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2019 HRS/EHRA/APHRS/LAHRS focused update to 2015 expert consensus statement on optimal implantable cardioverter-defibrillator programming and testing

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Abstract

The *2015 HRS/EHRA/APHRS/SOLAECE Expert Consensus Statement on Optimal Implantable Cardioverter-Defibrillator Programming and Testing* provided guidance on bradycardia programming, tachycardia detection, tachycardia therapy, and defibrillation testing for implantable cardioverter-defibrillator (ICD) patient treatment. The 32 recommendations represented the consensus opinion of the writing group, graded by Class of Recommendation and Level of Evidence. In addition, Appendix B provided manufacturer-specific translations of these recommendations into clinical practice consistent with the recommendations within the parent document. In some instances, programming guided by quality evidence gained from studies performed in devices from some manufacturers was translated such that this programming was approximated in another manufacturer's ICD programming settings. The authors found that the data, although not formally tested, were strong, consistent, and generalizable beyond the specific manufacturer and model of ICD. As expected, because these recommendations represented strategic choices to balance risks, there have been reports in which adverse outcomes were documented with ICDs programmed to Appendix B recommendations. The recommendations have been reviewed and updated to minimize such adverse events. Notably, patients who do not receive unnecessary ICD therapy are not aware of being spared potential harm, whereas patients in whom their ICD failed to treat life-threatening arrhythmias have their event recorded in detail. The revised recommendations employ the principle that the randomized trials and large registry data should guide programming more than anecdotal evidence. These recommendations should not replace the opinion of the treating physician who has considered the patient's clinical status and desired outcome via a shared clinical decision-making process.

Keywords Antitachycardia pacing · Bradycardia mode and rate · Defibrillation testing · Implantable cardioverter-defibrillator · Programming · Sudden cardiac death · Tachycardia detection · Tachycardia therapy · Ventricular tachycardia · Ventricular fibrillation

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‡The manufacturer-specific programming settings/choices set forth below are based on a compilation of clinical expertise and clinical trial data as reported in the *2015 HRS/EHRA/APHRS/SOLAECE Expert Consensus Statement on Optimal Implantable Cardioverter-Defibrillator Programming and Testing*, of which this Appendix B is a part. These recommended settings/choices represent a diligent and good faith effort on the part of the writing committee to translate the consensus statement recommendations to device settings/choices for the four specified clinical issues/implantable cardioverter-defibrillator (ICD) therapies where the writing committee considered that there was sufficient consensus and supporting data to make recommendations intended to improve the safety, morbidity, and mortality profile of patients with these clinical issues/ICD therapies. They are the recommendations of the writing committee only. They do not represent the position or recommendations of HRS, EHRA, LAHRS (formerly SOLAECE), or APHRS, nor are they the manufacturer's nominal settings or the precise programming tested during clinical trials of these devices, nor are they necessarily the settings/choices that would be recommended by the manufacturer. These recommended settings/choices are not applicable in all circumstances. As stated in the Introduction to the consensus statement, "The care of individual patients must be provided in context of their specific clinical condition and the data available on that patient." Each treating physician must carefully consider the circumstances of their individual patient and determine whether these recommended settings/choices are appropriate to their patient's circumstances.

1.1 Abbott (Formerly St. Jude Medical) *Settings that are not nominal are marked with an asterisk

Brady	Single Chamber VVI 40bpm Dual Chamber DDD, consider Ventricular Intrinsic Preference (VIP) ± rate response CRT DDD ± rate response Consider SyncAV* (if intact AV conduction) as appropriate
Detection	In patients with no VT history VF: 30 intervals*[1], 240 or 250bpm* VT2: 30 intervals*[1], 187bpm* VT: Monitor, at user discretion In patients where VT CL is known VF: 30 intervals*[1], 240 or 250bpm VT2: 30 intervals*[1], 187bpm or 10–20bpm < VT rate* VT: Therapy at 10–20bpm < VT rate or Monitor zone [1] Fewer intervals to detect may be reasonable due to the possibility of VT straddling 2 zones that may result in "binning" to both zones, effectively doubling time to detect. Beats that fall out of zone sometimes reset counters so patients with poor sensing should also have fewer detection intervals considered.
Therapy	VF: ATP While Charging, 8 pulses at 85% VT CL All shocks: Maximum output (unless DFT guided) Note: 1st shock 4–6J lower than full output VT2: ATP, ≥1 bursts of 8 pulses at 85% VT CL Scan step 10ms, Re-adaptive ON, Minimum CL 200ms All shocks ON VT: As for VT2, favoring more ATP[2] [2] Rarely, hemodynamically stable slow VT can be treated without programming a back-up shock.
SVT Discriminators[3]	Single Chamber Far-Field Morphology: ON, 90%, 3 of 10 All others: "Passive" Dual Chamber/CRT-D Far-Field Morphology: ON, 90%, 3 of 10 Arrhythmia onset: ON (default settings) Interval Stability: ON (default settings) If ALL For CRT: Template Auto Update 30 days and Template Pacing Hysteresis ON *or* Far-Field Morphology Auto Update OFF SVT Upper Limit: 230bpm SVT Discrimination Timeout: OFF VT Therapy Timeout: OFF [3] SVT Discriminators are not required in Complete Heart Block.
Oversensing Rejection	Low Frequency Attenuation: ON SecureSense RV Lead Noise Discrimination: ON

2 Manufacturer-specific translation of ICD programming recommendations‡

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2.1 BIOTRONIK
*Settings that are not nominal are marked with an asterisk

Brady	Single Chamber	
	VVI 40bpm	
	Dual Chamber	
	DDD, consider IRS Plus* / I OPT* ± Closed Loop Stimulation (CLS)* *or*	
	DDD with Vp Suppression* ± rate response	
	CRT	
	DDD; optional DDD-CLS* *or* rate response* at user discretion	
Detection	In patients with no VT history[1]	
	VF:	30/40 intervals* (if programmable, otherwise 24/30), 231bpm*
	VT2:	30 intervals*, 188bpm*
	VT1:	Monitor zone* at user discretion
	In patients where VT CL is known	
	VF:	24/30 intervals*, 231bpm*
	VT2:	30 intervals*, 188bpm* (or 10–20bpm < VT rate)
	VT1:	Therapy* at 10–20bpm < VT rate or Monitor zone* at user discretion
[1] SVT discriminators are linked to Detection Zones. An alternative configuration would be VF 250bpm, VT2 231bpm and VT1 188bpm with therapy (i.e., no Monitor zone) if >1 ATP attempt desired up to 250bpm.		
Therapy	VF:	ATP One-Shot, 1 burst of 8 pulses at 88%[2] CL*, full output shocks (unless DFT guided)
	VT2:	ATP ≥1 bursts* of 8 pulses* at 88%[2] CL*, 10ms scan decrement*, All shocks ON
	VT1:	Monitor zone* or Therapy* as for VT2 (favoring more ATP)[3]
[2] If programmable, otherwise 85%.		
[3] Rarely, hemodynamically stable slow VT can be treated without programming a back-up shock.		
SVT Discriminators[4]	Single Chamber	
	MorphMatch[5]	ON(*)
	Onset[6]	OFF
	Stability	OFF*
	Sustained VT Timer	OFF
	Dual Chamber/CRT-D	
	SMART	ON (at default settings or adapted to known VT)
[4] SVT Discriminators are not required in Complete Heart Block.		
[5] MorphMatch is recommended for patients with narrow QRS complexes and sufficient far-field amplitude. Otherwise, Onset 20% and Stability 48ms is a recommended alternative.		
[6] If Onset is programmed ON, the performance of this discriminator is enhanced with a Monitoring Zone enabled.		
Others	Lead Integrity check	ON (if available)
	HomeMonitoring	ON* (if available)

3 Manufacturer-specific translation of ICD programming recommendations‡

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3.1 Boston Scientific
*Settings that are not nominal are marked with an asterisk

Brady	Single Chamber VVI, 40bpm* Dual Chamber DDD, consider RYTHMIQ* or AV Search +* ± rate response CRT DDD ± rate response Consider Smart Delay optimization of AV delays
Detection	In patients with no VT history *Option 1* – delayed therapy VF: 8 of 10 intervals plus 5-second duration*, 250bpm* VT: 8 of 10 intervals plus 12-second duration*, 185bpm* VT-1: Monitor, at user discretion *Option 2* – high-rate therapy VF: 8 of 10 intervals plus 2.5-second duration*, 200bpm* VT-1: Monitor, at user discretion In patients where VT cycle length is known VF: 5-second duration*, 250bpm* VT: 12-second duration*, 185bpm* or 10–20bpm < VT rate VT-1: Monitor Zone or Therapy at ≥12-second duration*, 10–20bpm < VT rate
Therapy	VF: QuickConvert ON to 300bpm* (if available) All shocks: Maximum output (unless DFT guided) VT: ATP-1: Scan, ≥1 bursts, 8 pulses* at 84%* coupling interval and cycle length (Minimum 200ms*), 10ms decrement* ATP-2: OFF* All shocks: ON VT-1: As for VT, favoring more ATP[1] [1] Rarely, hemodynamically stable slow VT can be treated without programming a back-up shock.
SVT Discriminators[2]	ICD RhythmID: ON CRT-D Onset/Stability: ON *or* RhythmID: ON* Sustained Rate Duration (SRD): OFF* SVT Discriminators apply only up to 230bpm [2] SVT Discriminators are not required in Complete Heart Block.
Oversensing Rejection	Nonphysiological Signal Detected: ON (Latitude)
Others	Turn on "Beep When Out-of-Range" Daily Lead Measurements* RV Pacing Impedance Abrupt Change alert ON (Latitude) Single Chamber: Consider %RV pacing alert ON (Latitude) Dual Chamber: Consider %RV pacing alert in non-AVB patients ON (Latitude) CRT-D: Consider CRT % pacing alert ON (Latitude)
SUBCUTANEOUS ICD Settings:	Shock Zone: ≥230bpm Conditional Zone: ≥200bpm or 10–20bpm < VT CL (if known) Consider post-shock pacing ON

4 Manufacturer-specific translation of ICD programming recommendations‡

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4.1 Medtronic
*Settings that are not nominal are marked with an asterisk

Brady	Single Chamber	
	VVI 40bpm	
	Dual Chamber	
	DDD, consider Managed Ventricular Pacing (MVP; AAI↔DDD) ± rate response	
	CRT	
	DDD ± rate response	
	Patient with intact AV conduction and LBBB—Consider Adaptive BiV & LV*	
Detection	In patients with no VT history	
	VF:	30/40 intervals, 188bpm
	FVT:	OFF[1]
	VT:	OFF
	VT Monitor:	User discretion
	In patients where VT CL is known	
	VF:	30/40 intervals, 188bpm
	FVT:	OFF[1]
	VT:	24* intervals[2], 10–20bpm < VT rate
	VT Monitor:	User discretion
Therapy	VF:	ATP Before* Charging; ChargeSaver ON All shocks: Full output shocks (unless DFT guided)
	VT (if ON):	Rx1: ATP, ≥1 bursts of 8 pulses at 88% VT CL, 10ms Decrement Rx2-6: All Shocks ON[3]
SVT Discriminators[4]	Single Chamber	
	Wavelet:	ON
	Limit:	260ms (230bpm)
	Stability:	OFF
	Onset:	OFF
	Dual Chamber/CRT-D	
	PR Logic:	ON (Other 1:1 OFF until lead stabilized at ~3 months)
	Wavelet:	ON (if available)
	SVT Limit:	260ms (230bpm)
	Stability:	OFF
	Onset:	OFF
Oversensing Rejection	Lead Integrity Alert:	ON
	T-wave Oversensing:	ON (if available)
	RV Lead Noise:	ON* without timeout (if available)

[1] Use of ATP Before/During Charging in the VF zone achieves similar functionality as use of the FVT zone. Multi-zone programming using FVT may allow tiered ATP therapy.

[2] Consecutive count in VT zone; hence, lower NID as per PainFree SST data.

[3] Rarely, hemodynamically stable slow VT can be treated without programming a back-up shock.

[4] SVT Discriminators are not required in Complete Heart Block.

5 Manufacturer-specific translation of ICD programming recommendations‡

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5.1 MicroPort CRM (Formerly LivaNova and Sorin Group) *Settings that are not nominal are marked with an asterisk

Brady

Single Chamber
VVI 40bpm*

Dual Chamber
SafeR (AAI↔DDD) ± rate response, consider DDD* in complete heart block

CRT
DDD ± rate response, consider weekly AV + VV SonR optimization ON[1]

[1] Requires SonRtip atrial lead with integrated hemodynamic sensor.

Detection

In patients with no VT history

VF:	20 cycle* + 6/8 majority	>255bpm*
FVT:	20 cycle* + 6/8 majority	230bpm
VT:	20 or 30 cycle* + 6/8 majority	185bpm
Slow VT:	Monitor zone at user discretion	

In patients where VT CL is known

VF:	20 cycle* + 6/8 majority	>255bpm*
FVT:	20 cycle*+ 6/8 majority	230bpm
VT:	≥20 cycle* + 6/8 majority	185bpm (or 10–20bpm < VT rate)
Slow VT:	Monitor zone at user discretion	

Therapy

VF: 6 x 42J*
FVT: If stable[2]: 1 x ATP (Burst @ 85% x 8 beats) then 6 x 42J* (unless DFT guided)
If unstable: 6 x 42J* (unless DFT guided)
VT: ≥1 x ATP (Burst + Scan @ 85% x 8 beats; Scan 8ms) then all Shocks ON*[3]

[2] Satisfaction of stability (nominal value = 30ms) in the Fast VT zone will not prevent therapy but rather activate programmable burst pacing prior to shock therapy.
[3] Rarely, hemodynamically stable slow VT can be treated without programming a back-up shock.

SVT Discriminators[4]

Single Chamber
Single button programming; Stability+/Acc
Rate, Stability, Degree of Onset, VT long cycle search
Nominal settings: Onset 19%, Stability 65ms (Slow VT, VT); Long cycle extension 10 cycles; Long cycle gap 170ms

Dual Chamber/CRT-D
Single button programming; PARAD+
Rate, Stability, AV association analysis, Degree and Chamber of Onset, VT long cycle search
Nominal settings: Onset 25%, Stability 65ms (Slow VT, VT); Long cycle extension 10 cycles; Long cycle gap 170ms

[4] SVT Discriminators are not required in Complete Heart Block.

Oversensing Rejection

Daily check Lead impedance ON*
Daily check Lead coil continuity ON*
Daily check V oversensing alerts ON*
T-wave filtering and noise detection are hardcoded in firmware

Appendix

Appendix 1 Author disclosure table

Writing group member	Employment	Honoraria/ Speaking/ Consulting	Speakers' bureau	Research*	Fellowship support*	Ownership/Partnership/Principal/ Majority stockholder	Stock or stock options	Intellectual property/Royalties	Other
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* Research and fellowship support are classed as programmatic support. Sources of programmatic support are disclosed but are not regarded as a relevant relationship with industry for writing group members or reviewers

Appendix 2 Reviewer disclosure table

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Number value: **0** = $0; **1** = ≤ $10,000; **2** = > $10,000 to ≤ $25,000; **3** = > $25,000 to ≤ $50,000; **4** = > $50,000 to ≤ $100,000; **5** = > $100,000

ABIM = American Board of Internal Medicine

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