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R. A. Lerch steps down as editor-in-chief – F. Mach takes over

Thomas F. Lüscher
Cardiology, University Hospital, Zürich

After many years of service, René A. Lerch, former Professor of Cardiology at the University of Geneva and President of the Swiss Society of Cardiology stepped down as editor-in-chief Romandie for Cardiovascular Medicine at the end of 2015.

René Lerch has contributed enormously to Swiss cardiology in the course of his career. Immediately after his studies in medicine at the University of Zurich, he became a resident in the Cardiology Division at the Medical Policlinic of the University Hospital in Zurich, then run by Wilhelm Rutishauser. He continued his training in internal medicine and cardiology in Zurich and then under the leadership of Burton E. Sobel at Washington University in St. Louis Missouri. Upon his return to Switzerland he became a senior cardiologist at the Cardiology Centre of the University Hospital in Geneva, again under the leadership of Wilhelm Rutishauser. In 1992, he was named Professor of Cardiology as well as Director of the Research Laboratory on Myocardial Biology and of the Echocardiography Laboratory in Geneva. At the end of his career at the University Hospital in Geneva he also served as Acting Chief of the Cardiology Centre. He has been active in many professional societies, in particular the Swiss Society of Cardiology and the European Society of Cardiology. In the Swiss Society of Cardiology he was member and later honorary member of the Working Groups on Heart Failure, Echocardiography and Cardiovascular Biology, as well as WATCH. From 1998 he was board member and from 2004 to 2006 President of the Swiss Society of Cardiology and helped to shape our professional society. Specifically, he was member of the board during the important period when the board certification for cardiology was submitted to and later accepted by the Swiss Society of Physicians FMH, a truly important contribution to our specialty. After his presidency, he served as a cardiology delegate at the Swiss Society of Physicians FMH for the evaluation of training centres and as a council member of the Swiss Heart Foundation.

In 2000, it was a pleasure to nominate and welcome an experienced colleague such as René Lerch as successor of Patrice Delafontaine as editor-in-chief Romandie of our official journal Cardiovascular Medicine. Ever since, he has committed time and effort to developing the then young journal into what it is today. Indeed, we are proud that together with René Lerch we could make Cardiovascular Medicine one of the most read medical journals in Switzerland, with a strong focus on education thanks to the publication of well-balanced review articles as well as sections on imaging, ECGs, arrhythmias and alike.

It was, regrettably, René Lerch’s own decision to leave the position as editor-in-chief. With this editorial, we would like to thank an exceptional colleague and friend. René Lerch will stay member of the editorial board as Senior editor.

We are happy that, as of 1st January 2016, François Mach, Professor and Chairman of Cardiology at the University Hospital in Geneva, has agreed to follow René Lerch as editor-in-chief Romandie of Cardiovascular Medicine. With François Mach we will again be able to work with a well-known and experienced cardiologist and cardiovascular researcher of high standing who will help us to further develop our journal and motivate young cardiologist in particular to publish their work in our journal.
PFO closure may become first-line preventive therapy for patients with cryptogenic stroke

Percutaneous closure of patent foramen ovale: long-term follow-up shows benefit

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The foramen ovale is a door-like opening of the inter-atrial septum framed by the septum primum and septum secundum. In utero it serves as a pathway for oxygenated blood to shunt from the right to the left atrium, thereby bypassing the nonfunctional lungs. After birth a right-to-left shunt is undesirable and the foramen ovale closes. However, in a quarter of the population no permanent closure occurs, and the patent foramen ovale (PFO) may allow particulate or chemical material to pass from the venous to the arterial circulation, especially during increased right atrial pressure (e.g., Valsalva manoeuvre). A PFO has been associated with cryptogenic stroke, myocardial infarction, migraines, sleep apnoea, platypnoea-orthodeoxia, diving-associated decompression illness and high-altitude pulmonary oedema. Nevertheless, the majority of humans with a PFO live without experiencing a PFO-related medical condition [1]. Therefore, the PFO does not qualify as a screening target in the general population [2] and primary prophylactic PFO closure in asymptomatic individuals is not recommended.

Stroke is one of the most feared and devastating health disorders. One third of strokes are so-called cryptogenic because no apparent cause is found. The prevalence of a PFO in patients suffering a cryptogenic stroke is higher than in patients with known stroke causes [3, 4]. Nonetheless, in a large number of patients with cryptogenic stroke, no PFO is found [4]. Given the high background prevalence of PFO in the general population, many PFOs detected in patients with cryptogenic stroke are incidental. However, PFO patients who suffered a paradoxical embolism may represent a higher risk cohort and may benefit more from PFO closure compared with medical management, especially when an atrial septal aneurysm or large shunt is present.

In the 1970s and 1980s percutaneous closure of inter-atrial connections was developed. On the basis of mostly nonrandomised, observational data, PFO closure was advocated for patients with cryptogenic stroke [5]. However, three major randomised controlled trials [6–8] did not meet their predefined primary endpoint to establish the superiority of percutaneous PFO closure over medical management in patients with cryptogenic stroke. Meanwhile, 17 meta-analyses based on these results [9] have been published. The lack of long-term follow-up and controversies about intention-to-treat analyses versus device-in-place analyses have modified interpretation of randomised data. Indeed, short-term observations suffer from low recurrence rates. Adjudicating events occurring before PFO closure in the device arm, by obstinately following the intention-to-treat principle, is not helpful in defining the effect of PFO closure. Long-term follow-up in the as-treated cohort may finally establish percutaneous PFO closure as the preferred therapy for the prevention of recurrent paradoxical embolism in patients with cryptogenic stroke [10].

Accordingly, in this edition of the journal, Andreas Wahl et al. report the long-term outcome of PFO closure with the Sideris Buttoned Occluder. The authors should be congratulated for their persistence in following-up their patients for more than 10 years. The study tested the long-term safety of the device and showed a low stroke recurrence rate after PFO closure. The periprocedural complication rate in this cohort is somewhat historical, and in the meantime percutaneous PFO closure has become a relatively simple and safe procedure. Given the unsatisfactory closure rate with the Sideris Buttoned Occluder it is understandable that the authors stopped using this device and prefer others with higher closure rates and a better safety and efficacy profile (e.g., the AMPLATZER™ PFO Occluder).

This manuscript coincides with the long-term follow-up results of the RESPECT trial [6], which were recently reported at Transcatheter Cardiovascular Therapeutics 2015 in San Francisco. Extended follow-up
analysis of this randomised trial showed that PFO closure reduced the relative risk of recurrent cryptogenic stroke by 70% compared with medical therapy (1.5 to 4.3%; \( p = 0.004 \)). As paradoxical embolism is excluded after successful PFO closure and conservatively treated patients face a persistently increased bleeding risk due to continuous antithrombotic medication, it is expected that event-curves for safety and efficacy will continue to separate over the years. However, with increasing age the susceptibility to noncryptogenic stroke increases. Therefore, during long-term follow-up the effect of PFO closure becomes blurred by events unrelated to the PFO. In this setting, paradoxical embolism has to be discriminated from events caused by atherosclerotic plaque rupture, which becomes more prevalent with age. The scrutiny of scientific researchers is mandatory to dissect the various causes of ischaemia in an aging cohort and tease out the group that may benefit from PFO closure by sound analyses and adequately powered randomised controlled trials. The identification of cofactors such as hypercoagulability, deep vein thrombosis or cardiac anatomical peculiarities (e.g., atrial septal aneurysm or large shunt) may further transform the PFO from an innocent bystander to a vicious facilitator. Long-term follow-up—as reported by Andreas Wahl et al.—solidifies the biological impact of PFO closure so that it may become first-line therapy for the prevention of paradoxical embolism in patients with cryptogenic stroke.

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**References**
ESCeL platform: the tool to improve the harmonisation of cardiology education and training

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Summary

Several surveys demonstrated in the past a large heterogeneity of cardiology training and education in European countries. Taking into consideration the reality of the free movement of doctors and patients across borders, the cardiology community feels a strong need for the harmonisation of training and education of European health professionals. The ESC has already produced the standards, and recently developed the tool to deliver these standards: the ESCeL platform. This project is currently on the road to success. A challenge for the future is the possibility of massive participation of professionals, in thousands, not hundreds. Although this project raises a lot of questions and challenges it also opens a wealth of new possibilities for the future of our profession and particularly the delivery of a high standard of care to our cardiovascular patients.

Key words: e-learning; e-training; education; ESC core curriculum; ESCeL

ESCeL mission statement:
“The highest European standard of training and education, to as many as possible, at the lowest cost possible”

Background

Because of the subsidiarity principle, the European Union is not directly involved in the healthcare policy of member states, but it is very interested in the free exchange of services, including medical services. In fact, health professionals (mainly doctors and nurses) are among the European professionals who travel the most across borders to work in other countries.

It is clear that the free exchange of professionals and services (goods and capital) within the European Union is guaranteed by the Treaty of Rome. Free exchange of professionals and services within medicine was established by the Commission of the European Community in 1975. The directives have been consolidated in the Directive 93/16/44C of 5 April 1993 [1]. A patient safety directive called the “Luxembourg Declaration on Patient Safety” was also published in 2005. In this declaration it was clearly recommended “to include patient safety in the standard training of health professionals combined with integrated methods and procedures that are embedded in a culture of continuous learning and improvement” [2].

For these reasons, the European Union is paying a lot of attention to the harmonisation of medical education in Europe and to the safeguard professional standards in the field of medicine [3]. In order to achieve this goal, the delivery of harmonised high-standard training and education to healthcare professionals is essential. This harmonisation would facilitate the free movement of doctors across borders and would help patients have access to similar high standards of care across the different European countries. Scientific societies such as the European Society of Cardiology (ESC) are key players in the development of this harmonisation process.

However, this harmonisation of training and education is only the beginning of a long process. There will be a need in the future to reassure patients and regulatory authorities that qualified doctors keep themselves updated during their active professional life and are always able to provide their patients with a high standard of care. Therefore, it is reasonable to say that
continuing medical education (CME) of doctors contributes to their continuous professional development (CPD) and that this is of utmost importance for patient safety reasons.

Continuing medical education based on electronic distance-learning educational tools may have a strong impact on “classic” interpersonal relationships and interactivity between members of professional scientific societies, and may change the medical learning process in the future. We are already living in a new era of e-learning and e-training.

This new world of electronic distance learning and electronic distance training is rapidly changing the strategies of many professional associations. In fact, in this new era information and communication technologies have created a new series of educational products and tools that have the potential to enhance network learning not only at national level, but also at an international global level. All these electronic tools, by increasing the effectiveness of CME for health professionals on a large scale, bring with them the possibility of reaching a massive number of physicians and other health professionals around the world, even in remote areas [3–7]. Although these technologies present many questions and challenges they also open a wealth of new and exciting possibilities for the future.

Introduction

Cardiology is one of the most competitive specialties in medicine, and by its nature is leading many fields of medicine not only in Europe but also around the world. This leading role involves not only scientific research, but also organisational, training and educational aspects as well.

In terms of education and training the reality in Europe is largely heterogeneous. In fact, several surveys developed by the ESC over the years have clearly shown the existence of major discrepancies in terms of curriculum and duration of training between different European countries. In 2014, the European Association for Percutaneous Intervention (EAPCI) developed a survey with the goal of better understanding the current situation of the interventional cardiology training and education in Europe. The results of this survey were quite clear: there is a large heterogeneity in many parameters, including the duration of training needed to become a certified interventional cardiologist. The same is true for the number of procedures needed during the training. Data from another survey from the ESC showed that despite the fact that 66% of the countries reported having an educational platform, only 13% stated they had a training platform. This is probably the reason why 93% of these countries are willing to use ESCeL (ESC e-learning and training platform) at the national level.

The observed heterogeneity of education and training in Europe is possible because of the basic subsidiary principle of the EU member states and the lack of EU regulations that could force the standardisation and harmonisation of medical education and training in Europe. In order to help to change this heterogeneity in European education and training, the ESC took some strong steps forward.

The first step was taken together with the Union Européenne des Médecins Spécialistes Cardiology Section (UEMS-CS), which represents the profession at the EU level. These two organisations decided to create a specific body called the European Board for the Specialty of Cardiology (EBSC). In 1996, this organisation published a document of basic recommendations for the education and training of cardiology in Europe [1].

Taking into consideration the recognised urgent need for the harmonisation of training and education in Europe, some scientific societies, such as the ESC, decided to continue to move forward with the UEMS-CS collaboration, and developed a second step: the delivery, in 2006, of the “Core Curriculum for the General Cardiologist” [8]. This document was updated in 2008 [9], and a new document was recently published in 2013 [10]. These documents were an attempt to provide a framework for the continuing medical education and training of European General Cardiologists by defining the teaching, learning and assessment methods. This ESC core curriculum for general cardiology should be considered the standard for the education and training of this specialty across Europe, and it is structured in three main areas: knowledge, skills and attitudes (professionalism). Beyond general cardiology, other subspecialties inside the ESC have developed their own core curricula [4, 11]. ESC Nurses and Allied Professionals have recently published their own core curriculum [15].

Therefore, it is clear that at present we already have the standards, but the question still remains: how can we deliver these standards across Europe in a harmonised fashion? In order to answer this question the ESC then decided to start the third step: to develop an electronic tool that would be able to deliver these standards across Europe and, beyond Europe, around the world. This electronic tool is ESCeL (ESC e-Learning).

The ESCeL project structure

The ESCeL platform was developed with a modular structure (fig. 1) that would enable the platform to be
flexible and be adapted easily to different needs, and thereby to promote harmonisation. Integrated in the three main assessment areas described in the ESC Core Curriculum (knowledge, practical skills and professionalism) there are within its structure 10 smaller basic modules.

The knowledge area is based on the Core Syllabus and the Core Curricula, and follows their structure and hierarchy. Inside the different topics (chapters) there are courses dealing with one specific theme. Inside the course are a number of high-standard educational materials selected by a group of dedicated experts who are dealing with this specific theme. All these courses have in the introductory page a brief description of their content in order to give the user an overview of content before the decision is made to launch the course. Each one of these educational materials has a table of contents and the learning objectives. Inside the educational materials the user will find formative multiple choice questions (MCQs) intended, according to the learning objectives, to make sure the user is acquiring the most important pieces of information and not skipping any important point. As a formative MCQ an incorrect answer prompts the user to return to the related educational material, before attempting the question again. A progression bar shows where the trainee stands in terms of collecting the points needed to achieve the goals successfully. As a general rule, one point equals one hour of education.

The skills assessment area is formed by four components.

The first is the case logbook where the trainee is asked to upload a number of representative clinical cases from their clinical practice. In these clinical cases the patient is asked to present a short history of the clinical condition, and upload the most relevant examinations the patient performed. Because of confidentiality issues and data protection all submitted data must be anonymised. Each case is reviewed together with the local trainer to trigger a discussion in such a way as to encourage constructive feedback from the trainer to the trainee.

The next module is Directly Observed Practical Skills (DOPs). While observing the trainee undertaking a procedure, the trainer completes a questionnaire comprising a standard set of evaluable steps. Typically these address how the trainee interacts with the patient, the patient’s family and other health professionals, and the trainee’s collaboration in the organisation and research within the department, among many other important aspects. DOP assessments are recommended at the beginning, in the middle and towards the end of the training period. If the local trainer detects areas where the trainee can improve their performance, then feedback is provided to the trainee and progress in these specific areas is evaluated when the next DOP assessment takes place.

In the procedure logbook the trainee logs all procedures undertaken during training. These numbers are signed off every month by the local trainer. After sign-off, the trainee is not able to edit these numbers further. There are recommended indicative numbers of procedures that should be achieved during the training period, and the platform supports the trainee and the local trainer in this respect by automatically tracking the numbers.

The patient safety module is used by the trainee to log each month complications they have encountered.

**Figure 1:** The ESCeL platform modular structure. This structure was created in order to adapt easily to the different strategies and realities within countries and sub-specialties.
These numbers are verified by the local trainer and after sign-off the trainee is not allowed to edit the content. This tool is helpful to support the trainees’ improvement of performance and involves the local trainer directly in this important part of the training process.

The professionalism area is formed by two components. One is a tool that supports the trainee in the systematic recording of their activities during the training period. At any time the trainee can generate a curriculum vitae in PDF or HTML format by simply pushing a button. A second discretionary component is a “360-degree” appraisal. If the trainee decides to use this tool, he/she invites a colleague, such as a nurse, a technician or a clerical secretary and a patient to evaluate the trainee at the beginning, in the middle and before the end of the training period. The evaluation is based on the personal perspectives of these people on the capacity of the trainee as a communicator, a collaborator, a manager, a health advocate, a scholar, and as a professional [16]. This anonymous feedback is sent to the trainee and to the local trainer. If there are areas where the trainee needs to improve, the local trainer can always support this improvement.

This modular structure is useful because it allows the platform to adapt to the different needs and strategies of the several groups that are going to use the platform. Moreover, it allows the platform to cope with the different realities within European countries. For example, while some groups of professionals, or countries, may want only to use the knowledge area or only use the skills area, other groups/countries may want to use the full capacity of the platform. Furthermore, if in the future the groups, or the countries, decide to change their strategy and add or remove other modules they can also do so easily.

The ESCeL platform was built in such a way that all institutions involved in the teaching and training (ESC,}

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**Figure 2:** ESCeL platform workflow. Interaction between the local trainers, trainees and training directors within the training hospital with the national society, at the national level. Interaction between the trainee, European auditor, and European scientific organisation.
national societies, national accreditation authorities, training hospitals, training directors and local trainers) have specific roles and responsibilities. Without the active contribution of all these stakeholders the platform will simply not work at the national level. Therefore, the contribution of all these stakeholders is critical for the platform to work properly at the national level.

In terms of workflow (fig. 2), everything starts with the decision of the country (national society, national accreditation authority) to participate in the project. As soon as the national group informs the ESC that they want to participate, the ESC will ask the national group to provide a list of training hospitals, training directors and local trainers in this country. Once this information is registered, trainees from this country can start to enrol in the ESCeL platform where they will find this information. After trainee enrolment, the notice is sent automatically to the national society or national accreditation authority for verification. This is important to make sure that the person who has enrolled is legally entitled to undertake training, and to check if the training hospital, training director and local trainer are able to deliver training to the trainee. Only after sign-off of this national institution can the trainee start using ESCeL for training purposes. This is a critical contribution of the national group, and can only be performed at the national level.

The platform has two special features that are useful. One is a set of tracking rules that ensure that all important steps in the training process are undertaken in the correct sequence. This tracking system is automated obviating the need for human intervention. For example, if a trainee uploads a clinical case in his/her logbook, or if the local trainer is due to sign off the last month’s number of procedures, the ESCeL platform detects that automatically and generates an e-mail requesting specific actions of the local trainer, training director and trainee. The ESCeL platform will only stop sending the e-mail when the requested action has been taken. This automaticity is required to deal with large numbers. It is an example of a strategy used by Massive Open Online Courses (MOOCs), whereby automated interactions lessen the requirement for human resources and the time needed to achieve goals [6].

A second important feature available inside the ESCeL platform is the possibility for supervisors (local trainers and training directors) to view easily how their trainees are evolving, by accessing the trainees’ accounts at any time through the ESCeL platform. For the national societies it will also be easy to have a full perspective of the training process in their country and to see how the trainees inside the different training hospitals are performing. For the ESC it will be possible to have a view of all the countries, all the training hospitals and all the trainees. By using this approach it will be possible for the European auditors appointed by the ESC (experts in the field) to visit the trainees’ personal accounts through the ESCeL platform and give them constructive feedback on what they achieved and on
how they can perform better in the future. This will be valuable for the trainee and will contribute to the progressive harmonisation of training across Europe and beyond Europe.

Finally, the platform is prepared to deal with interruptions of training due to sick leave, pregnancy or military service. It is also able to integrate training periods in different institutions, when trainees seek specific training in some highly specialised techniques.

ESCeL project, current situation

Since the official launch of the project in 2012, the ESCeL Project continues on its road of success. The platform was created to respond to the need of developing a harmonisation tool able to provide a high standard of training and education not only for Europe, but also beyond Europe, in the rest of the world.

The ESCeL platform is today the backbone of all the processes of education and training inside the ESC (fig. 3). In fact, ESCeL connects the work of several committees inside the ESC with the goal of providing education, training, certification and re-certification. Only the ESC can offer these different features all together. Needless to say all these ESC committees depend on the hard work of volunteers who spend thousands of hours to support their profession and their patients in Europe through their work in the ESC. The main goal of all this effort is to improve procedures, to deliver a high standard of training and education to our European cardiologists and, at the end of the day, to deliver a high standard of care to our European patients suffering from cardiovascular diseases.

The news in 2015

The ESCeL platform project is an ongoing project that is continuously improving and adapting to changes and needs. Currently, it is bringing new features such as General Cardiology training (fig. 4), beyond the six subspecialties already available. The full delivery of the General Cardiology programme is expected to occur by the end of 2015.

Another important new feature of the ESCeL platform is the possibility to allow continuous medical education (CME) and continuous professional development (CPD) not only for those who finish their training inside ESCeL, but also for those who are qualified doctors and want to be updated in their field of expertise.

Finally, the current version of ESCeL platform allows the provision of educational materials in local languages in parallel to the ESC educational materials in English. These educational materials in local languages can be the result of direct translation of ESC educational material (guidelines, consensus documents, textbook chapters, among many others) or can be produced originally at the national level and uploaded into the ESCeL platform after the approval of the ESC.
Educational Committee. The national societies that want to translate ESC educational materials into their national languages and upload them into ESCeL will be responsible for the scientific quality of the translation. Moreover, the costs associated with this translation process will also be supported by the national societies. This new feature is certainly important, not only for some European countries but also for other countries around the world as well. Several national societies have already shown the willingness to translate ESCeL contents into their national languages.

The ESCeL platform success can be demonstrated in several different ways. One is the high number of trainees/users, who already enrolled in ESCeL. They are coming from more than 20 different countries around the world. Another objective fact is the impressive number of courses produced in the last 4 years for ESCeL (fig. 5). The interest shown in this project by nurses and allied professionals and by our industry partners, is further testament to its success.

The future: evidence-based education/training and performance evaluation

With the support of educationalists it will be possible in the near future to include within the ESCeL project totally new concepts in the cardiology field, such as evidence-based education and training and objective clinical performance evaluation. With the continuous use of ESCeL we will be able to generate large amounts of valuable data (evidence). Moreover, randomised clinical trials on education and training will generate evidence as well. All this information will allow us to identify gaps (gaps assessment) and to design better education and training for the future.

Clinical performance evaluation has been based until now on the number of procedures the trainee needs to perform in a specific period of time together with a subjective evaluation of the trainee’s technical and cognitive skills. There are, however, better ways of evaluating clinical performance, by using innovative techniques within the ESCeL platform. One of these techniques is biomedical simulation. Biomedical simulation allows the objective evaluation of performance by measuring the number of errors, the quality of the decisions that are taken, the time needed to achieve the goal and whether the goal is achieved. However, simulation is not widely available and this lack of availability is expected to remain for the near future. One good alternative is the development of “micro clinical cases” that are created with the purpose of measuring the trainees’ performance in the presence of their mentor. By using these “micro clinical cases” mentors will be able to evaluate in an objective way several clinical performance parameters and to measure trainees’ progress.

These concepts are the new frontiers of medical education and training in cardiology and are expected to be available within the ESCeL project in the near future.

Conclusion

There is a large heterogeneity of cardiology training and education in European countries. Taking into consideration the reality of the free movement of doctors and patients across borders, the cardiology community feels a strong need for harmonisation of the training and education of European health professionals. The ESC has already produced the standards, and recently developed the tool to deliver these standards: the ESCeL platform. This project is currently on its road of success. A challenge for the future is the possibility of massive participation of professionals, in the number of thousands, not hundreds. Although this project raises a lot of questions and challenges it also opens a wealth of new possibilities for the future of our profession and particularly to the delivery of a high standard of care to our cardiovascular patients.

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The full list of references is included in the online version of the article at www.cardiovascmd.ch.

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Figure 5: Development of educational courses for ESCeL during the last 4 years.
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Summary

Many patients undergoing elective or emergency surgery have a cardiac implantable electronic device (CIED), and their number continues to grow. This joint position paper of the Swiss Working Group on Cardiac Pacing and Electrophysiology of the Swiss Society of Cardiology and the Cardiovascular and Thoracic Anaesthesia Group of the Swiss Society of Anaesthesiology and Resuscitation gives a concise overview of the pre-, intra- and postoperative issues and management of pacemaker and defibrillator carriers in the setting of electrocautery used for surgery and strives to give practical and readily applicable guidance stressing the simple use of a magnet placed over the CIED.

Key words: pacemaker; defibrillator; electrocautery; magnet; reed switch; surgery

Introduction

In Switzerland approximately 45,000 patients live with a cardiac implantable electronic device (CIED). CIEDs comprise cardiac pacemakers, implantable cardioverter defibrillators (ICDs) and devices for cardiac resynchronisation therapy (CRT). Their number continues to grow and these patients are already undergoing elective or emergency surgery in great numbers. The Swiss Working Group on Cardiac Pacing and Electrophysiology published a checklist for the perioperative management of CIED patients in 2009 (www.pacemaker.ch/download/Checklist_Literature.pdf). The current recommendations update the previous ones and represent a joint position paper of the Swiss Working Group on Cardiac Pacing and Electrophysiology of the Swiss Society of Cardiology (SSC) and the Cardiovascular and Thoracic Anaesthesia Group of the Swiss Society of Anaesthesiology and Resuscitation (SGAR). It has been approved by the boards of the SSC and the SGAR.

In clinical practice, many patients undergo surgery at hospitals where reprogramming of the device is not possible. The main objective of these recommendations is to allow surgery at local centres as often as possible and to avoid unnecessary delays or referrals to centres with a cardiology service. There is also the real risk that the patient’s device is left programmed in an asynchronous pacing mode or that life-saving ICD therapy remains inactivated. In fact, the vast majority of patients can be operated on with the simple use of a magnet [1]. Following the modified recommendations of the Canadian Heart Rhythm and Anesthesiologists’ Society this position paper gives a pragmatic approach to elective and emergency surgery on CIED patients, stresses the importance of understanding the simple use of a magnet and explains in which conditions reprogramming really is necessary [1].

Abbreviations

ATP: antitachycardia pacing
CIED: cardiac implantable electronic device
CRT: cardiac resynchronisation therapy
EMI: electromagnetic interference
ICD: implantable cardioverter defibrillator
Potential perioperative risks

The main concerns when using cautery in a patient with a CIED is that it may inhibit pacing in a pacemaker-dependent patient or cause inappropriate anti-tachycardia pacing (ATP) or shock therapy in an ICD patient (table 1). Furthermore, though less threatening, inappropriate rapid pacing may occur if the rate response remains activated. The likelihood of occurrence of these events and the severity of their consequences depends on four factors:

1. Site of surgery
   Sensing electromagnetic interference (EMI) is more likely if surgery is performed <15 cm away from the device, i.e., above the umbilicus.

2. Underlying cardiac rhythm
   Only a minority of pacemaker patients are completely pacemaker-dependent and at risk for prolonged asystole. For the remainder, short periods of EMI (<5 seconds) during cautery will not result in a systole even if they temporarily inhibit pacing.

3. Type and programming of the device
   EMI is more likely in patients with unipolar leads (which have become very rare) and those with a very high programmed sensitivity. Inappropriately rapid pacing can be caused by manipulation in the vicinity of the generator (“activity sensors”) or by mechanical ventilation or monitoring of respiratory rate in patients with rate-modulation technology (minute ventilation sensors) [2]. These minute ventilation sensors are used in Boston Scientific and Sorin devices, and measure transthoracic impedance. Mechanical ventilation or the current delivered by external respiratory rate monitors may lead to rapid ventricular pacing which must not be misinterpreted as ventricular tachycardia. Hence suspension of rate response during the procedure should be considered; this can be accomplished with a magnet in pacemaker patients, but requires reprogramming with ICDs.

4. Type of cautery utilised
   EMI is more likely to occur with unipolar cautery. The grounding pad of the coagulation system should therefore be positioned away from the device (e.g., upper thigh). Bipolar cautery should be preferred over unipolar cautery, with bursts lasting <5 seconds with 5-second pauses between bursts. When using an argon beam coagulation system, reprogramming of the pacemaker in a dependent patient should be considered, since experience is still limited [1].

Of course, other consequences during surgery can impair the functionality of the device (e.g., physical damage to the leads, increase of pacing thresholds with loss of capture, increase of ICD defibrillation threshold owing to a perioperative pneumothorax, etc.).

Principle of magnet use

CIEDs possess a reed switch which is activated when a magnetic field is applied. In short, the reed switch consists of two magnetic metal strips, that are usually separated, in a glass capsule. The magnetic field will bring these two strips together, which results in a sudden voltage change sensed by the sensing amplifier that will trigger programmed functions such as asynchronous pacing [3]. Newer devices that are designed to be magnetic resonance imaging-safe are equipped with Hall-effect sensor switches, which trigger an electronic switch when activated by a magnetic field.

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Table 1: Patient- and procedure-related risk factors.

<table>
<thead>
<tr>
<th></th>
<th>Pacemaker</th>
<th>Implantable cardioverter defibrillator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Device always accessible and outside operation field</td>
<td>Bradyarrhythmia function</td>
<td>Tachyarrhythmia function</td>
</tr>
<tr>
<td>No or minimal cautery</td>
<td>No reprogramming</td>
<td>Have magnet available</td>
</tr>
<tr>
<td></td>
<td>No reprogramming</td>
<td>Apply magnet</td>
</tr>
<tr>
<td>Significant cautery</td>
<td>Not pacemaker-dependent</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>No reprogramming</td>
<td>Have magnet available</td>
</tr>
<tr>
<td></td>
<td>No reprogramming</td>
<td>Apply magnet</td>
</tr>
<tr>
<td>Pacemaker-dependent</td>
<td>No</td>
<td>No reprogramming</td>
</tr>
<tr>
<td></td>
<td>Reprogram</td>
<td>Reprogram</td>
</tr>
<tr>
<td>Pacemaker-dependent</td>
<td>Yes</td>
<td>Apply magnet</td>
</tr>
<tr>
<td></td>
<td>Consider reprogramming</td>
<td>Apply magnet</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>Reprogram</td>
</tr>
<tr>
<td></td>
<td>Reprogram</td>
<td>Reprogram</td>
</tr>
</tbody>
</table>

Pacemakers (table 2)
Applying magnets to pacemakers serves both diagnostic and therapeutic purposes. The magnets should have a field strength >10 Gauss aligned with the reed switch in order to activate the switch (magnets provided by the industry have field strengths >90 Gauss). In very obese persons two magnets may be required to activate the reed switch.
The application of a magnet switches the programmed mode to an asynchronous mode and inactivates the rate response feature. Biotronik pacemakers are an exception in that in the default “auto” setting they will pace asynchronously for 10 beats only and then revert to the programmed synchronised mode.

Implantable cardioverter defibrillators (table 3)
Generally, magnet application suspends antitachycardia therapy without any effect on the pacing mode. Sorin ICDs are an exception and will pace with the magnet rate. This means that the pacemaker part continues to function in the programmed synchronous mode, including rate responsiveness. Approximately 25% of ICD patients also require some kind of anti-bradycardia pacing.
Boston Scientific ICD can respond in a complex fashion. Older devices (PRIZM and VITALITY I families) have the “change the mode with magnet” feature that can be programmed on. In that case magnet placement can permanently switch antitachycardia detection and therapy off. In order to reactivate it, the magnet has to be reapplied for >30 seconds. In the more recent Boston Scientific models, the “change the mode with magnet” feature is absent and these ICDs behave like the others. If in doubt, interrogating the Boston Scientific defibrillators postoperatively is strongly recommended.

Minimal preoperative care
Before surgery one must ascertain whether the patient carries a CIED and if so which type. Usually, the patient presents with a pacemaker/ICD identification card that contains all important information. In the case of an emergency or other circumstances preventing the patient from providing this information, a scar in the left or right pectoral region should be sought. In most instances, the device can be palpated. The minimal information that has to be obtained before surgery is whether the patient carries a pacemaker or an ICD. This is important since the response to magnet application differs and may become an issue in a pacemaker-dependent patient. This information can easily be

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**Table 2: Specific responses of different pacemakers on magnet application.**

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Response*</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biotronik</td>
<td>Auto: DOO/VOO/VDO, 90 bpm for 10 beats, then back to synchronous</td>
<td>Can be programmed to Async or Sync response</td>
</tr>
<tr>
<td>Boston Scientific</td>
<td>DOO/VOO/VDO, 100 bpm</td>
<td>Can be programmed OFF</td>
</tr>
<tr>
<td>Medtronic</td>
<td>DOO/VOO/VDO, 85 bpm</td>
<td>Can be programmed OFF</td>
</tr>
<tr>
<td>St. Jude Medical</td>
<td>DOO/VOO/VDO, 100 bpm</td>
<td>Can be programmed OFF</td>
</tr>
<tr>
<td>Sorin/Ela</td>
<td>DOO/VOO/VDO, 96 bpm</td>
<td></td>
</tr>
</tbody>
</table>

* Depicted are the default settings of the device. Initial response is pacing in an asynchronous mode (DOO/VOO/VDO).

Rates refer to devices at beginning of life (BOL).

**Table 3: Manufacturer-specific implantable cardioverter defibrillator responses to magnet application.**

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Response to Brady function</th>
<th>Response to Tachy function</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biotronik</td>
<td>None</td>
<td>Detection/therapy: OFF</td>
<td>Since Lumax: during maximum of 8 hours</td>
</tr>
<tr>
<td>Boston Scientific</td>
<td>None</td>
<td>*</td>
<td>Patient alert “ON”: continuous tone: OK, alternating tone: alarm</td>
</tr>
<tr>
<td>Medtronic</td>
<td>None</td>
<td>Detection: OFF</td>
<td>Patient alert “ON”: continuous tone: OK, alternating tone: alarm</td>
</tr>
<tr>
<td>St. Jude Medical</td>
<td>None</td>
<td>Detection/therapy: OFF</td>
<td>Can be programmed to “Ignore magnet”: Atlas and Epic: vibratory alert</td>
</tr>
<tr>
<td>Sorin/Ela</td>
<td>Pace in programmed mode at magnet rate (96 bpm)</td>
<td>Detection/therapy: OFF</td>
<td></td>
</tr>
</tbody>
</table>

* If the function “Enable magnet use” is “ON” (nominal), 30” beep synchronous to R wave, then: i) continuous beep (some old models): Tachy mode OFF, magnet can be removed; to activate therapy magnet must be reapplied, ii) intermittent beep (new models): magnet must be left to inhibit antitachycardia therapy. If the function “Enable magnet use” is “OFF”: no effect.
obtained from a simple chest X-ray (figs 1 and 2). An ICD can easily be recognised from the shock coils that are identified as a “thickening” of the lead in the right ventricle. Many (“dual-coil”) ICD leads carry a second coil in the superior vena cava. If these are discerned, the patient should be treated like an ICD carrier. The presence of a third pacemaker lead pointing posteriorly indicates that this patient is a CRT-carrier in whom perioperative fluid challenges should be avoided since he or she had or has heart failure. Often, however, additional leads are simply abandoned leads (without contact to the generator on the chest X-ray).

It is important to know if the patient is pacemaker-dependent or not. A conservative assumption of pacemaker dependency is an intrinsic ventricular rate <40 bpm (measured by temporarily modifying the baseline rate to 40 bpm with a programmer) or if only paced QRS complexes are visible on the ECG. In CRT-patients this cannot be applied since 100% biventricular pacing is desired.

If possible, one should try to identify the manufacturer and model of the CIED. This is pertinent in pacemaker-dependent patients since the pacemakers of one manufacturer (Biotronik) revert after positioning of the magnet from an asynchronous to the programmed mode after ten asynchronous beats and may require reprogramming.

In ICD patients, the magnet will deactivate only the antitachycardia therapies of the device and leaves the antibradycardia mode unaffected. Sorin ICDs set the pacing rate to 96 bpm without any change in pacing mode. One manufacturer (Boston Scientific) has a feature in some of their older models (Boston Scientific PRIZM and VITALITY I) that permanently deactivates the defibrillator after 30 seconds.

**Intraoperative care**

In all patients with an implanted CIED, the anaesthetic workplace must be equipped with a defibrillator with pacing capability. In cases where the patient is completely pacemaker dependent, or where the ICD functionality will be switched off and where there is no unrestricted access to the patient’s torso, defibrillation/pacing pad must be installed and connected to the external defibrillator device preoperatively.

**Pacemakers**

The CIED should be accessible for magnet application. If this is not possible, transcutaneous pads for external pacing, defibrillation and cardioversion should be positioned (at least 5 cm from the generator) or a magnet applied and fixed to the CIED prior to scrubbing-up the patient. If the patient is not pacemaker dependent and a rate-responsive mode (“R” function) is not programmed in a device using a minute-ventilation sensor (Boston Scientific and Sorin devices), the operation may be performed without magnet application or reprogramming. If a device equipped with a minute-ventilation sensor is left programmed in a rate-responsive mode for the intervention, the healthcare personnel must be aware of the risk of rapid pacing, which may be diagnosed and interrupted by magnet application to pacemakers.

In suspected or known pacemaker dependency, a magnet should be positioned over the generator, which results in asynchronous pacing in a VOO, VDO or DOO mode at a manufacturer-specific rate (table I). Alternatively, the magnet may be applied only if inhibition by cautery is really observed (provided the device is read-
**Figure 3:** Perioperative management of patients with a pacemaker.

**Figure 4:** Perioperative management of patients with an implantable cardioverter-defibrillator.
Implantable cardioverter defibrillators

Regarding ICD carriers a magnet should always be securely applied in order to disable the antitachycardia functions. In fact, we recommend magnet positioning over reprogramming since the device will always immediately function as programmed after magnet removal. There is an abundance of clinical anecdotes of fatal and near-fatal events linked to failure to restore appropriate device settings [5]. In a pacemaker-dependent ICD patient, however, the device has to be reprogrammed to an asynchronous pacing mode and the tachycardia therapies have to be disabled, because the pacing mode is not affected by magnet application. Other scenarios where reprogramming is recommended are if the patient has to be placed in an abdominal position (since the magnet may dislocate without notice), a secure magnet position during surgery cannot be guaranteed for other reasons, or where a rate-responsive pacing mode is programmed with a minute-ventilation sensor (Boston Scientific devices).

Some ICDs will transiently emit an audible tone (e.g., Boston Scientific, Medtronic devices) or vibrate (St. Jude Medical) when coming into contact with the magnet, which is normal device behaviour. In cases of device reprogramming, institutions should have a standard operating procedure to ensure that the device functions will be correctly restored in a timely manner postoperatively.

Postoperative care

After the removal of the magnet, the programmed settings are usually restored. If the device programming has been changed, it is critical to continuously monitor the patient and his/her ECG in an adequately equipped environment with the possibility of immediate advanced life support until the device is reprogrammed. After thoracotomy, the lead position should be analysed on a postoperative X-ray and the leads checked if applicable. It is important to recognise, that pacemaker-dependent patients have different physiological responses to shock and that minute-ventilation sensors may have to be switched off in patients ventilated for a prolonged period postoperatively [6] or if the respiratory rate is being monitored externally.

Conclusion

The vast majority of patients with a CIED who undergo surgery will not experience any untoward effects and can be handled with the simple use of a magnet. The real challenge is to identify those few patients who are at higher risk and whose device should be reprogrammed before and after surgery. These comprise pacemaker-dependent patients with a CIED that is not accessible during surgery and ICD patients whose pacemaker function works in a rate-responsive mode using minute-ventilation sensors. The use of a magnet should be the preferred management since problems arising from forgotten, incomplete or faulty reprogramming cannot arise.

Disclosure statement

No financial support and no other potential conflict of interest relevant to this article was reported.

References


Summary

**Background:** Percutaneous patent foramen ovale (PFO) closure has been shown to be safe and feasible with a variety of devices, and its clinical efficacy appears favourable compared with medical treatment alone. However, long-term follow-up remains largely unknown. We report the late clinical results of our early experience with one of the first commercially available devices, the Sideris Buttoned Occluder.

**Methods:** Thirty-two patients (age 50 ± 12 years; 63% male; 28% atrial septal aneurysm) underwent PFO closure using the Sideris Occluder for secondary prevention of presumed paradoxical embolism.

**Results:** There were four procedural complications (13%), including two embolisations of the counteroccluder of the device with successful percutaneous removal in both cases, and one arteriovenous fistula requiring surgical repair. The implantation procedure failed in one patient (3%) because of laceration of the femoral artery, with ensuing retroperitoneal haematoma requiring surgical revision. None of these complications had long-term sequelae. Contrast transoesophageal echocardiography at 6 months showed complete closure in 55% of cases, and a minimal, moderate, or large residual shunt in 28%, 7%, and 10%, respectively. During a mean follow-up period of 12.3 ± 2.6 years (median 13 years; total 378 patient-years), one death, two ischaemic strokes, two transient ischaemic attacks (TIAs), and one peripheral embolism occurred. Survival free from recurrent ischaemic stroke, TIA, or peripheral embolism was 97% at 1 year, 90% at 5 years, and 84% at 10 years. There was one incident of atrial fibrillation.

**Conclusions:** Despite the high periprocedural complication and residual shunt rates, percutaneous PFO closure using the Sideris Occluder presented no long-term safety concerns. The rate of recurrent events 10 years after percutaneous PFO closure was low.

**Key words:** atrial septal aneurysm; patent foramen ovale; cerebral ischaemia; embolism; secondary stroke prevention

**Introduction**

The association of patent foramen ovale (PFO) with cryptogenic stroke, independently reported by Lechat [1] and Webster [2] in 1988, has been repeatedly confirmed [3, 4]. This observation has been extended to adults >55 years, with a significantly higher prevalence of PFO alone (28.3% vs 11.9%; odds ratio [OR] 2.9; 95% confidence interval [CI] 1.7–5.0; p <0.001) as well as of PFO associated with atrial septal aneurysm (ASA; 15.2% vs 4.4%; OR 3.9; 95% CI 1.8–8.5; p <0.001) among patients with cryptogenic stroke compared with those with stroke of known stroke cause [5]. In patients with presumed paradoxical embolism, secondary prevention remains a matter of debate. Patients with cryptogenic stroke related to PFO are at risk for recurrence despite medical treatment, with yearly recurrence rates ranging from 0.6–12% [6, 7], a risk that may be particularly pronounced in patients with PFO and associated ASA [6, 8]. Nonrandomised data suggest the superiority of percutaneous PFO closure for secondary prevention of paradoxical embolism as compared with medical treatment alone [7, 9–11]. However, three randomised studies failed to confirm these results [12–14]. As the protocols of all three trials overestimated the incidence of recurrent events in both groups, data on long-term clinical
follow-up of such patients are still of interest. In this study we report the late clinical results (up to 15 years of follow-up) of our experience with one of the first commercially available devices, the Sideris Buttoned Occluder (SBO, fig. 1).

Methods

Patients

Between April 1994 and November 1999, 32 patients underwent percutaneous PFO closure with the SBO for secondary prevention of presumed paradoxical embolism. An embolic event was considered due to paradoxical embolism when the following criteria were fulfilled: presence of PFO with or without ASA with spontaneous or inducible interatrial right-to-left shunt during contrast transesophageal echocardiography (TOE); clinically and/or radiologically confirmed ischaemic stroke, transient ischaemic attack, or peripheral embolism; and exclusion of any other conventional cause. The procedure was approved by the local Ethics Committee, and patients gave written informed consent.

Echocardiography

The diagnosis of PFO and ASA was based on contrast TOE, with aerated colloid solution injected into an antecubital vein at the end of a vigorous and sustained Valsalva manoeuvre. PFO was defined as flap-like opening in the atrial septum secundum, with the septum primum serving as one-way valve allowing for permanent or transient right-to-left shunt. ASA was diagnosed as an abnormally redundant interatrial septum with an excursion of >10 mm into the right or left atrium and a diameter at the base of the aneurysm of at least 15 mm [15]. Spontaneous or provoked right-to-left shunt was semiquantitatively graded according to the number of bubbles detected in the left atrium after crossing the interatrial septum on a still frame: grade 0 = none, grade 1 = minimal (1–5 bubbles), grade 2 = moderate (6–20 bubbles), and grade 3 = severe (>20 bubbles) [2]. In order to demonstrate unequivocally the presence of a PFO, care was taken to document the actual passage of contrast bubbles through the rent, but this was not possible in all cases.

Sideris Buttoned Occluder

The SBO (fig. 1) at the time was a polyester patch on a nitinol cross frame in the left atrium, retained by a polyester coated wire in the right atrium. It could be constrained within an 11 French (Fr) delivery system. The retaining wire was pushed over a nylon thread fed through a central hole in the polyester coat. The thread featured a knot which prevented disengagement of the retaining wire, once it was advanced over the knot.

Percutaneous PFO closure

The interventions were performed under local anaesthesia and fluoroscopic guidance [16]. Intraprocedural guidance by TOE [17–19] or intracardiac echocardiography [20, 21] was not used in any case. However, all patients had undergone contrast TOE for initial diagnosis of PFO prior to the intervention.

After venous access was gained via the right femoral vein, the PFO was crossed under fluoroscopic guidance in the anteroposterior view either with a standard length regular 0.035 inch guidewire alone, or with the help of a catheter, typically a 6 Fr multipurpose catheter. Balloon sizing was not used. Indeed, the maximal opening of the flap-like PFO is not instrumental for the success of closure.

An exchange guidewire was placed through the catheter in the left atrium. The multipurpose catheter was withdrawn, and an 11 Fr delivery sheath was advanced over the guidewire in the left atrium. The SBO consisted of three components: occluder, counteroccluder, and delivery system. The occluder was folded and placed in the delivery sheath, and then advanced through the sheath using a pushing catheter until it appeared in the left atrium. The delivery sheath was then gently retracted to the right atrium. The counteroccluder was placed in the delivery sheath, over the delivery nylon wire connected to the occluder, and similarly delivered into the right atrium under fluoroscopic guidance. The occluder was pulled towards the counteroccluder and the counteroccluder gently pushed with the tip of the sheath over the knot portion of the occluder; the device was thus buttoned across the interatrial septum under fluoroscopic guidance. Finally, the loading wire was cut and withdrawn, thus disconnecting the implanted device from the delivery system.

The transseptal sheath was then used for a final contrast medium injection. The contrast can be followed through to the levophase to delineate the left atrial contour and device placement also. Finally, the sheath was removed and haemostasis achieved by manual compression. Patients were released to full physical activity as early as a few hours after the procedure. Thoracic contrast echocardiography was performed before discharge in order to document correct and stable device position. Acetylsalicylic acid (100 mg) was prescribed once daily for 6 months for antithrombotic protection.

As reported in previous publications by our group, we performed systematic coronary angiography in patients undergoing percutaneous PFO closure aged
>50 in males and >60 in females. In this study, a rather high proportion of the examined patients (29%) presented with unsuspected coronary artery disease, justifying incidental coronary angiography in selected patients. Predictors were the age as well as the presence of conventional cardiovascular risk factors [22].

Follow-up evaluation
The outcome following the intervention was prospectively assessed for up to 15 years. A contrast TOE was repeated 6 months after percutaneous PFO closure. Thereafter, patients underwent structured telephone interviews, addressing recurrent embolic events, device related problems, and health status at regular intervals. Initial follow-up information was available for all patients, but two patients (6%) were eventually lost to follow-up. Death, and recurrent ischaemic stroke, TIA, or peripheral embolism were considered endpoints. Patients with suspected recurrent cerebrovascular events were re-examined by a neurologist, and a new imaging study of the brain was performed.

Statistical analysis
An intention-to-treat analysis was performed considering all patients selected for implantation of a SBO during the study period, including the patient in whom the implantation failed. Continuous variables are expressed as mean ± standard deviation, and were compared with a two-sided, unpaired t-test. Categorical variables are reported as counts and percentages, and were compared using the Fisher’s exact test. Estimates for freedom from the composite of recurrent TIA, stroke, and peripheral embolism were obtained by means of the Kaplan-Meier method. Binary logistic regression analysis was performed to identify independent predictors of recurrence. Estimates of the hazard ratio (HR) and 95% confidence interval (CI) for each independent variable were obtained by proportional hazard regression analysis. Statistical significance was assumed with a p-value <0.05. All data were analysed with the use of SPSS software (version 15.0.1, SPSS Inc.).

Results
In-hospital outcome
Demographic data are summarised in table 1. In one patient (3%), the planned SBO implantation was aborted because of laceration of the femoral artery during initial insertion of the 11 Fr venous sheath with an ensuing retroperitoneal haematoma. Because of the absence of concurrent embolic causes in the extensive preinterventional work-up, surgical PFO closure was deemed reasonable by an interdisciplinary team and was performed concomitantly to the required vascular revision. This patient is doing well at 18 years of follow-up. All other 31 (97%) implantation procedures were successful. Periprocedural complications, including the one described above, were observed in a total of four patients (13%). There were two cases of embolisation of the counteroccluder of the SBO with successful percutaneous removal. The occluder patch stayed in place in both. One patient who had undergone simultaneous coronary angiography developed an arteriovenous fistula at the puncture site requiring elective surgical closure. There was no in-hospital death, and none of the procedural complications resulted in long-term sequelae.

Total procedure time, including incidental coronary angiography [22] in 26 patients (81%), and an ad hoc percutaneous coronary intervention in two patients, was 71 ± 23 minutes (median 70 minutes). Total fluoroscopy time was 17 ± 8 minutes (median 14 minutes). One-vessel coronary artery disease was found in only three patients, one patient had coronary sclerosis without significant stenosis. In the six patients undergoing PFO closure only, total procedure time amounted to 48 ± 26 minutes (median 38 minutes).

Table 1: Baseline clinical characteristics.

| Patients | 32 |
| Age (years) | 50 ± 12 (median 51; range 18–73) |
| Male gender | 20 (63%) |
| Height (cm) | 169 ± 10 |
| Weight (kg) | 75 ± 14 |
| Atrial septal anatomy | |
| Left atrial size (mm) | 38 ± 7 |
| Patent foramen ovale alone | 23 (72%) |
| Patent foramen ovale and atrial septal aneurysm | 9 (28%) |
| Cardiovascular risk factors | |
| Arterial hypertension | 14 (44%) |
| Diabetes mellitus | 4 (13%) |
| Smoking history | 14 (44%) |
| Family history | 14 (44%) |
| Total cholesterol (mmol/l) | 5.6 ± 1.0 |
| Embolic index event | |
| Ischaemic stroke | 17 (53%) |
| Transient ischaemic attack | 12 (38%) |
| Peripheral embolism | 3 (9%) |
| Number of clinically apparent prior embolic events | |
| One | 18 (56%) |
| Two | 9 (28%) |
| Three | 2 (6%) |
| Four or more | 3 (10%) |
Complications were not significantly different in patients receiving small SBOs (<30 mm; n = 12) as compared with patients with large SBOs (≥30 mm; n = 20% vs 25%; p = 0.3), patients with an associated ASA (n = 9; 28%) as compared with patients with an isolated PFO (n = 23; 72%, and 0% vs 21%; p = 0.3), or patients ≥55 years (n = 12; 37%) as compared with <55 years (n = 20; 73%, 9% vs 18%; p = 1.0).

Transthoracic contrast echocardiography after a Valsalva manoeuvre within 24 hours of percutaneous PFO closure, performed in all 31 patients with an implanted device, detected a residual shunt in eight patients (26%).

Late echocardiographic outcome
Contrast TOE after Valsalva manoeuvre at 6 months (fig. 2), performed in 29/31 (94%) patients with an implanted device, showed complete PFO closure in 16 patients (55%), and a minimal, moderate, or large residual shunt in 8 (28%), 2 (7%), and 3 (10%), respectively (fig. 3).

There was no significant difference regarding residual shunts with smaller (<30 mm; n = 12; 39%) or larger SBOs (≥30 mm; n = 19; 61%, 42% vs 42%, respectively, p = 1.0), in older (≥55 years; n = 12; 39%) or younger patients (<55 years; n = 19; 61%, 50% vs 37%; p = 0.7), or PFO and associated ASA (n = 9; 29%) or isolated PFO (n = 22; 71%, 33% vs 45%, p <0.7). No thrombus was detected on the devices.

Late outcome
During 12.3 ± 2.6 years of follow-up (median 13 years, total 378 patient-years), one death, unrelated to a recurrent embolic event, two ischaemic strokes, two TIAs, and one peripheral embolism occurred (16%). One of

**Figure 2:** 1. Transoesophageal echocardiography of patent foramen ovale, 2. Bubble transit through PFO, 3. Follow-up TEE showing the Sideris Buttoned Occluder, 4. Complete closure documented by bubble test.

**Figure 3:** PFO-mediated interatrial shunt at baseline and 6 months after percutaneous closure of patent foramen ovale, as assessed by contrast transoesophageal echocardiography.

**Figure 4:** Freedom from recurrent stroke (solid red line), TIA (blue line), and the combined end point of death, ischaemic stroke, TIA, or peripheral embolism (green line) after percutaneous closure of patent foramen ovale using the Sideris Buttoned Occluder.
the TIAs occurred despite therapeutic oral anticoagulation in a 68-year-old patient who developed atrial fibrillation 4 years after PFO closure. There were no relevant bleeding complications. Survival free from recurrent ischaemic stroke, TIA, or peripheral embolism was 97% at 1 year, 90% at 5 years, and 84% at 10 years (fig. 4).

Two patients (with a 33 and 20 mm SBO in place, respectively) underwent implantation of a second PFO occluder device (second devices one SBO 25 mm and one SBO 15 mm) owing to a significant residual shunt, in one case after having suffered a recurrent peripheral embolism. No periprocedural complications occurred during the second intervention. Complete PFO closure was finally achieved in one patient. In the second patient, implantation of a third device (Amplatzer PFO 25 mm) was required and finally resulted in complete PFO occlusion. One patient with a documented residual shunt underwent surgical PFO closure after having suffered a recurrent TIA.

Increasing body mass index (OR 1.6; 95% CI 1–2.6; p = 0.045) and smoking history (OR 9.1; 95% CI 0.86–97.3; p = 0.04) were both significant predictors of recurrence.

Discussion

We report the late clinical follow-up of a cohort of 32 patients with presumed paradoxical embolism treated at a single centre using the SBO, mainly with regards to the follow-up duration of over 10 years. These data represent the early technical experience in the field of percutaneous PFO closure. The SBO, which was one of the first commercially available devices, has been modified since, but is no longer used at our centre because of the availability of more versatile, effective, and easier to use devices. However, despite the high procedural complication rate of 13%, and the fact that complete PFO closure could be achieved in 55% of cases only, the long-term clinical efficacy of percutaneous PFO closure turned out to be good.

In the literature, the reported success rates of percutaneous PFO closure varies between 90–100%, with complication rates between 0–10%. Complete PFO closure is reported in 51–100% of patients [23], depending on device type and methodology used (transcranial Doppler, transoesophageal or transthoracic echocardiography), and the yearly recurrence rates of ischaemic strokes and transient ischaemic attacks (TIAs) vary between 0–5% [7]. Important differences were observed between the devices used [24–26]. Initial device-related complications inflicted by large delivery systems, device dislodgement and embolisation, structural failure, thrombus formation [27], and inability to reposition or remove the device were reduced by improvements in device design. Anatomical and physiological differences between PFOs and atrial septal defects led to the development of devices specifically designed for percutaneous PFO closure. Current devices for percutaneous PFO closure, such as the Amplatzer PFO Occluder, achieve complete PFO occlusion in >90% of cases with complication rates <1% and yearly recurrence rates <1% [23]. This improvement in device performance is likely to positively impact clinical outcome.

During long-term follow-up of up to 15 years, the risk of stroke or death after transcatheter treatment of PFO with or without associated ASA was <1% per year. The low recurrence rate corresponds with the long-term outcome (mean follow-up of 9.2 ± 3.0 years) previously described by our group [28] and compares favourably with medical treatment [11, 29].

However, the three randomised trials completed so far, CLOSURE (Evaluation of the STARFlex septal closure system in patients with a stroke and/or transient ischaemic attack due to presumed paradoxical embolism through a patent foramen ovale) [12], RESPECT (Randomized evaluation of recurrent stroke comparing PFO closure to established current standard of care treatment) [13], and PC trial (Percutaneous closure of patent foramen ovale and cryptogenic embolism) [14], were negative with regards to their primary endpoints. It is of note that CLOSURE had important methodological weaknesses, particularly the presumably high rate of residual shunt owing to the use of the STARFlex occluder and the short follow-up period (<2 years). Nonetheless, secondary analyses of RESPECT (e.g., per protocol or as treated cohort) demonstrated more favourable outcomes in the closure group. Importantly, several dedicated meta-analyses reported superiority of device closure with the Amplatzer PFO Occluder, enforcing the crucial role of device selection [30, 31]. In the PC trial, obvious overestimation of the recurrence rate at 4 years of follow-up (12 vs 5.2% in the medical group) led to a clear lack of power preventing the study from reaching statistical significance. The long-term outcomes described in our study provided further evidence that recurrent embolic events after percutaneous PFO closure for treatment of cryptogenic embolism are rare.

Conclusions

Despite the high periprocedural complication and residual shunt rates, percutaneous PFO closure using the Sideris Occluder presented no long-term safety
concern. The rate of recurrent events 10 years after percutaneous PFO closure is low.

Limitations
Since both PFO and cryptogenic stroke are prevalent conditions, they may coexist without causal relationship in many patients. Percutaneous PFO closure in patients with falsely PFO-related strokes will not influence recurrent embolic events, a circumstance likely to contribute to the small recurrence rate despite successful PFO closure in our and other series. Nonetheless, these patients will be protected against true paradoxical embolism. It has to be emphasised that the true therapeutic efficacy of percutaneous PFO closure as adjunct or alternative to medical treatment can only be ascertained by randomised studies.

Remark
The abstract of this manuscript was displayed as a poster on 31st August 2010 at the occasion of the European Congress of Cardiology in Stockholm, Sweden, and as such published in European Heart Journal (DOI: http://dx.doi.org/10.1093/eurheartj/ehq289 589–871; First published online: 28 August 2010).

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References
Rivaroxaban dissolves postinfarction left ventricular thrombus

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Introduction

Despite early management of ST elevation myocardial infarction, prompt coronary revascularization and potent dual antiplatelet therapy, left ventricular thrombus still remains a dreaded complication especially in anterior STEMI. Little is known about the efficacy and safety of the new oral anticoagulants in the context of post STEMI left ventricular thrombus. We describe the case of a 54 old male Caucasian who developed an apical thrombus, despite a DAPT, 3 days after a triple stenting of the left anterior descending coronary artery, for a subacute STEMI. After one month of treatment using rivaroxaban, dissolution of the thrombus was evident on echocardiography. The present case report is the first to demonstrate left ventricular thrombus dissolution using NOAC in the setting of a subacute STEMI that forces an association with dual antiplatelet therapy. NOACs offer a rapid and more constant anticoagulation than vitamin K antagonists with less food interaction and do not require routine monitoring. For these reasons these molecules are potential good candidates to supplant VKA for the treatment of left ventricular thrombus, but randomized controlled trials are needed to demonstrate the advantages of the NOACs in this setting.

Key words: Left ventricular thrombus; myocardial infarction; new oral anticoagulant
Case description

A 54-year-old Caucasian male was admitted with retrosternal pain evolving during the past 2 weeks. The ECG showed a subacute anterior STEMI with marked ST elevation and Q waves in leads V2 to V4. The coronary angiogram revealed a total occlusion of the left anterior descending coronary artery (LAD) in its mid-portion, an ulcerated plaque in its proximal part and an intermediate lesion in its distal portion. The vessel was treated with three newer generation drug-eluting stents (Resolute Onyx™ stents, proximal 3.5 × 12 mm, mid 3.5 × 26 mm and distal LAD 3.0 × 15 mm, Medtronic, Minneapolis, MN, USA) with a good angiographic final result (fig. 1A–F). The left ventricular angiogram demonstrated apical ballooning (fig. 2A, B). DAPT was initiated with acetylsalicylic acid (100 mg/d) and prasugrel (10 mg/d). Fondaparinux (2.5 mg/d) was prescribed for 5 days. According to routine, transthoracic echocardiography was performed 3 days after the percutaneous coronary invention and revealed apical thrombus (fig. 2C), which was not detectible on ventriculography. HAS-BLED score was 1 point.

Consequently the patient was started on rivaroxaban, and prasugrel was switched to clopidogrel (75 mg/d) in order to limit the bleeding risk. At 1 month, echocardiography was repeated and revealed complete dissolution of the thrombus despite persistence of the apical dyskinesia (fig. 2D).

Discussion

Rivaroxaban is an oral inhibitor that binds directly to factor Xa. It is approved for treatment of deep venous thrombosis, pulmonary embolism and nonvalvular atrial fibrillation [5, 7, 12].

A Japanese team published three cases of left atrial appendage thrombus resolution using rivaroxaban 10 mg/d [13]. Another case report described the growth of a left atrial appendage thrombus despite well-conducted treatment with a VKA, which then disappeared during treatment with rivaroxaban 15 mg/d [14]. To the best of our knowledge, NOACs have so far been successfully used to treat left ventricular thrombi in four published cases. Kaku et al. described a case of thrombus dissolution in a 59-year-old patient suffering from left mid-ventricular obstruction with apical aneurysm formation [8]. Nagamoto et al. reported a case after an ancient myocardial infarction [9]. Padilla Pérez et al. summarised the case of a patient with left ventricular thrombus dissolution in a setting of dilated cardiomyopathy [10]. Nakasuka et al. reported complete apical thrombus disappearance in a case of tachycardiomyopathy [11].

The present case report is the first to demonstrate left ventricular thrombus dissolution using a NOAC (rivaroxaban) in the setting of a subacute STEMI that forced administration of DAPT. In this setting, the European Society of Cardiology has different antiplatelet and anticoagulation recommendations for patients at low risk of bleeding (HAS-BLED score of 0–2) compared with patients at high risk of bleeding (HAS-BLED ≥3) [15]. However, triple therapy using a NOAC could be hazardous and only a few studies have investigated triple therapy including a NOAC in patients suffering from coronary artery disease and nonvalvular atrial fibrillation. In the APPRAISE-2, apixaban was combined with aspirin and clopidogrel in 81% of patients, and led to a significant increase in fatal and intracranial bleeding without clinical benefit [16]. In ATLAS ACS 2, low-dose rivaroxaban (2.5–5 mg twice daily) was administered with aspirin and clopidogrel in 92% of patients. This was associated with a 16% reduction in the composite efficacy endpoint (cardiovascular death, myocardial infarction and stroke) and a small increase in major bleedings [17].

Risk of bleeding should be utilised in decision-making. The HAS-BLED score was 1 for this patient, who had normal renal function with a creatinine clearance of 83 ml/min (1 point because of the concomitant use of antiplatelet agents and oral anticoagulation, i.e., a risk of major bleeding of 1.0–1.5% per year). Based on the above described case reports, where rivaroxaban was the most frequently used molecule and always prescribed once a day (never 15 mg twice daily as for the first 3 weeks of the...
pulmonary embolism therapy), we decided to use rivaroxaban at a dosage of 20 mg/d during a period of 3 months. This permits us to avoid initial quadruple therapy (aspirin, clopidogrel, low-molecular-weight heparin and VKA) until achieving therapeutic anticoagulation.

Conclusion

Short duration rivaroxaban was effective for the treatment of left ventricular thrombus in a patient under DAPT after drug-eluting stent implantation for STEMI, and at low bleeding risk. Randomised controlled trials are urgently needed to confirm these encouraging observational data, to define the optimal dosage of NOACs when associated with DAPT, and to demonstrate that these molecules are effectively good candidates to supplant VKAs in the treatment of post-STEMI left ventricular thrombi.

Disclosure statement

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References


Early assessment may allow treatment before Chagas disease induces irreversible damage

A patient with arrhythmias and infective cardiac disease

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Summary

In western countries patients with a Trypanosoma cruzi infection and with Chagas cardiomyopathy are rare. We report the case of a patient with Chagas cardiomyopathy in Switzerland.

Methods: The family history was consistent with a possible T. cruzi infection. The patient came from Central America. The patient had symptoms of arrhythmia and congestive heart failure. ECG detected a complex arrhythmia, with brady-/tachycardic episodes, Atrioventricular- and bundle-branch blocks, paroxysmal atrial fibrillation and complex supraventricular and ventricular premature beats. Echocardiography detected a dilated, hypokinetic left ventricle with moderately reduced left ventricular ejection fraction and severe diastolic dysfunction. NT-proBNP (N-terminal of the prohormone brain natriuretic peptide) was highly elevated. The patient had also symptoms of gastrointestinal Chagas disease. The diagnosis of T. cruzi infection was confirmed by IgG serological testing with an ELISA test and PCR assessment.

Therapy: An implantable cardioverter defibrillator device was implanted and the patient was dismissed under medical treatment with amiodarone, perindopril, rivaroxaban, pantoprazole and benznidazole. In the follow-up, amiodarone was substituted with metoprolol retard and perindopril with candesartan. Congestive heart failure increased. The patient was treated with torasemide, low-dose spironolactone, metoprolol retard, valsartan/sacubitril, rivaroxaban and pantoprazole and signs and symptoms of heart failure were controlled.

Conclusion: The chronic parasitic T. cruzi infection may be asymptomatic. However, after decades a highly arrhythmogenic cardiomyopathy occurs in up to 30% of patients. Gastrointestinal Chagas disease is less frequent. The majority of infections in Europe are found in persons who lived in Latin America. European cases of Chagas disease are rare and underrecognised.

Suggestions: Persons who lived in Latin America may have been infected with T. cruzi. If there is a pertinent anamnesis, these persons should be checked for cardiac arrhythmias and dysfunction and also for gastrointestinal pathologies. Early assessment of these pathologies may allow treatment before the Chagas disease induces irreversible damage. There is no specific therapy for Chagas disease, but current empirical therapy allows a better prognosis.

Key words: Chagas disease; Chagas cardiomyopathy; gastrointestinal Chagas; arrhythmogenic cardiomyopathy; Trypanosoma cruzi

Introduction

In western countries Trypanosoma cruzi infection with secondary Chagas cardiomyopathy is unusual. The most frequent aetiologies of cardiac arrhythmias are related to atherosclerosis, valvular cardiac pathologies and genetic mutations. In 2013, a patient with Chagas cardiomyopathy was described in the USA [1]. We report a patient with a similar pathology.

Patient

A 58-year-old man was born and lived in rural areas of Central America until, at the age of 23, he immigrated to Switzerland. His parents (mother at the age of 50, father at the age of 54 years) died because of a cardiac pathology with symptomatic arrhythmias. The patient did not know the medical diagnosis. A 52-year-old sister suffers from symptomatic arrhythmias and chronic constipation. The patient drank alcohol rarely and for more than 30 years had smoked about 20 cigarettes/day. In 2012, an ECG (fig. 1), recorded prior to minor surgery, showed a regular sinus bradycardia (46 to 50 bpm), an incomplete right bundle-branch block (RBBB) and a long QTc-interval (474 ms). In 2013, the patient reported moderate dyspnoea and frequent dizziness. An ECG (fig. 2) showed a first-degree atrioventricular (AV) block Mobitz 1 (PR 256 ms) and delayed right ventricular conduction. Fatigue and dizziness increased, and the patient reported palpitations, reflux and epigastric distress. He came for evaluation.

Findings: The general status was moderately reduced, the weight was normal. The blood pressure was 138/78 mm Hg. The lungs were clear. Palpation of the epigastrium elicited mild pain. The first and second heart sounds had normal tone but there was a nonrespiratory sinus arrhythmia with many premature beats; first to second degree systolic murmurs were heard over all valves. Haematological and chemistry laboratory tests showed that troponin T and D-dimer values were normal but N-terminal of the prohormone brain natriuretic peptide (NT-proBNP) was highly increased (3 387 pg/ml). ECG (fig. 3) showed sinus tachycardia (100 bpm), frequent supraventricular premature beats.
with wide QRS complexes, and a complete left bundle-branch block (LBBB) with a QTc of 536 ms. ECG monitoring (fig. 4) showed sinus bradycardia alternating with sinus tachycardia, a second-degree AV block Mobitz 2, and a slightly prolonged QTc. A 24-hour dynamic ECG detected many episodes of first- and second-degree AV block, 35.5% complex supraventricular premature beats with wide QRS complexes and partial compensatory pauses and 18.3% complex ventricular premature beats. Frequent episodes (one is shown in fig. 4) of paroxysmal atrial fibrillation lasting to >40 QRS complexes were detected. Echocardiography demonstrated traces of mitral, tricuspid and pulmonary insufficiency; the left ventricle (fig. 5) was hypokinetic, with round morphology, and moderately dilated. The maximal left ventricular ejection fraction (LVEF)
Figure 3: The ECG shows sinus tachycardia (100 bpm), frequent supraventricular premature beats with wide QRS complexes, and a permanent left bundle-branch block with secondary repolarisation changes.

Figure 4: The ECG shows atrial fibrillation with horizontal R axis.
was 32% and the relaxation was pathological (pseudo-normalisation, E/E1 25). The patient was hospitalised for possible Chagas cardiomyopathy.

Hospital data: Ventriculo-coronarography showed normal coronary arteries, the left ventricle was dilated with increased end-diastolic pressure and diffusely hypokinetic; the systolic ejection fraction was <30%. Gastroscopy detected motility disorders and mild achalasia of the oesophagus (attributable to gastrointestinal Chagas disease). The diagnosis of chronic T. cruzi infection was confirmed by IgG serological testing with an enzyme-linked immunosorbent assay and polymerase chain-reaction assessment. A Medtronic EnTrust implantable cardioverter defibrillator (ICD) device was implanted with a VVI stimulation modus. The patient was discharged under amiodarone, perindopril, rivaroxaban and pantoprazole therapy. A consultant for tropical medicine added benznidazole.

Six-month follow-up

In the first 2 months the ICD interrupted two episodes of sustained ventricular tachycardia. A 48-hour dynamic ECG detected recurring (6 out of 48 hours) pacemaker stimulation on need because of bradycardia (rate from 38 to 52 bpm), frequent first- and second-degree AV-block Mobitz type, 20.4% complex supraventricular and 23.1% complex premature ventricular beats. Amiodarone was discontinued because of subclinical thyroid hyperfunction and was replaced by metoprolol retard. The patient developed dry cough and perindopril was replaced with candesartan.

Sixteen-month follow-up

The patient complained of recurring moderate dyspnoea and pitting leg oedema. NT-proBNP was increased (1312 pg/ml) and glomerular function was slightly decreased (MDRD estimated glomerular filtration rate 61 ml/min/1.73 m²). The ECG was unchanged. Echocardiography (mediocre quality, recorded in a half-sitting position, because the patient could not keep the supine left-lateral position) showed an enlarged, diffusely hypokinetic left ventricle with a maximal LVEF of 35%; the relaxation was moderately pathological (E/A 0.4, E/E' 20). Therapy with metoprolol retard, candesartan, rivaroxaban and pantoprazole were unchanged, and torasemide and low-dose spironolactone were added. The use of digoxin was considered and rejected because of the complex arrhythmia. Benznidazole was stopped: the trypanocidal drug had been prescribed because it had been shown to be effective in reducing serum parasite detection, and it was hypothesised that it would positively affect the cardiomyopathy [2]. Unfortunately, a recent paper confirmed that benznidazole significantly reduces se-
rum parasite detection but showed that it does not improve cardiac function in patients with chronic *T. cruzi* infection [3]. Under the new therapy leg oedema disappeared and dyspnoea decreased, but a few months later dyspnoea increased again. Candesartan was replaced with valsartan/sacubitril. The patient is doing well. At the last follow-up NT-proBNP was 623 pg/ml. A 48-hour dynamic ECG showed a marked reduction in supraventricular and ventricular premature beats (10.2 and 11.1%, respectively) and ventricular tachycardia was not detected. Intermittent pacemaker rhythm was detected because of recurring sinus bradycardia. Echocardiography showed a marginally enlarged left ventricle (fig. 7) with a LVEF of 52% and slightly impaired diastolic function (E/A 0.9, E/E’ 16).

In summary, it is likely that patient’s parents died because of Chagas cardiomyopathy. His sister may have Chagas disease. A Brazilian study [4] identified six independent prognostic factors for Chagas cardiomyopathy: NYHA class III–IV (5 points), cardiomegaly on radiography (5 points), left ventricular dysfunction on echocardiography (3 points), non-sustained ventricular tachycardia on 24-hour dynamic ECG (3 points), low QRS voltage on ECG (2 points), and male sex (2 points). Patients are categorised as low (0 to 6 points), intermediate (7 to 11 points) and high risk (12 to 20 points). The 10-year mortality rates were 10%, 44% and 84%, respectively. Our patient had 18 points and was at high risk.

Unfortunately, benznidazole was found to be unable to stop the progression of the cardiomyopathy in chronic Chagas disease. The long-term prognosis of Chagas cardiomyopathy remains poor.

**Infected European patients**

As in our case, infected European Chagas patients are people who have lived in Latin-America countries where *T. cruzi* infection is endemic [1, 2]. Direct assessments of prevalence of Chagas disease in Europe have been restricted to small-scale surveys in populations chosen because of an anticipated high risk (e.g., Latin American immigrants with nonischaemic heart disease) [2]. Because Chagas disease is rare in Europe, women at risk for congenital transmission to their infants are rarely screened and in patients cardiac and gastrointestinal pathologies are often diagnosed at a late stage [2].

**Diagnosis of Chagas disease**

The first step for diagnosing Chagas disease is the history. Patients who have lived in countries with endemic *T. cruzi* infection and who complain of cardiac and, less often, gastrointestinal symptoms. These patients need regular follow-up for arrhythmias (dynamic ECG) and/or cardiac dysfunction (echocardiography). In the asymptomatic phase of Chagas cardiomyopathy subtle changes can be detected [4–6] and allow early treatment. Also, in patients who complain of gastrointestinal symptoms, gastroenterological diagnostics are required and allow empirical therapy.

**Aetiology**

Chagas disease may occur in all countries in persons who have lived in Latin America. The disease is infectious and caused by the protozoan parasite *T. cruzi*. Vectorborne transmission is limited to Central and South America and a few areas of North America [1, 2, 6–11]. The protozoan parasite is transmitted through infected faeces of the triatomine vector, inoculated through a bite [1–4, 7–11]. Oral transmission occurs through an intact mucous membrane of the mammalian host [2, 11]. Other infection routes include transfusion, organ and bone marrow transplantation, and congenital transmission [2, 6–11]. Outbreaks attributed to contaminated food or water have been reported in northern South America, where transmission cycles involving wild vector populations and mammalian reservoir hosts are prominent [2–4, 8–10]. The incubation period after vectorborne transmission is 1 to 2 weeks [2]. The vast majority of acute infections are undetected. Parasitaemia disappears in 4 to 8 weeks [2, 4, 8–10].

Most infected persons are asymptomatic but are permanently infected [2–6, 8–10]. Over decades up to 30% of infected patients develop Chagas cardiomyopathy, which is highly arrhythmogenic [1–6, 8–10]. Orally transmitted *T. cruzi* infection appears to be associated with a higher incidence of myocarditis and death than vectorborne infection [11].

**Complications**

Chagas cardiomyopathy is highly arrhythmogenic. Many complex arrhythmias appear, such as multiple supraventricular ectopic beats, atrial flutter and/or fibrillation, sinus dysfunction with bradycardias and tachycardias, AV- and bundle-branch blocks, and complex ventricular premature beats with ventricular tachycardia [1–6, 9, 10]. Congestive cardiac failure follows, seldom appearing before the arrhythmias. In countries with endemic Chagas disease, echocardiography is performed in infected persons without cardiac symptoms and several echocardiographic changes have been described [5, 6]. These changes are not spe-
specific for Chagas cardiomyopathy but indicate that the heart is affected years before the pathology becomes symptomatic.

Gastrointestinal Chagas disease predominantly affects the oesophagus, colon, or both and results from damage to intramural neurons [2, 8]. It is less frequent than Chagas cardiomyopathy and is more common in Argentina, Bolivia, Chile, Paraguay, Uruguay, and parts of Brazil than in northern South and Central America [2, 8–11]. It was suggested that this geographic pattern might derive from different genotypes of *T. cruzi* [2, 11–13] but, in several studies, no strain differences have been detected between infections with and without gastrointestinal manifestations [8, 13, 14].

Pathogenesis

Parasite persistence is essential but many questions about the pathogenic factors are still open [2, 5–14]. In the acute phase of infection, inflammatory responses occur with involvement of native immune cells and macrophages, which are activated by interferon-γ and tumour necrosis factor-α.

In the chronic phase, T cell-mediated immunity reduces parasite replication [2, 7–10, 14]. However, parasite infection persists and, influenced by both host and parasite factors, plays a predominant role. The anti-parasitic reactions are inefficient to eradicate the parasite. The infection is lifelong and induces inflammatory responses with damage in the heart and in the gastrointestinal tract [2, 10, 15, 16].

Since the prevalence of severe Chagas cardiomyopathy has fallen in areas with effective vector control, it was postulated that repeated superinfection sustains the tissue antigen load and stimulates strong inflammatory responses which promote cardiac damage [2, 7–10]. However, it appears that the host’s inflammatory and immune responses might also be an important determining factor for the progression, whereas *T. cruzi* strain virulence and tissue tropism are possible contributory factors [2, 12–17].

Therapy

Progress has been made in the past 5 years toward improving the treatment of Chagas disease [2]. Rarely Chagas infection may be recognized in the early phase and the trypanocidal drug benznidazole can be used to reduce the level of parasitaemia of *T. cruzi* and might be useful to treat acute infections [2]. However, a recent study has demonstrated that therapy with benznidazole has no detectable effects in patients with established Chagas cardiomyopathy [3]. *T. cruzi* infection remains the most important parasitic disease in South, Central and North America, with an estimated disease burden (measured by disability-adjusted life-years) that is 7.5 times as great as that of malaria [18]. These facts show the need of an urgent search for a treatment with high efficacy during the chronic phase.

There is no specific cardiac therapy for Chagas cardiomyopathy. The disease is highly arrhythmogenic. Therefore, bradycardic arrhythmias, AV- and/or bundle-branch blocks and complex ectopic arrhythmias are a proven indication for a pacemaker and/or ICD implantation. Atrial flutter and/or fibrillation are frequent complications and high-risk patients (assessed with the CHA2DS2-VASc score) need oral anticoagulation. Congestive heart failure is empirically treated as recommended in modern guidelines [19]. As yet there are no trials on the use of valsartan/sacubitril in Chagas cardiomyopathy, but our personal opinion is to use this therapy when Chagas patients develop clear signs of heart failure.

The therapy of gastrointestinal Chagas is also empirical and is adapted to symptoms and signs of the pathology [7].

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The full list of references is included in the online version of the article at www.cardiovascmed.ch.
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How do you interpret the T-wave inversions after ablation?

Wolff-Parkinson-White syndrome and diverticulosis of the heart?

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Case presentation
A 77-year-old woman with a history of short palpitations lasting seconds, syncope, and one ( undocumented) episode of tachycardia lasting 2 hours was referred for electrophysiologic testing. Her 12-lead ECG is shown below (fig. 1). There was no evidence of structural heart disease based on echocardiography. The patient was taking flecainide and a β-blocker.

Questions
– What does the ECG in figure 1 show?
– Are there ECG clues with regard to the location of the accessory pathway?
– How do you interpret the T-wave inversions after ablation (fig. 3)?

Comment
The ECG (fig. 1) showed sinus rhythm with pre-excitation and negative delta waves in leads II, III, aVF and a transition in the precordial leads between V1 and V2 consistent with an antegrade conducting right posteroseptal accessory pathway.

For mapping and ablation, a nonirrigated 4-mm tip ablation catheter was placed at the right septal region. The earliest ventricular activation was found in a posteroseptal position. Radiofrequency energy (settings: 50 W, temperature limit at 60 °C) was delivered and pre-excitation was eliminated (average power...
38 W, starting impedance 116 Ω). Because of acute recovery of conduction after a waiting period of 30 minutes, we proceeded to coronary sinus angiography, which showed a diverticulum in the middle cardiac vein (fig. 2A). The accessory pathway was then ablated successfully at the neck of the diverticulum with the nonirrigated-tip ablation catheter and the same power settings (fig. 2B). The ablation site was approximately 5–10 mm from the first ablation site. The starting impedance was slightly higher at 132 Ω and the average power reached was 34 W. Impedance was closely monitored, but did not increase during ablation. The ECG after ablation revealed sinus rhythm, absence of delta waves and negative T waves in leads II, III, and aVF (fig. 3).

The hallmark of an epicardial posteroseptal accessory pathway is the presence of a steeply negative delta wave in lead II [1–3]. The delta wave in lead II was negative in our case, but not steeply negative. Nevertheless, an epicardial posteroseptal accessory pathway was...
present in our patient and searched for after acute recovery of accessory pathway conduction. Coronary sinus angiography was performed and showed a diverticulum in the middle cardiac vein. Coronary sinus diverticula are congenital anomalies that have been identified at autopsy in patients with Wolff-Parkinson-White syndrome or sudden death [4]. The diverticula contain myocardial fibers that connect the coronary sinus myocardial coat with the ventricle and serve as an often rapidly conducting accessory pathway [2, 5]. The association of posteroseptal accessory pathways and coronary sinus diverticula may result in unsuccessful or repeated catheter ablation procedures.

The ECG after ablation shows the phenomenon known as “cardiac memory” after successful radiofrequency catheter ablation of a posteroseptal accessory pathway. The phenomenon is characterised by transient T-wave abnormalities. The QRS vector is normalised immediately upon resumption of normal ventricular activation, but the T-wave vector persists, reflecting the vector of the previously altered QRS complex during pre-excitation. This phenomenon has been described after ventricular pacing, ventricular tachycardia, intermittent bundle-branch block and after catheter ablation of accessory pathways [6]. The underlying mechanism is not well understood, and various mechanisms have been described.

In conclusion, even when the ECG does not suggest an epicardial pathway location in the coronary sinus, this possibility should be kept in mind in patients with posteroseptal accessory pathways. Especially when there is acute recovery of conduction after a successful initial ablation or resistance to ablation, coronary sinus diverticula should be searched for. Ablation within the coronary sinus is often performed using irrigated-tip ablation catheters; however, in our case, nonirrigated ablation successfully eliminated accessory pathway conduction.

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