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ORIGINAL ARTICLE

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Safety of cardiac resynchronization device implantation — retrospective analysis from high-volume centre

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ABSTRACT

Aims: Cardiac resynchronization therapy (CRT) is a treatment dedicated to patients suffering from heart failure and asynchrony of systole typically due to left bundle branch block (LBBB). The aim of this study is to analyse the safety of CRT device implantation in a large single-centre group.

Methods and results: The retrospective analysis of 198 patients hospitalized in the Department of Cardiology, dr A. Jurasz University Hospital no 1 in Bydgoszcz, who underwent CRT devices implantations in two consecutive years (2015–2016) has been performed. Out of 198 patients, 136 underwent implantation of CRT de novo and 62 exchange of the device. Studied procedures included implantations of 121 (89.0%) cardiac resynchronization therapy defibrillators (CRT-D) and 15 (11.0%) cardiac resynchronization therapy pacemakers (CRT-P) de novo, as procedures of exchange were excluded from statistical analysis. Collected data included: reported complications, patients' basic clinical characteristics, comorbidities and details of implantation procedures. Development of any complication was observed in 43 patients (31.6%), out of whom 29 (21.3%) experienced one, 10 (7.4%) two and 4 (2.9%) three complications. Most of them were minor complications. Serious complications which included pneumothorax, mediastinal hematoma and cardiac tamponade were observed in 6 (4.4%) cases, there were no perioperative deaths. The occurrence of complications was significantly more frequent in females (OR , 3.45, 95% CI 1.37–8.71, p 0.008), was associated with prolonged procedure time (OR 1.11, 95% CI 1.04–1.20, p 0.003) and prolonged hospitalization time (OR 1.16, 95% CI 1.06–1.27, p 0.001).

Conclusion: Overall, implantations of CRT devices are burdened with a substantial risk of complications, although the majority of them are minor and do not require subsequent surgical intervention. The risk of developing serious complications is low, accounting for 4.4%.

Key words: Cardiac resynchronization therapy, heart failure, complications

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Introduction

Cardiac resynchronization therapy (CRT) is a specific type of pacemaker therapy that consists of the simultaneous pacing of the right and left ventricle of the heart. The CRT devices are divided into implantable cardioverter-defibrillators (CRT-D) and implantable pacemakers (CRT-P). CRT is a treatment dedicated to patients suffering from heart failure (HF) and asynchrony of systole typically due to left bundle branch block (LBBB). It helps to restore atrioventricular (AV), inter- and intra-ventricular synchrony, improving left ventricular (LV) function, reducing functional mitral regurgitation and inducing LV to reverse remodelling. According to large trials, the best responders to CRT therapy are females with wider QRS, LBBB and non-ischaemic cardiomyopathy [1]. Approximately 2% of the adult population in developed countries is burdened with HF. Although only a small fraction of HF patients (5–10%) match CRT indications, it is still a large group [2]. According to the guidelines, CRT is linked with a significant amount of complications with lead complications being the main reason for re-operation. A meta-analysis of 9082 patients in 25 CRT trials showed that peri-implantation deaths occurred in 0.3% of trial participants, mechanical complications

in 3.2%, lead problems in 6.2% and infections in 1.4% [3]. The aim of this study is to analyse the safety of CRT device implantation in a large single-centre group, to evaluate the incidence, type of complications and their potential determinants.

Methods

Study design and study population

The retrospective analysis of 198 patients hospitalized in the Department of Cardiology, dr A. Jurasz University Hospital no 1 in Bydgoszcz, who underwent CRT devices implantations in two consecutive years (2015–2016) has been performed. Procedures of exchange were excluded from statistical analysis. The reason for exclusion of exchange procedures was the desire to obtain a homogenous group of patients and to enable the comparison of complications' incidence, types and their determinants.

Data sources and data analysis

The data was obtained from the electronic database used in the Department of Cardiology, dr A. Jurasz University Hospital no 1 in Bydgoszcz. Retrospective analysis of patients' medical history collected by attending physicians enabled to obtain information about reported complications, patients' basic clinical characteristics, comorbidities and details of implantation procedures. Analysed medical data included: records pertaining to hospitalization due to CRT implantation as well as following hospitalizations and ambulatory appointments. Analysed patients' characteristics included: age, sex, body mass index, presence of hypertension, diabetes mellitus, New York Heart Association (NYHA) class, dyslipidaemia, coronary artery disease, chronic kidney disease, arteriosclerosis of lower limbs, valvular disease, atrial fibrillation, prior acute myocardial infarction, prior percutaneous coronary intervention, prior coronary artery bypass grafting, prior stroke or transient ischemic attack. Results of both Staphylococcus aureus test and echocardiographic examinations were collected. Following variables concerning hospitalization and implantation procedures were also taken into account: hospitalization time, procedure time, type of implanted device (CRT-P or CRT-D), the urgency of the procedure. All of the variables were concerned as potential complications' determinants.

Definition of complications

According to available literature the possible CRT complications were defined as follows: pneumothorax, mediastinal hematoma, pleural haemorrhage, cardiac tamponade, arrhythmias, pulmonary oedema, infectious endocarditis, subcutaneous emphysema, cerebral stroke, thrombus of subclavian vein, wound dehiscence, perforation of skin by the device, pocket infection, pocket hematoma, diaphragmatic stimulation, stimulation of pectoral muscles, damage of coronary sinus or cardiac venous system, perforation of free wall of the heart, accidental puncture of subclavian artery, damage of brachial plexus, thrombus on the lead, lead displacement, Twiddler's syndrome, breaking of the conductive spiral of the lead, breaking of the lead cover, inadequate discharges, increased threshold of stimulation, oversensing, undersensing, influence of electromagnetic field on device function, premature battery depletion, loose electrode in the pacemaker port, the need to remove electrode, the need to remove CRT device [4–10]. Observed complications were divided using time of their occurrence – whether they occurred during the hospitalization related to primary implantation of CRT, or after that hospitalization.

Statistical Analysis

Dichotomous variables were expressed as a number and percentage, whereas continuous variables were reported as median and interquartile range. The Chi^2 test was used for dichotomous variables, whereas the Mann Whitney U test was used to compare continuous variables. The prognostic relevance of the various baseline variables on the occurrence of complications was assessed with logistic regression analysis with results presented as odds ratios (OR) with a 95% confidence intervals (CI). Any variable with $P < 0.1$ on univariate analysis was included in the multivariate logistic regression analysis. A P value < 0.05 was considered significant. All statistical analyses were performed using Statistica 13.1.

Results

Study population

A total of 198 patients underwent a CRT device implantation, out of whom 136 underwent implantation of CRT de novo and 62 exchange of the device. Procedures of exchange were excluded from statistical analysis. During 2015, 69 patients (50.7%) underwent implantation of CRT de novo whereas in 2016, 67 patients (49.3%).

Patient and procedural characteristics

Key baseline features of patients enrolled in the study are shown in Table 1. Median age at implantation was 69 (interquartile range: 64.0–75.0). The analysed group included 102 men (75.0%) and 34 women (25.0%). Most

Table 1. Patient characteristics.

Clinical feature:	Overall study population (n = 136)	Patients with complications (n = 43)	Patients without complications (n = 93)	P-value
Age [years]	69.0 (64.0–75.0)	68 (62.0–73.0)	69 (64.0–76.0)	NS
Female	34 (25.0%)	15 (34.9%)	19 (20.4%)	NS
Body mass index [kg/m$^{2]}$	27.6 (24.7–31.9)	28.1 (25.5–32.9)	27.4 (24.7–31.9)	NS
Hypertension	93 (68.4%)	33 (76.7%)	60 (64.5%)	NS
Diabetes Mellitus	63 (46.3%)	19 (44.2%)	44 (47.3%)	NS
Dyslipidaemia	67 (49.3%)	23 (53.5%)	44 (47.3%)	NS
Coronary artery disease	83 (61.0%)	24 (55.8%)	59 (63.4%)	NS
Prior acute myocardial infarction	71 (52.2%)	20 (46.5%)	51 (54.8%)	NS
Prior percutaneous coronary intervention	61 (44.9%)	18 (41.9%)	43 (46.2%)	NS
Prior coronary artery bypass grafting	28 (20.6%)	7 (16.3%)	21 (22.6%)	NS
NYHA > II	39 (28.7%)	10 (23.3%)	29 (31.2%)	NS
Chronic kidney disease	30 (22.1%)	9 (20.9%)	21 (22.6%)	NS
Arteriosclerosis of lower limbs	11 (8.1%)	4 (9.3%)	7 (7.5%)	NS
Valvular disease	39 (28.7%)	19 (44.2%)	20 (21.5%)	< 0.01
Atrial fibrillation	50 (36.8%)	11 (25.6%)	39 (41.9%)	NS
Prior stroke/transient Ischemic attack	16 (11.8%)	6 (14.0%)	10 (10.8%)	NS
Ejection fraction [%]	30 (25.0–35.0)	30 (25.0–35.0)	30 (22.8–35.0)	NS
Left ventricle end-diastolic diameter [mm]	63 (56.0–69.0)	63 (57.8–68.0)	63 (55.3–69.0)	NS
Left atrium diameter [mm]	47 (42–53)	47 (42.3–51.8)	48.0 (42.0–54.0)	NS
Interventricular septum diameter [mm]	11 (10–13)	11 (10.0–12.0)	12 (10.8–13.0)	< 0.05
Posterior wall diameter [mm]	11 (10–12)	11 (10.0–12.0)	11 (10.0–12.0)	NS

NYHA — New York Heart Association

frequent comorbidities were as follows: hypertension 93 (68.4%), coronary artery disease 83 (61.0%), prior acute myocardial infarction 71 (52.2%), dyslipidaemia 67 (49.3%), diabetes mellitus 63 (46.3%). The median ejection fraction was 30 (interquartile range: 25.0–35.0).

Characteristics of CRT implantation procedures are shown in Table 2. Studied procedures included implantations of 121 (89.0%) CRT-D and 15 (11.0%) CRT-P de novo. The median time of procedure was 120 min (interquartile range: 87.3–160.0); 21.3% of procedures were urgent and in 45.6% of cases there was a device system upgrade to cardiac resynchronization therapy.

Complication risk

Complications were observed in 43 patients (31.6%), out of whom 29 (21.3%) experienced one, 10 (7.4%) two and 4 (2.9%) three complications. The most common complications were minor, including pocket hematoma: 13 patients (9.6%), lead dislodgement: 10 patients (7.4%) out of whom 9 patients needed to have reposition/replacement of electrode, diaphragmatic stimulation: 9 patients (6.6%), damage of coronary sinus or cardiac venous system without tamponade: 9 patients (6.6%). The serious complications were as follows: pneumothorax: 4 patients (2.9%), mediastinal hematoma: 1 patient (0.7%), cardiac tamponade: 1 patient (0.7%). Altogether serious complications were observed in 6 cases (4.4%), there were no perioperative deaths. Minor and rare complications included: ventricular arrhythmias: 3 patients (2.2%), inadequate discharges: 2 patients (1.5%), the need to remove damaged electrode: 1 patient (0.7%), pulmonary oedema: 1 patient (0.7%), wound dehiscence: 1 patient (0.7%), pocket infection with the need to reposition the CRT can: 1 patient (0.7%), infectious endocarditis with

Table 2. Procedural characteristics

Clinical feature:	Overall study population (n = 136)	Patients with complications (n = 43)	Patients without complications (n = 93)	P-value
Hospitalization time [days]	6 (5.0–9.0)	8 (5.5–13.0)	5 (5.0–7.0)	< 0.0001
Procedure time [min]	120 (87.3–160.0)	150 (120.0–182.5)	110 (85.0–140.0)	< 0.001
CRT-D	121 (89.0%)	41 (95.3 %)	80 (86.0%)	NS
Upgrade to cardiac resynchronization therapy	62 (45.6%)	16 (37.2%)	46 (49.5%)	NS
Urgent procedure	29 (21.3%)	11 (25.6%)	18 (19.4%)	NS

CRT-D — cardiac resynchronization therapy defibrillator

Table 3. Complications

Complication	Overall study population (n = 136)	Occurrence of complications during the hospitalization related to primary implantation of CRT	Occurrence of complications after the hospitalization related to primary implantation of CRT
Pocket hematoma	n = 13 (9.6%)	n = 11 (8.1%)	n = 2 (1.5%)
Lead displacement overall	n = 10 (7.4%)	n = 3 (2.2%)	n = 7 (5.1%)
With need to reposition/replace electrode	n = 9 (6.6%)	n = 3 (2.2%)	n = 6 (4.4%)
Without need to reposition/replace electrode	n = 1 (0.7%)	n = 0 (0%)	n = 1 (0.7%)
Damage of coronary sinus or cardiac venous system	n = 9 (6.6%)	n = 9 (6.6%)	n = 0 (0%)
Diaphragmatic stimulation	n = 9 (6.6%)	n = 7 (5.1%)	n = 2 (1.5%)
Pneumothorax	n = 4 (2.9%)	n = 4 (2.9%)	n=0 (0%)
Mediastinal hematoma	n = 1 (0.7%)	n = 1 (0.7%)	n=0 (0%)
Cardiac tamponade	n = 1 (0.7%)	n = 1 (0.7%)	n = 0 (0%)
Ventricular arrhythmias	n = 3 (2.2%)	n = 2 (1.5%)	n = 1 (0.7%)
Inadequate discharges	n = 2 (1.5%)	n = 0 (0%)	n = 2 (1.5%)
The need to remove damaged electrode	n = 1 (0.7%)	n = 1 (0.7%)	n = 0 (0%)
Pulmonary oedema	n = 1 (0.7%)	n = 1 (0.7%)	n = 0 (0%)
Wound dehiscence	n = 1 (0.7%)	n = 0 (0%)	n = 1 (0.7%)
Pocket infection with the need to reposition the CRT can	n = 1 (0.7%)	n = 0 (0%)	n = 1 (0.7%)
Infectious endocarditis with the need to remove the whole CRT system	n = 1 (0.7%)	n = 0 (0%)	n = 1 (0.7%)
Increased threshold of stimulation	n = 1 (0.7%)	n = 1 (0.7%)	n = 0 (0%)
Subcutaneous emphysema	n = 1 (0.7%)	n = 1 (0.7%)	n = 0 (0%)
Thrombus on the lead	n = 1 (0.7%)	n = 1 (0.7%)	n = 0 (0%)

CRT — cardiac resynchronization therapy

the need to remove the whole CRT system: 1 patient (0.7%), increased threshold of stimulation: 1 patient (0.7%), subcutaneous emphysema: 1 patient (0.7%), thrombus on the lead: 1 patient (0.7%). The summary and division of complications due to the time of occurrence are presented in Table 3.

The predictors of complications found in multivariate regression analysis were as follows: female gender (OR 3.45, 95% CI 1.37–8.71, p 0.008), prolonged procedure time (OR 1.11, 95% CI 1.04–1.20, p 0.003) and prolonged hospitalization time (OR 1.16, 95% CI 1.06–1.27, p 0.001. The summary in Table 4 and 5.

Table 4. Results of univariate analysis

Variable	OR	95% CI	P-value
Age [years]	0.96	0.92–1.01	0.087
Female	2.09	0.93–4.70	0.073
Body mass index [kg/m^2]	0.99	0.91–1.08	0.864
Hypertension	1.82	0.79–4.17	0.157
Diabetes Mellitus	0.88	0.42–1.84	0.734
Dyslipidaemia	1.28	0.62–2.66	0.503
Coronary artery disease	0.73	0.35–1.53	0.397
Prior acute myocardial infarction	0.72	0.34–1.49	0.367
Prior percutaneous coronary intervention	0.84	0.40–1.75	0.633
Prior coronary artery bypass grafting	0.67	0.26–1.73	0.400
NYHA > II	0.67	0.29–1.55	0.344
Chronic kidney disease	0.91	0.37–2.21	0.829
Arteriosclerosis of lower limbs	1.26	0.34–4.61	0.724
Valvular disease	2.89	1.32–6.34	0.008
Atrial fibrillation	0.48	0.21–1.07	0.069
Prior stroke/transient Ischemic attack	1.35	0.45–4.02	0.591
Ejection fraction [%]	0.99	0.95–1.04	0.815
Left ventricle end-diastolic diameter [mm]	0.99	0.96–1.03	0.835
Left atrium diameter [mm]	0.99	0.95–1.04	0.705
Interventricular septum diameter [mm]	0.75	0.58–0.98	0.033
Posterior wall diameter [mm]	0.77	0.54–1.11	0.156
Hospitalization time [days]	1.17	1.07–1.28	0.001
Procedure time [increase of 10 min]	1.11	1.04–1.18	0.001
CRT-D	3.33	0.71–15.69	0.125
Upgrade to cardiac resynchronization therapy	0.61	0.29–1.28	0.184
Urgent procedure	1.40	0.59–3.34	0.444

CRT-D — cardiac resynchronization therapy defibrillator, NYHA — New York Heart Association

Table 5. Clinical prognostic indicators of complications in multivariate regression analysis

Variable	OR	95% CI	P-value
Hospitalization time [days]	1.16	1.06–1.27	0.001
Procedure time [increase of 10 min]	1.11	1.04–1.20	0.003
Female	3.45	1.37–8.71	0.008

Discussion

Implantation of the CRT device is an invasive procedure, therefore there is a risk of complication as in any other surgical intervention. Usually during CRT implantation operator needs to perform either incision of a cephalic vein or separate punctures of subclavian vein, and each of them can cause complications like pneumothorax, bleeding into the pleural cavity, puncture of the subclavian artery, subcutaneous pneumothorax or brachial plexus injury.

According to Abraham et al. complications that are specific to CRT implantation include: LV lead dislodgement, diaphragmatic stimulation, coronary sinus dissection and perforation [11]. In the authors' study 10 patients (7.4%) had lead displacement, 9 patients (6.6%) diaphragmatic stimulation and 9 patients (6.6%) damage of coronary sinus or cardiac venous system without tamponade.

The most common complications in the authors' study were pocket hematoma (9.6%) and lead dislodgement (7.4%). Tajstra et al. [8] also reported pocket hematoma (6.1%) (within 2 months) as the most common complication. Similarly, Pakarinen et al. stated that lead displacement (3.7%) and pocket hematoma (3.2%) were the most common complications (during 3-months follow up) [5].

Limitations

There are some limitations of the study that should be acknowledged. First of all, it was a retrospective analysis. Secondly, there was a small group of patients who did not have an echocardiographic examination. Thirdly, due to the fact, that data derivation took place in April 2017, patients had different follow-up time ranging from 4 months to 2 years and 4 months.

Conclusion

The authors' analysis of complications related to CRT device implantation shows that this procedure is burdened with a substantial risk of complications, although the majority of them are minor and do not require subsequent surgical intervention. The risk of developing serious complications is low, accounting for 4.4%.

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Statement of competing interests

The authors declare that they have no conflict of interest.

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