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ORIGINAL ARTICLE / ОРИГИНАЛНИ РАД

Minithoracotomy as the primary alternative for left ventricular lead implantation during cardiac resynchronization therapy – Can the cardiac surgeon reduce the number of nonresponders

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SUMMARY

Introduction/Objective Numerous anomalies of the cardiac venous system prevent the optimal endovascular implantation of the left ventricular (LV) lead in more than 15% of patients with indication for cardiac resynchronization therapy (CRT). The endovenous approach in these patients can be one of the potential reasons for the large number of nonresponders reported in the literature.
The purpose of this study was to analyze the results of an alternative myoepicardial approach to the stimulation of the left ventricle in CRT.

Methods From June 2014 to December 2015 at the Department of Cardiac Surgery of the Clinical Centre of Serbia, 15 myoepicardial LV leads for CRT were implanted. Coronary sinus venography revealed thrombosis of the coronary sinus in nine patients, and unfavorable anatomy of the coronary venous system in six patients. In all patients, limited left thoracotomy was used as an approach to the lateral wall of the heart.

Results There were no major surgical complications and no lethal hospital outcomes. In a six-month follow-up period we registered a significant increase in the length of the six-minute walk test (for an average of 57.9 m), reduction of the QRS complex width (to 26.25 ms), increase in left ventricular ejection fraction (12.2%), and reduction of mitral regurgitation for 1+. Based on all the parameters, it was concluded that all patients responded favorably to the applied CRT.

Conclusion Closer cooperation between cardiologists and cardiac surgeons in identifying patients who would benefit the most from a myoepicardial approach for LV stimulation is necessary in order to attempt to reduce the nonresponder rate.

Keywords: CRT; minithoracotomy; surgically placed LV leads

INTRODUCTION

Cardiac resynchronization therapy (CRT) restores the synchronicity of the atrioventricular, interventricular, and intraventricular contractions [1]. Comprehensive trials have shown that CRT improves symptoms of congestive heart failure, improves ejection fraction and survival, increases exercise tolerance, and decreases hospital readmission [2]. Today, widely used is the less invasive transvenous approach of placing the left ventricular (LV) lead via the coronary sinus (CS) [3, 4]. However, 30–40% of patients fail to show improvement in clinical symptoms or cardiac function, and are considered nonresponders to this method [5].

Favorable response to CRT depends mostly on positioning the LV pacing lead coincident with the lattermost activated areas of the left ventricle so as to achieve the maximum hemodynamic effect. Therefore, the optimal LV lead placement is one of the most important aspects of CRT implantation [6]. Restrictions to achieve the maximum response are related to unfavorable coronary sinus anatomy, non-optimal position of the LV pacing lead, high-myocardial scar burden, and unintended stimulation of the left phrenic nerve [7]. Several studies showed that not all CS tributaries give the same response to CRT, leading to the group of lateral or posterolateral wall of the left ventricle to be the most suitable. Limited availability of suitable tributaries due to thrombosis of CS or the unfavorable coronary venous anatomy are among crucial factors that lead to the lack of the optimal hemodynamic effect of CRT [8, 9].

As an alternative to endovenous placement of LV lead in these patients, a surgical approach via mini-thoracotomy, video-assisted thoracoscopy, or with robotic assistance, should be considered [10].

The purpose of this study was to analyze the results of a myoepicardial approach to the stimulation of the left ventricle in CRT.

METHODS

Patient selection

Patient selection criteria were standard indications for CRT implantation [11]: severe

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congestive heart failure rated as New York Heart Association (NYHA) class III or IV despite the optimized pharmacologic heart failure treatment; dilated ischemic or non-ischemic cardiomyopathy with left ventricular systolic dysfunction defined as left ventricle ejection fraction (LVEF) ≤ 35% and left ventricular end-diastolic diameter of ≥ 60 mm; and LBBB as reflected on the surface electrocardiogram by a QRS duration of ≥ 120 ms in spontaneous rhythm. The indiciation for the surgical approach was the failure of transvenous approach to LV lead implantation, as well as limited availability of suitable CS tributaries.

Operative course

Left-sided operative approach was used in all the patients. Right atrium and right ventricle leads were placed in standard pacing sites. The device pocket was made in the upper left pre-pectoral area. The thrombosis of CS and unfavorable CS anatomy were the main criteria for the failure of the transvenous approach for the LV lead implantation.

Immediately after the failed transvenous approach, the LV lead connector was temporarily protected with a cap and the operating site was secured, while the patient was transferred to the operating theatre of the Cardiac surgery department, located on the same level, for the myoepicardial LV lead implantation. The surgery was done under general endotracheal anesthesia with single right-lung ventilation, using a double lumen endotracheal tube, while standard invasive hemodynamics monitoring was performed. Left antero-lateral minithoracotomy through the fourth intercostal space was used to access the left ventricle wall. Next, the pericardium was partially opened for 2–3 cm anterior to the phrenic nerve while ensuring sufficient distance. The pericardium was then fixed with traction sutures to the skin, rotating the heart to the right and creating the optimal exposure to the LV lateral wall. The LV lead was then placed between the left anterior descendent branch of the left coronary artery and the obtuse margin branch of the circumflex artery. We used the 5-0 or 6-0 polyprolene to secure the steroid eluting epicardial lead to avoid the trauma of the heart.

After completing the threshold measurements, the connector of the lead was brought through the third intercostal space and tunneled submuscularly to the previously made device pocket and the device itself. Minithoractomy was then closed by a standard wound closure and a small pleural drain was inserted.

CRT response criteria and follow-up

We recorded QRS complex width, LVEF, six-minute walk test, mitral regurgitation grade, and NYHA class prior to the intervention and six months after. Also, all the patients were observed for complications during their hospital stay.

The patients who had significant enhancement of one or more observed hemodynamic parameters (NYHA class reduction by one grade or more, LVEF + > 5%) after six months, were designated as responders to the CRT therapy [11].

RESULTS

The study involved 15 patients with myoepicardial LV leads for CRT implanted at the Department of Cardiac Surgery of the Clinical Centre of Serbia between June 2014 and December 2015. The venography revealed the thrombosis of CS in nine patients and unfavorable CS anatomy (non-accessible lateral or posterolateral group) in six patients. The hemodynamic characteristics of our patients before the surgery and after six months are shown in Table 1. There were 10 patients in NYHA class III and five were in NYHA class IV before the surgery, while after six months there were no patients in NYHA class IV, six were in NYHA I, eight in NYHA II, and just one patient was in NYHA III. The QRS complex width has decreased by the mean of 26.5 ms after the surgery. Also, at six months follow-up an increase in LVEF was recorded by the mean of 12.2%.

In addition, the value of the six-minute walk test increased by the mean of 57.9 m. The grade of mitral regurgitation decreased by the mean of 1.13. During the hospital stay, we did not record any major surgical complications or lethal outcomes.

Table 1. Hemodynamic parameters before the surgery and after a six-month follow-up

Characteristics	Baseline	After six months
NYHA class (n)		
I	-	6
II	-	8
III	10	1
IV	5	-
QRS complex (ms) ($\bar{x}$ ± SD)	165.3 ± 10.5	138.8 ± 15.6
LVEF (%) ($\bar{x}$ ± SD)	25.1±5.8	37.3 ± 7.3
MR (grade) ($\bar{x}$ ± SD)	2.38 ± 0.9	1.25 ± 0.5
Six-minute walk test (m) ($\bar{x}$ ± SD)	273.4 ± 22	331.3 ± 17

LVEF – left ventricle ejection fraction; MR – mitral regurgitation; NYHA – New York Heart Association

DISCUSSION

To maximize the hemodynamic effect of CRT and the number of responders to it, the LV lead must be placed near the lattermost activated areas of the heart [9]. The lateral and the posterolateral groups of CS tributaries have proven to be the most suitable ones and have the largest number of responders to CRT via transvenous approach [8, 12]. In the InSync study, the optimal LV lead position was achieved in only 71% of patients [13, 14]. Also, in the Easytrack pre-CE Mark clinical trial [15], only 50% of the implanted LV leads were in the lateral group, while 36% were in the anterior group, which, according to Nägele et al. [8], should be avoided. Ailawadi et al. [16] showed even greater percentage of transvenous approach failure, due to the fact that their center accepts only implantation in

these CS tributary groups. The percentage of optimal LV lead position went up to 80% in a MUSTIC trial, which is similar to the results in one of our previous studies [17, 18]. The overall success rate of the transvenous approach ranges 88–92% [12, 17].

The surgical approach gives an alternative solution to the patients who cannot have the LV lead placed or the suitable tributaries group could not be reached by the transvenous approach. Shaw et al. [10] pointed out in their research that the major determinant for transvenous procedure failure is the inability to place the LV lead in an adequate location in the coronary venous system. The thrombosis of CS or the unsuitable CS anatomy that leads to inability to implant the LV lead in the optimal CS tributaries were the main reasons for the surgical approach in our study. In addition to this, the coronary sinus perforation and dissection, cardiac tamponade, ventricular arrhythmia, as well as the LV lead dislodgement, could also be the indications for the shift to the surgical approach [10]. The MIRACLE study showed that 8% of their patients had a failed transvenous approach due to technical failure, 6% due to CS perforation, and another 6% due to LV lead dislodgement [4].

In our study, we showed a significant improvement of all observed hemodynamic parameters of each patient, which showed that all of them responded to CRT. Similar results were presented by Puglisi et al. [19]. Mair et al. [20], as well as Puglisi et al. [19], also compared successful transvenous LV lead implantation in the optimal sites to the surgical approach. They showed similar results between these two groups in response to CRT. Mair et al. [20] even showed better long-term results in the thoracotomy group and emphasized the more stable threshold capture in the thoracotomy group.

During the postoperative follow up, we had no major surgical complications and no lethal outcomes, which is in concordance with the studies mentioned above. The result of mortality outcome appears favorable with no obvious excess occurrence during the follow up.

However, Ailawadi et al. [21] reported a higher tendency for developing kidney failure in the thoracotomy group. They also reported a higher number of urinary tract infections, which may be the result of a longer hospital stay that can be prolonged due to intubation and general anesthesia. We did not observe any of these complications in our study.

The thoracotomy approach gives a lower percentage of lead dislodgement due to a less traumatic fixation mechanism and steroid eluting lead tips vs. screw-in leads used in the transvenous approach. Procedure duration is similar, even favorably shorter in the thoracotomy approach. The absence of X-ray exposure is a great benefit for the patient as well as for his physician. Also, X-ray exposure during the prolonged transvenous approach may present an indication to conversion to thoracotomy. This approach gives a surgeon a clear and vast possibility to place the LV lead closest to the desired site on the LV wall.

Video-assisted thoracic surgery and robotic surgery provide another advantage to surgical approach, reducing the invasive nature of the thoracotomic procedure. Several studies have shown that they are an equal alternative regarding the hemodynamic effect [22, 23]. They have also shown no mortality or an increase in hospital stay or procedure duration. Jansen et al. [24] showed conversion to thoracotomy in less than 0.1% of patients due to adhesions of previous operations or bleeding.

CONCLUSION

The surgical approach showed a high percentage of responders to CRT and a high hemodynamic effect. In addition, low mortality and complications of this procedure emphasize that it cannot be used only in patients with transvenous approach failure due to technical issues or complications. This approach gives a clear advantage for LV lead placement in patients with non-accessible optimal CS tributaries. Closer cooperation between cardiologists and cardiac surgeons in identifying patients who would benefit the most from a myoepicardial approach for LV stimulation is necessary, in order to attempt to reduce the nonresponder rate.

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Миниторакотомија као примарна алтернатива за уградњу електрода за леву комору код срчане ресинхронизационе терапије – може ли кардиохирург смањити број нонреспондера

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САЖЕТАК

Увод/Циљ Бројне аномалије срчаног венског система спречавају оптималну ендоваскуларну имплантацију електрода за леву комору код више од 15% болесника са индикацијом за срчану ресинхронизациону терапију (CPT). Ендовенски приступ код ових болесника може бити један од могућих разлога великог броја нонреспондера пријављених у литератури. Циљ ове студије је да анализира резултате алтернативног миоепикардиалног приступа стимулације леве коморе у CPT.

Методе Од јуна 2014. до децембра 2015. године уграђено је петнаест миоепикардиалних електрода за CPT. Венографијом коронарног синуса откривена је тромбоза коронарног синуса код девет и неповољна анатомија коронарног венског система код шест болесника. Код свих болесника лева миниторакотомија је коришћена као хируршки приступ бочном зида срца.

Резултати Није било већих хируршких компликација ни интрахоспиталних смртних исхода. У периоду праћења од шест месеци регистровали смо значајно повећање у дужини теста хода од шест минута (у просеку 57,9 *m*), смањење *QRS* комплекса ширине (до 26,25 *msec*), повећање ејекционе фракције леве коморе (12,2%) и смањење митралне инсуфицијенције за 1+. На основу свих параметара закључено је да су сви болесници одговорили позитивно на примењену CPT.

Закључак Ближа сарадња између кардиолога и кардиохирурга у идентификацији група болесника је неопходна у покушају смањивања броја нонреспондера у CPT и групе болесника која би имала највише користи од овог приступа.

Кључне речи: CPT; миниторакотомија; хируршко постављање миоепикардијалних електрода