We are IntechOpen,
the world's leading publisher of
Open Access books
Built by scientists, for scientists

4,800
Open access books available

122,000
International authors and editors

135M
Downloads

Our authors are among the

154
Countries delivered to

TOP 1%
most cited scientists

12.2%
Contributors from top 500 universities

CLARIVATE ANALYTICS
BOOK CITATION INDEX
INDEXED

WEB OF SCIENCE™

Selection of our books indexed in the Book Citation Index
in Web of Science™ Core Collection (BKCI)

Interested in publishing with us?
Contact book.department@intechopen.com

Numbers displayed above are based on latest data collected.
For more information visit www.intechopen.com

20

Long-Term Consequences of Endocardial Leads Present in Cardiovascular System

Barbara Małecka

Department of Electrocardiology, Institute of Cardiology,
Jagiellonian University Collegium Medicum,
John Paul II Hospital in Krakow, Krakow
Poland

1. Introduction

Endocardial leads for permanent heart stimulation and cardioverter/defibrillator ones have been implanted for 52 and 20 years, respectively. From the very beginning of the age of heart stimulation with the use of endocardial leads, there have been considered reactions of coagulation and immunological systems as well as the changes to the endocardium and the blood vessels in response to the leads in them. In the technological process the leads are covered by external insulation made by polymer materials with bio-compatible properties, that is ones not inducing side effects. Mass implantation of systems for permanent stimulation and implantable cardioverter/defibrillator (ICD) could take place only at the age of developed electronics. Recently we have celebrated the 50th anniversary of permanent heart stimulation. Since that time the number of patients with cardio implants in the right heart have proliferated and also their life expectancy have become substantially prolonged. Over a 50 year-old history of permanent heart stimulation presents a number of arguments to show that ideas of full bio-compatibility of polymer covered leads (usually silicone and polyurethane) were only a wishful thinking. Patients with pacemaker (PM) and ICD systems tend to live longer and possess more, sometimes up to 20 or 30 years old leads in their hearts, which causes a variety of complications.

2. Cardiovascular system response to the leads

2.1 Vegetations and a need for broadening indications for anticoagulant treatment in patients with endocardial leads

Nowadays, an easy access to the echocardiography and especially transesophageal echocardiography (TEE), allows to reveal in the hearts of some patients (5-14%) masses of various consistency, shape and diameter, associated with the leads or the surrounding endocardium, called vegetations (Lo et al., 2006). The term 'vegetation' is a histological term

and means "*a shapeless mass of platelets or fibre, which can contain microorganisms and inflammatory cells*".

In the echocardiography there can be observed vegetations in shape of loose, moving whips or spherical, compact ones. The former occur in connection with the leads coming across the cavity lumen and follow the flow of blood filling or emptying the heart. The latter, spherical, compact vegetations are sometimes connected with the endocardium surrounding the leads like the stalk. It follows the Byrd division (Byrd, 2007), according to which the right heart vegetations divide into:

1. less compact, long, greatly movable (clot) and
2. more compact, spherical, sometimes having a stalk and less movable (thrombus).

TEE examinations repeated several times in the same patients revealed that vegetations in the right heart are not permanent phenomena, but tend to appear and disappear in the same place; some of them undergo lysis, and other move to the pulmonary bed. According to the above, the existence of vegetations and accounting from it danger of pulmonary embolism needs further detailed studies. Nowadays, there are only case reports of a pulmonary embolism on removal of an infected stimulation system, or an embolism caused by a missing part of a broken lead.

Theoretically there is a number of reasons for pulmonary embolism after an implantation of a PM/ICD system. They are as follows:

1. Stimulation system is a foreign body and stimulates clotting.
2. Anti-thrombotic drugs are stopped for the time of the procedure.
3. In the lead dependent infective endocarditis (LDIE) infected vegetations move to the pulmonary bed.

Yet, the guidelines for the prophylactic anticoagulant drug administration do not list endocardial leads as one of the threats. That suggests the need for broadening the indications for anticoagulant treatment in patients with multi-lead PM/ICD systems, especially in patients with incidentally diagnosed asymptomatic vegetations. Until now, the existence of a vegetation in the left heart could be revealed only after the diagnosis or the suspicion of endocarditis.

A vegetation in the right heart with multiple leads constitutes an element of the diagnosis of the endocarditis only in presence of other infective clinical or laboratory symptoms. Finally, the importance of an isolated vegetation with no inflammatory symptoms, is still an unknown. Does the vegetation lead to the infection or result from it?

A conception of the thrombotic endocarditis casts some light on the above doubt. The damage of the endothelium leads to the creation of the microscopic thrombus composed of platelets and fiber and much more exposed to bacterial colonization than healthy endothelium. Two mechanisms take part in the primary creation of the thrombus: damaged endothelium and hyper-coagulability. Hemodynamic situations increasing the turbulence of the blood flow lead to endothelium lesions. A logical conclusion, thus, is that the leads, moving in the blood that continuously flows, can stimulate clotting along their surface, and the thrombi, created in that way, can become infected. An additional stimulus for clotting can be rubbing of the endocardium with the leads moving around or abrasion of the external lead insulation with exposure of its internal metal wire.

2.2 Endothelialization processes

Observations made by cardio-surgeons during the lead removal procedures with the use of cardio-pulmonary bypass present the effects of the productive changes connected with the

existence of the leads in the heart cavities. One of those changes is the endothelialization, that is process of covering the leads with smooth endothelium and attaching them firmly to the walls of the cardiovascular system. Thus, the lead, which is a foreign body, becomes separated from the blood flow which makes contact with the bacteria during periods of bacteremia impossible. Endothialization takes place in the regions where the lead is relatively stable regarding the walls of the blood vessel or the heart and adheres well to their endothelium (Esposito et al., 2002).

Can we assume that the process of endothalialization has been already well known, altogether with all its consequences during removal procedures? It is well known though, that it doesn't cover the whole length of the lead. The extent of the lead closed in the tunnel created by the endothelium depends most probably on the polymer used for the lead's insulation, as well as on the spatial localization of the leads in regards to the walls of the blood vessels and the heart cavities. The most privileged places of in growing of the leads to the walls of the blood vessels and the heart, observed during percutaneous and cardio-surgical procedures of lead extraction, constitute a marked map of technical difficulties during these procedures. The strongest, most durable and therefore most difficult to cut off adhesions occur at the junction of the vena innomina and vena cava superior, in the upper part of the right atrium, in the vicinity of the tricuspid valve as well as in the very right auricle (Byrd, 2007). In these places there is an increased risk of perforation and bleeding during lead removal procedures.

3. Lead dependent infective endocarditis

Infective endocarditis (IE) was first described over a 100 years ago. Since late 20th century New Duke's criteria, broadened by echocardiographic examination results, have been introduced. Textbook descriptions of this disease mention, insufficiently though, the difference in the course of IE regarding the left and the right heart. There are significant differences in etio-pathogenetic factor, clinical course of disease and prophylactic indications. The descriptions of the disease and the experience gained after observing the course of IE were obtained on the basis of observation of infected left heart valves and their prostheses. Such observations were possible due to the development of cardio-surgical methods of valve defect corrections since mid 20th century and because of an increasing popularity of left heart implants. IE proceeds with bacteremia of the systemic circulation and severe infection symptoms such as fever (80%), weakness (25-40%), joint and muscle pain (15-30%), appetite and weight loss (30%) accompanied by characteristic skin color (café au lait). The object examination revealed symptoms of heart failure, valve damage, and the effects of complications caused by embolism in the systemic circulation (spleen, skin, kidneys, brain, extremities). There were also noted spectacular but rare vascular symptoms (5-15%): skin extravasations, the effect of a splinter driven into the nail, Ossler's nodules, Roth's retinal spots and a Janeway symptom (Habib et al., 2009). The second part of the 20th century brought the news about the bacterial endocarditis of the right heart. The problem was noticed in drug addicts, and as a iatrogenic complication in patients with catheters in their right heart cavities as well as in patients under long-term hospitalization (Baddour et al., 2003). In the recent years infective complication of long term existence of endocardial leads in the blood vessels and heart cavities have been increasingly observed. Possibility of the right heart infective endocarditis was implicated in patients with permanent PM/ICD systems (Klug et al., 1997). A certain delay in appreciation of the right heart IE in patients

with PM/ICD can be well understood in the face of a later development of the contemporary electrotherapy compared to the cardio-surgical corrections of heart valve defects.

Risk factors of infections connected with PM/ICD systems are as follows: fever prior to the implantation procedure, temporary stimulation, repeated procedure e.i. exchange /revision of a system, early repairs and lack of antibiotic prophylaxis (Klug et al., 2007).

The etiology of the LDIE is predominantly bacterial (90%) and the pathogens responsible are mainly Staphylococci (Aureus and Epidermidis), Streptococci, Enterococci, Pneumococci, Gonococci, group HACEK gram- bacteria, mycobacterium and sporadically fungi (Candida albicans, Aspergillus sp., Histoplasma capsulatum) and other (chlamydia, rickettsias, mycoplasmus).

From the pathomorphologic point of view LDIE is characterized by vegetations visible in the echocardiography, especially in TEE. Vegetations can, in a natural way, migrate to the pulmonary circulation and consequently, lead to pulmonary embolism.

Classic symptoms of LDIE are:

1. Local PM/ICD pocket infection (of different frequency).
2. Pulmonary symptoms: cough and pleural chest pain, dyspnoea, advanced symptoms of pneumonia, atypical lung changes in the x-ray chest scan suggesting pulmonary embolism by infected vegetations (26-41%).
3. Severe inflammatory state of the whole organism: persistent fever (80%), shivers (75%), weakness, feeling tired (75%), loss of appetite (36%), sweats (32%), café au lait skin color (relatively late).
4. Laboratory IE indicators such as blood culture tests results (about 70%), anaemia (66%), leukocytosis (59), increased ESR, CRP (59%), erythrocyturia and albuminuria are rare symptoms of the disease (Greenspon et al., 2008; Massour et al., 2007; Sohail et al., 2008).

This disease entity lacks the symptoms typical for infected vegetations in the left heart (small Duke's symptoms). Vegetations and embolisms do exist but in the pulmonary circulation. For the fact that several symptoms may not reveal, the disease is usually diagnosed very late, and sometimes left undiagnosed until patient's death. Patients with LDIE happen to be referred for pulmonary, medical or even oncologic diagnostic investigations due to atypical and ambiguous changes seen in their chest x-ray scans. Those changes usually subside after antibiotic treatment, with no permanent recovery, though. The disappearance of a vegetation from the echocardiography picture is not synonymous with recovery if the leads are left in heart cavities. In case of repetitive infections it is crucial to consider LDIE in a patient with a cardio-implant in the form of a lead in the right heart, with possible vegetations on it [Figure 1].

4. Multiple endocardial leads, abandoned, migrated – a growing problem in electrotherapy

4.1 Multiple leads

It was assumed that the implanted lead is inexchangable and should be sufficient for the patient's whole life. Thanks to the extended life expectancy of patients with PM/ICDs there has appeared an opportunity to observe endocardial leads staying long in the human body. However, time has verified the above assumption negatively. A logical conclusion seems to be, that the risk of breakage, abrasion or migration ('dropping in') of the inactive lead
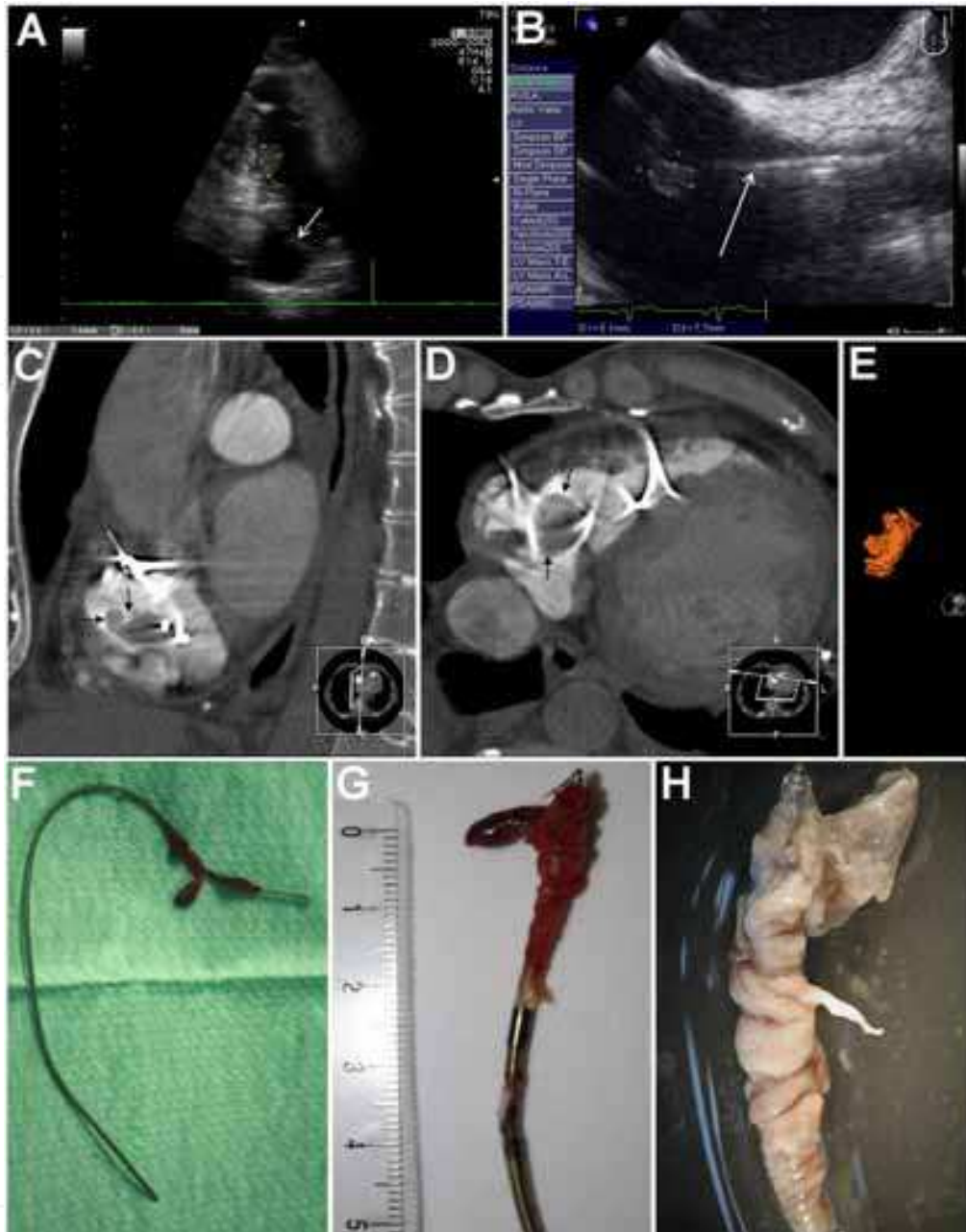
Fig. 1. Vegetations in the course of LDIE visualized by different techniques.

A. TTE: modified 4 – cavity projection. The vegetation connected with the lead in the right ventricle (crosses); the lead (arrow).
B. TEE: 2 – cavity projection. The vegetation connected with the lead in the right atrium (crosses); the lead (arrow).
C. C,D,E. Figures presented thanks to courtesy of dr E. Czekajska – Chehab; Lublin Medical University.
D. C,D. MSCT (Multi Sliced Computer Tomography) of the thorax. MIP (maximum intensity projection) reconstructions. The vegetation connected with the lead in the right atrium (arrow).
E. 3D reconstruction of the vegetation in the patient from figure C&D.
F. Intraoperative picture of the endocardial lead removal procedure with cardio – pulmonary bypass. Visible vegetation connected with the lead.
G. Magnified vegetation from fig. F.
H. Vegetation connected with the lead under the optic microscope.

increases every year further from the implantation. All inactive leads need to be substituted with new ones, older systems can be upgraded and PM systems changed into ICD systems, which results in multiple lead existence in cardiovascular system [Figure 2].
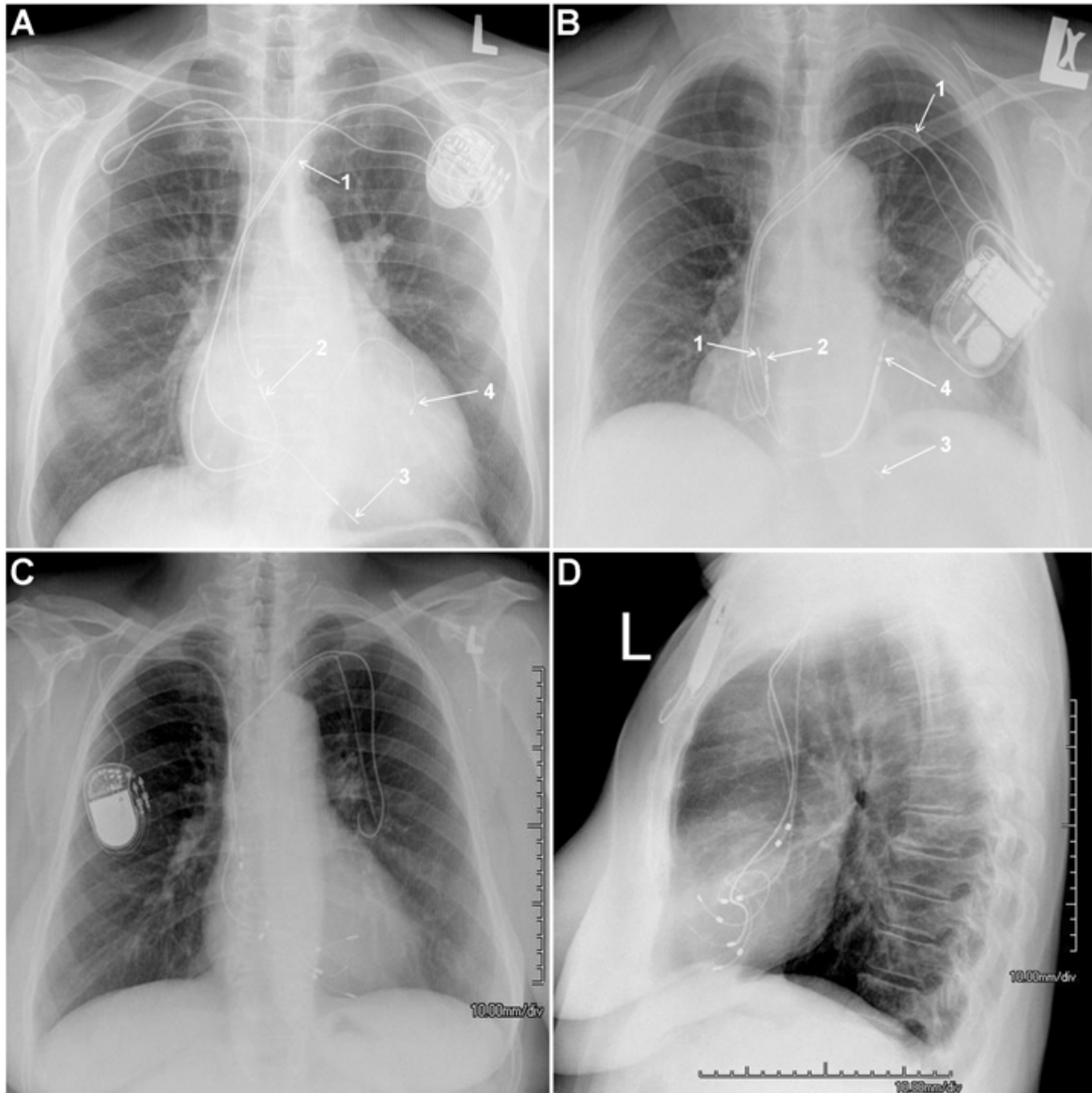

Fig. 2. Multiple leads in chest x–ray scan.

A.   Postero-anterior projection in a patient with PM – CRT (Cardiac Resynchronization Therapy).Visible 4 leads: One of the atrial leads broken and migrated to the left subclavian vein (arrow 1); Second atrial lead implanted from the right subclavian vein and lead to the left PM pocket due to the obstruction of the left subclavian vein (arrow 2); Remaining leads: right ventricular (arrow 3) and left ventricular (arrow 4).

B.   Postero – anterior projection in the patient with ICD. Visible 4 leads: one of the atrial leads broken and migrated to the left subclavian vein (arrows 1), the other atrial lead is active (arrow 2), abandoned PM lead for right ventricle apical stimulation (arrow 3), ICD lead implanted to the right ventricle outlet track (arrow 4).

C.   Postero – anterior projection in the patient with a single lead atrio – ventricular PM system on the right side. Additionally visible two abandoned leads implanted from the left side.

D.   Lateral projection in the patient with from fig. C.

4.2 Vascular obstruction

The existence of leads in the veins causes thrombosis and vascular obstruction in high percentage of patients (Rozmus et al., 2005) [Figure 3]. This lead dependent complication of a permanent stimulation can sometimes significantly lower the quality of life of a patient
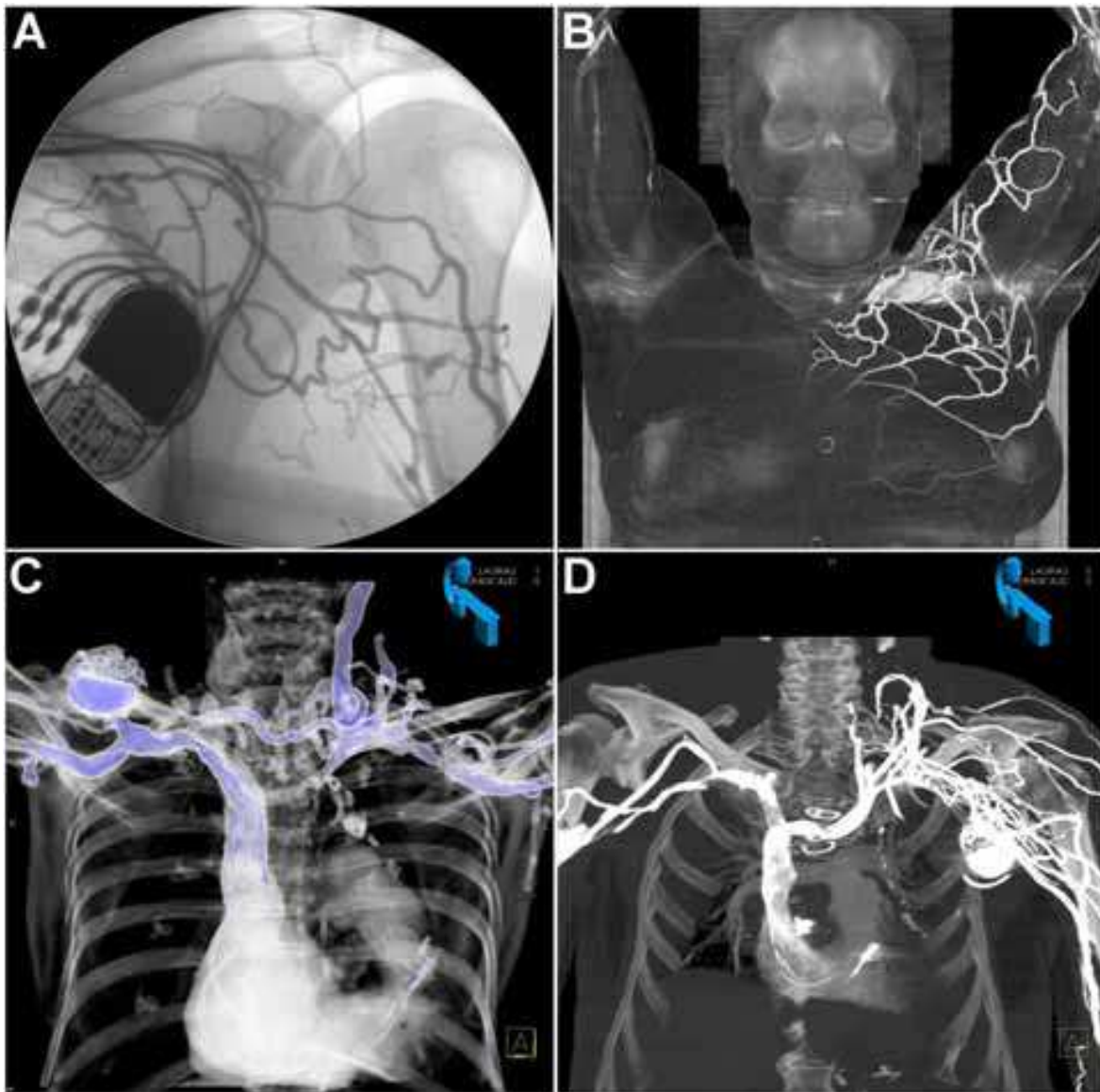

Fig. 3. Vascular obstruction in the presence of the endocardial leads visualized by different techniques

A. Chest X-ray scan: postero-anterior projection. Intraoperative venography of the left vein flow in a patient with PM – CRT. Visible lateral circulation as a result of the obstruction of the left subclavian vein.
B. MSCT in a patient with PM. Visible lateral circulation as a result of obstruction of the left subclavian vein.
C. MSCT in the patient with PM on the right side and abandoned leads on the left side. Visible obstruction of the innominate vein and current lateral circulation as well as narrowing of the right subclavian vein lumen.
D. MSCT in the patient with PM. Visible lateral circulation as a result of obstruction of the left subclavian vein.

(edema of an upper limb, face, in extreme cases a typical vena cava syndrome) but, what is even more important, it makes an implantation of the lead for the planned system upgrade impossible. In such situations it is possible to regain vein lumen by removal of one of the leads, since the lead in the obstructed vein constitutes "the access door" to the heart. There is also a possibility to treat the vascular obstruction by plastic surgery (with the use of the stent or without). The analysis of long-term efficiency of plastic surgery of great veins with endocardial leads present in them has not been made so far.

4.3 Abandoned leads resulting in multiple lead existence in cardio-vascular system

What do we know about the potential risk of abandoning inactive leads in the heart cavities? From the clinical practice it is known that increased number of the leads in the cardio-vascular system causes negative effects to the veins, to the function of the tricuspid valve and PM/ICD pocket. Multiple leads in the heart increase the risk of lead external insulation abrasions, for the fact that the leads continuously rub against one another with frequency of the heart rhythm. External insulations of the leads can, for that reason, undergo mechanical abrasion, exposing their metal wire, and generate thrombosis and secondary pulmonary embolism in those places. In this way a place for 'anchorage' of the dangerous LDIE is created. Coils of the leads' proximal part lying in the pocket enlarge its volume and so increase the risk of the decubitus of the skin which covers the PM/ICD pocket. Apart from that there is a high risk of migration of the proximal end of the abandoned lead inside the vascular system, which can trigger a number of further complications (Bohm et al., 2001). Even though Heart Rhythm Society (HRS) 2009 guidelines present indications for lead removal in particular cases, we should focus not on asking whether to remove an inactive lead but whether if and when we are allowed to leave it in the cardiovascular system (Wilkoff et al., 2009).

4.4 Migrating leads

An abandoned, cut short and not sufficiently fixed lead creates the risk of migration to the cardiovascular system. Active endocardial leads may also migrate to the cardiovascular system after being damaged up to the total break-up. This may occur as a result of the crush syndrome in case of unfavorable position of the lead and the clavicle (Magney et al., 1993). There is also a risk of lead's break-up at the site of ligature tightening on the lead in the pacemaker pocket.

The migration of the lead's proximal end to the subclavian, brachio-cephalic vein or vena cava superior creates loops, which in turn move through the tricuspid valve to the right ventricle provoking valve dysfunction and ventricular arrhythmias [Figure 4].

Sometimes the free end of the lead drops in the right heart cavities or pulmonary artery causing pulmonary embolism.

Practically, every lead, the free end of which is dropped in the cardiovascular system becomes a potential source of the consequences mentioned above and is class 1 (*lead with ending in CVS, which may pose an immediate threat to the patient if left in place, life threatening arrhythmias secondary to retained lead or lead fragment*) or class 2b (*lead which may pose a potential future threat to the patient if left in place*) according to the latest guidelines of the HRS (Wilkoff et al., 2009).

There are no descriptions of percutaneous lead removal procedures with free ends migrated to the cardiovascular system, based on a larger population of patients with such a problem, except single or a few patients case reports.
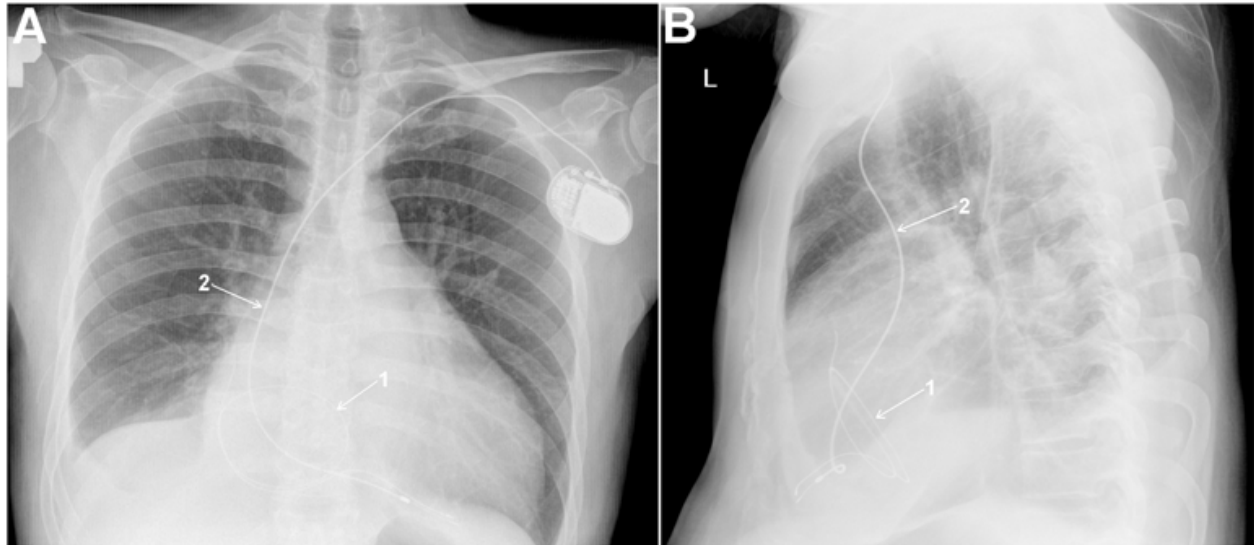
Fig. 4. The lead dropped in and coiled in the heart in the X-ray chest scan in a patient with PM.

A.   Postero-anterior projection. Dropped in lead (arrow 1); Active lead (arrow 2)
B.   Lateral projection. Labeling leads in A.

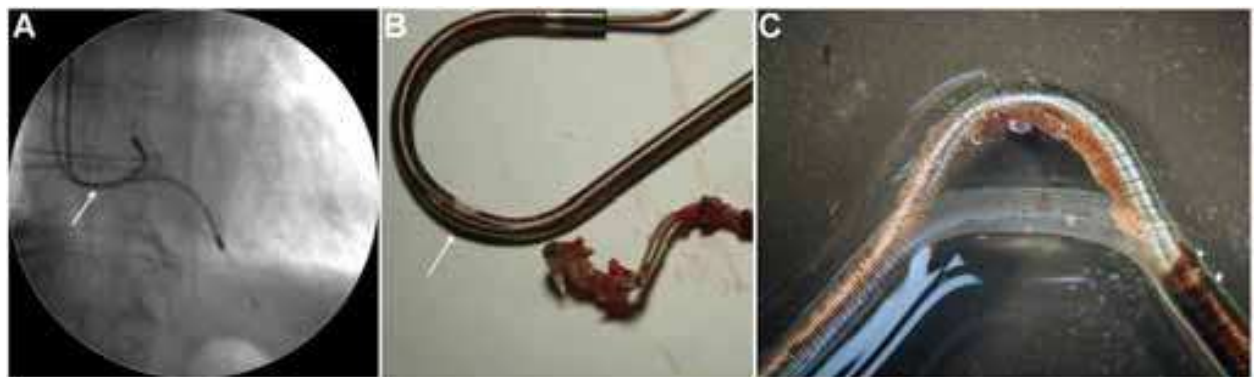

Fig. 5. Inside-heart abrasions of leads in a patient with PM.

A.   Chest X-ray scan: postero-anterior projection. Atrio-ventricular PM system with 2 leads. Visible mutual contact of two leads at the bottom of the right atrium (arrow).
B.   Intraoperative picture with the removed atrial lead in a patient from figure A: visible abrasion of the lead's silicone insulation (arrow).
C.   Optic microscope picture: visible abrasion of the silicone external insulation.

4.5 Mechanical damage of the leads

Studies on the subject have given a number of information about mechanical damage to the endocardial leads resulting from their construction imperfections, implantation procedures as well as human anatomy. A phenomenon of lead abrasion between the clavicle and the first rib in the 'crush syndrome' mechanism as well as external insulation abrasions of the leads coiled in the PM/ICD pocket caused by rubbing against the system can are well known phenomena.

Inside-heart abrasions of silicone lead insulations have also been discovered (Kutarski et al., 2009; Kołodzińska et al., 2010) [Figure 5]. This phenomenon is probably a significant factor in creation and/or generation of vegetations, thrombi and LDIE. It has been proved, that in the group of patients with abraded leads, patients with several leads are predominant. Thus,

it can be concluded that there is a certain relation between the number of leads in the heart and incidents of their abrasion. The abrasions have been observed more often in the older stimulation systems: after at least 2 years in the CRT systems and four years in DDD systems. Such findings mean that probability of leads' abrasions is similar in every multi-lead system. A condition under which an abrasion occurs is a specific spacial localization of multiple leads in the right heart. It predisposes bumping or/and rubbing of the leads against one another, with the frequency of the heart beat. The phenomenon of lead abrasion occurs only in the right heart cavities, especially in the atrium and sporadically in the ventricle. Leads' abrasions are possible to occur only when the leads move in opposite directions to one another, with different spatial configurations:

a.   a too long atrial lead loop with its distal end in the auricle, which continously rubs against the atrial part of the ventricular lead,
b.   a lead running through the coronary sinus outlet crosses right above the tricuspid valve with the ventricular lead running towards the right ventricle,
c.   two lead loops cross each other in the right ventricle.

The discovery of endocardial lead abrasions puts the durability of leads for permanent heart stimulation as well as current techniques of their implantation in a new light. Abrasions in the atrio-ventricular systems in which the atrial lead was implanted in the sites where it couldn't move was not observed. This applies to Bachman's bunch (roof of the right atrium), as well as to the anterior part of the atrial septum.

Prospective, randomized research of lead abrasions in people are not possible for ethic reasons. They would have to assume planned lead removals for solely cognitive reasons, with no therapeutic indications for the procedure carrying nearly 1% risk of death. The process of abrasion takes too long to observe it in studies on animals. Endocardial lead external insulation abrasions have been discovered in the leads covered with silicone, which does not exclude the possibility of abrasions in the leads covered with polyurethane or other polymer materials.

4.6 Choice of the lead model

Considering to use a lead for heart stimulation we often tend to forget about possible late, even very far away complications. A lead which is too long for the patient's heart needs to be looped in the pocket several times. In this way a skin decubitus or abrasion of the lead's insulation inside the stimulator pocket is created. We pay too much attention to stimulation conditions ('low-treshold) and leads' dislocation percentage (non-dislocating leads) and much too little to the ways of removing the leads years later. Deffibrillation leads cause most technical problems. Most adhesions (bridges) of the connective tissue are formed in the vena innomina and vena cava superior, and the strongest ones (often obstructing the vein's lumen) are formed on the proximal coil. However, removability constitutes one of the most crucial features of the lead.

5. Lead removal procedures

Percutaneous removal of endocardial leads is the most difficult electrotherapy procedure carrying 1% risk of intraoperative death. It is still an alternative for cardio-surgical procedures, which are more strenuous for the patients and carry 10 times as high percentage of death (Camboni et al., 2008). The later from the implantation procedure the more technical difficulties are encounted during removal with significant increase of its risk. The

growth of the connective tissue around the leads is a well known factor which makes the procedures of percutaneous lead removal more difficult. It increases the risk of great vein and the right heart ruptures with fatal bleeding.

Technical details of every lead removal can contain elements going beyond a stereotypical procedure. Individual anatomical conditions or specific leads' configuration force the operators to create unique, original modifications.

A percutaneous lead removal in presence of large (over 2cm in diameter) vegetations with protection of the pulmonary bed against the pulmonary embolism becomes the challenge of the oncoming times (Małecka el al., 2010). The literature describing lead removal with no laser or radiofrequency back up presents Bongiorni's technique, which uses rotation-cutting forces with/and change of the leads into free floating ones (Bongiorni et al. 2008).

5.1 Removal of leads with proximal ends accessible in the PM/ICD pockets with the use of rotation-cutting forces

Extraction of the leads is initiated by removing the stimulator from the pocket. In presence of an infection, a smear of the pocket discharge and/or blood culture test of the tissue is required. Next, the leads are let off the ligatures in the pocket and the tunnel leading to the large vessel (usually the subclavian vein). Inside the leads 'anchoring' or ' non-anchoring' leaders are introduced. The choice of the type of the leader mostly depends on the condition of the lead's lumen. Our own experience shows that it is usually impossible to use the 'anchoring' leader, which is supposed to carry the pulling forces onto the distal end (of the lead) or the whole lead. It is connected with the advanced age of the removed leads and resulting from it destruction of their structure, a common phenomenon of a 'crush syndrome" in Polish patients (having leads implanted from the unfavourable peristernal puncture of the subclavian vein or working physically hard despite implantation of the endocardial leads).

Not infrequently it is associated with failed attempts to remove the stimulation system in patients' home centers. In the situation when the lead's lumen is distorted and the leader cannot reach the very end of the lead, it seems to be the best solution to stiffen as long section of the lead as possible with a 'non-anchoring' metal leader.

At a later stage of the procedure the proximal lead ends are secured with long, strong, ligatures, which, at the same time, tighten the lead during the process of its being freed from the connective tissue bridges. Those strong ligatures are tied to the leads in such a way to crush and connect all layers of the lead, together with the metal leader inside. The ligatures are tied around the lead in a way to prevent leads' diameter from considerable growth , as well as from cutting it. In case of an 'anchoring' leader being used, the ligatures are additional elements of the traction system.

Steel preparation sheaths of possibly smallest diameter are used to overcome the resistance of tissues in the subclavian region. Having gained the access to the subclavian vein the steel sheaths are substituted with a pair of teflon or polypropylene sheaths, so called Byrd dilators, which act in a telescopic way. The experience shows that the operator should have all dilator sizes (according to colors) and two standard lengths 33/38 and 41/46 cm at hand. In case of encountering a significant resistance (usually in vena cava superior) polypropylene dilators are exchanged for the other ones, usually of a bigger diameter (blue, yellow, green, white, and orange). Recommendations of the company can be confirmed that unipolar leads can usually be removed with the use of blue and yellow dilators, bipolar ones

with yellow or green sheaths, and ICD leads with green or white and sporadically orange dilators.

The lead removal procedure builds upon slow (millimeter after millimeter!) freeing the lead from connective tissue bridges, vegetations, endothelialization tunnels with the use of rotation of a catheter cut diagonally, that is with the use of rotation-cutting forces. At this stage of the procedure and maneuvers associated with it, it is essential for the other operator to keep a proper tension of the lead. The first operator is at the same time highly occupied with proper position (i.e. lengthwise to the wall the blood vessel and later to the heart cavities) of the dilators during maneuvers, which are mainly rotation movements exerting delicate pressure on the lead. A single catheter meets the increased friction resistance the deeper it goes into the vascular system, whereas the technique of a 'catheter in a catheter' allows to move (rotate) dilators with much less resistance from the tissues and a lower risk of breaking or wrenching the dilator off.

From the moment of reaching the ingrown distal end of the lead with the dilators, the phenomenon of a counter traction is put into use, i.e. supporting the tissue around the lead's end and preventing it from moving along with the lead which is being freed and pulled outside.

At all stages of the procedure a careful observation of patient's heart rhythm and vital signs is necessary.

5.2 Removal of dropped-in leads

Such procedures usually do not proceed in a typical way. Most frequently they are a demonstration of operators skills in using various types of anchoring and pulling catheters, and *ad hoc* modifications of techniques offered by the companies.

In order to remove a lead without its end accessible in the pocket, a Byrd workstation is introduced into one of the femoral veins. The catheters to catch the lead are introduced via the workstation. The choice of the catheter depends on the experience and liking of an operator and also on the spatial situation. The 'pigtail' catheter is considered to be the one of the first choice.

The next popular catheter is the Dotter's basket.' Needle snare eye', though, has proved to be of little use in many of the procedures performed so far. It is probably connected with presence of multiple leads in the heart and with the situation when the coiled lead being removed is only one of the leads in the heart. Having grasped the floating end of the lead, it is moved outside the femoral vein. Then the traction used in the sheath that creates counter traction should be sufficient, according to the equipment producers, for pulling the lead from the adhesion in the heart. Own experience shows that the situation is much more complicated. Usually, the lead being removed has some more adhesions to the heart or to another lead. In such cases cutting properties of polypropylene Byrd dilators or other diagonally cut, sharpened catheters can be successfully used.

5.3 Potential complications and safety precautions during percutaneous lead removal procedures

Contrary to the general opinion, the possibility to damage the wall of the right ventricle does not constitute the greatest danger caused by releasing the leads from the connective tissue bridges or the endothelialization tunnels. During percutaneous removals of the old and strongly ingrown and immobilized leads we are mostly concerned with the following:

- Damage of the subclavian vein / vena innomina / vena cava superior: the surgical intervention is most difficult due to the difficult access,
- Damage of the subclavian artery, creation of V –A fistula to a lesser extent,
- Massive pulmonary embolism by the torn off large vegetation,
- Damage of the coronary sinus: applies to removals of left - atrial leads and left - ventricular leads.

During the procedures we are much less concerned with their consequences in the form of damage of the right atrium, right ventricle or tricuspid valve. In such situations the cardio-surgical intervention is not always necessary, and technically easier due to the easy access in case the intervention is indispensable. Massive bleeding to the mediastinum or pleural cavity or massive pulmonary embolism are the most dangerous complications and can lead to death before the delayed cardio-surgical intervention. Thus, the back up of the cardio-surgical and anaesthesiological team ready to act at any moment is essential.

In the presented technique of percutaneous lead removal the key role is the experience of the main operator. Independently from the degree of their training and having in mind the risk of potential complications, it is necessary to backup every procedure of percutaneous lead removal by an experienced cardio-surgeon, prepared for a quick joining of the great vessels or removing of the embolic material from the pulmonary trunk. Safety of such procedures is also increased by the angio-surgeon being available and, if possible, an experienced operative radiologist. It is also desirable to perform the procedure in a cardio-surgical operation room with a high class X-ray apparatus.

6. Spontaneous delayed heart perforation caused by endocardial lead

Incidence of the delayed heart perforation is proved to be low (at 0,1-0,8% for pacemakers implantation and 0,6-5,2% in ICDs) (Khan et al., 2005), probably due to "self-sealing" properties of the ventricle wall: fibrosis, muscle contraction or by the lead itself.

Suspected risk factors for heart perforation are as follows:

- temporary stimulation,
- atrial stimulation,
- stimulation with active fixation system,
- defibrillator leads, with double spirals (more wires, stiffer),
- when excessive length during implantation is left,
- small diameter (increased force per unit area),
- the so-called high resistance (small tip surface).

The literature presents reports about higher perforation rate in case of a certain lead types (eg. Riata ST Jude Medical leads), which might indicate that some constructive elements of the leads may predispose heart perforation. It is known that this condition occurs more often in localizations of the distal end of the lead such as right ventricular apex.

Apart from the two above conditions the state of the heart may also favor perforation.

Anticoagulation and steroid therapy, low body mass index, female gender and incidental chest trauma may trigger perforation.

Delayed right ventricle perforation may have several clinical symptoms:

- chest pain,
- dyspnea,
- syncope (due to improper stimulation or its complete failure),

- inadequate ICD shocks,
- muscle or diaphragm stimulation,
- abdominal pain (due to diaphragm stimulation or lead migration to the peritoneal cavity),
- hiccup (as a symptom of the phrenic nerve stimulation),
- mammary hematoma,
- consequences of the diaphragm, lung, chest wall perforation,
- pleural or pericardial effusion, rarely demanding drainage.

The most common symptom is the electric dysfunction: sensing, pacing and impedance. Sometimes perforation occurs also with normal electrophysiological parameters. Thus, it can be concluded, that improper function may indicate perforation but its normal function does not exclude it.

Perforation diagnosis can be confirmed by visualization techniques:

chest X-ray, transthoracic (TTE) or transoesophageal (TEE) echocardiography and computed tomography [Figure 6]. X-ray is efficient in revealing distal lead end migrations outside the heart and assessing pleural effusion.

Echocardiography can present more discreet changes in lead migration. It is also a good technique for assessing pericardial effusion. The golden mean, however, stays computed tomography (CT).
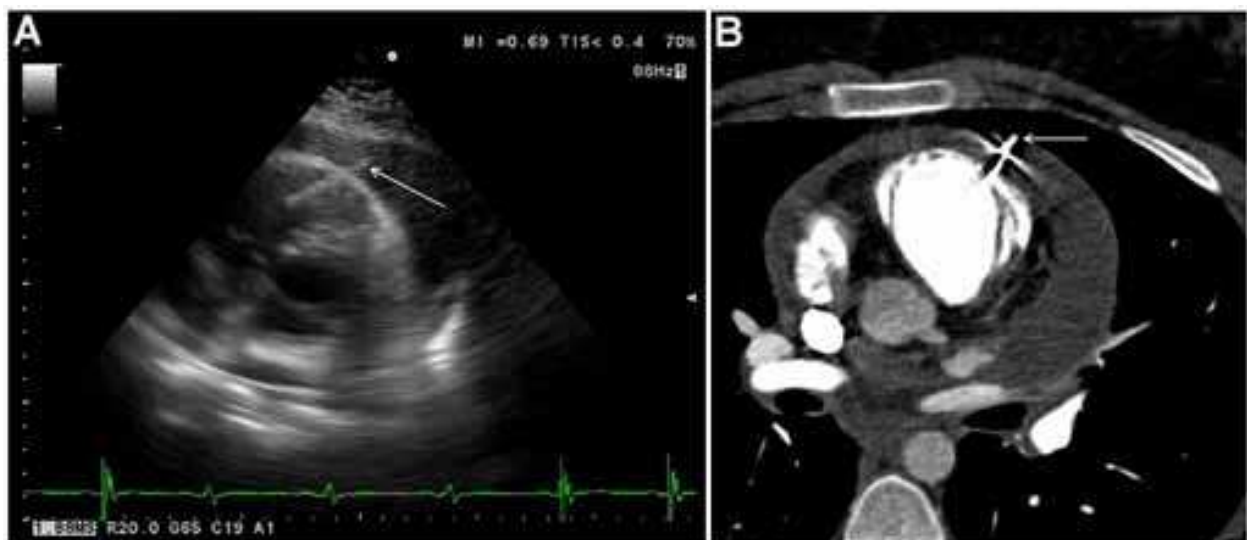

Fig. 6. Delayed heart perforation by endocardial lead visualised by different techniques.
A. Transthoracic echocardiography (TTE).
B. MSCT in the same patient. MIP projection. The lead is perforating the wall of the right ventricle (arrow).

7. References

Baddour L.M., Bettmann M.A., Bolger A.F., Epstein A.E, Ferrieri P., Gerber M.A., Gewitz M.H., Jacobs A.K., Levison M.E., Newburger J.W., Pallasch T.J., Wilson W.R., Baltimore R.S., Falace D.A., Shulman S.T., Tani L.Y., Taubert K.A. (2003). Nonvalvular Cardiovascular Device-Related Infections. *Circulation*, Vol. 108, No. 16 pp. 2015-2031, ISSN 0009-7322

Bohm A., Pinter A., Duray G., Lehoczky D., Dudas G., Tomcsanyi I., Preda I. (2001). Complications due to abandoned noninfected pacemaker leads. *PACE*, Vol. 24, No. 12, pp. 1721-1724, ISSN 0147-8389

Bongiorni M.G., Soldati E., Zucchelli G., Di Cori A., Segreti L., De lucia R., Solarino G., Balbarini A., Marzilli M., Mariani M. (2008). Transvenous removal of pacing and implantable cardiac defibrillating leads using sheath mechanical dilatation and multiple venous approaches: high success rate and safety in more than 2000 leads. *Eur. Heart J.*, Vol. 29, No. 23, pp. 2886-2893, ISSN 0195-668X

Byrd C. L. Managing Device-Related Complications and Transvenous Lead Extraction 855. Ellenbogen K. A., Kay G. N., Lau C.P., Wilkoff B. L. *Clinical Cardiac Pacing, Defibrillation, and Resynchronization Therapy*, Third Edition, Saunders Elsevier 2007. ISBN 978-1-4160-2536-8

Camboni D., Wollmann C. G., Löher A., Gradaus R., Scheld H. H., Schmid C. (2008). Explantation of Implantable Defibrillator Leads Using Open Heart Surgery or Percutaneous Techniques. *Ann Thorac Surg* Vol. 85, No. 1, pp. 50-55, ISSN 0003-4975

Esposito M., Kennergren C., Holmström N., Nilsson S., Eckerdal J., Thomsen P. (2002). Morfologic and Immunohistochemical Observations of Tissues Surrounding Retriver Transvenous Pacemaker Leads. *Biomed Mater Res* Vol. 63, No. 5, pp. 548-558, ISSN 1552-4965

Greenspon A.J., Rhim E.S., Mark G., Desimone J., Ho R.T. (2008). Lead-Associated Endocarditis: The Important Role of Methicillin-Resistant Staphylococcus aureus. *PACE* Vol. 31, No. 5, pp. 548-553, ISSN 0147-8389

Habib G., Hoen B., Tornos P., Thuny F., Prendergast B., Isidre Vilacosta I., Moreillon P., Antunes M., Thilen U., Lekakis J., Maria Lengyel M., Muller L., Naber CK., Nihoyannopoulos P., Moritz A., Zamorano JL., ESC Committee for Practice Guidelines: Guidelines on the prevention, diagnosis, and treatment of infective endocarditis (new version 2009) (2009). Task Force on the prevention, diagnosis, and treatment of infective endocarditis of the European Society of Cardiology; European Society of Clinical Microbiology and Infectious Diseases; International Society of Chemotherapy for Infection and Cancer, *Eur. Heart J.*, Vol. 30, No. 19, pp 2369-2413, ISSN 0195-668X

Khan M., Joseph G., Khaykin Y, Ziada K. M., Wilkoff B. L. (2005). Delayed lead perforation: a disturbing trend. *PACE*, Vol. 28, No. 3, pp. 251-253, ISSN 0147-8389

Klug D., Lacrox D., Savoye C., Goullard L., Grandmougin D., Hennequin J. L., Kacet S., Lekieffre J. (1997). Systemic infection related to endocarditis on pacemaker leads. Clinical presentation and management. *Circulation*, Vol. 95, No. 8, pp. 2098-2107, ISSN 0009-7322

Klug D., Balde M., Pavin D., Hidden_lucet F., Clementy J., Sadoul N., Rey J. L., Lande G., Lazarus A., Victor J., Barnay C., Grandbastien B., Kacet S., for the People Study Group. (2007). Risk Factors Related to Infections of Implanted Pacemakers and Cardioverter-Defibrillators: Results of a Large Prospective Study. *Circulation*, Vol. 116, No. 12, pp. 1349-1355, ISSN 0009-7322

Kołodzińska A., Kutarski A., Grabowski M., Małecka B., Opolski G. (2010). The Late Silicone Leads Abrasions In Their Intracardiac Part. *Heart Rhythm* , Vol. 7, No. 5S, pp. S248-9, ISNN 1547-5271

Kutarski A., Małecka B., Ząbek A. (2009). Mutual abrasions intracardiac leads-important finding among explanted leads. *Europace*, Vol. 11, No. S2, ISNN 1099-5129

Lo R., D'Anca M., Cohen T., Kervin T. (2006). Incidence and prognosis of pacemaker lead-associated masses: a study of 1,569 transesophageal echocardiograms. *J Invasive Cardiol*, Vol.18, No. 12, pp. 599-601, ISSN 1042-3931

Magney J.E., Flynn D.M., Parsons J.A., Staplin D.H., Chin-Purcell M.V., Milstein S., Hunter D.W. (1993). Anatomical mechanisms explaining damage to pacemaker leads, defibrillator leads, and failure of central venous catheters adjacent to the sternoclavicular joint. *PACE*, Vol. 16, No. 3 Pt 1, pp. 445-457, ISSN 0147-8389

Małecka B., Kutarski A., Tomaszewski A., Czekajska – Chehab E., Ząbek A. (2010). Transvenous removal of endocardial leads with coexisting great vegetation (3.5 cm) – case report. *Europace* , Vol. 12, No. 3, pp. 445-446, ISSN 1099-5129

Massoure P-L., Reuter S., Lafitte S., Laborderie J., Bordachard P., Clementy J., Raudaut R. (2007). Pacemaker Endocarditis: Clinical Features and Management of 60 Consecutive Cases. *PACE*, Vol. 30, No. 1, pp. 12-19, ISSN 0147-8389

Rozmus G., Daubert J. P., Huang D. T., Rosero S., Sala B., Francis C. (2005). Venous Thrombosis and Stenosis After Implantation of Pacemakers and Defibrillators. *Journal of Interventional Cardiac Electrophysiology* 2005, Vol. 13, No. 1, pp. 9-19, ISSN 1383-875X

Sohail M. R., Uslan D. Z., Khan A. H., Friedman P.A., Hayes DL, Wilson W.R., Steckelberg JM, Jenkins S.M., Baddour L.M. (2008). Infective Endocarditis Complicating Permanent Pacemaker and Implantable Cardioverter-Defibrillator Infection. *Mayo Clin Proc*. Vol. 83, No. 1, pp. 46-53, ISNN 0025-6196

Wilkoff B.L., Love C.J., Byrd C.L., Bongiorni M.G., Carrillo R.G., Crossley G.H. 3rd, Epstein L.M., Friedman R.A., Kennergren C.E., Mitkowski P., Schaerf R.H., Wazni O.M. (2009). Transvenous lead extraction: Heart Rhythm Society expert consensus on facilities, training, indications, and patient management: this document was endorsed by the American Heart Association (AHA), *Heart Rhythm*, Vol. 6, No. 7, pp. 1085-104, ISNN 1547-5271
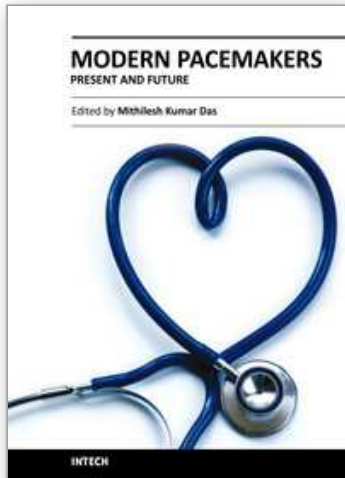
Modern Pacemakers - Present and Future

Edited by Prof. Mithilesh R Das

ISBN 978-953-307-214-2

Hard cover, 610 pages

Publisher InTech

Published online 14, February, 2011

Published in print edition February, 2011

The book focuses upon clinical as well as engineering aspects of modern cardiac pacemakers. Modern pacemaker functions, implant techniques, various complications related to implant and complications during follow-up are covered. The issue of interaction between magnetic resonance imaging and pacemakers are well discussed. Chapters are also included discussing the role of pacemakers in congenital and acquired conduction disease. Apart from pacing for bradycardia, the role of pacemakers in cardiac resynchronization therapy has been an important aspect of management of advanced heart failure. The book provides an excellent overview of implantation techniques as well as benefits and limitations of cardiac resynchronization therapy. Pacemaker follow-up with remote monitoring is getting more and more acceptance in clinical practice; therefore, chapters related to various aspects of remote monitoring are also incorporated in the book. The current aspect of cardiac pacemaker physiology and role of cardiac ion channels, as well as the present and future of biopacemakers are included to glimpse into the future management of conductions system diseases. We have also included chapters regarding gut pacemakers as well as pacemaker mechanisms of neural networks. Therefore, the book covers the entire spectrum of modern pacemaker therapy including implant techniques, device related complications, interactions, limitations, and benefits (including the role of pacing role in heart failure), as well as future prospects of cardiac pacing.

How to reference

In order to correctly reference this scholarly work, feel free to copy and paste the following:

Barbara Małecka (2011). Long-Term Consequences of Endocardial Leads Present in Cardiovascular System, Modern Pacemakers - Present and Future, Prof. Mithilesh R Das (Ed.), ISBN: 978-953-307-214-2, InTech, Available from: http://www.intechopen.com/books/modern-pacemakers-present-and-future/long-term-consequences-of-endocardial-leads-present-in-cardiovascular-system

INTECH

open science | open minds

www.intechopen.com