RESEARCH LETTER

Adherence to consensus-based implantable cardioverter-defibrillator programming and impact on therapy delivery in clinical practice: A national cohort study

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Optimized implantable cardioverter-defibrillator (ICD) programming strategies, particularly high-rate or delayed therapy, have been shown to reduce unnecessary therapies and improve clinical outcomes.[1] These approaches were already emphasized in the 2015 Heart Rhythm Society/European Heart Rhythm Association/Asia Pacific Heart Rhythm Society/Latin American Heart Rhythm Society expert consensus statement, which advocated individualized programming and supported minimizing unnecessary interventions through higher detection thresholds and longer detection durations.[2] In 2019, manufacturer-specific recommendations for implementing these strategies were published,[3] and in June 2020, Boston Scientific updated nominal ICD settings to facilitate the adoption of high-rate programming. To evaluate how these changes translated into real-world practice, we analyzed ICD and cardiac resynchronization therapy-defibrillator programming in Italy using data from the LATITUDE remote monitoring network between 2009 and 2023. Patients enrolled in LATITUDE in Europe provide their consent to data storage. This analysis was conducted within the framework of the MULTITUDE registry (ClinicalTrials.gov ID NCT06311149). The study was approved by the institutional review boards. The research adhered to relevant ethical guidelines. The dataset included 4021 patients monitored at 27 Italian centers (aged 72 ± 13 years; ICDs 2222 [55%]; cardiac resynchronization therapy-defibrillators 1799 [45%]), with a median period from implantation to the last data transmission of 37 months (25th–75th percentile 15–62 months). Programming was extracted from the first in-office interrogation and the most recent remote transmission.

Programming trends changed markedly after the 2020 nominal updates (Figure 1). Before 2020, only 0.3% of devices (8 of 2286) met all high-rate criteria compared

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KEY FINDINGS

- Implantable cardioverter-defibrillator programming in Italy shifted toward evidence-based high-rate detection strategies after 2020, closely following manufacturer updates to nominal device settings, although overall adoption remained modest, reaching 15% by 2023.
- Programming consistent with the high-rate strategy was associated with significantly fewer therapies, including both antitachycardia pacing and shocks, confirming in real-world practice the benefits previously demonstrated in randomized trials and registries.
- Reprogramming during follow-up was rare, indicating that initial programming choices largely persisted over time and highlighting the need for more systematic use of remote monitoring to promote guideline-directed optimization.

with 15% (73 of 471) in 2023. The ventricular tachycardia (VT)-1 zone was programmed in monitor mode in 18% of cases (410 of 2286) before 2020 and 88% (415 of 471) in 2023, whereas ventricular fibrillation zones set at >200 beats per minute for >2.5 seconds increased from 22% (509 of 2286) to 61% (287 of 471) (all $P < .001$). These shifts closely paralleled the manufacturer's modification of nominal settings. By contrast, the proportion of devices with a VT zone programmed in monitor mode changed only slightly over time, from 19% (434 of 2286) before 2020 to 23% (110 of 471) in 2023 ($P = .030$). The comprehensive combination of conditions required for a delayed therapy strategy was almost never applied, that is, 0.3% (14 of 4021).

Reprogramming during follow-up—that is, comparing initial and final individual device programming—was infrequent. Final transmissions showed only minimal movement toward guideline-recommended configurations, with devices meeting all high-rate criteria increasing from 4% (179 of 4021) to 5% (183 of 4021) ($P = .980$).

During follow-up, 1291 patients (32%) received antitachycardia pacing or shocks, and 927 (23%) received at least 1 shock. Programming consistent with the high-rate strategy was associated with fewer pacing or shock therapies (hazard ratio 0.53; 95% confidence interval 0.40–0.69; $P < .001$) (Figure 1) and fewer first shocks (hazard ratio 0.49; 95% confidence interval 0.35–0.68; $P = .002$).

In summary, ICD programming practices in Italy have evolved since the 2020 nominal update, with a measurable increase in adherence to high-rate detection parameters, although overall adoption remains modest. These findings highlight the impact of manufacturer-led

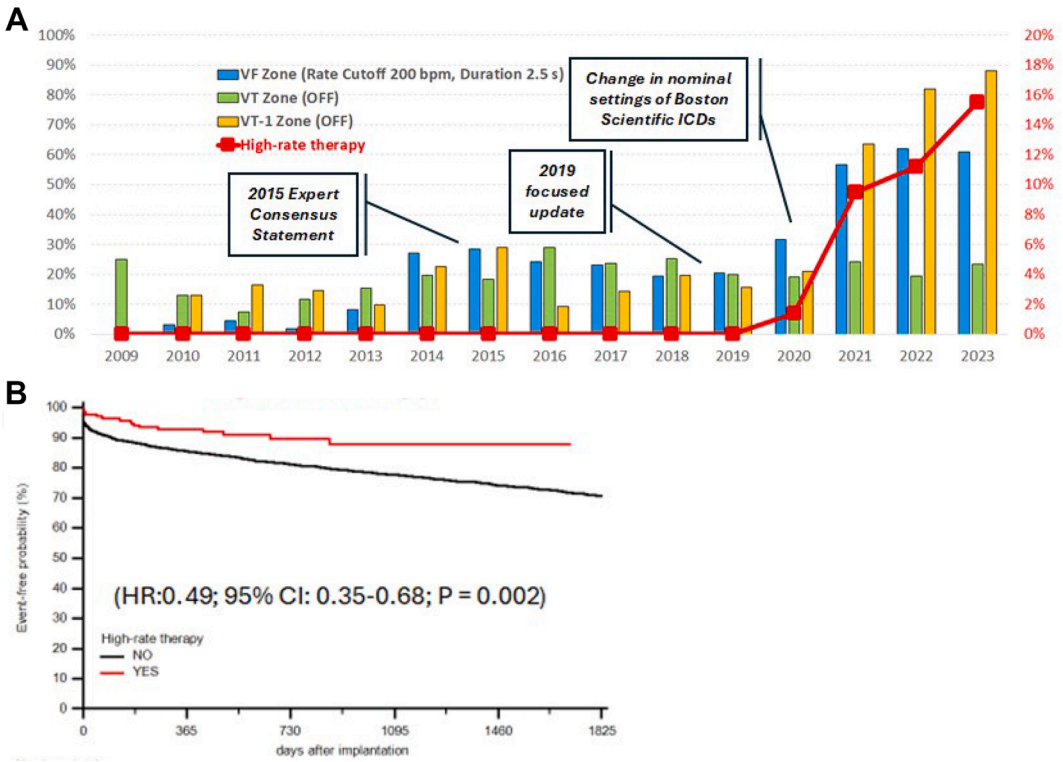

Figure 1 **A:** Trends in initial programming adherence to individual high-rate strategy criteria (2009–2023). The proportion meeting all combined criteria is shown in *red*. **B:** Kaplan-Meier estimates of time to the first antitachycardia pacing or shock according to adherence to all high-rate strategy criteria. bpm = beats per minute; CI = confidence interval; HR = hazard ratio; ICD = implantable cardioverter-defibrillator; VF = ventricular fibrillation; VT = ventricular tachycardia.

updates in promoting evidence-based programming and the persistent gap between recommended and real-world practice.

Our results also show that the high-rate strategy was associated with fewer therapies, including shocks alone, aligning with evidence from randomized trials and registries showing fewer inappropriate and overall therapies with high-rate detection.[1,4] However, we did not review electrograms to validate precise rhythm discrimination. Consequently, we could not differentiate between appropriate and inappropriate therapy occurrences.

Because only device-derived information was available, patient-level characteristics such as primary vs secondary prevention indication, atrial fibrillation prevalence, heart failure severity, mortality, or syncope events could not be assessed. In the Italian ICD population, approximately 15% of implants are typically performed for secondary prevention,[5] which may have influenced clinicians' choice to maintain lower-rate detection zones in selected patients. Although this analysis reflects Italian practice specifically, a similar uptake pattern might be suspected in other European countries; however, additional studies would be required to verify this.

Although mortality and syncope outcomes could not be evaluated, randomized and registry data indicate that conservative detection strategies are safe in broad ICD populations.[1] The present device-only dataset cannot further address safety outcomes, and future studies linking clinical and device information will be required to determine whether programming patterns in Italy—including the hesitant adoption of therapy deactivation in VT zones—reflect appropriate risk–benefit considerations at the patient level.

In conclusion, ICD programming in Italy has become more aligned with evidence-based recommendations after 2020, but substantial room for improvement remains, particularly in the broader adoption of high-rate strategies and systematic reprogramming during follow-up.

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Patient Consent: Patients enrolled in LATITUDE in Europe provide their consent to data storage.

Ethics Statement: The study was approved by the institutional review boards. The research adhered to relevant ethical guidelines.

Data Availability: The experimental data used to support the findings of this study are available from the corresponding author upon request.

References

1. Moss AJ, Schuger C, Beck CA, et al. Reduction in inappropriate therapy and mortality through ICD programming. N Engl J Med 2012;367:2275–2283.
2. Wilkoff BL, Fauchier L, Stiles MK, et al. 2015 HRS/EHRA/APHRS/SOLAECE expert consensus statement on optimal implantable cardioverter-defibrillator programming and testing. Europace 2016;18:159–183.
3. Stiles MK, Fauchier L, Morillo CA, Wilkoff BL; ESC Scientific Document Group. HRS/EHRA/APHRS/LAHRS focused update to 2015 expert consensus statement on optimal implantable cardioverter-defibrillator programming and testing. Europace 2019;21:1442–1443.
4. Bennett MT, Brown ML, Koehler J, Lexcen DR, Cheng A, Cheung JW. Trends in implantable cardioverter-defibrillator programming practices and its impact on therapies: insights from a North American Remote Monitoring Registry 2007–2018. Heart Rhythm 2022;19:219–225.
5. Proclemer A, Zecchin M, Zanotto G, et al. The pacemaker and implantable cardioverter-defibrillator registry of the Italian association of Arrhythmology and cardiac pacing - report 2020. G Ital Cardiol (Rome) 2022;23:309–313.