BRIEF REPORT

Management of implantable cardioverter-defibrillator patients with appropriate ICD shocks: A 3-step treatment concept

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Introduction

It is known that appropriate implantable cardioverter-defibrillator (ICD) shocks are associated with increased morbidity and mortality.[1] Despite the poor prognosis and high rate of appropriate ICD shocks, treatment after the occurrence of ICD shocks remains unclear. Current guidelines recommend amiodarone or ablation after appropriate ICD shocks, but these treatments do not improve the prognosis.[2] Prognostic heart failure treatment such as valsartan/sacubitril, cardiac resynchronization therapy, or MitraClip are known to improve the survival of patients with heart failure while reducing the rate of sudden cardiac death and the occurrence of ventricular arrhythmias.[3–5] It is not known whether these heart failure treatments are applicable to patients with ICD shock. Therefore, the present study analyzed the treatment and management of patients with appropriate shocks and defined a treatment concept based on these results.

Methods

The study consisted of 2 parts: (1) a retrospective analysis of the management of ICD patients after appropriate ICD shocks in 601 of 2378 (25%) patients (control group) of the prospective single-center ICD registry Ludwigshafen who received the first appropriate ICD shock between 2000 and August 2018; and (2) the development of a treatment concept and its prospective evaluation in 80 consecutive ICD patients (ToVAMI group) who received appropriate ICD shocks between September 2018 and January 2021. The treatment protocol is shown in Figure 1.

KEYWORDS Appropriate ICD shock; Defibrillation; Implantable cardioverter defibrillator; ICD shock management; Trigger; Ventricular arrhythmia

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Statistical analysis

The patient population is described by absolute numbers and percentages. The distribution of continuous variables is characterized by means and standard deviation or medians with upper/lower quartile. Categorical variables were compared using the Pearson χ^2 or Fisher exact test, as appropriate. All P values were 2-tailed. A P value $< .05$ was considered statistically significant.

Results

Patient characteristics

An overview of the key clinical characteristics of the patients at the time of the index ICD shock is shown in Table 1.

Analysis of the management after ventricular tachycardia/ventricular fibrillation shock

The management of ICD patients with appropriate ICD shock essentially consisted of 3 steps, which can be summarized as the ToVAMI treatment concept (Table 2):

(1) Trigger identification and optimization (To = Trigger optimization). The following trigger categories have been identified and can be summarized under the acronym ICD-STEMi: Ischemia, Compliance, Decompensation, Stress, Technical, Electrolyte/endocrinological disorder, and Medical intoxication. Acute therapy after ventricular tachycardia/ventricular fibrillation shock relied on finding triggers and comprised a wide variety of treatment measures, including revascularization by coronary artery bypass graft or percutaneous coronary intervention, counseling of patients and physicians, recompensation, reprogramming of devices, treatment of comorbidities including urgent surgery, lead revision, optimization of electrolyte or endocrinological disorders, or withdrawal of drugs owing to serious side effects.
(2) Ventricular Arrhythmia (VA) treatment, which consisted of ventricular ablation or antiarrhythmic drugs.

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KEY FINDINGS

- Management of patients with appropriate implantable cardioverter-defibrillator (ICD) shock consists of 3 steps, which can be summarized as the ToVAMI treatment concept: Trigger optimization, Ventricular Arrhythmia therapy, and optimized Medical and Interventional heart failure treatment.
- The acronym ICD-STEMi is a useful screening tool for trigger identification and stands for Ischemia, Compliance, Decompensation, Stress, Technical, Electrolyte/endocrinologic disorders, and Medication intoxication.
- Prospective application of ToVAMI in current daily clinical practice is feasible and significantly increases trigger identification and optimization of heart failure treatment after an appropriate ICD shock.

(3) Medical and Interventional (MI) prognostic heart failure treatment. This included review of current medications, implementation of prognostic heart failure medication according to guidelines, and use of interventional therapies known to improve the condition of the underlying heart disease.

Comparison of therapy between the ToVAMI and the control group

Prospective application of the ToVAMI treatment approach resulted in a 2-fold increase in trigger identification and a 5-fold increase in the rate of heart failure treatment optimization (Table 2).

Discussion

The management of ICD patients with appropriate ICD shock essentially consists of 3 steps that can be summarized as the ToVAMI treatment concept: trigger optimization, ventricular

Management of VT/VF ICD shocks – the ToVAMI treatment concept

Name of patient

1) To = Trigger optimization according to the ICD-STEMi scheme

Yes	No			to do
☐	☐	**I** →	Ischemia? (TNI, Angina, known CAD)	TNI, Coro, stress test
☐	☐	**C** →	Compliance issue? (check drugs)	Counseling
☐	☐	**D** →	Decompensation (worsing heart failure)	Echo, recompensation
☐	☐	**S** →	Stress (emotional, concomitant disease, surgery)	Disease therapy
☐	☐	**T** →	Technical (device/lead defect, arrhythmia induction?)	Device optimization
☐	☐	**E** →	Electrolyte/ endocrinology disorders?	E'lyte, glucose, TSH
☐	☐	**Mi** →	Medication intoxication? (Long QT? Digitalis?)	ECG, drug level?

2) VA = Ventricular Arrhythmia therapy

☐ ☐ VT ablation (VT, ischemic CMP, electrical storm)

☐ ☐ Amiodarone (no trigger, no VT ablation)

3) Medical and Interventional prognostic heart failure therapy

☐ ☐ Medication optimization: Entresto, BB, Spiro, Dapagliflozine, Empagliflozine

☐ ☐ Interventional optimization: → ECG, echo

- CRT upgrade
- TAVI (severe aortic valve stenosis)
- Mitra Clip (severe mitral valve insufficiency)
- PVI (paroxysmal or persistent AF < 1 year) or AV nodal ablation
- other

Figure 1 The ToVAMI treatment protocol.

Table 1 Clinical characteristics of patients at implantable cardioverter-defibrillator shock

	Control group (n = 601)	ToVAMI group (n = 80)	*P* value
Clinical characteristics			
Age (years)	66 ± 11*	68 ± 11	n.s.
Female sex	16%	7.5%	.04
EF < 30%	63%	83%	<.001
Coronary artery disease	60%	60%	n.s.
History of AF	41%	60%	.001
Diabetes	30%	34%	n.s.
Renal impairment	26%	33%	.01
Primary prophylactic ICD	52%	61%	n.s.
Biventricular device	23%	19%	n.s.
Medication			
ACE/ARB	93%	56%	<.001
Sacubitril/valsartan	0,3%	35%	<.001
Beta blocker	94%	88%	.02
Spironolactone	43%	68%	<.001
Amiodarone	8.2%	6.3%	n.s.
Arrhythmia characteristics			
First ICD shock	100%	56%	<.001
VF shock	38%	41%	n.s.
Electrical storm	26%	34%	n.s.

ACE = angiotensin converting enzyme; AF = atrial fibrillation; ARB = angiotensin receptor antagonist; EF = ejection fraction; ICD = implantable cardioverter-defibrillator; n.s. = nonsignificant; VF = ventricular fibrillation.

*Values are presented as mean ± standard deviation.

arrhythmia therapy, and medical and interventional prognostic heart failure treatment.

According to the guidelines, treatment options after appropriate ICD shocks consist of antiarrhythmic therapy with amiodarone or ablation therapy.[2] The present study clearly demonstrates that the therapy is far more complex. The occurrence of malignant ventricular tachyarrhythmias and their management is determined by the interaction of the factors triggers, arrhythmogenic substrate, and progression of heart failure (Figure 2). It highlights the need for systematic workflows for the treatment of patients with appropriate ICD shock. The application of the ToVAMI concept in the current ICD population was feasible and increased the rate of identified triggers and the rate of optimized heart failure treatment. This is mainly due to the recent development of new prognostic drugs or interventional therapies, which offer new perspectives in the treatment of heart failure.[3–5]

In conclusion, the ToVAMI concept represents a treatment approach for patients with appropriate ICD shock. Further studies should investigate whether the ToVAMI concept can improve mortality in ICD patients with appropriate ICD shocks.

Table 2 Trigger identification and therapy after ventricular tachycardia/ventricular fibrillation shock according to the ToVAMI scheme

	Control group, (n = 601)	ToVAMi group, (n = 80)	*P* value
To = Trigger optimization	28%	55%	<.001
Ischemia	13 (2%)	7 (8.8%)	.001
Revascularization (CABG/PCI)	33 (6%)	9 (11%)	.04
Compliance	13 (2%)	8 (10%)	<.001
Decompensation	64 (11%)	20 (25%)	<.001
Stress	19 (3%)	10 (13%)	<.001
Technical issue	9 (1.5%)	2 (2.5%)	n.s.
Electrolyte/ endocrinologic disorders	44 (7%)	7 (8.8%)	n.s.
Medical intoxication	10 (1.7%)	0 (0%)	n.s.
VA = Ventricular Arrhythmia therapy	32%	51%	.001
VT ablation	41 (7%)	15 (19%)	<.001
New antiarrhythmic drug	172 (29%)	28 (35%)	n.s.
Amiodarone	115 (19%)	23 (29%)	.04
MI = Medical/ Interventional optimization of heart failure therapy	7%	36%	<.001
Medical optimization	37 (6%)	24 (30%)	<.001
New beta blocker	19 (3.2%)	5 (6.3%)	n.s.
New spironolactone	15 (2.5%)	6 (7.5%)	.02
New valsartan/ sacubitril	4 (0.7%)	18 (23%)	<.001
Interventional optimization	16 (2.7%)	11 (14%)	<.001
Upgrade to CRT	6 (1%)	9 (11%)	<.001
PVI, AV nodal ablation, isthmus ablation	3 (0.5%)	3 (3.8%)	.02
TAVI/surgical aortic valve replacement	2 (0.3%)	0 (0%)	n.s.
MitraClip/mitral valve replacement	5 (0.7%)	0 (0%)	n.s.
No change of therapy	46%	10%	<.001

AV = atrioventricular; CABG = coronary artery bypass surgery; CRT = cardiac resynchronization therapy; PCI = percutaneous coronary intervention; PVI = pulmonary vein isolation; TAVI = transcatheter aortic valve implantation; VT = ventricular tachycardia.

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Disclosures

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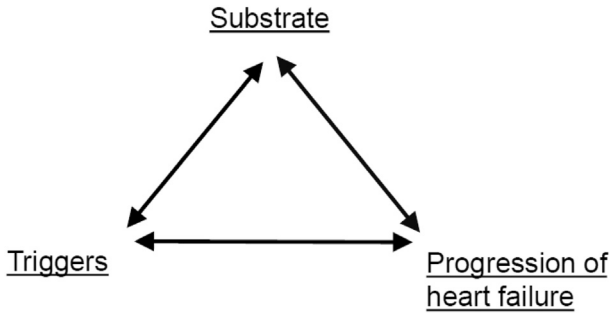

Figure 2 The triad of implantable cardioverter-defibrillator shock is determined by the interaction of the factors trigger, arrhythmogenic substrate, and progression of heart failure (adapted from Figure 1 in Kowlgi and colleagues[6]).

Authorship

All authors attest they meet the current ICMJE criteria for authorship.

Patient Consent

All participants gave written informed consent.

Ethics Statement

The study complied with the Declaration of Helsinki and the ICD registry was approved by the local ethics committee of the Landesärztekammer Rheinland Pfalz.

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