

The localisation of the electrode in permanently paced heart — an echocardiographical study

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Permanent cardiac pacing is a widely applied procedure in invasive cardiology. The aim of our study was the analysis of the localisation of the tip of the pacemaker lead and its course in the right ventricle. Research was carried out on a group of 12 patients (5F, 7M), from 40 to 93 years of age (average 70 ± 15 yrs) with permanent cardiac pacing or implantable cardioverter-defibrillator (ICD). Subsequent echocardiographic views were applied: an apical four chamber view, a subcostal one and a parasternal right ventricular inflow tract view.

At the level of the tricuspid annulus the electrode was positioned: the anterior leaflet – 41.7% (5 pts), the anteroseptal commissure 25% (3 pts), the posterior leaflet 8.3% (1 pt) and the septal one – 8.3% (1 pt). In 16.7% (2 patients) the lead was positioned centrally in the right atrioventricular orifice. Regarding the further positioning of the electrode in the ventricle, in 41.7% (5 pts) the leads were placed along the interventricular septum, in 16.7% (2 pts) along the anterior wall of right ventricle and in 41.7% (5 pts) across the centre of the right ventricle. The tip of the lead was positioned in the apex of the right ventricle in 83.4% (10 pts). In the remaining 16.7% (2 pts) the position was not apical — in 1 patient the anterior wall of the right ventricle and in 1 patient the interventricular septum. In the VVI pacing mode the electrode did not lie on the interventricular septum. In contrast to this in 80% of patients (4 pts) having the DDD pacing mode the lead was situated on the interventricular septum on its course downwards to the ventricle. Conclusions: 1) On the level of the leaflets of the tricuspid valve the lead most often was positioned at the level of the anterior leaflet and the anteroseptal commissure. 2) Most patients had an apical localisation of the tip of the lead. 3) Differences between morphological and echocardiographic studies are related to the intravital and the two-dimensional character of echocardiography, and probably to the small population of the group examined.

key words: echocardiography, cardiac pacing, postpacing cardiopathy

INTRODUCTION

Permanent cardiac pacing is a widely applied procedure in invasive cardiology. Indications of pacing include not only conduction disturbances with synco-

pe but also atrial tachyarrhythmias or haemodynamic disturbances in the course of hypertrophic or dilative cardiomyopathies [17]. Many new techniques of implantation are used as a consequence of such

different indications of pacing. The most widespread place of implantation is the right cardiac auricle for the atrial pacing and the apex of the right ventricle for the ventricular one [3]. Electrophysiologists are searching for more optimal places of stimulation. Possible suggestions include the right ventricular outflow tract [2,16], the coronary sinus (pacing of the left atrium) [5], or coronary veins (pacing of the left ventricle) [1]. The main criterion of proper localisation of the lead is a chest X-ray although the parameters of pacing play an important role too [3]. As results from morphological studies [8,9] the proper place of pacing is covered by intentional localisation of the lead in 50% of cases. Therefore the aim of our study was the analysis of the localisation of the tip of the pacemaker lead and its course in the right ventricle in relation to the tricuspid valve leaflets and the right ventricular walls in echocardiographical studies.

MATERIAL AND METHODS

Research was carried out on a group of 12 patients (5F, 7M), from 40 to 93 years of age (average $70 \pm \pm 15$ yrs) with permanent cardiac pacing or implantable cardioverter-defibrillator (ICD). Six (50%) patients had single-chamber ventricular pacemaker - the lead was positioned in the right ventricle (pacing modes: VVI — 5 pts, VDD — 1pt), four (33.33%) dual chamber pacemaker — two electrodes were positioned in the right atrium and the right ventricle respectively (pacing mode DDD) and two (16.67%) patients ICD — a single electrode was positioned in the right ventricle. The average time from implantation was 30 ± 41 months (1–123 months). The main indication for pacing was II or III degree of atrioventricular block — 4 patients, additionally sick sinus syndrome (3 pts), chronic atrial fibrillation — (2 pts) and cardiodepressive type of vasovagal syncope (1 pt). Two patients with symptomatic, recurrent ventricular tachycardia were implanted with transvenous cardioverter-defibrillator. In order to obtain the position of the electrode in the right ventricle we used two-dimensional (2-D) echocardiography (Sonos 2000, Hewlett Packard) in the following echocardiographic views: an apical four chamber view, a subcostal one and a parasternal right ventricular inflow tract view. We looked at the course of the electrode at the level of the tricuspid ring, the inferior part of the ventricle and the possible reaction of the cardiovascular system to the electrode. We judged the direct location of the lead as result-

ing from the above views relating to echocardiographic anatomy rules [18]. The results of echocardiography were recorded using printer in Sonos 2000 equipment.

RESULTS

In 41.7% of examined patients (5 pts) the pacing leads were positioned at the level of the anterior leaflet of the tricuspid valve (Fig. 1), in 25% (3 pts) just over the anteroseptal commissure, in 8.3% (1 pt) at the level of the posterior leaflet of the tricuspid valve (Fig. 2) and finally in 8.3% (1 pt.) at the septal level. In 16.7% of the cases (2 pts) the lead was positioned centrally in the right atrioventricular orifice without adherence to any leaflets (Fig. 3).

Regarding the further positioning of the electrode in the ventricle, we confirmed that in 41.7% of the patients (5 pts) the leads were placed along the interventricular septum; at the horizontal plane of the interventricular septum the lead was near the posterior part of the septum e.g. the angle between the septal and the posterior walls in 4 patients. In the remaining patients the electrode was lying along the anterior wall of the right ventricle in 16.7% (2 pts) and in 41.7% (5 pts) it ran just across the centre of the right ventricle. In the latter group of patients the course of the lead was not homogenous. In all patients from this group the lead was located centrally in the cavity of the right ventricle in the proximal part of the right ventricle (from leaflets of the tricuspid valve to half of the length of the right ventricle). In the distal part of one in 40% of cases (2 pts) it turned to the interventricular septum, in 20% (1 pt) — to the anterior wall of the right ventricle, and in 40% (2 pts) it was further positioned centrally in the right ventricle to its apex.

The tip of the lead was positioned exactly in the apex of the right ventricle in 83.4% of examined patients (10 pts) (Fig. 4). In the remaining 16.7% (2 pts) the position was not apical. In 1 patient we found it on the anterior wall of the right ventricle (Fig. 5) and in 1 patient on the interventricular septum. There is no correlation between the position of the lead and the pacing mode (VVI v. DDD/VDD). However we stated that in the VVI pacing mode the electrode did not lie on the interventricular septum. In one patient only the distal portion of the lead was situated on the interventricular septum. In contrast to this in 80% of patients (4 pts) having the DDD pacing mode the lead was situated on the interventricular septum on its course downwards to the ventricle.

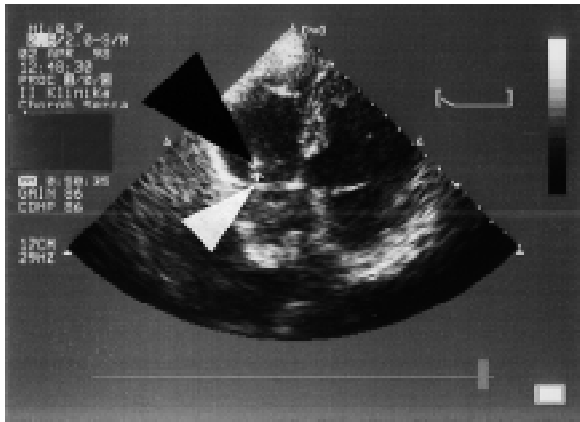


Figure 1. The apical four chamber view. The electrode positions at the level of the anterior leaflet of the tricuspid valve. Black arrow — the lead, white arrow — the anterior leaflet.

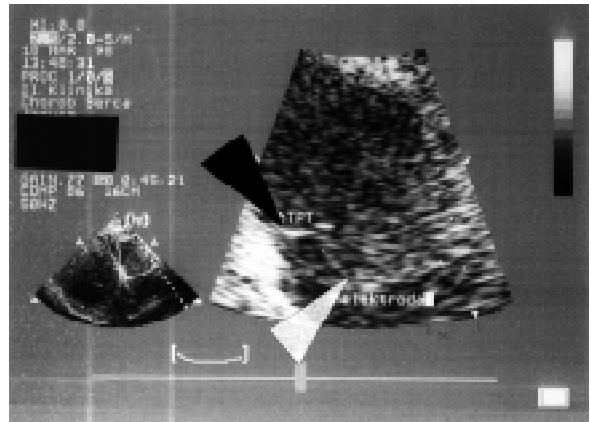


Figure 2. The parasternal right ventricular inflow tract view. The electrode positions at the level of the posterior leaflet of the tricuspid valve. White arrow — the lead, black arrow — the posterior leaflet.

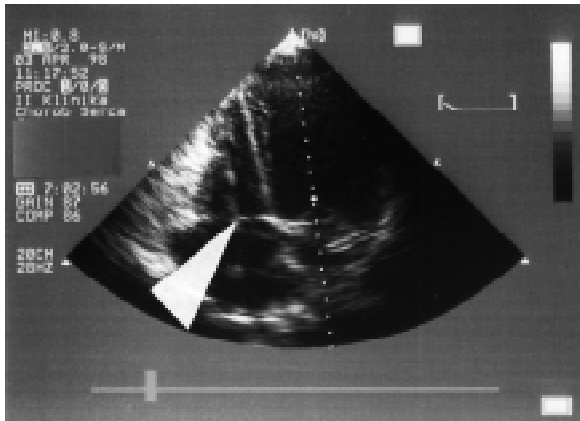


Figure 3. The apical four chamber view. The electrodes is placed between the anterior and septal leaflets of the tricuspid valve. Arrow — the electrode.

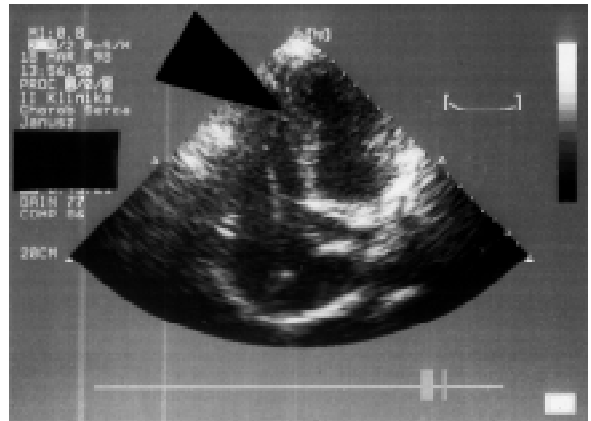


Figure 4. The apical four chamber view. The tip of the lead is positioned exactly in the apex of the right ventricle. Arrow — the tip of the electrode.

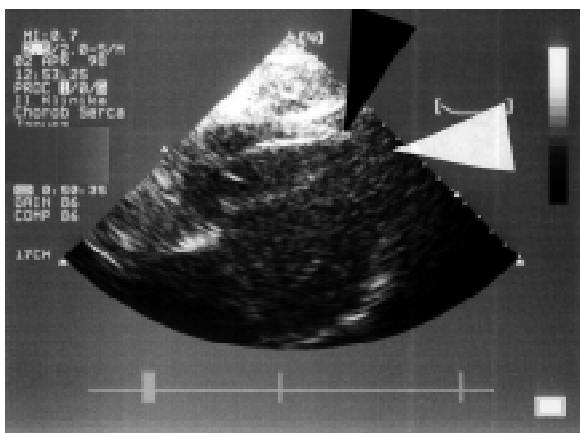


Figure 5. The subcostal view. The tip is located above the apex of the right ventricle, on the anterior wall of the right ventricle. White arrow — the apex of the right ventricle, black arrow — the tip of the lead.

DISCUSSION

Implantation of pacemakers is a commonly used therapeutic procedure in clinical cardiology. Implantation of the electrode takes place under the control of an X-ray and the electrophysiologic parameters of pacing [3]. In our study we decided to use two-dimensional echocardiography in order to view the course of the electrode in relation to the structures of the right ventricle. Echocardiography is a technique often used to assess the position of catheter in invasive cardiology for example in electrophysiologic studies [12] or in endomyocardial biopsies [14]. In the assessment of the position of the pacemaker lead the X-ray plays the most important role undoubtedly. However, there are clinical situations where echocardiography is a more effective procedure than

X-ray examination e.g. in aberrantly placed transvenous leads [15] or in pacing in the emergency ward [7]. In special situations such as pregnancy it is the only possible control of the localisation of the lead [12]. Meier et al. stated that by using an echocardiographic examination it was possible to show the electrode in 85% as opposed to 100% in fluoroscopy [13]. In the light of our study the assessment of the three echocardiographic views allowed us to monitor the course of the lead in the right ventricle in all patients. In literature the subcostal echocardiographic view is highly recommended in the assessment of the localisation of the electrode [6]. Additionally we used the apical four-chamber view and parasternal right ventricular inflow tract view.

In morphological studies which assessed the localisation of the electrode [8,9,11] the findings referring to the level of the leaflets of the tricuspid valve differed from our. Most often, in our study, the electrode was positioned at the level of the anterior leaflet of the tricuspid valve and along the antero-septal commissure. Such a position of the lead in morphological studies appeared in 3.5% of hearts studied [11]. The location of the leads at the level of the posterior and the septal leaflets occurred only in 16.7% of cases in comparison with approximately 65% of hearts in morphology. We did not find the localisation of the lead at the level of the posteroseptal commissure. A very important finding is the central position of the electrode in the right atrioventricular orifice in 16.7% of patients without adherence to any leaflets. Those locations did not occur in the morphological studies which is certainly related to the intravital character of the echocardiographical examination.

Further course of the lead, below the level of the tricuspid ring was variable. In 41.7% of patients the electrode runs along the interventricular septum, with location of the lead at the posterior part of the interventricular septum in 4 patients (80%) at the horizontal plane. In the remaining 41.7% the electrode was positioned in the centre of the right ventricle and in 16.7% along the anterior wall of the right ventricle. This is partly concordant with morphological research [8,9] where in the horizontal plane the electrode was positioned in the region of the posterior wall in approximately 60% of hearts. In those cases where the lead runs in the right ventricle centrally its distal course was not homogenous — only in 40% of cases the full course of the lead run in the centre of the right ventricle. In further 40% of cases the electrode ran along the interventricular septum and in 20% on the anterior wall. These findings are proba-

bly related to electrode's curves in right ventricle observed in morphology. Those bends are related to the neointima-inflammatory tissue ranged between the lead and endocardium. We did not observe those reaction in echocardiographic views.

There are differences between morphology and echocardiography in relation to localisation of the tip of the electrode. In our present study it was positioned exactly in the apex of the right ventricle in 83.4% of cases in comparison with 53% in morphological papers. It seems that anatomical findings are more precise in connection with two-dimensional character of echocardiography and small examined population. The changes of localisation of the lead related to autopsy examination should be ignored due to fibrous reactions between the lead and the endocardium [4,8,9]. In literature there are descriptions of morphological changes in paced hearts defined as *postpacing cardiopathy* [10]. The main component of these is the dysfunction and the remodelling of the interventricular septum. In our patients we did not see changes in the structure of the interventricular septum although more precise conclusions should be obtained using a larger group of patients and in comparison with control group. In this aspect it was emphasised that the electrode of the pacemaker (without ICD) was connected directly (during the entire course) or indirectly (only in the distal portion) with the interventricular septum in 50% of patients; in 80% of those patients they were related with the DDD/VDD pacing mode, in 20% — VVI. In literature we did not find articles about postpacing morphological changes in correlation to the pacing mode. It seems that the localisation of the electrode in the interventricular septum may increase the possibility of the development of *postpacing cardiopathy*. The higher occurrence of this location of the lead in the DDD/VDD mode versus the VVI may reveal different mechanisms in the *postpacing cardiopathy* and the pacemaker syndrome which is related first of all to VVI pacing mode.

We concluded that:

1. On the level of the leaflets of the tricuspid valve the lead most often was positioned at the level of the anterior leaflet and the antero-septal commissure.
2. Most patients had an apical localisation of the tip of lead.
3. Differences between morphological and echocardiographic studies paper are related to the intravital and the two-dimensional character of echocardiography, and probably to the small population of the group examined.

REFERENCES

- Alonso C, Leclercq C, Victor F, Mansour H, de Place C, Pavin D, Carre F, Mabo P, Daubert JC (1999) Electrocardiographic predictive factors of long-term clinical improvement with multisite biventricular pacing in advanced heart failure. *Am J Cardiol*, 84: 1417–1421.
- Barin ES, Jones SM, Ward DE, Camm AJ, Nathan AW (1991) The right ventricular outflow tract as an alternative permanent pacing site: long-term follow-up. *Pacing Clin Electrophysiol*, 14: 3–6.
- Brinker J., Midei M (1996) Techniques of pacemaker implantation. In: Ellenbogen KA (ed.) *Cardiac pacing*. Blackwell Science, pp. 216–277.
- Candinas R, Duru F, Schneider J, Luscher TM, Stockes K (1999) Postmortem analysis of encapsulation around long-term ventricular endocardial pacing leads. *Mayo Clin Proc*, 74: 120–125.
- Cazeau S, Ritter P, Bakdach S, Lazarus A, Limousin M, Henao L, Mundler O, Daubert JC, Mugica J (1994) Four chamber pacing in dilated cardiomyopathy. *Pacing Clin Electrophysiol*, 17: 1974–1979.
- Drinkovic N (1983) Subcostal 2D echocardiography in cardiac pacing and intracardiac electrophysiologic studies. *Ultrasound Med Biol*, Suppl 2: 293–297.
- Kaemmerer H, Kochs M, Hombach V (1993) Ultrasound-guided positioning of temporary pacing catheters and pulmonary artery catheters after echogenic marking. *Clin Intensive Care*, 4: 4–7.
- Kozłowski D, Dubaniewicz A, Koźluk E, Adamowicz M, Grzybiak M, Walczak E, Walczak F, Kosiński A, Woźniak P (1998) Morfologiczne aspekty jednojamowej prawokomorowej stałej stymulacji serca. Część I: Położenie elektrody w prawej komorze serca. *ESS*, 5: 38–44.
- Kozłowski D, Dubaniewicz A, Koźluk E, Adamowicz A, Grzybiak M, Walczak E (1997) Possible mechanism of the tricuspid insufficiency in the permanent right ventricular pacing. Morphological study. Proceedings of the 8th European Symposium on Cardiac Pacing. Athens, Greece, Monduzzi Editore, 99–101.
- Kozłowski D (1999) Morfologia łącza przedsionkowo-komorowego w aspekcie powstawania zaburzeń przewodzenia i krążącego pobudzenia. Rozprawa habilitacyjna. Gdańsk.
- Kozłowski D, Dubaniewicz A, Koźluk E, Grzybiak M, Krupa W, Kołodziej P, Pazdyga A, Adamowicz-Kornacka M, Walczak E, Walczak F (2000) The morphological conditions of the permanent pacemaker lead extraction. *Folia Morphol*, 59: 25–29.
- Lee MS, Evans SJ, Blumberg S, Bodenheimer MM, Roth SL (1994) Echocardiographically guided electrophysiologic testing in pregnancy. *J Am Soc Echocardiogr* 7: 182–186.
- Meier B, Felner JM (1982) Two-dimensional echocardiographic evaluation of intracardiac transvenous pacemaker leads. *J Clin Ultrasound* 1982, 10: 421–425.
- Pierard L, El Allaf D, D'Orio V, Demoulin JC, Carlier J (1984) Two-dimensional echocardiographic guiding of endomyocardial biopsy. *Chest*, 85: 759–762.
- Schwartz C, Nicolosi R, Lapinsky R, Grodman R (1986) Use of two-dimensional echocardiography in detection of an aberrantly placed transvenous pacing catheter. *Am J Med*, 80: 133–138.
- Staniewicz J, Wilczek R, Świątecka G, Stanke A, Krzyńska-Stasiuk E, Baczyńska A, Krupa W (1998) Short versus long term results in right ventricular outflow tract pacing – prospective randomised study. *Pacing Clin Electrophysiol*, 21 (p. II): 419 (abstract).
- Świątecka G (ed.) (1999) Standardy postępowania w elektroterapii serca. *Folia Cardiol*. 1 (Supl. 1): 1–13.
- Tajik AJ, Seward JB, Hagler DJ, Mair DD, Lie JT (1978) Two-dimensional real-time ultrasonic imaging of the heart and great vessels. Technique, image orientation, structure, identification and validation. *Mayo Clin. Proc.* 53: 271–303.