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The impact of the Chaser application on the medical knowledge of cardiac patients

Wpływ aplikacji Chaser na wiedzę medyczną pacjentów kardiologicznych

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Abstract

Background. Anticoagulants and antiplatelet drugs are pillars of modern cardiology treatment, which proved to be associated with benefits and an increased risk of bleeding. Chaser is a mobile application that educates patients taking anticoagulants to improve their knowledge and adherence.

Objective. This study aimed to evaluate Chaser in patients taking anticoagulant medications, assess the application's usefulness, and determine whether it contributes to increased patient knowledge of anticoagulant treatment.

Methods. Fifty consecutive participants were recruited for the study and given access to the application. Consecutive patients on anticoagulant or antiplatelet therapy who could use a mobile phone with Internet access were included in the study. All patients had Chaser installed on their phones for at least 24 hours. The patients were given a questionnaire two times: before intervention and one day later. The authors created it and tested the patients' cardiology knowledge, including anticoagulation or antiplatelet treatment, symptoms, and diseases.

Results. There were 29 (58%) males and 21 (42%) females. The median age of the patients was 68 years old. All patients suffered from at least one cardiac disease requiring anticoagulant or antiplatelet therapy. The majority (29 of 50 (58%)) of participants improved their score, and 18 of 50 (36%) had the same result. The rest scored worse.

Conclusions. Chaser can potentially increase patient education and self-care in the complex anticoagulation or antiplatelet therapy treatment. The potential integration of the Chaser application into clinical practice could improve the effectiveness and safety of the treatment.

Keywords: mobile health applications, mHealth, cardiovascular diseases, educated patients

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1. Introduction

Cardiovascular diseases are the leading cause of morbidity and mortality worldwide, taking an estimated 17.9 million lives each year and accounting for nearly one-third of global deaths [1]. About 697,000 people in the United States die from heart disease each year — that is 1 in every five deaths [2]. The problem seems to be multifactorial since it results in the vast costs of healthcare services, medicines, and lost productivity due to premature death. There is a necessity to identify people with the highest risk of developing cardiovascular diseases and to provide them with appropriate prevention and treatment. One of the pillars of the treatment of cardiovascular diseases is anticoagulant therapy. Several indications for anticoagulation treatment have been described in the guidelines provided by the European Society of Cardiology (ESC) [3–5]. If recommended, anticoagulants contribute to an improved prognosis, which is why patient compliance and adherence are so substantial. It is worth emphasising that treating according to recommended schemes can be challenging, which is why anticoagulants are associated with complications, mainly bleeding. Among side effects, various types of haemorrhages could be listed [7]. Significant improvement in the involvement of both patients and doctors could translate into better adherence and compliance. Strict cooperation between both sides is crucial.

It has been proven that the risk of morbidity and mortality associated with cardiovascular diseases can be significantly reduced through the prolonged use of specific medications. However, the maximum therapeutic benefits of these medications cannot be acquired if patients do not adhere to their prescribed treatment regimens. In Europe, approximately 9% of all cardiovascular disease events are attributed to inadequate medication adherence. Moreover, adherence rates are calculated to be as low as 57% [8]. According to one of the studies, mobile applications contribute to an increased percentage of patients taking medications regularly.

Consequently, these applications can contribute to better effectiveness of the entire therapy [9]. Multiple systematic reviews have suggested that mobile applications enhance medication adherence among individuals with cardiovascular diseases. For instance, in one of them, it has been described that using smartphone applications as part of interventions aimed at promoting lifestyle changes was effective in improving medication adherence and increasing physical activity [10]. Additionally, in another review, which focused on secondary prevention in patients with cardiovascular disease, it has been shown that mHealth interventions, including mobile applications, led to improved medication adherence, better control of blood pressure and lipid levels, and reduced occurrences of angina, transient ischemic attack, and stroke [11]. The degree of digitisation in the world is growing rapidly. New mobile applications are introduced to the market, offering many services in the field of medicine [12]. The number and value of medical applications translated into slow but constant growth in utility during everyday practice [13]. Patients are willing to try new technologies, such as applications that provide needed information. However, a reliable source of knowledge is significant since lots of unverified data show up on the internet [14]. Recent research has indicated that more educated patients comply better with medical recommendations, and thus, the therapy becomes safer and improves the prognosis of patients [5, 15]. Undoubtedly, it is a convenient and functional solution that significantly affects a person's health. The use of medical applications has become frequent and widespread; 70% of physicians and medical school students declare that they regularly use at least one medical application, and 50% of the respondents declare they use their favourite application daily [16].

CHASER is a mobile application designed to assist medical professionals in making treatment decisions and provide patients with information about their condition, treatment options, and medication reminders. This manuscript focuses on evaluating the CHASER application in patients taking anticoagulant or antiplatelet medications. The results of our study indicate a significant improvement in patients' knowledge and awareness of their medical conditions and treatment options after using the CHASER application.

2. Methods

This study is a non-randomized, open-label study with one arm, focusing on patients with cardiovascular conditions who are on anticoagulant or antiplatelet therapy. This single-centre study was conducted at the tertiary cardiology department within the Medical University. The study was executed by experienced cardiologists and fellows specialised in cardiology, who monitored all aspects of the research procedures. The department offers a comprehensive

array of advanced treatment modalities for patients with cardiovascular conditions. The study conforms to the ethical guidelines with registration number KB/150/2020.

2.1. Objectives

The study aimed to evaluate a new educational smartphone application called "CHASER" for cardiac patients on anticoagulant or antiplatelet therapy and investigate its influence on patients' cardiological knowledge. We hypothesised that CHASER would improve the patients' awareness and knowledge regarding underlying conditions.

2.2. Application Description

Chaser was designed within the framework of the Polish-German project called "AntiCoagulation Help App for Surgery". The application was created by healthcare professionals and funded by the German Federal Ministry of Education and Research (BMBF) and the Polish National Centre for Research and Development (NCBR) (grant APP/2494/OP/CHASER/2018). The CHASER application offers two profiles tailored to different user groups: one specifically designed for patients and another for medical professionals. The primary objective of this application is to foster a comprehensive understanding of anticoagulant or antiplatelet therapy among patients, empowering them with information about the specific medications prescribed. It further encourages patients to delve deeper into their medical conditions, facilitating self-education and promoting a proactive approach to managing their health. Additionally, the application is a valuable tool for healthcare professionals, supporting and assisting patients throughout their treatment journey. By leveraging the features and functionalities of CHASER, medical practitioners can enhance their ability to effectively communicate vital information, offer guidance, and ensure optimal patient care and adherence to treatment protocols.

CHASER offers a wide range of features and functionalities, providing its users with a comprehensive range of possibilities. One of its key components is an extensive educational panel encompassing a diverse array of articles elucidating the fundamental aspects of the blood clotting process and the essential principles of anticoagulant therapy. Furthermore, the application includes descriptive materials and engaging podcasts of various medical conditions and diseases that may indicate the need or requirement for anticoagulant therapy. A significant feature of CHASER is the capability for users to record and monitor their International Normalized Ratio (INR), a crucial parameter used to evaluate the effectiveness of anticoagulant medications administered to patients. Allowing users to track their INR levels

within the application facilitates the management of their anticoagulation therapy and provides valuable insights into the efficacy of the treatment.

Moreover, the application enables patients to create a comprehensive list of all their medications, providing a centralised platform for medication management. Including daily reminders, CHASER assists patients in adhering to their prescribed medication regimen. This feature plays a significant role in enhancing patient compliance, leading to improved therapeutic outcomes and prognosis. Overall, the multifaceted functionalities offered by CHASER contribute to empowering patients with knowledge, facilitating effective self-management, and ultimately optimising the benefits derived from anticoagulant or antiplatelet therapy.

2.3. Participants

Criteria for enrolling patients in the study included:

- all participants gave an informed consent to participate in the study,
- a patient was on an anticoagulant or antiplatelet therapy, which means they received at least one drug containing a substance that was responsible for preventing or reducing coagulation of blood and prolonging the clotting time, such as unfractionated heparin (UFH), low molecular weight heparin (LMWH), vitamin K dependent antagonists (VKA), direct Thrombin inhibitors, direct factor II and Xa inhibitors, irreversible cyclooxygenase inhibitors (Aspirin), glycoprotein IIB/IIIA inhibitors, adenosine diphosphate (ADP) receptor inhibitors or phosphodiesterase inhibitors.
- the patient was able and willing to use the mobile phone,
- a patient had a mobile phone with Internet access and the Android/iOS operating systems, the patient should have been able to answer questions with full awareness,
- a patient had to be over 18 years of age.

2.4. Recruitment

Consecutive patients were coming from the cardiology ward of a tertiary cardiovascular care centre. They were admitted to the hospital between August and November 2021 based on medical indications. Participant recruitment occurred daily from Monday to Friday. All of them were instructed on the objectives and course of the study and gave informed consent for their participation.

2.5. Intervention description

Each participant received an inquiry form in Polish with ten questions regarding anticoagulant or antiplatelet therapy and cardiological conditions during the first days of hospital stay. Experts in the field of cardiology prepared the questionnaire. Patients were supposed to answer the questions according to their current state of knowledge. The questionnaire consisted of 10 questions. During its completion, the participant was accompanied by a person responsible for ensuring the proper course of the study procedure. All questions are included in Supplement 1 (in English) and 2 (in Polish).

Subsequently, the participants were given access to the CHASER application on their mobile phones and were supposed to use it for at least one day in Polish. They were given full access to the patient version only. Following this period, the inquiry form with the same questions was provided to each patient. The answers to both inquiries were then compared and assessed.

2.6. Statistical analysis

Categorical variables are presented as numbers (n) with percentages (%). Distributions of continuous variables were assessed using the Shapiro–Wilk test. All continuous variables were non-normally distributed and presented presented as median and interquartile range (IQR). For categorical variables, absolute and relative frequencies were presented. Differences in continuous parameters were compared using a non-parametric Wilcoxon signed-rank test. A value of $p < 0.05$ was considered significant for all tests. Statistical analysis was performed using SAS® software, version 9.4.

3. Results

In total, 50 patients were included in the study: 29 (58%) were male and 21 (42%) were female. The essential characteristics of the study population are shown in Table 1. The main indications for anticoagulation included atrial fibrillation (AF), venous thromboembolism, and post-heart valve replacement. However, it was common for a patient to have several indications for anticoagulant or antiplatelet therapy (Table 2).

Qualified respondents answered the same questionnaire twice, with an interval of one day. The median score of the first approach to the questionnaire was 7 points (IQR 3–10 points). However, from the second approach, it was already 8 points (IQR 4–10). More than half of the participants (62%) improved their scores. The most challenging question in the questionnaire (9) concerned the knowledge of classes of anticoagulants. After using the

application, 4% of participants increased their scores. The easiest question (4) was of the true/false type and concerned the predisposition to the formation of blood clots in the veins and, consequently, pulmonary embolism. After using the application, only 3 participants answered this question incorrectly. The most remarkable difference in correctness (26%) was shown by question (8) about the possible side effects of anticoagulant therapy. Statistical significance was observed in questions 1, 3, 8, and 10. The results of the questionnaire are described in Tables 3 and 4.

4. Discussion

Many mobile health (m-health) applications are used to assist in treating cardiological diseases. Using applications is increasingly popular. In one of the recent analyses, it has been shown that there may be as many as 1.7 billion health users globally. The area most studied in cardiology concerns mobile heart monitoring systems and techniques for classifying cardiac symptoms to detect abnormalities. Research on mobile systems in cardiology has become increasingly important in recent years. This fact shows that the mobile technology part of cardiology has recently become the subject of research since cardiovascular disease, and heart disease, in particular, is the leading cause of death worldwide [13].

Limited health awareness is associated with reduced access to preventive services, difficulties in compliance with medical recommendations, increased costs of healthcare, and poorer health outcomes. Mobile health aims to make health education and resources available regardless of health awareness level [14]. Nowadays, specialists have less and less time for the patient, which is a considerable limitation in explaining and answering each patient's question. Medical mobile applications could help doctors in their daily practice, and the patient would have answers regarding knowledge about diseases or prescribed medications [14].

Importantly, it has been found that most mobile applications lack scientific validation. Lack of supervision over the medical and scientific quality of the information provided by mobile health applications is expected. An essential challenge to mobile health is that health applications are primarily not regulated or monitored regarding the scientific validity or truthfulness of application information [14]. Medical experts in cardiology wrote the texts in the Chaser application. They were based on the guidelines provided by the ESC, which guarantees the quality of the educational materials. That is why patients can use it without worrying about being misled. Experts concluded the latest guidelines on anticoagulation therapy and basic knowledge about how these drugs work. Therefore, it was necessary to

provide simple and uncomplicated explanations. The key was for patients to understand and be aware of precisely what medications they were taking and how they were affected by the pharmaceuticals. The results show an increase in patients' knowledge after using the application. For this reason, we may suspect that its application in a broader range of medical practice would contribute to better-educating patients with cardiovascular diseases.

Another study used an app (called Blood Pressure Assistant) to compare changes in patients' knowledge about hypertension using an 8-item questionnaire. The results were similar to our study; the questionnaire results suggest that participants in the intervention group significantly improved their knowledge in 8 aspects ($p < 0.05$) after six months of the intervention [17]. One more study confirmed our results that patients using the mAF App for three months also increased their medical knowledge ($p < 0.05$) using an 11-item questionnaire regarding AF [18].

Another problem is the large number of patients who do not take their medications. Twenty to thirty per cent of new prescriptions are never filled at the pharmacy, and medication is not taken as prescribed fifty per cent of the time. For patients prescribed medications for chronic diseases, after six months, the majority take less medication than prescribed or stop the medication altogether [15].

Statistical significant differences ($p < 0.01$) were observed in questions 1, 3, 8, and 10 concerning cardiovascular and vascular health aspects. Patients demonstrated a better understanding of questions related to the association between diseases and atrial fibrillation and the specific anatomical locations commonly affected by vascular conditions. However, they struggled with questions concerning the complications of antiplatelet therapy and the management of bleeding during anticoagulation treatment. This represents the first such analysis available, making it difficult to provide further commentary.

The statistical significance of these particular questions may be due to several factors. Firstly, there might be diversity in educational content. Questions that showed statistical significance could have addressed areas where users had lower baseline knowledge or required more detailed education. Content focusing on complex topics like the associations between diseases and AF or complications of anticoagulation therapy may demand greater attention and deeper analysis, leading to higher educational effectiveness. Secondly, the application of practical scenarios could have played a role. Answers that were statistically significant might have been more centred on practical aspects of cardiovascular health, such as managing bleeding during anticoagulation therapy. As these issues directly apply to clinical practice, users may have been more diligent in absorbing information. Thirdly, prioritisation of knowledge could be a

factor. The content contained in the questions may have been crucial for users in understanding and managing their cardiovascular health. For instance, understanding the anatomical locations affected by vascular diseases could be pivotal for patients diagnosed with cardiovascular conditions, resulting in increased engagement in learning this information. Lastly, the accessibility of information might have contributed. Questions that demonstrated statistical significance could have been better tailored to how information was conveyed in the application. If the educational materials were clear, accessible, and readily available to users, this could have facilitated better understanding and retention of the discussed topics.

A methodological limitation surfaced as we compared the same group at distinct time intervals. Another limitation is the short follow-up period and the lack of assessment of how long the positive effect lasts. To enhance future analyses, considering a control group or a longitudinal design would provide a more reliable examination of variable relationships over time.

5. Conclusion

Due to its vast possibilities and effectiveness, the CHASER application has the potential to increase patient education and self-care in the comprehensive treatment of antiplatelet therapy. The results should be encouraging because it was just a feasibility study. Further studies are underway to assess the final indications for using Chaser.

Additional information

Author contribution

WKo, WKi — first co-authors, data curation, writing, conducting research; MK — data curation, writing, conducting research; BK — data curation, funding acquisition, methodology, software, supervision, review and editing; PL, ŁK, MG, MP, PB — data curation, funding acquisition, methodology, software, supervision

Conflicts of interest

The Authors declare no conflict of interests.

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Table 1. Patient characteristics.

Baseline demographics	N (%) or IQR
Gender (male)	29 (58%)
Age (years)	68 (26–84)
Body mass (kg)	78 (56–120)
Height (cm)	170 (155–188)
Body mass index	28 (20–42)
Medical history	
Nicotinism (history)	27 (54%)
Diabetes mellitus	16 (32%)
Hypertension	30 (60%)
Dyslipidemia	26 (52%)
Cardiovascular history:	
Heart failure:	26 (52%)
Atrial Fibrillation/flutter	35 (70%)
Myocardial infarction (history)	
STEMI	6 (12%)
NSTEMI	5 (10%)
Pulmonary embolism	2 (4%)
Implantation	25 (50%)
Catheter Ablation	15 (30%)
Coronary artery disease	19 (38%)

Data presented as median (interquartile range) or number (%).

Table 2. Indication for anticoagulant treatment.

Analyzed variable	N (%)*
Coronary artery disease	19 (38%)
Atrial fibrillation	35 (70%)
Valve prosthesis implantation	4 (8%)
Pulmonary hypertension	1 (2%)

Percutaneous Coronary Interventions	4 (8%)
Venous thromboembolism	2 (4%)
Pulmonary embolism	2 (4%)

*Due to numerous indications for anticoagulant or antiplatelet therapy, the sum of indications exceeds 100%.

Table 3. Questionnaire results.

Analyzed tests	**N (%) or IQR**	**p-value**
Average of Test1 (points)	7 (3–10)	p < 0.001
Average of Test2 (points)	8 (4–10)	
Improved score	29 (58%)	
Same score	18 (36%)	
Worse score	3 (2%)	

Data presented as median (interquartile range) or number (%).

Table 4. The questionnaire results in consecutive questions.

Question	**Correct, N (%)**		**Incorrect, N (%)**		**p-value**
	Test1	**Test2**	**Test1**	**Test2**	
1	34 (68%)	42 (84%)	16	8	0.039
2	41 (82%)	41 (82%)	9	9	1.000
3	32 (64%)	44 (88%)	18	6	0.002
4	46 (92%)	47 (94%)	4	3	1.000
5	41 (82%)	42 (84%)	9	8	1.000
6	39 (78%)	42 (84%)	11	8	0.375
7	33 (66%)	39 (78%)	17	11	0.146
8	27 (54%)	40 (80%)	23	10	0.002
9	11 (22%)	13 (26%)	39	36	0.581

10	12 (24%)	34 (68%)	28	16	0.004

Supplement 1. Questionnaire in English

Patient form

For each of the following questions, please select one correct answer.

1. Indicate which of the following diseases may be associated with atrial fibrillation:

a. Gastritis

b. Asthma

c. Stroke

d. Psoriasis

2. Which of the following is not considered a risk factor for cardiovascular diseases (including heart attack)?

a. Nicotinism

b. Diabetes

c. High physical activity

d. Obesity

3. Where are the most frequently affected arteries in peripheral vascular disease?

a. In the legs

b. In the hands

c. In the belly

d. In the pelvis

4. An individual predisposition to excessive blood clotting may result in the formation of blood clots in the veins in the legs and secondarily cause pulmonary embolism:

a. True

b. False

5. In the course of coronary artery disease, the vessels that feed the heart are most often narrowed by:

a. Developing atherosclerotic plaques

b. Foreign bodies

c. Blood too thick

d. Abnormal structure of the artery

6. Indicate which symptom is not typical for coronary artery disease.

a. Chest pain

b. Dyspnoea

c. Weakness

d. Cramps in the hands

7. What are the two main treatment strategies for valvular heart disease?

a. Meditation and treatment

b. Conservative and meditation

c. Conservative and procedural

d. Homeopathic and surgical

8. What is the most common complication of antiplatelet therapy?

a. Cramps

b. Bleeding

c. Fainting

d. Cough

9. What is the preferred class of drugs for the prevention of thromboembolic events in patients with atrial fibrillation?

a. Vitamin K antagonists

b. New oral anticoagulants that are not vitamin K antagonists

c. Antiplatelet drugs

d. Steroids

10.What should be the first action for bleeding in patients under anticoagulation therapy?

a. Compressing the source of the bleeding

b. Urgent contact with a physician, regardless of whether the bleeding has stopped

c. Retention of breath for as long as possible

d. Rinse the source of bleeding with warm water

Supplement 1. Questionnaire in Polish

Formularz dla pacjentów

W każdym z poniższych pytań zaznacz jedną prawidłową odpowiedź.

1. Wskaż z którą z poniższych chorób może być związane migotanie przedsionków:

a. Zapalenie błony śluzowej żołądka

b. Astma

c. Udar mózgu

d. Łuszczyca

2. Wskaż które z poniższych nie jest uznawane za czynnik ryzyka chorób sercowo-naczyniowych (w tym zawału serca)

a. Nikotynizm

b. Cukrzyca

c. Wysoka aktywność fizyczna

d. Otyłość

3. Gdzie znajdują się tętnice, które są najczęściej zajęte w przebiegu choroby naczyń obwodowych

a. W nogach

b. W rękach

c. W brzuchu

d. W miednicy

4. Indywidualna predyspozycja do nadmiernej krzepliwości krwi może skutkować powstawaniem zakrzepów w naczyniach żylnych w nogach i wtórnie spowodować zatorowość płucną:

a. Prawda

b. Fałsz

5. W przebiegu choroby wieńcowej naczynia odżywiające serce są najczęściej zwężone przez:

a. Rozwijające się blaszki miażdżycowe

b. Ciała obce

c. Zbyt gęstą krew

d. Nieprawidłową budowę tętnicy

6. Wskaż który z objawów nie jest typowy dla choroby wieńcowej

a. Ból w klatce piersiowej

b. Duszność

c. Osłabienie

d. Skurcze w rękach

7. Jakie są dwie główne strategie leczenia wad zastawkowych serca

a. Medytacja i zabiegowa

b. Zachowawcza i medytacja

c. Zachowawcza i zabiegowa

d. Homeopatyczna i zabiegowa

8. Jakie jest najczęstsze powikłanie terapii przeciwpłytkowej

a. Skurcze

b. Krwawienie

c. Omdlenia

d. Kaszel

9. Jaka jest preferowana grupa leków w ramach prewencji zdarzeń zakrzepowo-zatorowych u pacjentów z migotaniem przedsionków:

a. Antagoniści witaminy K

b. Nowe doustne antykoagulanty niebędące antagonistami witaminy K

c. Leki przeciwpłytkowe

d. Sterydy

10. Jakie powinno być pierwsze działanie w przypadku krwawienia u pacjentów w trakcie terapii przeciwkrzepliwej:

a. Uciśnięcie źródła krwawienia

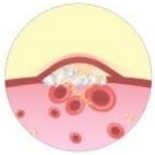
b. Pilny kontakt z lekarzem, niezależnie od tego czy krwawienie ustąpiło

c. Zatrzymanie oddechu na maksymalnie długi okres

d. Przemycie źródła krwawienia ciepłą wodą

EDUCATION

INTRODUCTION



Blood clotting basics

What you need to know about blood clotting

Antithrombotic therapy basics

What you need to know about antithrombotic drugs

INDICATIONS FOR ANTITHROMBOTIC THERAPY

Below you will find short educational content on the most common indications for antithrombotic therapy.

Peripheral artery disease (PAD)

Deep vein thrombosis (DVT) / pulmonary embolism (PE)

Coronary artery disease (CAD)

Atrial fibrillation (AFib)

Heart valve disease

Antiplatelets

Vitamin K antagonists (VKAs)

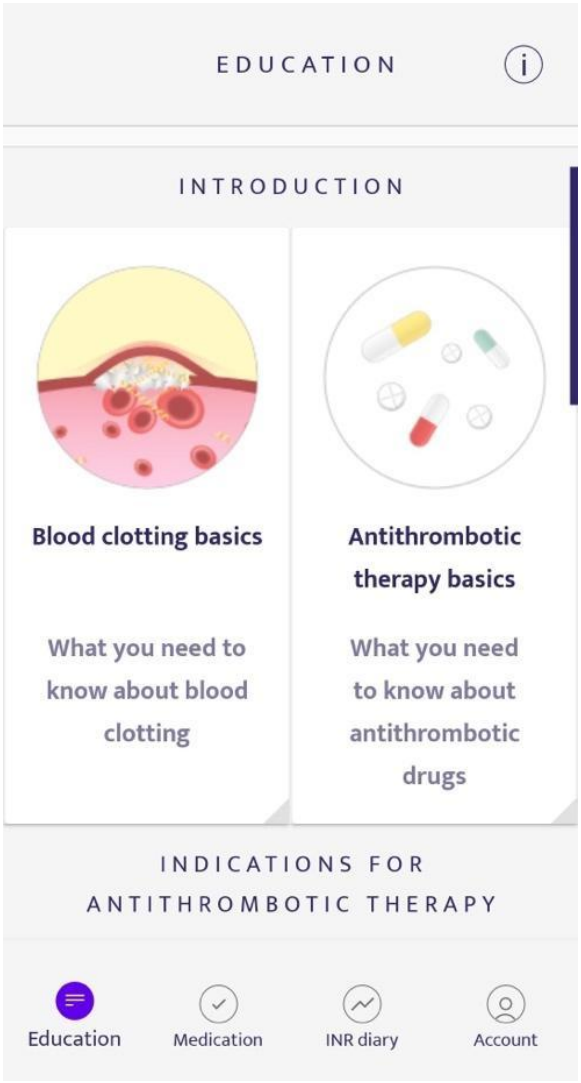
Novel oral anticoagulants (NOACs)

Welcome to CHASER

Please select whether you wish to use CHASER for physicians or patients

PHYSICIAN

PATIENT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