



Injuries of previously stent stabilized left ventricular pacemaker lead during simulated lead extraction

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ABSTRACT. During biventricular pacemaker implantation stents can be applied for coronary sinus lead stabilization to prevent lead dislocations. A lot of issues occurred in connection with the use of the stent. In some cases the implanted left ventricular lead must be explanted. The removal of the electrode without any injury of the heart is substantial. An other very important question is that, what kind of injuries could the electrode get during the removal process. An extraction model had been prepared including a specified curve and using a polymer tube. After extraction of the pacemaker leads different microscopic examinations were executed. The results can make the operations more successful by making the electrode in a more stable position and keeping the injuries during operation in a minimum level.

INTRODUCTION

A pacemaker (PM) is an electronic device implanted in the body to regulate the heart beat. It consists of a battery and electronic circuits enclosed in a hermetically sealed can. The PM delivers electrical stimuli over leads with electrodes in contact with the heart [1].

Cardiac resynchronization refers to stimulation techniques that change the degree of atrial and ventricular electromechanical asynchrony in patients with major intra-atrial or interatrial and ventricular conduction disorders. More recently for the treatment of heart failure, the left ventricle may be paced by insertion of a lead into a tributary of the coronary sinus, a venous structure on the epicardial surface of the left ventricle [1]. Despite major advances of lead and pacemaker techniques, the implantation of a biventricular pacemaker is still a challenging and complex procedure. To introduce the left ventricular pacing lead into the sinus coronarius may cause difficulties. Dislocation rate of coronary sinus (CS) leads used for biventricular stimulation is high. Stent implantation to stabilize the left ventricular lead is a useful and safe procedure in the treatment of CS lead instability. The electrode is positioned into the desired position, and a metal coronary stent is introduced via guide wire through the coronary sinus. After pacing measurements the stent is deployed at 5 to 30 mm proximal to the tip of the electrode [2].

Cases can occur especially infections when the implanted left ventriculum lead needs to be explanted. In these cases it is determinate that removing of the electrodes should not cause injury of the heart. During the process of explantation the vein wall can be injured. Avoiding this the possibility the electrode explantation has to be examined, if the stent can damage the electrode in the way it might brake and the tip remain in the vessel. Another important issue is that which type and size of stent can insure the most appropriate fixation. The aim of our article is to examine the injuries of the electrodes and stents caused by electrode explantation and to find the most convenient stent for electrode fixation.



METHODS

A special curve was shaped to modelling the bend of the outer surface of the left ventriculum. The curve was formed in a sheet made from foamed polystyrol. The sheet was 50 mm long, 30 mm wide and the thickness of the sheet was 30 mm. The typically Left Ventricular Diastolic Diameter (LVDD) is about 70 mm and the representative wallthickness of the left ventriculum by Cardiac resynchronization therapy treated patients is 10 to 20 mm [3]. Accordingly the radius of the testing curve was 90mm. A silicon tube was placed into the curve and the electrodes were stabilized with coronary stents in this tube. The first step of the procedure was to fill physiological saline into the tube. The electrode is surrounded by blood in the ventriculum so to ensure the wet conditions and decrease the friction the stent and the electrode physiologic solution was present in the tube.

Secondly the electrode was led up to the end of the tube and balloon expandable coronary stents were used to fix the electrode. The expansions of the stents were carried out with indeflator. The indeflator is a pump applied with pressuremeter and need to be filled with Ringer's solution. In practice usually maximum pressure is used to expand stents, therefore our experiments were made the same way (26 bar). Our aim was to achieve the maximum available diameter of stents by this method. After the fixation of the electrode with the expanded stent, the guide wire and balloon catheter were removed. Finally the electrode was extracted at a slow pace circumspectly. The procedure was followed up with stereomicroscope. The indeflator was filled with turquoise liquid for better visibility because the vein modelling polymer tube is not completely transparent. Applying this method the process of the expansion is more traceable: in the picture the silhouette is sharp.

EXAMINED ELECTRODES AND STENTS

Five coronary stents and Corox OTW 75-UP steroid eluting electrodes were investigated. The inner diameter of the polymer tube was 5 mm and the maximum diameter of the electrodes was 1.95 mm. By this method the experiments were made only with the minimum 3 mm – diameter stents. They were examined with stereo microscope (Nikon SMZ2T), scanning electron microscope (Philips XL 30) and metallograph inspection microscope (Olympus PMG-3 with Olympus digital camera).

4.5/13 mm stent

During the process shown in Fig.1 the stent didn't slip out or split. This way the vein can be secured against perforation. In picture a) the stent is placed next to the electrode. In b) the stent is expanded with the balloon filled with turquoise liquid. In picture c) the balloon is removed and the electrode is fixed by the stent. In d) the electrode is extracted and the stent is deformed slightly.

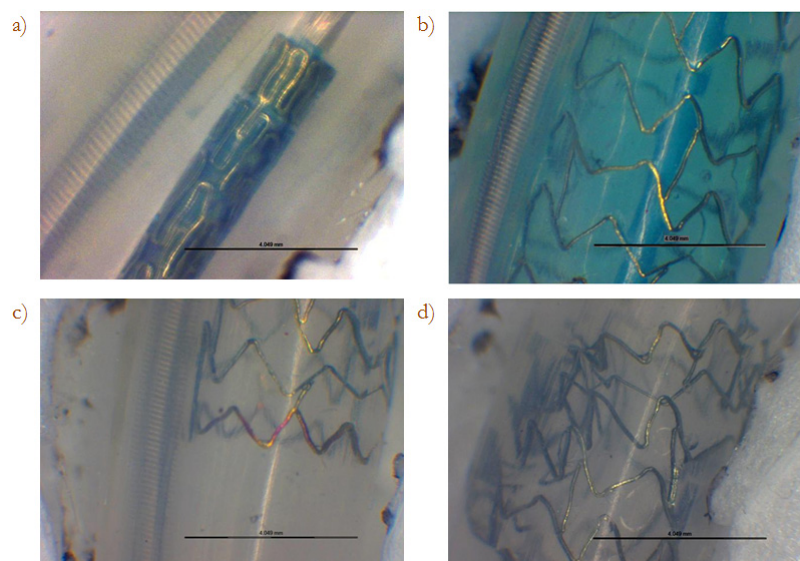


Figure 1: Stereomicroscopic pictures of the procedure: stent in crimped state and electrode in the tube (a), balloon expanded stent (b), fixed electrode (c), stent after the extraction of the electrode (d).



4.5/24 mm stent

The head of the electrode caught the stent which can cause injuries to vessels inner surface. Fig. 2 demonstrates the injuries of the stent after electrode extraction.

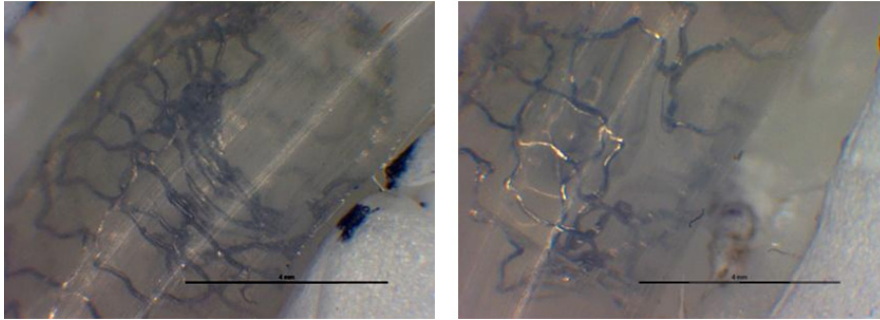


Figure 2: Liberté stent creased (left) and fractured (right) parts.

4.5/30 mm stent

In the picture (Fig.3) it is clearly remarkable how the flanges stick up on the strut of the stent. The struts were deformed sorely.

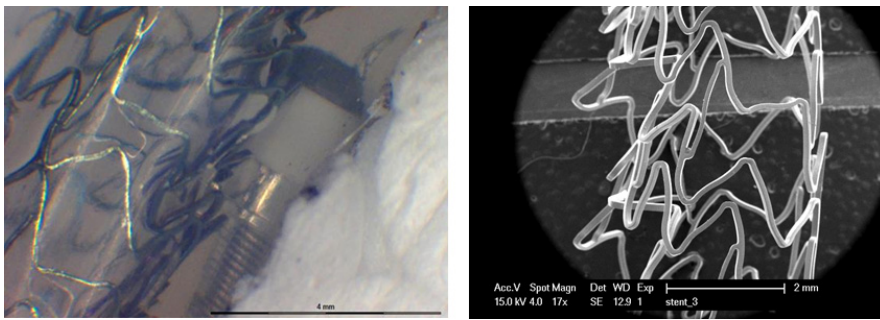


Figure 3: The head of the electrode during extraction (left) and deformed stent after the procedure (right).

3.5/10 mm stent

This is a drug-eluting stent with reservoir-base stent design. The stent completely lost its shape and turned across in the tube which would involve grave consequences making explantation in human vessel. The reservoirs and slim parts of struts can become strain concentrating places. This way the mechanical characteristics can be weakened. Fig. 4 shows electron microscopic photographs of damaged stent.

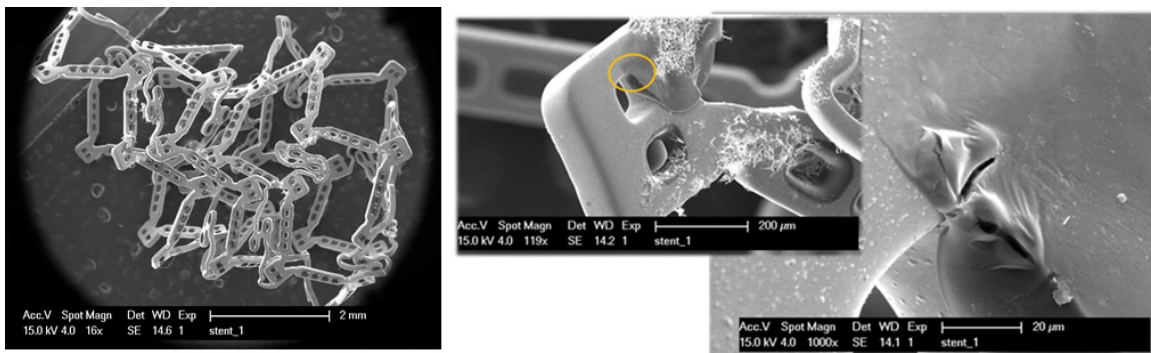


Figure 4: Deformed shape and injuries of reservoir stent



3.5/10 mm stent

Stent slipped out as the electrode was removed. In case of in vivo implantation endothelisation appears in time so a stent slipping out can cause internal injury.

INJURIES OF THE ELECTRODES

The insulation of the electrode was injured only once and it was not considerably. The scratch is not deep or long enough to prejudice the electric functioning. At the same time the steroid ring was broken several times. In the course of experiments the electrodes were in the tube for a few minutes; implanted in vessels they work years and the steroid comes loose. This arise a question if an aged ring could generate complication in pursuance of explantation. For the sake of bigger security another type of electrodes is expedient to use in case of stent implantation.

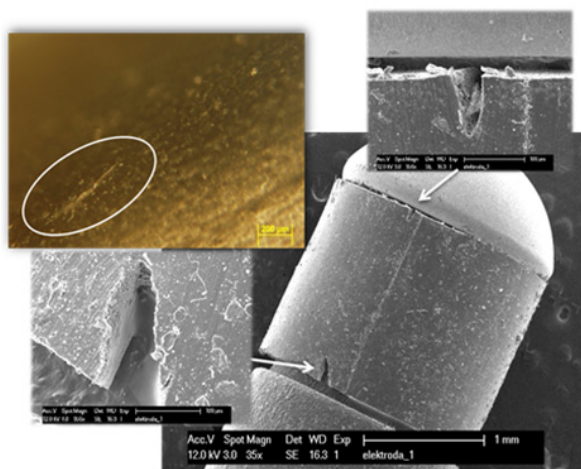


Figure 5: Injuries of electrode tip fixed with 2. stent.

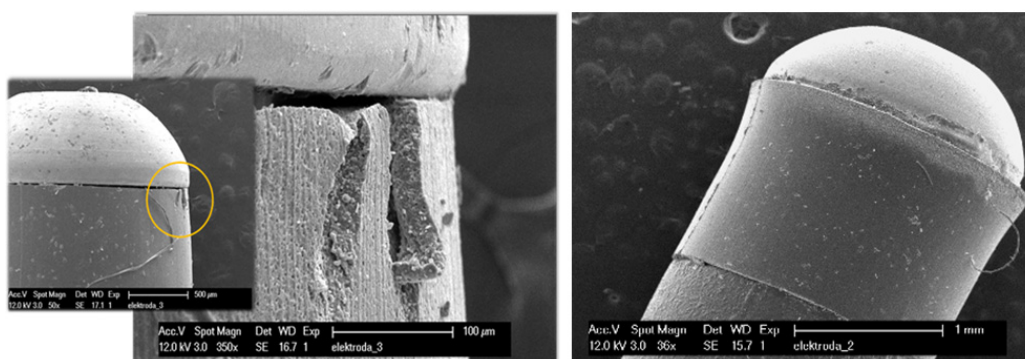


Figure 6: injured steroid rings on electrodes fixed by stent 3. (left) and stent 4. (right).

CONCLUSIONS

No injuries were discovered during the microscopic examinations on the coating of the electrodes. The steroid ring peeled off from the tip of the electrode. It can cause complication only in the situation of when the peeling is so substantial that the ring slips off and remains in the vessel during explantation. Concerning construction of stents those having reservoirs can cause more problems during explantation. Comparing the length of the stents the shorter types - 4. 3.5/10 mm and 5. 3.5/10 mm - are less suitable for fixation like the longer stents. Stent implantation to stabilize the left ventricular lead with suitable stents is a useful and safe procedure in the treatment of CS lead instability.



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