# Technical Aspects of Coronary Sinus Catheterization Based on the Atrial Component of the Intracavitary Electrogram and Radiological Anatomy During the Implantation Procedure of a Biventricular Pacemaker

Fernando Sérgio Oliva de Souza, Nicola Luciano Mortati, Domingo Marcolino Braile, Reinaldo Wilson Vieira, Salomon Ordinola Rojas, Alessandre Caputo Rabelo, Januário Manuel de Souza, Sérgio Almeida de Oliveira

*Real e Benemérita Sociedade Portuguesa de Beneficência e Universidade de Campinas - UNICAMP - São Paulo, SP - Brazil*

## Objective

To present a technical proposal based on the experience of 130 implantations using a simplified technique for coronary sinus catheterization, based on the atrial component of the intracavitary electrogram and radiological anatomy.

## Methods

From October, 2001 to October, 2004, 130 biventricular pacemaker implantations were performed, using radiological anatomy and observation of the intracavitary electrogram, focusing on the atrial component.

## Results

The implantation of the system using left ventricular pacing via coronary sinus was not possible in 8 patients. Difficulties on the cannulation of the coronary ostium were felt in 12 patients and difficulties of lead advancement through the coronary sinus were felt in 15 patients. The mean time of radioscopy utilization was 18.69 min.

## Conclusion

The implantation technique, using the atrial component morphology of the intracavitary electrogram and radiological anatomy showed to be workless, safe and effective for the cannulation of the coronary sinus ostium requesting reduced time of radioscopy.

## Key words

Congestive heart failure, dilated cardiomyopathy, pacemaker.

**Mailing Address: Fernando Sérgio Oliva de Souza** • Rua Caiowaa, 710/153 - 05018-001- São Paulo, SP - Brazil
E-mail: fssouza@cardiol.br
*Received on 02/11/05 • Accepted on 04/29/05*

Nowadays, heart failure (HF) is a very frequent clinical situation with an elevated rate of morbidity and mortality given the high prevalence and incidence of cardiovascular diseases in the occidental world[1].

Although the therapeutical stock developed for the disease management in the last years, there are many refractory to the treatment patients. In a context of relative disappointment regarding to the clinical and surgical therapeutic modalities, the cardiac pacemaker has recently arisen as a new surgical alternative for the primary treatment of patients with refractory to drugs HF[2].

Recent studies have shown that the therapy of cardiac resynchronization through biventricular pacing is an important coadjutor treatment to the optimized medicamental therapy in patients with refractory HFs caused by chronic left ventricular dysfunction and disorder of the intraventricular conduction improving the cardiac function and quality of life[3-5].

The technique for left ventricular pacing can be performed either by epimyocardial mode through thoracotomy or transvenously through the epicardium. Since the last technique is the choice one, the biggest limitation of this treatment is the catheterization and lead insertion in the coronary sinus (CS) and its tributaries for left ventricular pacing[6].

Implantation of the specific lead for left ventricular pacing is a relatively complex procedure, which involves the variants of coronary veins anatomy, quality of the material used and physician's experience[7]. The impossibility of CS catheterization, variants of the venous coronary system anatomy and diaphragmatic pacing are the most frequent causes for an unsuccessful lead positioning. The unsuccessful rate might decrease with the enhancement on the variants of lead models and physician's experience[8-11].

Based on the good outcomes presented by this coadjutor treatment, cardiac resynchronization therapy has become a routine treatment in previously selected patients. Over the time, due to the complexity of the procedure, the medical-scientific engineering community has been investing on material adaptation in order to facilitate the implantation technique[9,12,13].

Despite the evolution of procedure material and technique, the unsuccessful rate mainly among the less experienced professionals is still relevant. The purpose of this work is to present a technical proposal based on the experience of 130 implantations using a simplified technique for coronary sinus catheterization through the radiological anatomy and intracavitary electrogram, with focus on the atrial component, showing the success rate, complications and total time of radioscopy utilization.

## Methods

Study characterization - It is a retrospective study conducted at the Cardiovascular Clinical and Surgery Service of Prof. Dr. Sérgio Almeida de Oliveira (MD) at the Hospital Real e Benemérita Sociedade Portuguesa de Beneficência de São Paulo with the data collected on patients submitted to a biventricular pacemaker implantation in the period between October, 2001 and October, 2004.

Population: 130 patients with ages between 31 and 84 years, mean 59.0 ± 12.6 years, being 58 (44.6%) female and 72 (55.4%) male, with dilated cardiomyopathy (DCM).

Inclusion criteria: patients with dilated cardiomyopathy (DCM) and 1) congestive heart failure functional NYHA Class III or IV refractory to the optimized medicamental therapy; 2) DCM with no possibility of surgical correction; 3) patients without primary indication of cardiac frequency restoring and/or atrioventricular synchronism restoring; 4) disorder of the interventricular conduction expressed as the standard of left branch blockage, right branch blockage or left branch blockage induced by exclusive right ventricular cardiac pacing, either associated or not to the anterosuperior divisional blockage; 5) duration of the QRS complex equal or bigger than 130 ms and 6) presence of sinusal rhythm.

Exclusion criteria: 1) infarction or unstable angina within the last three months; 2) acute myocarditis; 3) pregnancy and 4) abuse of drugs and alcohol.

All procedures were performed under local anesthesia and eventually under sedation depending on the grade of the HF and the tolerance to the long time on decubitus. Prophylactic antibiotic was intravenously administered to the patients one hour before the procedure. Patients were put on horizontal dorsal decubitus and the electrocardiographic monitoring was performed with all leads positioned on the right hemithorax in the case of surgery conducted on the left side (of choice), or positioned on the left hemithorax in the case of surgery conducted on the right side (cases with impossibility of implantation on the preference side or when the patient had already a permanent pacemaker implanted on the right), in such a way all leads were far away from the heart profile (two leads at the right deltoid region [anterior and posterior] and one lead at the left anterior axillary line in the seventh intercostal space. The derivation used was the D2 bipolar derivation with the active lead always positioned at the deltoid region.

The first lead to be positioned was the right ventricle (RV) one followed by the right atrium lead both, when possible, through the left cephalic vein. When passing one or none of both leads was not possible a new venous puncture to obtain the passage pathway was performed. These leads (active fixation) were positioned at traditional places (atrial lead in the right atrium and right ventricular lead in the right ventricle end) or where acceptable pacing, sensing and impedance thresholds were obtained. In the cases with concomitant indication for the implantation of an implantable cardioverter defibrillator (ICD) a lead with dual coil of passive fixation was used positioned at the right ventricle end. In patients with a previously implanted dual chamber pacemaker just one puncture for the passing of a left ventricular pacing lead was performed. The last lead to be positioned was the coronary sinus lead for left ventricular pacing. It was passed through a new puncture of the subclavian vein, and the coronary sinus catheterization was obtained using the radiological anatomy with fluoroscopy in left anterior oblique incidence at a 35 degrees angle and the unipolar intracavitary electrogram was obtained by connecting the coronary sinus lead to the explorer lead of the electrocardiographic monitoring.

The lead was fitted in such a way to respect the right atrium anatomy. Its fitting was performed by shaping its guides.

After its shaping, the lead was positioned at the low atrial septum region. In this position the lead was slightly mobilized in superior and inferior directions (using the radiological anatomy), and anterior and posterior directions through counterclockwise and clockwise rotations, respectively (using the intracavitary electrogram). The regions next to the atrioventricular ring exhibited well-defined electrograms with the presence of the atrial and ventricular component.

After the catheterization of the coronary sinus ostium with the lead, it was positioned at the tributary vein of the coronary sinus using the shape of the guide used for the ostium catheterization or, in some cases, a new "S"-shaped guide was introduced in the lead making easy its positioning. This choice was made giving preference to the veins of the left ventricle lateral and posterior walls followed by catheter stability, absence of diaphragmatic pacing with maximum power pacing (10 Volts), biventricular and left ventricular pacing, sensing and impedance thresholds, in cases of generators without independent outlet.

## Results

Left ventricular pacing was obtained in all patients. The cannulation of the coronary sinus using the radiological anatomy and the intracavitary electrogram was successfully performed in 129 patients. In 7 patients in whom the cannulation of the coronary sinus was obtained we did not get any success with lead positioning. Due to the impossibility of getting acceptable thresholds in four cases, in two due to the angulation of the coronary sinus entry, which made impossible the stabilization of the lead within the venous sinus, and in one case due to the diaphragmatic pacing at the only place in which performing left ventricular pacing was possible. In 8 patients left ventricular pacing was attained through the implantation of an epimyocardial lead by thoracotomy (Figure 1).

The atrial component in the coronary sinus ostium was isodiphasic (Figure 2A). In so far as the lead went to a posterior position being far away from the coronary sinus (CS) ostium, the atrial component progressively became more negative (Figure 2B) and, unlike, in so far as the lead went to an anterior position being far away from the ostium, the atrial component progressively became positive (Figure 2C). In this situation, it was not

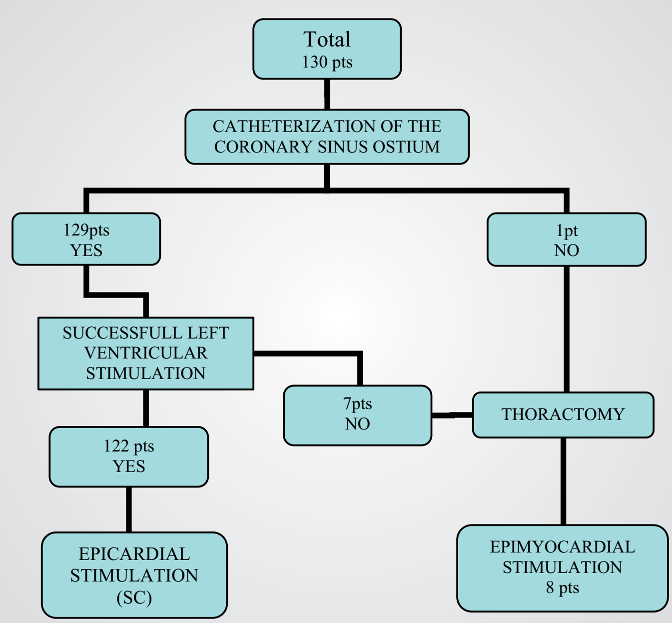


*Fig. 1 - Organogram showing the total number of patients submitted to a biventricular pacemaker implantation, number of patients that was possible to canulate the coronary sinus or not, number of patients with successfull left ventricular epicardial stimulation by coronary venous system tributaries and number of patients submitted to a thoracotomy for left ventricular epimyocardial stimutation. (CS - coronary sinus ostium, pts - patients)*

impossible that the lead crossed the tricuspid valve and migrated to the ventricle producing ventricular potentials of high amplitude eventually inducing non-sustained ventricular tachycardia.

At the cannulation of the ostium, the atrial component was isodiphasic in 126 (96.9%) patients and predominantly positive in 3 (2.3%) patients. Lead positioning in the tributaries of the coronary sinus was successfully attained in 122 (91.5%) patients with radioscopy mean time of 18.69 (±15,2) min. Upon the training of the physician, the success rate increased progressively. In the first year it was 55.5% with radioscopy mean time of 43.6 (±18,6) min, in the second year 92.6% with 18.21 (±13) min and in the third year 97.9% with 13.18 (±4,9) min.

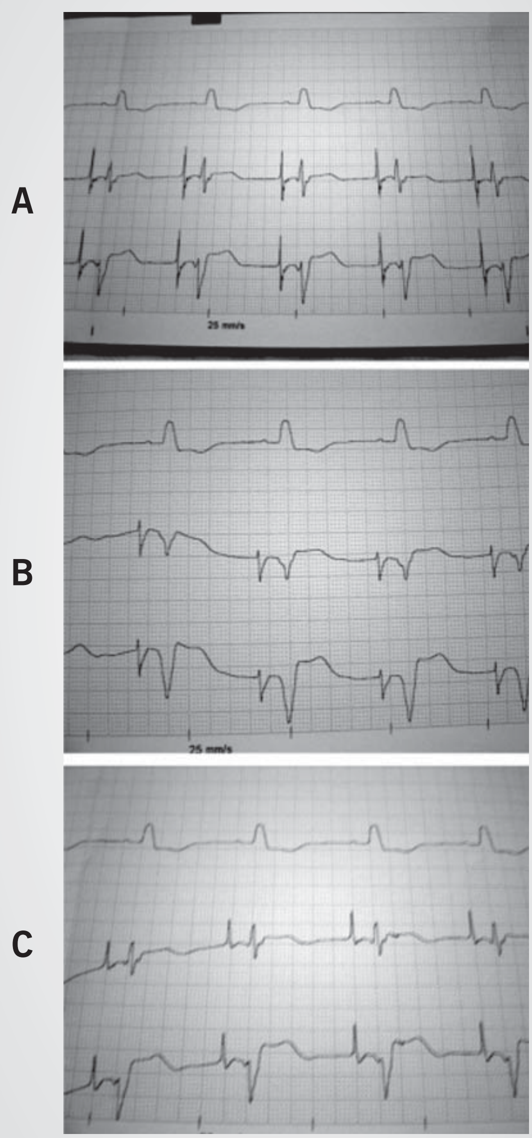


*Fig. 2 – Diary with three strips. The superior strip shows the surface electrocardiogram at 25 mm/s. The inferior strips show the unipolar intracavitary electrograms obtained during the procedure with the lead positioned at the right posteroseptal region. A) Intracavitary electrogram obtained at the coronary sinus ostium. B) Electrogram obtained next to but in most posterior to the coronary sinus ostium regions. C) Electrogram obtained next to but in most anterior to the coronary sinus ostium regions*

Although appropriate intracavitary potentials and anatomicoradiological positioning, difficulties to cannulate the coronary sinus were found in 12 patients. Maneuvers with the lead and the guide were performed in five cases allowing the lead to pass through the ostium and showing that the coronary sinus went to a posterior position. A more stiffness guide with a more pronounced curvature was used in seven cases making easier the passage of the lead. Difficulties on lead advancement were felt in 15 patients approximately at the likely region of drainage of the great cardiac vein in the coronary sinus. This problem was solved in 9 patients through successive manipulations of the lead and its guide. In six cases the pre-shaped guide was changed by a straight and more stiffness one. In twelve cases the lead had to be repositioned after guide removal and accidental dislodgment of the lead. Ten patients experienced diaphragmatic pacing and the lead was successfully repositioned in 9 patients. Three patients experienced transient total atrioventricular blockage after lead manipulation in the right ventricular cavity being necessary to perform temporary ventricular pacing. Dislodgment of the atrial lead occurred in two cases during lead manipulation in the coronary sinus requesting it's repositioning.

In two cases the implantation at the left side was discontinued and successfully performed at the right side. In one case due to the impossibility of advancing the leads to the right cavities due to the angulation at the drainage of the innominate vein with the superior vena cava and in the other case due to the presence of persistent left vena cava and narrow coronary sinus making the passage of the three leads impossible by the same access pathway.

## Discussion

The therapy of cardiac resynchronization has shown good outcomes in the treatment of previously selected patients with HF[3,4,5]. The historical routine of lead implantation for left ventricular pacing has been epimyocardial fixation of the lead under direct view by thoracotomy, lateral or subxiphoideus, or by thoracoscopy. These methods have already proved their efficacy and were routine methods before the discovery of the transvenous leads for epicardial pacing through the endocardial pathway[14]. The greatest obstacle to the routine lead implantation for epimyocardial left ventricular pacing in patients with dilated cardiomyopathy and ICD are the risks associated with the general anesthesia and the postoperative morbidity[14]. At present, the transvenous method for endocardial access is the choice method because reduces the surgical complexity as well as its morbidity and the period of hospital stay[9].

One of the main limitations of the transvenous technique application is the coronary sinus catheterization and the special lead positioning in one of its tributaries for left ventricular pacing[7,14]. The implantation success depends on many variants including the experience and technique of the physician, coronary sinus anatomy, availability and variety of special material[8].

Although the great progress on technology and the evolution of the implantation techniques such as sheath systems, special guide systems, side-the-wire[13] and over-the-wire[10, 14], or proposals of coronary sinus cannulation directed by electrophysiological catheter[9] have been shown effective, these proposed techniques either by means of sheaths associated to contrast, special guides or unspecific intracavitary electric signal still use only the radiological anatomy and a series of attempts and errors for the cannulation of the coronary sinus. Taking into account this still remaining limitation, the authors of this work present the experience at just one center of a technique intended to facilitate the cannulation of the coronary sinus based on the radiological anatomy and the intracavitary electrogram focusing on atrial electrogram morphology.

The procedure was preferably performed at the left by two reasons. First, by the easiness of lead tunneling for pacemaker pocket in the cases in which pacing should be performed via epimyocardial by thoracotomy. The second reason is that eventually patients experience left vena cava with atresia of the coronary sinus ostium[15, 16], making the implantation at the right impossible. We choose implanting the usual leads first, for right ventricular and atrial pacing, respectively, because they act as anatomical definition points and because during lead manipulation in these patients with left branch blockage there is a risk of right branch trauma, which leads to total atrioventricular blockage requesting temporary cardiac pacing. This occurred in two patients, as described in literature[8].

With the utilization of radioscopy in left anterior oblique (LAO) incidence at 35º the bidimensional anatomical relation of the tricuspid and mitral ring was obtained and the lateral and septal wall of the right atrium could be clearly showed. With the aid of the intracavitary electrogram we could identify the regions next to the atrioventricular ring showing atrial and ventricular intracavitary electrograms with a ratio of 1:2 or smaller[17]. Once knowing that the coronary sinus ostium is located at the right posteroseptal region next to the atrioventricular right or on it, the lead was positioned in this region using a previously shaped guide of the own lead considering the presence of atrial and ventricular electrogram. Using the radiological anatomy we could easily perform manipulations to the superior and inferior regions. However, the radioscopy provided bidimensional images and, thus, mobilizations to anterior and posterior regions could not be monitored by it. In this way, these lead mobilizations were followed based on the atrial component of the intracavitary electrogram. It was noticed that in the coronary sinus ostium, point from which the catheterization of the coronary sinus was possible, the intracavitary electrogram was isodiphasic in 126 out of 129 patients in which this catheterization was possible. It was also noticed that small lead mobilizations to posterior region let the atrial component predominantly negative and mobilizations to anterior region let it predominantly positive; these positions were checked with the radioscopy in right anterior oblique (RAO) incidence. It is known that the right atrial intracavitary electrogram shows different morphologies and components, which depend on the lead positioning in its different anatomical regions. High right atrium regions show predominantly negative potentials, medium right atrium regions show isodiphasic potentials and low right atrium regions show predominantly positive potentials[18] (Figures 3A, B and C).

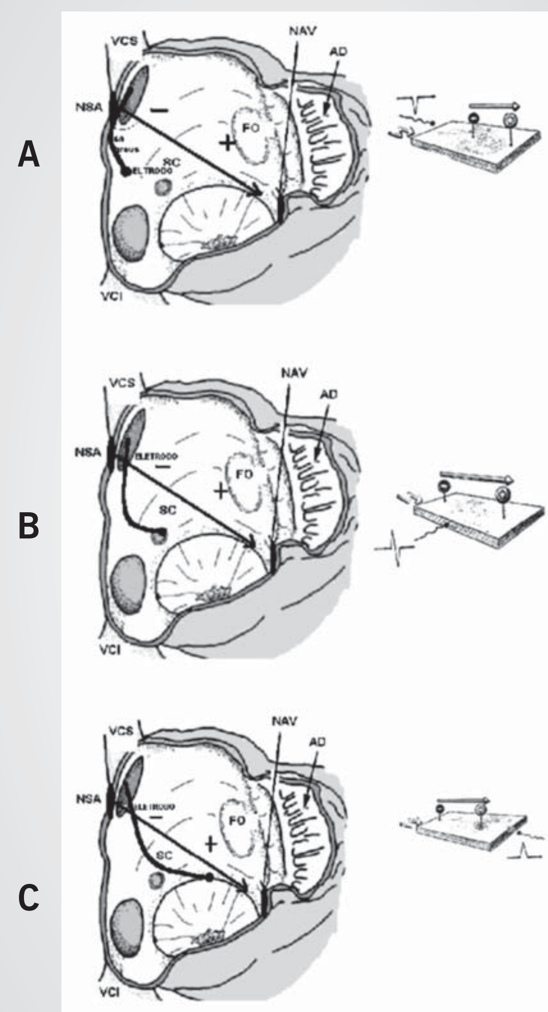


*Fig. 3 – Schematic illustration of the right atrial cavity showing lead positioning at the high, medium and low right atrium regions, and the vector resultant of the right atrial depolarization. At left, the schematic illustration of the intracavitary electrogram obtained in the three situations. A) Lead positioned at the most posterior to the coronary sinus ostium region (high right atrium). B) Lead positioned at the sinus ostium region (medium right atrium). C) Lead positioned at the most anterior to the coronary sinus ostium region (low right atrium). (SC- coronary sinus ostium, FO- fossa ovalis, VCI- inferior vena cava, VCS- superior vena cava, NAV- atrioventricular node, NSA- sinoatrial node, AD- right atrium*

We found a possible explanation for these findings. It is known that the vector resultant of the right atrial depolarization begins at the sinusal node region and is directed downwards, onwards and a little leftwards[19]. Considering that the coronary sinus ostium is located at the posterior region of the right atrium, anterolateral to the inferior vena cava valve and previously related to the septal cuspid of the tricuspid valve[20], due to its anatomical position it should be perpendicular to the atrial depolarization vector. Taking into account that the atrial electrogram obtained with the lead is unipolar, the positioning of this lead on the coronary sinus ostium would put it at a vertical position of approximately 90º creating isodiphasic potentials[19]. In this situation, moving the lead in posterior direction it would tend to observe vector's tail and would let the signal more negative; unlike, moving the lead in anterior direction would let the signal more positive since the lead would observe vector's tip[19], as shown in Figure 3. In 1990, Galvão Filho[18], also demonstrated that the atrial electrogram varies according to its localization in the right atrium. However, he used a way of anatomical description of the right atrium different from the one other authors use, based on a bidimensional image. What Galvão Filho designed as high right atrium and low right atrium corresponded to the superior and "inferior" regions (next to the tricuspid ring) of the right atrium. In the radiological anatomy used by the present authors (left anterior oblique incidence), posterior to the coronary sinus ostium regions corresponded to the superior region of the right atrium and anterior to the coronary sinus ostium regions corresponded to the "inferior" region.

Our success rate of 91.5% is similar to the one of the literature[8,9,10], with a learning curve clearly showed by the percentage of success of 55.5% in the first year of experience compared to the 97.9% of the last year. The CONTAK European registry revealed with details that the mean time of procedure duration and the success rate were directly proportional to the experience of the physician[10]. Physicians with experience of more than 20 implantations attained the smaller procedure times associated with the smaller times of radioscopy utilization for the implantation. The mean time for the implantation was 90 ± 38 min, with radioscopy time of 27 ± 21 min. Our total mean time of radioscopy utilization was 18.69 min. Compared to the literature, our total mean time of radioscopy was smaller than the ones mentioned by Kautzer J[8], Butter C[9], Purerfellner HF[12], Yee R[21]. The explanation for this fact is that in these works there was a lot of physicians involved and in some cases of many centers the outcomes can be influenced by the experience of each physician. In our work, the outcomes were influenced by the learning curve of just one physician. Also, in our experience the sheath for coronary sinus catheterization was not used and the cannulation was performed with the lead itself thus decreasing the chances of lead dislodgment upon sheath removal and the resultant extension on procedure time[6].

Checking the intraoperative difficulties, we found difficulties in the cannulation of the coronary sinus ostium in 12 patients. In 1 patient the cannulation was not possible and in 2 patients the lead stabilization in the coronary sinus was not possible due to the angulation between the ostium and the venous sinus, showing perhaps, in the coronary sinus catheterization, the importance of the coronary sinus ostium anatomy, which eventually can be in a posterior position[8], or even showing the presence and the anatomy of the Thebesius valve. In an study of 143 patients, 62.9% showed the valve: in 73 patients it had a semilunar form, in 10 septum form and in 7 crest form[22]. In 15 patients, we felt difficulties to advance the lead through the coronary venous sinus, approximately at the drainage place of the great cardiac vein, probably place of the Vissencius valve found in 87% of the cases studied by Lundinghausen[23], also showing the importance of the presence of this valve in the coronary sinus lead implantation procedure.

The implantation technique, proposed by the author, using the atrial component morphology of the intracavitary electrogram and radiological anatomy showed to be workless, safe and effective for the cannulation of the coronary sinus ostium requesting reduced times of radioscopy.

No potential conflict of interest relevant to this article was reported.

## References


1. Carvalho Filho ET, Curiati JAE. Insuficiência cardíaca no idoso. Rev Bras Med 2001;58:109-31.
2. Brito Jr HL, Bianchi FN, Nascimento LEP et al. Estimulação cardíaca artificial como tratamento dos pacientes com miocardiopatia dilatada e insuficiência cardíaca. Novos conceitos, novas técnicas e necessidades de atualização. Reblampa 2000;13:185-93.
3. Auricchio A, Stellbrink C, Sack S et al. Chronic benefit as a result of pacing in congestive heart failure: results of the PATH-CHF trials [abstract]. Circulation 2000;102:3352A.
4. Linde C, Leclercq C, Rex S et al. Long-Term benefits of Biventricular Pacing in Congestive heart Failure: results From the MUltisite STimulation In Cardiomyopathy (MUSTIC) Study. J Am Coll Cardiol 2002;40:111-8.
5. Abraham WT, Fisher WG, Smith AL et al. Cardiac resynchronization in chronic heart failure. N Engl J Med 2002;346:1845-53.
6. Fatemi M, Etienne Y, Gilard M et al. Short and long-term single-centre experience with an S-shaped unipolar lead for left ventricular pacing. Europace 2003;5:207-11.
7. Curnis A, Neris R, Mascioli G et al. Left ventricular pacing lead choice base on coronary sinus venous anatomy. Eur Heart J 2000;21(suppl J):J31-J35.
8. Kautzner J, Riedlbauchova L, Cihak R et al. Technical aspects of implantation of LV lead for cardiac resynchronization therapy in chronic heart failure. Pacing Clin Electrophysiol 2004;27:783-90.
9. Purerfellner H, Nesser HJ, Winter S et al. Transvenous left ventricular lead implantation with the EASYTRACK lead system: The European Experience. Am J Cardiol 2000;86(suppl):157K-164K.
10. Neuzer J, Pappone C, Aurrichio A et al. Learning curve for the first 1000 over-the-wire left ventricular transvenous lead implants-a Europe

experience. Eur J Heart Failure 2001;3 (suppl 1):S13.

11. Curley J, Lamba S, Moulton K et al. Does the availability of left heart lead and delivery system options matter for cardiac resynchronization therapy? Pacing Clin Electrophysiol 2002;24:597.

12. Butter C, Gras D, Ritter P et al. Comparative prospective randomized efficacy testing of different guiding catheters for coronary sinus cannulation in heart failure patients. J Interv Card Electrophysiol 2003;9:343-51.

13. Walker S, Levy T, Rex S, Paul VE. The use of a "side-wire" permanent transvenous-pacing electrode for left ventricular pacing. Europace 1999;1:197-200.

14. Auricchio A, Klein H, Tockman B et al. Transvenous biventricular pacing for heart failure: Can the obstacles be overcome? Am J Cardiol 1999;83:136D-142D.

15. Santosky R, Walter III HL, Ross RD. Coronary sinus ostial atresia with persistent left superior vena cava. Ann Thorac Surg 1996;61:879-82.

16. Gogna A, Tan HT et al. Atresia of coronary sinus ostium with retrograde drainage via persistent left superior vena cava. Ann Torca Surg 2003;76:2091-2.

17. Niebauer MJ, Daoud E, Williamson B et al. Atrial electrogram characteristics in patients with and without atrioventricular nodal reentrant tachycardia. Circulation 1995;156:61-9.

18. Galvão Filho S.S. Passagem de cabo eletrodo para estimulação cardíaca artificial provisória, orientada por monitorização endocavitária. An Paul Med Cir 1990;117:47-53.

19. Carneiro EF. A ativação do coração. In: O Eletrocardiograma - 10 Anos Depois. Rio de Janeiro: Cervantes Editora Ltda., 1997.

20. Gpnotebook.co.uk [homepage on the Internet]. Warwickshire: General Practice Notebook – a UK medical encyclopedia on the world wide web; c2004 [cited 2004 Dec 1]. Available from: http://www.gpnotebook.co.uk

21. Yee R, Pappone C, Maertens S et al. Clinical experience with over-the-wire left ventricular pacing lead for biventricular pacing in heart failure patients: multicenter report. Can J Cardiol 2001;(suppl C):89C-288C.

22. Bergman RA, Afifi A, Miyauchi R. Coronary Sinus. In: Anson BJ. Illustrated Encyclopedia of Human Anatomic Variation: Opus II: Cardiovascular System: Veins: Head, Neck, and Thorax. 12 ed. New York: McGraw-Hill Book Company, 1966.

23. Lundinghausen M, Ohmachi N, Boot C. Myocardial coverage of the coronary sinus and related veins. Clin Anat 1992;5:1-15.