Automated history-taking improves data quality for clinical decision-making in outpatient cardiology examinations

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Abstract

Background: Healthcare delivery now mandates shorter visits despite the need for more data entry, undermining patient-provider interaction. Furthermore, enhancing access to the outcomes of prior tests and imaging conducted on the patient, along with accurately documenting medication history, will significantly elevate the quality of healthcare service delivery.

Objective: To enhance the efficiency of clinic visits, we have devised a patient-provider portal that systematically gathers symptom and clinical data from patients through a computer algorithm known as Automated Assessment of Cardiovascular Examination (AACE). We intended to assess the quality of computer-generated Electronic Health Records (EHRs) with those documented by physicians

Methods: We conducted a cross-sectional study employing a paired-sample design, focusing on individuals seeking assessment for active cardiovascular (CV) symptoms at outpatient adult cardiovascular clinics. Participants initially completed the AACE, and subsequently, in the first protocol, patients were subjected to routine care without providing the AACE forms to examining physicians. In the second protocol, the AACE form was presented to the physician before the examination, and participants were subjected to routine care. We assessed the impact of AACE forms generated through computerized history taking method on the examination, considering various clinical outcomes and satisfaction surveys.

Results: Totaling 762 patients (394 patients in protocol 1 and 368 patients in protocol 2) were included in the study. The mean overall impression score for computer-generated EHRs was higher versus physician EHRs (4.2 vs. 2.6; p<.001). Our study demonstrated that Electronic Health Records (EHRs) created by physicians exhibit inaccuracies or deficiencies in various pieces of information. In the second protocol, in which the AACE form was presented to the physician before the examination, it was determined that the examination time was shorter, the number of tests requested and the number of new drugs prescribed were less.

Conclusions: We found that the patient-provider portal, systematically collecting symptom and clinical data from patients through a computer algorithm known as AACE, yielded records that were of higher quality, more comprehensive, better organized, and more relevant compared to those documented by physicians. Clinical Trial: T.C Atlas University Medical Faculty, Non-invasive Scientific Research Ethics Committee
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ABSTRACT

Healthcare delivery now mandates shorter visits despite the need for more data entry, undermining patient-provider interaction. Furthermore, enhancing access to the outcomes of prior tests and imaging conducted on the patient, along with accurately documenting medication history, will significantly elevate the quality of healthcare service delivery. To enhance the efficiency of clinic visits, we have devised a patient-provider portal that systematically gathers symptom and clinical data from patients through a computer algorithm known as Automated Assessment of Cardiovascular Examination (AACE). We intended to assess the quality of computer-generated Electronic Health Records (EHRs) with those documented by physicians

We conducted a cross-sectional study employing a paired-sample design, focusing on individuals seeking assessment for active cardiovascular (CV) symptoms at outpatient adult cardiovascular clinics. Participants initially completed the AACE, and subsequently, in the first protocol, patients were subjected to routine care without providing the AACE forms to examining physicians. In the second protocol, the AACE form was presented to the physician before the examination, and participants were subjected to routine care. We assessed the impact of AACE forms generated

through computerized history taking method on the examination, considering various clinical outcomes and satisfaction surveys.

Totaling 762 patients (394 patients in protocol 1 and 368 patients in protocol 2) were included in the study. The mean overall impression score for computer-generated EHRs was higher versus physician EHRs (4.2 vs. 2.6; p<.001). Our study demonstrated that Electronic Health Records (EHRs) created by physicians exhibit inaccuracies or deficiencies in various pieces of information. In the second protocol, in which the AACE form was presented to the physician before the examination, it was determined that the examination time was shorter, the number of tests requested and the number of new drugs prescribed were less.

We found that the patient-provider portal, systematically collecting symptom and clinical data from patients through a computer algorithm known as AACE, yielded records that were of higher quality, more comprehensive, better organized, and more relevant compared to those documented by physicians.

INTRODUCTION

Nowadays, it has become a necessity to use technology in the most effective way in order to provide better health services. Rapidly developing and growing technology continues to be widely used in the field of healthcare as in every field. The increasing availability of healthcare data and the rapid development of big data analytics methods have enabled recent successful applications of these technologies in healthcare[1].

Medical histories are salient datasets for characterizing clinical conditions and informing diagnostic and treatment decisions[2]. Even under optimal conditions, medical history data recorded by physicians have been consistently found to be incomplete, inaccurate, biased and not always factual[3-7]. In part, these inadequacies may reflect inadequate documentation of what the physician knows about the patient. However, real-time observations also reveal deficiencies in the history taking process[8,9]. Since inadequate history data can lead to diagnostic errors[10,11], it seems that we need better methods for history taking than physicians interviewing patients. Studies have also found that physicians engage in computer-related behaviors that patients find distracting, including performing computational tasks on a computer screen while recording a patient's history[12,13].

Self-reported computerized history taking (CAHTS) is a method to collect a structured medical history by direct interaction between patients and a digital device[2]. CAHTS has the potential to improve outcomes and quality of care, provide cost savings and increase patients' involvement in their own healthcare[14,15]. Despite promising results, CAHTS is rarely used in clinical practice[16]. CAHTS systems are currently designed mainly to support the transactional needs of administrators and invoice issuers rather than to foster the relationship between patients and health professionals[17].

Turkey completed many standardizations and infrastructural improvement initiatives in the health information technology (IT) domain during the first phase of the Health Transformation Program between 2003 and 2017[18]. Among the personal health records applications, Personal Health Information Record Systems of the Turkish Ministry of Health (e-nabız) is used in our country. In the e-nabız system, in addition to prescription, report, analysis-test and imaging information, there are also modules in the application where the health consumer can upload materials such as allergies, emergency notes, some pictures to be sent to the physician. In other words, the health consumer can update their own health profile and add information about their health to the system[19].

In our country, there is an application in EHR systems that enables physicians to access the patient's e-nabız information in every examination. However, data on the rate and efficiency with which the information in e-health applications is used by healthcare professionals both in our country and in the world are very limited[20]. In addition, the content structure of the e-nabız application used in Turkey, which is not summarized and is a large mass of information, restricts its use by making it impractical to access the desired information in short outpatient clinic examination times.

The most important barriers to effective history taking by physicians are insufficient time spent with patients and the sheer volume of information available for history taking[21,22]. It was recognized even at the beginning of the computer age that expert system software could solve these problems[23]. However, there is still lack of academic interest in developing expert systems for computerized history taking, i.e. automatic, dynamic history taking while the patient interacts with the computer[24]. There is also a lack of clarity about the content of these computerized algorithms and the extent to which they influence outcomes. We utilized the anamnesis taking methods presented in standard medical texts and created an algorithm that sheds light on possible diagnoses in the cardiology outpatient clinic created by us, questioning the complaints that led to the current admission, revealing the background and risk factors, and containing guiding questions that aim to remove the patient's subjective interpretations as much as possible with yes/no answers. We also extracted the information that is considered important in the cardiology examination in the patients' e-nabız system and added it to the form.

We bring attention to the possible value of CAHTS in the present work. In our study, we compared medical history data collected by physicians during usual care in the cardiology outpatient clinic and entered into EHRs to the cardiology examination using information obtained from computer software based on the algorithm we organized, in terms of various clinical outcomes and satisfaction surveys.

METHODS

Experimental design

Our planned experimental intervention used two different methods for collecting and storing medical history data. The first was physicians providing routine cardiology care and entering their findings into the electronic health record (EHR). The second was expert system software trained to interview patients presenting for cardiology examinations.

Study setting and recruitment of patients

This study is a single-center (Atlas University Medical Faculty Hospital, Istanbul) retrospective, observational cohort study and includes non-randomized eligible patients who applied to 7 general cardiology outpatient clinics between 18.09.2023-27.10.2023 in 7 general cardiology outpatient clinics staffed by the same physicians who were unaware of the content and details of the study. Patients with their first visit to the examining physician were included in the study, and patients with follow-up visits, patients who applied only for interpretation of previously ordered test results and for various reports and official documents were excluded. In addition, patients who volunteered to comply with the study protocol and had an e-nabız system record were included in the study. All eligible patients who applied to the selected outpatient clinics for examination were asked to answer the questions in the computer-assisted history taking system we created.

CAHTS software

The logic of CAHTS software has been described in detail elsewhere[23-29]. In brief, CHATS is a dynamic expert system for history-taking from adults with acute and long-term complications from chronic disease. The knowledge base of questions and answers was developed in Turkish so that a native Turkish speaker with primary school education could understand it. Textual questions have answers sets of Yes/No or Yes/No/Uncertain answers. Each answer is coded to indicate the question asked and the answer entered. In these algorithms, questions about the patient's medical history, substance use, dietary habits, drug allergies and intolerances, mobility, stress and sleep status, questions evaluating genealogical characteristics, and the complaint that led to the current admission (1) chest pain, (2) shortness of breath, (3) palpitations and arrhythmia, (4) high blood pressure and instability, (5) dizziness and fainting, (6) ankle edema, and (5) dizziness and fainting, (6) dizziness and fainting, and (6) ankle edema. The patient selected which of the cardiovascular symptoms he/she was experiencing, and under these headings, questions questioning the character of the symptom were presented on the screen in such a way that written and read aloud simultaneously, and the patient was asked in a guiding character by marking one of the options including yes, no and sometimes quantity. In addition, the information selected in the algorithm was obtained from the patients' e-nabız systems. Laboratory tests (glucose, HbA1c, urea, creatinine, sodium, potassium, total cholesterol, ldl, hdl, triglyceride, alt, ggt, creatine kinase, TSH, uric acid) selected from the e-nabız system were recorded with the date of the most recent value. In addition, if available, the results of echocardiography, MPS, PA chest radiography, CT, MRI and ultrasonography of the thoracic and vascular structures were recorded with the date of the most recent examination. Finally, the medications that the patients were currently taking were questioned and recorded together with the dose and method of use. In patients who did not bring their medications with them and could not remember their names, all medications previously prescribed to the patient were taken from the e-nabız system, the package picture of the medication was displayed on the screen and asked if they were currently taking the medication on the screen. Filling in the pre-examination algorithms and scanning the e-nabız information in the study protocol and adding it to the form were done under the supervision and with the help of high school students who were given a basic training on this subject. The high school students explained to the patients the purpose of the research program and showed them how to interact with the CAHTS program running on an iPad (Apple Inc, Cupertino, CA, USA). Patients were told that agreeing or refusing to participate would not affect their care. Patients were informed that the data collected by computerized interviewing would only be used for clinical research. At the end of these procedures, the patients' responses to the questions in the computer-assisted history taking system were organized to create a form called the Automated Assessment of Cardiovascular Examination (AACE), which systematically collects information about the patient's medical history and current disease history. After the questions and inquiries were completed, the AACE form was organized in 4 parts. In the first part, in line with the answers given to the questions inquiring the medical history and surname, the results that negatively affected the risk of cardiovascular disease were marked in red, and the results that had a positive or neutral effect were marked in green and included in the form. In the second part, the patient was asked to select the complaints that led to the current application, and the answers given to the questions within the selected complaint title were marked in green if yes, and in red if no, and added to the form. If the patient could not fit the complaint under any of these 6 headings, none of them was selected and noted on the form without additional questioning. In the third part, the results of the most recent laboratory tests and imaging tests selected in the algorithm in the e-nabız system were written with the date of the available ones. Finally, in the fourth section, all medications currently used by the patients were written on the form together with the dose and method of use (sample form appendix 1).

Time-relationship between physician history-taking and CHATS interview

In the first week, the AACE form was completed in the patients included in the study, but the form was not given to the physician. Each patient leaving the examination was questioned by the experienced cardiologist in charge of the study and the number of patients who were found to have incorrect, misleading and incomplete information was recorded under the subheadings of the AACE form organized in 4 sections. In addition, the duration of the examination, the number of tests ordered, and the number of new medications prescribed for each patient were questioned and recorded. At the end of each day, all information filled in by the physicians in the electronic health record system was taken for examination.

In the second week, patients who applied to the same outpatient clinics were subjected to the protocol applied in the first week before the examination, and the forms prepared for 7 physicians who were not informed about the details of the study were given before the examination of the patient. The physicians were asked to record the number of patients for whom the information filled in the 4 main sections and their subheadings in the AACE forms was incorrect, misleading and incomplete. After the examination, the duration of the examination, the number of tests requested, and the number of new medications prescribed were recorded. At the end of the study, a 5-point Likert-type scale (1=extremely poor; 5=excellent) consisting of questions in six areas (1. richness of content; 2. utility; 3. usefulness; 4. organization; 5. accuracy; and 6. understandability) was applied to the blinded physicians who performed the examination to question the effect of AECVS forms on examination quality.

RESULT

Of the 773 patients included in the study, 9 were excluded because they initially agreed to participate in the CAHTS program but later did not want to complete the program, and 2 were excluded because it was observed that all inconsistent answers to the questions during the CHT were randomly selected and it was thought that they intentionally entered incorrect answers. As a result, 394 patients in protocol 1 and 368 patients in protocol 2, totaling 762 patients, were included in the study. The mean age of the patients was 56.6±17.4 years and 51.5% were female. 11.1% of the patients had never attended school, 23.8% were Primary school graduates, 17.6% Secondary school graduates, 35.4% Lycee/High school graduates and 12.1% University graduates. The mean time to complete the AACE was 13.4± 4.2 minutes.

At the end of the patient recruitment period of the first protocol, the content of the AACE forms filled in by the physician in the electronic health record system (EHR) of the patients who were examined in the 7 outpatient clinics included in the study and the content of the AACE forms filled in by the patients themselves before the examination were examined in 4 sections (1. Curriculum vitae and surname data 2. Complaints that caused the current application 3. laboratory and imaging tests 4. medications used) and their subheadings were examined in detail. Accordingly, the number of patients who did not include any positive or negative informative statement about each heading or who were considered to have incomplete or inaccurate information was also determined (table 1).

In the AACE forms of the patients included in the first protocol, 61% (240/394) of the patients checked more than one symptom, whereas in the physician record system, this rate was significantly lower at 30% (118/394). We evaluated whether the chief symptom complaint documented in the physician EHR matched the self-reported chief complaint in AACE. We limited this analysis to patients who reported a most bothersome symptom listed on the AACE form (n=382). The physician-documented chief complaint matched the patient's self-report in 69% (271/382). Eighty-four percent (331/382) of physician EHRs made at least some mention of the patient's self-reported chief complaint. We assessed how well the physician-documented chief complaint matched the patient's self-report and how often the patient's self-reported main symptom was mentioned at least partially in the physician EHRs. Table 2 shows these results for different cardiovascular symptoms.

In the second week, the AACE forms filled out by the patients who applied to the same outpatient clinics were given to the physicians before the examination and they were told that they could use these forms during the examination. At the end of the study, a 5-point Likert-type scale (1=extremely poor; 5=excellent) consisting of questions in six areas (1. richness of content; 2. utility; 3. usefulness; 4. organization; 5. accuracy; and 6. understandability) was applied to the blinded physicians who performed the examination to question the effect of AACE forms on examination quality and the results are summarized in table 3. Finally, the duration of examination, the number of tests ordered, and the number of new medications prescribed were compared between the two groups and the results are summarized in table 4. We did not control for individual differences in physician performance because HPI quality indices were homoscedastic across groups in most cases, and no subgroups demonstrated statistically significant deviations from normality.

DISCUSSION

We compared the AACE generated by a computer algorithm collecting patients' data in a cardiology examination with records created by physicians during usual care. We found that computer-generated AACE were of higher quality, more comprehensive, better organized and more relevant than records documented by physicians. These results provide evidence that a computer can generate clinically meaningful and useful forms of anamnesis, and the findings are consistent with recent evidence that patients are comfortable disclosing their health information to "virtual human" interviewers as supportive and "safe" interaction partners[25].

In contrast, these results do not indicate that computers could ever replace healthcare providers. The art of medicine requires physicians to connect with patients, interpret complex and often confusing data, diagnose despite incomplete information, and communicate effectively. While the number of visits to physicians per capita has increased over the years, the insufficient increase in the number of physicians has led to a decrease in the average examination time per capita[26]. This is particularly evident in developing countries such as Turkey[27]. Inadequate time allocation for outpatient diagnosis and treatment has been shown to have negative effects on the quality of care. Short consultation times have been shown to adversely affect public health by leading to poor management of disease screening and inappropriate diagnosis and treatment[28-29]. Therefore, this study suggests that computers can remove at least some of the burden by collecting and organizing data to help clinicians focus on what they do best: practicing the human art of medicine.

Studies show that the quality of physician-created EHRs is highly variable, with many EHRs providing inaccurate or incomplete[30]. In our study, it was shown that the information filled in EHRs by physicians in the examinations performed by the standard method was quite incomplete and inadequate. On the other hand, it was observed that ACVS forms filled this deficiency quite successfully. In particular, it was observed that most of the physician EHRs did not make any notes on the patient's lifestyle characteristics (mobility in life, nutritional properties, stress level, sleep quality and disorders), which have been shown to play an important role in the risk profile of cardiovascular diseases. There was either no or incomplete information in the physician EHR notes on family history of cardiovascular disease and Socioeconomic determinants. Even information on patients' history of cardiovascular disease and other chronic diseases was insufficient. It was observed that computer-generated EHRs could be filled in correctly and appropriately in most of the patients and the rate of missing or incorrect information in the generated AVCS forms was below 5% in most topics. It was also observed that the program was successful in extracting the results of selected laboratory and cardiovascular diagnostic tests planned in the study protocol from the e-nabız system and summarizing them in the AVCS form in patients who had e-nabız system and allowed access to records. In physician EHR records, almost all patients (91.9%) did not have any information notes about previous diagnostic tests. Of course, this does not mean that the physician did not access these results from the e-nabız system during the examination. Nevertheless, summarizing the results, if any, of selected tests in the AVCS form within a short examination period was found to be practical, useful and beneficial by physicians. In our study, the CHATS program was applied to patients under the supervision of two high school students who were given a simple training. This increased patient compliance with the program. The fact that these supervisors were high school students shows that patients who are illiterate or who have difficulty in comprehending the program are more likely to have a relative with high school education in their homes, indicating the applicability of the program and that there is no need for an expert supervisor. It is very important that patients' current regular medications are accurately conveyed to the physician during the examination in order to organize the treatment correctly and to avoid harmful drug interactions. However, in practice, many patients do not bring their medications with them and often do not remember their names and usage patterns. In our country, all medications and reports previously prescribed to the patient can be accessed through the e-nabız system. However, when the patient is questioned about which medications he/she is currently using among all the medications prescribed, this takes a lot of time during the examination period and the patient often cannot remember the name of the drug being questioned. In the program we created, for patients who could not remember the medications they were taking, the previously prescribed medications were taken from the e-nabız system, the package picture of the medication was displayed on the screen and the patient was asked if they were currently taking the medication on the screen. Thus, the list of medications used in only 9.6% of the patients in the AVCS form could not be created properly. However, this rate is significantly higher in physician EHRs with 48.2%.

Physicians question the complaint that led to the current admission during the examination, but do not record the summary of this questioning in sufficient detail in EHRs, possibly due to lack of time. This leads to serious diagnostic and therapeutic inadequacy in controls and subsequent examinations due to lack of data. Indeed, in our study, in 24.6% of the patients, the primary complaint was only included as a title and it was observed that no query note was made about this complaint. Data reveal that clinicians spend up to one third of the patient encounter looking at a computer and, as a result, missing important non-verbal cues from the patient[12,31]. In addition to strengthening the physician-patient relationship, adequate eye contact is extremely important in terms of increasing patient satisfaction, better identification of health problems and improving service quality and effectiveness. The ACVS algorithms tested in this study provide a model to begin to address these issues, as they generate EHRs informed by patient self-report and e-nabız query, thereby increasing the validity of the EHR and reducing data inconsistencies. Furthermore, the use of computer-generated EHRs can improve the patient-physician relationship by informing the clinician before the patient encounter and saving more time by reducing computational tasks. We found that there was a 21% discrepancy between the most bothersome symptom self-reported by the patient and the main complaint documented by the physician. In addition, the rate of patients ticking more than one symptom on the AECVS forms of the patients recruited in the first week of the study (61%) was significantly higher than the rate in the physician record system (30%). It is possible that some patients did not mention their most bothersome symptom to their physicians, or perhaps felt more comfortable reporting it to the computer.

When the AECVS forms completed by patients attending outpatient clinics in the second week were given to the physicians before the examination, we found that the examining physicians felt that the computer-generated ACVS forms were of better quality, more comprehensive, better organized and more relevant than their own records. Although we did not have a method to measure it in this study, physicians expressed that they thought that obtaining these forms before the examination would help them diagnose patients more accurately and prevent possible incorrect or unnecessary treatment. They also stated that these forms made the examination more efficient and enabled them to perform a longer and more comprehensive physical examination. It has been shown that short examination times negatively affect public health by leading to poor management of disease screening and inappropriate diagnosis and treatment[28,29]. It is also important to show these positive results despite the shorter duration of the examination with ACVS forms.

It is indisputable that knowing patients' previous examinations will improve the quality of examination and reduce the rate of unnecessary tests ordered. In Turkey, patients' past tests can be accessed through the e-nabız system. However, as in our program, we tested the additional effect of summarizing selected tests and sections of all tests in addition to the existing e-nabız system. In the examination accompanied by ACVS forms, we found that while the frequency of ordering general laboratory tests, Exercise Stress Testing, Cardiac SPECT and general imaging tests was lower, the frequency of ordering gold standard tests such as coronary angiography and Coronary CT Angiography was higher. We attributed this to improved examination quality and the ability to reach a diagnosis in a shorter and more precise way without the need for preliminary tests. We also thought that the fact that ACVS forms reduced the number of new drug prescriptions would have a beneficial effect on both public health and cost-effectiveness.

This study has important limitations. The fact that the AVCS forms were evaluated by the physicians who conducted the study and the cardiologists who performed the examination contains significant potential for bias. In addition, the fact that the evaluators knew which group (AVCS form and physician EHR) the forms they evaluated can be considered as a disadvantage.While we observe a notable corrective impact of the expert system software we developed for gathering medical information from patients on the quality of cardiology examinations, it cannot be denied that enhancements may be necessary concerning the content, presentation, and order of the questions in the system. The software will get better with additional observations and studies.

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Table 1. The number of patients in the first protocol for whom records filled out by physicians in the electronic health record system and forms self-completed by patients, focusing on selected headings that lacked informative expressions or were deemed to have incomplete or inaccurate information

	Electronic health records recorded by physicians in the first protocol (n:394)	Self-reported computerized history taking in the first protocol (n:394)
Curriculum vitae and Personal background data		
32. Family history of cardiovascular disease n, %	211, 53.6%	12, 3.0%
33. The person's history of cardiac events n, %	203, 51.6%	19, 4.8%
34. Existence and content of chronic disease n, %	193, 49.0%	13, 3.3%
35. Harmful substance addiction n, %	133, 33.8%	5, 1.3%
36. Mobility in life n, %	239, 60.7%	11, 2.7%
37. Nutritional properties n, %	292, 74.1%	15, 3.8%
38. Stress level n, %	333, 84.5%	13, 3.3%
39. Socioeconomic determinants n, %	387, 98.2%	15, 3.8%
40. Sleep quality and disorders n, %	373, 94.9%	18, 4.5%
41. Drug side effects n, %	352, 89.4%	17, 4.3%
Primary cardiovascular symptom n, %	97, 24.6%	24, 6.1%
History of laboratory and imaging tests n, %	362, 91.9%	-
Current medications used n, %	190, 48.2%	38, 9.6%

Table 2. Physician EHR's primary cardiovascular symptom matched patient's self-reported primary cardiovascular symptom

Self-reported primary CVS symptom	Physician 's primary cardiovascular symptom matched patient's self-reported primary cardiovascular symptom	The physician's assessment of insufficient documentation of the primary cardiovascular symptom in their own records
Chest pain	99/129 (77)	106/129 (82)
Shortness of breath	16/31 (52)	28/31 (90)
Heart rhythm disorder	57/94 (61)	44/94 (42)
High blood pressure or imbalance	60/105 (57)	66/105 (63)
Dizziness, blackout or syncope	4/14 (28)	6/14 (43)
Ankle edema	8/9 (88)	3/9 (33)

Self-reported by patient as most troublesome cardiovascular symptom through AACS

Table 3. Impression scores

	Physician EHRs	Data from patients through a computer algorithm known as AACE	p
Completeness	2.3 (0.7)	4.6 (0.4)	< .001
Relevance	3.1 (0.7)	4.3 (0.4)	< .001
Usefulness	2.5 (0.8)	4.4 (0.3)	< .001
Organization	2.8 (0.8)	3.9 (0.5)	< .001
Efficacy	2.9 (0.6)	4.5 (0.3)	< .001
Overall impression	2.6 (0.7)	4.2 (0.4)	< .001

Data are presented as mean (standard deviation).

EHR, Electronic health record, AACE, Automated Assessment of Cardiovascular Examination

Table 4. Various effectiveness outcomes in examinations conducted under the two protocols

	Group 1 (n: 394)	Group 2 (368)	p
Examination period	16.7±6.2	12.8±5.1	<0.01
Number of examinations requested			
42. Laboratory measurement	209 (53.1%)	138 (37.5%)	<0.01
43. Echocardiography	185 (46.9%)	161 (43.7%)	ns
44. Exercise Stress Testing	151 (38.3%)	91 (24.7%)	<0.01
45. Cardiac SPECT	40(10.1%)	7 (1.9%)	<0.01
46. Coronary angiography	39 (9.9%)	53 (14.4%)	0.02
47. Coronary CT Angiography	8 (2.0%)	24 (6.5%)	<0.01
48. Radiological examinations	44 (11.2%)	37 (10.1%)	ns
New medications prescribed			
• Patient rate	239 (60.6%)	148 (40.2%)	<0.01
• Number	623	325	<0.01

Supplementary Files

Figures

Automated Assessment of Cardiovascular Examination Form.

Form 1

Part 1

Family history of cardiovascular disease

- Do you have any first-degree relatives (parents or siblings) who have experienced a heart attack, stroke, or undergone procedures such as stent placement or bypass surgery before the age of 60?
- Do you have any second-degree relatives (grandparents, uncles, aunts) who have had a heart attack, undergone stent placement, or had bypass surgery before the age of 60?
- Have either of your parents (respond with 'yes' if either one has) lived or is currently living beyond the age of 80?

The person's history of cardio-vascular events:

- Have you ever consulted with a cardiovascular specialist who indicated that you have a cardiovascular issue?
- Have you ever experienced a heart attack and been hospitalized as a result?
- Have you ever undergone a cardiac angiogram?
- Have stents been placed in your coronary arteries?
- Have you undergone open-heart surgery for coronary artery bypass grafting (CABG)?
- Have you had any surgery or intervention related to blood vessels other than your coronary arteries?
- Has a cardiologist ever mentioned any issues with your heart valves?
- Have you undergone valve surgery?
- Has a cardiologist ever informed you of a rhythm disturbance in your heart?
- Have you undergone an ablation procedure for rhythm disturbance?
- Have you had a pacemaker implanted?
- Have you ever had a cerebrovascular accident (stroke)

Existence and content of chronic disease

Diabetes

Hypertension

Heart Failure

Other Medical Conditions

Part 3

History of laboratory and imaging tests

14.08.2023 (Glucose 111 mg/dl, HbA1c 5.9%, urea 18 mg/dl, creatinine 1.1 mg/dl, sodium 142 mmol/L, potassium 4.4 mmol/L, total cholesterol 143 mg-dl, LDL 80 mg-dl, HDL 49 mg-dl, triglyceride 221 mg-dl, ALT 11 U/L, GGT 112 U/L, creatine kinase 72 U-L, TSH 1.02 mIU-L, uric acid 7.1 mg/dl, hematocrit 30%)

17.05.2023 **CT chest (non-contrast):** The trachea and main bronchi are open. Millimetric lymph nodes were observed in the mediastinal area. Dense wall calcifications were observed in the thoracic aorta. There is global enlargement of the heart. No pericardial or pleural effusion was detected. When the sections were evaluated in the parenchymal window: Density increases, which were evaluated in favor of fibrotic sequelae changes accompanied by pleural recessions, were observed in both lungs. A few parenchymal and subpleural nodules smaller than 5 mm were observed at different levels in both lungs. Density increases that may be compatible with subsegmental collapse were observed in the upper lobe lingual segments of the left lung, in the right middle lobe segments, and, more prominently on the left, in the basal segments of the lower lobes of both lungs. Focal light ground glass densities and accompanying reticular light opacities affecting the peripheral parenchymal areas at different levels were observed in both lungs, more prominently in the right and lower lobes. Intense degenerative changes and osteophyte formations were observed in the vertebrae. Operation materials were observed in the sternum.

Harmful substance addiction

- Do you smoke? No/Yes/Quit

If yes: --- Less than 5 cigarettes per day, Less than 1 pack per day, one to two packs per day, two to three packs per day

If quit: --- How many years did you smoke?

- Do you consume alcohol? No

If yes: --- I drink less/more than 2-3 glasses per week

Mobility in life

- I lead a sedentary lifestyle
- I engage in regular exercise at least three times a week.
- Even if I don't exercise regularly, I walk a lot in my daily life or perform physically demanding tasks

Nutritional properties

- I frequently dine out
- I consume snacks and packaged foods (such as chips, biscuits, cakes, chocolates, etc.) almost every day
- I regularly consume pastries, pastries, and simit (a type of Turkish bagel)
- I eat a sufficient amount of vegetables, fruits, and salads every day
- Almost every day, I consume a bowl or more of nuts (seeds, peanuts, etc.)
- I primarily consume meat-based meals (almost every day)
- I regularly consume processed meat (sausage, salami, hot dogs) every day
- I eat three or more meals a day
- I refrain from rising until fully satiated from the meal
- I make sure my meals are less salty
- Stress level
- I lead an excessively stressful life
- I tend to get angry quickly and raise my voice
- I easily become saddened, anxious, and irritated, but I keep it to myself

Socioeconomic determinants

- Income status low/ medium/ high

Sleep quality and disorders

- I frequently experience insomnia
- I frequently utilize sleep aids to facilitate the process of falling asleep
- The quality of my sleep is poor (characterized by frequent waking, difficulty falling asleep, sleeping through medication and shallow sleep)
- My close relatives often mention that I snore excessively at night
- My close relatives say that during episodes of snoring, I experience prolonged pauses in breathing
- I wake up extremely tired every morning and often feel drowsy while sitting during the day
- I pay attention to sleeping in a dark and quiet environment

Drug side effects

- Do you have any allergies to medications?
- Have you ever taken any medication that you had to discontinue due to side effects?

17.05.2023 **Echocardiography:** Good LV systolic function, diastolic dysfunction, normal cavity size, moderate concentric LVH, mild MR, mild TR, estimated RVSP 40+JVP

10.01.2023 **Color Doppler imaging of the carotid arteries:** Arterial lumens are open, and no flow turbulence or perivascular color scattering that may be compatible with significant stenosis is observed. Spectral waveforms taken from all arteries and their determined values are within physiological limits. Intima-media thickness was measured as 0.9 mm bilaterally and increased. A few millimetric-sized mixed-type plaques that did not cause hemodynamically significant stenosis were observed in both CCA, ICA and ECA.

Part 2

Primary cardiovascular symptom

Chest pain

Where exactly do you feel pain? Select all sites in which you have symptom

- The pain occurs only during exertion (fast walking, climbing ramps and stairs, exercise, etc.) and rapidly subsides when the exertion is stopped.
- My pain occurs only at rest.
- My pain lasts for more than 20 minutes when it starts.
- My pain lasts for less than a few minutes when it occurs.
- I have had continuous pain for a long time.
- The pain in my chest is in the form of pressure at the center.
- During the pain, it predominantly radiates to my throat, jaw, and left arm.
- During the pain, I experience nausea, vomiting, and excessive sweating (respond 'yes' if any of these are present).
- I have recently had a flu-like infection, fatigue, cough, and fever.
- I experience a sensation of scratching in my stomach, a sour taste, and the regurgitation of bitter fluid (respond 'yes' if any of these are present).
- My pain worsens after eating out or consuming processed foods.
- The pain suddenly and intensely felt like tearing from my chest to my back, and after the pain, there was a significant darkening of vision and a feeling of fainting.
- After the pain, there is persistent shortness of breath.
- My pain significantly increases with specific movements of my arm or back.
- My pain intensifies in a stabbing manner when taking a deep breath.

Shortness of breath

Heart rhythm disorder, Palpitation

- My heartbeats become noticeably faster.
- Heartbeats occur intermittently with skipping, stopping, gaps, and extra beats.
- During palpitations, I feel that my heartbeats are completely irregular.
- During palpitations, my heart rate becomes much faster than during heavy exercises.
- Palpitations occur almost every day.
- My palpitations occur intermittently, with attacks happening once a month or less frequently.
- My palpitations occur only during exertion (exercise) or moments of stress.
- Palpitations start suddenly.
- Palpitations start gradually, accelerating.
- Palpitations suddenly stop, and I immediately feel that the palpitation has subsided.
- My palpitations last for a few minutes.
- My palpitations can last for hours.
- An EKG (electrocardiogram) was taken during the episode of palpitations, even if the results were not provided to you.
- During a palpitation attack, there can be significant darkening of vision, fainting, and shortness of breath (respond 'yes' if any of these are present).
- I experience chest pain during palpitations.

High blood pressure or imbalance

Dizziness, blackout or syncope

Ankle edema

Part 4

List of medications used by the patient

Delix plus 5/12,5 1*1

Lercadip 10 mg 1*1

Ecopirin 100 mg 1*1

Ator 20 mg 1*1