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Cardiac Resynchronisation Therapy (CRT) Survey II: CRT implantation in Europe and in Switzerland

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Summary

AIM: Between October 2015 and December 2016, 11,088 patients from 42 countries having cardiac resynchronisation therapy (CRT) devices implanted were included in the CRT II Survey. We compared the characteristics of Swiss CRT recipients with the overall European population.

METHODS: Demographic and procedural data from seven Swiss centres recruiting all consecutive patients undergoing either *de-novo* CRT implantation or an upgrade to a CRT system were collected and compared with the European population.

RESULTS: A total of 320 Swiss patients (24.4% female, mean age 71.0 ± 10.2 years, 47% ischaemic cardiomyopathy) were enrolled, which amounts to 38% of all CRT implantations in Switzerland during this period. Of the patients enrolled, 38% had atrial fibrillation, 27% second- or third-degree atrioventricular block, and 68% complete left bundle-branch block. Swiss patients had significantly less often the classical indication of heart failure with a wide QRS complex (40 vs 61%; odds ratio [OR] 0.44, 95% confidence interval [CI] 0.35–0.55; p <0.001). Compared with the European population, Swiss patients were significantly older (71 vs 68.5 years, p <0.001), less symptomatic from heart failure and had more chronic kidney disease. Swiss patients significantly more often received a CRT-pacemaker (37 vs 30%; OR 1.37; 95% CI 1.09–1.73; p = 0.007) and quadripolar left ventricular leads (69 vs 57%; OR 1.67, 95% CI 1.32–2.13; p <0.001).

: CONCLUSION: Compared with European CRT recipients, Swiss CRT patients are older, less symptomatic and suffer more often from comorbidities. Although two thirds of the implantations were CRT-defibrillator systems, Swiss patients more often received CRT-pacemaker systems than their European counterparts.

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Introduction

The benefits of cardiac resynchronisation therapy (CRT) on long-term clinical outcomes in symptomatic heart failure patients (New York Heart Association [NYHA] class II–IV) with reduced left ventricular (LV) ejection fraction (EF) and electrical dyssynchrony have been repeatedly proven in randomised controlled trials (RCTs) [1–3]. Surveys and registries supplement RCTs by providing important data on daily clinical practice [1, 3]. These data complement results from RCTs, which tend to exclude high-risk patients [3–5]. The European Cardiac Resynchronisation Therapy (CRT) Survey was conducted in 2008, as a joint project by the Heart Failure Association (HFA) and the European Heart Rhythm Association (EHRA) of the European Society of Cardiology (ESC) [6]. This 6-month snapshot survey included data from 2438 CRT recipients in 13 ESC member countries. At the time, it showed underutilisation of resynchronisation therapy and indicated that large numbers of CRT-pacemaker (CRT-P) or -defibrillator (CRT-D) devices were implanted outside the guideline recommendations [6]. The design of the European CRT Survey II was based on the first CRT Survey [7]. The CRT II survey included 42 ESC member countries and its aim was to gather real-life clinical and demographic data on current patient selection, and implantation and follow-up practice [8]. Ultimately, it provides information relevant for assessing healthcare resource utilisation and the adherence to latest guidelines on CRT implantation [7, 8]. We compared the Swiss CRT utilisation with that in the overall European population.

Materials and methods

The rationale and design of the CRT Survey II have been published earlier [7]. All consecutive patients planned for CRT-P/CRT-D device implantation, *de-novo* or upgrade, in a 15-month period (October 2015 to December 2016), were included regardless of the success of the procedure. Data were collected prospectively using an online database. A central database was created and maintained at the data management centre at the Institut für Herzinfarktforschung in Ludwigshafen at the Heidelberg University, Germany. The data management centre also performed the analyses.

The European CRT Survey II included two internet-based questionnaires [7]. The first was a one-time questionnaire completed by participating centres and characterised the facility, its catchment area, invasive procedures and device implantations performed, cardiac facilities, types of imaging equipment employed, number and speciality of implanting physicians and the follow-up options provided, as well as the type and source of hospital reimbursement. The second questionnaire was an electronic case report form (eCRF) for each patient, which collected demographic, medical history and clinical data as well as procedural and postprocedural details. Importantly, data from unsuccessful CRT implantations were also included.

Ethics approval from the relevant Ethics Committee in Switzerland was obtained. The study protocol complied with the Declaration of Helsinki and Good Clinical Practice.

Statistical analysis

Continuous variables are presented as median with interquartile range or mean with standard deviation, as appropriate. Categorical variables are presented in absolute values and percentages. Continuous variables were compared with nonparametric Mann-Whitney U-tests and categorical variables were compared with Pearson χ^2 tests. Descriptive statistics were calculated for the available cases. All p-values are the results of two-tailed tests and a value of <0.05 was considered significant. Statistical analysis was carried out using SAS statistical software, version 9.1 (Cary, North Carolina, USA).

Results

Participating centres

Seven out of 36 CRT-implanting centres in Switzerland participated in the CRT II survey (Universitätsspital Basel, Hôpitaux Universitaires de Genève, Universitätsspital Zurich, Cardiocentro Lugano, Kantonsspital St. Gallen, Stadtspital Triemli Zurich and Clinique Cecil Lausanne) [9]. During the 15-month enrolment period (October 2015 to December 2016), out of 11,088 patients recruited by 288 centres in 42 ESC member countries participating in the CRT II Survey, 320 patients (2.9%) were recruited in Switzerland (table 1). This was 38% of all CRT implantations in Switzerland during this period (n = 838), according to data from the national device registry [9].

Baseline characteristics and procedural

The patient demographics are shown in table 2, procedural data in table 3, and postprocedural data in table 4, together with comparisons between the Swiss and European populations. There were no procedural deaths or bleeding complications. One Swiss patient died during hospitalisation from progressive heart failure.

Differences between Swiss and European CRT recipients

Compared with European CRT recipients, Swiss patients were older (71 vs 68.5 years, p <0.001), with a significantly higher proportion of patients older than 75 years (42 vs 32%, p <0.001). In both groups women were underrepresented (24 vs 24%, p = 0.975). Swiss patients significantly less often had the classical indication of heart failure with a wide QRS complex (40 vs 61%; odds ratio [OR] 0.44, 95% confidence interval [CI] 0.35–0.55; p <0.0001), less often presented with complete left bundle-branch block (68 vs 75%; OR 0.7, 95% CI 0.55–0.89) and consequently displayed a shorter mean duration of the QRS complex (152 ± 29 vs 157 ± 27 ms, p <0.01). Conversely, they significantly more often had underlying second or third degree atrioventricular block (27 vs 19%, OR 1.6, 95% CI 1.24–2.06) with CRT employed for expected dyssynchrony induced by a high amount of right ventricular pacing.

Although there was no overall difference in the NYHA status, more Swiss patients were in NYHA functional class I (6 vs 3%; OR 1.73, 95% CI 1.07–2.82) and they were significantly less often hospitalised for heart failure the year before implantation (32 vs 47%; OR 0.54, 95% CI 0.42–0.68), although they had significantly higher levels of preprocedural brain natriuretic peptide (BNP) (1422 vs 1104 pg/ml, p = 0.012). Swiss patients had a higher prevalence of chronic kidney disease (OR 1.58, 95% CI

Table 1: Analysis overview and participating centres in Switzerland.

	Switzerland	All other countries
Number of patients	320	10,768
Advanced analysis population	99.7% (319/320)	96.7% (10,411/10,768)
Number of centres	7	281
Swiss centres (no. of patients)		
Universitätsspital Basel	76	
Hôpitaux universitaires de Genève	71	
Universitätspital Zurich	43	
Kantonspital St. Gallen	41	
Triemli Zurich	42	
Cardiocentro Lugano	34	
Clinique Cecil Lausanne	13	

Table 2: Baseline characteristics and pre-procedural data of Swiss cardiac resynchronisation therapy (CRT) population and comparison with the European population.

	Switzerland	Europe	p-value	OR (95% CI)
Demographics				
Age (years)	71 ± 10	68 ± 11	**<0.001**	
Men (%)	75.6	75.7	0.98	
BMI (kg/m^2)	27 ± 5	28 ± 5	**<0.001**	
Medical history				
Hypertension	69 (221/320)	64 (6741/10580)	0.05	0.66 (0.51–0.86)
Diabetes mellitus	23 (75/320)	32 (3353/10601)	**0.002**	
Obstructive lung disease	11 (35/320)	12 (1280/10602)	0.54	
Atrial fibrillation	38 (121/320)	41 (4338/10600)	0.26	
Paroxysmal	37 (45/121)	35 (1503/4338)		
Persistent	28 (34/121)	22 (960/4338)		
Permanent	35 (42/121)	43 (1847/4338)		
Chronic kidney disease (<60 ml/min)	41 (132/320)	31 (3263/10587)	**<0.001**	1.58 (1.26–1.98)
Prior revascularisation (CABG or PCI)	43 (138/320)	39 (4107/10604)	0.11	
HF hospitalisation during last year	32 (103/320)	47 (4975/10597)	**<0.001**	0.54 (0.42–0.68)
Prior device (PPM, ICD)	33 (105/320)	28 (2954/10672)	**0.043**	1.28 (1.01–1.62)
Primary HF aetiology			0.34	
Ischaemic	47 (149/320)	44 (4726/10633)		
Non-ischaemic	49 (157/320)	50 (5296/10633)		
Other	4 (14/320)	6 (611/10633)		
ECG				
Heart rate (beats/min)	71 ± 19	72 ± 16	0.23	
Sinus rhythm	68 (218/319)	69 (7278/10517)	0.55	
Atrial fibrillation	24 (77/319)	26 (2701/10517)	0.55	
PR interval (ms)	193 ± 53	189 ± 50	0.39	
AV block II or III	27 (86/320)	18.7 (1940/10380)	**<0.001**	1.60 (1.24–2.06)
QRS duration (ms)	152 ± 29	157 ± 27	**<0.001**	
QRS duration <120 ms	13 (37/285)	7 (674/9250)		1.90 (1.33–2.71)
QRS duration 120–130 ms	5 (15/285)	5 (490/9250)		0.99 (0.59–1.68)
QRS duration 130–150 ms	23 (66/285)	18 (1713/9250)		1.33 (1.00–1.75)
QRS duration 150–180 ms	40 (115/285)	47 (4371/9250)		0.76 (0.59–0.96)
QRS duration >180 ms	18 (52/285)	22 (2002/9250)		0.81 (0.60–1.10)
QRS morphology				
LBBB	68 (213/312)	75 (7625/10105)	**0.004**	0.70 (0.55–0.89)
RBBB	6 (20/312)	7 (668/10105)	0.89	0.97 (0.61–1.53)
Other	25 (79/312)	18 (1812/10105)	**<0.001**	1.55 (1.20–2.01)
CRT indication				
Heart failure with wide QRS	40 (128/317)	61 (6422/10606)	**<0.001**	0.44 (0.35–0.55)
HF or LV dysfunction and an indication for ICD	43 (137/317)	48 (5091/10606)	0.09	
PPM indication + expected pacing dependency	32 (103/317)	22 (2391/10606)	**<0.001**	1.65 (1.30–2.10)
Evidence of medical dyssynchrony	4 (13/317)	12 (1247/10606)	**<0.001**	0.32 (0.18–0.56)
Clinical evaluation			0.70	
NYHA I	6 (18/318)	3 (352/10530)		
NYHA II	34 (108/318)	38 (3975/10530)		
NYHA III	55 (174/318)	54 (5735/10530)		
NYHA IV	6 (18/318)	4 (468/10530)		
Echocardiography				
Mean LV ejection fraction (%)	30 ± 8	28 ± 8	**0.005**	
<35%	71 (226/320)	77 (8056/10485)		1.01 (0.80–1.27)
35–50%	27 (86/320)	21 (2242/10485)		1.44 (1.08–1.94)
>50%	2 (8/320)	2 (187/10485)		1.41 (0.69–2.89)
LV end-diastolic diameter (mm)	60 ± 9	64 ± 9	**<0.001**	
Mitral regurgitation (%)	46 (136/297)	46 (4508/9703)	**<0.001**	
Mild	16 (49/297)	27 (2597/9703)		0.97 (0.77–1.23)
Moderate	9 (26/297)	7 (664/9703)		0.54 (0.40–0.74)
Severe	29 (86/297)	20 (1934/9703)		1.31 (0.87–1.97)
Laboratory results				
BNP (pg/ml)	1422 ± 2038	1104 ± 1973	**0.012**	
NT-pro-BNP (pg/ml)	7163 ± 11993	5055 ± 8010	0.14	
Haemoglobin (g/l)	132 ± 18	133 ± 18	0.32	
Creatinine (µmol/l)	121 ± 68	113 ± 65	**0.032**	

BMI = body mass index; BNP = brain-type natriuretic peptide; CABG = coronary artery bypass grafting; HF = heart failure; ICD = implantable cardioverter-defibrillator; LBBB = left bundle-branch block; LV = left ventricle; NT-pro-BNP = N-terminal prohormone of brain natriuretic peptide; PCI = percutaneous coronary intervention; PPM = permanent pacemaker; RBBB = right bundle-branch block Values are % (n) for categorical and mean ± standard deviation or median (interquartile range) for continuous variables.

1.26–1.98; p <0.001) and previously implanted devices (OR 1.28, 95% CI 1.01–1.62; p = 0.043).

In Switzerland, CRT-D systems were more often implanted than CRT-P systems (63 vs 37%). Compared with the European population, however, Swiss patients received fewer CRT-D devices (63 vs 70%, p = 0.007). This may be explained by the older age of the patients and the fact that the procedure was done significantly more often by an electrophysiologist (OR 2.84, 95% CI 1.95–4.12; p <0.001). In Switzerland, the quadripolar left ventricular lead was used more often (OR 1.67, 95% CI 1.32–2.13; p <0.001), reflecting unhindered access to modern technology.

The overall complication rate was 4% and not different from the European average. Postprocedural QRS duration was not different nor was the incidence of major adverse events. Total length of hospital stay was lower in Swiss hospitals (5.5 vs 6.3 days, p <0.001). There was a statistically significant difference between the groups regarding the discharge medication therapy, programming of the device and follow-up planning.

Discussion

The most important findings in this registry study comparing Swiss CRT recipients with their European counterparts is that Swiss patients were older, had fewer heart failure hospitalisations in the year before implantation and significantly less often had the "classical" CRT indication of symptomatic heart failure in the presence of a wide left bundle-branch block. Although the reimbursement system in Switzerland allows for easy access to all available technologies, significantly fewer Swiss patients received the more expensive CRT defibrillator (CRT-D) system than in the rest of Europe. Nonetheless, CRT-D systems still account for two thirds of all CRT implants in Switzerland.

Table 3: Procedural data of Swiss cardiac resynchronisation therapy (CRT) population and comparison with the European practice.

	Switzerland	Europe	p-value	OR (95% CI)
Elective procedure	84 (268/320)	77 (8190/10678)	**0.003**	1.56 (1.16–2.11)
Location of procedure			0.22	
EP/Catheterisation lab.	83 (266/320)	89 (9354/10439)		
Operating room	5 (16/320)	10 (1068/10439)		
Other	12 (38/320)	0.2 (17/10439)		
Operator			**<0.001**	
Electrophysiologist	90 (288/319)	77 (8014/10460)		2.84 (1.95–4.12)
Heart failure physician	0 (0/319)	5 (541/10460)		/
Invasive cardiologist	8 (26/319)	12 (1304/10460)		0.62 (0.42–0.93)
Surgeon	2 (5/319)	4 (459/10460)		0.35 (0.14–0.84)
Duration of procedure (min)	110 (82, 136)	90 (65, 120)	**<0.001**	
Fluoroscopy time (min)	16 (10, 25)	14 (8, 22)	**<0.001**	
Successful attempt of implantation	98.8	97.2	0.09	
RV lead position			**0.019**	
Apex	67 (211/313)	61 (6069/9940)		1.32 (1.04–1.68)
Septum	31 (98/313)	37 (3635/9940)		0.79 (0.62–1.01)
RVOT	1 (4/313)	2 (236/9940)		0.53 (0.20–1.44)
LV lead position			**<0.001**	
Anterior	2 (8/317)	4 (439/9983)		0.56 (0.28–1.14)
Lateral	78 (249/317)	84 (8416/9983)		0.68 (0.52–0.90)
Posterior	19 (60/317)	11 (1128/9983)		1.83 (1.37–2.44)
Epicardial	14 (44/319)	9 (923/10214)		1.61 (1.16–2.23)
LV lead type			**<0.001**	
Unipolar	0 (0/319)	0.7 (77/10282)		
Bipolar	31 (100/319)	43 (4378/10282)		0.62 (0.48–0.78)
Multipolar	69 (219/319)	57 (5827/10282)		1.67 (1.32–2.13)
Coronary venogram performed	93 (298/319)	91 (9338/10210)	0.22	
Venogram performed with occlusion	61 (183/298)	47 (4303/9224)	**<0.001**	1.82 (1.44–2.31)
Periprocedural complications	4 (13/320)	6 (611/10768)	0.21	
Bleeding	0 (0/320)	1 (108/10768)	0.07	
Pocket haematoma	0 (0/320)	0.8 (85/10768)	0.11	
Pneumothorax	2 (7/320)	1 (105/10768)	**0.033**	2.27 (1.05–4.92)
Pericardial tamponade	0.3 (1/320)	0.3 (27/10768)	0.56	
Coronary sinus dissection	0.3 (1/320)	2.0 (213/10768)	**0.023**	0.16 (0.02–1.11)
Type of the device			**0.007**	
CRT-P	37 (118/318)	30 (3138/10451)		1.37 (1.09–1.73)
CRT-D	63 (200/318)	70 (7313/10451)		0.73 (0.58–0.92)

CRT-P = cardiac resynchronisation therapy pacemaker system; ; CRT-D = cardiac resynchronisation therapy cardioverter-defibrillator system; EP = electrophysiology; LV = left ventricle; RV = right ventricle, RVOT = RV outflow tract Values are % (n) for categorical and mean ± standard deviation or median (interquartile range) for continuous variables

The higher prevalence of CRT pacemaker (CRT-P) systems may in part be explained by the fact that Swiss patients were older and that more procedures were done by electrophysiologists with potentially more detailed knowledge of current risk stratification for sudden cardiac death [10–13]. On the other hand, it may also reflect a different attitude of the patient population to the mode of death. Swiss patients were less often hospitalised for heart failure before CRT implantation, although they had higher levels of preprocedural BNP. Better access to ambulatory healthcare services than in other countries may be the reason for that.

After the type of CRT system was chosen, Swiss patients received the latest technology with a higher proportion of quadripolar left ventricular leads than the European population. Furthermore, although our population had the same overall incidence of comorbidities, they had a higher prevalence of chronic kidney disease, a risk factor repeatedly identified as hampering the effectiveness of implantable cardioverter-defibrillator (ICD) therapy and which is not improved by CRT [14, 15]. As in other CRT and ICD trials and registries, only 25% of the recipients were women, reflecting the fact that women are undertreated in the field of cardiovascular diseases [1, 8, 16–18].

The "classical" class I indication of symptomatic heart failure and a wide left bundle-branch block was less often the indication for implantation in Switzerland. Relatively more patients received an upgrade or a *de-novo* CRT system because they had the indication for pacing with or without defibrillation therapy, with an expected or actual high percentage of ventricular pacing (e.g., in the presence of atrioventricular block II or III). Consequently, the Swiss group had a greater share of patients with preprocedural QRS duration <120 ms and NYHA class I. However, most patients had symptomatic heart failure as an indication for CRT implantation, displayed a left bundle-branch block morphology on the 12-lead ECG, had a LVEF <35% and very high

Table 4: Postprocedural data of Swiss cardiac resynchronisation therapy (CRT) population and comparison with the European average.

	Switzerland	Europe	p-value	OR (95% CI)
Hospital mortality	0.3 (1/320)	0.4 (44/10525)	0.79	
Device related complications	4 (13/320)	4.8 (515/10768)	0.55	
Lead displacement	2 (8/320)	1.7 (180/10510)	0.29	
RV	37 (3/8)	31 (52/169)	0.68	
LV	37 (3/8)	53 (90/169)	0.38	
Atrial	37 (3/8)	18 (31/169)	0.18	
Lead malfunction	0 (0/320)	0.2 (23/10510)	0.40	
Phrenic nerve stimulation	0.6 (2/320)	1.2 (121/10510)	0.38	
Infection	0.6 (2/320)	0.6 (58/10496)	0.86	
Stroke	0 (0/320)	0.6 (58/10496)	0.67	
Worsening of HF	0.6 (2/320)	0.7 (76/10496)	0.84	
Arrhythmias	0.9 (3/320)	1.2 (125/10496)	0.68	
Total length of hospital stay	2 (2, 5)	3 (2, 7)	**<0.001**	
Paced QRS duration (sec)	138 ± 26	138 ± 24	0.77	
Medical therapy at discharge				
Diuretic	70 (223/318)	81 (8398/10317)	**<0.001**	0.54 (0.42–0.69)
ACE inhibitor / ARB	87 (277/319)	86 (8886/10284)	0.83	
Aldosterone antagonist	48 (153/319)	64 (6529/10254)	**<0.001**	0.53 (0.42–0.66)
Beta-blocker	85 (272/319)	89 (9200/10329)	**0.032**	0.71 (0.52–0.97)
Digoxin	5 (17/319)	11 (1083/10225)	**0.002**	0.48 (0.29–0.78)
Calcium channel blocker	7 (23/317)	9 (923/10214)	0.27	
Amiodarone	20 (62/317)	17 (1763/10230)	0.28	
Ivabradine	0.6 (2/319)	6 (591/10224)	**<0.001**	0.10 (0.03–0.41)
Other antiarrhythmic agent	4 (12/318)	2 (169/10213)		
Oral anticoagulation	43 (136/319)	47 (4792/10258)	0.15	0.85 (0.68–1.06)
Vitamin K antagonist	59 (80/136)	71 (3383/4792)	**0.003**	0.59 (0.42–0.84)
Dabigatran	3 (4/136)	7 (323/4792)	0.08	0.42 (0.15–1.14)
Rivaroxaban	29 (40/136)	12 (571/4792)	**<0.001**	3.08 (2.11–4.50)
Apixaban	6 (8/136)	10 (501/4792)	0.08	0.54 (0.26–1.10)
Edoxaban	3 (4/136)	0.3 (14/4792)	**<0.001**	10.34 (3.36–31.84)
Platelet inhibitor	51 (162/320)	43 (4684/10768)	**0.011**	1.33 (1.07–1.66)
ASA	48 (152/319)	41 (4205/10228)	**0.019**	1.30 (1.04–1.63)
Clopidogrel	11 (35/319)	12 (1269/10228)	0.44	
Ticagrelor	3 (8/319)	1 (128/10228)	0.051	
Dual antiplatelet therapy	11 (34/319)	9 (947/10228)	0.39	
OAC plus P2Y12 inhibitor	3 (10/319)	4 (430/10301)	0.36	
Triple therapy	1 (4/319)	2 (214/10302)	0.31	
Device follow-up planned				
At implanting centre	68 (219/320)	87 (9126/10498)	**<0.001**	0.33 (0.26–0.42)
Other hospital	10 (33/320)	8 (840/10498)	0.14	
Private cardiologists	22 (71/320)	5 (498/10498)	**<0.001**	5.73 (4.33–7.57)

ACE = angiotensin converting-enzyme; ARB = angiotensin-receptor blocker; ASA = acetylsalicylic acid; LV = left ventricle; OAC = oral anticoagulation; RV = right ventricle Values are % (n) for categorical and mean ± standard deviation or median (interquartile range) for continuous variables.

mean NT-pro BNP, which also means high adherence to guideline recommendations by physicians [19].

Electrocardiographically, the average QRS duration decreased significantly with biventricular pacing, which is expected and a predictor of good clinical response [1–3]. The reported perioperative complication rates were low, which is in line with the fact that most of the participating Swiss centres are high-volume centres [9, 16, 17]. The Swiss group had no relevant bleeding complications, despite the fact that almost 80% of patients took either oral anticoagulation, antiplatelet therapy, or even both. This could be explained by high adherence to new recommendations on antithrombotic dual and triple therapy, as well as by the experience of the recruiting centres [19–22].

In conclusion, when compared with other European countries, Swiss CRT recipients were older, less symptomatic, received more device upgrades, had a higher incidence of chronic kidney disease and more frequently received quadripolar left ventricular leads. At the same time, the percentage of CRT-D implantations was lower than in the overall European population. Our data indicate that, despite almost free access to modern technology, Swiss patients and physicians more often use the less expensive CRT-pacemaker system with the primary goal of symptomatic relieve from heart failure when compared with their European counterparts. The data from Swiss patients participating in the European CRT Survey II provide important information for physicians, patients and health economists and demonstrate significant differences between Swiss and European patients in some aspects of the application of CRT.

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Potential competing interests

AA is consultant for Biosense Webster, Boston Scientific, Corúa, Daichii-Sankyo, EBR Systems, Medtronic and Microport CRM, and has received speaker fees from Boston Scientific, Medtronic and Microport CRM. No other potential conflict of interest relevant to this article was reported.

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