atrial fibrillation using a novel risk factor-based approach: the Euro Heart Survey on atrial fibrillation. Chest 2010;137:263–272.

[3] Camm AJ, Kirchhof P, Lip GY, et al. Guidelines for the management of atrial fibrillation: the Task Force for the Management of Atrial Fibrillation of the European Society of Cardiology (ESC). Europace 2010;12:1360–1420.

[4] Camm AJ, Lip GY, De Caterina R, et al. 2012 focused update of the ESC Guidelines for the management of atrial fibrillation: An update of the 2010 ESC Guidelines for the management of atrial fibrillation. Europace. 2012; 14: 1385-1413.

[5] The openEHR Clinical Knowledge Manager, http://openehr.org/knowledge/ (last accessed 2012/12/08)

[6] Atwater, Brett D; Dai, David; Allen-Lapointe, Nancy M; Al-Khatib, Sana M; Zimmer, Louise O; Sanders, Gillian D. Is heart failure guideline adherence being underestimated? The impact of therapeutic contraindications. Am Heart J, ISSN 0002-8703, 11/2012, Volume 164, Issue 5, pp. 750 - U153

Address for correspondence

Rong Chen, M.D, Ph.D.
Cambio Healthcare Systems
Ringvägen 100
SE-118 60 Stockholm
Sweden
rong.chen@cambio.se